

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ



مقام معظم رهبری:

علم برای یک ملت مهم‌ترین ابزار آبرو و پیشرفت و اقتدار است.

۱۳۹۴/۰۸/۲۰





# Qt Training in C++

Lecturer: Ali Panahi

## What is Qt ?

Qt is cross-platform software for creating graphical user interfaces as well as cross-platform applications that run on various software and hardware platforms such as Linux, Windows, macOS, Android or embedded systems with little or no change in the underlying codebase while still being a native application with native capabilities and speed.

Qt is currently being developed by The Qt Company, a publicly listed company, and the Qt Project under open-source governance, involving individual developers and organizations working to advance Qt. Qt is available under both commercial licenses and open-source GPL 2.0, GPL 3.0, and LGPL 3.0 licenses.

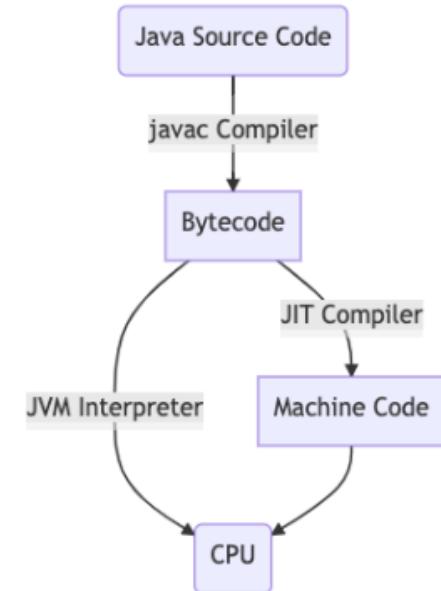
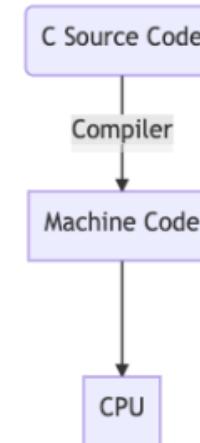
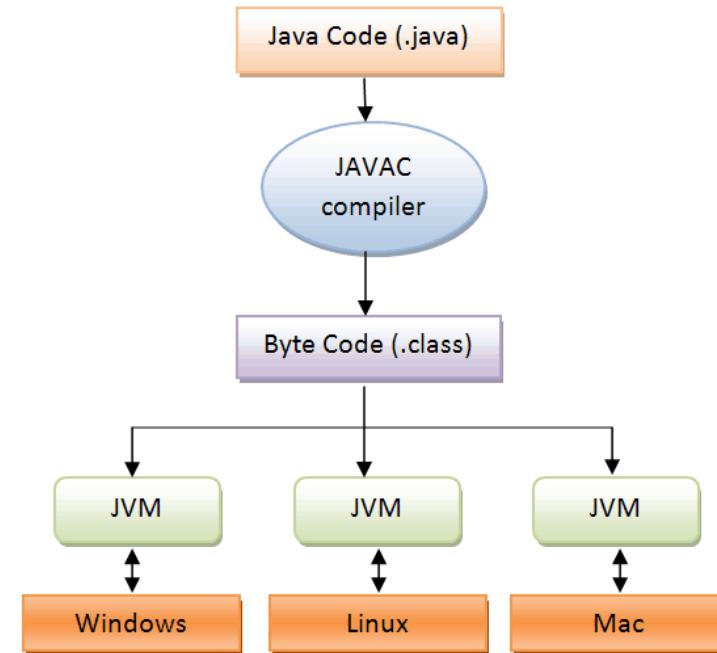
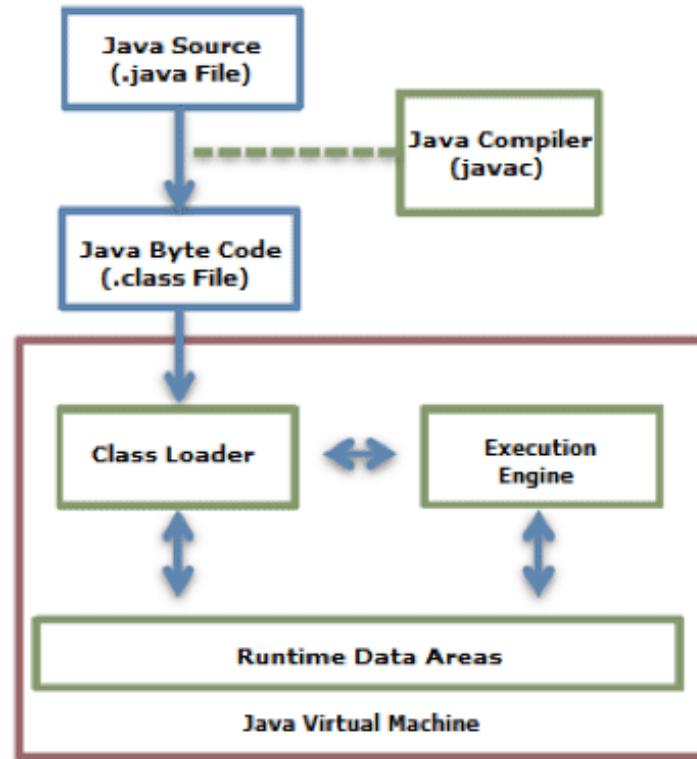
## Why use Qt ?

- Design and develop great user experiences
- Qt saves you money
- Get your products to market faster
- Performance, delivered
- One framework, fewer dependencies
- Develop for any platform
- We speak many languages
- Flexible. Reliable. Qt.
- Open source and future-proof

## Java vs .Net vs C++ vs QT vs .Net Core

- Java
  - Java is object-oriented programming language
  - Java is a general-purpose
  - Java is cross-platform
  - Java is class-based
  - Java is managed
  - Java is free
  - Low execution speed
  - Disassembling object code
  - High development speed

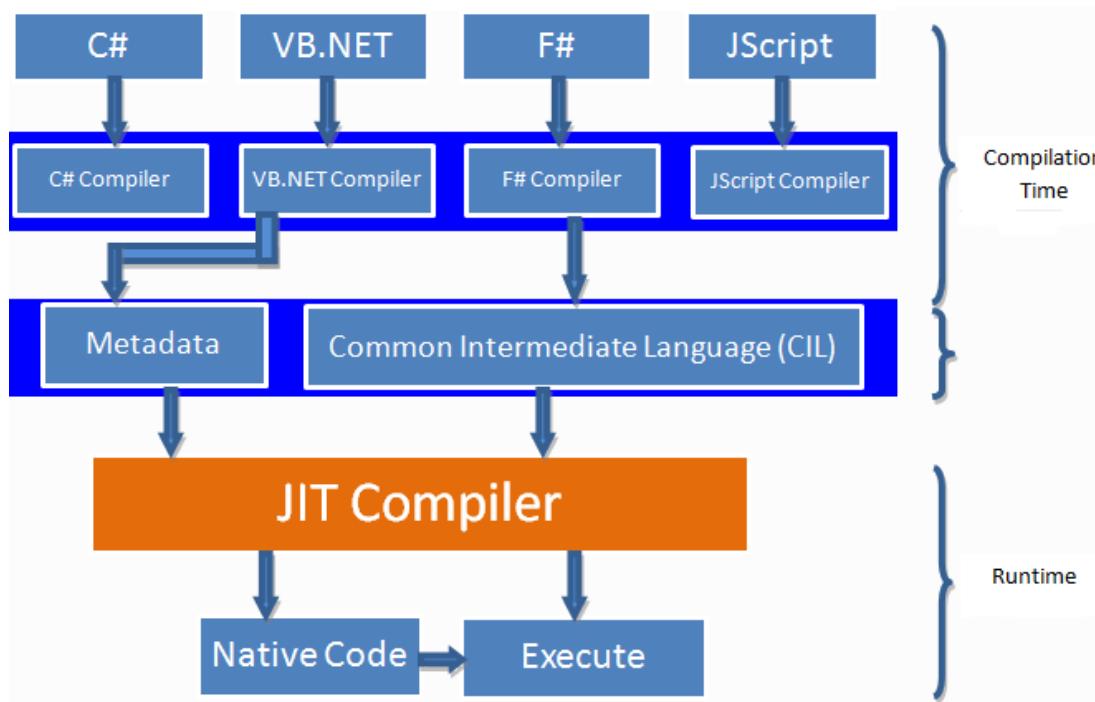




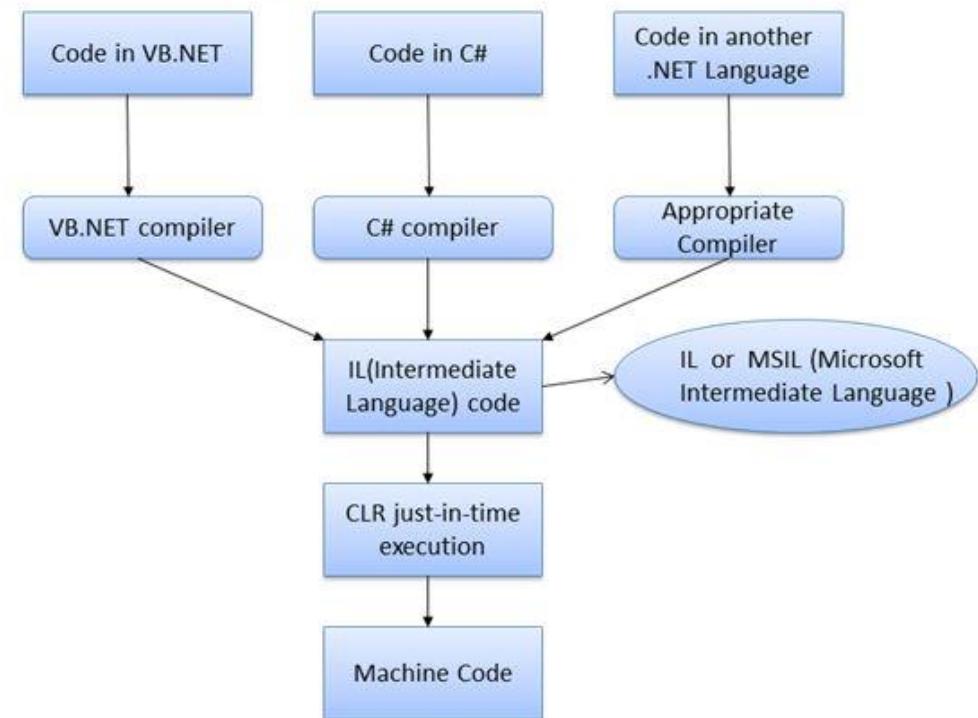
## Java vs .Net vs C++ vs QT vs .Net Core

- .Net
  - Multi-language Support
  - .Net is managed
  - Automatic resource management
  - .Net is commercial (Microsoft)
  - Low execution speed
  - Disassembling object code
  - Only for windows
  - High development speed



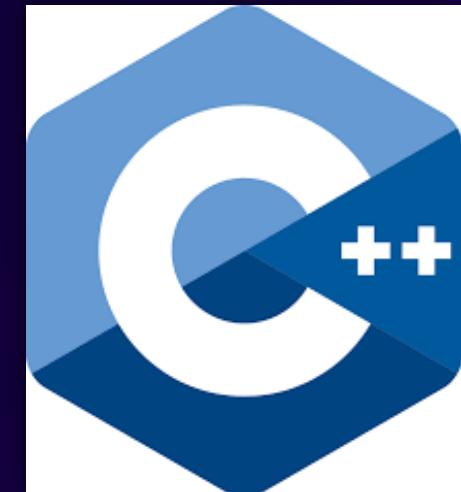


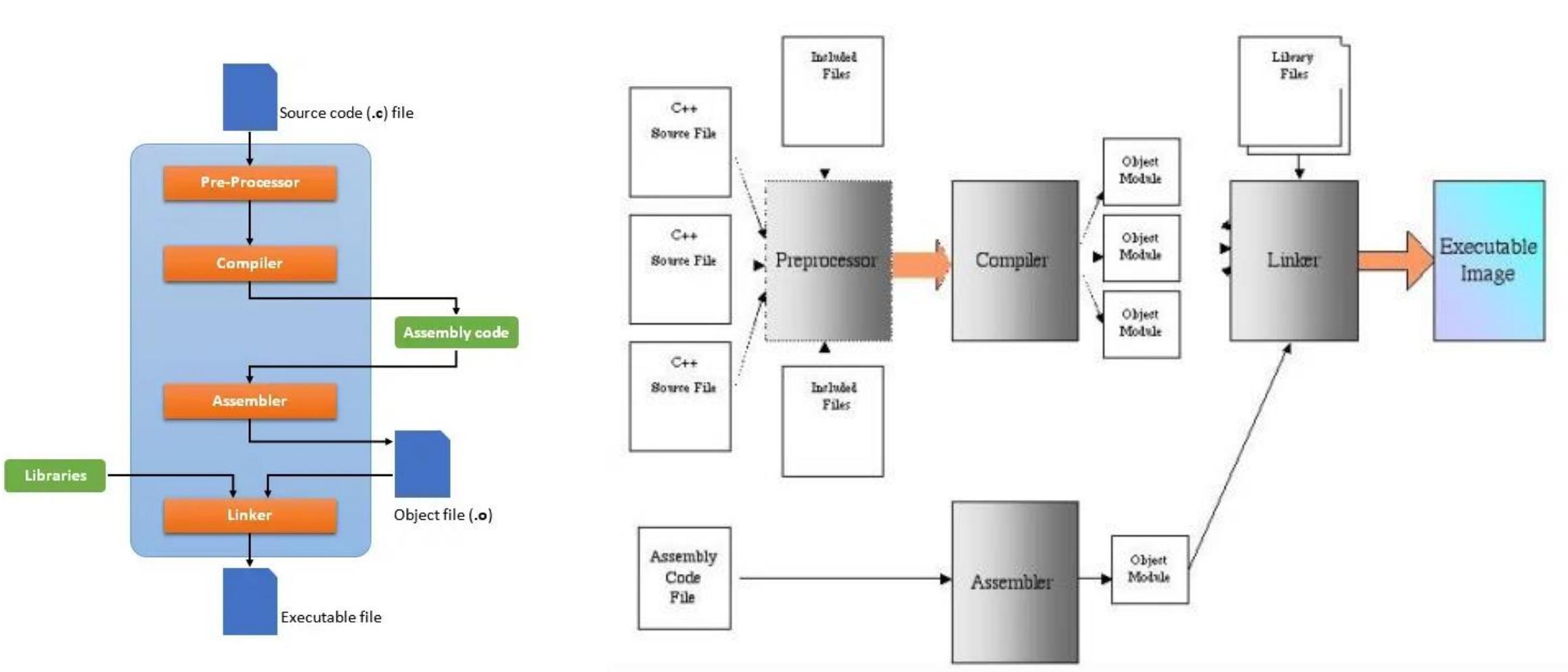
## Compilation in .NET



## Java vs .Net vs C++ vs QT vs .Net Core

- C/C++
  - It is native
  - Creating libraries that can be used in other languages
  - Powerful & fast
  - High security
  - Platform dependent
  - Irreversibility and reverse engineering of codes
  - It has no memory management
  - Low development speed

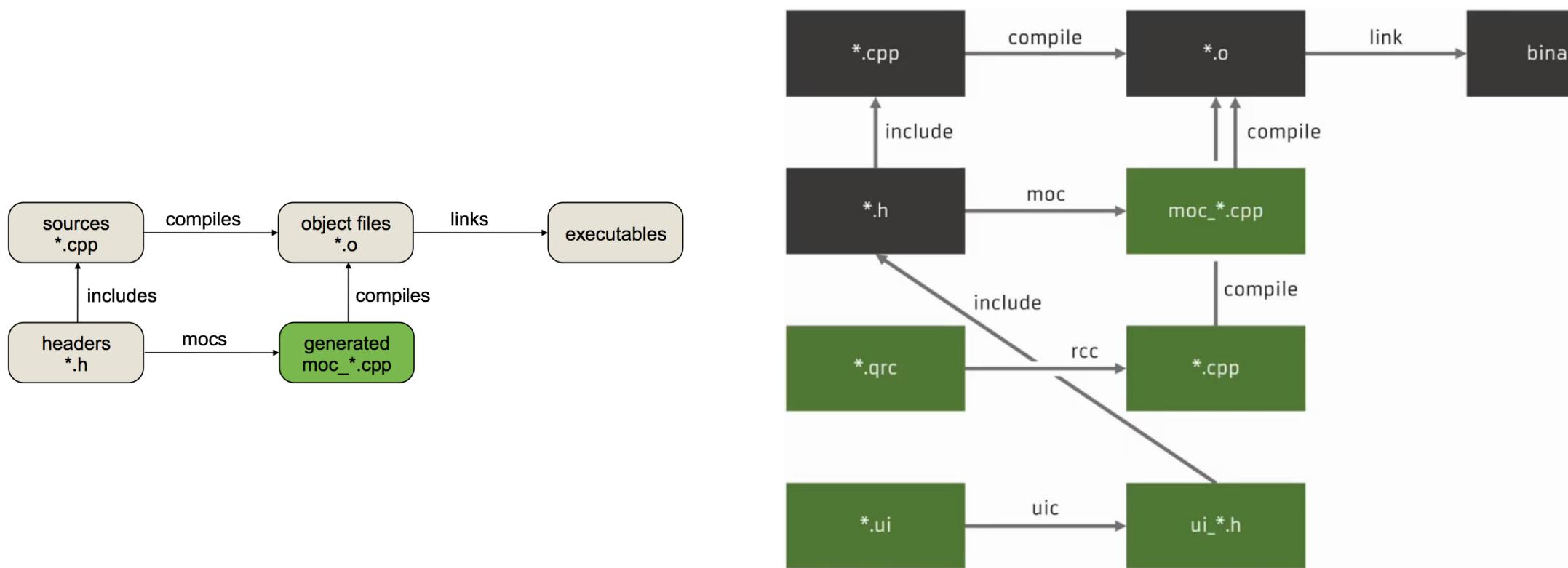


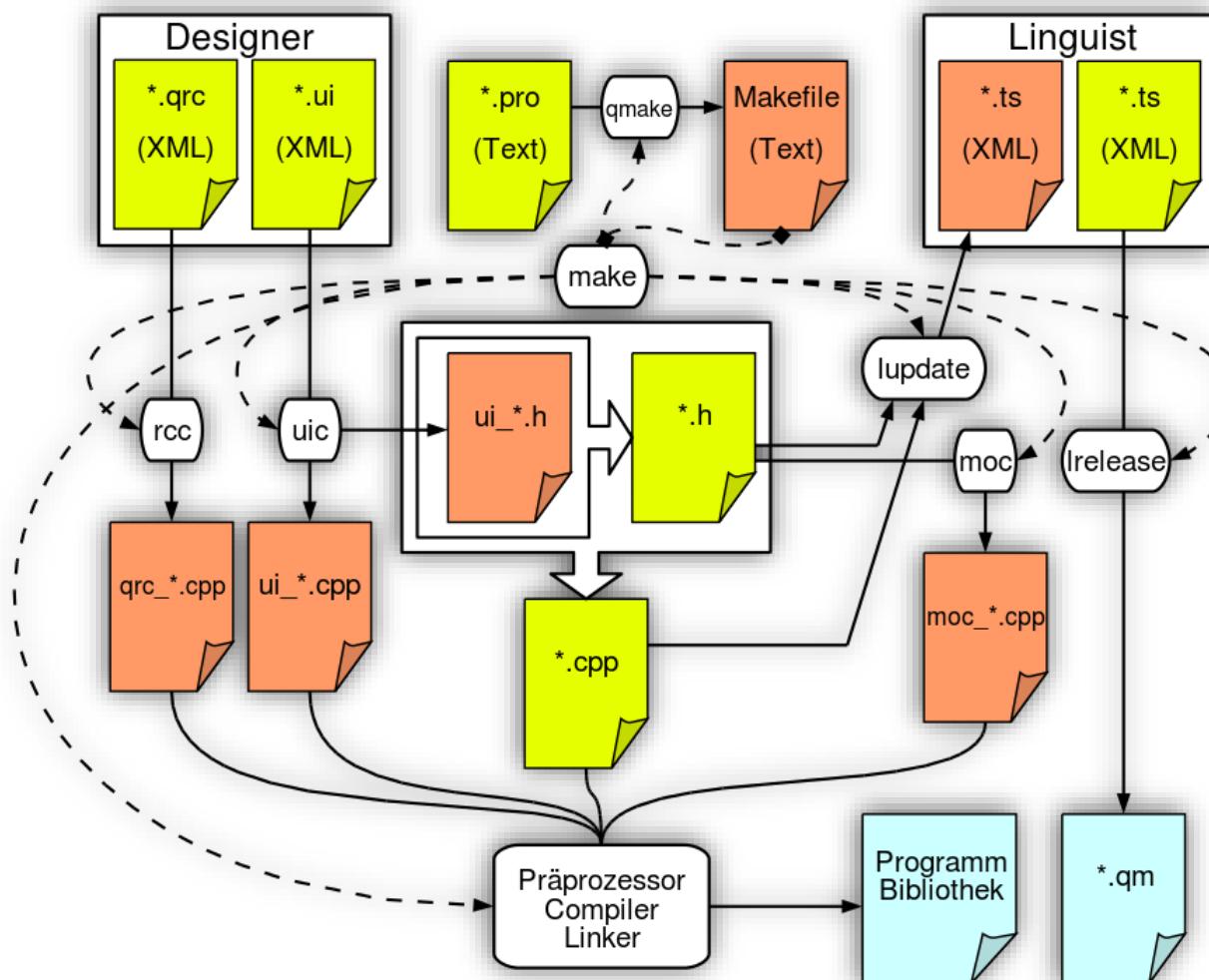


## Java vs .Net vs C++ vs QT vs .Net Core

- Qt
  - It is native
  - High security
  - Cross-platform (Windows, Linux, Mac)
  - Many possibilities
  - Free and open source

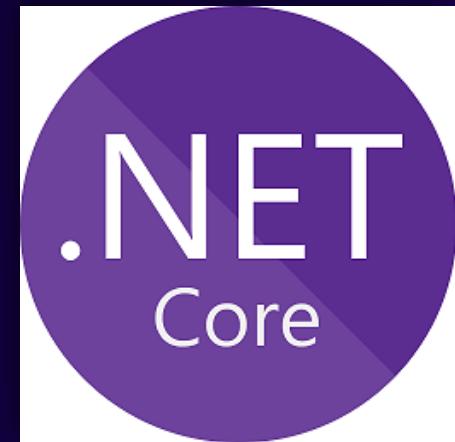






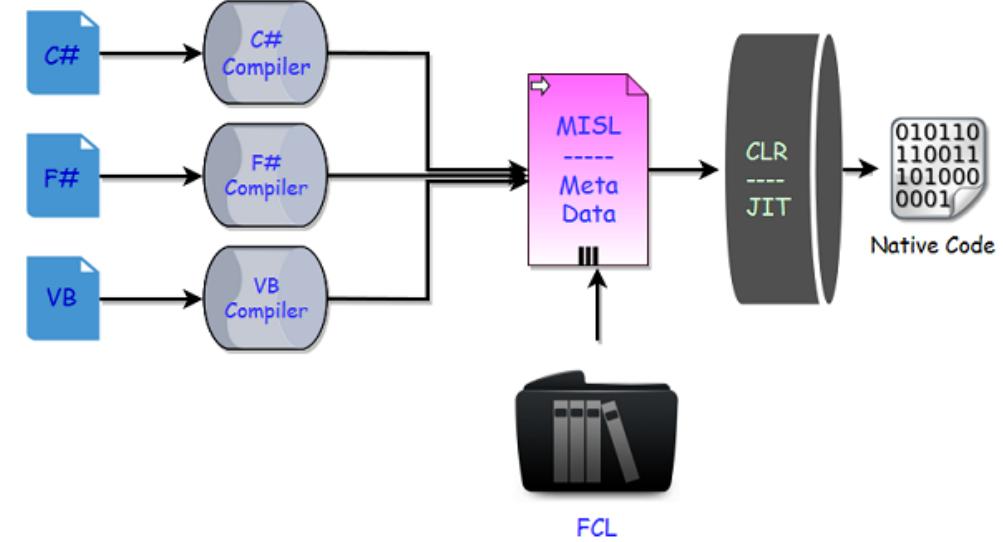
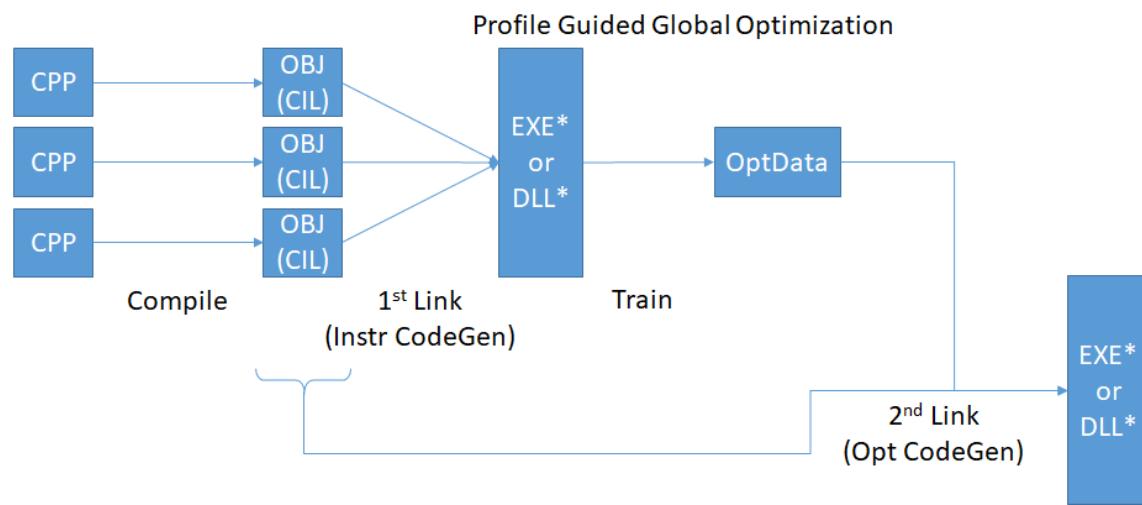
## Java vs .Net vs C++ vs QT vs .Net Core

- .Net Core
  - Multi-language support
  - .Net core is managed
  - Automatic resource management
  - .Net core is free and open source (Microsoft)
  - Low execution speed
  - Disassembling object code
  - Cross-platform (Windows, Linux)
  - High development speed



# Introduction to Qt >> .Net Core

Qt



## Companies using Qt

Qt helps the best companies in the world deliver better user experiences faster.



In-flight  
entertainment  
systems



In-vehicle  
infotainment  
system



Graphics software



Anesthesia &  
critical care  
medical devices



EDA & CAD end-  
to-end  
engineering  
solutions



Automotive  
mobility  
technology

Version	Release date / Support until	Target (Windows)
Qt 0.90	1995	-
Qt 1.0	1996	-
Qt 2.0	1999	-
Qt 3.0	2001	-
Qt 4.0	2005	-
Qt 4.8 LTS (4.8.7)	2011	XP, 7, 8.1, 10
Qt 5.6 LTS (5.6.3)	2016 / 2019	-
Qt 5.9 LTS (5.9.9)	2017 / 2020	-
Qt 5.12 LTS (5.12.12)	2018 / 2021	-
Qt 5.15 LTS	2020 / 2025	7, 8.1, 10, 11
Qt 6.2 LTS (6.2.6)	2021 / 2024	10, 11
Qt 6.4	2022 / 2023	10, 11

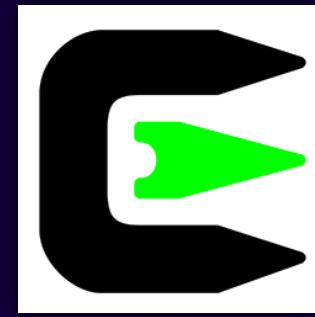
## Languages that support the Qt library

Qt is developed with C++ language.

Qt can be used in several programming languages other than C++, such as Python, Javascript, C# and Rust via language bindings; many languages have bindings for Qt 5 and bindings for Qt 4.

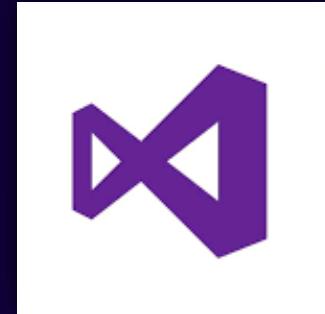
## Qt compilers

- Windows
  - MSVC
  - MinGW (Gnu Based)
  - Cygwin (BSD Based)
- Linux
  - GCC/G++
  - CLang



## Qt development environments

- Qt Creator
  - Windows
  - Linux
- Visual Studio
  - Windows
- PyCharm (Only for PyQt)
  - Windows
  - Linux



## Installation methods

- From installer
  - Offline installer
  - Online installer
    - From Packages (Linux)
    - From Setup wizard
- From source

## Offline Installer

- It can be downloaded from the link below:
  - URL: <https://www.qt.io/offline-installers>
- It is precompiled
- Only available for limited editions
- No internet required
- The installer size is large

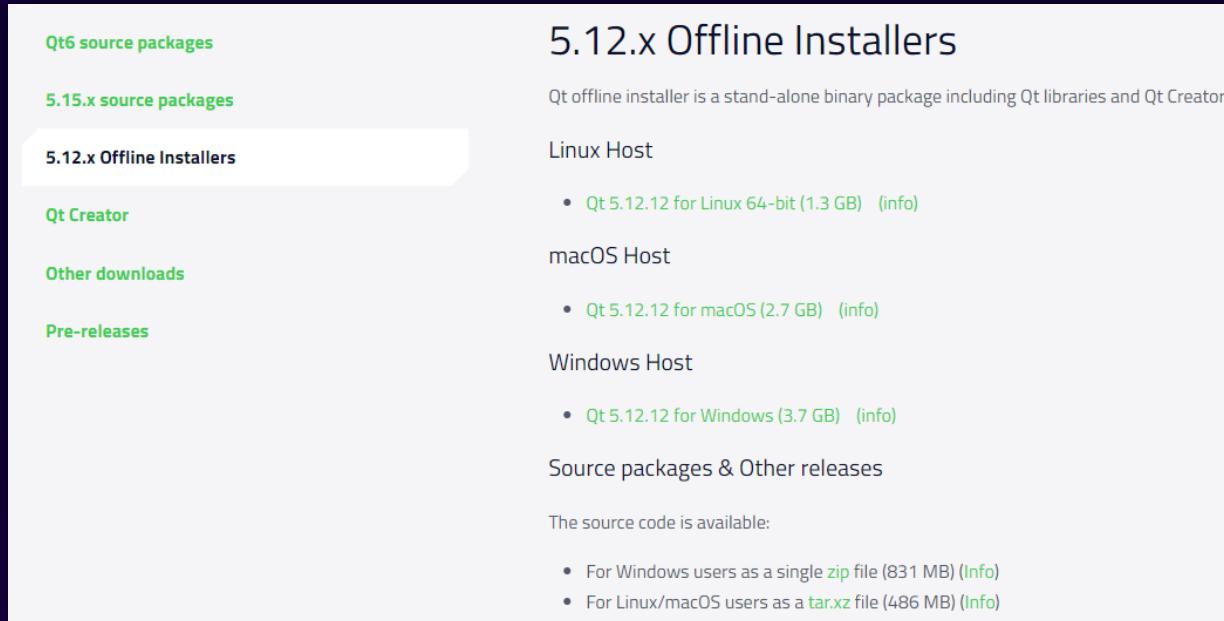
## Offline Installer

### On Windows

qt-opensource-windows-x86-%VERSION%.exe

### On Linux

qt-opensource-linux-x64-%VERSION%.run



**5.12.x Offline Installers**

Qt offline installer is a stand-alone binary package including Qt libraries and Qt Creator.

**Linux Host**

- [Qt 5.12.12 for Linux 64-bit \(1.3 GB\)](#) (info)

**macOS Host**

- [Qt 5.12.12 for macOS \(2.7 GB\)](#) (info)

**Windows Host**

- [Qt 5.12.12 for Windows \(3.7 GB\)](#) (info)

**Source packages & Other releases**

The source code is available:

- For Windows users as a single [zip](#) file (831 MB) ([Info](#))
- For Linux/macOS users as a [tar.xz](#) file (486 MB) ([Info](#))

## Online Installer

- It can be downloaded from the link below:
  - URL: [https://download.qt.io/official\\_releases/online\\_installers/](https://download.qt.io/official_releases/online_installers/)
- It is precompiled
- Only available for limited editions
- Internet required
- The installer size is small

## Online Installer On Windows

qt-unified-windows-x64-%VERSION%-online.exe

## On Linux

qt-unified-linux-x64-%VERSION%-online.run

Name	Last modified	Size	Metadata
Parent Directory	-	-	
qt-unified-windows-x64-online.exe	09-Nov-2022 10:52	41M	<a href="#">Details</a>
qt-unified-mac-x64-online.dmg	09-Nov-2022 10:52	18M	<a href="#">Details</a>
qt-unified-linux-x64-online.run	09-Nov-2022 10:52	55M	<a href="#">Details</a>

For Qt Downloads, please visit [qt.io/download](https://qt.io/download)

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The Qt Company Ltd, Bertel Jungin aukio D3A, 02600 Espoo, Finland. Org. Nr. 2637805-2

[List of official Qt-project mirrors](#)

## Online Installer

### On Windows

Run “qt-unified-windows-x64-%VERSION%-online.exe” as administrator

### On Linux

This prerequisite must be installed in the Debian operating system

```
sudo apt-get install libxcb-xinerama0
```

A file with the name qt-unified-linux-x-online.run will be downloaded, then add exec permission.

```
chmod +x qt-unified-linux-x-online.run
```

Remember to change 'x' for the actual version of the installer. Then run the installer.

```
./qt-unified-linux-x-online.run
```

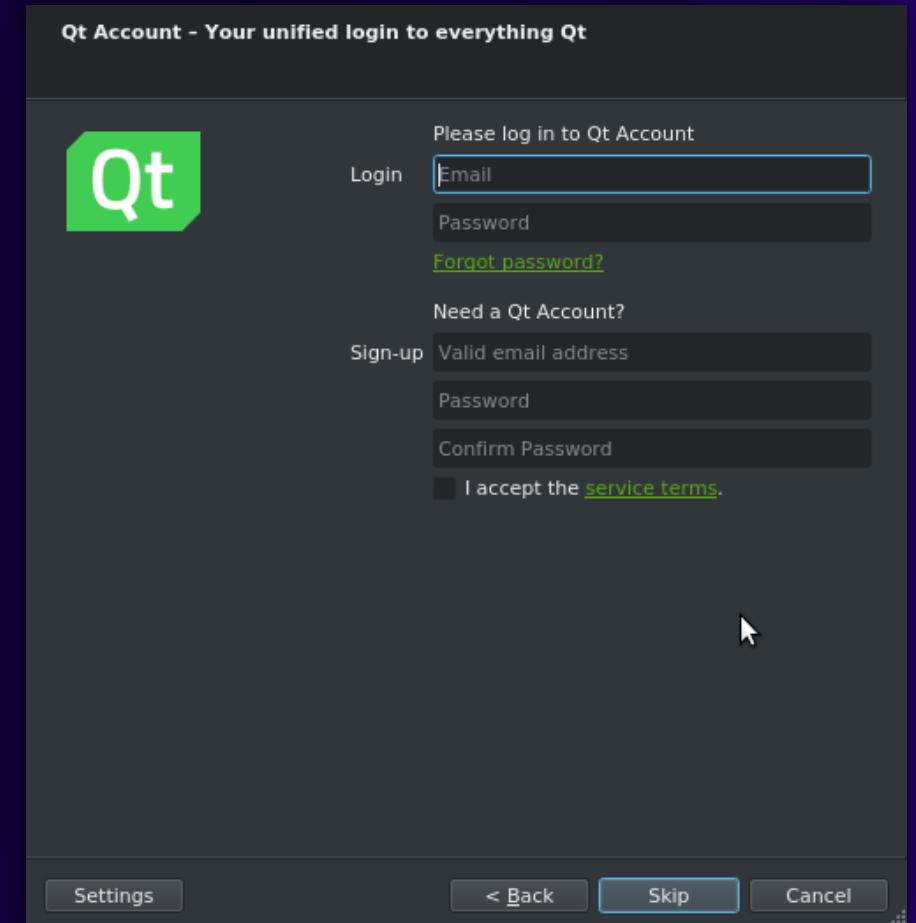
## Offline/Online Installer

Install Qt in any operative system

Current sample is 4.5.0 version.

Once you've downloaded Qt and opened the installer program, the installation procedure is the same for all operative systems, although the screenshots might look a bit different. The screenshots provided here are from Linux.

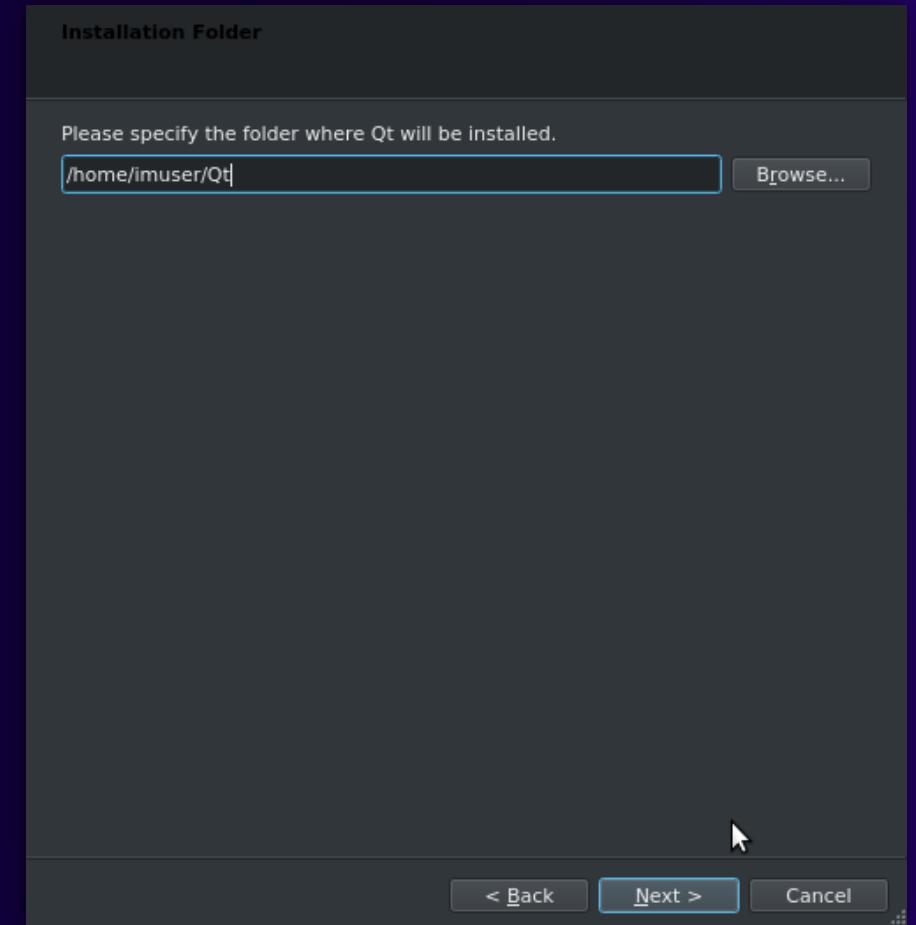
Login with a existing Qt account or create a new one:



## Offline/Online Installer

### Install Qt in any operative system

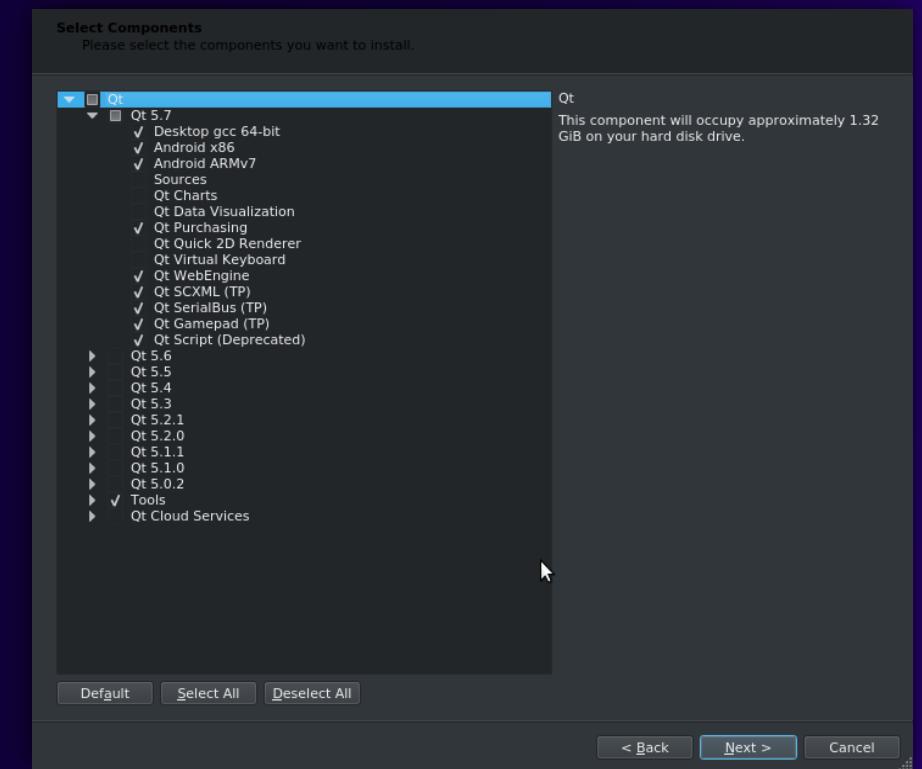
Select a path to install the Qt libraries and tools



## Offline/Online Installer

### Install Qt in any operative system

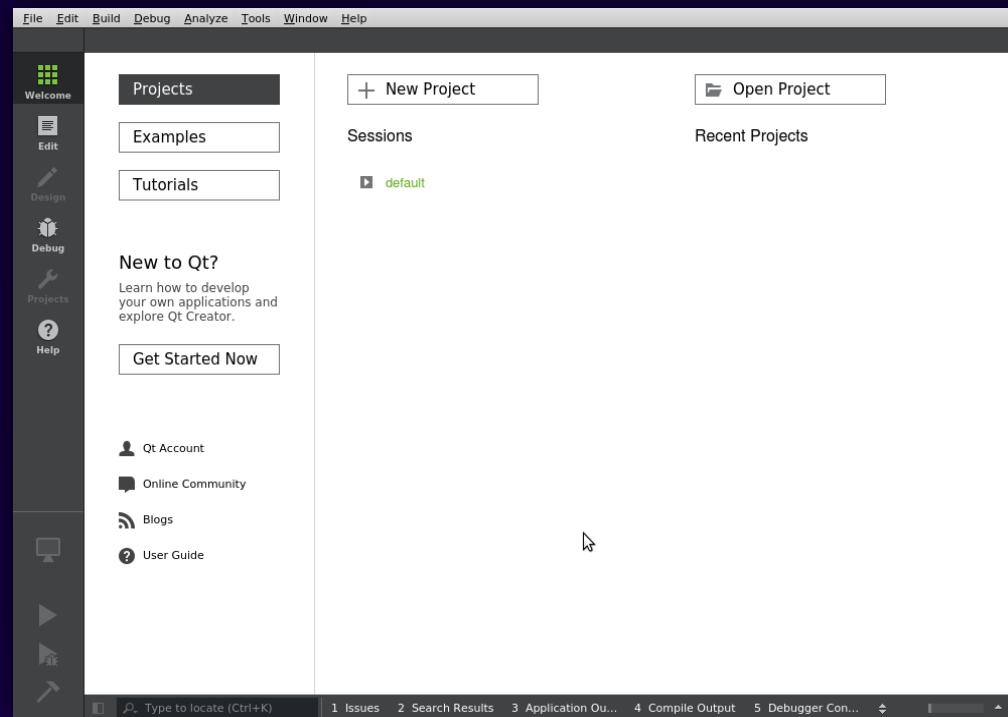
Select the library version and the features you want



## Offline/Online Installer

### Install Qt in any operative system

After downloading and the installation is finished, go to the Qt installation directory and launch Qt Creator or run it directly from the command line.



## Installation From Packages (Linux)

Installation in Debin (11.x) distribution

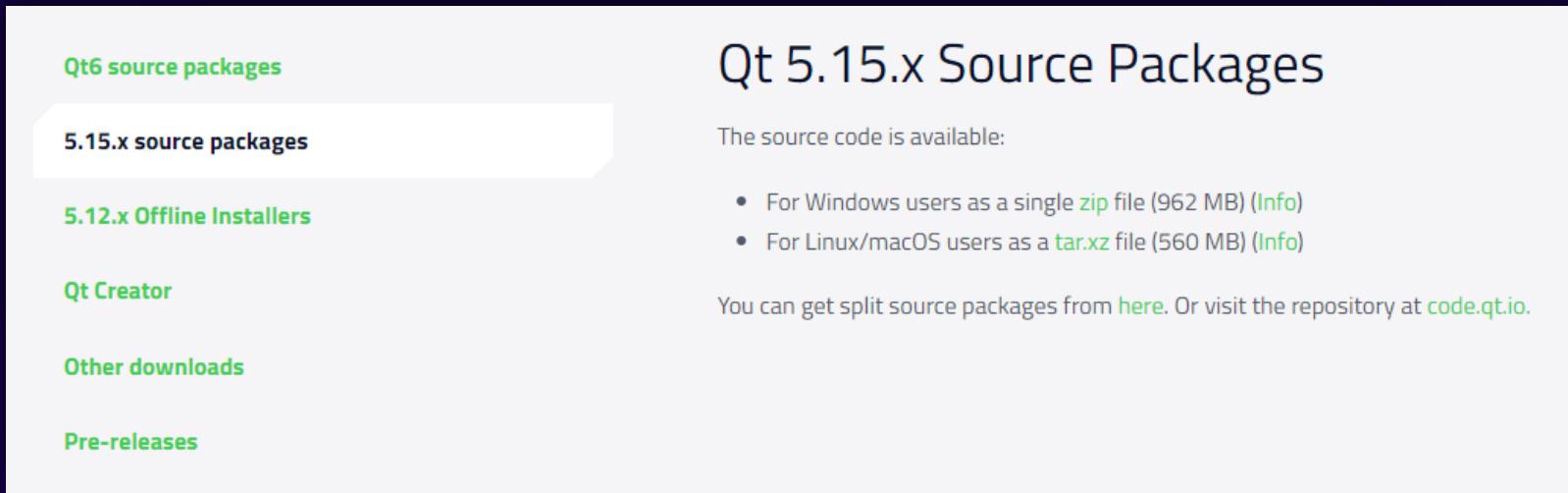
```
$ sudo apt-get update && sudo apt-get upgrade  
$ sudo apt install qtbase5-dev qt5-qmake qtbase5-dev-tools  
$ sudo apt-get install qtcreator  
$ qtcreator
```

## Type of build

- Dynamic
  - Dynamic plug-in is basically a shared library which is loaded at runtime.
    - ✓ Ability to update and patch Qt libraries.
    - ✓ The Qt libraries should be included with the final executable file
- Static
  - Static plug-in is built into your executable (like a static lib).
    - ✓ The libraries are combined with the executable file and a final file is created

## Build in Windows

- It can be downloaded from the link below (windows version 5.15.2):
  - URL: <https://www.qt.io/offline-installers>
- Ability to customize modules
- The ability to change the source code
- Ability to compile statically



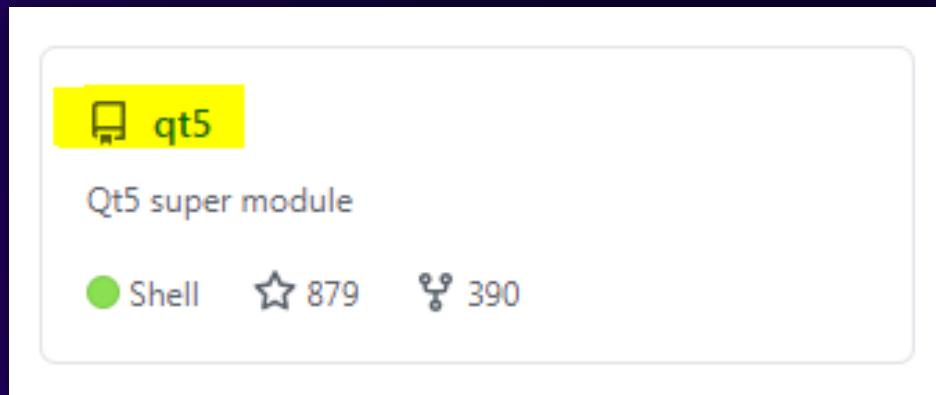
The screenshot shows the "Qt 5.15.x Source Packages" section of the Qt download page. On the left, there's a sidebar with links: "Qt6 source packages", "5.15.x source packages" (which is highlighted in blue), "5.12.x Offline Installers", "Qt Creator", "Other downloads", and "Pre-releases". The main content area has a heading "Qt 5.15.x Source Packages" and a sub-heading "The source code is available:". Below this, there are two bullet points:

- For Windows users as a single [zip](#) file (962 MB) ([Info](#))
- For Linux/macOS users as a [tar.xz](#) file (560 MB) ([Info](#))

At the bottom, it says "You can get split source packages from [here](#). Or visit the repository at [code.qt.io](#).

## Build in Windows

- Enter the following website (Qt requirements to compile):
  - URL: <https://github.com/qt>



### System requirements

- CMake 3.18 or later
- Perl 5.8 or later
- Python 2.7 or later
- C++ compiler supporting the C++17 standard

It's recommended to have ninja 1.8 or later installed.

For other platform specific requirements, please see section "Setting up your machine" on:  
[http://wiki.qt.io/Get\\_The\\_Source](http://wiki.qt.io/Get_The_Source)

## Build in Windows

- Prerequisites for compiling Qt on the windows platform

### Windows:

1. Open a command prompt.
2. Ensure that the following tools can be found in the path:
  - Supported compiler (Visual Studio 2019 or later, or MinGW-builds gcc 8.1 or later)
  - Perl version 5.12 or later [<http://www.activestate.com/activeperl/>]
  - Python version 2.7 or later [<http://www.activestate.com/activepython/>]
  - Ruby version 1.9.3 or later [<http://rubyinstaller.org/>]

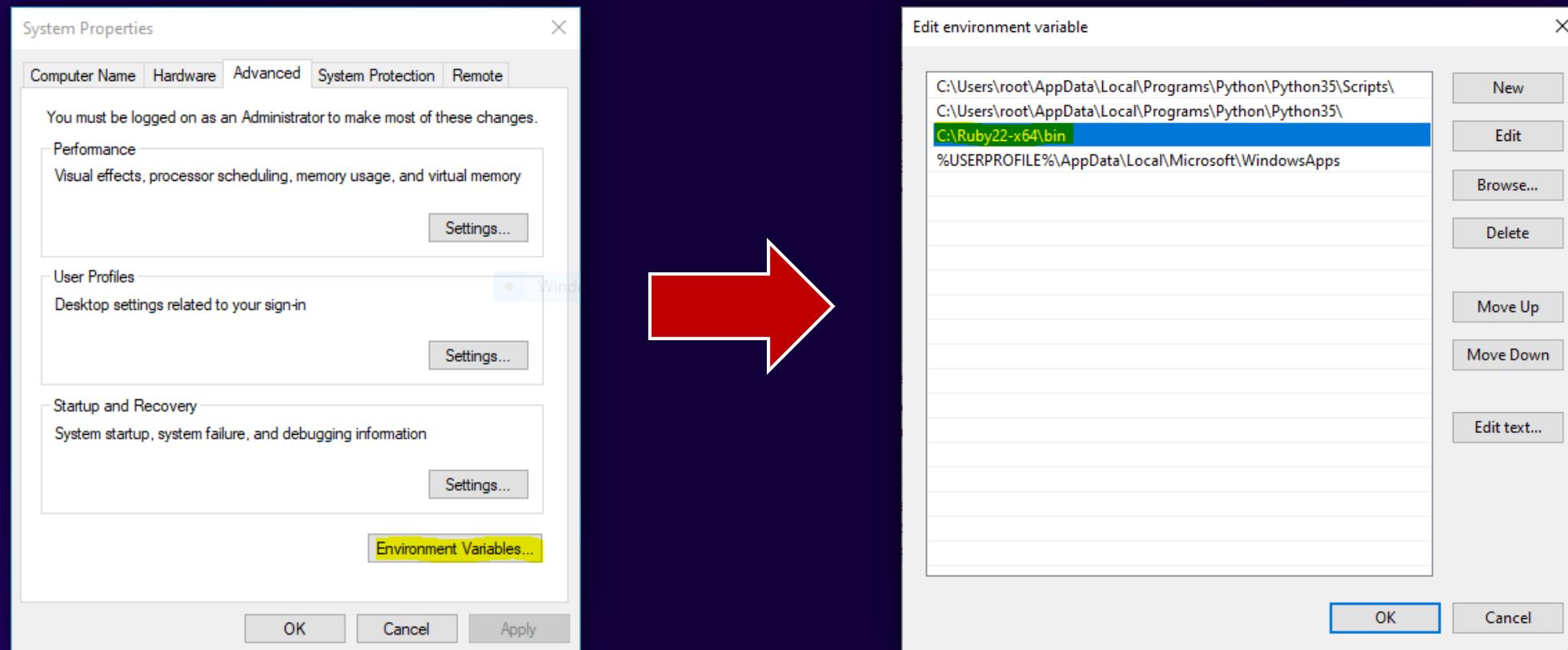
```
cd <path>\<source_package>
configure -prefix %CD%\qtbase
cmake --build .
```

## Build in Windows

- Compiler:
    - Visual Studio 2019 or later
    - MinGW-builds gcc 8.1 or later
  - Tools:
    - Perl version 5.12 or later [<http://www.activestate.com/activeperl/>]
    - Python version 2.7 or later [<http://www.activestate.com/activepython/>]
    - Ruby version 1.9.3 or later [<http://rubyinstaller.org/>]
- Note: “Python” and “Perl” installation requires internet.
- Note: Compilation requires Windows version 7 or higher.

## Build in Windows

- After installing the tools (Perl, Python, Ruby), their path should be added to the “System Environment”



## Build in Windows

- First, download the source code
  - Example: qt-everywhere-src-5.15.2.zip
- Decompress the source code in the desired path, for example "c:\\"

## Build in Windows >> Compile with MSVC

- Install Visual Studio 2019
- Depending on the required architecture (32-bit or 64-bit version), we run the Visual Studio command line from start menu:
  - x86 Native Tools Command Prompt for VS 2019
  - x64 Native Tools Command Prompt for VS 2019
- Enter the following commands in the command line:

```
> SET _ROOT=C:\Qt\qt-everywhere-src-5.15.2
> SET PATH=%_ROOT%\qtbase\bin;%_ROOT%\gnuwin32\bin;%PATH%
> SET PATH=%_ROOT%\qtrepotools\bin;%PATH%
```

## Build in Windows >> Compile with MSVC

- Enter the Qt source code path

```
> Cd C:\Qt\qt-everywhere-src-5.15.2
```

- Configure the compiler

```
> configure -debug-and-release -platform win32-msvc -developer-build  
-prefix "C:\Qt\5.15.2-x86" -nomake examples -nomake tests  
-skip qtwebengine -opensource -mp
```

- Start the compilation with the following command:

- nmake

- install Qt with the following command

- nmake install

- Clean source code

- nmake clean

## Build in Windows >> Compile with MinGW

- Install MinGW 8.1 or later
  - URL: <http://mingw-w64.org/>
- Run mingw command line or run it in the "cmd" and set mingw path in system environment (Path variable).
- Enter the following commands in the command line:

```
> SET _ROOT=C:\Qt\qt-everywhere-src-5.15.2  
> SET PATH=%_ROOT%\qtbase\bin;%_ROOT%\gnuwin32\bin;%PATH%  
> SET PATH=%_ROOT%\qtrepotools\bin;%PATH%
```

- Enter the Qt source code path

```
> Cd C:\Qt\qt-everywhere-src-5.15.2
```

## Build in Windows >> Compile with MinGW

- Configure the compiler

```
> configure -debug-and-release -platform win32-g++ -developer-build  
-prefix "C:\Qt\5.15.2-mingw-x86" -nomake examples -nomake tests  
-skip qtwebengine -opensource -no-angle -mp
```

- Start the compilation with the following command:

```
> mingw32-make -jn (n is number of cpu for parallel build)
```

- Install Qt with the following command

```
> mingw32-make install
```

## Build in Windows

- Clean source code

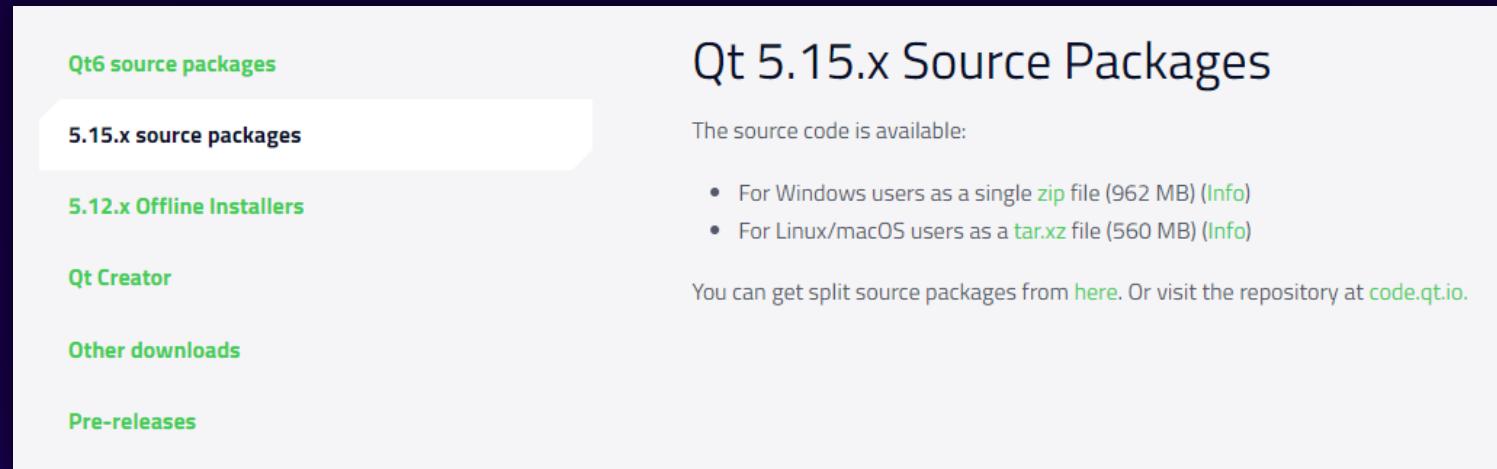
```
> mingw32-make clean
```

- Remove source code directory

```
> del /q "C:\Qt\qt-everywhere-src-5.15.2\*"  
FOR /D %%p IN ("C:\Qt\qt-everywhere-src-5.15.2\*.*") DO rmdir "%p" /s /q
```

## Build in Linux

- It can be downloaded from the link below (linux/mac version 5.15.2):
  - URL: <https://www.qt.io/offline-installers>
- Ability to customize modules
- The ability to change the source code
- Ability to compile statically



## Build in Linux

- Compiler:
  - GCC/g++
  - Clang
- Tools and library:
  - Perl (>=5.14)
  - Python (>=2.6.x)
  - build-essential
  - Libxcb

## Build in Linux / Dependency Packages

- Build Essentials

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt-get install build-essential perl python3 git
Fedora 30:	\$ su - -c "dnf install perl-version git gcc-c++ compat-openssl110-devel harfbuzz-devel double-conversion-devel libzstd-devel at-spi2-atk-devel dbus-devel mesa-libGL-devel"
OpenSUSE:	\$ sudo zypper install git-core gcc-c++ make

## Build in Linux / Dependency Packages

- Libxcb

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt-get install '^libxcb.*-dev' libx11-xcb-dev libglu1-mesa-dev libxrender-dev libxi-dev libxkbcommon-dev libxkbcommon-x11-dev
Fedora 30:	\$ su - -c "dnf install libxcb libxcb-devel xcb-util xcb-util-devel xcb-util-*-devel libX11-devel libXrender-devel libxkbcommon-devel libxkbcommon-x11-devel libXi-devel libdrm-devel libXcursor-devel libXcomposite-devel"
OpenSUSE 12+:	\$ sudo zypper in xorg-x11-libxcb-devel xcb-util-devel xcb-util-image-devel xcb-util-keysyms-devel xcb-util-renderutil-devel xcb-util-wm-devel xorg-x11-devel libxkbcommon-x11-devel libxkbcommon-devel libXi-devel
Centos 7:	\$ yum install libxcb libxcb-devel xcb-util xcb-util-devel mesa-libGL-devel libxkbcommon-devel

## Build in Linux / Dependency Packages

- OpenGL support
  - For Qt Quick 2, a graphics driver with native OpenGL 2.0 support is highly recommended.
- Accessibility
  - It is recommended to build with accessibility enabled, install libatspi2.0-dev and libdbus-1-dev packages.

## Build in Linux / Dependency Packages

- Qt WebKit

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt-get install flex bison gperf libicu-dev libxslt-dev ruby
Fedora 30:	\$ su - -c "dnf install flex bison gperf libicu-devel libxslt-devel ruby"
OpenSUSE:	\$ sudo zypper install flex bison gperf libicu-devel ruby
Mandriva/ROSA/Unity:	\$ urpmi gperf

## Build in Linux / Dependency Packages

- Qt WebEngine

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt-get install libxcursor-dev libxcomposite-dev libxdamage-dev libxrandr-dev libxtst-dev libxss-dev libdbus-1-dev libevent-dev libfontconfig1-dev libcap-dev libpulse-dev libudev-dev libpci-dev libnss3-dev libasound2-dev libegl1-mesa-dev gperf bison nodejs
Fedora/RHEL:	\$ sudo dnf install freetype-devel fontconfig-devel pciutils-devel nss-devel nspr-devel ninja-build gperf cups-devel pulseaudio-libs-devel libcap-devel alsa-lib-devel bison libXrandr-devel libXcomposite-devel libXcursor-devel libXtst-devel dbus-devel fontconfig-devel alsa-lib-devel rh-nodejs12-nodejs rh-nodejs12-nodejs-devel
OpenSUSE:	\$ sudo zypper install alsa-devel dbus-1-devel libXcomposite-devel libXcursor-devel libXrandr-devel libXtst-devel mozilla-nspr-devel mozilla-nss-devel gperf bison nodejs10 nodejs10-devel

## Build in Linux / Dependency Packages

- Qt Multimedia
  - You'll need at least alsa-lib (>= 1.0.15) and gstreamer (>=0.10.24) with the base-plugins package.

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt-get install libasound2-dev libgstreamer1.0-dev libgstreamer-plugins-base1.0-dev libgstreamer-plugins-good1.0-dev libgstreamer-plugins-bad1.0-dev
Fedora 30:	\$ dnf install pulseaudio-libs-devel alsa-lib-devel gstreamer1-devel gstreamer1-plugins-base-devel wayland-devel

## Build in Linux / Dependency Packages

- QDoc Documentation Generator Tool

Distribution	Packages
Ubuntu and/or Debian:	\$ sudo apt install clang libclang-dev
Fedora 30:	\$ su -c 'dnf install llvm-devel'

## Build in Linux

- Enter the following website (Qt requirements to compile):
  - URL: <https://doc.qt.io/qt-5/linux-building.html>
  - URL: [https://wiki.qt.io/Building\\_Qt\\_5\\_from\\_Git#Linux.2FX11](https://wiki.qt.io/Building_Qt_5_from_Git#Linux.2FX11)
- First, download the source code
  - Example: qt-everywhere-src-5.15.2.tar.xz
- Installing the License File (Commercially Licensed Qt Only)
- Decompress the source code in the desired path, for example “/tmp“

```
$ cd /tmp  
$ tar -xvf qt-everywhere-src-5.15.2.tar.xz  
Or  
$ cd /tmp  
$ gunzip qt-everywhere-opensource-src-%VERSION%.tar.gz      # uncompress the archive  
$ tar xvf qt-everywhere-opensource-src-%VERSION%.tar          # unpack it
```

## Build in Linux

- Installing the license file (Commercially licensed Qt only)
- Enter the Qt source code path

```
$ cd /tmp/qt-everywhere-opensource-src-%VERSION%
```

- Compile with GCC/g++
  - Configure the compiler

```
$ ./configure -platform linux-g++ -developer-build -prefix  
"/opt/qt5.15.2-x64" -nomake examples -nomake tests -skip qtwebengine  
-opensource -mp
```

- Start the compilation with the following command:

```
$ gmake
```

## Build in Linux

- Compile with GCC/g++
  - Compile Qt Docs

```
$ make docs
```

- Install Qt Docs

```
$ sudo gmake install_docs      # Need to root privileges
```

- Remove source code directory

```
$ rm -rf /tmp/*
```

## Build in Linux

- Compile with GCC/g++
  - Install Qt with the following command

```
$ sudo gmake install # Need to root privileges
```

- Clean source code

```
$ gmake clean
```

WARNING: -debug-and-release is only supported on Darwin and Windows platforms. Qt can be built in release mode with separate debug information, so -debug-and-release is no longer necessary.

## Build Options

- Compiler Options: Compile with GCC/g++ (32 bit)

```
-platform linux-g++-32
```

- Compiler Options: Compile with Clang

```
-platform linux-clang
```

- Compiler Options: Cross-Compilation Options. To configure Qt for cross-platform development and deployment, the development toolchain for the target platform needs to be set up. This set up varies among the Supported Platforms.

```
-xplatform
```

## Build Options

- Install Directories

```
-prefix /opt/qt
```

- Excluding Qt Modules. Configure's -skip option allows top-level source directories to be excluded from the Qt build.

```
./configure -skip qtconnectivity
```

- Including or Excluding Features. The -feature-<feature> and -no-feature-<feature> options include and exclude specific features, respectively.

```
./configure -no-feature-accessibility
```

## Build Options

- Third-Party Libraries. The Qt source packages include third-party libraries. To set whether Qt should use the system's versions of the libraries or to use the bundled version, pass either `-system` or `-qt` before the name of the library to configure.

```
./configure -no-zlib -qt-libjpeg -qt-libpng -system-xcb
```

Library Name	Bundled in Qt	Installed in System
zlib	<code>-qt-zlib</code>	<code>-system-zlib</code>
libjpeg	<code>-qt-libjpeg</code>	<code>-system-libjpeg</code>
libpng	<code>-qt-libpng</code>	<code>-system-libpng</code>
freetype	<code>-qt-freetype</code>	<code>-system-freetype</code>
PCRE	<code>-qt-pcre</code>	<code>-system-pcre</code>
<u>HarfBuzz-NG</u>	<code>-qt-harfbuzz</code>	<code>-system-harfbuzz</code>

## Build Options

- OpenGL Options for Windows
  - Dynamic: With the dynamic option, Qt will try to use native OpenGL first. If that fails, it will fall back to ANGLE and finally to software rendering in case of ANGLE failing as well.

```
configure.bat -opengl dynamic
```

- Desktop: With the desktop option, Qt uses the OpenGL installed on Windows, requiring that the OpenGL in the target Windows machine is compatible with the application. The -opengl option accepts two versions of OpenGL ES, es2 for OpenGL ES 2.0 or es1 for OpenGL ES Common Profile.

```
configure.bat -opengl desktop
```

- You can also use -opengl dynamic, which enable applications to dynamically switch between the available options at runtime. For more details about the benefits of using dynamic GL-switching, see Graphics Drivers.

```
configure.bat -opengl es2
```

Note: For a full list of options, consult the help with `configure -help`.

## Checking Build and Run Settings

- The Qt Installer attempts to auto-detect the installed compilers and Qt versions. If it succeeds, the relevant kits will automatically become available in Qt Creator.

## Adding Kits

- Qt Creator groups settings used for building and running projects as kits to make cross-platform and cross-configuration development easier. Each kit consists of a set of values that define one environment, such as a device, compiler, Qt version, and debugger command to use, and some metadata, such as an icon and a name for the kit. Once you have defined kits, you can select them to build and run projects.

## Specifying Kit Settings

- Select Edit > Preferences > Kits > Add
- Specify kit settings. The settings to specify depend on the build system and device type.

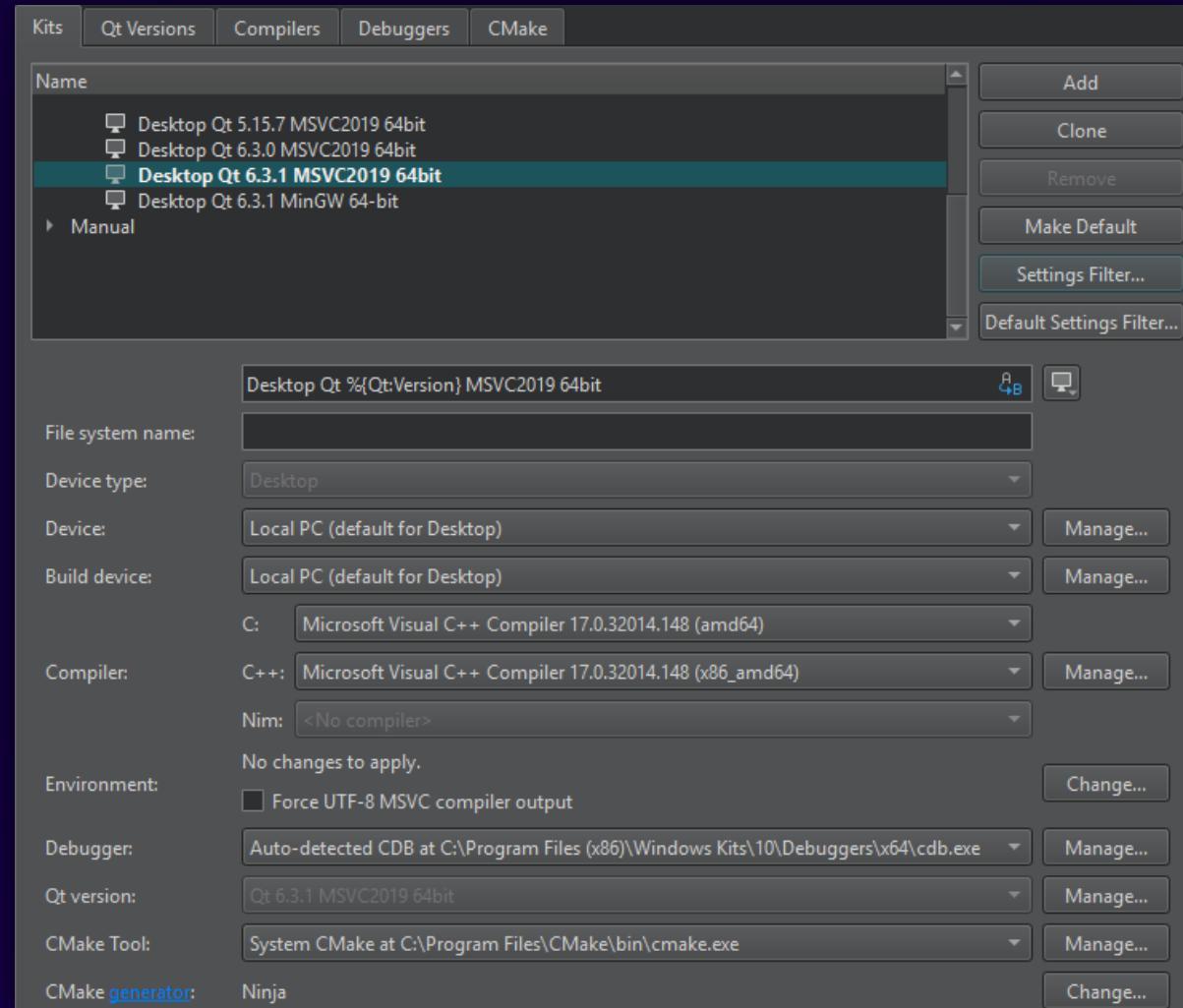
## Kit Settings

- Name:
  - Name of the kit.
- Device type:
  - The device to build applications on.
- Device:
  - The device to run applications on.
- Compiler:
  - C or C++ compiler that you use to build the project. You can add compilers to the list if they are installed on the development PC.

## Kit Settings

- Debugger:
  - Debugger to debug the project on the target platform. Qt Creator automatically detects available debuggers and displays a suitable debugger in the field. You can add debuggers to the list.
- Qt version
  - Qt version to use for building the project. You can add Qt versions to the list if they are installed on the development PC.

## Kits:



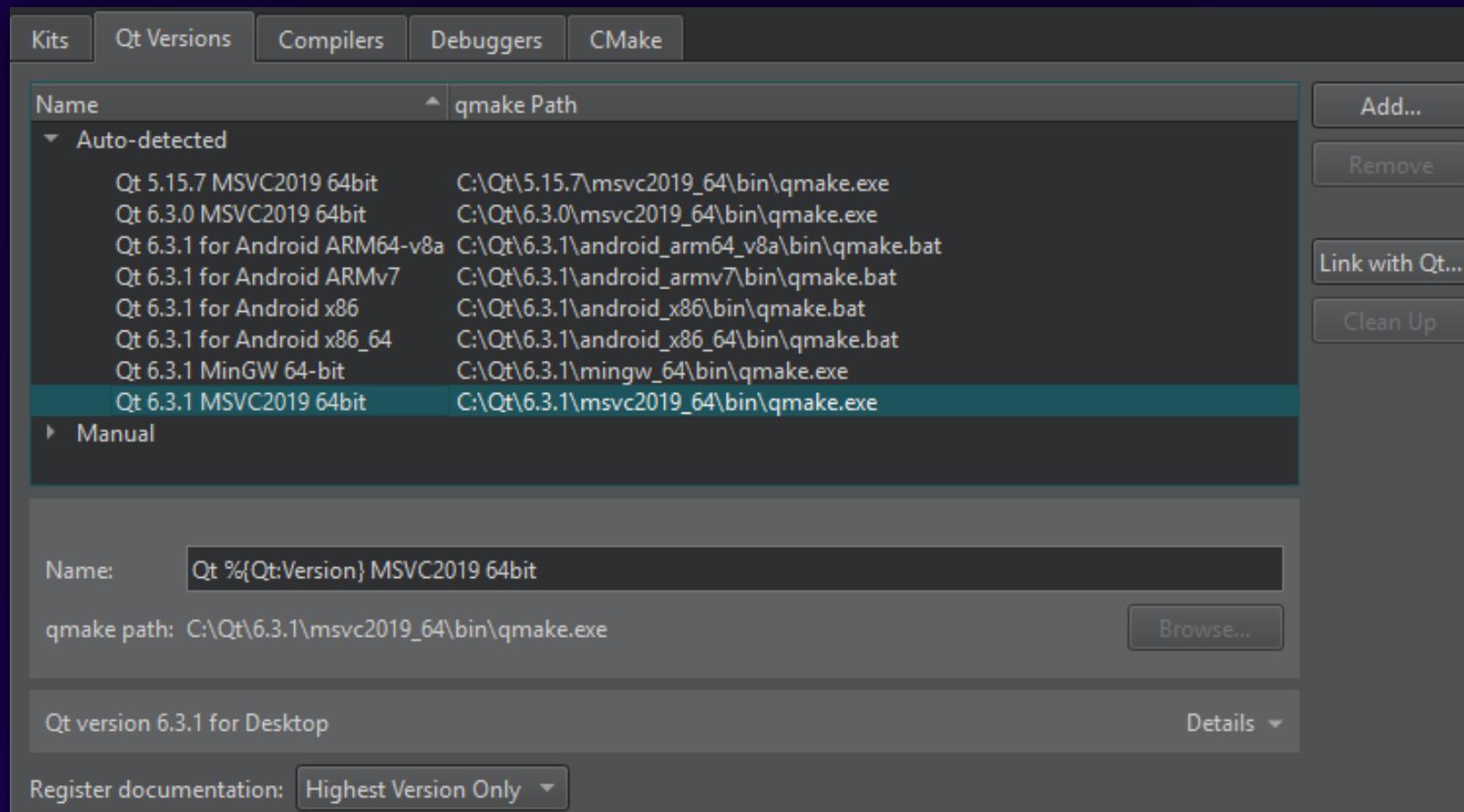
## Adding Qt Versions

- Qt Creator allows you to have multiple versions of Qt installed on your development PC and use different versions to build your projects.

## Setting Up New Qt Versions

- Select Edit > Preferences > Kits > Qt Versions > Add.
- Select the qmake executable for the Qt version that you want to add.

## Qt Versions:



## Adding Compilers

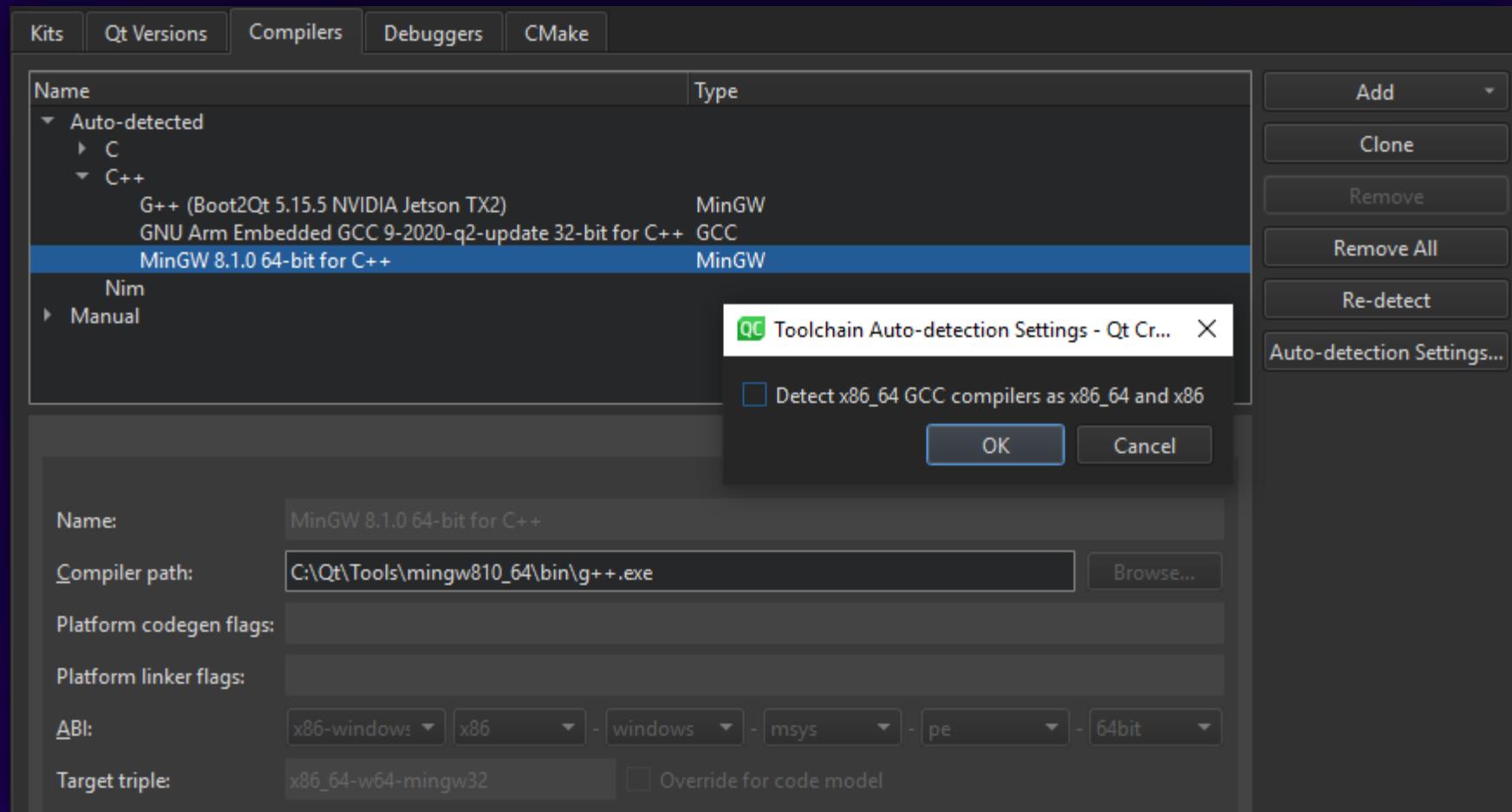
- Qt is supported on a variety of 32-bit and 64-bit platforms, and can usually be built on each platform with GCC, a vendor-supplied compiler, or a third party compiler.

## You can add the following compilers to build applications

- **Clang** is a C, C++, Objective C, and Objective C++ front-end for the LLVM compiler for Windows, Linux, and macOS.
- **clang-cl** is an alternative command-line interface to Clang that is compatible with the Visual C++ compiler, cl.exe.
- **GNU Compiler Collection (GCC)** is a compiler for Linux and macOS.
- **ICC (Intel C++ Compiler)** is a group of C and C++ compilers. Only the GCC-compatible variant, available for Linux and macOS, is currently supported by Qt Creator.
- **MinGW (Minimalist GNU for Windows)** is a native software port of GCC and GNU Binutils for use in the development of native Microsoft Windows applications on Windows. MinGW is distributed together with Qt Creator and Qt for Windows.
- **MSVC (Microsoft Visual C++ Compiler)** is a C++ compiler that is installed with Microsoft Visual Studio.
- **Nim** is the Nim Compiler for Windows, Linux, and macOS.
- **QCC** is the interface for compiling C++ applications for QNX.

Note: MSVC compiler exists in Windows Software Development Kit (SDK)

## Qt Compilers:



## Adding Debuggers

- The Qt Creator debugger plugin acts as an interface between the Qt Creator core and external native debuggers such as the GNU Symbolic Debugger (GDB), the Microsoft Console Debugger (CDB), a QML/JavaScript debugger, and the debugger of the low level virtual machine (LLVM) project, LLDB.
- Select Edit > Preferences > Kits > Debuggers > Add.
- In the Path field, specify the path to the debugger binary:
  - For CDB (Windows only), specify the path to the Windows Console Debugger executable.
  - For GDB, specify the path to the GDB executable. The executable must be built with Python scripting support enabled.
  - For LLDB (experimental), specify the path to the LLDB executable.

Note: CDB compiler exists in Windows Software Development Kit (SDK)

## Qt Debuggers:

The screenshot shows the 'Debuggers' tab of the Qt Creator settings. The interface includes a header with tabs: Kits, Qt Versions, Compilers, Debuggers (selected), and CMake. Below the tabs is a table with columns: Name, Location, and Type. The table lists several debuggers, both auto-detected and manual. A modal dialog is open at the bottom, allowing configuration for a selected debugger named 'CDB'. The dialog fields include: Name (CDB), Path (C:\Program Files (x86)\Windows Kits\10\Debuggers\x86\cdb.exe), Type (CDB), ABIs (x86-windows-msvc2017-pe-32bit), Version (10.0.18362.1), and Working directory (empty). At the bottom right of the dialog are OK, Cancel, and Apply buttons.

Name	Location	Type	Add
Auto-detected			
GNU gdb 7.10.1 for MinGW 5.3.0 32bit	C:\Qt\Tools\mingw530_32\bin\gdb.exe	GDB	Clone
GNU gdb 8.1 for MinGW 7.3.0 64-bit	C:\Qt\Tools\mingw730_64\bin\gdb.exe	GDB	Remove
System LLDB at C:\Program Files\LLVM\bin\lldb.exe	C:\Program Files\LLVM\bin\lldb.exe	LLDB	
Auto-detected CDB at C:\Program Files (x86)\Windows Kits\10\Debuggers\x86\cdb.exe	C:\Program Files (x86)\Windows Kits\10\Debuggers\x86\cdb.exe	CDB	
Auto-detected CDB at C:\Program Files (x86)\Windows Kits\10\Debuggers\x64\cdb.exe	C:\Program Files (x86)\Windows Kits\10\Debuggers\x64\cdb.exe	CDB	
Android Debugger (armeabi-v7a, NDK 20.1.5948944)	C:\Users\rimietti\AppData\Local\Android\Sdk\ndk-bundle\prebuilt\windows\bin\gdb.exe	GDB	
Android Debugger (armeabi-v7a, arm64-v8a, x86, x86_64, NDK 20.1.5948944)	C:\Users\rimietti\AppData\Local\Android\Sdk\ndk-bundle\prebuilt\windows\bin\gdb.exe	GDB	
Android Debugger (x86, NDK 20.1.5948944)	C:\Users\rimietti\AppData\Local\Android\Sdk\ndk-bundle\prebuilt\windows\bin\gdb.exe	GDB	
Manual			
<b>CDB</b>	<b>C:\Program Files (x86)\Windows Kits\10\Debuggers\x86\cdb.exe</b>	<b>CDB</b>	

## Concepts

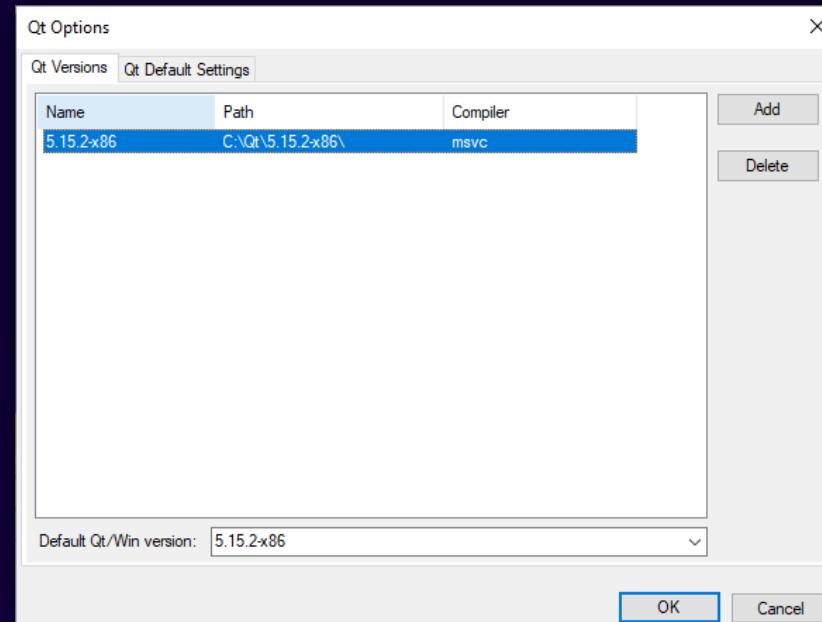
- **Shadow building** means building a project in a separate directory, the build directory. The build directory is different from the source directory. One of the benefits of shadow building is that it keeps your source directory clean, which makes it faster to switch between build configurations.
- Abi
- Illvm

## Prerequisite

- Install Visual Studio (Example: Visual Studio 2019)
- Install Visual Studio addin (Example: qt-vsaddin-msvc2019-2.6.0-rev.07.vsix)

## Adding Kits

- Select Extensions > Qt VS Tools > Qt Options > Add (qmake file from Compiled Qt for MSVC)



## C Console Application

- Create the helloworld.c program using a Vim editor as shown below.

```
/* Hello World C Program */

#include <stdio.h>

int main()
{
    printf("Hello World!\n");
    return 0;
}
```

- Compile the helloworld.c Program

```
$ gcc main.cpp
```

- Execute the C Program (a.out)

```
$ ./a.out
```

## C++ Console Application

- Create a file titled main.cpp somewhere on your computer. Within the file, include the following:

```
#include <iostream>

int main() {
    std::cout << "Hello World\n";
    return 0;
}
```

- To compile our application we can execute the following from the command line:

```
$ g++ main.cpp -o app
```

- The app file can be ran by executing the following:

```
./app
```

## Qt Console Application

- Let's begin with a simple C++ program. Open a text editor and enter the following source code. Create a directory "hello" and save the source code into a file hello.cpp residing in this directory.

```
#include <QTextStream>
int main() {
    QTextStream(stdout) << "Hello, world!" << endl;
    return 0;
}
```

- Now enter the "hello" directory and type: "qmake -project". This will create an qmake project file. Thereafter run just "qmake" without arguments. this will create a "Makefile" which contains the rules to build your application. Then run "make" (called nmake or gmake on some platforms), which will build your app according to the rules layed out in the "Makefile". Finally you can run the app "./hello".

```
$ cd my\dir\hello
$ qmake -project
$ qmake CONFIG+=debug|release ${qmake_options}
$ make ${make_options}
$ ./hello | ./hello &
$ make clean
```

g++

```
> cd my\dir\hello
> qmake -project
> qmake
> nmake -f Makefile.Release | nmake -f Makefile.Debug
> hello.exe | start /wait hello.exe
> nmake clean
```

MSVC

## Qt Console Application

- Add this line in \*.pro file

```
QT -= gui  
  
CONFIG += c++11 console
```

- Show exit code:

```
$ echo $?
```

Linux

```
> echo %errorlevel%
```

Windows

## Qt Desktop Application

- Simply replace the source code in hello.cpp by:

```
#include <QtGui>
#include <QApplication>
#include <QLabel>

int main(int argc, char **argv) {
    QApplication app(argc, argv);
    QLabel label("Hello, world!");
    label.show();
    return app.exec();
}
```

- Add the following lines to the .pro file after the include path:

```
...
INCLUDEPATH += .

QT += gui
QT += widgets
...
```

- Run "qmake" and then "make" again. If you launch the application should see a small window saying "Hello, world!".

## Running qmake

- The behavior of qmake can be customized when it is run by specifying various options on the command line.

## Command Syntax

- The syntax used to run qmake takes the following simple form:

```
qmake [mode] [options] files
```

Note: If you installed Qt via a package manager, the binary may be qmake6.

## Operating Modes

- qmake supports two different modes of operation. In the default mode, qmake uses the information in a project file to generate a Makefile, but it is also possible to use qmake to generate project files.
  - makefile: qmake output will be a Makefile.
  - project: qmake output will be a project file.

## Files

- The files argument represents a list of one or more project files, separated by spaces.

## General Options

- **-help**  
qmake will go over these features and give some useful help.
- **-o file**  
qmake output will be directed to file. If this option is not specified, qmake will try to use a suitable file name for its output, depending on the mode it is running in.  
If '-' is specified, output is directed to stdout.
- **-d**  
qmake will output debugging information. Adding -d more than once increases verbosity.

- **-t tmpl**  
qmake will override any set TEMPLATE variables with tmpl, but only after the .pro file has been processed.
- **-tp prefix**  
qmake will add prefix to the TEMPLATE variable.
- **-Wall**  
qmake will report all known warnings.
- **-Wnone**  
No warning information will be generated by qmake.
- **-Wparser**  
qmake will only generate parser warnings. This will alert you to common pitfalls and potential problems in the parsing of your project files.
- **-Wlogic**  
qmake will warn of common pitfalls and potential problems in your project file. For example, qmake will report multiple occurrences of files in lists and missing files.

## Makefile Mode Options

- In Makefile mode, qmake will generate a Makefile that is used to build the project.

```
qmake -makefile [options] files
```

- **-after**  
qmake will process assignments given on the command line after the specified files.
- **-nocache**  
qmake will ignore the .qmake.cache file.
- **-nodepend**  
qmake will not generate any dependency information.
- **-cache file**  
qmake will use file as the cache file, ignoring any other .qmake.cache files found.
- **-spec spec**  
qmake will use spec as a path to platform and compiler information, and ignore the value of QMAKESPEC.

Note: You may also pass qmake assignments on the command line. They are processed before all of the files specified. For example, the following command generates a Makefile from test.pro:

```
qmake -makefile -o Makefile "CONFIG+=test" test.pro  
qmake "CONFIG+=test" test.pro
```

## Project Mode Options

- In project mode, qmake will generate a project file. Additionally, you may supply the following options in this mode:

```
qmake -project [options] files
```

- **-r**  
qmake will look through supplied directories recursively.
- **-nopwd**  
qmake will not look in your current working directory for source code. It will only use the specified files.

## Project File Elements

- Project files contain all the information required by qmake to build your application, library, or plugin.

## Variables

- In a project file, variables are used to hold lists of strings. In the simplest projects, these variables inform qmake about the configuration options to use, or supply filenames and paths to use in the build process.

Variable	Contents
CONFIG	General project configuration options.
DESTDIR	The directory in which the executable or binary file will be placed.
FORMS	A list of UI files to be processed by the user interface compiler (uic).
HEADERS	A list of filenames of header (.h) files used when building the project.
QT	A list of Qt modules used in the project.
RESOURCES	A list of resource (.qrc) files to be included in the final project. See the The Qt Resource System for more information about these files.
SOURCES	A list of source code files to be used when building the project.
TEMPLATE	The template to use for the project. This determines whether the output of the build process will be an application, a library, or a plugin.

## Variables

- The following snippet illustrates how lists of values are assigned to variables:

```
HEADERS = mainwindow.h paintwidget.h
```

- The list of values in a variable is extended in the following way:

```
SOURCES = main.cpp mainwindow.cpp \
           paintwidget.cpp
CONFIG += console
```

- The contents of a variable can be read by prepending the variable name with **\$\$**. This can be used to assign the contents of one variable to another:

```
TEMP_SOURCES = $$SOURCES
```

## Whitespace

- Usually, whitespace separates values in variable assignments. To specify values that contain spaces, you must enclose the values in double quotes:

```
DEST = "Program Files"
```

## Comments

- You can add comments to project files. Comments begin with the # character and continue to the end of the same line. For example:

```
# Comments usually start at the beginning of a line, but they  
# can also follow other content on the same line.
```

Note: To include the # character in variable assignments, it is necessary to use the contents of the built-in LITERAL\_HASH variable.

## Built-in Functions and Control Flow

- qmake provides a number of built-in functions to enable the contents of variables to be processed. The most commonly used function in simple project files is the include() function which takes a filename as an argument.

```
include(other.pro)
```

- Support for conditional structures is made available via scopes that behave like if statements in programming languages:

```
win32 {  
    SOURCES += paintwidget_win.cpp  
}
```

## Project Templates

- The TEMPLATE variable is used to define the type of project that will be built.

Template	qmake Output
app (default)	Makefile to build an application.
lib	Makefile to build a library.
subdirs	Makefile containing rules for the subdirectories specified using the SUBDIRS variable. Each subdirectory must contain its own project file.

## General Configuration

- The CONFIG variable specifies the options and features that the project should be configured with. For example, if your application uses the Qt library and you want to build it in debug mode, your project file will contain the following line:

```
CONFIG += qt debug
```

## Declaring Qt Libraries

- If the CONFIG variable contains the qt value, qmake's support for Qt applications is enabled. This makes it possible to fine-tune which of the Qt modules are used by your application. we can enable the XML and network modules in the following way:

```
QT += network xml
```

Note: QT includes the core and gui modules by default, so the above declaration adds the network and XML modules to this default list. The following assignment omits the default modules, and will lead to errors when the application's source code is being compiled:

```
QT = network xml # This will omit the core and gui modules.
```

- If you want to build a project without the gui module, you need to exclude it with the "-=" operator. By default, QT contains both core and gui, so the following line will result in a minimal Qt project being built:

```
QT -= gui # Only the core module is used.
```

## Declaring Other Libraries

- The paths that qmake searches for libraries and the specific libraries to link against can be added to the list of values in the **LIBS** variable. For example, the following lines show how a library can be specified:

```
LIBS += -L/usr/local/lib -lmath
```

- The paths containing header files can also be specified in a similar way using the **INCLUDEPATH** variable. For example, to add several paths to be searched for header files:

```
INCLUDEPATH = c:/msdev/include d:/stl/include
```

## Volatile

- Volatile keyword indicates that a value may change between different accesses, even if it does not appear to be modified. This keyword prevents an optimizing compiler. Volatile values primarily arise in hardware access (memory-mapped I/O), where reading from or writing to memory is used to communicate with peripheral devices, and in threading, where a different thread may have modified a value.
  - Pointer variable to the register of a peripheral
  - The value of the variable is changed in the service routine of an interrupt
  - In Multithread systems that use two or more threads with this variable
- In this example, the code sets the value stored in foo to 0. It then starts to poll that value repeatedly until it changes to 255:

```
1 static int foo;
2
3 void bar(void) {
4     foo = 0;
5
6     while (foo != 255)
7         ;
8 }
```

## Volatile

- An optimizing compiler will notice that no other code can possibly change the value stored in foo, and will assume that it will remain equal to 0 at all times. The compiler will therefore replace the function body with an infinite loop similar to this:

```
1 void bar_optimized(void) {  
2     foo = 0;  
3  
4     while (true);  
5 }  
6
```

- To prevent the compiler from optimizing code as above, the volatile keyword is used:

```
1 static volatile int foo;  
2  
3 void bar(void) {  
4     foo = 0;  
5  
6     while (foo != 255);  
7 }  
8
```

## Overloading Function

- C++ lets you specify more than one function of the same name in the same scope. These functions are called overloaded functions, or overloads. Overloaded functions enable you to supply different semantics for a function, depending on the types and number of its arguments.
- Overloading Considerations:

Function declaration element	Used for overloading
Function return type	No
Number of arguments	Yes
Type of arguments	Yes
Presence or absence of ellipsis	Yes
Use of <b>typedef</b> names	No
Unspecified array bounds	No
<b>const</b> or <b>volatile</b>	Yes, when applied to entire function (Must be referenced)
Reference qualifiers ( <b>&amp;</b> and <b>&amp;&amp;</b> )	Yes

## Overloading Function

- Example 1:

```
1 #include <iostream>
2 using namespace std;
3
4 void add(int a, int b)
5 {
6     cout << "sum = " << (a + b);
7 }
8
9 void add(int a, int b, int c)
10 {
11     cout << endl << "sum = " << (a + b + c);
12 }
13
14 // Driver code
15 int main()
16 {
17     add(10, 2);
18     add(5, 6, 4);
19
20     return 0;
21 }
```

- Output:

```
sum = 12
sum = 15
```

## Overloading Function

- Example 2:

```
1 #include <iostream>
2 using namespace std;
3
4 void print(int i)
5 {
6     cout << " Here is int " << i << endl;
7 }
8 void print(double f)
9 {
10    cout << " Here is float " << f << endl;
11 }
12 void print(char const* c)
13 {
14     cout << " Here is char* " << c << endl;
15 }
16
17 int main() {
18     print(10);
19     print(10.10);
20     print("ten");
21     return 0;
22 }
```

- Output:

```
Here is int 10
Here is float 10.1
Here is char* ten
```

## Optional Arguments/Default Arguments

- Allows a function to be called without providing one or more trailing arguments.

```
1 void f(int a, int b = 2, int c = 3); // trailing defaults
2 void g(int a = 1, int b = 2, int c); // error, leading defaults
3 void h(int a, int b = 3, int c); // error, default in middle
```

- Once a default argument has been given in a declaration or definition, you cannot redefine that argument, even to the same value. However, you can add default arguments not given in previous declarations. For example, the last declaration below attempts to redefine the default values for a and b:

```
1 void f(int a, int b, int c = 1); // valid
2 void f(int a, int b = 1, int c); // valid, add another default
3 void f(int a = 1, int b, int c); // valid, add another default
4 void f(int a = 1, int b = 1, int c = 1); // error, redefined defaults
```

## Optional Arguments/Default Arguments

- Example:

```
1 #include <iostream>
2
3 void f(int a, int b, int c = 1);      // valid
4 void f(int a, int b = 1, int c);      // valid, add another default
5 void f(int a = 1, int b, int c);      // valid, add another default
6 void f(int a, int b, int c)
7 {
8     std::cout << a << ", " << b << ", " << c << std::endl;
9 }
10
11 int main()
12 {
13     f();
14     f(8);
15     f(8, 9);
16     f(8, 9, 10);
17
18     return 0;
19 }
```

- Output:

```
1, 1, 1
8, 1, 1
8, 9, 1
8, 9, 10
```

## static\_cast

- static\_cast is used for cases where you basically want to reverse an implicit conversion, with a few restrictions and additions. static\_cast performs no runtime checks. This should be used if you know that you refer to an object of a specific type, and thus a check would be unnecessary. Example:

```
1 void func(void* data) {
2     // Conversion from MyClass* -> void* is implicit
3     MyClass* c = static_cast<MyClass*>(data);
4     ...
5 }
6
7 int main() {
8     MyClass c;
9     start_thread(&func, &c) // func(&c) will be called
10    .join();
11 }
```

- In this example, you know that you passed a MyClass object, and thus there isn't any need for a runtime check to ensure this.

## dynamic\_cast

- `dynamic_cast` is useful when you don't know what the dynamic type of the object is. It returns a null pointer if the object referred to doesn't contain the type casted to as a base class (when you cast to a reference, a **bad\_cast** exception is thrown in that case).

```
1  if (JumpStm* j = dynamic_cast<JumpStm*>(&stmt)) {  
2      ...  
3  }  
4  else if (ExprStm* e = dynamic_cast<ExprStm*>(&stmt)) {  
5      ...  
6  }
```

- You can not use `dynamic_cast` for downcast (casting to a derived class) if the argument type is not polymorphic. For example, the following code is not valid, because `Base` doesn't contain any virtual function:

```
1  struct Base { };  
2  struct Derived : Base { };  
3  int main() {  
4      Derived d; Base* b = &d;  
5      dynamic_cast<Derived*>(b); // Invalid  
6  }
```

- An "up-cast" (cast to the base class) is always valid with both `static_cast` and `dynamic_cast`, and also without any cast, as an "up-cast" is an implicit conversion (assuming the base class is accessible, i.e. it's a public inheritance).

## reinterpret\_cast

- To force the pointer conversion, in the same way as the C-style cast does in the background, the reinterpret cast would be used instead.

```
1 char c = 10;           // 1 byte
2 int* p = (int*)&c; // 4 bytes
3 int* q = static_cast<int*>(&c); // compile-time error
4 int* r = reinterpret_cast<int*>(8); // forced conversion
```

## Regular Cast

- Needless to say, this is much more powerful as it combines all of const\_cast, static\_cast and reinterpret\_cast, but it's also unsafe, because it does not use dynamic\_cast.

### Remarks

- GTK is a free and open-source cross-platform widget toolkit for creating graphical user interfaces.
- Installation:

```
sudo apt-get install libgtk-3-dev
```

### GtkWidget

- GtkWidget is the base class that all widgets in GTK+ derive from. It manages the widget lifecycle, states, and style.

### gtk\_init

- The gtk\_init function initializes GTK+ and parses some standard command line options. This function must be called before using any other GTK+ functions.

### gtk\_main

- The This code enters the GTK+ main loop. From this point, the application sits and waits for events to happen.



### Sample 1

```
1 #include <gtk/gtk.h>
2
3 int main(int argc, char* argv[])
4 {
5     gtk_init(&argc, &argv);
6     GtkWidget* win = gtk_window_new(GTK_WINDOW_TOPLEVEL);
7     g_signal_connect(win, "delete_event", gtk_main_quit, NULL);
8     gtk_widget_show(win);
9     gtk_main();
10    return 0;
11 }
```

```
$gcc -o appOut main.c `pkg-config --libs --cflags gtk+-3.0`
```

## Sample 2

```
1 #include <gtk/gtk.h>
2
3 void button_clicked(GtkWidget * widget, gpointer data)
4 {
5     g_print("\tButton Clicked - %d was passed.\n", data);
6 }
7
8 int main(int argc, char* argv[])
9 {
10     gtk_init(&argc, &argv);
11
12     GtkWidget* win = gtk_window_new(GTK_WINDOW_TOPLEVEL);
13     gtk_window_set_title(GTK_WINDOW(win), "GTK+ Sample");
14     gtk_window_set_default_size(GTK_WINDOW(win), 230, 150);
15     gtk_window_set_position(GTK_WINDOW(win), GTK_WIN_POS_CENTER);
16     g_signal_connect(win, "delete_event", gtk_main_quit, NULL);
17
18     GtkWidget* btn = gtk_button_new_with_label("Button");
19     gtk_widget_set_tooltip_text(btn, "Button widget");
20     g_signal_connect(btn, "clicked", G_CALLBACK(button_clicked), (gpointer)10);
21     GtkWidget* halign = gtk_alignment_new(0, 0, 0, 0);
22     gtk_container_add(GTK_CONTAINER(halign), btn);
23     gtk_container_add(GTK_CONTAINER(win), halign);
24     gtk_widget_show_all(win);
25
26     gtk_main();
27
28     return 0;
}
```

```
$g++ -o appOut main.cc `pkg-config --libs --cflags gtk+-3.0`
```

## Remarks

- QObject class is the base class for all Qt objects.

## Description

- Q\_OBJECT macro appears in private section of a class. Q\_OBJECT requires the class to be subclass of QObject. This macro is necessary for the class to declare its signals/slots and to use Qt meta-object system.
- If Meta Object Compiler (MOC) finds class with Q\_OBJECT, it processes it and generates C++ source file containing meta object source code.

## QMetaObject

- QMetaObject class contains meta-information about Qt objects.

## Examples

- Here is the example of class header with Q\_OBJECT and signal/slots:

```
1 #include <QObject>
2
3 class MyClass : public QObject
4 {
5     Q_OBJECT
6
7     public:
8     public slots:
9         void setNumber(double number);
10
11    signals:
12        void numberChanged(double number);
13
14    private:
15};
```

## qobject\_cast

- A functionality which is added by deriving from QObject and using the Q\_OBJECT macro is the ability to use the qobject\_cast. Example:

```
1 class myObject : public QObject
2 {
3     Q_OBJECT
4     //...
5 };
6
7 QObject* obj = new myObject();
```

- To check whether obj is a myObject-type and to cast it to such in C++ you can generally use a dynamic\_cast. This is dependent on having RTTI enabled during compilation.
- The Q\_OBJECT macro on the other hands generates the conversion-checks and code which can be used in the qobject\_cast.

```
1 myObject* my = qobject_cast<myObject*>(obj);
2
3 if (!myObject)
4 {
5     //wrong type
6 }
```

- This is not reliant of RTTI. And also allows you to cast across dynamic library boundaries (via Qt interfaces/plugins).

## QObject Lifetime and Ownership

- QObjects have the possibility to build an objecttree by declaring parent/child relationships.
- The simplest way to declare this relationship is by passing the parent object in the constructor. As an alternative you can manually set the parent of a QObject by calling `setParent`. This is the only direction to declare this relationship. You cannot add a child to a parents class but only the other way round.

```
1 | QObject parent;  
2 | QObject child* = new QObject(&parent);
```

- To When parent now gets deleted in stack-unwind child will also be deleted.
- When we delete a QObject it will "unregister" itself from the parent object;

```
1 | QObject parent;  
2 | QObject child* = new QObject(&parent);  
3 | delete child; //this causes no problem.
```

- The same applies for stack variables:

```
1 | QObject parent;  
2 | QObject child(&parent);
```

Note: child will get deleted before parent during stack-unwind and unregister itself from its parent.

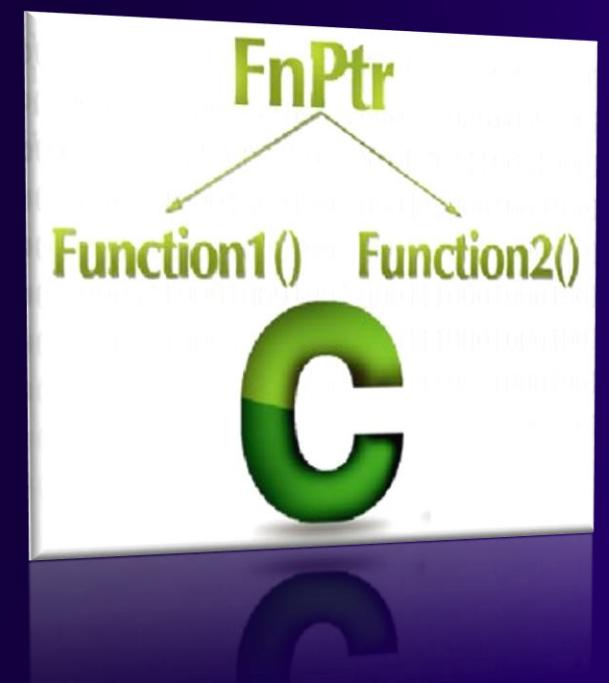
Note: You can manually call `setParent` with a reverse order of declaration which will break the automatic destruction.

## Remarks

- Signals and slots are used for communication between objects.

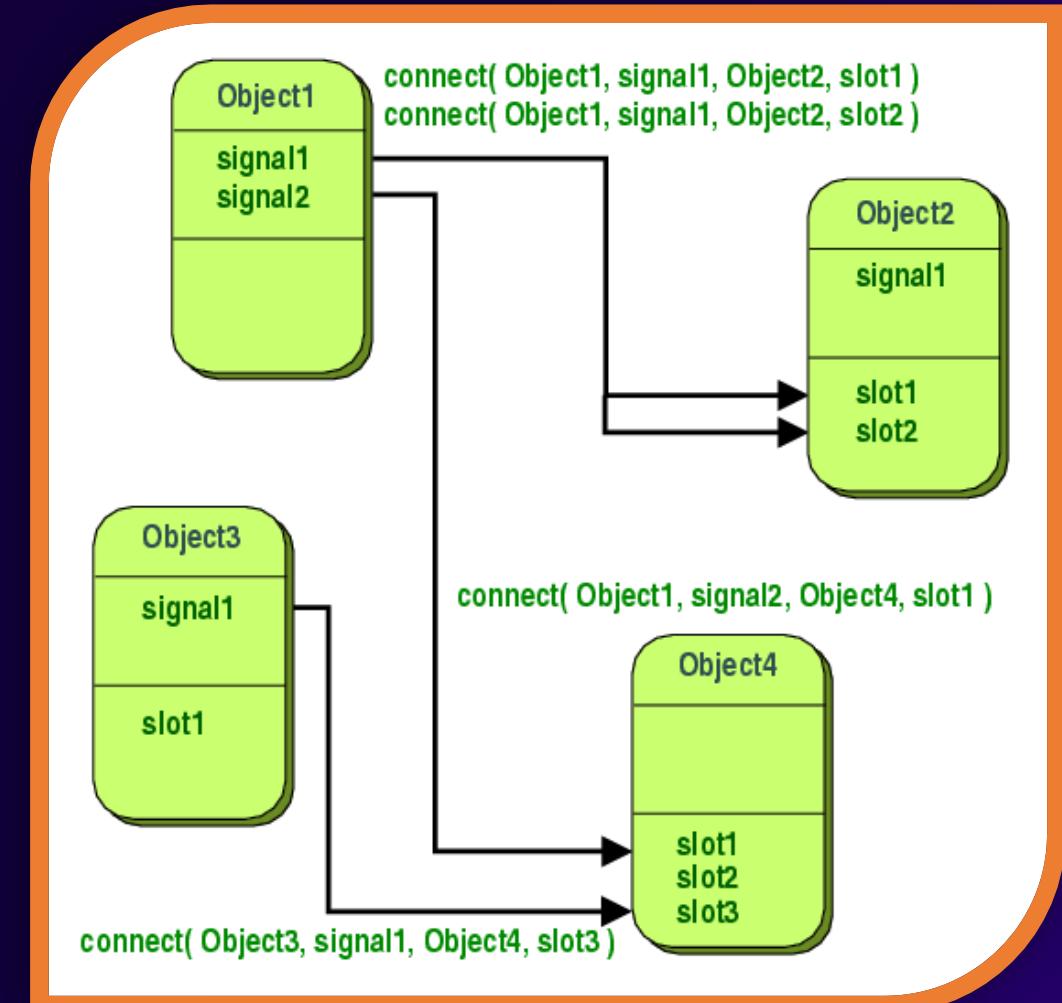
## Introduction

- In GUI programming, when we change one widget, we often want another widget to be notified. More generally, we want objects of any kind to be able to communicate with one another.
- Other toolkits achieve this kind of communication using callbacks. A callback is a pointer to a function, so if you want a processing function to notify you about some event you pass a pointer to another function (the callback) to the processing function. The processing function then calls the callback when appropriate.



## Description

- In Qt, we have an alternative to the callback technique: We use signals and slots. A signal is emitted when a particular event occurs. A slot is a function that is called in response to a particular signal.
- The signals and slots mechanism is type safe: The signature of a signal must match the signature of the receiving slot.



## Signals

- Signals are public access functions and can be emitted from anywhere, but we recommend to only emit them from the class that defines the signal and its subclasses.
- When a signal is emitted, the slots connected to it are usually executed immediately, just like a normal function call. When this happens, the signals and slots mechanism is totally independent of any GUI event loop. Execution of the code following the emit statement will occur once all slots have returned. The situation is slightly different when using queued connections; in such a case, **emit** keyword will continue immediately, and the slots will be executed later.
- A signal can be connected to many slots and signals. Many signals can be connected to one slot.
- If a signal is connected to several slots, the slots are activated in the same order in which the connections were made, when the signal is emitted.

## Slots

- A slot is called when a signal connected to it is emitted. Slots are normal C++ functions and can be called normally; their only special feature is that signals can be connected to them.
- You can also define slots to be virtual, which we have found quite useful in practice.
- Compared to callbacks, signals and slots are slightly slower because of the increased flexibility they provide, although the difference for real applications is insignificant.

## Connect

- Creates a connection of the given type from the signal in the sender object to the method in the receiver object. Returns a handle to the connection that can be used to disconnect it later.

## Disconnect

- Disconnects signal in object sender from method in object receiver. Returns true if the connection is successfully broken; otherwise returns false.

## Connect

- SIGNAL() and SLOT() macros:

```
1 QLabel* label = new QLabel;
2 QScrollBar* scrollBar = new QScrollBar;
3 QObject::connect(scrollBar, SIGNAL(valueChanged(int)), label, SLOT(setNum(int)));
```

- A signal can also be connected to another signal:

```
1 class MyWidget : public QWidget
2 {
3     Q_OBJECT
4 public:
5     MyWidget() {
6         myButton = new QPushButton(this);
7         connect(myButton, SIGNAL(clicked()), this, SIGNAL(buttonClicked()));
8     }
9 signals:
10     void buttonClicked();
11 private:
12     QPushButton* myButton;
13 };
```

## Connect

- Creates a connection of the given type from the signal in the sender object to the method in the receiver object.

```
1 QLabel* label = new QLabel;
2 QLineEdit* lineEdit = new QLineEdit;
3 QObject::connect(lineEdit, &QLineEdit::textChanged, label, &QLabel::setText);
```

- Creates a connection from signal in sender object to functor, and returns a handle to the connection.

```
1 void someFunction();
2 QPushButton* button = new QPushButton;
3 QObject::connect(button, &QPushButton::clicked, someFunction);
```

- You can also connect to functors or C++11 lambdas:

```
1 connect(sender, &QObject::destroyed, this, [=]() { this->m_objects.remove(sender); });
```

## Connection Type

- **Qt::AutoConnection:**
  - (Default) If the receiver lives in the thread that emits the signal, Qt::DirectConnection is used. Otherwise, Qt::QueuedConnection is used. The connection type is determined when the signal is emitted.
- **Qt::DirectConnection:**
  - The slot is invoked immediately when the signal is emitted. The slot is executed in the signalling thread.
- **Qt::QueuedConnection:**
  - The slot is invoked when control returns to the event loop of the receiver's thread. The slot is executed in the receiver's thread.

## Disconnect

- Disconnect everything connected to an object's signals:

```
1 disconnect(myObject, nullptr, nullptr, nullptr);
2 // equivalent to the non - static overloaded function
3 myObject->disconnect();
```

- Disconnect everything connected to a specific signal:

```
1 disconnect(myObject, SIGNAL(mySignal()), nullptr, nullptr);
2 // equivalent to the non-static overloaded function
3 myObject->disconnect(SIGNAL(mySignal()));
```

- Disconnect a specific receiver:

```
1 disconnect(myObject, nullptr, myReceiver, nullptr);
2 // equivalent to the non - static overloaded function
3 myObject->disconnect(myReceiver);
```

- Disconnect a connection from one specific signal to a specific slot:

```
1 QObject::disconnect(lineEdit, &QLineEdit::textChanged, label, &QLabel::setText);
```

## Sample

Note: When x is used, the class should be written in a separate file.

```
1 #include <QObject>
2
3 class Counter : public QObject
4 {
5     Q_OBJECT
6
7 public:
8     Counter() { m_value = 0; }
9     int value() const { return m_value; }
10
11 public slots:
12     void setValue(int value);
13
14 signals:
15     void valueChanged(int newValue);
16
17 private:
18     int m_value;
19 };
```

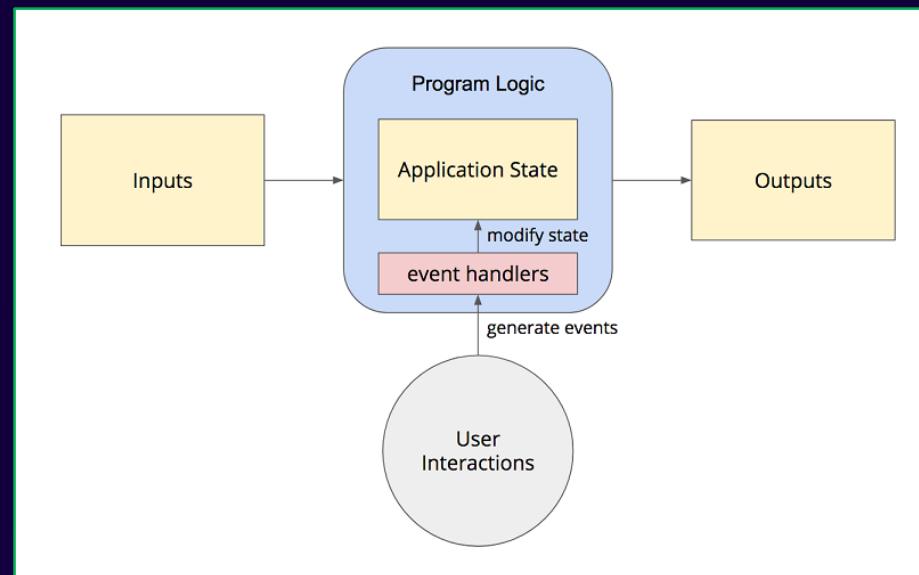
```
1 void Counter::setValue(int value)
2 {
3     if (value != m_value) {
4         m_value = value;
5         emit valueChanged(value);
6     }
7 }
8
9 Counter a, b;
10 QObject::connect(&a, &Counter::valueChanged,
11                  &b, &Counter::setValue);
12
13 a.setValue(12); // a.value() == 12, b.value() == 12
14 b.setValue(48); // a.value() == 12, b.value() == 48
```

## Application Type

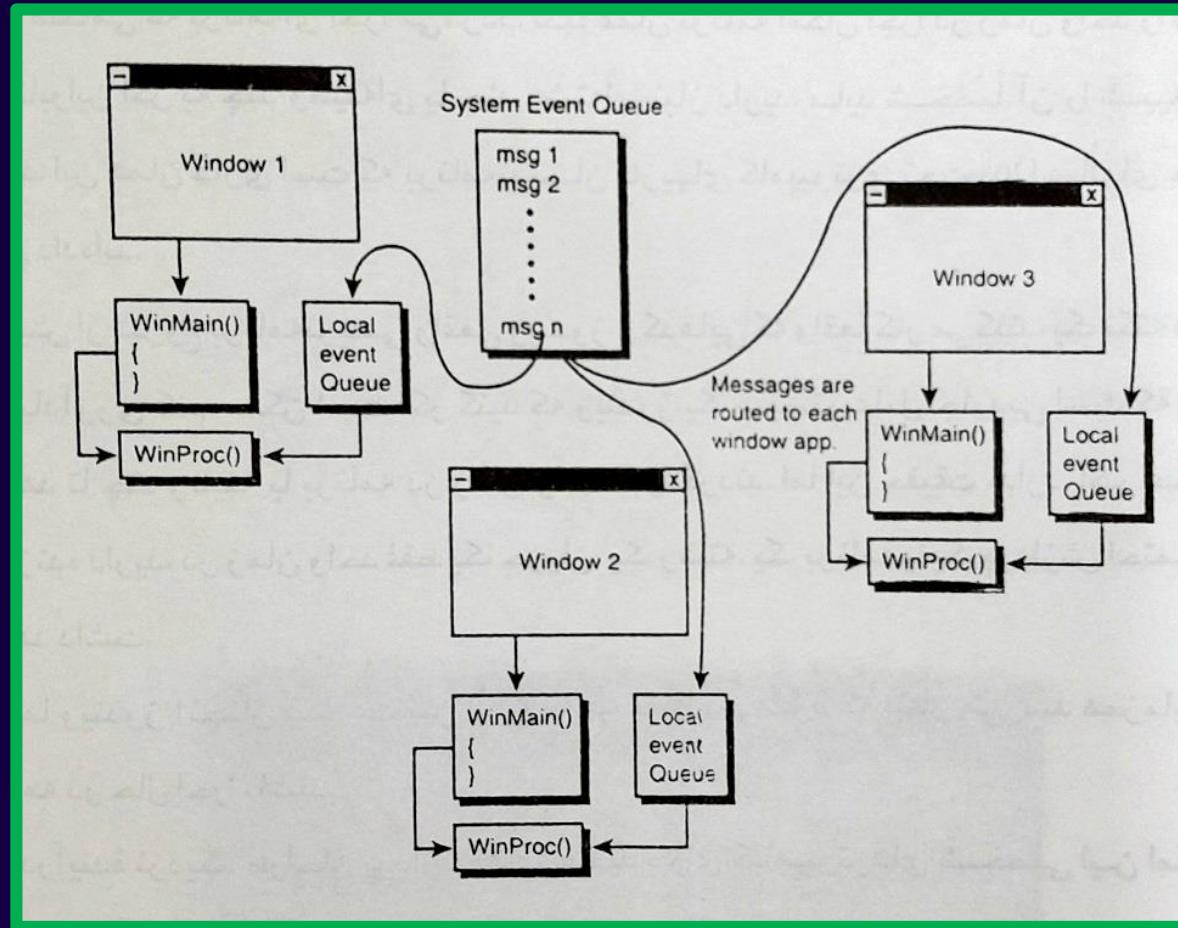
- Procedural
  - The program starts from a point and ends after doing the necessary tasks.
- Interactive (Event based)
  - The program always resides in the memory and waits for the user's commands.

## Thread Type

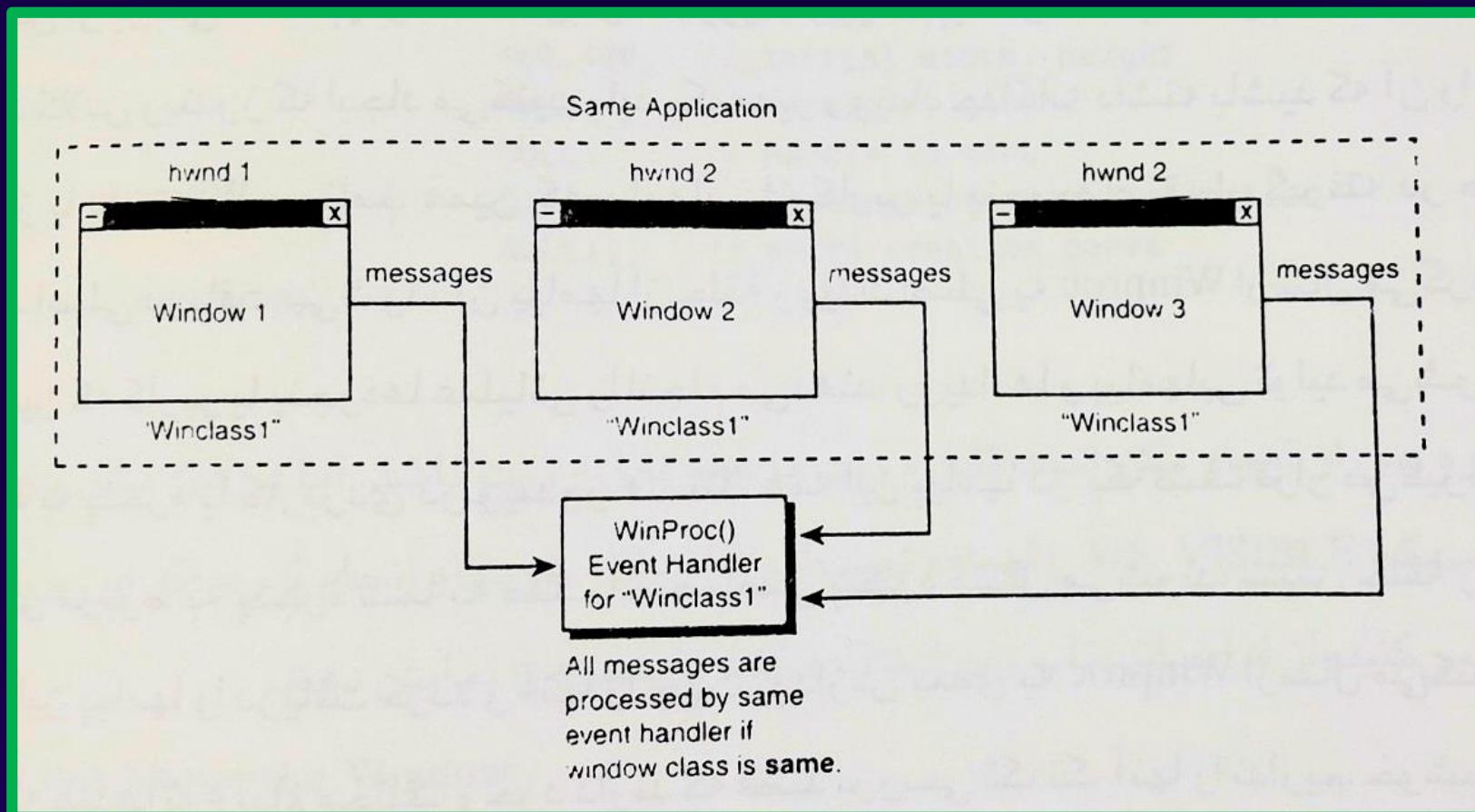
- Worker
- Ui



## Windows Application



## Windows Application



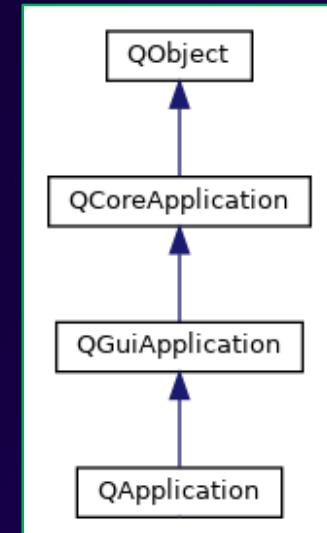
## QCoreApplication

- The QCoreApplication class provides an event loop for Qt applications without UI

## QApplication

- The QApplication class manages the GUI application's control flow and main settings.

```
1 #include <QtWidgets/QApplication>
2 #include <QWidget>
3
4 int main(int argc, char *argv[])
5 {
6     QApplication app(argc, argv);
7     QWidget w;
8
9     w.show();
10    return app.exec();
11 }
```



## QCoreApplication

Header:	#include <QCoreApplication>
qmake:	QT += core
Inherits:	QObject

## QGuiApplication

Header:	#include <QGuiApplication>
qmake:	QT += gui
Inherits:	QCoreApplication
Inherited By:	QApplication

## QApplication

Header:	#include <QApplication>
qmake:	QT += widgets
Inherits:	QGuiApplication

## QString

- The QString class provides a Unicode character string.

## Methods

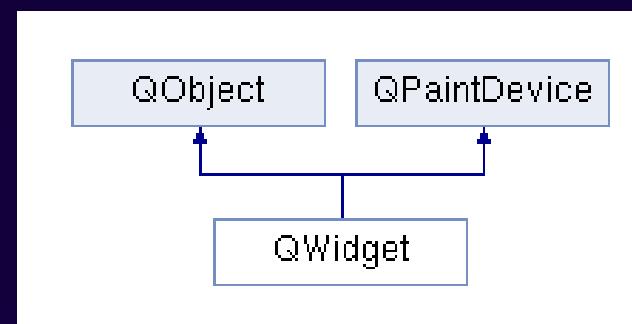
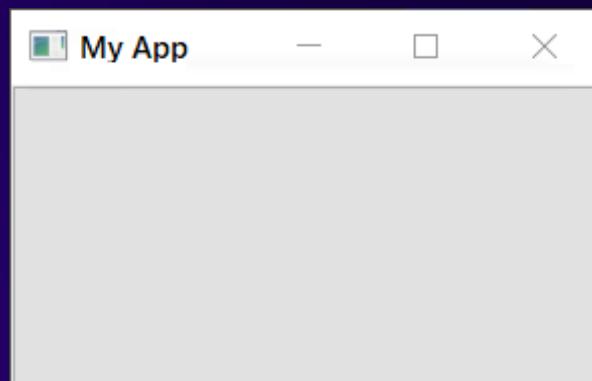
- `QString(const char *str);`
  - Constructs a string initialized with the 8-bit string str.
- `QString();`
  - Constructs a null string. Null strings are also empty.
- `int length() const;`
  - Returns the number of characters in this string. Equivalent to size().
- `void clear();`
  - Clears the contents of the string and makes it null.

Header: #include <QString>

qmake: QT += core

## QWidget

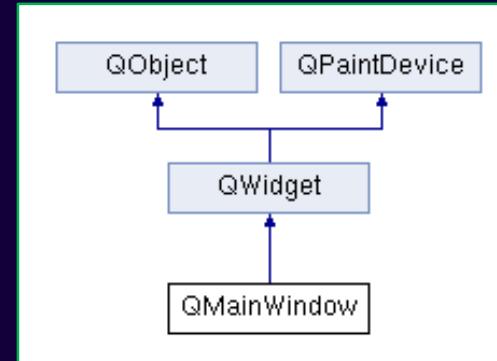
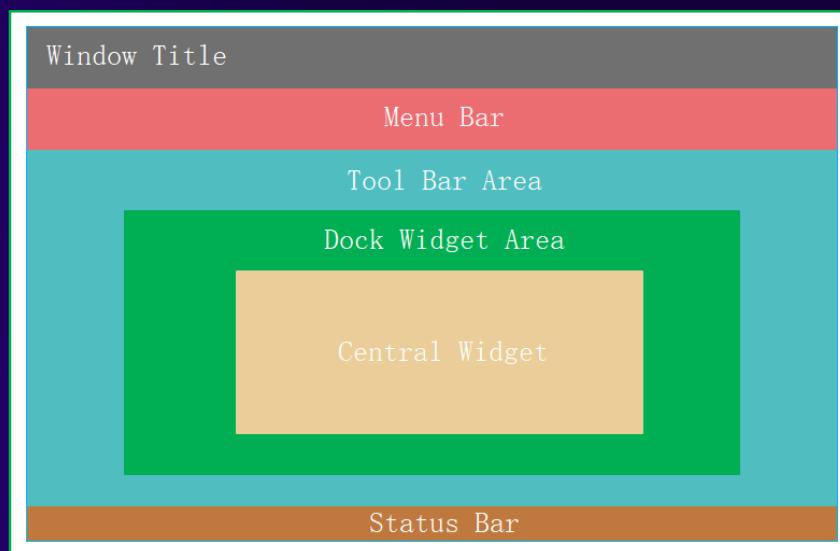
- The QWidget class is the base class of all user interface objects.
- The widget is the atom of the user interface: it receives mouse, keyboard and other events from the window system, and paints a representation of itself on the screen. Every widget is rectangular, and they are sorted in a Z-order. A widget is clipped by its parent and by the widgets in front of it.
- A widget that is not embedded in a parent widget is called a window. Usually, windows have a frame and a title bar, although it is also possible to create windows without such decoration using suitable window flags



```
Header: #include <QWidget>
qmake: QT += widgets
```

## QMainWindow

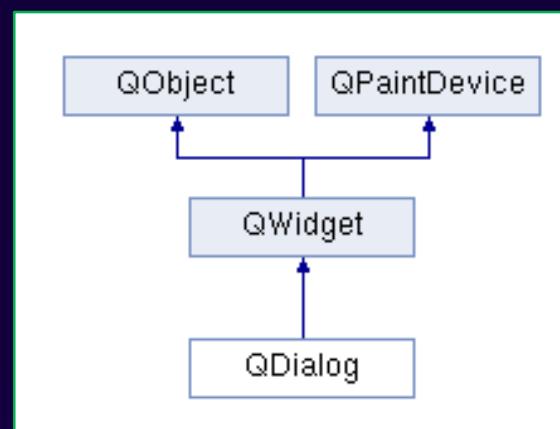
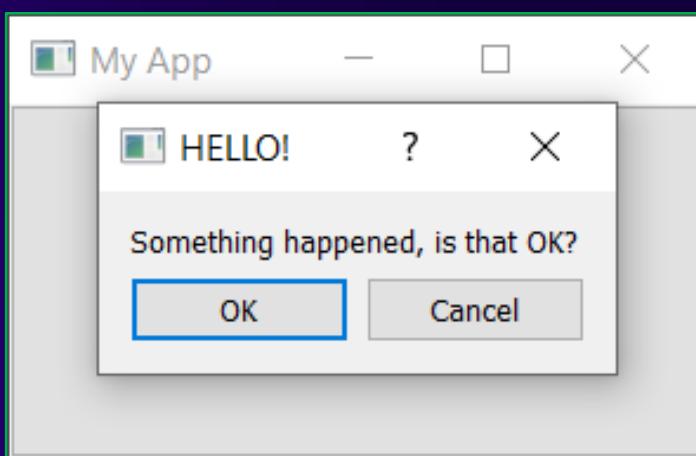
- The QMainWindow class provides a main application window.
- QMainWindow has its own layout to which you can add QToolBars, QDockWidgets, a QMenuBar, and a QStatusBar. The layout has a center area that can be occupied by any kind of widget.



```
Header: #include <QMainWindow>
qmake: QT += widgets
```

## QDialog

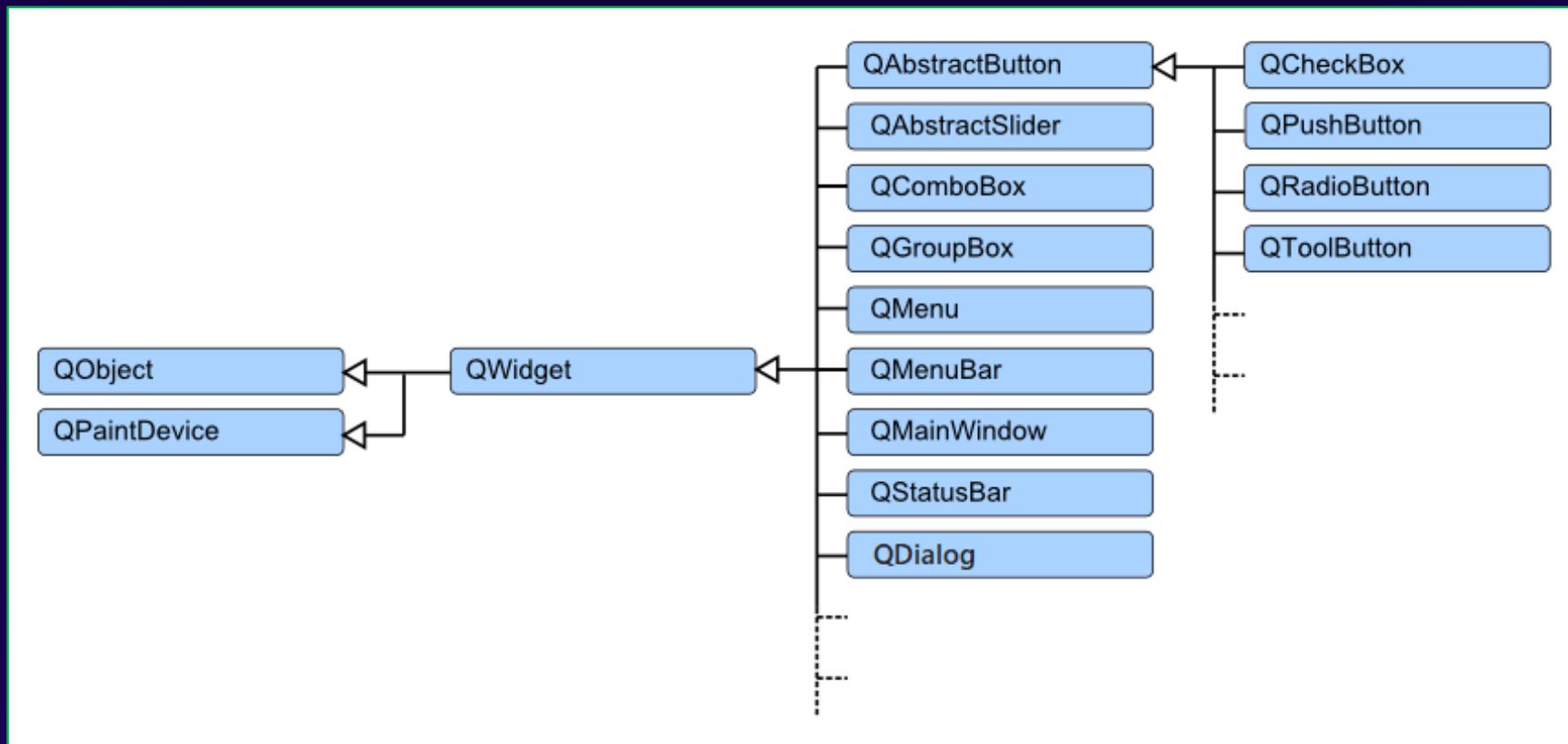
- The QDialog class is the base class of dialog windows.
- A dialog window is a top-level window mostly used for short-term tasks and brief communications with the user. QDialogs may be modal or modeless. QDialogs can provide a return value, and they can have default buttons.
- Modal Dialogs:
  - A modal dialog is a dialog that blocks input to other visible windows in the same application.



```
Header: #include <QDialog>
qmake: QT += widgets
```

## Controls

- The Qt Controls module provides a set of controls that can be used to build complete interfaces in Qt.



## QLabel

- The QLabel widget provides a text or image display. No user interaction functionality is provided.

## Methods

- `QLabel(const QString &text, QWidget *parent = nullptr, Qt::WindowFlags f = Qt::WindowFlags());`
  - Constructs a label that displays the text, `text`.
- `QLabel(QWidget *parent = nullptr, Qt::WindowFlags f = Qt::WindowFlags());`
  - Constructs an empty label.
- `QString text() const;`
- `void setText(const QString &);`
- `void setNum(double num);`
  - This is an overloaded function.
  - Sets the label contents to plain text containing the textual representation of double `num`. Any previous content is cleared.
- `void show();`
  - Shows the widget and its child widgets.

Header: #include <QLabel>

qmake: QT += widgets

## QPushButton

- The QPushButton widget provides a command button. Push (click) a button to command the computer to perform some action.

## Methods

- QPushButton(const QIcon &icon, const QString &text, QWidget \*parent = nullptr);
  - Constructs a push button with an icon and a text, and a parent.
- QPushButton(const QString &text, QWidget \*parent = nullptr);
  - Constructs a push button with the parent parent and the text text.
- QPushButton(QWidget \*parent = nullptr);
  - Constructs a push button with no text and a parent.

## Signals

- void clicked(bool checked = false);
  - This signal is emitted when the button is activated (i.e., pressed down then released while the mouse cursor is inside the button), when the shortcut key is typed, or when click() or animateClick() is called.

Header: #include <QPushButton>

qmake: QT += widgets

## QLineEdit

- A line edit allows the user to enter and edit a single line of plain text.

## Methods

- `QLineEdit(const QString &contents, QWidget *parent = nullptr);`
  - Constructs a line edit containing the text contents.
- `QLineEdit(QWidget *parent = nullptr);`
  - Constructs a line edit with no text.
- `QString text() const;`
- `void setText(const QString &);`

## Signals

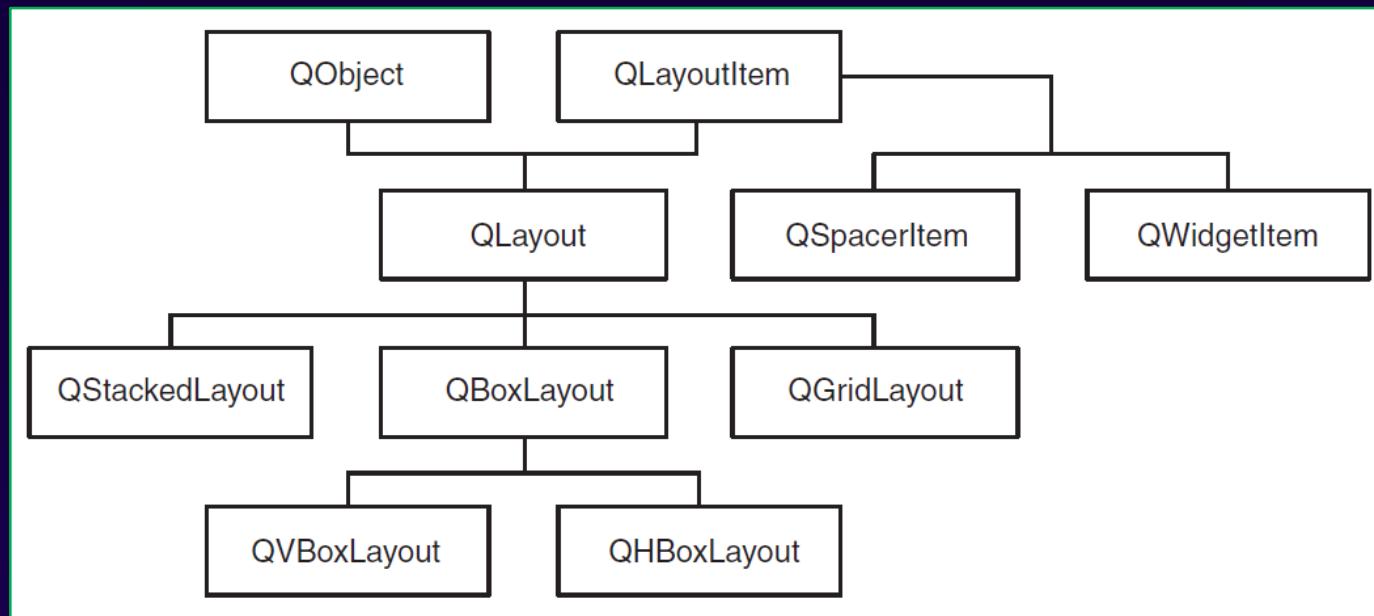
- `void textChanged(const QString &text);`
  - This signal is emitted whenever the text changes. The text argument is the new text.

Header: `#include <QLineEdit>`

qmake: `QT += widgets`

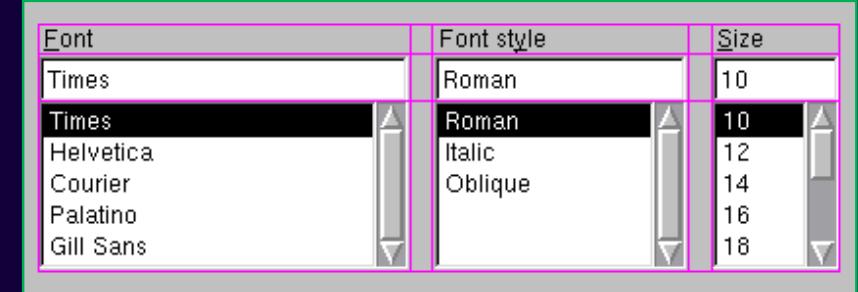
## QLayout

- The Qt layout system provides a simple and powerful way of automatically arranging child widgets within a widget to ensure that they make good use of the available space.
- The QLayout class is the base class of geometry managers.



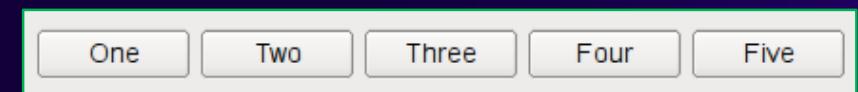
## QGridLayout

- The QGridLayout class lays out widgets in a grid.



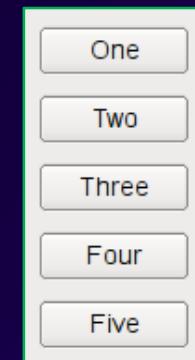
## QHBoxLayout

- The QHBoxLayout class lines up widgets horizontally.



## QVBoxLayout

- The QVBoxLayout class lines up widgets vertically.



## QMessageBox

- The QMessageBox class provides a modal dialog for informing the user or for asking the user a question and receiving an answer.

## Methods

- `QMessageBox(QMessageBox::Icon icon, const QString &title, const QString &text, QMessageBox::StandardButtons buttons = NoButton, QWidget *parent = nullptr, Qt::WindowFlags f = Qt::Dialog | Qt::MSWindowsFixedSizeDialogHint);`
  - Constructs a message box with the given icon, title, text, and standard buttons.
- `QMessageBox::QMessageBox(QWidget *parent = nullptr);`
  - Constructs a message box with no text and no buttons. parent is passed to the QDialog constructor.

Header: #include <QMessageBox>

qmake: QT += widgets

## Methods

- `QMessageBox::Function(QWidget *parent, const QString &title, const QString &text, QMessageBox::StandardButtons buttons = Ok, QMessageBox::StandardButton defaultButton = NoButton);`
  - **Function:**
    - **critical:** Opens a critical message box with the given title and text in front of the specified parent widget.
    - **information:** Opens an information message box with the given title and text in front of the specified parent widget.
    - **warning:** Opens a warning message box with the given title and text in front of the specified parent widget.

## Methods

- `QMessageBox::StandardButton QMessageBox::question(QWidget *parent, const QString &title, const QString &text, QMessageBox::StandardButtons buttons = StandardButtons(Yes | No), QMessageBox::StandardButton defaultButton = NoButton);`
  - Opens a question message box with the given title and text in front of the specified parent widget.
- `void QMessageBox::about(QWidget *parent, const QString &title, const QString &text)`
  - Displays a simple about box with title title and text text. The about box's parent is parent.

## Separator

- Windows and Unix systems use different conventions for the file separator.
  - **"\" in Windows, "/" in Unix**
- Windows:  
C:\Program Files\Java\jre6\bin;C:\MATLAB;C:\Some\Other\Path\bin;
- Unix:  
/usr/bin:/usr/local/bin:/home/billybob/xmlbeans/bin

## Absolute vs Relative Path

- You can do this by using relative path names instead. The relative path will find the file assuming you run the program directory.
- Absolute Path:  
C:\Documents and Settings\billybob\My Documents\data\foo.txt
- Relative Path:  
data/foo.txt

## Case Sensitive Names

- Not all operating systems have case sensitive file systems. For example, Windows considers "FOO.txt" and "foo.txt" as the same. So avoid using file names that are case sensitive.
- Linux file system treats file and directory names as case-sensitive. FOO.txt and foo.txt will be treated as distinct files.

## Special Characters

- The backslash (\) escape character turns special characters into string characters.

Escape character	Result	Description
\'	'	Single quote
\"	"	Double quote
\\	\	Backslash
\n	New Line	-
\t	Tab	-

- Example:
  - string txt = "We are the so-called \"Vikings\" from the north.;"
  - string txt = "It\'s alright.;"
  - string txt = "C:\\a\\b\\c.txt";

## Line Breaks

- The simple fact is that it is different for all operating systems. There is no "universal" newline. The best you can do is be aware of the differences.
  - For Windows, it is CRLF
  - For UNIX, it is LF
  - For MAC (up through version 9) it was CR
  - For MAC OS X, it is LF
- The new line character (\n or endl) is translated into the equivalent character according to the type of operating system and compiler.

Character Name	Char	Decimal
Line Feed	LF	10
Carriage Return	CR	13

## QDebug

- qDebug is used whenever the developer needs to write out debugging or tracing information to a device, file, string or console.

## Methods

- `qDebug(const char *message, ...);`

## Example

- `qDebug("Items in list: %d", myList.size());`
- `qDebug() << "Brush:" << myQBrush << "Other value:" << i;`

```
Header: #include <QDebug>
```

```
qmake: QT += widgets
```

## File Types

- **Text File**

A text file stores data in the form of alphabets, digits and other special symbols by storing their ASCII values and are in a human readable format. For example, any file with a .txt, .c, etc extension.

- **Binary File**

A binary file contains a sequence or a collection of bytes which are not in a human readable format. For example, files with .exe, .mp3, etc extension. It represents custom data.

- There are three major differences between the two, i.e., Handling of newlines, storage of numbers, encoded and representation of EOF(End of File).

## Binary vs Text files

### Text Files vs Binary Files

- text files contain "text", usually in ASCII
- everything else is a binary file
- 1234 vs "1234"

byte 0	byte 1	byte 2	byte 3
00000000	00000000	00000100	11010010
0	0	4	210
49	50	51	52

## QFile

- QFile is an I/O device for reading and writing text and binary files and resources. A QFile may be used by itself or, more conveniently, with a QTextStream or QDataStream.

## Methods

- **QFile(const QString &name, QObject \*parent);**
  - Constructs a new file object with the given parent to represent the file with the specified name.
- **QFile(QObject \*parent);**
  - Constructs a new file object with the given parent.
- **QFile(const QString &name);**
  - Constructs a new file object to represent the file with the given name.
- **QFile();**
  - Constructs a QFile object.

Header: #include <QFile>

qmake: QT += core

## Methods

- `bool copy(const QString &newName);`
  - Copies the file named `fileName()` to `newName`.
  - This file is closed before it is copied.
  - If the copied file is a symbolic link (`symlink`), the file it refers to is copied, not the link itself. With the exception of permissions, which are copied, no other file metadata is copied.
  - Constructs a new file object with the given parent to represent the file with the specified name.
- `bool exists() const;`
  - Returns true if the file specified by `fileName()` exists; otherwise returns false.
- `bool remove();`
  - Removes the file specified by `fileName()`. Returns true if successful; otherwise returns false.
  - The file is closed before it is removed.
- `bool rename(const QString &newName);`
  - Renames the file currently specified by `fileName()` to `newName`. Returns true if successful; otherwise returns false. The file is closed before it is renamed.

## Methods

- `bool open(QIODevice::OpenMode mode);`
  - Opens the file using OpenMode mode, returning true if successful; otherwise false.
  - The mode must be QIODevice::ReadOnly, QIODevice::WriteOnly, or QIODevice::ReadWrite. It may also have additional flags, such as QIODevice::Text and QIODevice::Unbuffered.
- `qint64 write(const char *data, qint64 maxSize);`
  - Writes at most maxSize bytes of data from data to the device.
- `qint64 read(char *data, qint64 maxSize);`
  - Reads at most maxSize bytes from the device into data, and returns the number of bytes read.
- `qint64 readLine(char *data, qint64 maxSize);`
  - This function reads a line of ASCII characters from the device, up to a maximum of maxSize - 1 bytes, stores the characters in data, and returns the number of bytes read. If a line could not be read but no error occurred, this function returns 0. If an error occurs, this function returns the length of what could be read, or -1 if nothing was read.
- `void close();`
  - Calls QFileDevice::flush() and closes the file. Errors from flush are ignored.

## QTextStream

- QTextStream can operate on a QIODevice, a QByteArray or a QString. Using QTextStream's streaming operators, you can conveniently read and write words, lines and numbers. For generating text, QTextStream supports formatting options for field padding and alignment, and formatting of numbers.

```
Header: #include <QTextStream>
qmake: QT += core
```

## QDataStream

- A data stream is a binary stream of encoded information which is 100% independent of the host computer's operating system, CPU or byte order. For example, a data stream that is written by a PC under Windows can be read by a Sun SPARC running Solaris.

```
Header: #include <QDataStream>
qmake: QT += core
```

## QByteArray

- The QByteArray class provides an array of bytes.

Header: #include <QByteArray>

qmake: QT += core

## QChar

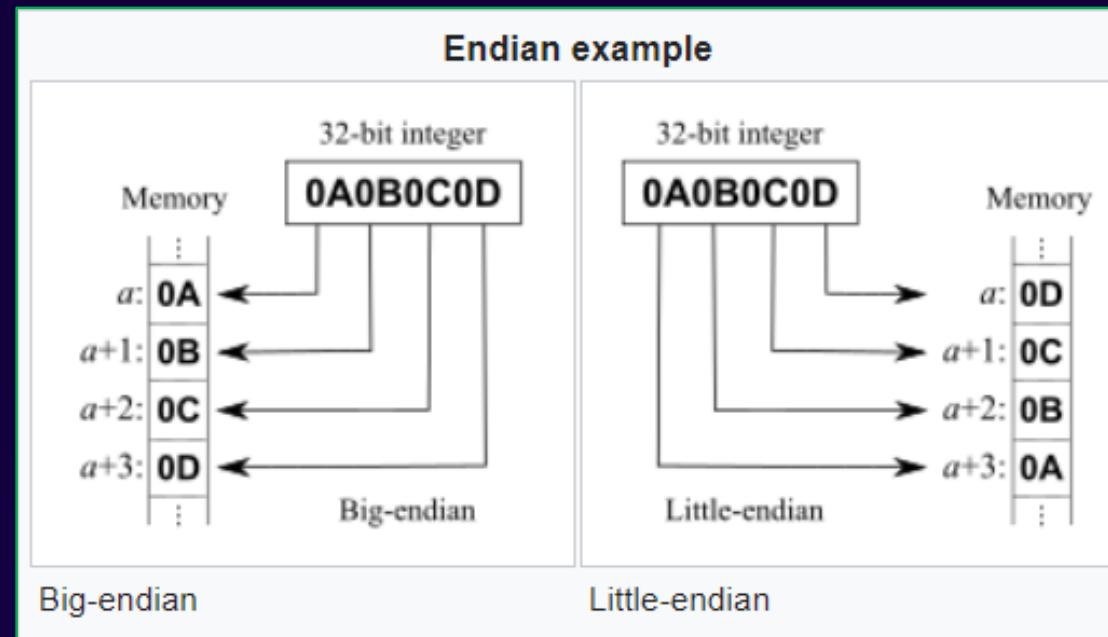
- The QChar class provides a 16-bit Unicode character.

Header: #include <QChar>

qmake: QT += core

## LittleEndian vs. BigEndian architecture

- Computers store data in memory in binary. Specifically, little-endian is when the least significant bytes are stored before the more significant bytes, and big-endian is when the most significant bytes are stored before the less significant bytes.



## LittleEndian vs. BigEndian architecture

Little endian memory: Data structure		Big endian memory: Data structure	
Data structure fields	Byte organization	Data structure fields	Byte organization
elem8_1	0x11	elem8_1	0x11
elem8_2	0x22	elem8_2	0x22
elem8_3	0x33	elem8_3	0x33
elem8_4	0x44	elem8_4	0x44
elem16_1	0x55	elem16_1	0x66
elem16_2	0x66	elem16_2	0x55
elem32	0x77	elem32	0x88
	0x88		0x77
	0x99		0xCC
	0xAA		0xBB
	0xBB		0xAA
	0xCC		0x99

## Example

- 0x12345678 storing this 4-byte value into memory
  - little-endian: 78 56 34 12
  - big-endian: 12 34 56 78
- 0x123456789abcdef0 storing this 8-byte value into memory
  - little-endian (value is at memory address 0x00): f0 de bc 9a 78 56 34 12
  - big-endian (value is at memory address 0x00): 12 34 56 78 9a bc de f0
- `int a[] = {0x12345678, 0x9abcdef0};`
  - little-endian:
    - 0x00: 78 56 34 12
    - 0x04: f0 de bc 9a
  - big-endian: 12 34 56 78
    - 0x00: 12 34 56 78
    - 0x04: 9a bc de f0

## Example

- `char s[] = {0x12, 0x34, 0x56, 0x78, 0x9a, 0xbc, 0xde, 0xf0};`
  - **little-endian:**
    - 0x00: 12
    - 0x01: 34
    - 0x02: 56
    - 0x03: 78
    - 0x04: 9a
    - 0x05: bc
    - 0x06: de
    - 0x07: f0
  - **big-endian:**
    - 0x00: 12 34 56 78 9a bc de f0

# Thank You

