CS241 Principles and Practice of Problem Solving

Lecture 10: GUI Programming with Qt I

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October 17, 2019

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What is a graphical user interface?

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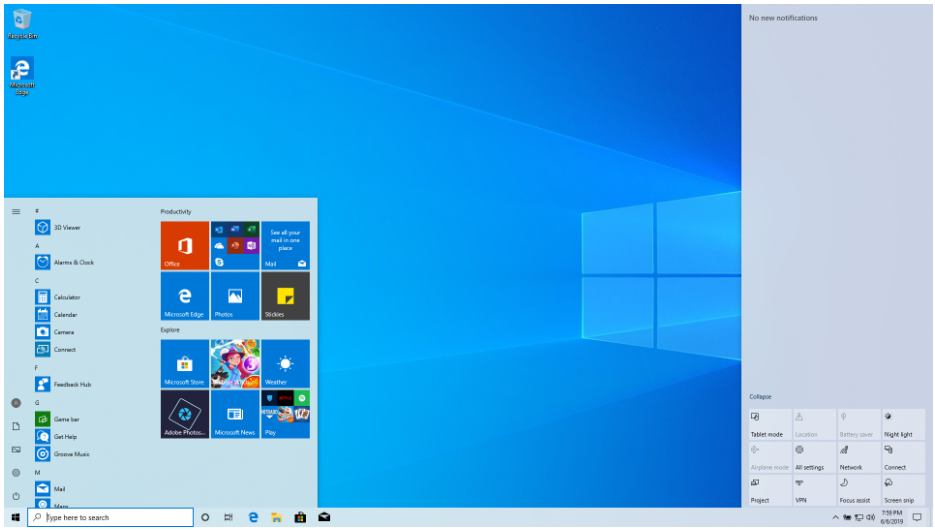

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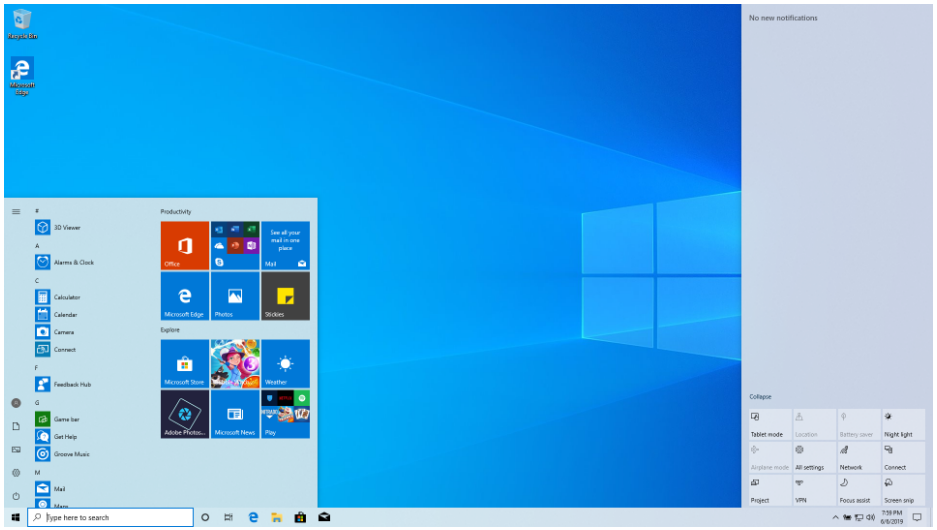
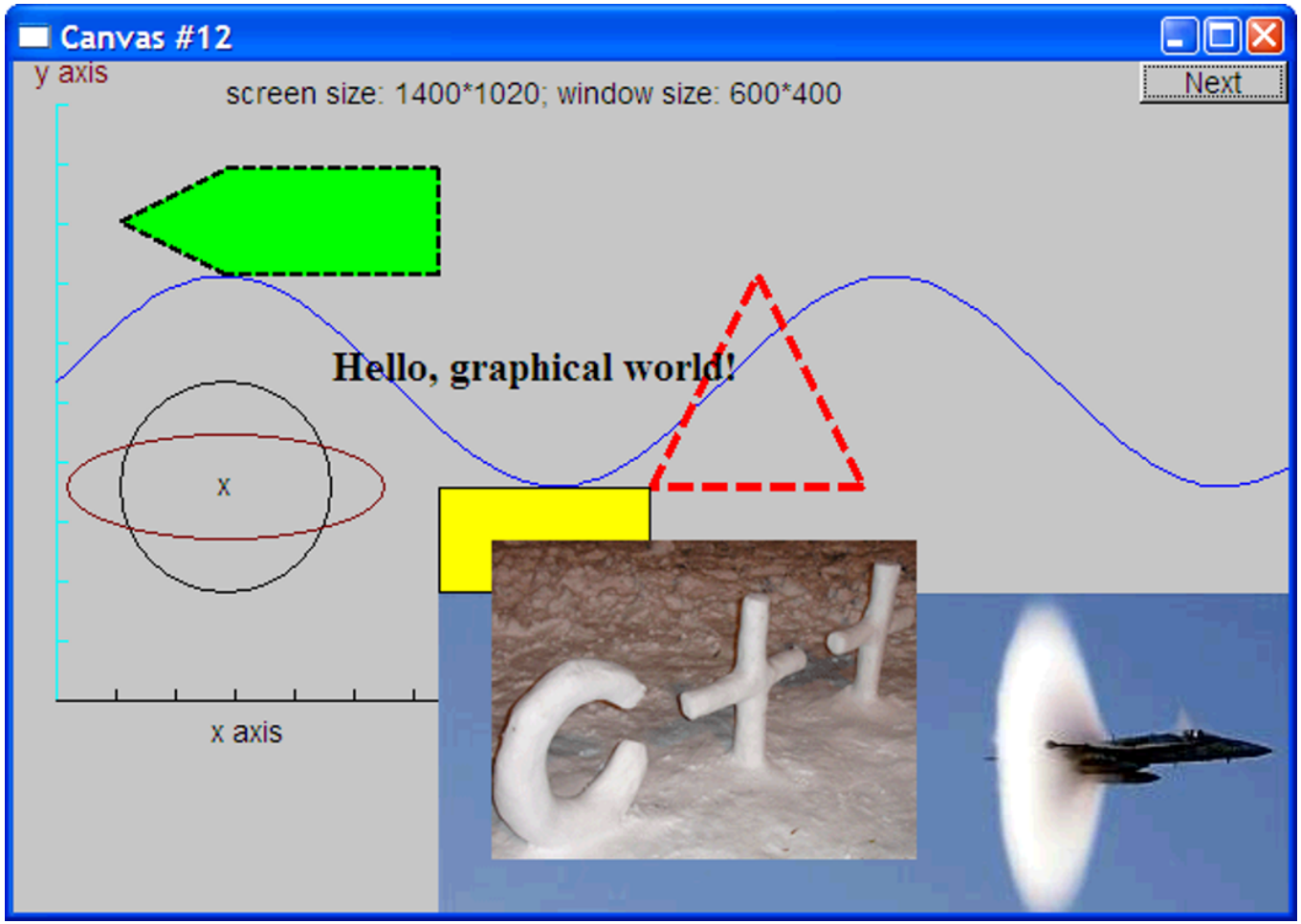


Definition: a computer program designed to allow a computer user to interact easily with the computer typically by making choices from menus or groups of icons.

What (I think) is NOT a GUI

GUI is more than drawing a picture on the canvas.



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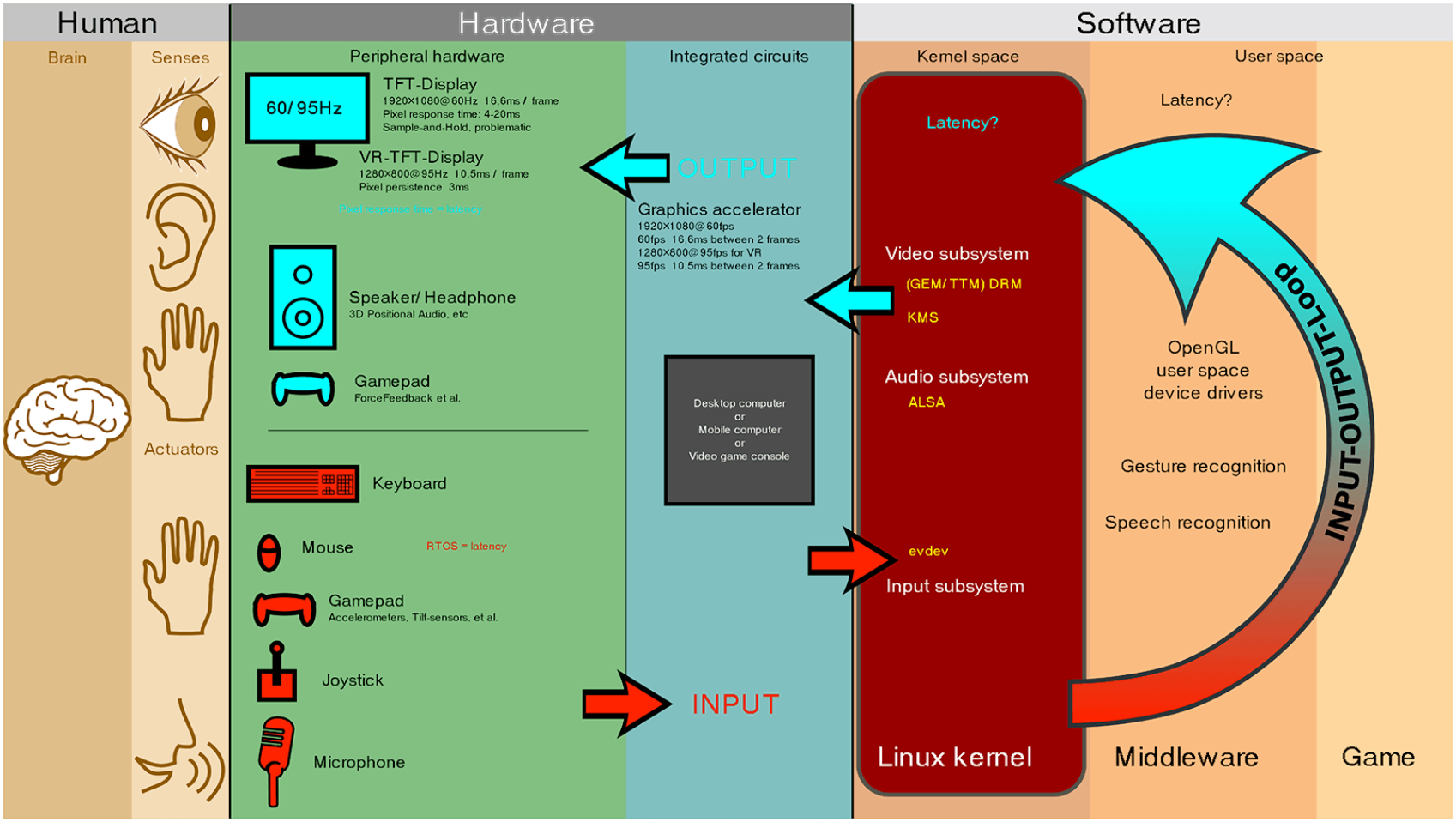
Human
Brain
Senses
Actuators
Hardware
Peripheral hardware
60/95Hz
TFT-Display
1920X1080@60Hz 16.6ms / frame
Pixel response time: 4-20ms
Sample-and-Hold, problematic
VR-TFT-Display
1280X800@95Hz 10.5ms / frame
Pixel persistence 3ms
Pixel response time = latency
Speaker/ Headphone
3D Positional Audio, etc
Gamepad
ForceFeedback et al.
Keyboard
Mouse
RTOS = latency
Gamepad
Accelerometers, Tilt-sensors, et al.
Joystick
Microphone
Integrated circuits
OUTPUT
Graphics accelerator
1920X1080@60fps
60fps 16.6ms between 2 frames
1280X800@95fps for VR
95fps 10.5ms between 2 frames
Desktop computer
or
Mobile computer
or
Video game console
INPUT
Software
Kernel space
Latency?
Video subsystem
(GEM/ TTM) DRM
KMS
Audio subsystem
ALSA
evdev
Input subsystem
Linux kernel
User space
Latency?
OpenGL
user space
device drivers
Gesture recognition
Speech recognition
Middleware
Game
INPUT-OUTPUT-LOOP

Class schedule

- I: Introduction & Object communication
- II: Widgets & Painting
- III: Application & Dialog
- IV: Multi-threading in Qt
- V: Brief introduction on OpenGL

Some general issues before we go

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  - E.g. Design patterns
  - Model-view separation, callbacks, inheritance v.s. delegation

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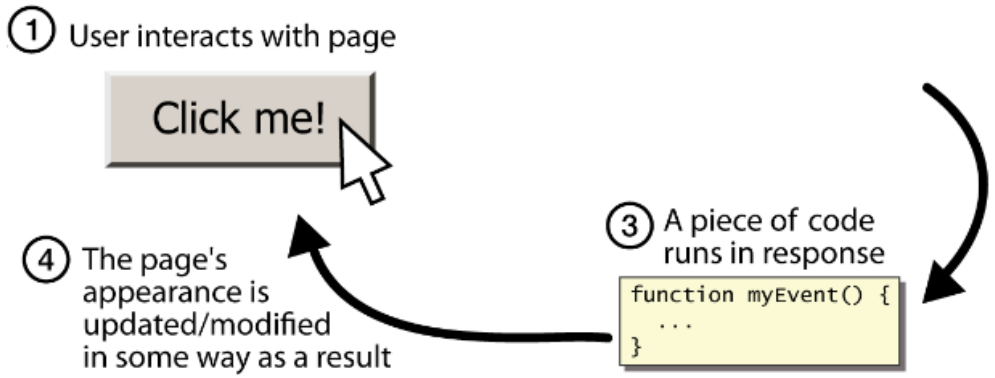

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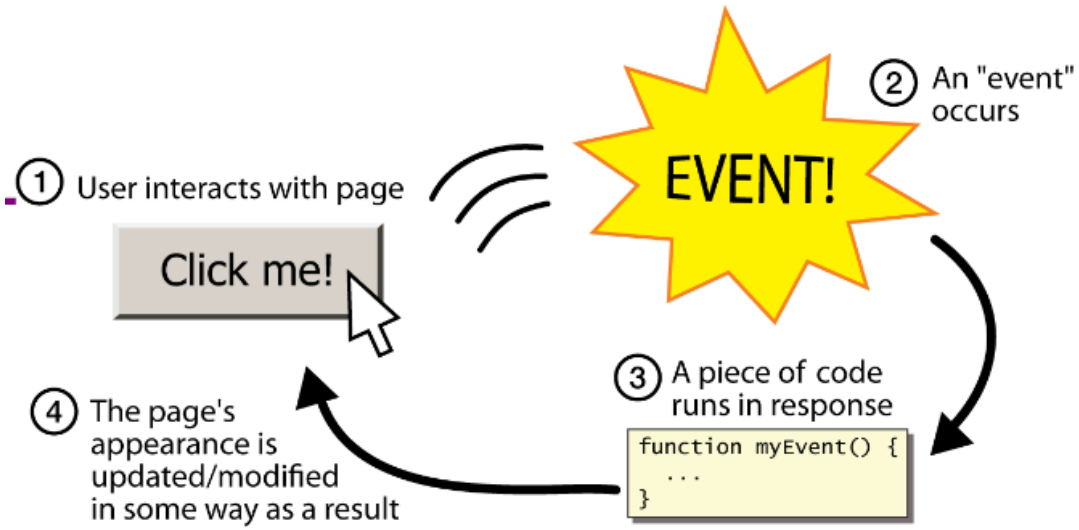

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- As each event occurs, the program runs particular code to respond.
- The overall flow of what code is executed is determined by the series of events that occur
- Quick summary: It is essentially a communication system

Graphical events

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- Can be "handled" to create interactive component

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Event

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- Can be "handled" to create interactive component
- Question: does this recall you anything we have learned before?

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The main body of the program is an event loop.
Abstractly:

```
do {
    e = getNextEvent();
    process event e;
} while (e != quit)
```

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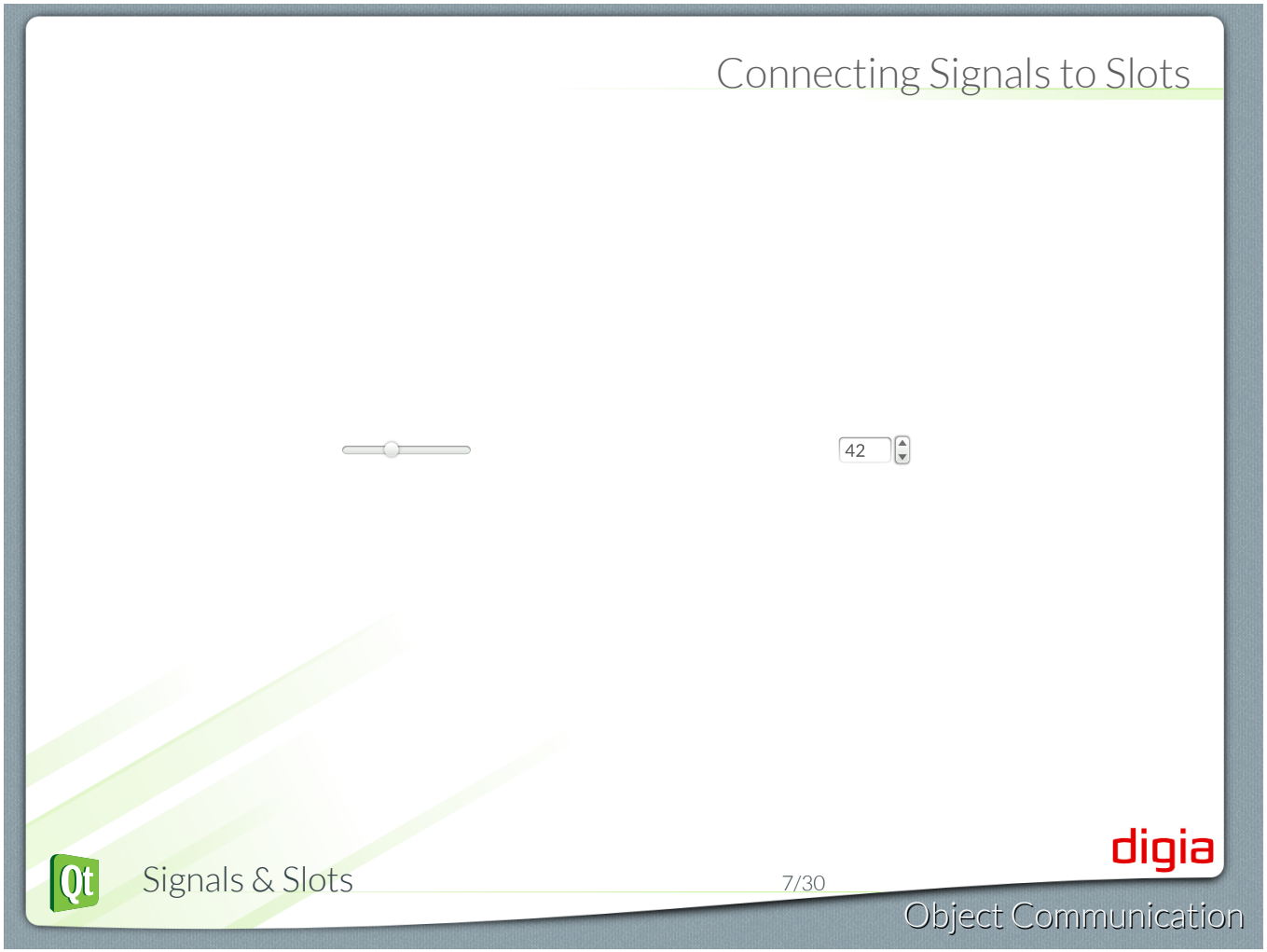
  - From certain perspective, *exception handling* could be viewed as an unusual event handling
  - Why unusual?

Signals and slots

Signals and slots



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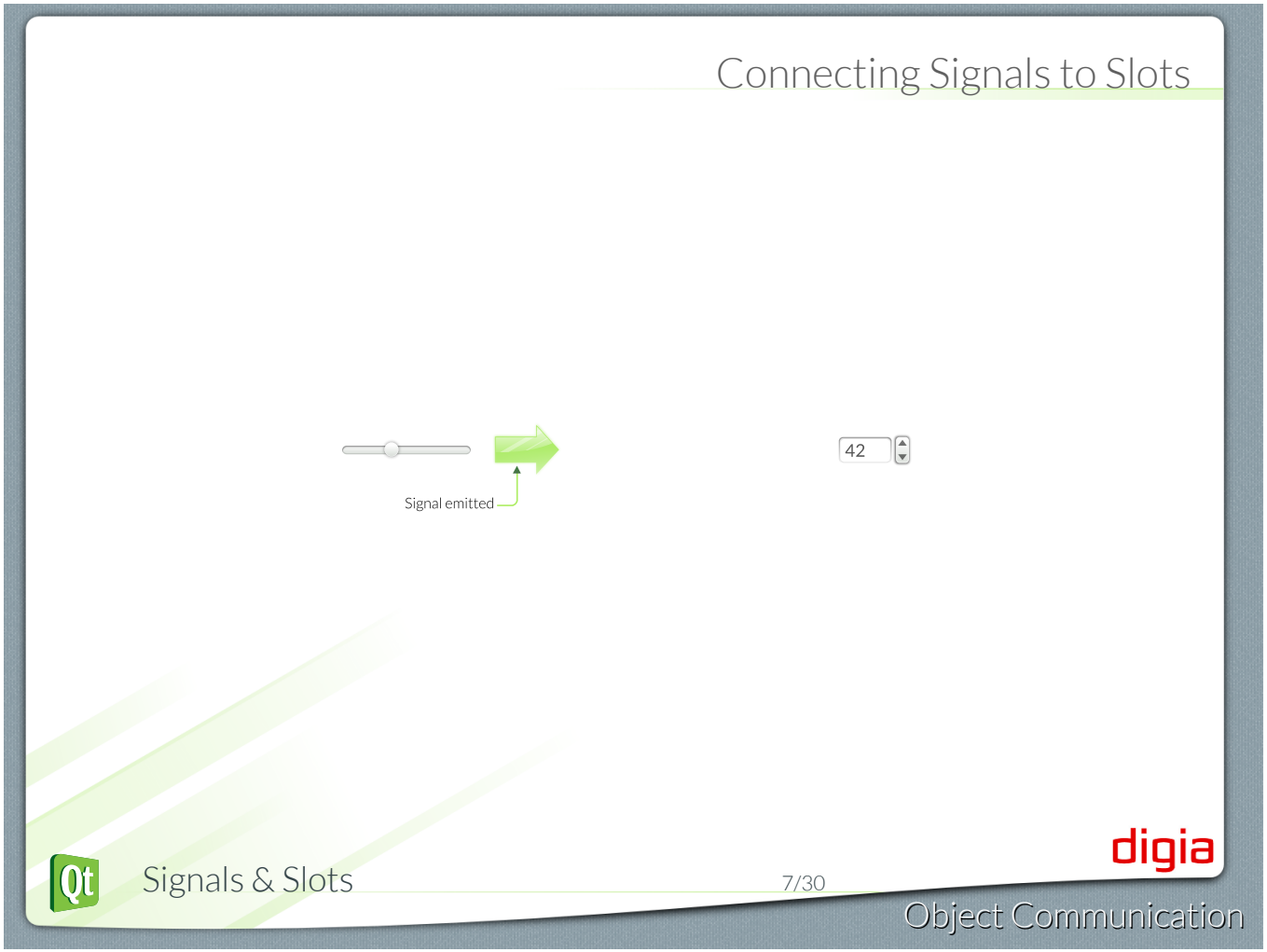

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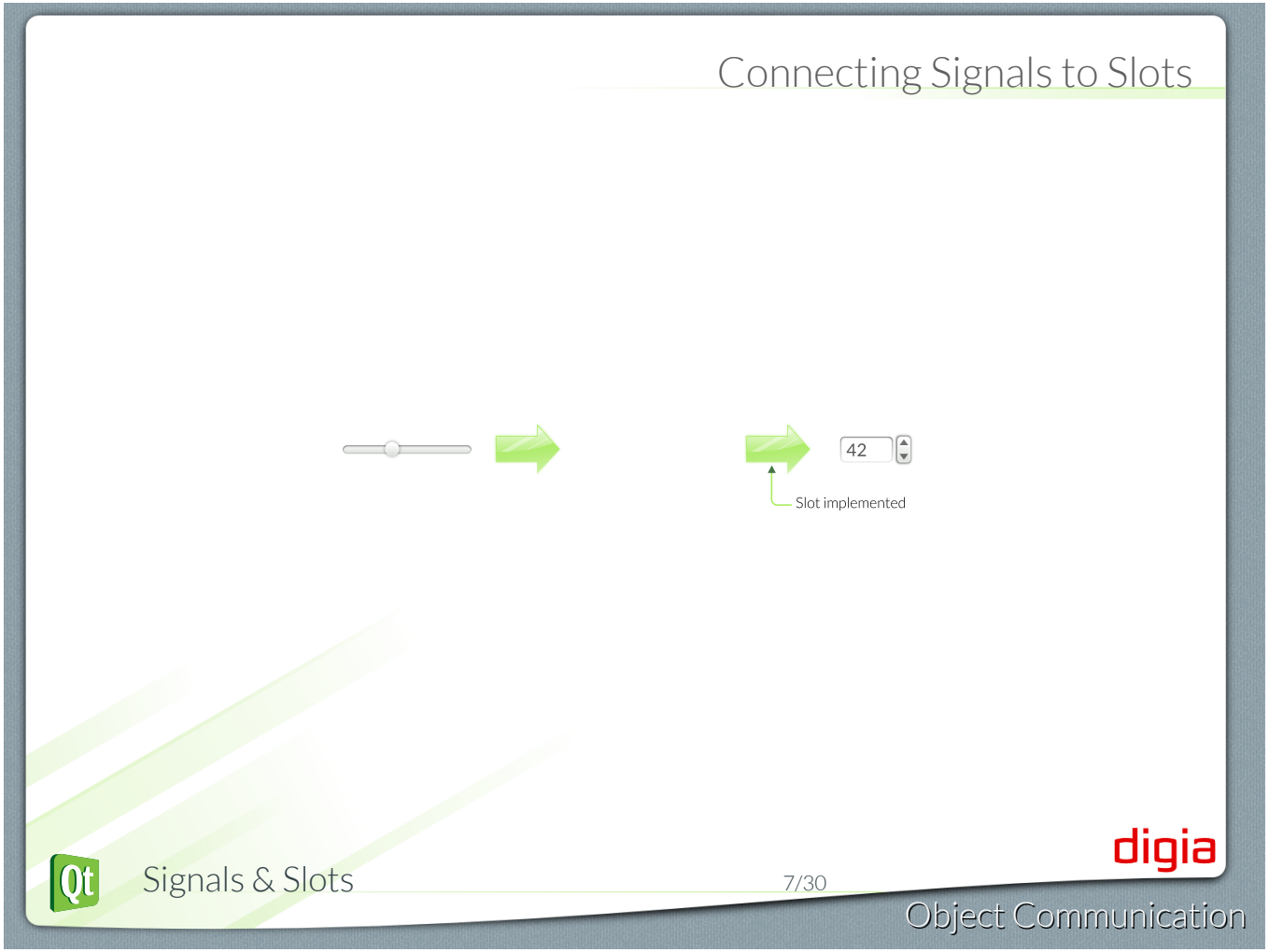

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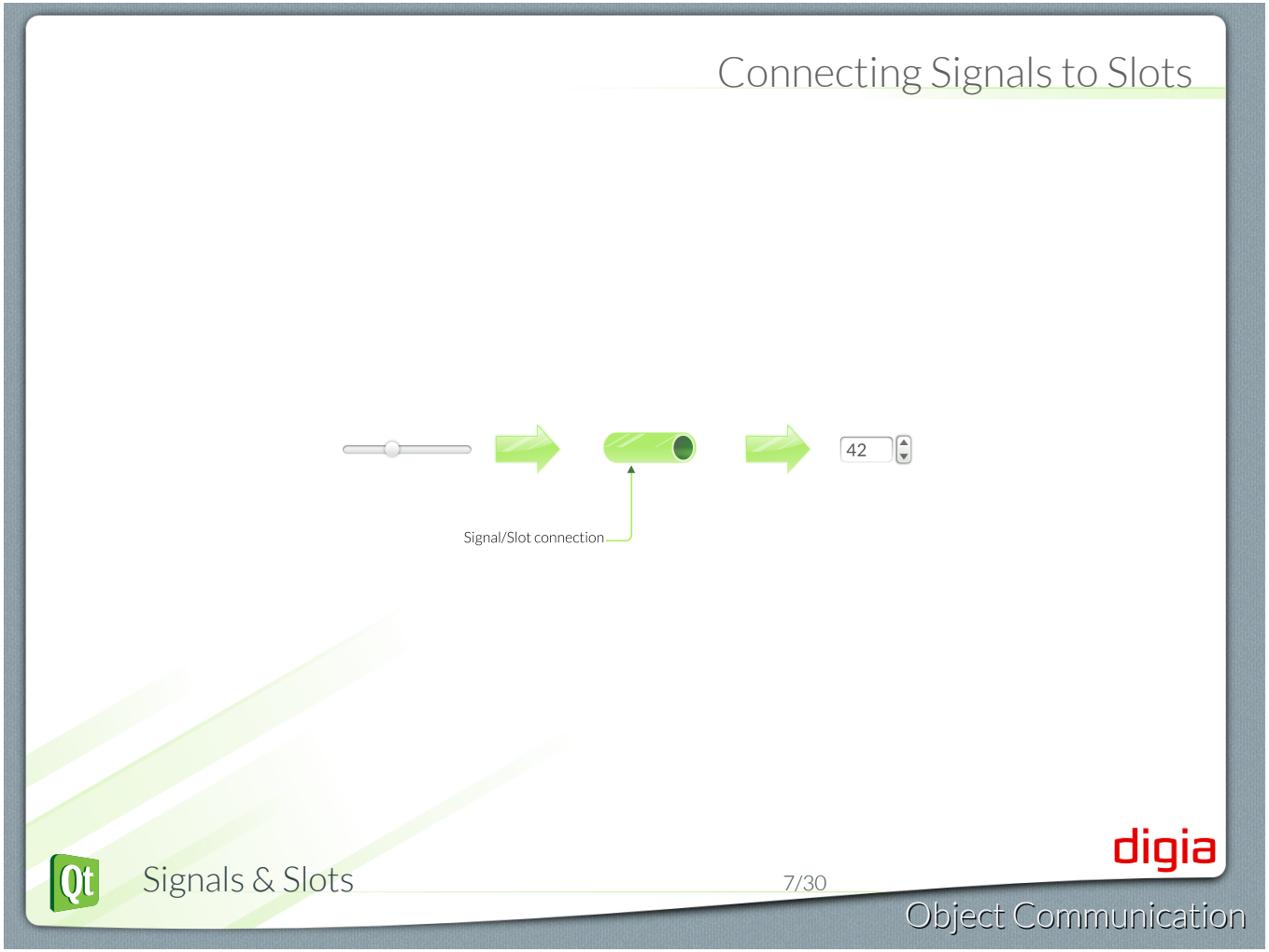

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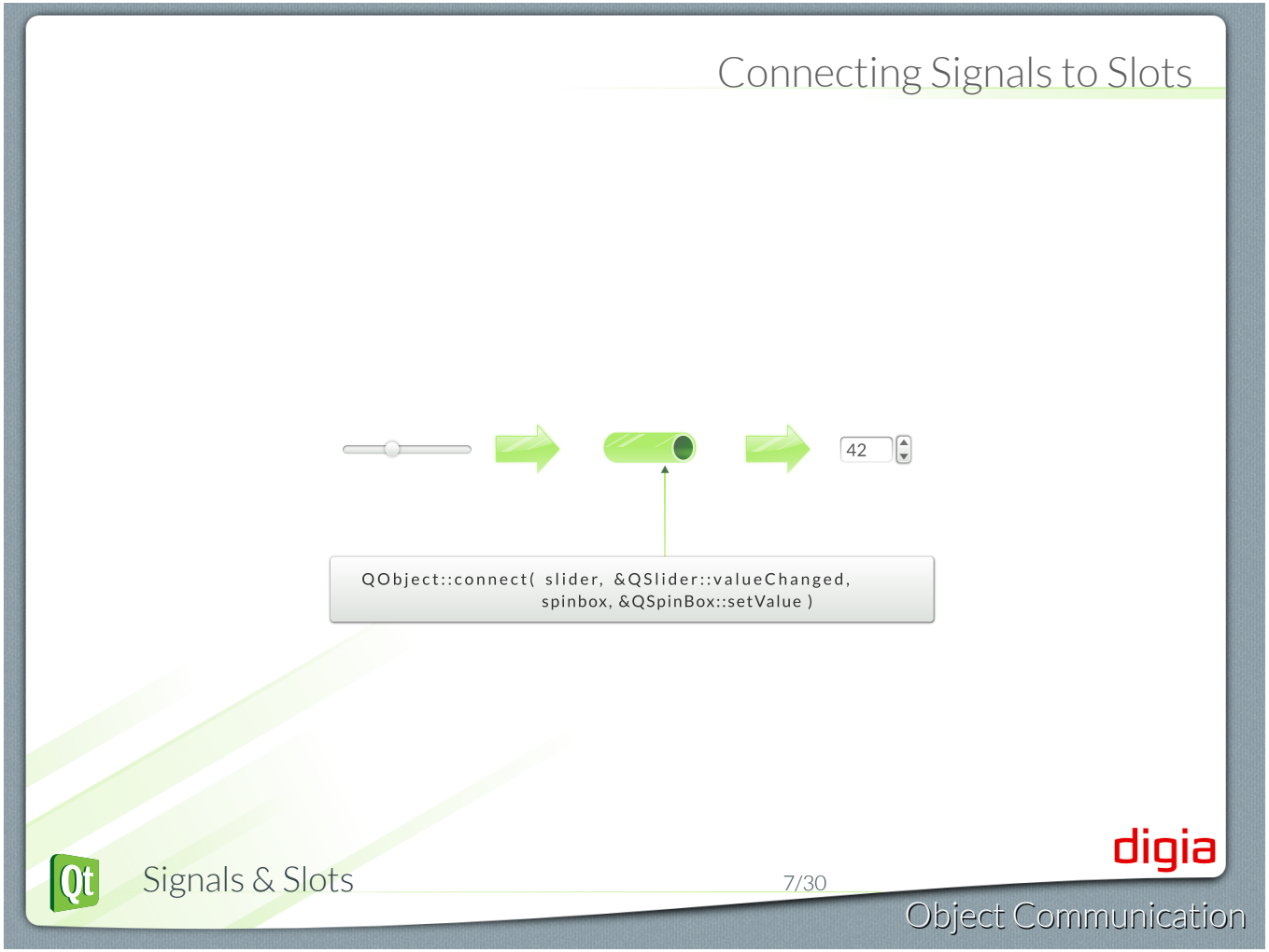

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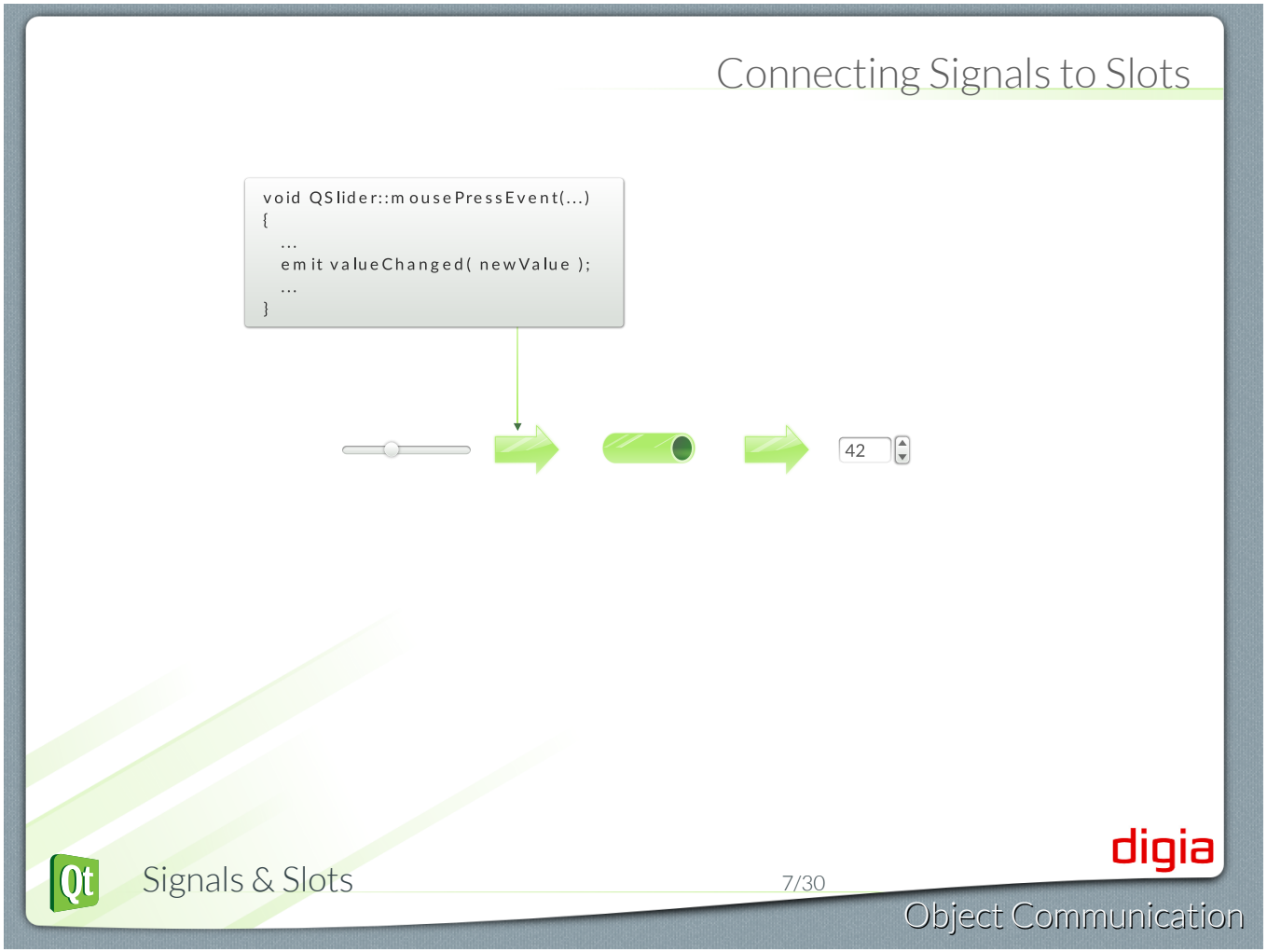

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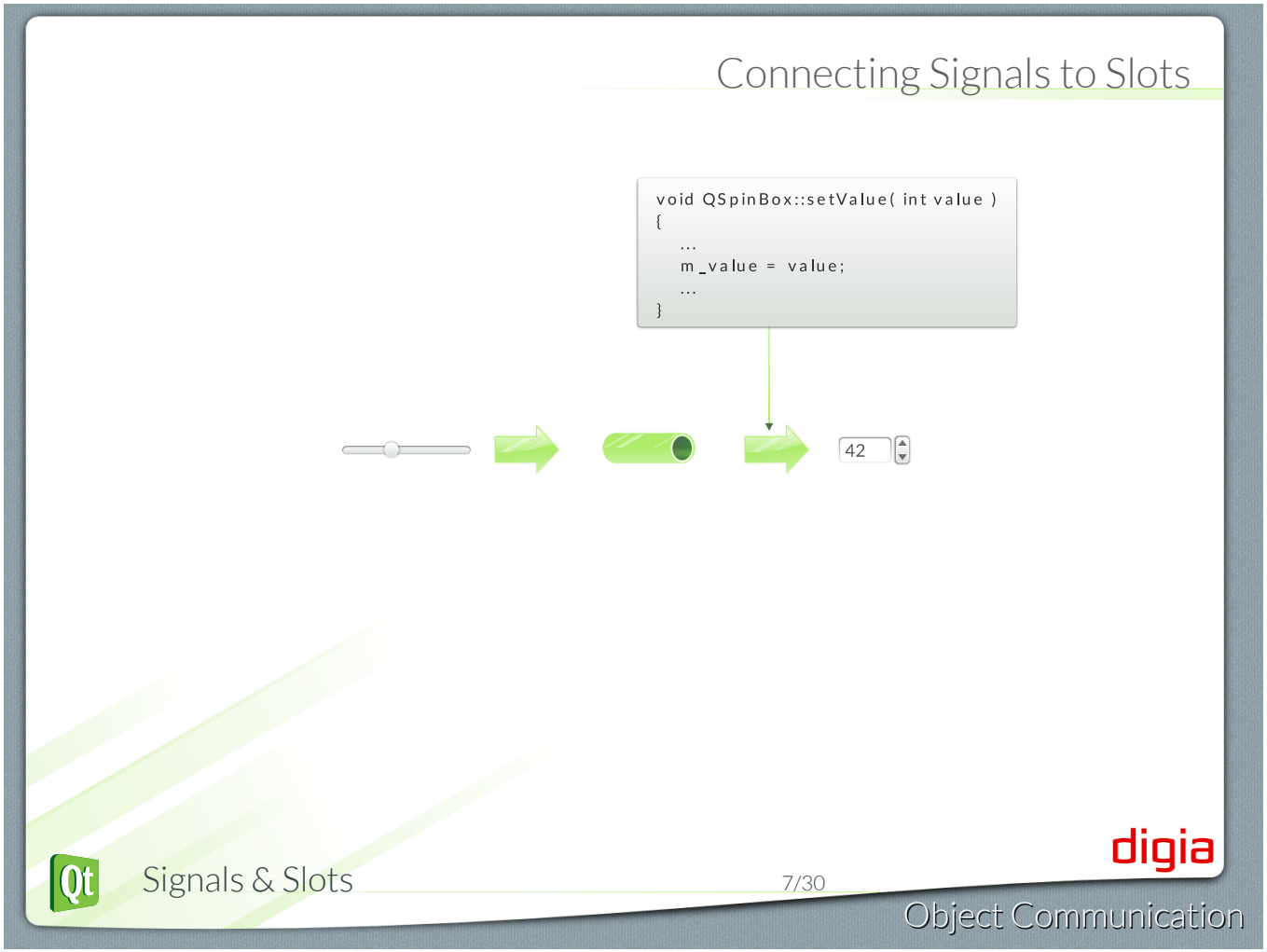

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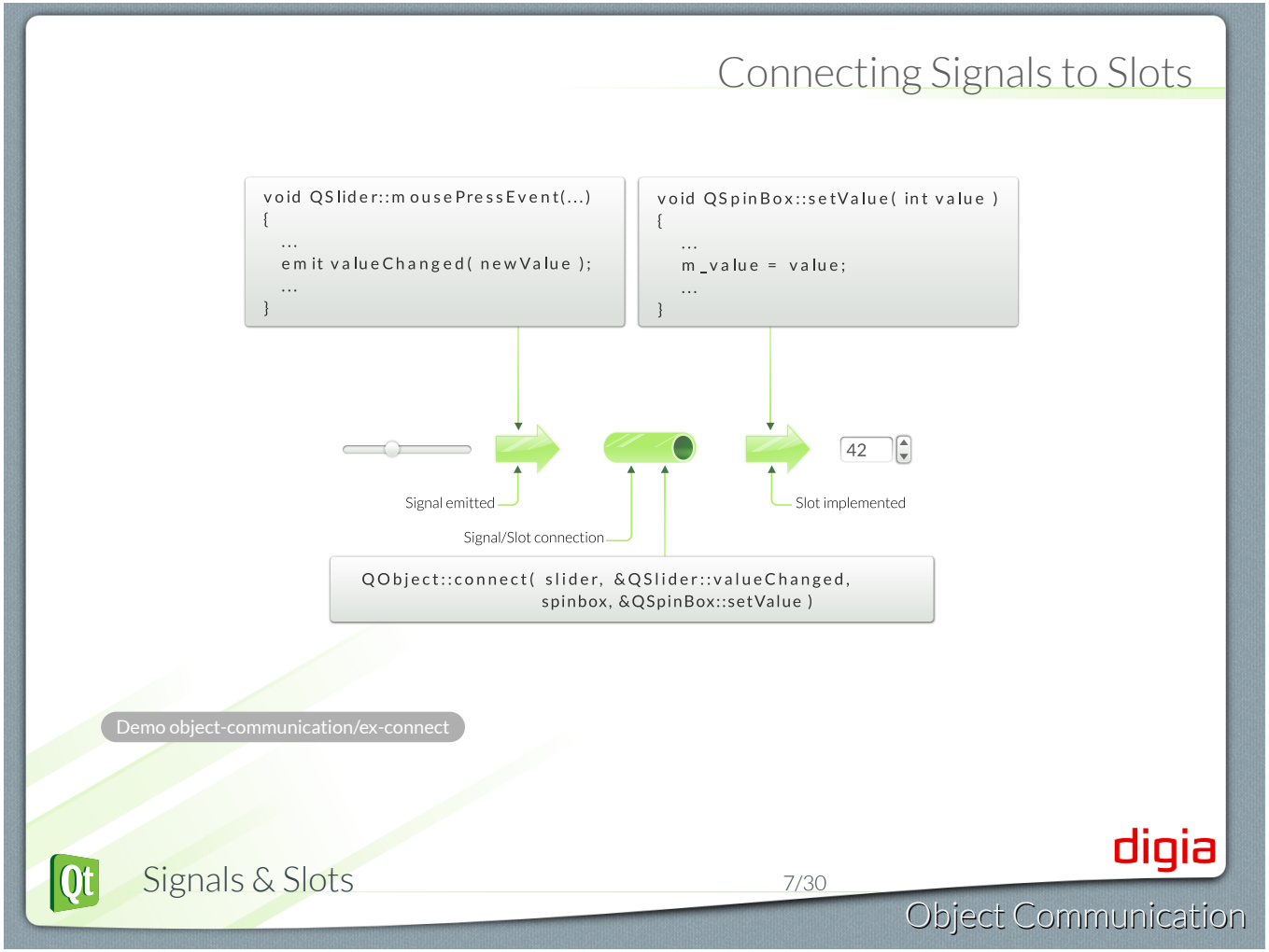

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- Always return `void`
- No need to be implemented
- Can be connected to multiple slots : slots are activated in arbitrary order
- A signal is emitted using the `emit` keyword

```
1     emit aSignal();
2
```

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  - It is implemented as an ordinary method
  - It can be called as an ordinary method
- A slot can return values, but not through connections

Connect

Qt 4 style

```
1 connect(slider, SIGNAL(valueChanged(int)),
2         spinbox, SLOT(setValue(int))
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String-based syntax

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Functor-based syntax

Some basic rules about connection

Variations of Signal/Slot Connections

Signal(s)	Connect to	Slot(s)
one	√	many
many	√	one
one	√	another signal

- Signal to Signal connection

```
connect(bt, SIGNAL(clicked()), this, SIGNAL(okSignal()));
```

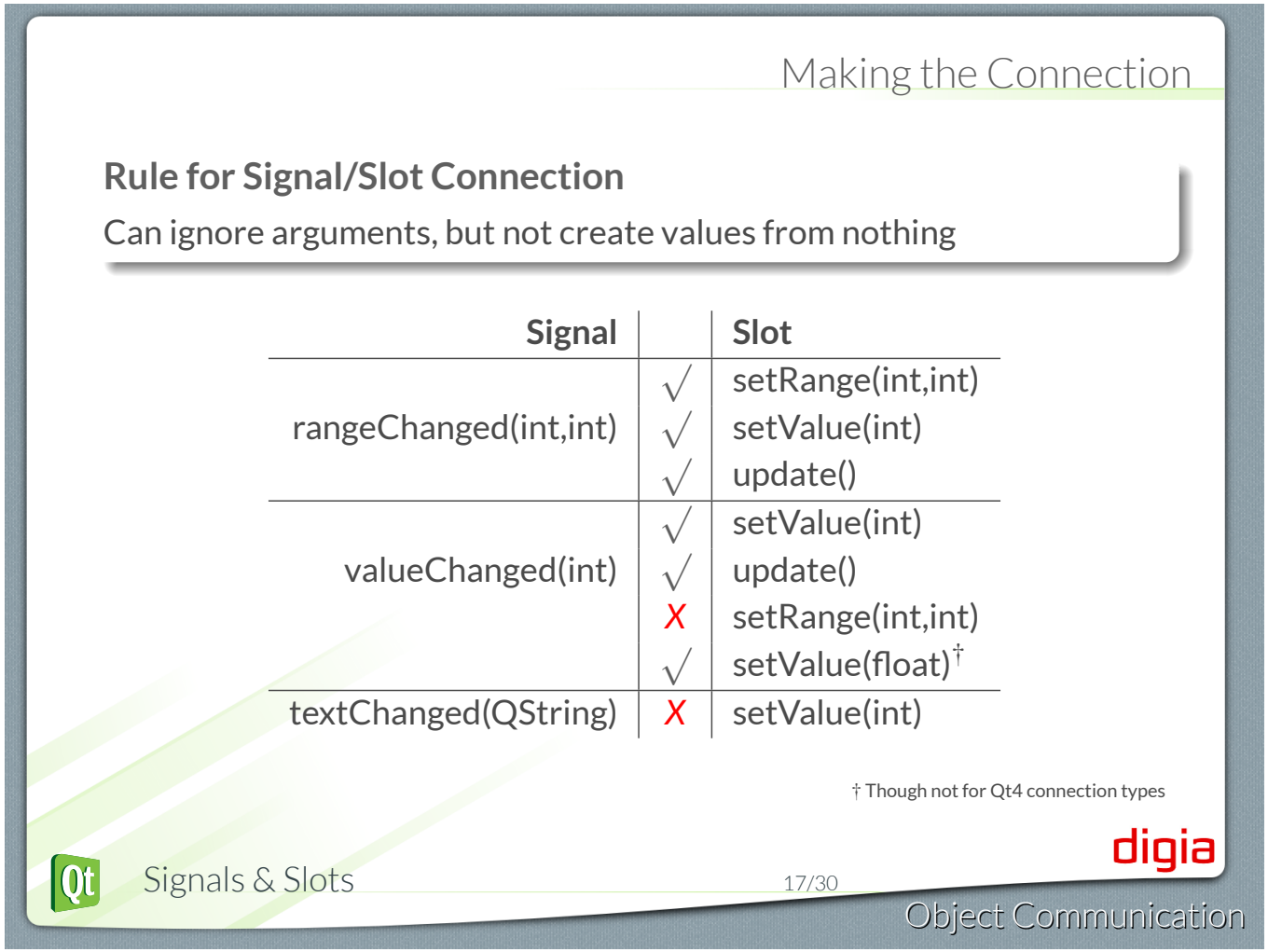
- **Not** allowed to name parameters

connect(m_slider, SIGNAL(valueChanged(int ~~value~~))
this, SLOT(setValue(int ~~newValue~~)))

Signals & Slots 16/30 digia

Object Communication

Some basic rules about connection



Making the Connection

Rule for Signal/Slot Connection

Can ignore arguments, but not create values from nothing

Signal		Slot
rangeChanged(int,int)	√	setRange(int,int)
	√	setValue(int)
	√	update()
valueChanged(int)	√	setValue(int)
	√	update()
	X	setRange(int,int)
	√	setValue(float)†
textChanged(QString)	X	setValue(int)

† Though not for Qt4 connection types

Signals & Slots 17/30 Object Communication

Synchronizing values

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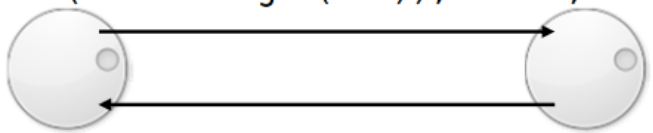

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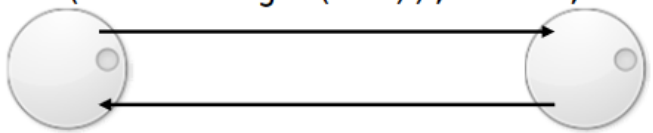

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  - Infinite loop!

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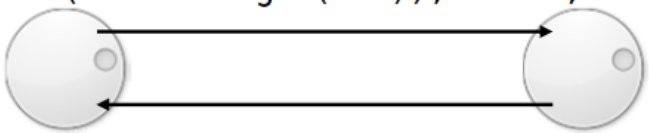

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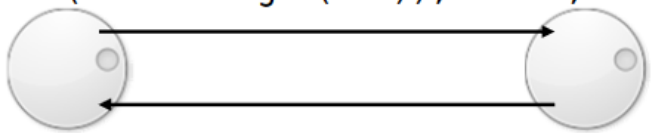

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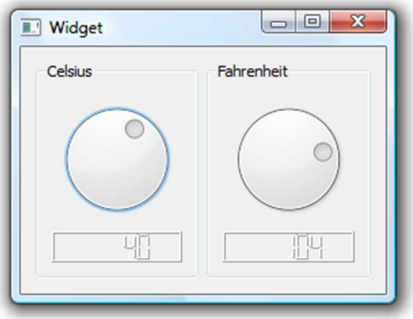
```
1 void QDial::setValue(int v)
2 {
3     if(v==m_value)
4         return;
5     ...
6
```

Synchronization: example

Temperature Converter



- Uses the `TempConverter` class to convert between Celsius and Fahrenheit
- Emits signals when temperature changes

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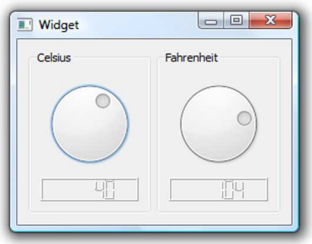
Synchronization: example

Temperature Converter

- The dialog window contains the following objects
  - A `TempConverter` instance
  - Two `QGroupBox` widgets, each containing
    - A `QDial` widget
    - A `QLCDNumber` widget



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Synchronization: example

Temperature Converter

```
class TempConverter : public QObject
{
    Q_OBJECT

public:
    TempConverter(int tempCelsius, QObject *parent = 0);

    int tempCelsius() const;
    int tempFahrenheit() const;

public slots:
    void setTempCelsius(int);
    void setTempFahrenheit(int);

signals:
    void tempCelsiusChanged(int);
    void tempFahrenheitChanged(int);

private:
    int m_tempCelsius;
};
```

QObject as parent

Q_OBJECT macro first

parent pointer

Read and write methods

Emitted on changes of the temperature

Internal representation in integer Celsius.

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Synchronization: example

Temperature Converter

- The `setTempCelsius` slot:

```
void TempConverter::setTempCelsius(int tempCelsius)
{
    if(m_tempCelsius == tempCelsius)
        return;

    m_tempCelsius = tempCelsius;

    emit tempCelsiusChanged(m_tempCelsius);
    emit tempFahrenheitChanged(tempFahrenheit());
}
```

Test for change to break recursion

Update object state

Emit signal(s) reflecting changes

- The `setTempFahrenheit` slot:

```
void TempConverter::setTempFahrenheit(int tempFahrenheit)
{
    int tempCelsius = (5.0/9.0)*(tempFahrenheit-32);
    setTempCelsius(tempCelsius);
}
```

Convert and pass on as Celsius is the internal representation

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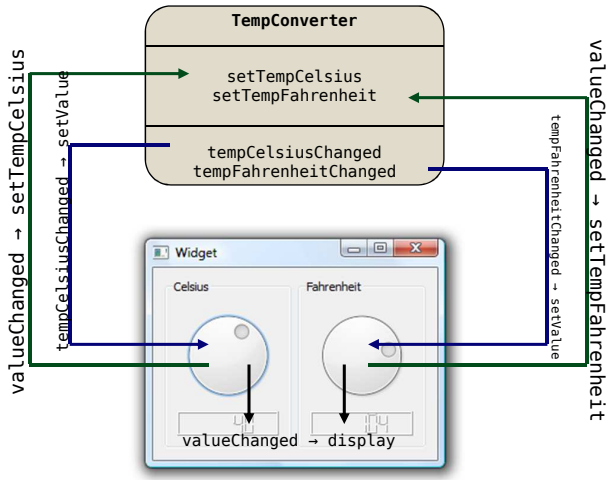
Synchronization: example

Temperature Converter

- The dials are interconnected through the `TempConverter`
- The LCD displays are driven directly from the dials

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connect(celsiusDial, SIGNAL(valueChanged(int)), tempConverter, SLOT(setTempCelsius(int)));
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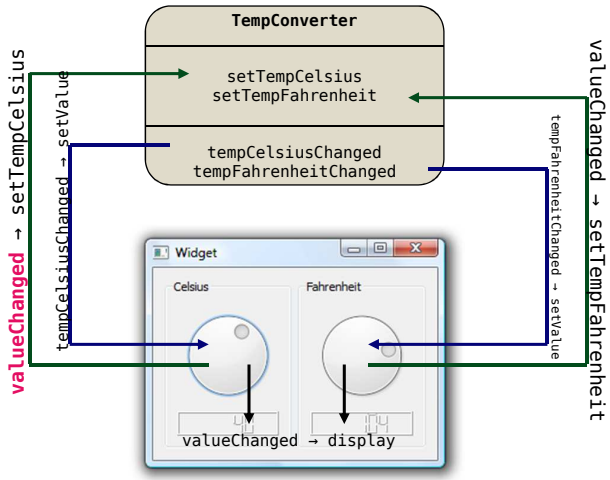
Synchronization: example

Temperature Converter

- The user moves the celsiusDial

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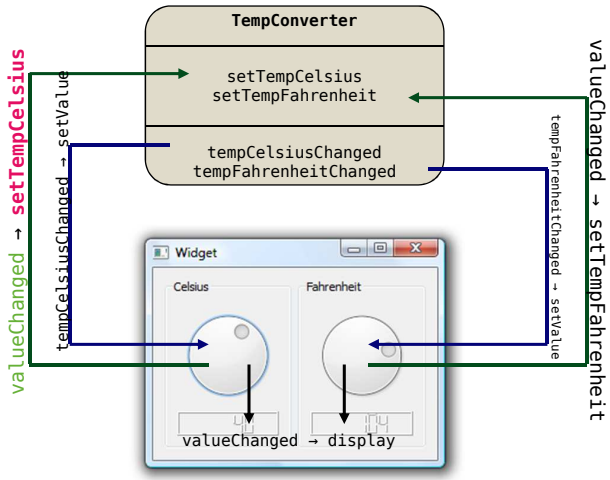


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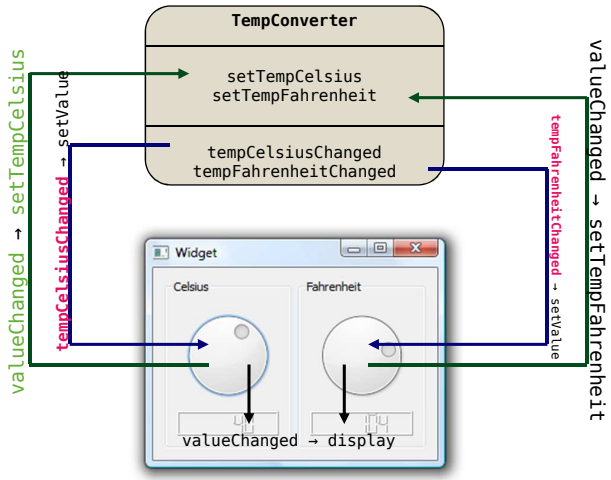


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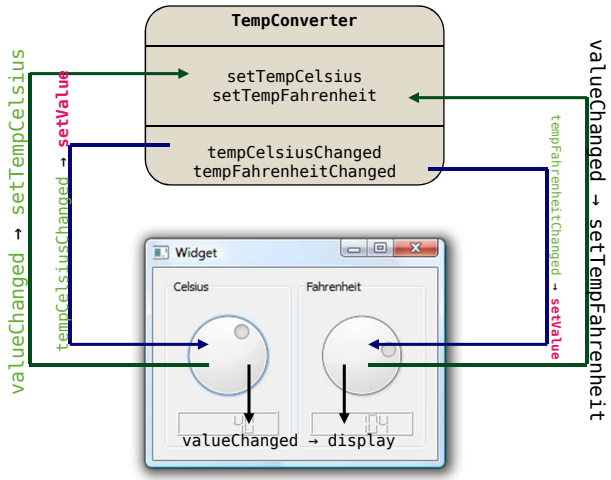


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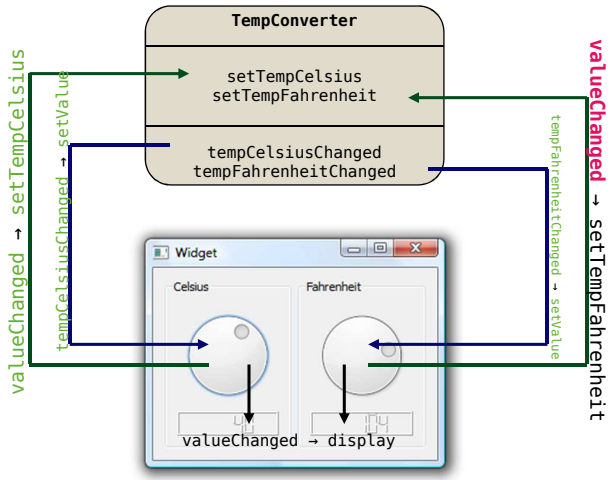


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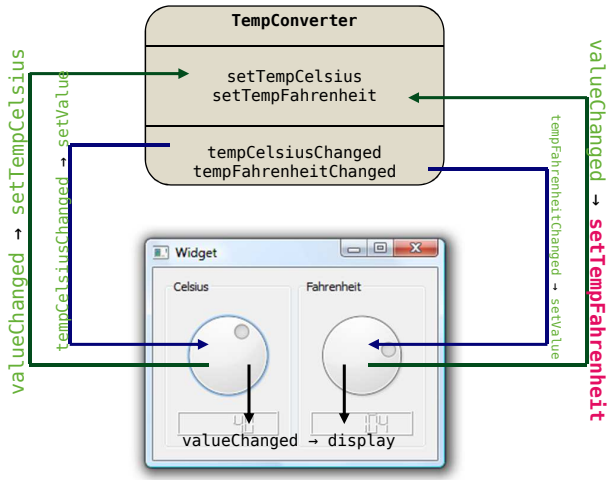


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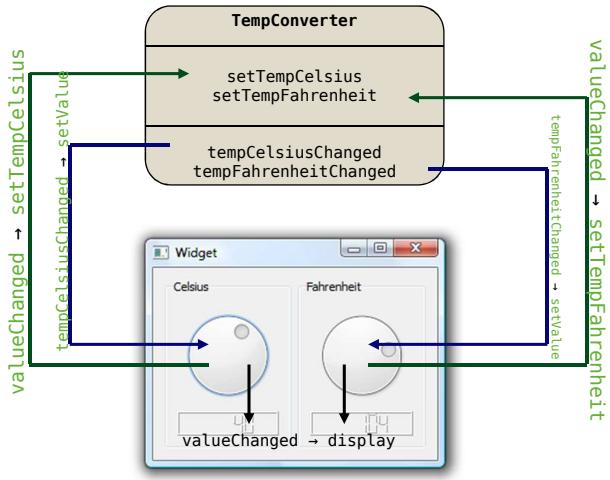


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Discussion

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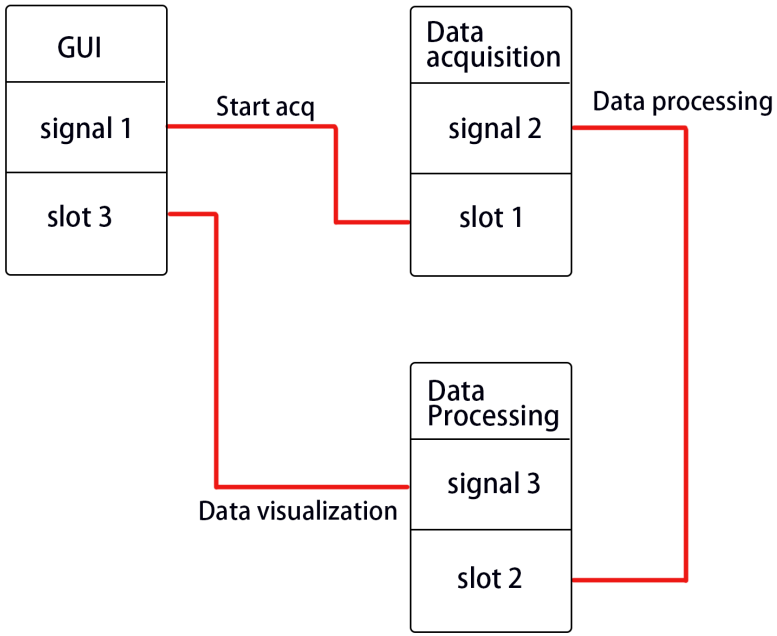

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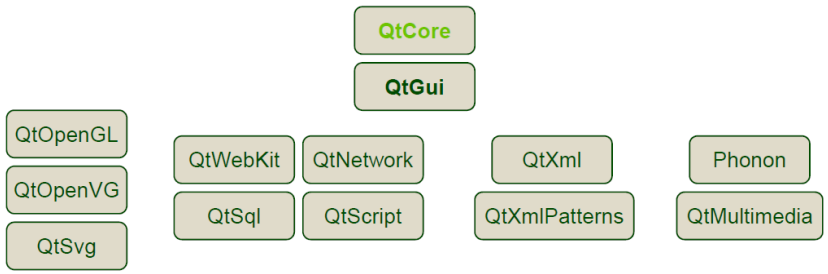
- Qt is made up of modules

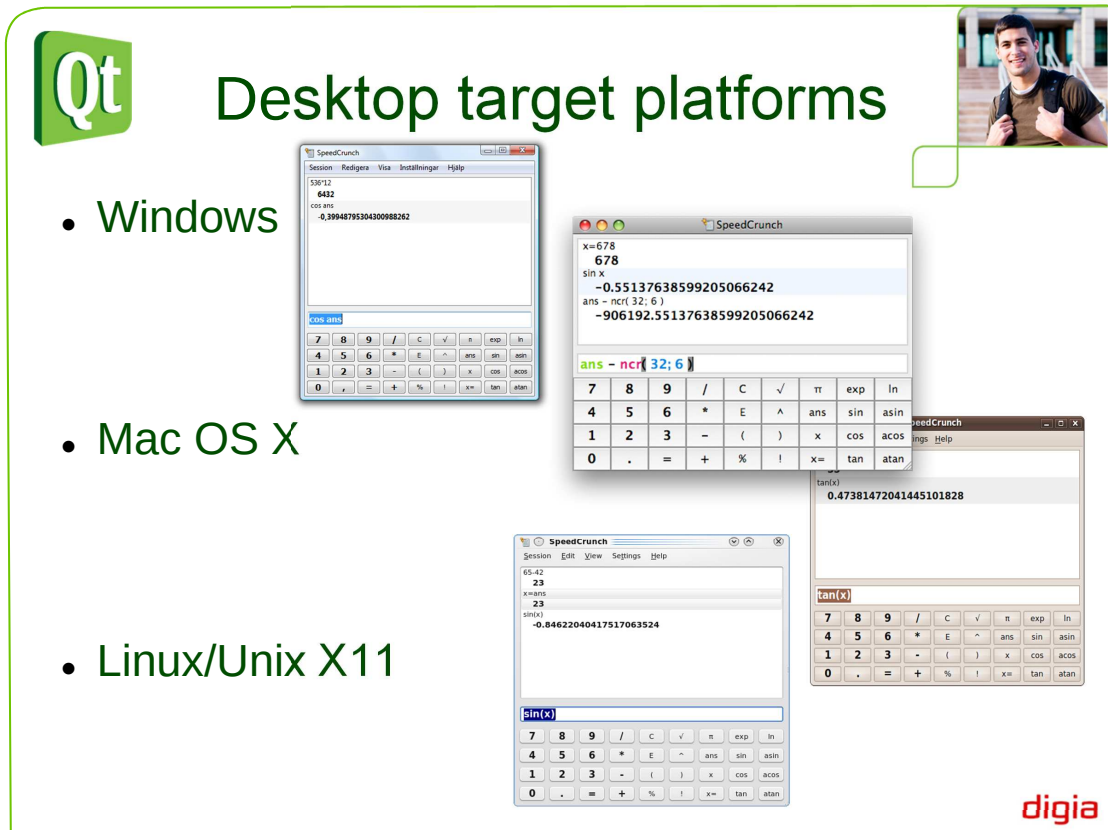


The purpose of Qt

- Cross platform applications built from one source

The purpose of Qt

- Cross platform applications built from one source
- Builds native applications with native look and feel



Qt is used everywhere

From embedded devices to desktop applications

By companies from many industries

AMD, Google, Canon, Alcatel·Lucent, BT, DAIMLER, EPSON, esa, freescale semiconductor, HITACHI Inspire the Next, GENERAL DYNAMICS C4 Systems, Mentor Graphics, PGS, HONDA The Power of Dreams, MITSUBISHI HEAVY INDUSTRIES, LTD., NORTEL NETWORKS, ORACLE, PHILIPS, Pioneer, skype, Raytheon, Schlumberger, ROHDE&SCHWARZ, SCANIA, SENNHEISER, SHARP, xerox, VOLVO, vodafone, THOMSON REUTERS

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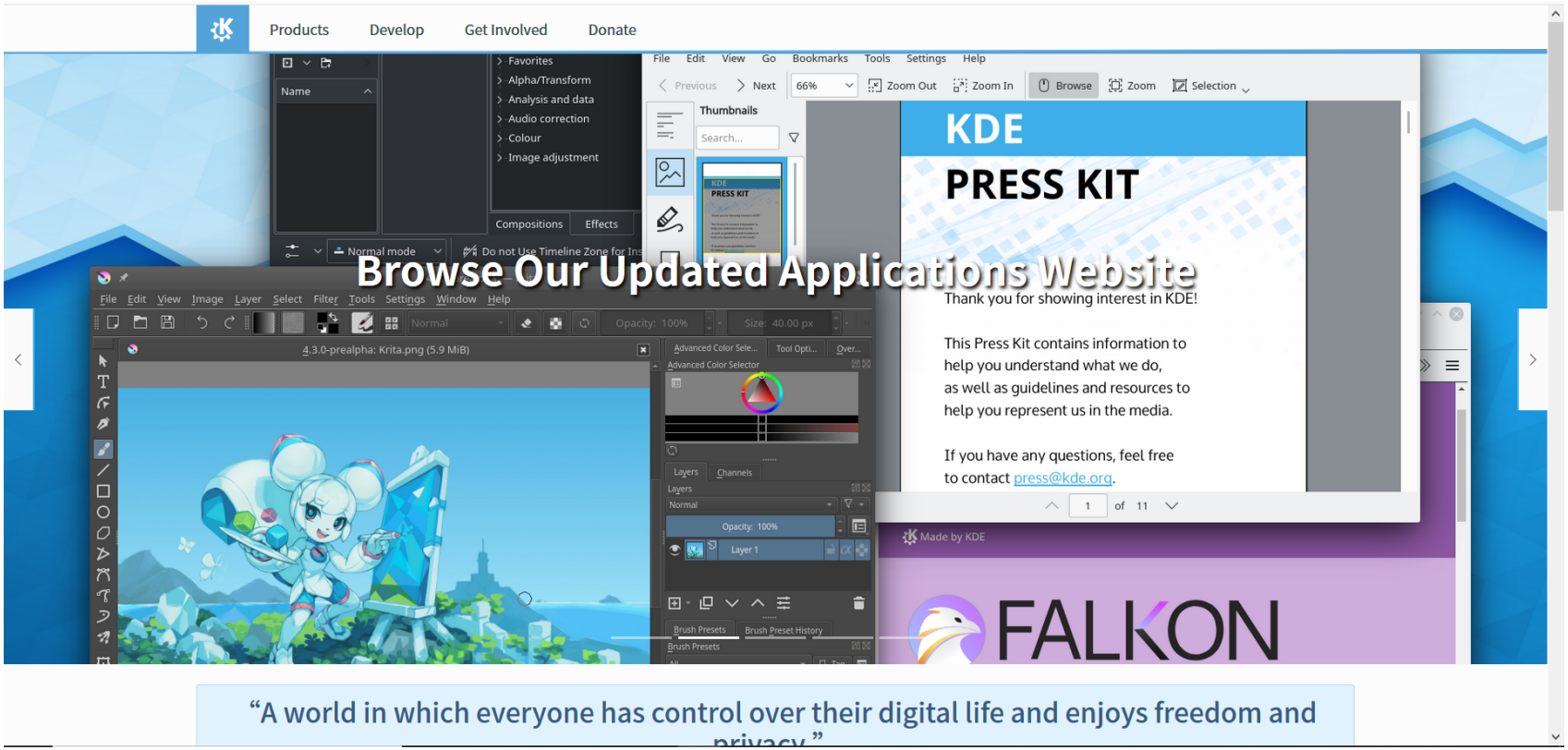
KDE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"A world in which everyone has control over their digital life and enjoys freedom and privacy"

Conclusion

- In this lecture, we have discussed the underlying mechanism (signals and slots) of Qt

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- In this lecture, we have discussed the underlying mechanism (signals and slots) of Qt
- Please follow the walkthrough posted online and install Qt environment on your computer