

GUIs

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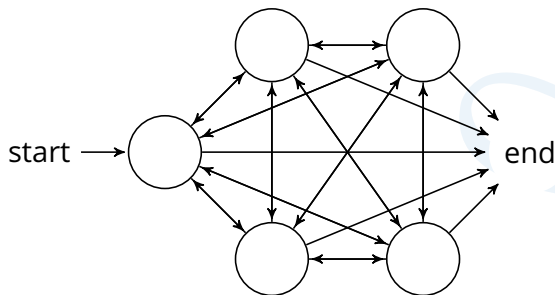
You're programs so far have followed a procedural pattern.

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



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.



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

- GUIs
- Control systems
- Embedded systems

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

How to create a GUI.

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

Terminology

- Window
- Component/widget/element


```
import sys
from tkinter import *

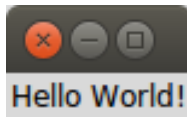
def main():
    root = Tk()

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

    root.mainloop()

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

lec_getting_started.py



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

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

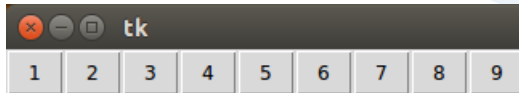


Can use the side parameter for `.pack()`.

- 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



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

Need to learn about containers.

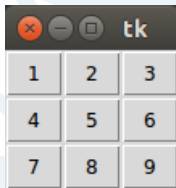
- Windows are containers.
 - Elements are 'contained' inside.
- Tkinter also has frames.
 - Special type of element.
 - Contains other elements.
- Group elements together using frames.
 - Can be visible/invisible.

Frames

```
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()
```

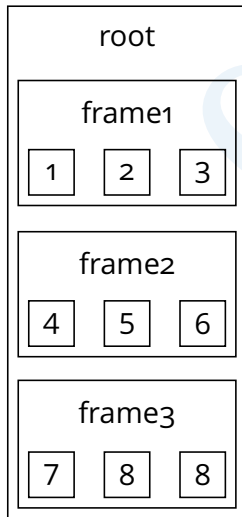


```
Button(self.frame1, text=1).pack(side=LEFT)
Button(self.frame1, text=2).pack(side=LEFT)
Button(self.frame1, text=3).pack(side=LEFT)
```

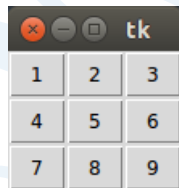
```
Button(self.frame3, text=7).pack(side=LEFT)
Button(self.frame3, text=8).pack(side=LEFT)
Button(self.frame3, text=9).pack(side=LEFT)
```

So what's happening?

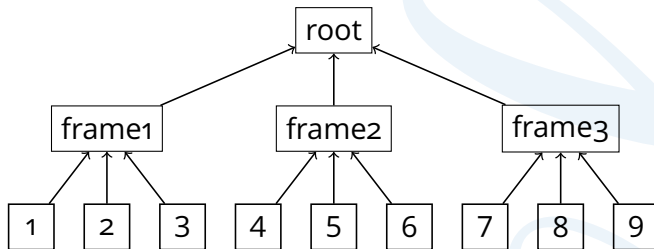
- Elements are nested in containers.
- Containers are nested in other containers.



Nesting



Hierarchical structure



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.

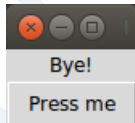
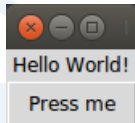
```
class Gui:
    def __init__(self, root):
        self.root = root

        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 are how we respond to events.

```
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

User → Event → Listener → Callback

User actions can trigger multiple events.

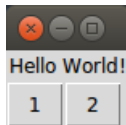
- I.e. clicking on button.
 - 1 Press LMB whilst pointer over button.
 - 2 Release LMB whilst pointer over button.
- Standard interaction code included in Tkinter.
 - Use `command` parameter.

```
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



```
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)
```

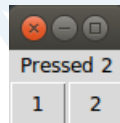
```
    def pressed_1(self):
        self.label.config(text='Pressed 1')
```

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

Event arguments II

Much better to have one function.

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



```
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)

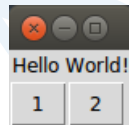
    def pressed_button(self, number):
        self.label.config(text='Pressed %d' % number)
```

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

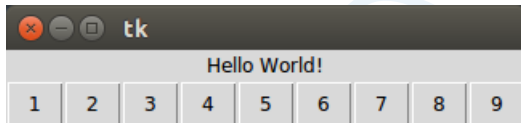
Already seen we can use create elements in loops.

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

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

```
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 lambda 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.

lambda arguments.

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

```
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

- 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