Introducing Qt

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Introducing Qt

(from M.Christie's slides)

- www.trolltech.com : C++ toolkit)
- many system and hardware support : one source many compilers
- Event based mechanism (signals /slots)
- Design tool ($QtDesigner$)
- Advanced support for
  - 3D ,3D graphism (OpenGL),
  - easy internationalization,
  - XML, SQL, MDI (multiple document interfaces),
  - network, threads,
  - scripting language.

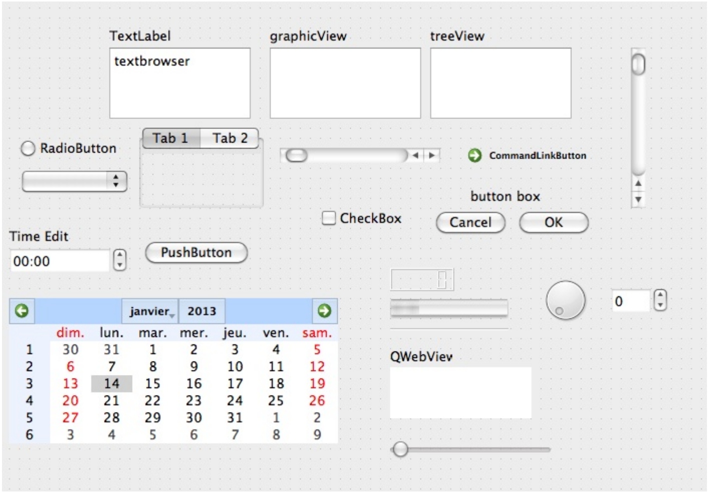
Introducing Qt (2)

- support for mobile system
- Commercial licence (Adobe, IBM, Motorola, NASA, Volvo)
- Open source community (base of KDE)
- Qt is licensed under a commercial and open source license (GNU Lesser General Public License version 2.1).
- Model-View-Controller design pattern with Qt4
  `http://doc.qt.digia.com/qt/model-view-programming.html`

Plan

- many librairies (focus on HCI in this course)
- widgets : tree organization
- event based
- compilation through meta-compiler `moc`
- componants handling by the `layout`
- design through *QtDesigner*
- Internationalisation

Widgets Samples

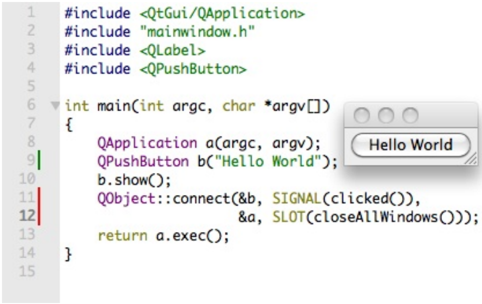


A tree organization

Objects are organized by tree and are extension of an abstract class :`QWidget`

- when an object is created, it is attached to his ancestor
- when the ancestor is destroyed the attached object are destroyed as well;
- the root is an object of type `QApplication` (derived from `QWidget`) which allows the communication between graphical and non-graphical objects;

A simple sample: main.cpp



```
#include <QtGui/QApplication>
#include "mainwindow.h"
#include <QLabel>
#include <QPushButton>

int main(int argc, char *argv[])
{
        QApplication a(argc, argv);
        QPushButton b("Hello World");
        b.show();
        QObject::connect(&b, SIGNAL(clicked()),
                                 &a, SLOT(closeAllWindows()));
        return a.exec();
}
```

An event based handling

The communication is performed through a signal/slot model;

- every components (deriving from `QObject`) is allowed to send *signals*
  - signal may contain data;
  - common components have many default signalsQPushButton::clicked() or `QPushButton::stateChanged ( int state )`
- every component (deriving from `QObject`) is allowed to receive signals:
  - receiver are called *slots*
- connecting *signals* and *slots* permits the communication (function `connect()`)

An Event Based Management

- technically:
  - signals and slots are class methods;
  - when a signal method is fired, the connected slot methods are fired too (order is not guaranteed)
- avantages:
  - writing of our signal and slots within a class;
  - inheritance support

Connection

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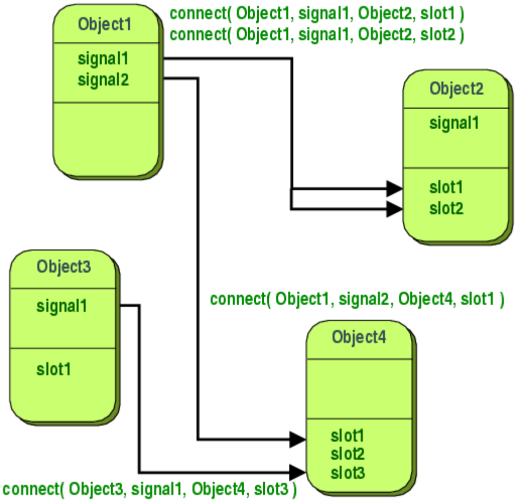

connect(Object1, signal1, Object2, slot1)
connect(Object1, signal1, Object2, slot2)
Object1
signal1
signal2
Object2
signal1
slot1
slot2
Object3
signal1
slot1
connect(Object1, signal2, Object4, slot1)
Object4
slot1
slot2
slot3
connect(Object3, signal1, Object4, slot3)

Signals

- a signal can be emit by its class or by the derived classes;
- when a signal is fired, the connected slots are executed soon after; (no guaranty on order)
- a signal does not have a source code nor a return type;
- the various graphical components are all emitting signals, a few are connected;
- a signal emission can be forced (function `emit signal(value)`)

Slots

- are class methods as well (which could be executed out of the communication system)
- are executed on signal reception
- An object is not aware of other connected objects (this allows to write independant components)
- slots allow encapsulation :
  - `public slots` : every signals can fire these slots
  - `protected slots` : limited to its class and derived classes signals
  - `private slots` : limited to its class signals
- slots allow inheritance and polymorphic connection

Connexion

In order to establish a link between two entities the static method `connect()` is used:

```
QObject::connect( QObject *src, SIGNAL(sig),
                  QObject *dest, SLOT(slo) );
```

- `src` is the object that emit the signal sig
- `dest` is the object that receive the signal slo;
- methods `sig` and `slo` must have arguments of same types.
  It is possible to connect to signals:

  ```
  QObject::connect( QObject *src, SIGNAL(sig1),
                    QObject *dest, SIGNAL(sig2) );
  ```

Sample (1)

```
class Foo : public QObject {
Q_OBJECT
public:
   Foo();
   int value() const { return val; }
// declare a possible connection from outside
public slots:
   void setValue( int );
// emitted signal
signals:
   void valueChanged( int );
// private field
private:
   int val;
};
```

Sample(2)

The signal informs the outside that the state of an object has changed

```
void Foo::setValue( int v ) {
       if ( v != val ) {
              val = v;
              emit valueChanged(v);
       }
}
```

Sample(3)

```
Foo a, b;
connect(&a, SIGNAL(valueChanged(int)),
        &b, SLOT(setValue(int)));
b.setValue( 11 ); // a == unknown b == 11
a.setValue( 79 ); // a == 79 b == 79
b.value();        // returns 79
```

The call to `a.setValue(79)` emits a signal `valueChanged()`
which is received by the object `b` ,
which emits a signal ,too (ignored because not connected)

Event Management

Every graphical components (derived from QWidget) handles the events:

- which relate to the window manager
  `closeEvent(), focusInEvent(), enterEvent(), paintEvent()`
- which relate to keyboard
  `keyPressEvent(), keyReleaseEvent()`
- which relate to the mouse
  `mouseMoveEvent(), mousePressEvent()`
- which relate to a clock: `timerEvent()`
- which relate to user-defined events : `event()`

Sample

```
bool MyClass::keyPressEvent( QKeyEvent *e) {
      if (e->key() == Key_F1) {
            ....
            e->accept();
      }
      if (e->key() == Key_Escape) {
            e->ignore(); // send the event to the ancestor
            }
}
```

Meta-compiler compilation

Signal/Slot communication provided by Qt are handled by a meta-compiler: `moc` (Meta Object Compiler)

- `moc` takes as input C++ files that contains the declaration : `Q_OBJECT`
- `moc` generates a C++ file that implements mechanisms for :
  - communication on object during the executing of the soft ;
  - dynamic libraries management;
- the resulting file is then parsed by a traditional compiler.

Compilation through the command make

(c.f
http://doc.qt.digia.com/qt/moc.html#command-line-options)

```
moc_%.cpp: %.h
        moc $(DEFINES) $(INCPATH) $< -o $@
```

or by invidual rules:

```
moc_foo.cpp: foo.h
        moc $(DEFINES) $(INCPATH) $< -o $@
```

Compilation through the command make (2)

- You must also remember to add
  - `moc_foo.cpp` to your `SOURCES` (substitute your favorite name) variable
  - and `moc_foo.o` or `moc_foo.obj` to your `OBJECTS` variable.
- Both examples assume that
  - `$(DEFINES)` and `$(INCPATH)` expand to the define and include path options that are passed to the C++ compiler.
  - These are required by `moc` to preprocess the source files.

Compilation through the command `qmake`

(`http://doc.qt.digia.com/qt/qmake-manual.html#qmake`)

Qt provides us with the tool `qmake` to create `Makefile` which are platform specific (files with `.pro` extensions)

```
SOURCES = hello.cpp main.cpp
FORMS = hello.ui
HEADERS = hello.h
CONFIG += qt
```

a qmake command looks like:

```
qmake -o Makefile hello.pro
```

and then simply

```
make
```

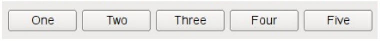
The Layout

The *Layout* mechanism allows :

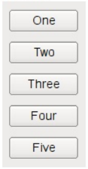
- the location of the attached components;
- the default size of components;
- the minimum size of components;
- the management of resizing ;
- the management of updates (contents of components, adding, suppress...).

Some Layouters

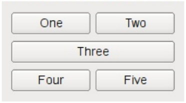
- A QHBoxLayout lays out widgets in a horizontal row, from left to right (or right to left for right-to-left languages).



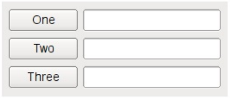
- A QVBoxLayout lays out widgets in a vertical column, from top to bottom.



- A QGridLayout lays out widgets in a two-dimensional grid. Widgets can occupy multiple cells.



- A QFormLayout lays out widgets in a 2-column descriptive label- field style.



Some Layouters

- `QHBoxLayout` presents elements on horizontal basis;
- `QVBoxLayout` presents elements on vertical basis;
- `QFormLayout` presents elements on a two-colums grid ;
- `QGridLayout` presents elements on complex grid (elements spreading has to be specified)

Placement Policy

1. every components possess a spreading space according to their properties;
2. the `stretchfactor` is taken into account if it is greater than 1;
3. if the `stretchfactor` is equal to 0, the remaining space is allowed;
4. a component is never smaller than its default minimum size;
5. a component is never greater than its default maximum size;

Sample : QHBoxLayout

from http://doc.qt.digia.com/qt/layout.html

```
QWidget *window = new QWidget;
     QPushButton *button1 = new QPushButton("One");
     QPushButton *button2 = new QPushButton("Two");
     QPushButton *button3 = new QPushButton("Three");
     QPushButton *button4 = new QPushButton("Four");
     QPushButton *button5 = new QPushButton("Five");

     QHBoxLayout *layout = new QHBoxLayout;
     layout->addWidget(button1);
     layout->addWidget(button2);
     layout->addWidget(button3);
     layout->addWidget(button4);
     layout->addWidget(button5);

     window->setLayout(layout);
     window->show();
```

Sample : Grid Layout

from `http://doc.qt.digia.com/qt/layout.html`

```
QWidget *window = new QWidget;
QPushButton *button1 = new QPushButton("One");
QPushButton *button2 = new QPushButton("Two");
QPushButton *button3 = new QPushButton("Three");
QPushButton *button4 = new QPushButton("Four");
QPushButton *button5 = new QPushButton("Five");

QGridLayout *layout = new QGridLayout;
layout->addWidget(button1, 0, 0);
layout->addWidget(button2, 0, 1);
layout->addWidget(button3, 1, 0, 1, 2);
layout->addWidget(button4, 2, 0);
layout->addWidget(button5, 2, 1);

window->setLayout(layout);
window->show();
```

The third QPushButton spans 2 columns. This is possible by specifying 2 as the fifth argument to QGridLayout::addWidget().

Sample : QFormLayout

from `http://doc.qt.digia.com/qt/layout.html`

```
QWidget *window = new QWidget;
QPushButton *button1 = new QPushButton("One");
QLineEdit *lineEdit1 = new QLineEdit();
QPushButton *button2 = new QPushButton("Two");
QLineEdit *lineEdit2 = new QLineEdit();
QPushButton *button3 = new QPushButton("Three");
QLineEdit *lineEdit3 = new QLineEdit();

QFormLayout *layout = new QFormLayout;
layout->addRow(button1, lineEdit1);
layout->addRow(button2, lineEdit2);
layout->addRow(button3, lineEdit3);

window->setLayout(layout);
window->show();
```

Personal Layouts

It is possible to create your own *layouts*, you just have to :

- derive from the class `QLayout`
- overload the method`resizeEvent(QEvent *e)`
- re-calculate the size of every objects using `setGeometry()`

Menus (Qt 4.7)

`http://doc.qt.digia.com/4.7/qmenu.html`

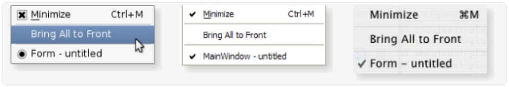


Fig. A menu shown in Plastique widget style, Windows XP widget style, and Macintosh widget style.

- A menu consists of a list of action items.
- added with the addAction(), addActions() and insertAction() functions,
- actions can have :
  - a text label,
  - an optional icon drawn on the very left side,
  - and shortcut key sequence such as "Ctrl+X".
- When inserting action items you usually specify a receiver and a slot.
  - The receiver will be notifed whenever the item is triggered().
  - In addition, QMenu provides two signals, activated() and highlighted(), which signal the QAction that was triggered from the menu.

Menu Sample (Qt 4.7)

```
#include "menus.h"
#include <QAction>
#include <QAxFactory>
#include <QMenuBar>
#include <QMessageBox>
#include <QTextEdit>
#include <QPixmap>
#include "fileopen.xpm"
#include "filesave.xpm"
```

Menu Sample(Qt 4.7)

```
QMenus::QMenus(QWidget *parent) : QMainWindow(parent, 0)
    // QMainWindow's default flag is WType_TopLevel
{
    QAction *action;
    QMenu *file = new QMenu(this);

    action = new QAction(QPixmap((const char**)fileopen),
                         "\&Open", this);
    action->setShortcut(tr("CTRL+O"));


    connect(action, SIGNAL(triggered()),
            this,  SLOT(fileOpen()));
    file->addAction(action);

    action = new QAction(QPixmap((const char**)filesave),
                         "\&Save", this);
    action->setShortcut(tr("CTRL+S"));
    connect(action, SIGNAL(triggered()),
            this, SLOT(fileSave()));
    file->addAction(action);
```

Menu Sample(Qt 4.7)

```
    if (!QAxFactory::isServer())
        menuBar()->addMenu(file)->setText("\&File");
    editor = new QTextEdit(this);
    setCentralWidget(editor);

   statusBar();
}
 void QMenus::fileOpen()
{editor->append("File Open selected.");
}

void QMenus::fileSave()
{ editor->append("File Save selected.");
}
```

QtDesigner

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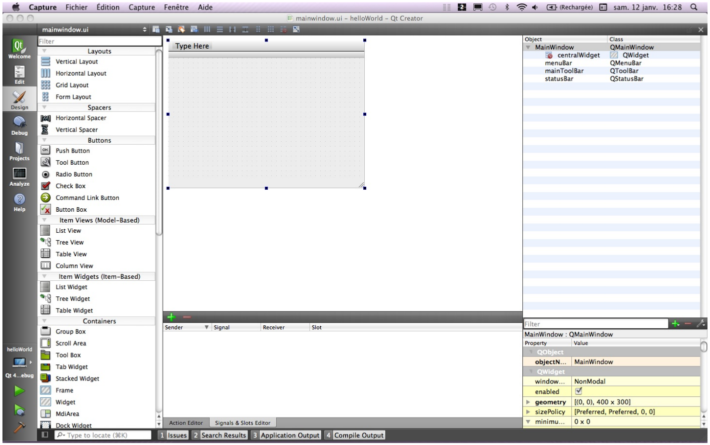

Object	Class
MainWindow	QMainWindow
centralWidget	QWidget
menuBar	QMenuBar
mainToolBar	QToolBar
statusBar	QStatusBar

MainWindow : QMainWindow

Property	Value
QObject	
objectN...	MainWindow
QWidget	
window...	NonModal
enabled	✓
geometry	[(0, 0), 400 x 300]
sizePolicy	[Preferred, Preferred, 0, 0]
minimu...	0 x 0

Using *QtDesigner*

QtDesigner is a full and easy to use tool that permits the design of graphical apps.

- QtDesigner generates files with `.ui` extensions that describe the interface while respecting the XML format;
- a source genrator `uic` create the associated Qt source
- the user derives the created class to write the application.

Internationalization

Internationalization is easily handled by Qt :

- using 16 bits characters, class `QString`
- providing a support for translation :
  - `tr` is a static method which handle the translation `saveButton->setText(tr ("Enregistrer"));`
  - during the execution, the translation will be performed according to environment variables;
  - translations are handled by the application `QtLinguist`.

A few limitations

- Multiple Inheritance Requires QObject to Be First
- Function Pointers Cannot Be Signal or Slot Parameters
- Enums and Typedefs Must Be Fully Qualified for Signal and Slot Parameters
- Type Macros Cannot Be Used for Signal and Slot Parameters
- Nested Classes Cannot Have Signals or Slots
- Signal/Slot return types cannot be references
- Only Signals and Slots May Appear in the signals and slots Sections of a Class

Custom Widgets in Layouts

(c.f `http://doc.qt.digia.com/qt/layout.html`)

- if you your own widget class, you must communicate its layout properties.
- If the widget has a one of Qt's layouts, this is already taken care of
- If the widget does not have any child widgets, or uses manual layout, you can change the behavior of the widget using any or all of the following mechanisms:
  - Reimplement QWidget::sizeHint() to return the preferred size of the widget.
  - Reimplement QWidget::minimumSizeHint() to return the smallest size the widget can have.
  - Call QWidget::setSizePolicy() to specify the space requirements of the widget.
  - Call QWidget::updateGeometry() whenever the size hint, minimum size hint or size policy changes. This will cause a layout recalculation.