DESKTOP GUI

HOW GUI APPLICATIONS WORK?

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- GUI is only redrawn after an event happens (keyboard, mouse, network, timer, ...)
- without events the application sleeps

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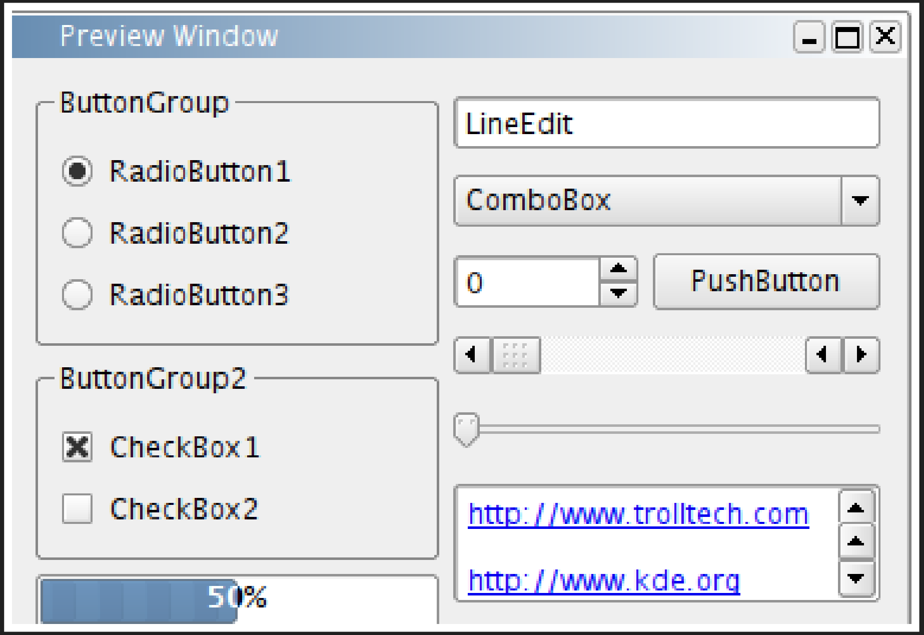
- Together they form a tree of widgets with parent/child relationships
- Composite design pattern
- Sometimes the hierarchy is specified with XML files or UI designer app

HOW THE HIERARCHY LOOKS IN (PSEUDO)CODE?

```
window = Window()
row = Row()                           # widget container
row.add(Button("Click me!"))  # add widgets to container
row.add(Label("Hello world"))
window.add(row)
```

TYPICAL WIDGETS



- Button
- Label
- TextInput
- Checkbox/Radio
- ComboBox
- ...

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def on_button_click():
  print("button was clicked")
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```
def on_button_click():
  print("button was clicked")

app = Window()
btn = Button("Click me!")
btn.onclick.set_callback(on_button_click)
app.add(btn)
app.mainloop()
```

GUI FRAMEWORKS

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- Common widget implementation
- Should be multi-platform
- You don't want to implement this yourself

GUI FRAMEWORKS

- **Qt** (C++, Python, cross-platform)
- GTK (C++, Python, cross-platform)
- WxWidgets (C++, Python, cross-platform)
- Tcl/Tk (Python, Perl, Ruby, cross-platform)
- WinForms/WPF (C#, Windows)
- AWT/Swing/SWT/JavaFX (Java, cross-platform)
- Cocoa (Objective C, OS X/iOS)
- ...

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- VLC player
- and many others...

- We will use Qt 5 with Python binding PyQt5

```
$ pip install PyQt5
```

MINIMAL QT APP

```python
from PyQt5.QtWidgets import QApplication, QPushButton

app = QApplication()
button = QPushButton("Hi!")
button.show()   # tells the button to be visible
app.exec_()     # start the GUI loop
```

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window = QWidget()
window.setLayout(layout)
window.show()
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  MyEvent = pyqtSignal(int, int)

  def fn():
    self.MyEvent.emit(1, 2)
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widget = MyWidget()
widget.MyEvent.connect(lambda x, y: print(x + y))
widget.fn()  # prints 3
```

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```
class LikeCountDisplay(QWidget):
  def __init__(self, state):
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counter = LikeCounter(tweet)
widget = LikeCountDisplay(counter)
...                    # sometime later
counter.add_like()     # widget is refreshed automatically
```

2D DRAWING

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```
class MyWidget(QWidget):
  def paintEvent(self, *args, **kwargs):
    painter = QPainter(self)

    # pen is used for drawing (rectangle edges)
    painter.setPen(QColor.fromRgb(255, 0, 0))
    painter.drawRect(x1, y1, width, height)

    # brush is used for filling (rectangle area)
    painter.setBrush(QColor("red"))
    painter.fillRect(x, y, width, height)
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```
painter.save()    # save painter attributes to an internal sta
painter.setPen(QPen(QColor.fromRgb(255, 0, 0))) # set red pen
painter.drawLine(x1, y1, x2, y2)  # draw red line
painter.restore() # revert to the original state
```

UI/LOGIC SEPARATION

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```
class GameBoard(QWidget):
  def mousePressEvent(self, event):
    x = event.x()
    y = event.y()
    cell = self.board[x][y]
    if cell == Empty:
      self.board[x][y] = Cross
    if self.check_win():
      print("game ended")

  def check_win():
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App (game) logic is combined with UI code!

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```
class GameBoard(QWidget):                    # game logic is bound to U
  def mousePressEvent(self, event): # input is bound to mouse
    x = event.x()
    y = event.y()
    cell = self.board[x][y]
    if cell == Empty:
      self.board[x][y] = Cross
    if self.check_win():
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- want to run game as a multiplayer server without UI? rewrite
- want to test the game code? rewrite
- want to support multiple UI outputs (console, web, desktop GUI)? rewrite
- want to change the GUI framework? rewrite
- want to change the game code? must touch the UI code

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- separate UI code and logic (domain) code
- the game code should not know anything about the UI
- dependency inversion - observer pattern again very useful

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class Game: # in separate file, knows nothing about the UI
  def move(self, x, y): pass
  def set_on_move_listener(self, listener): pass
```

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- separate UI code and logic (domain) code
- the game code should not know anything about the UI
- dependency inversion - observer pattern again very useful

```
class Game: # in separate file, knows nothing about the UI
  def move(self, x, y): pass
  def set_on_move_listener(self, listener): pass

class GameBoard(QWidget):
  def __init__(self, game):
    self.game = game
    self.game.set_on_move_listener(lambda: self.redraw())
  def mousePressEvent(self, event):
    x = event.x()
    y = event.y()
    self.game.move(x, y)
    if self.game.check_win():
      print("game ended")
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