COS121 Programming Tools

Introduction to programming tools for C++ development

What are Programming Tools?

- Programs and applications that help developers to
  - **create** software
  - **debug** software
  - **maintain** software
  - **support** software
- Helps to create **quality software**.
- Also known as **software development tools**.

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Qt - The Mother of all Frameworks

- Qt is a cross-platform **application framework** written in C++.
- **Cross-platform**: Windows, Mac, Linux, Android, iOS, …
- Created by **Trolltech** (1991), bought by **Nokia** (2008), moved to **Digia** (August 2012).
- Qt version 5 (**Qt 5**) should have been released in August 2012.
- Qt uses **design patterns** extensively.

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Qt - The Mother of all Frameworks

- All though Qt is written in C++ there are numerous **bindings** available:
  - Java (Qt Jambi)
  - PHP (PHP-Qt)
  - C# (Qyoto and qt4dotnet)
  - Ada (QtAda)
  - Python (PyQt, PySide and PythonQt)
  - Ruby (QtRuby)
  - Perl (PerlQt4)
  - Lisp (CommonQt)
  - Many more …

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Qt - The Mother of all Frameworks

- Qt provides extensive and advanced **programming tools**:
  - GUI design (Qt Designer)
  - IDE (Qt Creator)
  - Debugging (integrated Qt debugger)
  - Build Automation (qmake, uic and rcc)
  - Simulations (Qt Simulator)
  - Advanced XML support (QML)
  - Language translation (Qt Linguist)

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Qt - The Mother of all Frameworks

- Qt is used by many applications and companies:
  - VLC media player
  - VirtualBox
  - Google
  - Walt Disney Animation Studio
  - DreamWorks
  - European Space Agency
  - Skype
  - Adobe Photoshop
  - Opera
  - Volvo
  - Siemens
  - Many more …

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Categories

- Compilers
- Build Automation
- Profilers
- Integrated Development Environments (IDEs)
- Graphical User Interface (GUI) Designers
- Debuggers

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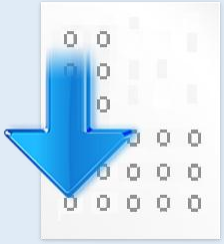
Compilers

- Computer programs that transform **source code** into **computer code** (eg: binary).
- Source code is written in a specific **programming language**.
- Example C++ compilers:
  - GCC/G++ (Linux & Mac)
  - MinGW (GCC for Windows)
  - Bloodshed Dev-C++ (Windows)
  - Visual C++ (Windows)
  - Borland C++ (Windows)
  - Many more …



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Build Automation

- Programs that automate the **compiling**, **linking** and **deployment** process of software.
- Often **automates makefile** generation.
- Examples:
  - CMake (Windows, Linux & Mac)
  - Qt's qmake (Windows, Linux & Mac)
  - GNU's Automake (Windows, Linux & Mac)
  - Microsoft's nmake (Windows)
  - Many more …

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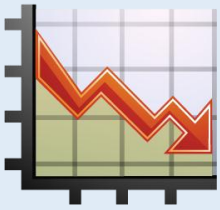
Profilers

- Programs used to dynamically analyse software.
- Measures the space and time complexity of programs:
  - Memory usage
  - Disk space requirements
  - Execution time
- Mainly used for program optimization.
- Examples:
  - Apple's Shark (Mac)
  - oprofile (Linux)
  - AMD's CodeAnalyst (Linux)
  - .NET's profiler (Microsoft)
  - Many more …



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Integrated Development Environments

- Commonly known as **IDE**s.
- A software application that provides a **comprehensive programming** and **development facility**.
- Often consists of:
  - **Source code editor**
  - **Build automation** and **compiler**
  - **Debugger**
- Examples:
  - Qt Creator (Windows, Linux & Mac)
  - Visual Studio (Windows)
  - Dev-C++ (Windows)
  - Xcode (Mac)
  - Many more …

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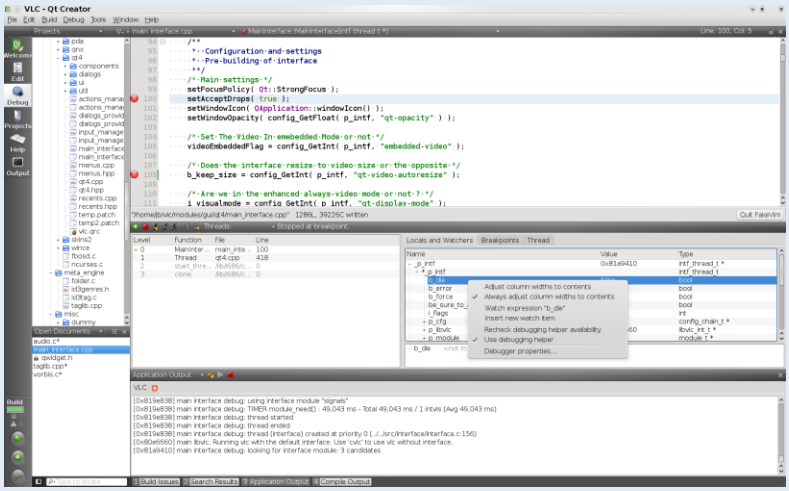
IDE – Qt Creator



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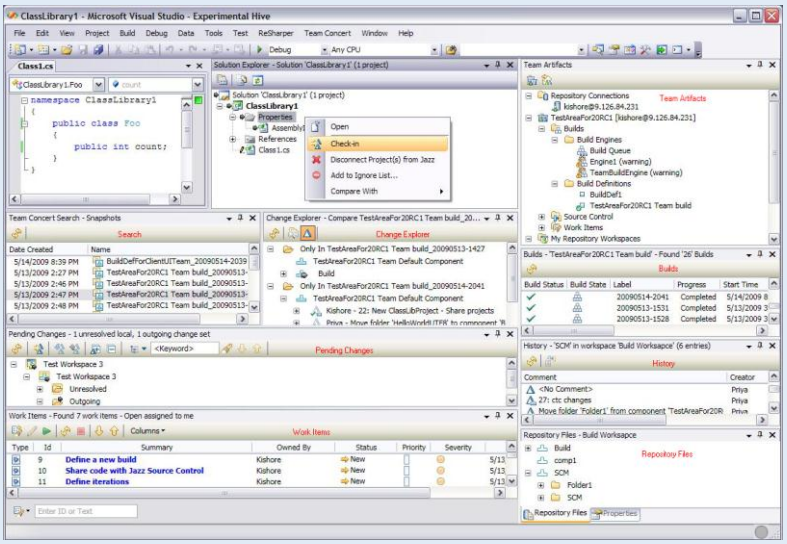
IDE – Visual Studio



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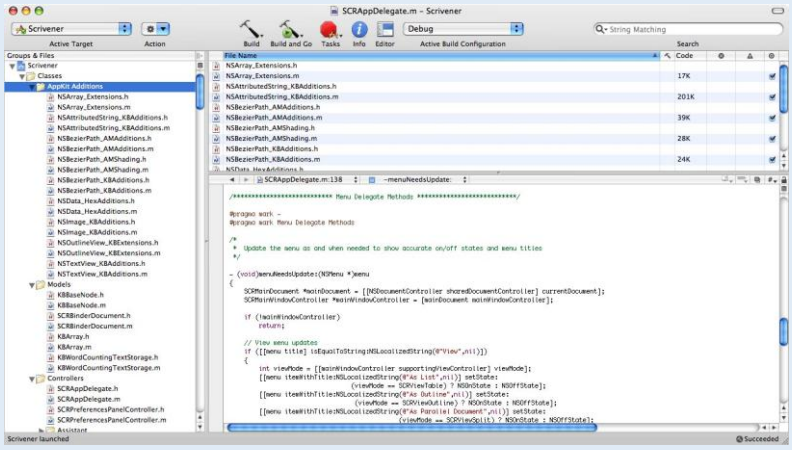
IDE – Xcode



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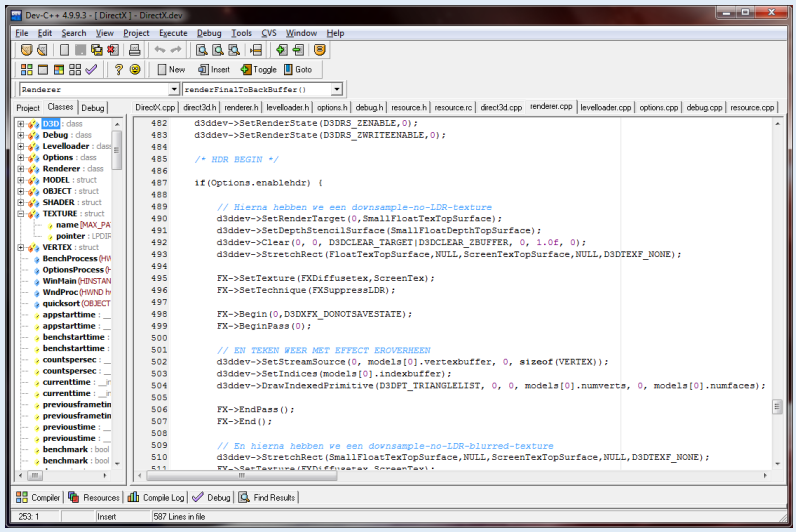
IDE – Dev-C++



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Graphical User Interface Designers

- A software application that provides functionality for designing **graphical user interfaces** (GUIs).
- They are often based on the **drag-and-drop** principle.
- Examples:
  - Qt Designer (Windows, Linux & Mac)
  - Visual Studio (Windows)
  - Xcode (Mac)
  - Many more …

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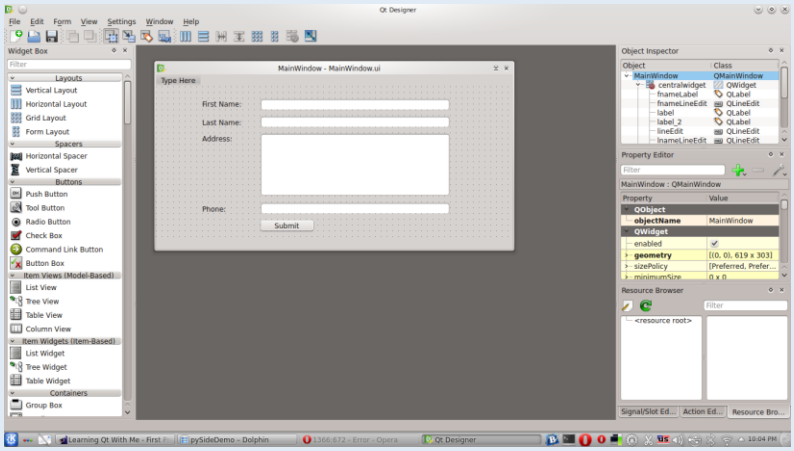
GUI Designer – Qt Designer



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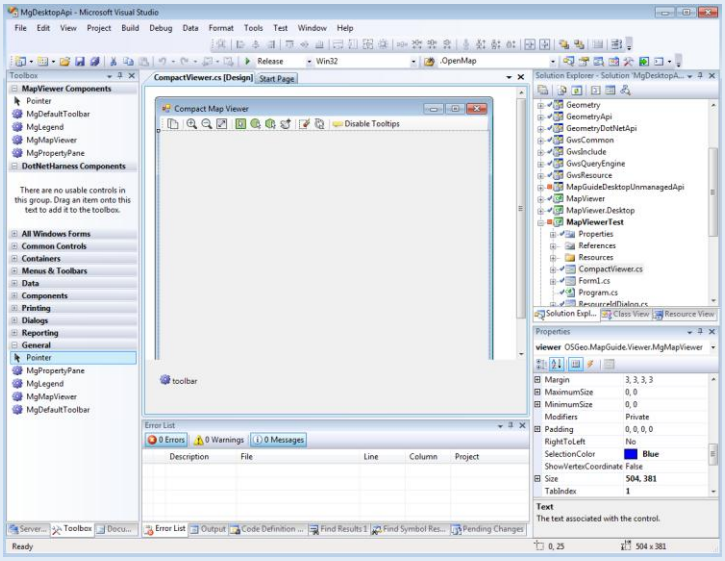
GUI Designer – Visual Studio



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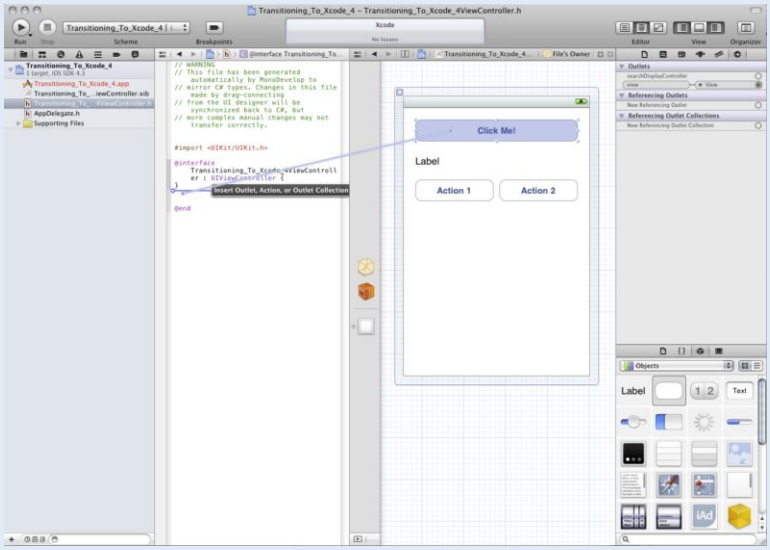
GUI Designer – Xcode Designer



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Debuggers

- Programs used to **test** and **debug** a target program.
- Mostly used to find the reason for a program **misbehaviour** or **crash**.
- Examples:
  - GNU's Debugger (Windows, Linux & Mac)
  - WinDbg (Windows)
  - Qt's Debugger (Windows, Linux & Mac)
  - Visual Studio Debugger (Windows)
  - Many more …

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GDB - The GNU Project Debugger

- Allows you to see what is going on inside another program.
- Helps to detect program crashes such as Segmentation Faults (SegFaults).
- Supports **back tracing**.
- Supports manual manipulation of **breakpoints**.
- Helps with the **stack inspection**.

- http://www.gnu.org/software/gdb

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GDB – Installation

- Ubuntu/Debian:
  - **sudo apt-get install gdb**
- Fedora/RedHat:
  - **sudo yum install gdb**
- Windows:
  - Use MinGW
  - http://www.mingw.org

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GDB – Debugging a Program

- When compiling with gcc/g++ use the **–g flag**:
  - Eg: **g++ -c -g main.cpp**
  - You can also add –g to your makefile.
  - Tells g++ to create internal debug information and symbols.
- Once compiled, run gdb on your executable:
  - Eg: **gdb program**
  - **program** is the name of the executable.

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GDB – Debugging a Program

visore@ubuntu: ~/Desktop/tools

File Edit View Search Terminal Help

```
visore@ubuntu:~/Desktop/tools$ gdb program
GNU gdb (Ubuntu/Linaro 7.4-2012.04-0ubuntu2) 7.4-2012.04
Copyright (C) 2012 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
For bug reporting instructions, please see:
<http://bugs.launchpad.net/gdb-linaro/>...
Reading symbols from /home/visore/Desktop/tools/program...done.
(gdb)
```

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GDB – Navigation Commands

- To run the program:
  - **run** or **r**
- To start a step-wise debugging process:
  - **start**
- To stop a step-wise debugging process:
  - **stop**

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GDB – Navigation Commands

- To continue by taking a single step:
  - **step** or **s**
- To continue to the next breakpoint:
  - **continue** or **c**
- To back trace after an error:
  - **backtrace**
- To exit gdb:
  - **quit** or **q**

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GDB – Breakpoint Commands

- To add a breakpoint at a specific line:
  - **break <line number>**
  - **b <line number>**
  - Eg: **break 16**
- To add a breakpoint at a specific function:
  - **break <function name>**
  - **b <function name>**
  - Eg: **break main**
  - Eg: **break Student::print**

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GDB – Breakpoint Commands

- To add a breakpoint at a specific line in a specific file:
  - **break <file name>:<line number>**
  - **b <file name>:<line number>**
  - Eg: **break student.cpp:32**
- To view all breakpoints:
  - **info breakpoints**

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GDB – Example

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GDB – Alternatives

- GNU DDD – GNU graphical front-end to GDB.
- Nemiver – Gnome graphical front-end to GDB.
- Qt Creator – Integrated debugger in Qt Creator.
- Visual Studio – Integrated debugger in Visual Studio.
- Xcode – Integrated debugger in Xcode
- WinGDB – GDB implementation for Windows.
- KGDB – Debugger for the Linux kernel.
- Eclipse – CDT integrated in Eclipse.

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Valgrind

- Allows you to analyse **memory management** and **threading bugs**.
- Has characteristics of a **debugger** and **profiler**.
- Mainly use to detect **memory leaks**.
- Memory leaks are chunks of memory that are allocated by a program but can't be accessed at a later stage or returned back to the operating system.

- http://valgrind.org

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Valgrind – Installation

- Ubuntu/Debian:
  - **sudo apt-get install valgrind**
- Fedora/RedHat:
  - **sudo yum install valgrind**
- Windows:
  - Not officially supported.
  - Use Valgrind4Win
  - http://sourceforge.net/projects/valgrind4win

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Valgrind – Debugging a Program

- When compiling with gcc/g++ use the **–g flag**:
  - Eg: **g++ -c -g main.cpp**
  - You can also add –g to your makefile.
  - Tells g++ to create internal debug information and symbols.
- Once compiled, run valgrind on your executable:
  - Eg: **valgrind ./program**
  - **program** is the name of the executable.

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Valgrind

```
visore@ubuntu: ~/Desktop/tools
File  Edit  View  Search  Terminal  Help
Student address: 10 25
==27894==
==27894== HEAP SUMMARY:
==27894==     in use at exit: 1,024 bytes in 1 blocks
==27894==   total heap usage: 1 allocs, 0 frees, 1,024 bytes allocated
==27894==
==27894== 1,024 bytes in 1 blocks are definitely lost in loss record 1 of 1
==27894==    at 0x4C2AC27: operator new[](unsigned long) (in /usr/lib/valgrind/v
gpreload_memcheck-amd64-linux.so)
==27894==    by 0x400A66: main (main.cpp:6)
==27894==
==27894== LEAK SUMMARY:
==27894==    definitely lost: 1,024 bytes in 1 blocks
==27894==    indirectly lost: 0 bytes in 0 blocks
==27894==      possibly lost: 0 bytes in 0 blocks
==27894==    still reachable: 0 bytes in 0 blocks
==27894==         suppressed: 0 bytes in 0 blocks
==27894==
==27894== For counts of detected and suppressed errors, rerun with: -v
==27894== Use --track-origins=yes to see where uninitialised values come from
==27894== ERROR SUMMARY: 19 errors from 5 contexts (suppressed: 2 from 2)
visore@ubuntu:~/Desktop/tools$
```

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Valgrind – Important Flags

- Check for memory leaks:
  - **--leak-check=<no|summary|yes|full>**
  - Default: **summary**
- When checking, specify how willing backtraces are considered to be the same
  - **--leak-resolution=<low|med|high>**
  - Default: **low**
- When disabled, only blocks for which no pointer can be found will be shown:
  - **--show-reachable=<yes|no>**
  - Default: **no**

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Valgrind – Supported Errors

- Valgrind can be used to detect the following errors:
  - Memory leaks
  - Invalid pointers
  - Use of uninitialized variables
  - Double memory deallocation

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Valgrind – Example

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Valgrind – Alternatives

- Dr Memory – Windows and Linux memory management tool.
- Visual Studio – Visual Leak Detector integrated in Visual Studio.
- Rational Purify – Commercial IBM product.
- Insure++ - Commercial Parasoft product.
- Memory Validator – Commercial SoftwareVerify product.

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