Developing User Experiences on Genivi Demo Platform

Hands On Seminar - Genivi AMM April 2016

Visit us at http://www.ics.com

Produced by Integrated Computer Solutions

Material based on Qt 5.5.x

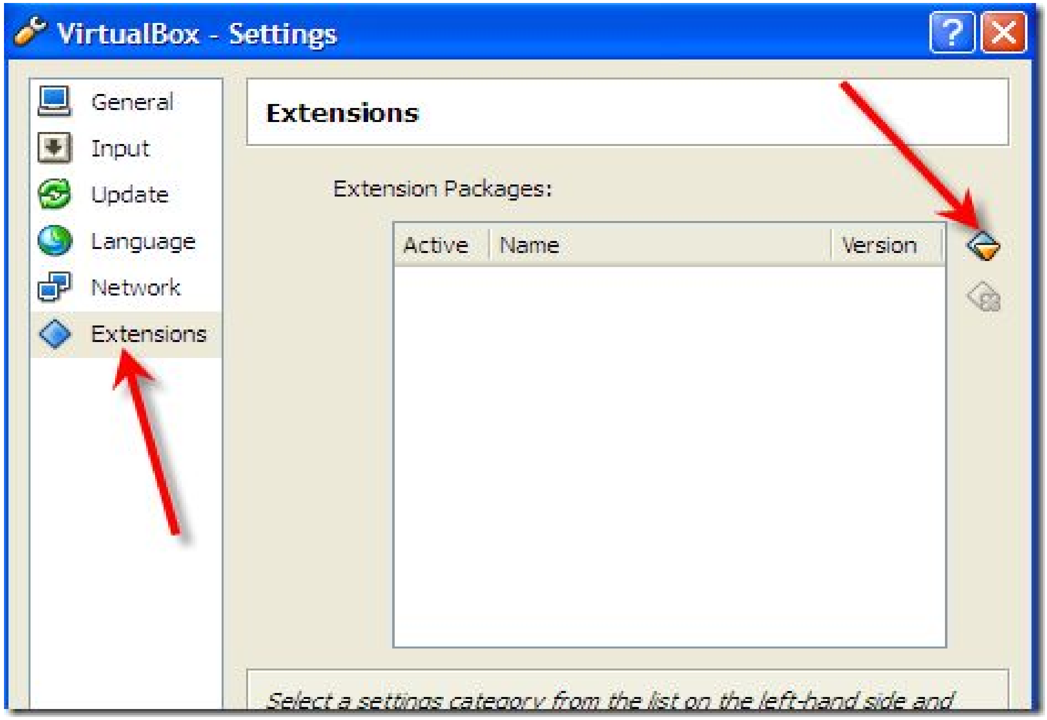
Module: Board Bringup

- Introductions
  - VirtualBox Installation and ICS VirtualBox Image
- Board Unwrap
  - Connections, Peripherals, Power
  - Gentlemen, Connect your Devices
- Yocto Linux - The Boot Process
  - Raspberry Pi boot using firmware loader
  - Renesas Porter, u-Boot
  - options, setting mac addresses and configuration

Install the ICS Development Image

Step 1: Install VirtualBox

Step 2: Install the ExtensionPack by selecting **`File->Preferences`**



VirtualBox - Settings

Extensions

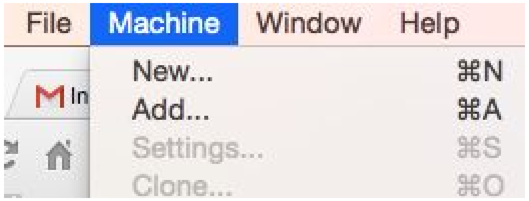
Extension Packages:

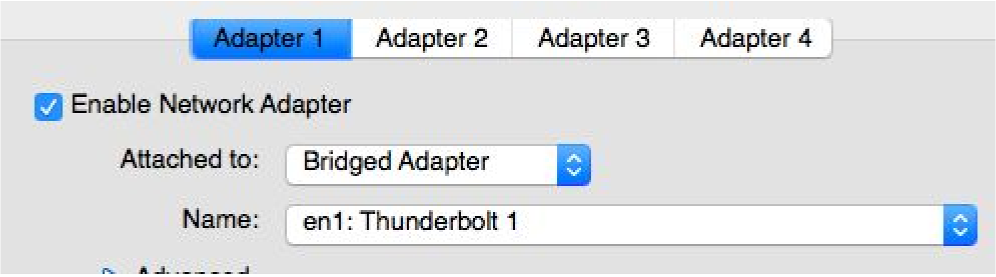
Active	Name	Version

Select a settings category from the list on the left-hand side and

Setup of Development Host

- Copy all files from the provided USB pen drive to your desktop first
- Unzip the file `ICS-Ubuntu-Qt-RPi.zip`
- Add the virtual machine
- Click on Settings -> Network and set Adapter 1 to
  Bridged Adapter
  Select your ***Ethernet Adapter*** *and not your Wifi Adapter!*





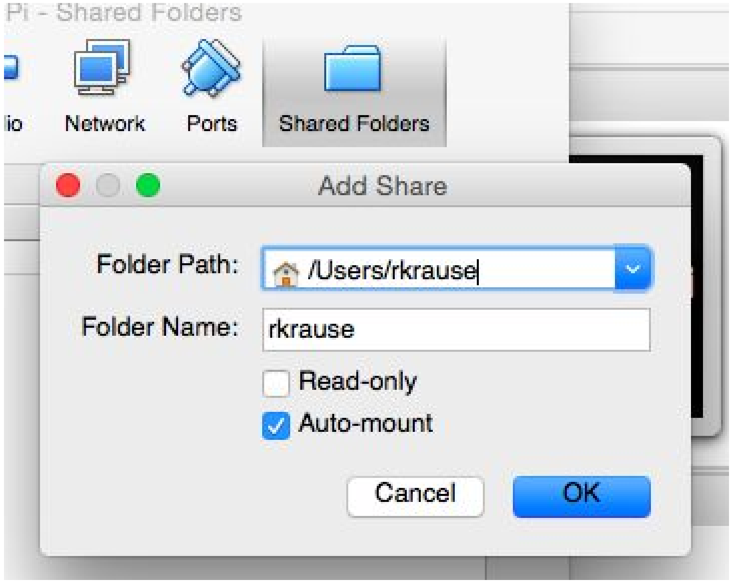
☑ Enable Network Adapter

Attached to: Bridged Adapter

Name: en1: Thunderbolt 1

Setup of Development Host (cont.)

- Next, enable a shared folder between your laptop and the virtual machine
- Start the virtual machine
- Username: ics, password: ics

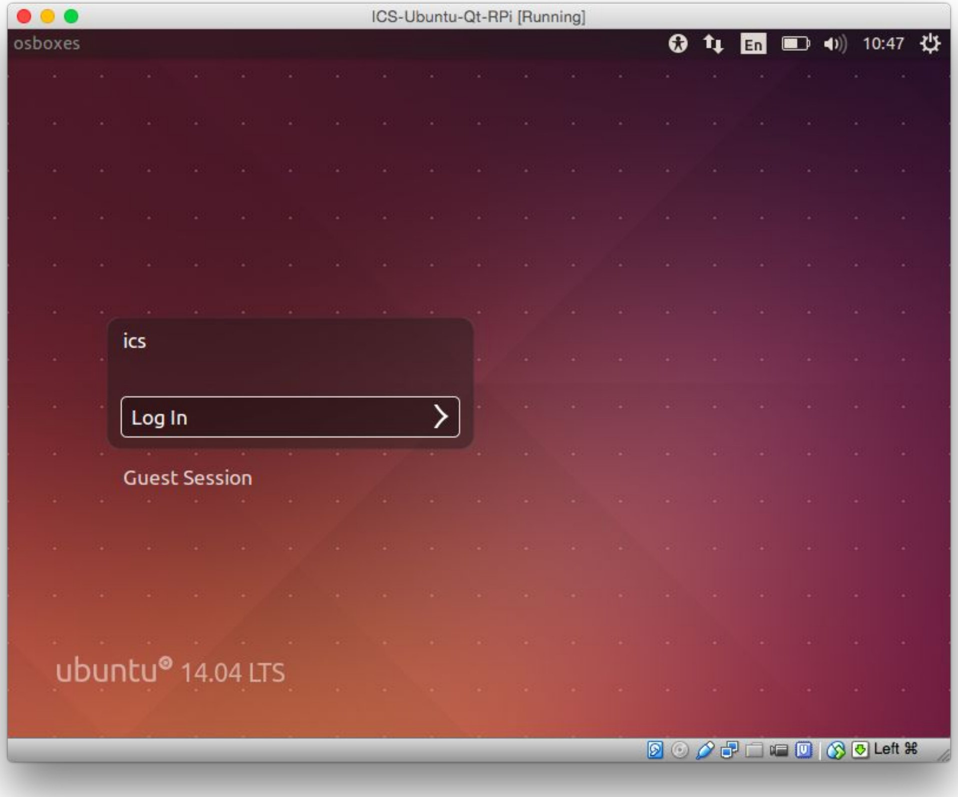


Folder Path: /Users/rkrause

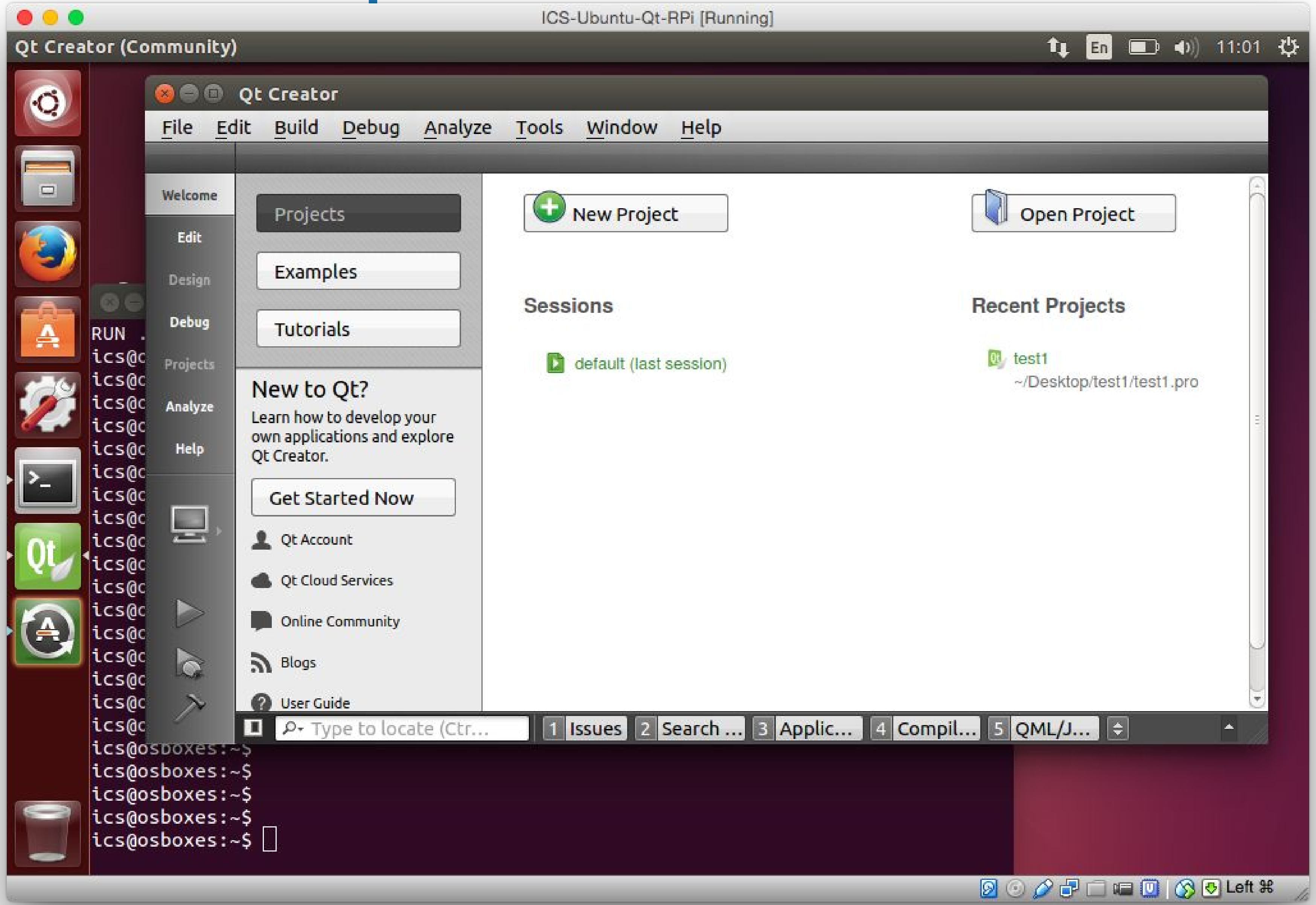
Folder Name: rkrause

□ Read-only

☑ Auto-mount



Development Host - A First Look



New to Qt?

Learn how to develop your own applications and explore Qt Creator.

default (last session)

test1
~/Desktop/test1/test1.pro

```
RUN .
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@c
ics@osboxes:~$
ics@osboxes:~$
ics@osboxes:~$
ics@osboxes:~$
ics@osboxes:~$
```

The ICS Development Image

- ICS created virtual machine image for VirtualBox
  - Supplied via USB pen drive.
  - VirtualBox installer for Windows, Linux and Mac hosts included
- Contains GDP-9 SDKs with cross-compiler and sysroot
  - RaspberryPi-2 and Renesas Porter targets
  - Contains a cross-compiled version of Qt 5 and Qt tool-chain (qmake, moc, uic, etc..)
- Contains Qt Creator
- Default user “ics” has sudo w/o password,
  Use with care!

Module: Board Bringup

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- Raspbian Linux - The Boot Process
  - BOOTP and TFTP
  - U-Boot and disk based boot process
  - Micro-kernel, options, loading drivers

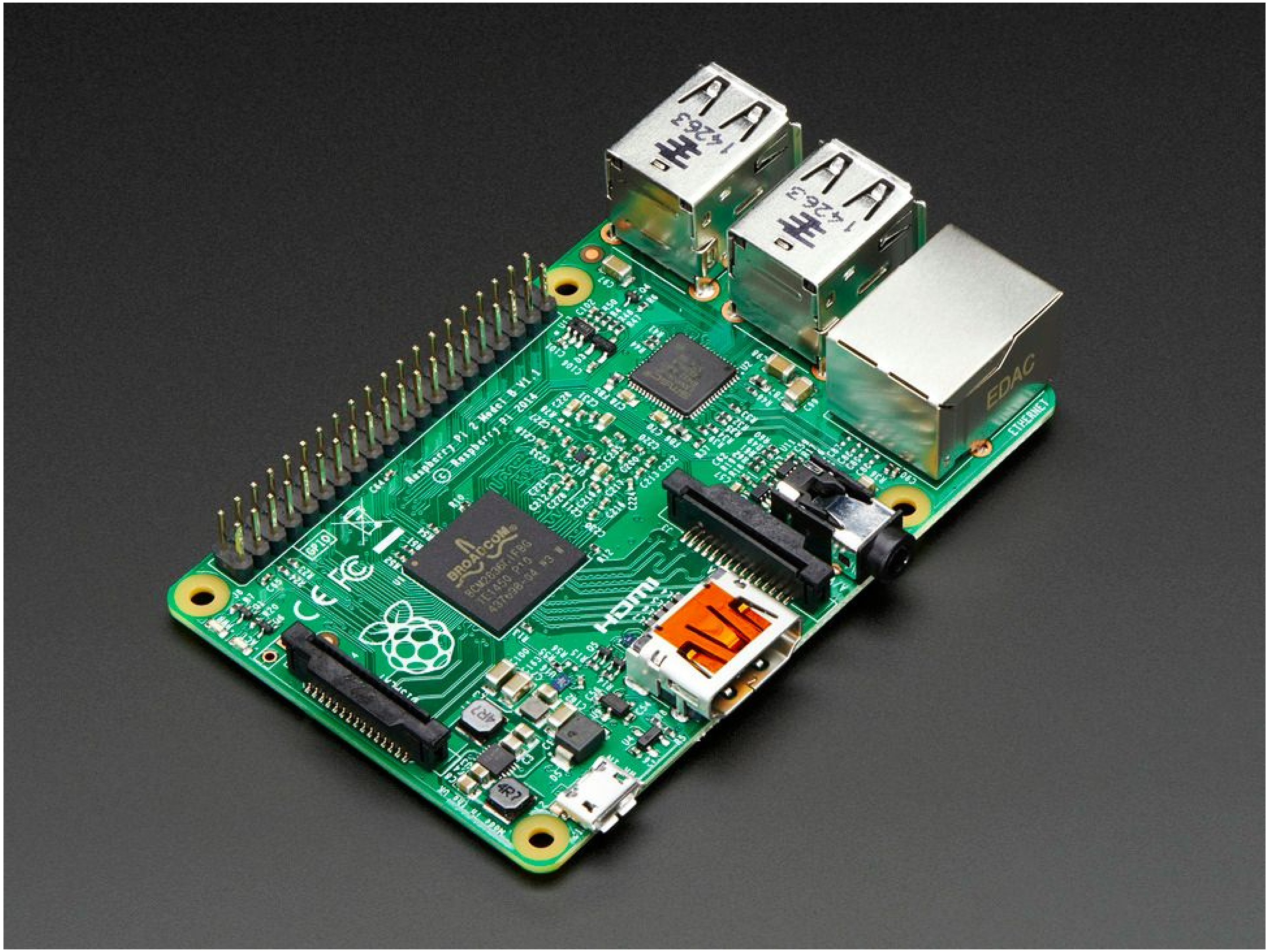
Raspberry Pi 2 - Specifications

- Broadcom BCM2836 ARM7 quad core processor powered single board computer running at 900 MHz
- 1 GB RAM
- 40 pin extended GPIO
- 4 x USB2 ports
- 4 pole stereo output and composite video port
- Full size HDMI
- CSI camera port for Raspberry Pi camera
- DSI display port for Raspberry Pi touch screen display
- Micro SD port for loading operating system and data
- Micro USB power source

Raspberry Pi Touchscreen

- RGB 800×480 display @60fps
- 24-bit color
- FT5406 10 point capacitive touchscreen
- 70 degree viewing angle
- Metal-backed display with mounting holes for the Pi

Demo - Booting with Yocto



Renesas Porter Boot

Connect to the Porter board using a USB cable.

Open a terminal, type:

```
sudo minicom porter
```

Now you can observe and interrupt the system during the boot process.

Login as root, password “root”

Type `ifconfig`

If the ip-address is anything but: `192.168.1.26`

Type

```
ifconfig eth0 192.168.1.26
```

First Contact

- When the target boots
  - We have configured the device to have a static ip-address:

    ```
    192.168.1.28  raspberrypi
    192.168.1.26  porter
    ```
  - The development host also has static ip:
    `192.168.1.211`
  - We aliased the ip to `rpi` and `porter` in `/etc/hosts`
- Connect to the target from the terminal in the development machine;
  - `ssh root@rpi`
  - `ssh root@porter`
  - The password is: `root`

Module: Board Bringup

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  - BOOTP and TFTP
  - U-Boot and disk based boot process
  - Kernel, options, loading drivers

Boot Process - Raspberry Pi

Boots off the first partition of the SD card using the GPU:

1. GPU loads `start.elf`, which includes the firmware for the GPU.
2. GPU firmware then loads `bootcode.bin`, which is the 2nd stage bootloader.
3. The second stage then loads `loader.bin`, which is 3rd stage (moved into bootcode.bin recently)
4. The third stage then loads `kernel.img` with the options in `cmdline.txt`, and boots it.

Boot Process - Das U-Boot

- Bootloader, similar in function to GRUB
- Supports most architectures, including ARM
- Can boot from local storage or network (including network rootfs)
- Works with most UNIX derivatives, including QNX
- Written in C and released under the GPL

Boot Process - Das U-Boot

- Can be configured at boot via a feature rich command line
- Configured using environment variables
  - Pre-set at compile time
  - Can be changed via command line or uEnv.txt file
  - Changes can be saved if storage is writable
- Must be cross-compiled for your specific hardware.
- Can be installed via JTAG or custom board tools. Also supports updating itself.

BOOTP

- UDP based network protocol used to configure network devices.
- Device broadcasts UDP BOOTP packet
- BOOTP server identifies device based on ethernet (MAC) address and sends configuration data
  - IP Address device should use
  - Address of boot server where initial kernel should be downloaded via gateway, nameserver, and other information
- Device downloads kernel and boots it
  - TFTP protocol

Connecting to the Device

- For development and deployment we have to connect host and target
  - SD Card process is very simple, slow and cumbersome
  - Serial TTY - this is a must have for many use cases
  - USB: If the device supports client mode it can be mounted.
- Network Connection:
  - Target: DHCP assigned or static ip address must be known to the host
  - Connect via ssh
  - Set up private-public key pair for effortless login
- NFS mount part or all of the target file-system
  - Mount the Raspberry Pi SD card to `/mnt/rpi-rootfs`
  - Must be executed before we can compile and run code on the device

Module: Development for Device

- Developing Using a cross-compiler
  - Why you need it, Where to get it.
- `SYSROOT`
  - What is it, Why you need it, Where to put it.
- Qt Creator and Qt 5 on the ICS Development Image.
  - Qt Creator Concepts: Kits, Devices, Toolchains, Qt-versions
- `Hello World` with and without Qt Creator

Cross-Compilers

- A cross-compiler is a compiler capable of creating executable code for a platform other than the one on which the compiler is running.
- Cross-compiler tools are used to generate executables for embedded system or multiple platforms.
- Often used to compile for a platform where compilation is not feasible.
  - Embedded computers where a device has extremely limited resources.

Cross-Compilers

- Also use for bootstrapping to a new platform.
- For ARM the most popular and widely used are from Linaro (www.linaro.org)
    - A not-for-profit engineering organization consolidating and optimizing open source Linux software and tools for the ARM architecture
    - Compilers based on gcc of course: Open Source
- Usually board supplier has a cross-compiler as part of the BSP, SDK or tool-chain.

```
./rpi-tools/tools/arm-bcm2708/gcc-linaro-arm-linux-
gnueabihf-raspbian/bin/arm-linux-gnueabihf-gcc -v
```

- Cut and paste the above (into a single line)

SYSROOT

- Sysroot is usually the "/" filesystem of your target device
- When cross-compiling you will not include nor link against libraries on the host system
- You might keep a version of sysroot on your host file system
- Sometimes you NFS mount sysroot - we do!
- In any case you must specify where sysroot is during compilation and linking
    - GCC has a -sysroot option that makes it easier to specify cross-compile libraries and header locations. Look it up!

What is Qt?

Development Framework

- C++ and QML/JS
- Cross-platform
- Write once,
  deploy everywhere

- Comprehensive Class Library
  - Over 800 classes
  - Qt Quick, Qt Widgets, Data I/O, XML, Canvas, OpenGL, Network, WebEngine,...
- Advanced development tools:
  - Rapid UI development
  - Internationalization
  - Documentation

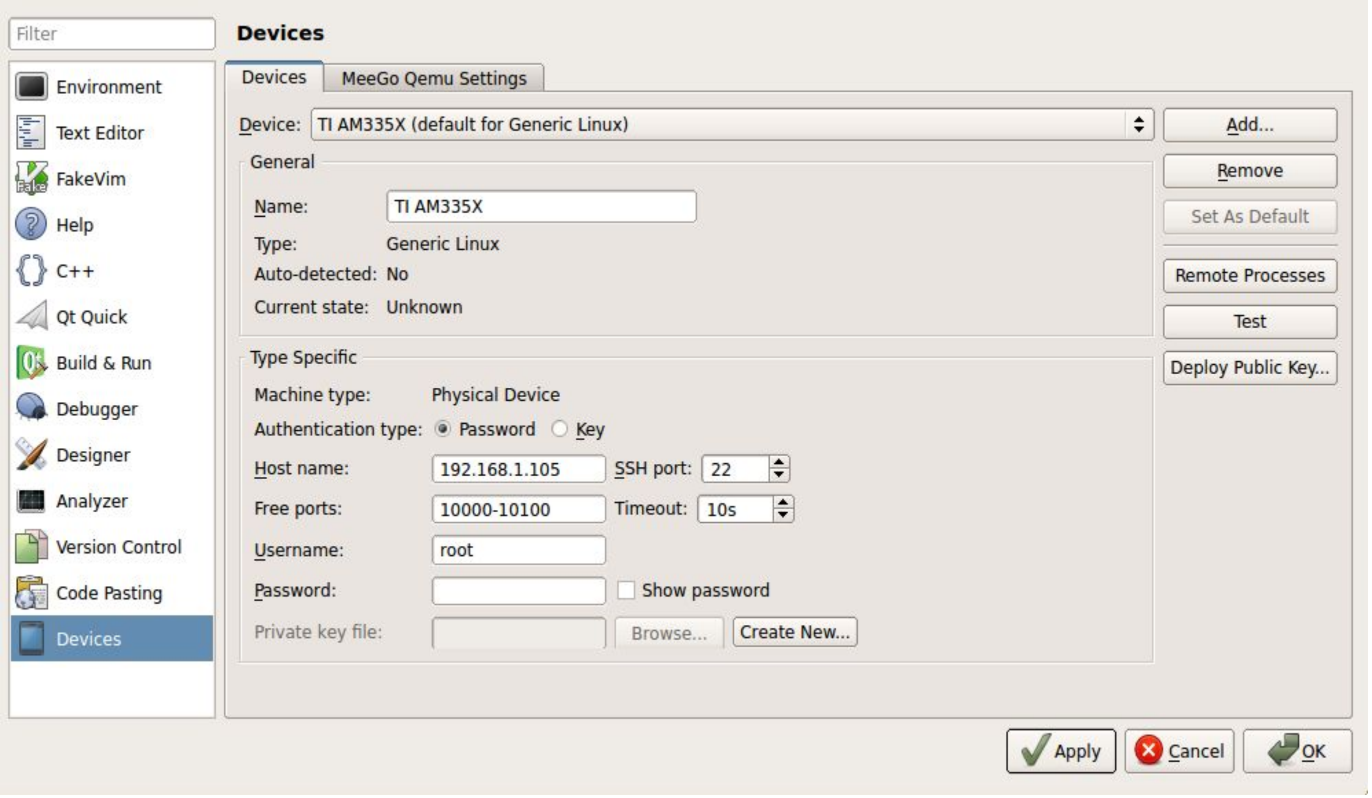
Qt Creator – The IDE for Qt

- Integrated Development Environment
  - Written in Qt/C++
  - Free, Open Source, Highly Configurable
- Ideal for Qt Development
  - Editor, Project Management, Build System Management, Debugging Front-End, Documentation and much more
  - User Interface for Qt Tools from qmake to assistant
  - Code completion, Code navigation, Follow symbol, Find usages
- Knows about Qt versions, Cross-Compilers, Sysroot, Devices etc..

Qt Creator – The IDE for Qt (cont.)

- Integrates with native compilers and tool-chains:
  - GNU gcc, gdb, make,
  - Microsoft Visual Studio Compilers
  - Apple LLVM
- Integrates common third party build systems
  - CMake, Automake
- Integrates common source control systems
  - Git, Mercurial, SVN, CVS, Perforce

Qt Creator: Add the Raspberry Pi Device



Devices

Device: TI AM335X (default for Generic Linux)

General

Name: TI AM335X

Type: Generic Linux

Auto-detected: No

Current state: Unknown

Type Specific

Machine type: Physical Device

Authentication type: ● Password ○ Key

Host name: 192.168.1.105 SSH port: 22

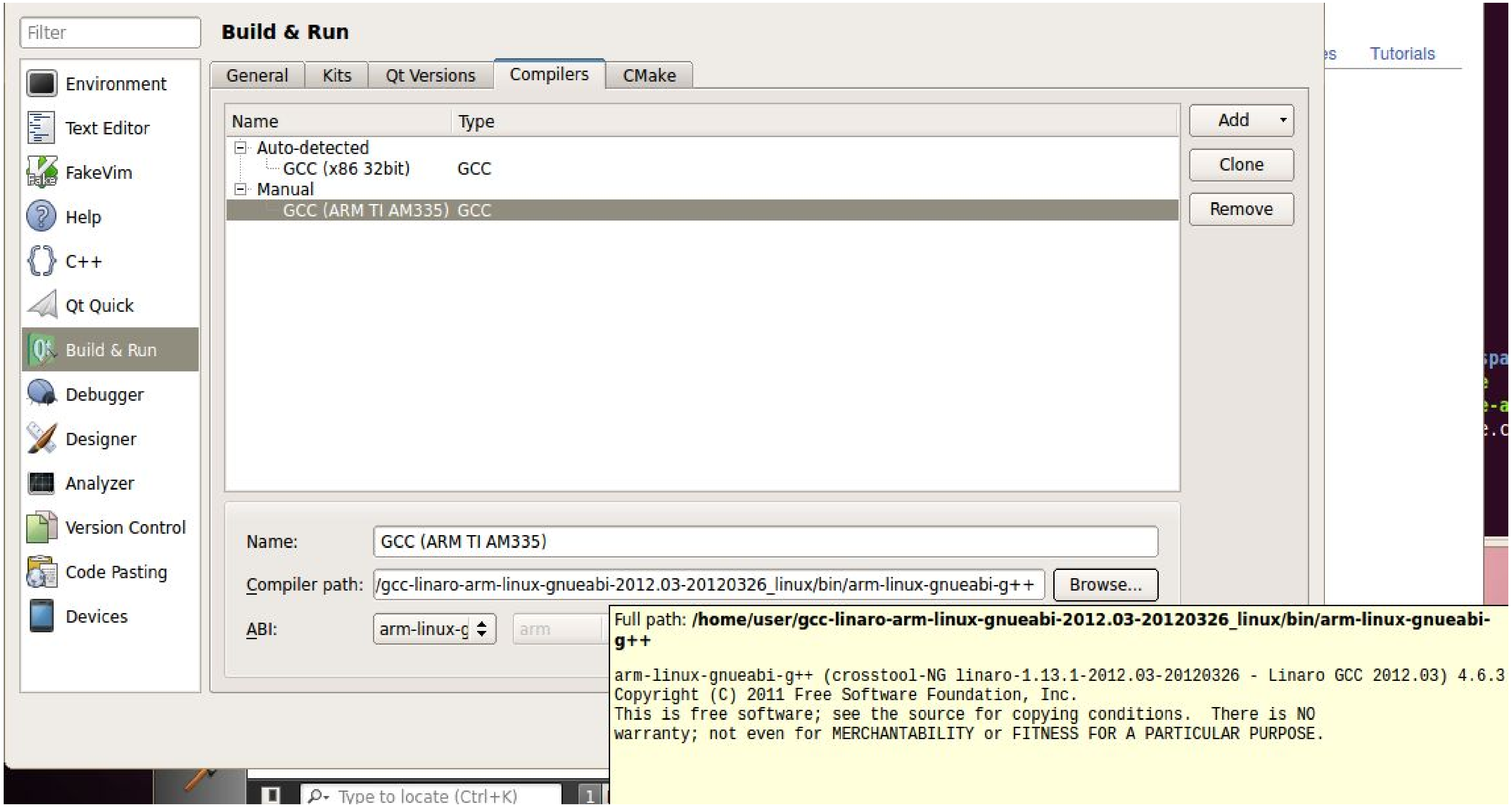
Free ports: 10000-10100 Timeout: 10s

Username: root

Password: □ Show password

Private key file:

Qt Creator: Add the Cross-Compiler



Name	Type
Auto-detected	
GCC (x86 32bit)	GCC
Manual	
GCC (ARM TI AM335)	GCC

Name: GCC (ARM TI AM335)

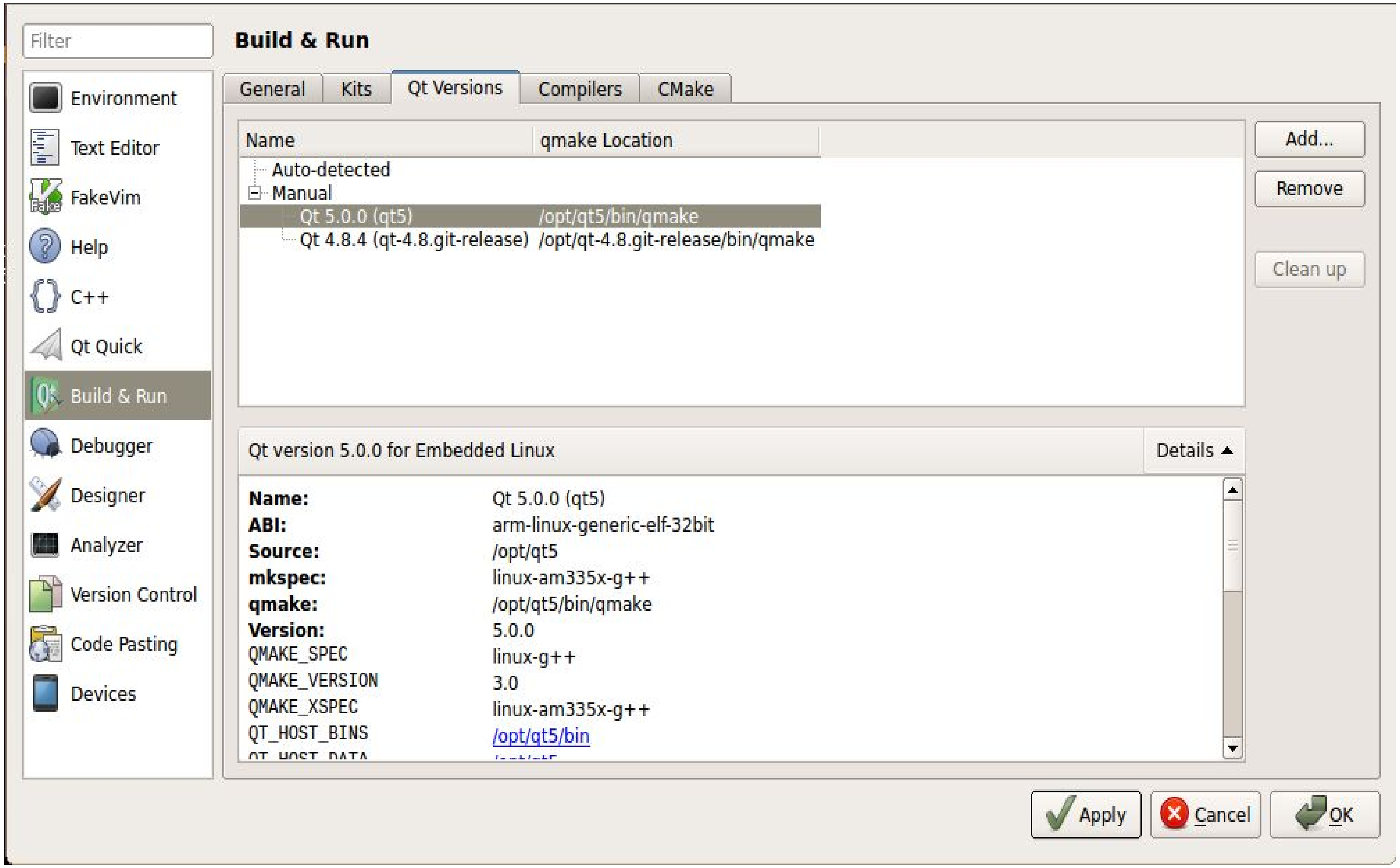
Compiler path: /gcc-linaro-arm-linux-gnueabi-2012.03-20120326_linux/bin/arm-linux-gnueabi-g++

ABI: arm-linux-g arm

Full path: **/home/user/gcc-linaro-arm-linux-gnueabi-2012.03-20120326_linux/bin/arm-linux-gnueabi-g++**

```
arm-linux-gnueabi-g++ (crosstool-NG linaro-1.13.1-2012.03-20120326 - Linaro GCC 2012.03) 4.6.3
Copyright (C) 2011 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

Qt Creator: Add a Qt Version

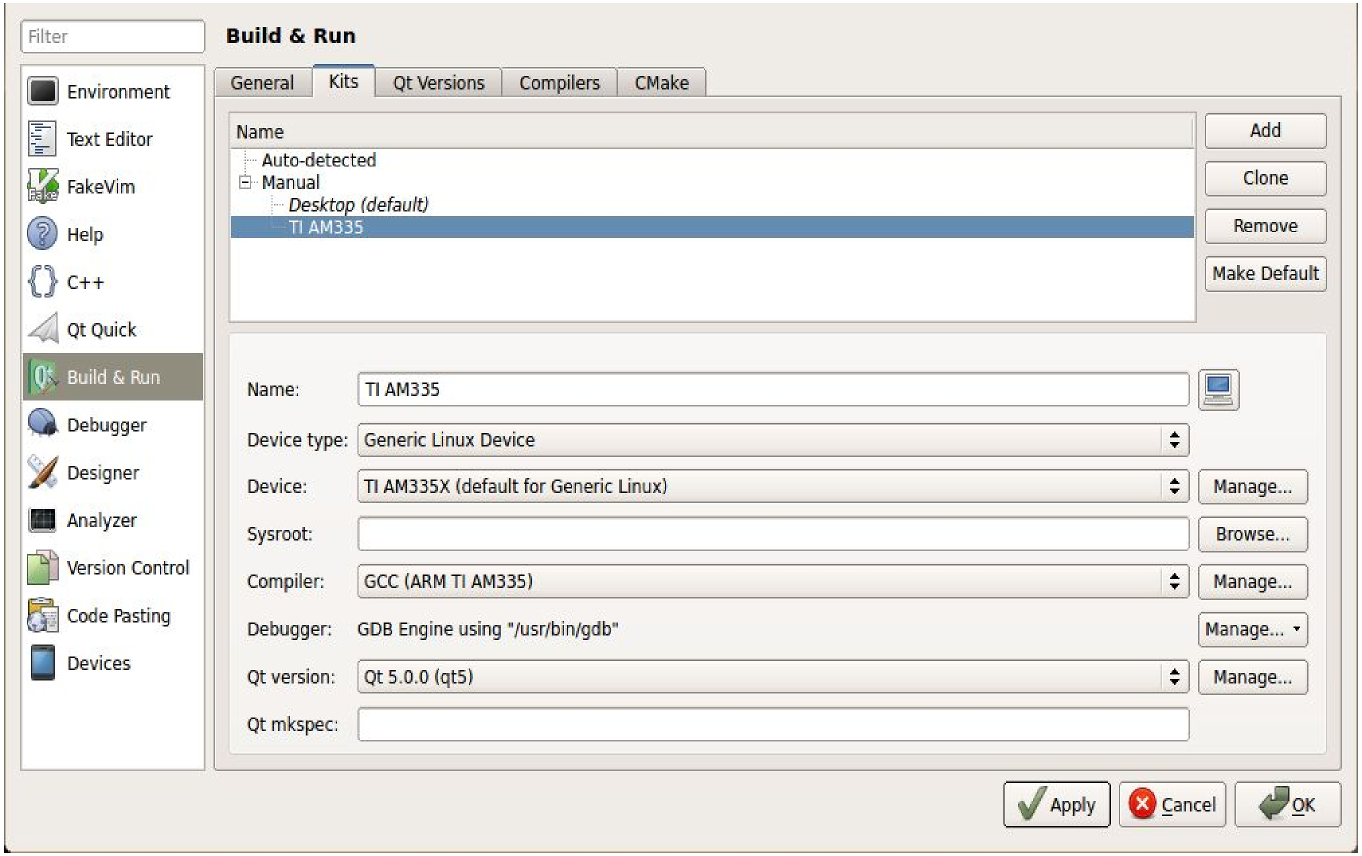


Name	qmake Location
Auto-detected	
Manual	
Qt 5.0.0 (qt5)	/opt/qt5/bin/qmake
Qt 4.8.4 (qt-4.8.git-release)	/opt/qt-4.8.git-release/bin/qmake

Qt version 5.0.0 for Embedded Linux

Name:	Qt 5.0.0 (qt5)
ABI:	arm-linux-generic-elf-32bit
Source:	/opt/qt5
mkspec:	linux-am335x-g++
qmake:	/opt/qt5/bin/qmake
Version:	5.0.0
QMAKE_SPEC	linux-g++
QMAKE_VERSION	3.0
QMAKE_XSPEC	linux-am335x-g++
QT_HOST_BINS	/opt/qt5/bin
QT_HOST_DATA	/opt/qt5

Qt Creator: Defining Kits



Build & Run

Name
- Auto-detected
- Manual
  - *Desktop (default)*
  - TI AM335

Name: TI AM335

Device type: Generic Linux Device

Device: TI AM335X (default for Generic Linux)

Sysroot:

Compiler: GCC (ARM TI AM335)

Debugger: GDB Engine using "/usr/bin/gdb"

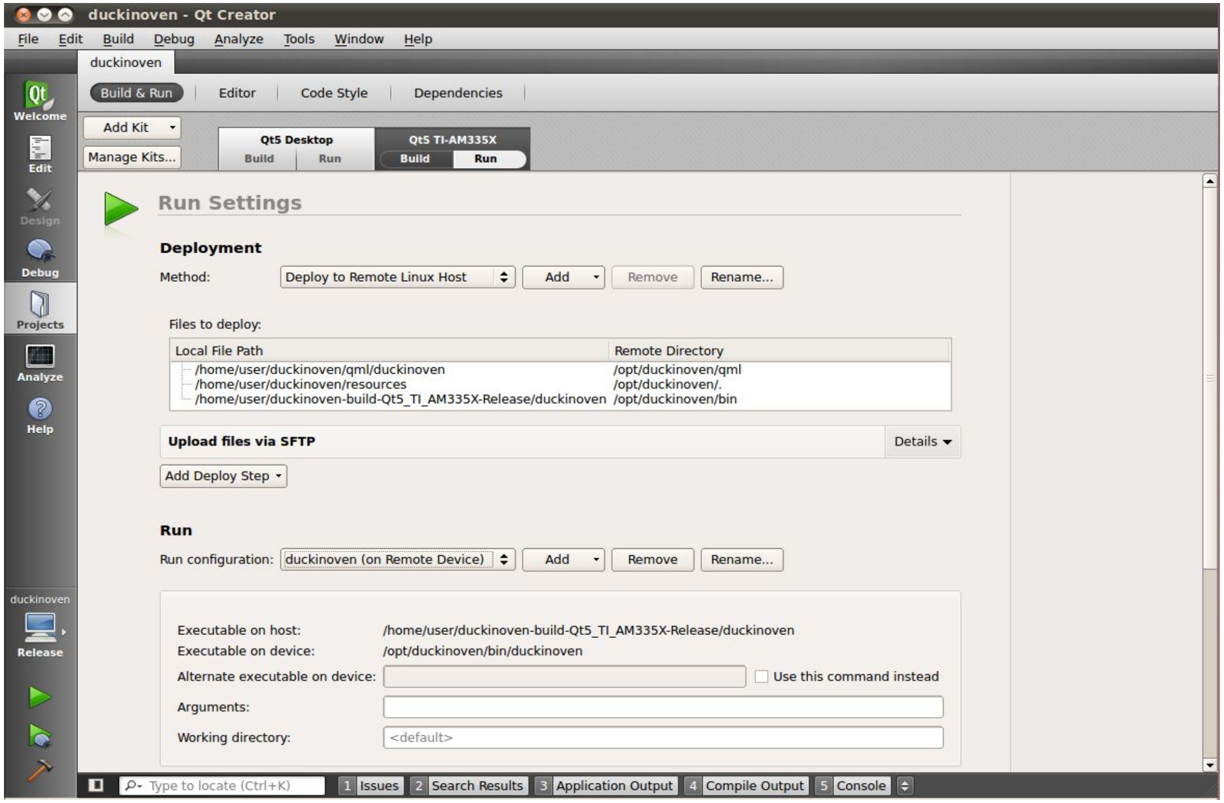
Qt version: Qt 5.0.0 (qt5)

Qt mkspec:

Qt Creator: Shadow Builds

- Qt Creator builds projects outside source
  - Useful when building for different targets or Qt versions
  - Avoids polluting source directory with temporaries
  - side-effect: your executable runs from a different location
  - Files accessed by relative path may not be found
- Workarounds
  - Use absolute paths or resources instead of relative paths
  - Un-check “use shadow build” in build settings
  - Set “working directory” from Run Settings
  - Environment variables can be set there too

Qt Creator: Project Settings



Run Settings

Deployment

Method: Deploy to Remote Linux Host   Add   Remove   Rename...

Files to deploy:

Local File Path	Remote Directory
/home/user/duckinoven/qml/duckinoven	/opt/duckinoven/qml
/home/user/duckinoven/resources	/opt/duckinoven/.
/home/user/duckinoven-build-Qt5_TI_AM335X-Release/duckinoven	/opt/duckinoven/bin

Upload files via SFTP   Details

Add Deploy Step

Run

Run configuration: duckinoven (on Remote Device)   Add   Remove   Rename...

Executable on host: /home/user/duckinoven-build-Qt5_TI_AM335X-Release/duckinoven

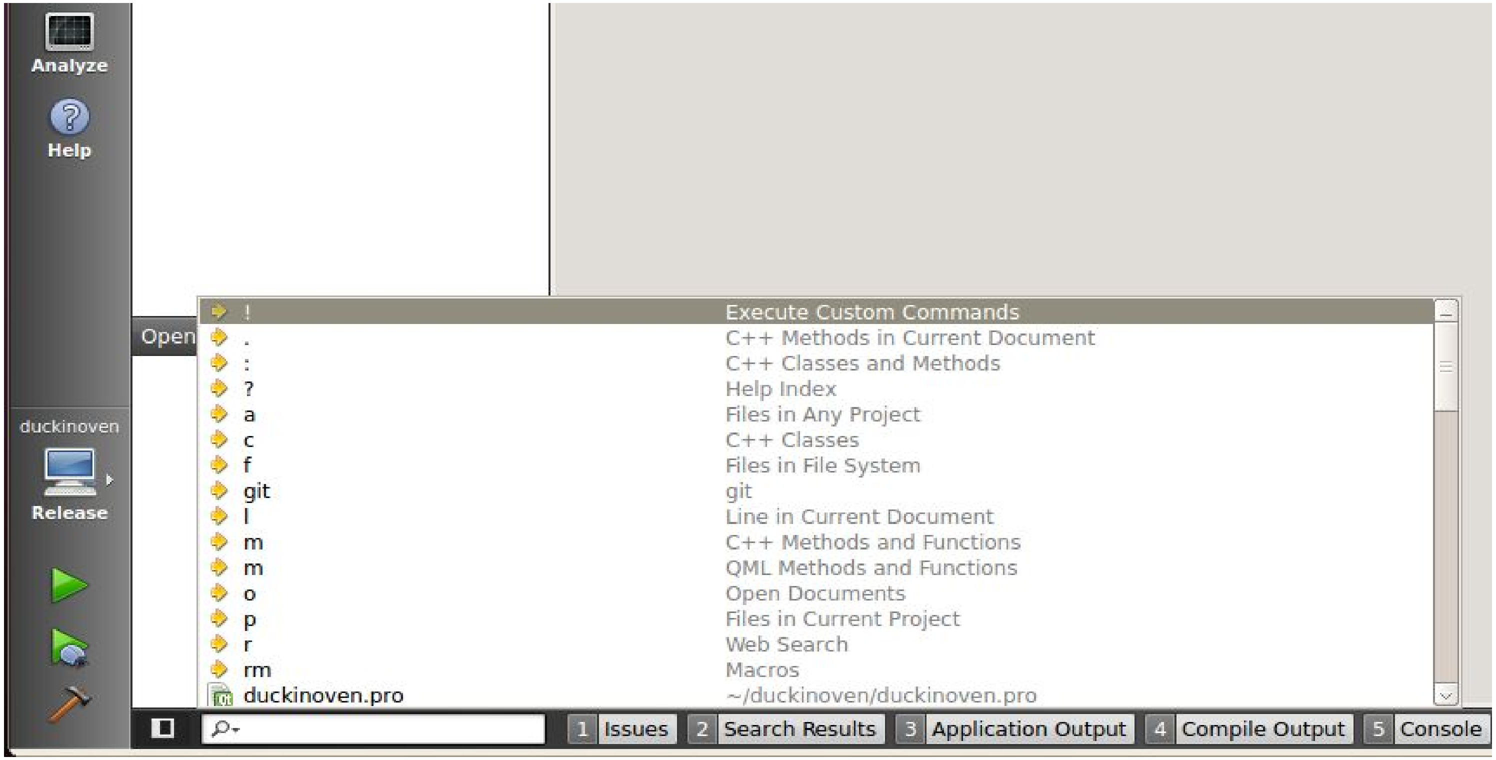
Executable on device: /opt/duckinoven/bin/duckinoven

Alternate executable on device: □ Use this command instead

Arguments:

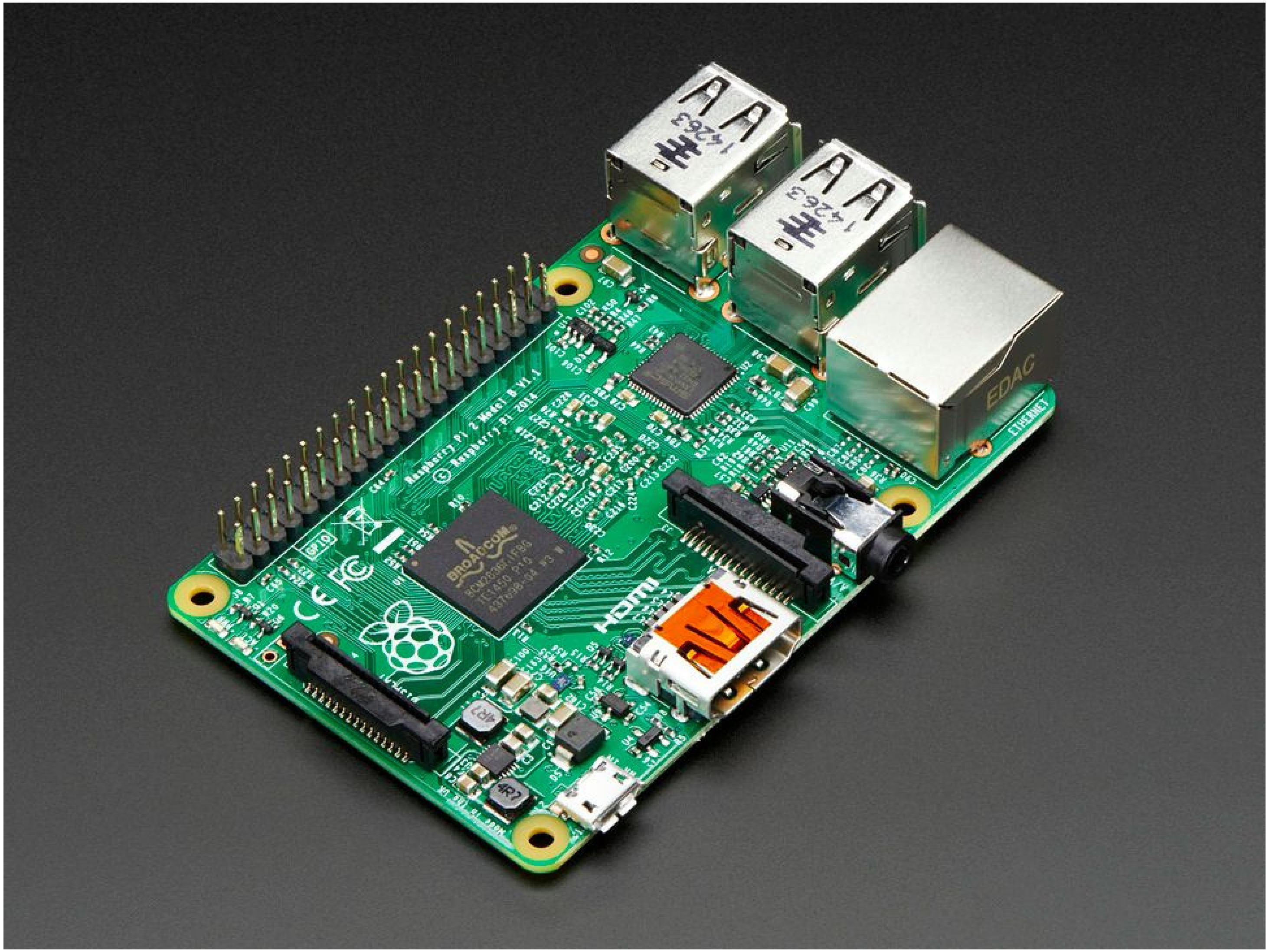
Working directory: <default>

Qt Creator: Locator



!	Execute Custom Commands
.	C++ Methods in Current Document
:	C++ Classes and Methods
?	Help Index
a	Files in Any Project
c	C++ Classes
f	Files in File System
git	git
l	Line in Current Document
m	C++ Methods and Functions
m	QML Methods and Functions
o	Open Documents
p	Files in Current Project
r	Web Search
rm	Macros
duckinoven.pro	~/duckinoven/duckinoven.pro

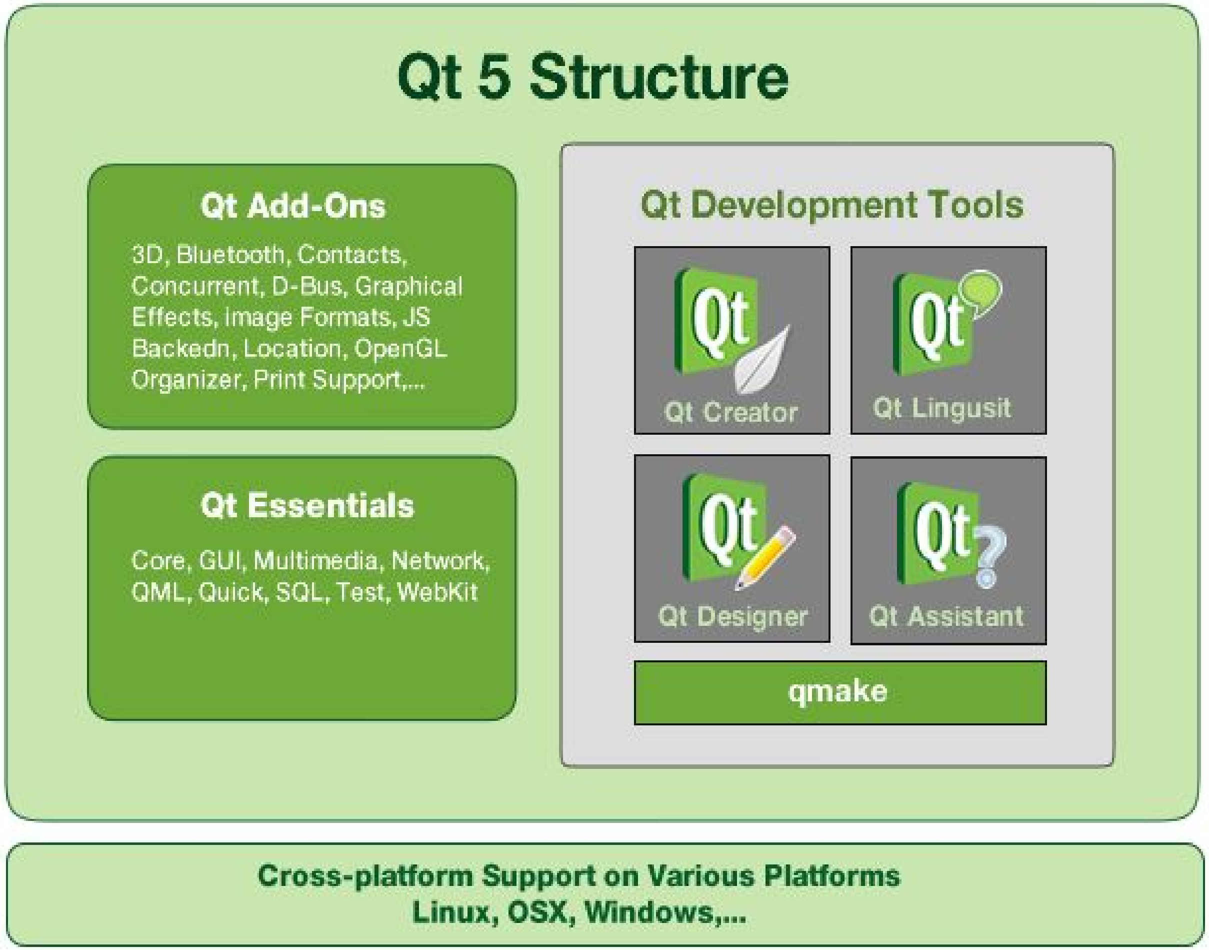
Lab: Hello World with Qt Creator



Module: Development for Device

- Qt 5 Architecture
- Qt Platform Abstraction
- Building Qt 5 for the target
- The Boot Process and How, When and Why you load your application
- Debugging

Qt 5 - Architecture



Qt 5 Structure

Qt Add-Ons

3D, Bluetooth, Contacts, Concurrent, D-Bus, Graphical Effects, Image Formats, JS Backedn, Location, OpenGL Organizer, Print Support,...

Qt Essentials

Core, GUI, Multimedia, Network, QML, Quick, SQL, Test, WebKit

Qt Development Tools

Cross-platform Support on Various Platforms
Linux, OSX, Windows,...

Single Surface Architecture with Qt 5

For eglfs plugins (and minimalegl) and also for QNX using screen:

- We are operating on a single surface. There is no real compositor
  - Consequences for your software architecture!
  - Since there is neither Window System nor Compositor provided Applications will operate in single window, single process mode.
- An alternative is to use a compositor that is able to handle multiple surfaces. e.g. Wayland is a protocol for a compositor to talk to its clients as well as a C library implementation of that protocol.
- QtWayland is an implementation of that

Debugging

- Pre-Historic debugging concepts:
  - printf, qDebug, console.log and other personal sharks
- Modern debugging concepts:
  - gdb is your friend (no really)
- Debugging on target
  - gdbserver started manually
  - With Qt Creator
- Debugging QML apps

Debugging the Old Fashioned Way

There is nothing wrong with the "print statement"

`printf(stdout,...), std::cout`

Just don't try it to untangle multi-threaded code and don't forget to flush.

Debugging the Old Fashioned Way

- In Qt programs it is called qDebug:

```
qDebug() << "Debug Statement" << myObject;
```

- Takes care of serializing Qt types
- Inserts spaces between operands
- Appends end of line (CR)
- qWarning() and qError()
- In QML it's called console.log()

gdb - the GNU Debugger

- Demo of gdb command line on the VM
- Demo of gdb within Qt Creator
- Remote debugging with gdb:
  - gdbserver started on the target
  - Listening on <comm>

```
gdbserver <comm> <program> [arg1[arg2[...argN]]]
```

  - <comm> can be device name (e.g. /dev/com1)
  - Or TCP hostname and port number (e.g. localhost:110264)
  - Remote program can be stripped of dbg symbols

gdb - the GNU Debugger

Remote debugging with gdb:

- On host start gdb with program name
- Listening on <comm>

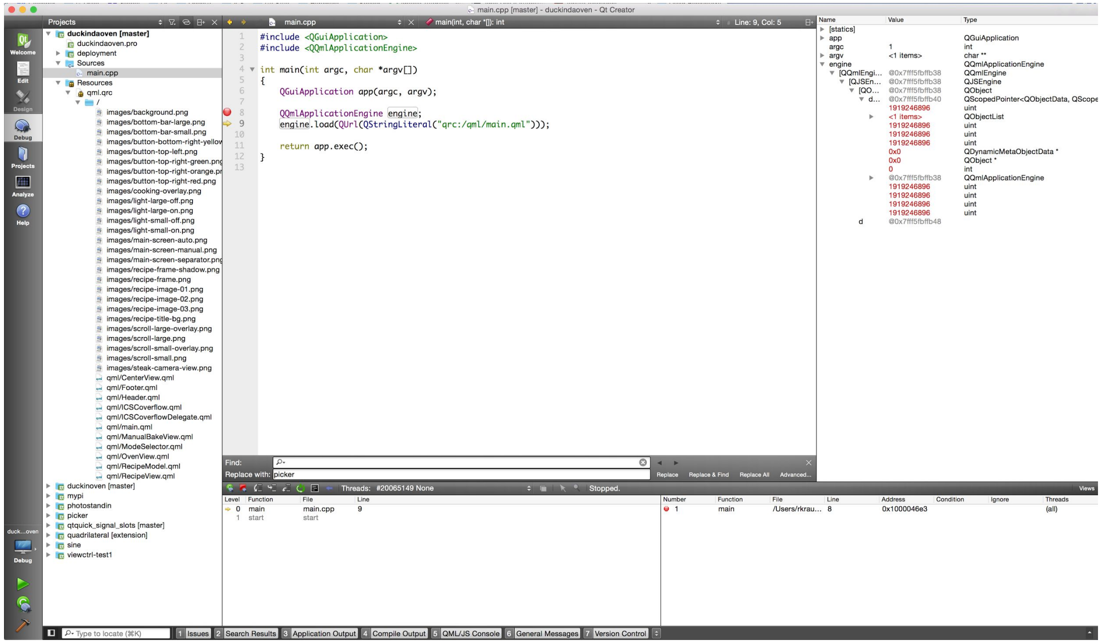
```
gdb <program>
target remote <comm>
```

- <comm> is the device name (e.g. target-ip:110264)
- Local program needs to be unstripped copy of your program, since GDB needs symbols and debugging information

```
break, cont, next, ...
```

Remote Debugging with Qt Creator

Need to make sure you have the correct debugger executable from your tool-chain



```
duckindaoven [master]
    duckindaoven.pro
    deployment
    Sources
        main.cpp
    Resources
        qml.qrc
            /
                images/background.png
                images/bottom-bar-large.png
                images/bottom-bar-small.png
                images/button-bottom-right-yellow
                images/button-top-left.png
                images/button-top-right-green.png
                images/button-top-right-orange.pn
                images/button-top-right-red.png
                images/cooking-overlay.png
                images/light-large-off.png
                images/light-large-on.png
                images/light-small-off.png
                images/light-small-on.png
                images/main-screen-auto.png
                images/main-screen-manual.png
                images/main-screen-separator.png
                images/recipe-frame-shadow.png
                images/recipe-frame.png
                images/recipe-image-01.png
                images/recipe-image-02.png
                images/recipe-image-03.png
                images/recipe-title-bg.png
                images/scroll-large-overlay.png
                images/scroll-large.png
                images/scroll-small-overlay.png
                images/scroll-small.png
                images/steak-camera-view.png
                qml/CenterView.qml
                qml/Footer.qml
                qml/Header.qml
                qml/ICSCoverflow.qml
                qml/ICSCoverflowDelegate.qml
                qml/main.qml
                qml/ManualBakeView.qml
                qml/ModeSelector.qml
                qml/OvenView.qml
                qml/RecipeModel.qml
                qml/RecipeView.qml
duckinoven [master]
mypi
photostandin
picker
qtquick_signal_slots [master]
quadrilateral [extension]
sine
viewctrl-test1
```

```cpp
#include <QGuiApplication>
#include <QQmlApplicationEngine>

int main(int argc, char *argv[])
{
    QGuiApplication app(argc, argv);

    QQmlApplicationEngine engine;
    engine.load(QUrl(QStringLiteral("qrc:/qml/main.qml")));

    return app.exec();
}
```

```
Name              Value              Type
[statics]
app                                  QGuiApplication
argc              1                  int
argv              <1 items>          char **
engine                               QQmlApplicationEngine
  [QQmlEngi...    @0x7fff5fbffb38    QQmlEngine
    [QJSEn...     @0x7fff5fbffb38    QJSEngine
      [QO...      @0x7fff5fbffb38    QObject
        d...      @0x7fff5fbffb40    QScopedPointer<QObjectData, QScope
                  1919246896         uint
                  <1 items>          QObjectList
                  1919246896         uint
                  1919246896         uint
                  1919246896         uint
                  0x0                QDynamicMetaObjectData *
                  0x0                QObject *
                  0                  int
                  @0x7fff5fbffb38    QQmlApplicationEngine
                  1919246896         uint
                  1919246896         uint
                  1919246896         uint
                  1919246896         uint
      d           @0x7fff5fbffb48
```

Find:
Replace with: picker

Threads: #20065149 None   Stopped.

Level	Function	File	Line
0	main	main.cpp	9
1	start	start	

Number	Function	File	Line	Address	Condition	Ignore	Threads
1	main	/Users/rkrau...	8	0x1000046e3			(all)

Basic Elements of Modern Qt Applications

- QtQuick:
  - QML, Elements, Rectangles and Images, Properties, Bindings, Anchors, Rows and Columns, Objects
- QCore:
  - Strings, Containers
- QtQuick:
  - States, Transitions and Animations
- C++ QObjects
  - QObjects, Properties, Signals and Slots

Rewinding the Lab

This will rewind the lab to an initial state:

```
cd ~/Desktop/gdp/amm-examples/amm-handson-lab
forward-to.sh 0
```

To get to the solution of part 1 for example:

```
forward-to.sh 1
```

To get to the end result of the lab exercise type:

```
forward-to.sh
```

Hands-on Lab - Part 1

Begin by opening amm-handson-lab in QtCreator:

```
#include <QGuiApplication>
#include <QQuickView>

int main(int argc, char *argv[])
{
   QGuiApplication app(argc, argv);

   QQuickView mainView;
   mainView.setSource(QUrl("../amm-handson-lab/main.qml"));
   mainView.show();

   return app.exec();
}
```

Hands-on Lab - Part 1

- We begin working in main.qml
- Create a Rectangle, Add Text
  - Let’s call this a “WorkSpace” assign the id: workSpace
- Create a second Rectangle underneath, Add Text
- Make the second Rectangle into a Button by adding a MouseArea
- Implement:
  - onClicked: output to console
  - onPressed; change the main workspace text color to “white”
  - onReleased: revert the change to workspace text color back
- Add a “Board Kit”, Deploy! - Enjoy!

Lab: Deployment Hints

Genivi Demo Platform uses Wayland and a custom Wayland Shell as well as IVI Layer Management Extension

```
    setenv("QT_QPA_PLATFORM","wayland",1);
```

We like our applications to run “full screen” without Window Decoration

```
    setenv("QT_WAYLAND_DISABLE_WINDOWDECORATION","1",1);
```

In order for GDP IVI Layer Management to recognize our layer we will “borrow” a well known “Surface ID”

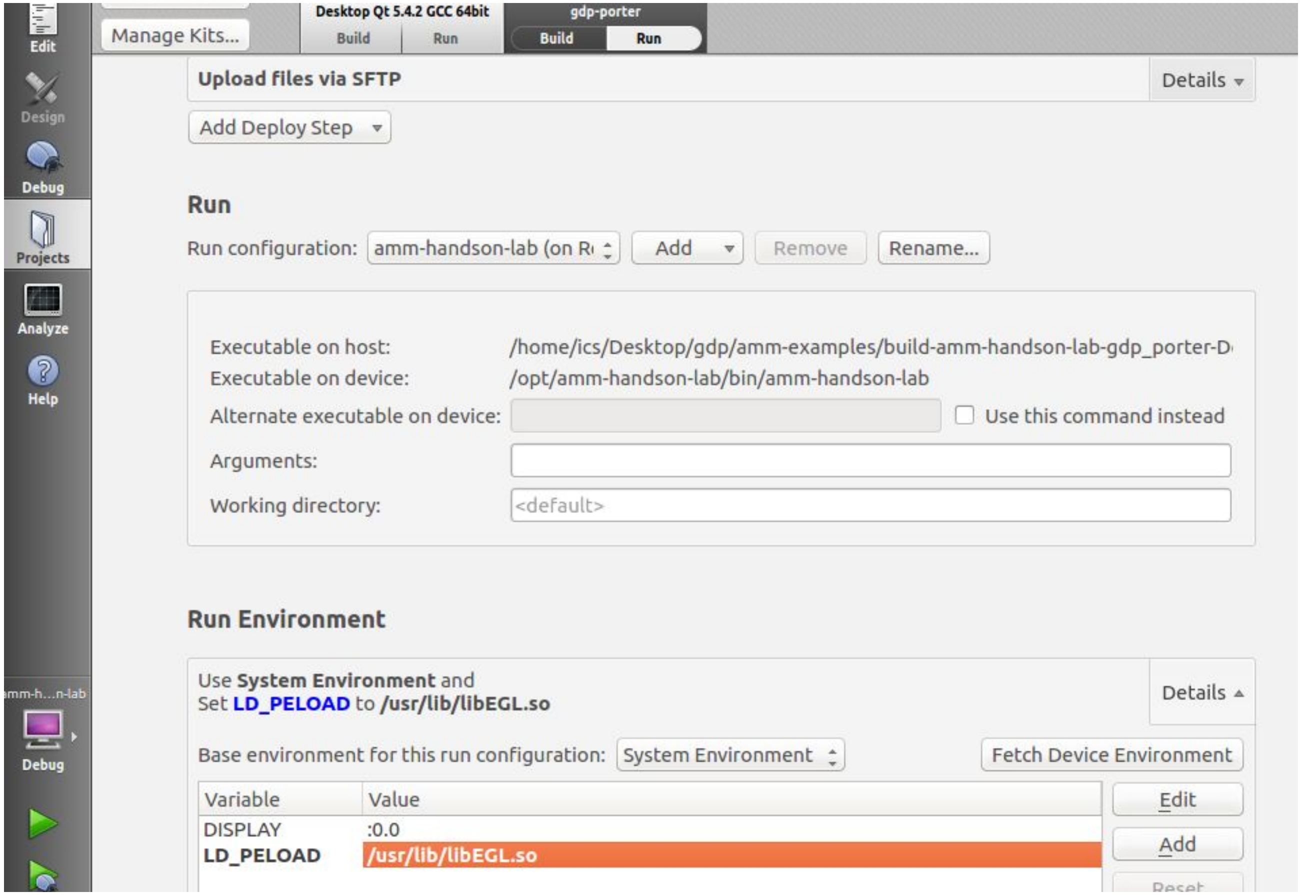
```
#define LAB_SURFACE_ID 3

    mainView.setProperty("IVI-Surface-ID",LAB_SURFACE_ID);
```

This has to be done before the window is “shown”

Running on Renesas Porter

Need to add the environement variable:

`LD_PRELOAD /usr/lib/libEGL.so`



Upload files via SFTP

Run

Run configuration: amm-handson-lab (on R

Executable on host: /home/ics/Desktop/gdp/amm-examples/build-amm-handson-lab-gdp_porter-D

Executable on device: /opt/amm-handson-lab/bin/amm-handson-lab

Alternate executable on device: ☐ Use this command instead

Arguments:

Working directory: <default>

Run Environment

Use **System Environment** and
Set **LD_PELOAD** to **/usr/lib/libEGL.so**

Base environment for this run configuration: System Environment

Variable	Value
DISPLAY	:0.0
LD_PELOAD	**/usr/lib/libEGL.so**

Lab: How to Deploy QML

In order to deploy extra files add this to .pro:

```
ExtraQml.files += main.qml
ExtraQml.path = /opt/${{TARGET}
INSTALLS += ExtraQml
```

And in main.cpp load the qml file with an absolute path.

This will become a lot easier when we use resource files.

ICS GDP Image

- Has a few extra packages (QtMultiMedia, etc.)
- Has a LayerManagerControl script (lmc.sh) that can be used to put non-registered surfaces “on top”
- Use systemctl to stop qml-example before deploying and running

```
   systemctl --user stop qml-example
```

- To permanently disable it:

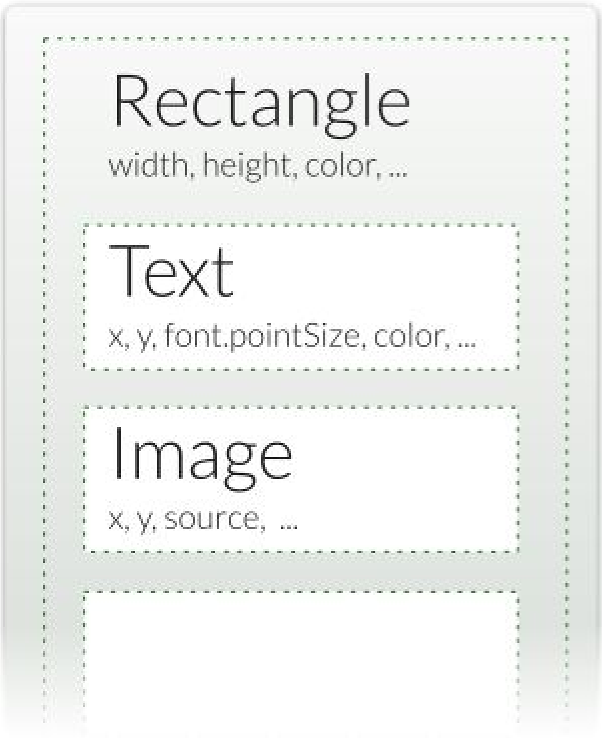
```
mv \
/usr/lib/systemd/user/qml-example.service \
~/usr-lib-systemd-user
```

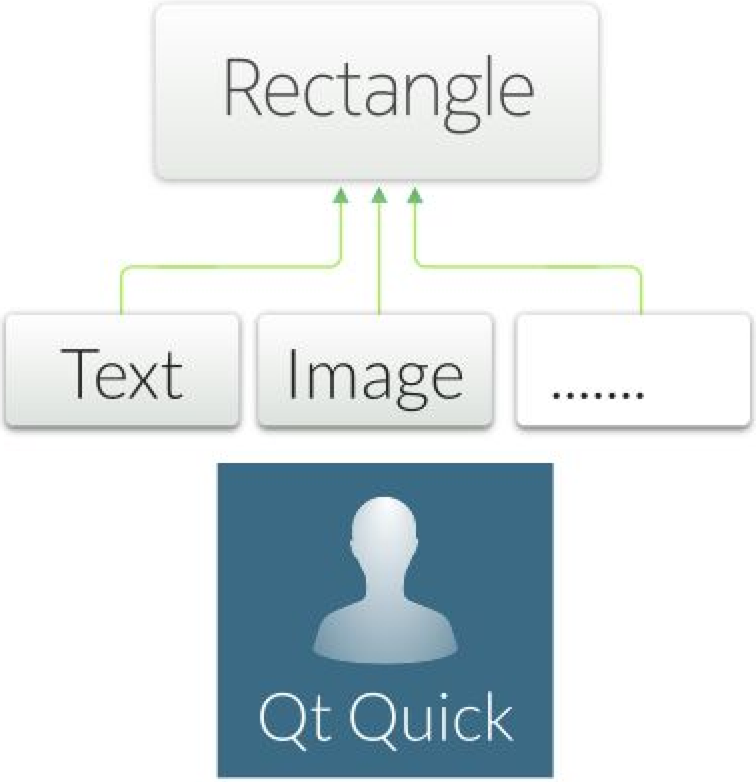
What is QML?

Declarative language for User Interface structure

- Describes the user interface
  - What items look like
  - How items behave
- UI specified as tree of QML structures with properties
  - Elements and identities
  - Properties and property binding

A Tree of QML Structures





QML Types

- Item is the base type for Visible QML objects
  - Has a position, dimensions
  - Usually used to group other visual Items
  - Often used as the top-level Item
  - Rectangle, Text, TextInput, ...
- Non-visual structures also exist:
  - State, Transition, ...
  - ListModel, ListElement, Path, ...
  - Gradient, Timer, ...
- QQuickItem extends QObject and thus, has properties
  - QML Objects can be extended with custom properties from C++ or QML

Properties

Objects are described by properties

- Simple name-value definitions
  - width, height, color, ...
  - With default values
  - Each has a well-defined type
  - Separated by semicolons or line breaks
- Used for
  - Customizing their appearance
  - Changing their behavior

Property Examples

- **Standard properties** can be given values:

```
Text {
    text: "Hello world"
    height: 50
}
```

- **Grouped properties** keep related properties together

```
Text {
    font.family: "Helvetica"
    font.pixelSize: 24
}
```

Identifying QML structures

The `id` defines an identity of a QML structure

- Lets other QML structures refer to it
  - For relative alignment and positioning
  - To access or modify an Item's properties
  - To re-use common structures (e.g., gradients, images)
- Used to *create relationships* between structures
- `id` is not a property
  - Not stored in the `QObject` with other properties
  - More like a "label"
  - A single `Item` can have different identities in other files/scopes.
- `parent` is a special `id` referring to the relative parent structure

Attached and Custom Properties

- **Attached properties** are applied to QML structures

```
TextInput {
    text: "Hello world"
    KeyNavigation.tab: nextInput
}
```

  - `KeyNavigation.tab` is not a standard property of `TextInput`
  - Is a standard property that is attached to Items

- **Custom properties** can be added to any QML type

```
Rectangle {
    property real mass: 100.0
}
Circle {
    property real radius: 50.0
}
```

Binding Properties

```
import QtQuick 2.0

Item {

    width: 400; height: 200

    Rectangle {

        x: 100; y: 50
        width: height * 2; height: 100

        color: "lightblue"

    }
}
```

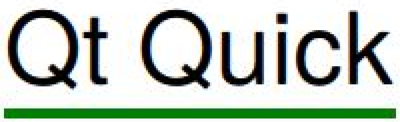
Demo qml-intro/ex-concepts/expressions.qml

- Properties can contain expressions
  - See above: `width` is twice the `height`
- Not just initial assignments
- Expressions are re-evaluated when needed

See Property Binding Documentation

Using Identities

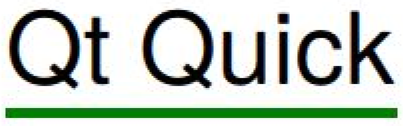
```
import QtQuick 2.0

Item {
    width: 300; height: 115

    Text {
        id: title
        x: 50; y: 25
        text: "Qt Quick"
        font.family: "Helvetica"
        font.pixelSize: 50
    }

    Rectangle {
        x: 50; y: 95; height: 5
        width: title.width
        color: "green"
    }
}
```



Qt Quick

Using Identities

```
Text {
    id: title
    x: 50; y: 25
    text: "Qt Quick"
    font.family: "Helvetica"
    font.pixelSize: 50
}

Rectangle {
    x: 50; y: 95; height: 5
    width: title.width
    color: "green"
}
```



Qt Quick

- `Text` item has the identity, `title`
- `width` of `Rectangle` bound to `width` of `title`
- Try using `TextInput` instead of `Text`

Lab: Part 2

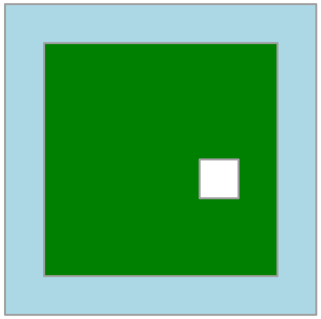
- Move the button into its own *Component* ”Button_1.qml”
  - Create a Component Button_1.qml, move the button code
  - Note that “naively” moving the code into a file does not give us the same functionality
  - Name the button with an id to fix the size issues
- Create a second Button: button2, put buttons in a *Row*
  - Try to get the buttons evenly spaced.
- The button refers to `workspaceText` property directly
  - If the button is to be re-used, then this needs to be fixed
  - Introduce “signals” for pressed, released, clicked
  - Using these signals now have the left button set the text color “white” and the right button set the text color “yellow”
- Add an image if the Genivi Logo to the workspace in the top right corner
  - Deploy the application again: Where is the image?
  - Add a resource file, add the image as a resource and deploy again

Module: Composing User Interfaces

- Nested Elements
- Graphical Types
- Text Items
- Anchor Layout

Nested Elements

```
import QtQuick 2.0
Rectangle {
    width: 400; height: 400
    color: "lightblue"

    Rectangle {
        x: 50; y: 50; width: 300; height: 300
        color: "green"

        Rectangle {
            x: 200; y: 150; width: 50; height: 50
            color: "white"

        }

    }

}
```



- Each Item is positioned relative to its parents

Demo qml-composing-uis/ex-elements/nested2.qml

Module: Composing User Interfaces

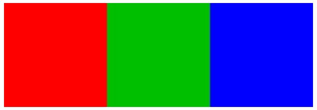
- Nested Elements
- Graphical Types
- Text Items
- Anchor Layout

Colors

- Specifying colors
  - Named colors (using SVG names): `"red"`, `"green"`, `"blue"`, …
  - HTML style color components: `"#ff0000"`, `"#008000"`, `"#0000ff"`, …
  - Built-in function: `Qt.rgba(0,0.5,0,1)`
- Changing items opacity:
  - Using the `opacity` property
  - Values from `0.0` (transparent) to `1.0` (opaque)

See QML basic Type: color Documentation

Colors



```
import QtQuick 2.0

Item {
  width: 300; height: 100

  Rectangle {
    x: 0; y: 0; width: 100; height: 100; color: "#ff0000"
  }
  Rectangle {
    x: 100; y: 0; width: 100; height: 100
    color: Qt.rgba(0, 0.75, 0, 1)

  }
  Rectangle {
    x: 200; y: 0; width: 100; height: 100; color: "blue"
  }
}
```

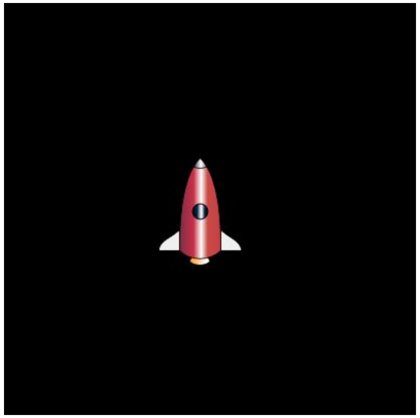
Demo qml-composing-uis/ex-elements/colors.qml

Images

- Represented by the `Image` class
- Refer to image files with the `source` property
  - Using absolute URLs
  - Or relative to the QML file
- Can be transformed
  - Scaled, rotated
  - About an axis or central point

Images

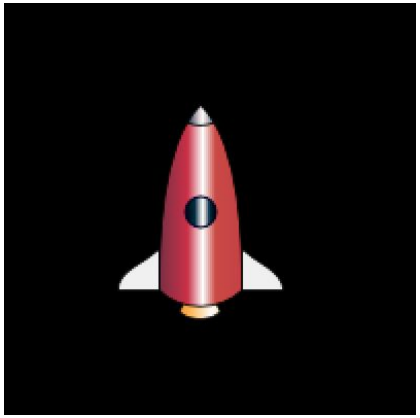
```
import QtQuick 2.0

Rectangle {

    width: 400; height: 400
    color: "black"

    Image {
        x: 150; y: 150
        source: "../images/rocket.png"
    }
}
```



- `source` contains a relative path
- `width` and `height` are obtained from the image file

Image Scaling

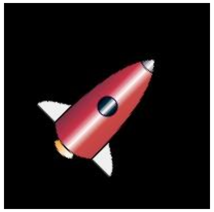
```
import QtQuick 2.0

Rectangle {

    width: 400; height: 400
    color: "black"

    Image {
        x: 150; y: 150
        source: "../images/rocket.png"
        scale: 2.0

    }
}
```



- Set the `scale` property
- By default, the center of the item remains in the same place

Image Rotation

```
import QtQuick 2.0

Rectangle {

    width: 200; height: 200

    color: "black"

    Image {

        x: 50; y: 35
        source: "../images/rocket.png" rotation: 45.0

    }

}
```

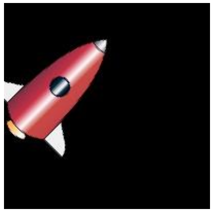


- Set the `rotate` property
- By default, the center of the item remains in the same place

Demo qml-composing-uis/ex-elements/image-rotation.qml

Image Rotation

```
import QtQuick 2.0

Rectangle {

    width: 200; height: 200
    color: "black"

    Image {
        x: 50; y: 35
        source: "../images/rocket.png"
        rotation: 45.0

        transformOrigin: Item.Top
    }
}
```



- Set the `transformOrigin` property
- Now the image rotates about the top of the item

Lab: Part 3

Begin with the solution to Part 2

- Create a Component: WorkspaceContent
  - It should contain an Image that fills it out
  - Create a property alias for the image source!
- Swap the current content of the workspace (but not the workspace itself) for this component, load image “genivi_screenshot.png”
  - Create two additional WorkSpaceContent elements with images: “gdp_block_diagram.png” and “mm-screen.png”
- Observe that only the third one is now visible:
  - Set `content1` visible instead
  - Two other ways to determine what is *visible* on the screen: Opacity, Position, try them both
- Replace your own button box with the one from file buttonBox_qml.txt

Property Aliases

```
// AliasLineEdit.qml  Rectangle {
    ...
    TextInput {
        id: text_input
        ...
        text: "Enter text..."
        ...
    }
    property alias text: text_input.text
}
```

- Custom `text` property *aliases* `text_input.text`
- Setting the custom property
  - Changes the `TextInput`'s `text`
- Custom property acts like a proxy

Demo qml-modules-components/ex-modules-components/alias-property/AliasLineEdit.qml

Lab: Part 4

Create 3 States such as:

```
        State {
            name: "content1Active"
            PropertyChanges {
                target: content1; visible:true
            }
        },
```

Set the default state to be content1Active

Change the current state of the root object when a button is clicked such as:

```
            onButtonClicked: {root.state = "content2Active"}
```

Test this with changes to opacity and x position instead of visbility

Lab: Part 5

- When changing the opacity - what happens when a new state is set?
  - The affected other properties return to their default values
- Implement a simple Animation on opacity:

  In WorkspaceContent:

```
Behavior on opacity {
    PropertyAnimation {
        duration: 1000
    }
}
```

This can also be accomplished with a *Transition* and corresponding PropertyAnimation

Lab: Part 5 continued

Note that even though the WorkspaceContent is moved out of the Workspace it is still active.

- Need to set “visible” to false.
  - How can we accomplish this?
- The solution is to run a *ScriptAction* at the beginning and end of the Animation:

```
Behavior on opacity {
    SequentialAnimation {
        ScriptAction {
            script: {
                if (opacity===0.0) visible=true;
            }
        }
        PropertyAnimation {
            duration: 1000
        }
 // ...
```

Module: States and Transitions

- States
- State Conditions
- Transitions

States

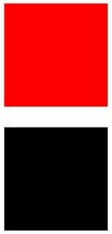
States manage named items

- Represented by the `State` class
- Each item can define a set of states
  - With the `states` property
  - Current state is set with the `state` property
- Properties are set when a state is entered
- Can also
  - Modify anchors
  - Change the parents of items
  - Run scripts

See QML States Documentation

States Example

```
import QtQuick 2.0

Rectangle {
  width: 150; height: 250

  Rectangle {
      id: stop_light
      x: 25; y: 15; width: 100; height: 100
  }
  Rectangle {
      id: go_light
      x: 25; y: 135; width: 100; height: 100
  }
  ...
```



- Prepare each item with an `id`
- Set up properties not modified by states

Defining States

```
states: [ State {

    name: "stop"
    PropertyChanges { target: stop_light; color: "red" }
    PropertyChanges { target: go_light; color: "black" }

  },
  State { name: "go"
    PropertyChanges { target: stop_light; color: "black" }
    PropertyChanges { target: go_light; color: "green" }
  }

]
```

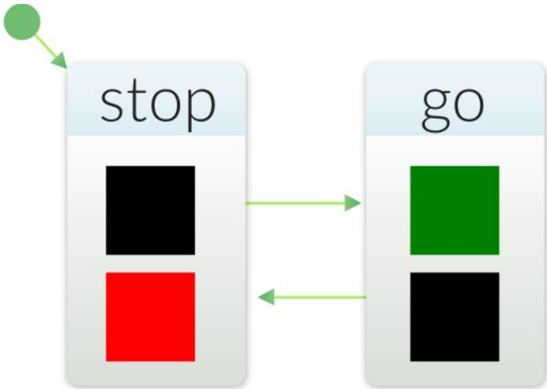
- Define states with names: `"stop"` and `"go"`
- Set up properties for each state with `PropertyChanges`
  - Defining differences from the default values

Demo qml-states-transitions/ex-states/states.qml

Setting the State

Define an initial state:

```
state: "stop"
```



Use a `MouseArea` to switch between states:

```
MouseArea {
     anchors.fill: parent
     onClicked: parent.state == "stop" ? parent.state =
        "go" : parent.state = "stop"

}
```

- Reacts to a click on the user interface
    - Toggles the parent's `state` property
    - Between `"stop"` and `"go"` states

Changing Properties

States change properties with the `PropertyChanges` class:

```
State {
  name: "go"
  PropertyChanges { target: stop_light; color: "black" }
  PropertyChanges { target: go_light; color: "green" }
}
```

- Acts on a target structure named using the `target` property
  - The `target` refers to an `id`
- Applies the other property definitions to the target structure
  - One `PropertyChanges` class can redefine multiple properties
- Property definitions are evaluated when the state is entered
- `PropertyChanges` describes new property values for an item
  - New values are assigned to items when the state is entered
  - *Properties left unspecified are assigned their default values*

Lab: Part 6

Next we want to add a C++ backend that will get notified by events on the UI and also will update the UI with data.

Create a class MainController, with two properties for the UI state and the value of a “Slider”

```
class MainController : public QObject
{
   Q_OBJECT
public:
   Q_PROPERTY(QString uiState READ uiState
          WRITE setUiState NOTIFY uiStateChanged)
   Q_PROPERTY(int sliderValue READ sliderValue
          WRITE setSliderValue  NOTIFY sliderValueChanged)
```

Lab: Part 6 continued

To export the “Properties” of a `QObject` into the *Context* of a QtQuick Presentation

```
MainController * mc = new MainController;
QQuickView mainView;
QQmlEngine * engine = mainView.engine();
QQmlContext * ctxt = engine->rootContext();
ctxt->setContextProperty("controller",mc);
mainView.setSource(QUrl(QStringLiteral("qrc:/main.qml")));
```

We grab the view’s engine root context and set a context property named “controller”. In our MainComponent.qml:

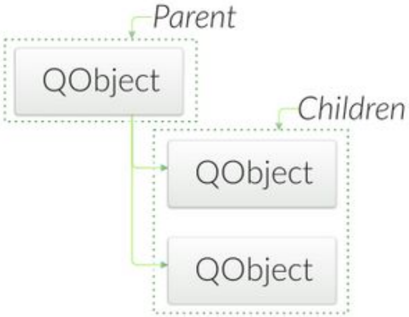
```
state: controller.uiState
onStateChanged: controller.uiState=state
```

Qt's C++ Object Model - `QObject`

- `QObject` is the heart of Qt's object model
- Include these features:
  - Memory management
  - Object properties
  - Introspection
  - Signals and Slots
  - Event handling
- `QObject` has no visual representation

Object Trees

- QObjects organize themselves in object trees
    - Based on parent-child relationship
- `QObject(QObject *parent = 0)`
    - Parent adds object to list of children
    - Parent owns children
- Construction/Destruction
    - Trees can be constructed in any order
    - Trees can be destroyed in any order
        - If object has a parent: object is first removed from the parent
        - If object has children: deletes each child first
        - No object is deleted twice



Note: Parent-child relationship is NOT inheritance

Q_OBJECT - flag for MOC

- Meta Object Compiler (MOC)
- **Q_OBJECT**
  - Enhances **QObject** with **QMetaObject** information
  - Required for **Q_PROPERTY**, **QObject**::metaObject(), qobject_cast, etc.
  - Required for signals, slots, and **QMetaObject**::**invokeMethod()**
- **moc** creates generates the **QMetaObject** code for each **Q_OBJECT**

```
moc -o moc_myclass.cpp myclass.h
c++ -c myclass.cpp; c++ -c moc_myclass.cpp
c++ -o myapp moc_myclass.o myclass.o
```

- Makefiles generated by qmake take care of making the **Q_OBJECT**-marked classes automatically for you.

Properties

- Qt Quick example

```
import QtQuick 2.0
Rectangle {
    width: 400; height: 400
    color: "lightblue"
}
```

- Generic property access:

```
QObject* root = view->rootObject();
if (root != NULL) {
    QString color = root->property("color").toString();
    int width = root->property("width").toInt();
}
```

Properties

- `Q_PROPERTY` is a macro:

```
Q_PROPERTY(type name READ getFunction
           [WRITE setFunction] [RESET resetFunction]
           [NOTIFY notifySignal] [DESIGNABLE bool]
           [SCRIPTABLE bool] [STORED bool])
```

- Property access methods:

```
QVariant property(const char* name) const;
void setProperty(const char* name,const QVariant& value);
```

- If `setProperty()` is used to set a property `name` that has not been declared as a `Q_PROPERTY`
    - Stored as a *dynamic property* in `QObject` not in `QMetaObject`
    - Hence not accessible from Qt Quick
- Note:
    - `Q_OBJECT` macro is required for `Q_PROPERTY` to work

Providing Properties from QObject

```
class Customer : public QObject
{
    Q_OBJECT
    Q_PROPERTY(QString custId READ getId WRITE setId NOTIFY
              idChanged);

public:
    QString getId() const;
    void setId(const QString& id);

signals:
    void idChanged();

...
};
```

Lab: Part 7

To simulate “Automotive Hardware Layers” changing values, let’s fire a QTimer in main.cpp and connect a signal to change the state of the UI.

```
QTimer timer;
timer.setInterval(5000);
QObject::connect (&timer,&QTimer::timeout,mc,
                 &MainController::nextUiState);
timer.start();
```

As a final exercise:

Add a Slider (Slider.qml) to one of the three workspaces. Connect the slider’s `valueChanged` signal to the MainController `setSliderValue()` slot.

Conclusion

Thanks for Drinking from the Firehose!

Join us at www.ics.com and come to one of our trainings!