GUIs

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Overview

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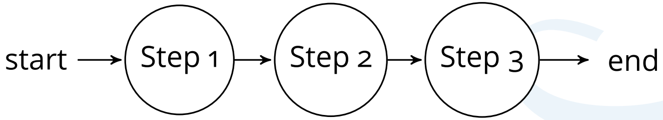
Event driven

C

You're programs so far have followed a procedural pattern.

- Program is a series of steps.
- Moves through those steps in a predetermined pattern.
- Expects user input in a very specific order.



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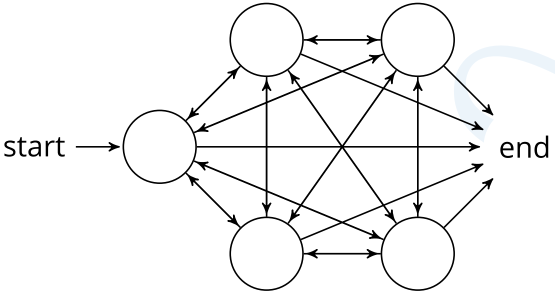
Event driven II

C

Going to look at event driven programming.

- Program reacts to events.
- Events have actions associated with them.
- Order and frequency of events is unpredictable.
- Does not have a predefined sequence of actions to perform.
- Does not have a predefined end.



Benefits

C

What sort of applications would benefit from an event driven paradigm?

Benefits

C

What sort of applications would benefit from an event driven paradigm?

- GUIs
- Control systems
- Embedded systems

Events examples

C

GUI events would include...

- Button presses
- Text entry
- Keyboard events
    - Pressing a key
    - Releasing a key
- Mouse events
    - Pressing a button
    - Releasing a button
    - Moving
    - Scrolling

Hello World!

C

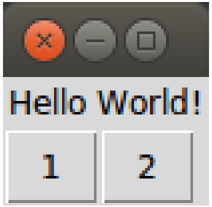
How to create a GUI.

- Wide range of different libraries available.
    - Depends on language and platform.
- Tkinter is the built-in Python default.

Terminology

C

- Window
- Component/widget/element



Hello World!

C

```
import sys
from tkinter import *

def main():
    root = Tk()

    label = Label(root, text='Hello World!')
    label.pack()

    root.mainloop()

if __name__ == '__main__':
    sys.exit(main())
```

lec_getting_started.py

Hello World!

C

```
import sys
from tkinter import *

def main():
    root = Tk()

    label = Label(root, text='Hello World!')
    label.pack()

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if __name__ == '__main__':
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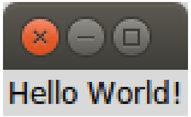
lec_getting_started.py


Hello World!

Classes

I

GUI code should be structured as a class.

- Become clear later.

```
class Gui:
    def __init__(self, root):
        self.root = root

        self.label = Label(self.root, \
                           text='Hello World!')
        self.label.pack()

def main():
    root = Tk()
    gui = Gui(root)
    root.mainloop()
```

lec_classes.py

Layout

C

So far we have seen how elements are added to window.

```
class Gui:
    def __init__(self, root):
        self.root = root

        for i in range(1,10):
            button = Button(self.root, text=i)
            button.pack()
```
lec_layout.py

Layout

C

So far we have seen how elements are added to window.

```
class Gui:
    def __init__(self, root):
        self.root = root

        for i in range(1,10):
            button = Button(self.root, text=i)
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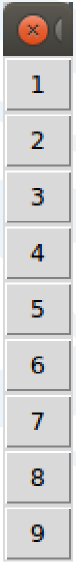
lec_layout.py



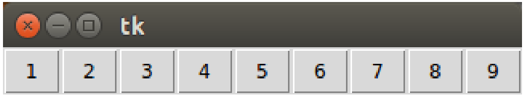
Layout II

Can use the `side` parameter for `.pack()`.

- `TOP` (default).
- Also `LEFT`, `RIGHT` and `BOTTOM`.

```
class Gui:
    def __init__(self, root):
        self.root = root

        for i in range(1,10):
            button = Button(self.root, text=i)
            button.pack(side=LEFT)
```

lec_layout2.py



Layout III

I

Use `side` to control layout?

```
class Gui:
  def __init__(self, root):
    self.root = root

    Button(self.root, text=1).pack(side=TOP)
    Button(self.root, text=2).pack(side=LEFT)
    Button(self.root, text=3).pack(side=LEFT)
    Button(self.root, text=4).pack(side=TOP)
    Button(self.root, text=5).pack(side=LEFT)
    Button(self.root, text=6).pack(side=LEFT)
    Button(self.root, text=7).pack(side=TOP)
    Button(self.root, text=8).pack(side=LEFT)
    Button(self.root, text=9).pack(side=LEFT)
```

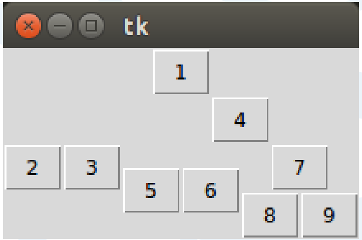
lec_layout3.py

Layout III

Use `side` to control layout?

```
class Gui:
  def __init__(self, root):
    self.root = root

    Button(self.root, text=1).pack(side=TOP)
    Button(self.root, text=2).pack(side=LEFT)
    Button(self.root, text=3).pack(side=LEFT)
    Button(self.root, text=4).pack(side=TOP)
    Button(self.root, text=5).pack(side=LEFT)
    Button(self.root, text=6).pack(side=LEFT)
    Button(self.root, text=7).pack(side=TOP)
    Button(self.root, text=8).pack(side=LEFT)
    Button(self.root, text=9).pack(side=LEFT)
```

lec_layout3.py



Containers

C

Need to learn about containers.

- Windows are containers.
  - Elements are 'contained' inside.
- Tkinter also has frames.
  - Special type of element.
  - Contains other elements.
- Group elements together using frames.
  - Can be visible/invisible.

Frames

I

```
class Gui:
  def __init__(self, root):
    self.root = root

    self.frame1 = Frame(self.root)
    self.frame1.pack()

    self.frame2 = Frame(self.root)
    self.frame2.pack()
```

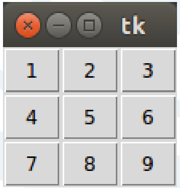
```
    Button(self.frame1, text=1).pack(side=LEFT)
    Button(self.frame1, text=2).pack(side=LEFT)
    Button(self.frame1, text=3).pack(side=LEFT)
```

```
    Button(self.frame3, text=7).pack(side=LEFT)
    Button(self.frame3, text=8).pack(side=LEFT)
    Button(self.frame3, text=9).pack(side=LEFT)
```

lec_frames.py

Frames

```
class Gui:
  def __init__(self, root):
    self.root = root

    self.frame1 = Frame(self.root)
    self.frame1.pack()

    self.frame2 = Frame(self.root)
    self.frame2.pack()
```



```
    Button(self.frame1, text=1).pack(side=LEFT)
    Button(self.frame1, text=2).pack(side=LEFT)
    Button(self.frame1, text=3).pack(side=LEFT)
```

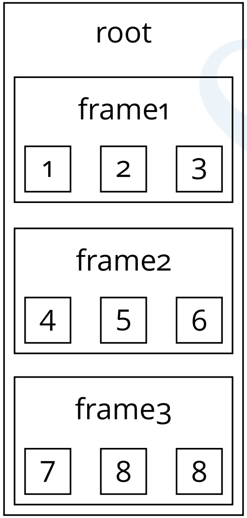
```
    Button(self.frame3, text=7).pack(side=LEFT)
    Button(self.frame3, text=8).pack(side=LEFT)
    Button(self.frame3, text=9).pack(side=LEFT)
```

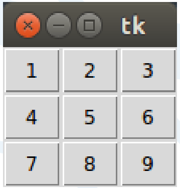
lec_frames.py

Nesting

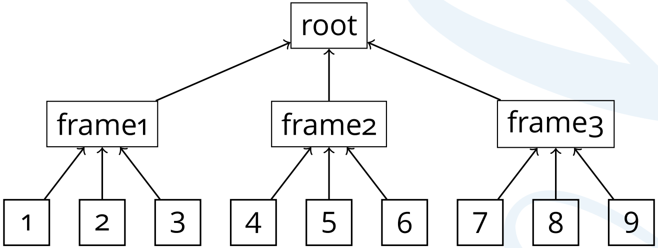
So what's happening?

- Elements are nested in containers.
- Containers are nested in other containers.





Hierarchical structure



$$\begin{tikzcd}
 & & & & root & & & & \\
 & frame1 \arrow[urrr] & & & frame2 \arrow[u] & & & frame3 \arrow[ulll] & \\
1 \arrow[ur] & 2 \arrow[u] & 3 \arrow[ul] & 4 \arrow[ur] & 5 \arrow[u] & 6 \arrow[ul] & 7 \arrow[ur] & 8 \arrow[u] & 9 \arrow[ul]
\end{tikzcd}$$

Events

C

How do we get our code to actually DO stuff?

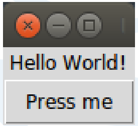
- Using Python/Tkinter.
- Other languages/frameworks == different syntax.
  - Same concepts.
- Event handling.
  - Bind events to elements.

Events II

C

```
class Gui:
  def __init__(self, root):
    self.root = root

    self.label = Label(self.root, text='Hello World!')
    self.label.pack()

    self.button = Button(self.root, text='Press me')
    self.button.bind('<Button-1>', self.say_bye)
    self.button.pack()

  def say_bye(self, event):
    self.label.config(text='Bye!')
```

lec_events.py

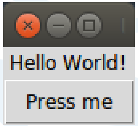


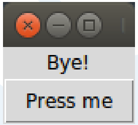
Events II

C

```
class Gui:
  def __init__(self, root):
    self.root = root

    self.label = Label(self.root, text='Hello World!')
    self.label.pack()

    self.button = Button(self.root, text='Press me')
    self.button.bind('<Button-1>', self.say_bye)
    self.button.pack()

  def say_bye(self, event):
    self.label.config(text='Bye!')
```

lec_events.py





Callbacks

C

Callbacks are how we respond to events.

- Functions that are passed to another function as an argument.

```
class Gui:
    def __init__(self, root):
        self.root = root

        self.label = Label(self.root, text='Hello World!')
        self.label.pack()

        self.button = Button(self.root, text='Press me')
        self.button.bind('<Button-1>', self.say_bye)
        self.button.pack()

    def say_bye(self, event):
        self.label.config(text='Bye!')
```
lec_events.py

$$\text{User} \longrightarrow \text{Event} \longrightarrow \text{Listener} \longrightarrow \text{Callback}$$

Standard behaviour

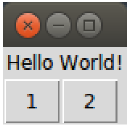
User actions can trigger multiple events.

- I.e. clicking on button.
  1. Press LMB whilst pointer over button.
  2. Release LMB whilst pointer over button.
- Standard interaction code included in Tkinter.
  - Use `command` parameter.

```
class Gui:
    def __init__(self, root):
        self.root = root

        self.button = Button(self.root, text='Press me' , \
                                command=self.say_bye)
        self.button.pack()

    def say_bye(self):
        self.label.config(text='Bye!')
```

lec_events2.py

Event arguments



```
class Gui:
    def __init__(self, root):
```

```
        Button(self.root, text='1', \
            command=self.pressed_1).pack(side=LEFT)
        Button(self.root, text='2', \
            command=self.pressed_2).pack(side=LEFT)

    def pressed_1(self):
        self.label.config(text='Pressed 1')

    def pressed_2(self):
        self.label.config(text='Pressed 2')
```

lec_event_args.py

Event arguments II

I

Much better to have one function.

- Function takes argument.
- Reuse of each button.

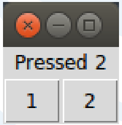
```
class Gui:
    def __init__(self, root):

        Button(self.root, text='1', \
            command=self.pressed_button(1)).pack(side=LEFT)
        Button(self.root, text='2', \
            command=self.pressed_button(2)).pack(side=LEFT)

    def pressed_button(self, number):
        self.label.config(text='Pressed %d' % number)
```

lec_event_args2.py

Event arguments II

Much better to have one function.

- Function takes argument.
- Reuse of each button.
- Doesn't work.
    - Calls function immediately.
- DEMO



```
class Gui:
    def __init__(self, root):
```

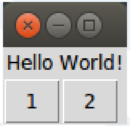
```
        Button(self.root, text='1', \
            command=self.pressed_button(1)).pack(side=LEFT)
        Button(self.root, text='2', \
            command=self.pressed_button(2)).pack(side=LEFT)

    def pressed_button(self, number):
        self.label.config(text='Pressed %d' % number)
```

lec_event_args2.py

Event arguments III

lambda functions.

- Only calls function when button is pressed.



```
class Gui:
    def __init__(self, root):
```

```
        Button(self.root, text='1', \
            command=lambda: self.pressed_button(1)).pack(side=LEFT)
        Button(self.root, text='2', \
            command=lambda: self.pressed_button(2)).pack(side=LEFT)

    def pressed_button(self, number):
        self.label.config(text='Pressed %d' % number)
```

lec_event_args3.py

Loops

A

Already seen we can use create elements in loops.

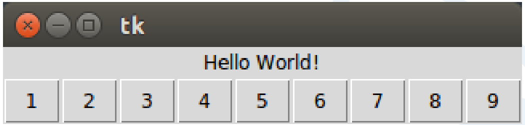
- Create lots of elements easily.
- How can we combine this with callback arguments?

Loop arguments

A

`lambda` function in loop.

- What happens when any button is pressed?



```
class Gui:
  def __init__(self, root):

      for i in range(1,10):
          b = Button(self.root, text=i, \
             command=lambda: self.pressed_button(i))
          b.pack(side=LEFT)

  def pressed_button(self, number):
      self.label.config(text='Pressed %d' % number)
```

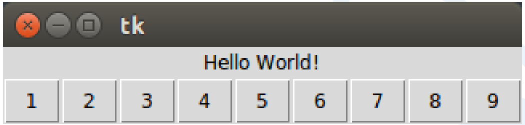
lec_loop_args.py

Loop arguments

A

`lambda` function in loop.

- What happens when any button is pressed?
  - DEMO.



```
class Gui:
    def __init__(self, root):
```

```
        for i in range(1,10):
            b = Button(self.root, text=i, \
                command=lambda: self.pressed_button(i))
            b.pack(side=LEFT)

    def pressed_button(self, number):
        self.label.config(text='Pressed %d' % number)
```

lec_loop_args.py

Loop arguments II

A

```
for i in range(1,10):
    b = Button(self.root, text=i, \
        command=lambda: self.pressed_button(i))
    b.pack(side=LEFT)
```

lec_loop_args.py

- Each button will call a `lamda` function when pressed.
- The `lambda` function will call `self.pressed_button(i)`.
- `pressed_button()` will change the label using the value of `i`.

Loop arguments II

A

```
  for i in range(1,10):
      b = Button(self.root, text=i, \
          command=lambda: self.pressed_button(i))
      b.pack(side=LEFT)
```

lec_loop_args.py

- Each button will call a `lamda` function when pressed.
- The `lambda` function will call `self.pressed_button(i)`.
- `pressed_button()` will change the label using the value of `i`.
    - What is the value of `i`?

Loop arguments II

A

```
    for i in range(1,10):
        b = Button(self.root, text=i, \
            command=lambda: self.pressed_button(i))
        b.pack(side=LEFT)
```

lec_loop_args.py

- Each button will call a `lamda` function when pressed.
- The `lambda` function will call `self.pressed_button(i)`.
- `pressed_button()` will change the label using the value of `i`.
  - What is the value of `i`?
- It's whatever it was at the end of the loop, i.e. `9`.
  - No matter what button we press, `i` is always `9`.

Loop arguments III

A

`lamda` arguments.

- The `lambda` function for each button copies the value of `i` right then.
- Uses that value when it runs in the future.

```python
class Gui:
  def __init__(self, root):

    for i in range(1,10):
      b = Button(self.root, text=i, \
        command=lambda n=i: self.pressed_button(n))
      b.pack(side=LEFT)

  def pressed_button(self, number):
    self.label.config(text='Pressed %d' % number)
```

lec_loop_args2.py

Quiz

Recap

- 🟢 GUIs are an example of event driven programming.
- 🟢 GUI elements are arranged in containers.
- 🟡 Containers can hold other containers.
- 🟢 User actions generate events.
- 🟢 Callbacks are functions that are run in response to events.

The End