Qt Fundamentals

Qt Basics

Agenda

Lecture 1: Qt quick start
Lecture 2: Qt core
Lecture 3: Mobile development overview (iPhone, Windows Phone 7 and Java ME).
Lecture 4: Qt Project, Tools & Qt Designer
Lecture 5: Qt Widgets & Nice to know Qt classes
Lecture 6: Qt Mobility
Lecture 7: Qt Networking and general networking
Lecture 8: Deploy your applications. Mobile app. stores etc.
Lecture 9: Android part 1
Lecture 10: Android part 2

- Objectives
  - Get familiar with basic Qt classes and concepts

Agenda

- Here we will cover the basic Qt concepts
  - Basic types
  - Memory management
  - QObject base class
  - Parent/Child relationship
  - Signal/Slot mechanism

Basic Types & Qt Core Classes

- Basic data types are normal C++ data types
  - int, bool, double, char etc.
- Structs and arrays are created normally
- Qt variants of most of the containers in the C++ Standard Library
  - QList<T>
  - QVector<T>
  - QMap<T,C>
  - etc.
- For string types, Qt holds its own type: QString

Qt contains versions of almost all of the standard library - some say with a friendlier API

Basic Types & Qt Core Classes

- **QDate**, **QDateTime** – Can be compared, converted to strings
- **QChar** – 16-bit Unicode character
- **QString** – Unicode character string. Can be resized, may contain 8-bit \0 terminating strings or binary data
- **QByteArray**- Used instead of QString, when memory conservation is important (Qt for embedded Linux)
- **QEventLoop**, **QEvent** – Used to enter and exit event loop
- **QHash** – Template providing a hash-table-based dictionary

Basic Types & Qt Core Classes

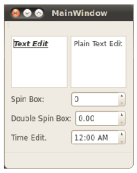
- **QQueue** – Template class implementing a FIFO queue
- **QPoint**, **QRect** – Rectangle is defined using the top left and bottom right
- **QTimer** – One shot or periodic 1 ms timer (accuracy depends on platform)
- **QVariant** – Union of the common Qt types
- **QVector** – Template class for dynamic arrays (flat), QLinkedList more efficient, if many insertion and deletion operations needed
- Iterator classes – Java (QVectorIterator) and STL-like (QVector<T>::iterator) iterators exist

Creating Your Own Qt Application

- Widget
  - A UI building block, base class QWidget
    - Label
    - Text editors
    - Empty window
    - Main window
    - Buttons
    - etc.
- Often your own application UI is a widget of your own which consists of multiple inner widgets

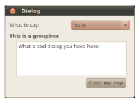
Quick Widget Overview

Input Widgets

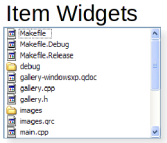


Buttons

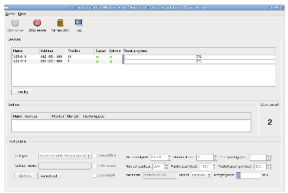
Dialogs



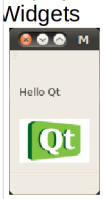
Item Widgets



Main Windows



Display Widgets



Container Widgets

Very First Application

```
#include <QtGui>

int main(int argc, char *argv[])
{
    QApplication app(argc, argv);
    QLabel *label = new QLabel("this is great");
    label->show();

    return app.exec();
}
```


QApplication - the core of our app.

- Initializes application settings
  - Palette, font
- Defines application's look and feel
- Provides localization of strings
- Knows application's windows

- Derived from QCoreApplication [QtCore]
  - Used in **console applications** (or Qt processes without any UI, servers for instance).

- Performs **event handling**, receives and dispatches events from the underlying window system

More Widgets?

```
#include <QtGui>

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

    QLabel *labelOne = new QLabel("this is great");
    labelOne->show();

    QLabel *labelTwo = new QLabel("it just works");
    labelTwo->show();

    return app.exec();
}
```


More Widgets?

```
#include <QtGui>

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

    QLabel *labelOne = new QLabel("this is great");
    labelOne->show();

    QLabel *labelTwo = new QLabel("it just works");
    labelTwo->show();

    return app.exec();
}
```

- Not exactly what was intented..
- Each widget **without** a parent becomes a windows of its own

QObject Class Role

Ownership tree
&
Widget tree

- Heart of **Qt's object model**
  - Parent / Child relationship
  - Base class for all object classes
  - So, all QWidgets are QObjects also
  - Provides object trees and object ownership
  - QObject's responsibility is to provide a central location for the most important concepts in Qt
- Has three major *responsibilities*:
  - Memory Management
  - Introspection (runtime identification of object types)
  - Event handling

Parent/Child Relationship

Ownership tree

- Each QObject instance *may take a parent argument*
- Child *informs its parent* about its existence, upon which the parent adds it to its own list of children

Widget tree

- If a widget object does not have a parent, it is a window
- The parent does the following for its children:
  - Hides and shows children, when hidden/shown itself
  - Enables and disables children when enabled or disabled itself
- Note that a child may be explicitly hidden, although the parent is shown

Memory Management

- The ownership of all child QObjects is transferred to the parent
  - ***Automatic deletion*** by the parent
  - Allocated from the **heap** with new
  - Manual deletion won't however cause **double deletion** because the child informs its parent of the deletion
- All QObjects without a parent must be deleted manually
- Occasionally it may seem like Qt would hold some sort of automatic garbage collection but this is not true!
  - Always pay attention to ownerships and responsibilities!

No garbage collector

Creating Objects

- Objects inheriting from QObject are allocated on the **heap** using **new**
  - If a ***parent*** object is assigned, it takes ownership of the newly created object – and eventually calls delete

```
QLabel *label = new QLabel("Some Text", parent);
```

- Objects ***not*** inheriting QObject are typically allocated on the **stack**, not the heap
  - QStringList list;
  - QColor color;
- Exceptions
  - QFile and QApplication (inheriting QObject) are usually allocated on the stack
  - Modal dialogs are often allocated on the stack, too

Another Try

```
#include <QtGui>

int main(int argc, char *argv[])
{
    QApplication app(argc, argv);
    QLabel labelOne("this is great");

    QLabel *labelTwo = new QLabel("it just works", &labelOne);
    labelOne.show();

    return app.exec();
}
```

- Nearly, but not quite enough..
  - Let's try with layouts

Final Try, Now With a Layout

```
#include <QtGui>

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

    QWidget window; // Needed as a layout cannot be a window
    QVBoxLayout *layout = new QVBoxLayout(&window);

    layout->addWidget(new QLabel("this is great"));
    layout->addWidget(new QLabel("it just works"));
    layout->addStretch();

    window.show();
    return app.exec();
}
```

Another Example, Anything Wrong Here?

```
#include <QtGui>

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

    QLabel label("Testing");
    QWidget window;

    label.setParent(&window);
    window.show();

    return app.exec();
}
```


Conclusions So Far

- Widgets are put inside a main widget
  - Main widget becomes a *parent* for its *child widgets*
  - No garbage collection, ownership tranferships!
- Layout classes are used for non-hard-coded positioning
- But… Do we really need to code everything manually?
  - No, we can use **Qt Designer**

Meta-Object System

- Meta-object system extends C++ with dynamic features – similar to those in Java, for example
- Dynamic features include
  - Mechanism to access any functions in the class
    - Also private ones
    - Used by **signals and slots**
  - Class information
    - Type without RTTI (Run-Time Type Information)
    - Information about base classes
  - Translate strings for internationalization
  - Dynamic properties

Meta-Object System - Example

- A simple class declaration
- Simple QObject subclass
- One slot
- One signal

```
class MyObject : public QObject
{
    Q_OBJECT

public:
    MyObject(QObject *parent = 0);

public slots:
    void mySlot();

signals:
    void mySignal();
};
```


Signals and Slots

- Observer pattern
- Type-safe callbacks
- More secure than callbacks, more flexible than virtual methods
- Many-to-many relationship
- Implemented in QObject

Signals

- A signal is a way to inform a possible observer that something of interest has happened inside the observed class
  - A QPushButton is clicked
  - An asynchronous service handler is finished
  - Value of QSlider is changed
- Signals are *member functions* that are automatically implemented in the meta-object
  - Only the function declaration is provided by the developer
- Signal is sent, or ***emitted***, using the keyword emit
  - **emit clicked();**
  - **emit someSignal(7, “Hello”)**;

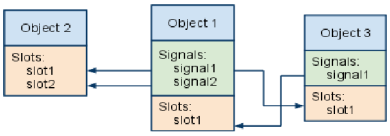
Slots

- A slot is a function that is to be executed when a signal has been emitted.
  - (When QPushButton is pressed), close QDialog
  - (When service is ready), ask for the value and store it
  - (When QSlider value is changed), show a new value in QLCDNumber
- A Slot function is a **normal member function** implemented by the developer

Signals and Slots

The signals and slots mechanism is fundamental to Qt programming. It enables the application programmer to bind objects together without the objects knowing anything about each other.

- Slots are almost identical to ordinary C++ member functions.
  - The main difference is that they can be connected to a signal - in which case it is automatically called when the signal is ***emitted***



Signals and Slots

- To setup the signal-slot connection, we must first define the connection.
- The connect() statement looks like this:

connect(*sender*, SIGNAL(*signal*), *receiver*, SLOT(*slot*));

```
int main(int argc, char *argv[])
{
    QApplication a(argc, argv);

    QPushButton button("Quit");
    button.resize(150,150);
    QObject::connect(&button, SIGNAL(clicked()), &a, SLOT(quit()));
    button.show();

    return a.exec();
}
```


Signals and Slots

Main features:

- One signal can be connected to many slots

```
connect(slider, SIGNAL(valueChanged(int)),
        spinBox, SLOT(setValue(int)));

connect(slider, SIGNAL(valueChanged(int)),
        this, SLOT(updateStatusBarIndicator(int)));
```

- Many signals can be connected to the same slot

```
connect(lcd, SIGNAL(overflow()),
        this, SLOT(handleMathError()));

connect(calculator, SIGNAL(divisionByZero()),
        this, SLOT(handleMathError()));
```

- A signal can be connected to another signal

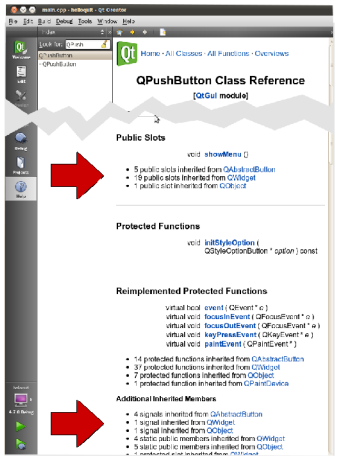
```
connect(lineEdit, SIGNAL(textChanged(const QString &)),
        this, SIGNAL(updateRecord(const QString &)));
```

- Connections can be removed

```
disconnect(lcd, SIGNAL(overflow()),
           this, SLOT(handleMathError()));
```


Find Signals and Slots

- Find the signals and slots defined in Qt classes in the Qt documentation.



Exercises

- Use a QPushButton instead of a QLabel in our HelloWorld application and connect its *clicked()* signal to the QCoreApplication's *quit()* slot.
- Create a QMainWindow and see if you can add a menu item that also quits the application.

Next lecture: Tomorrow 10.15