Programming Languages and Techniques (CIS120)

Lecture 20

GUI: Events & State
Chapter 18

Announcements

- HW5: GUI programming
  - Due: Tuesday, October 22nd at 11:59 pm
  - The project is structured as *tasks*, not *files* (one task may touch multiple files)

- Java Bootcamp
  - Wednesday, October 23rd 6:00-8:00PM
  - Towne 100
  - Java refresher / crash course: basic syntax, fields & methods, arrays, Eclipse setup, using the debugger

  - *Please respond to poll on Piazza if you plan to attend*

How far along are you in HW05: GUI Programming?

Not started yet

Task 0 finished

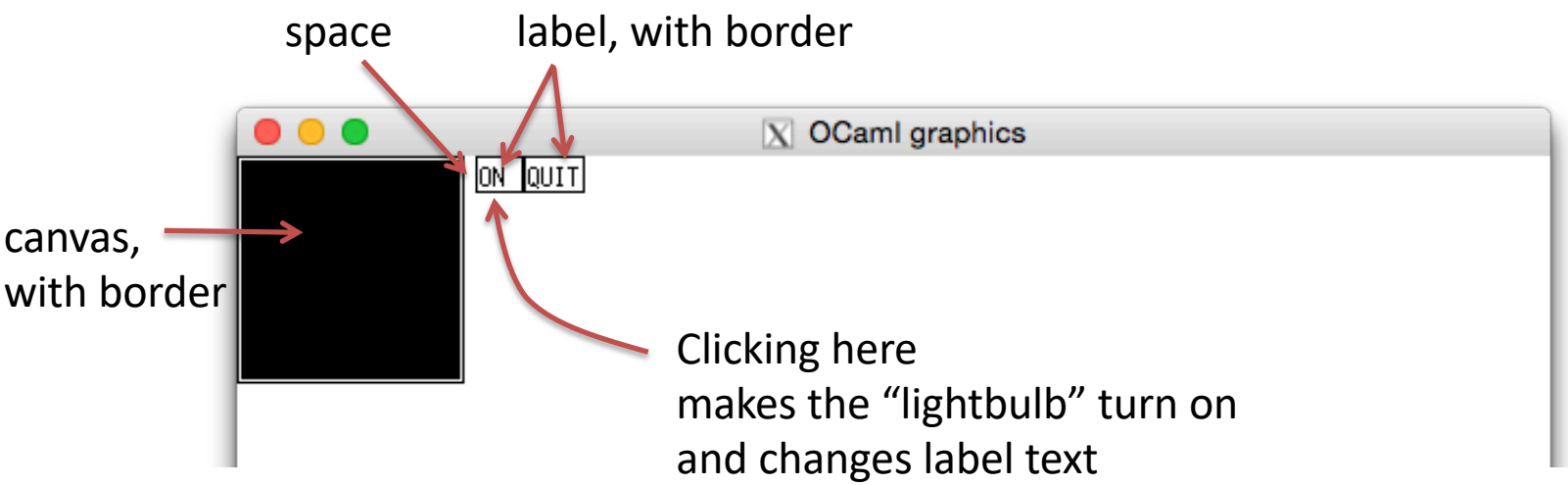
Working on tasks 1-4

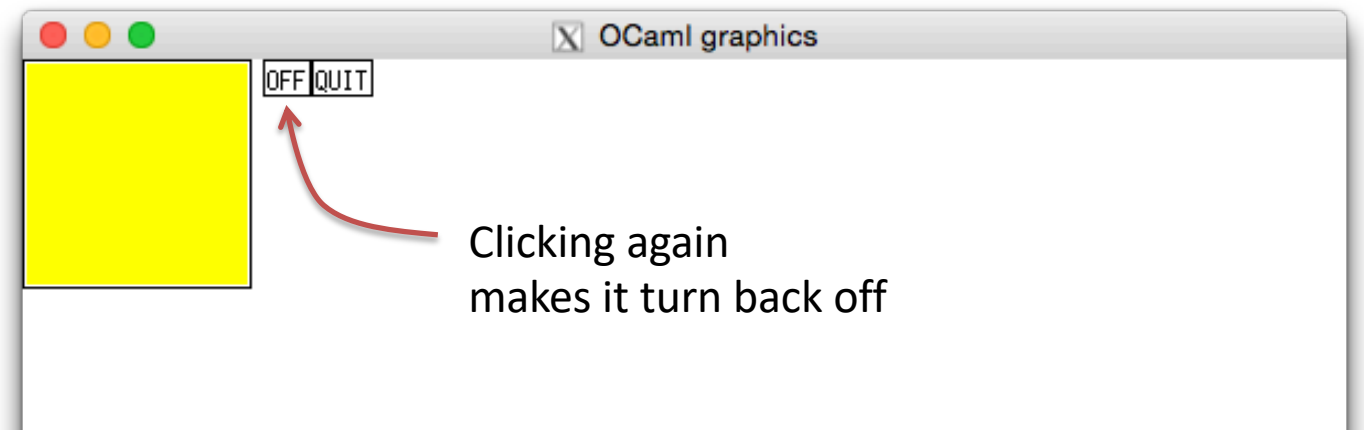
Working on Task 5

Working on Task 6

All done!

lightbulb demo





Reactive Widgets

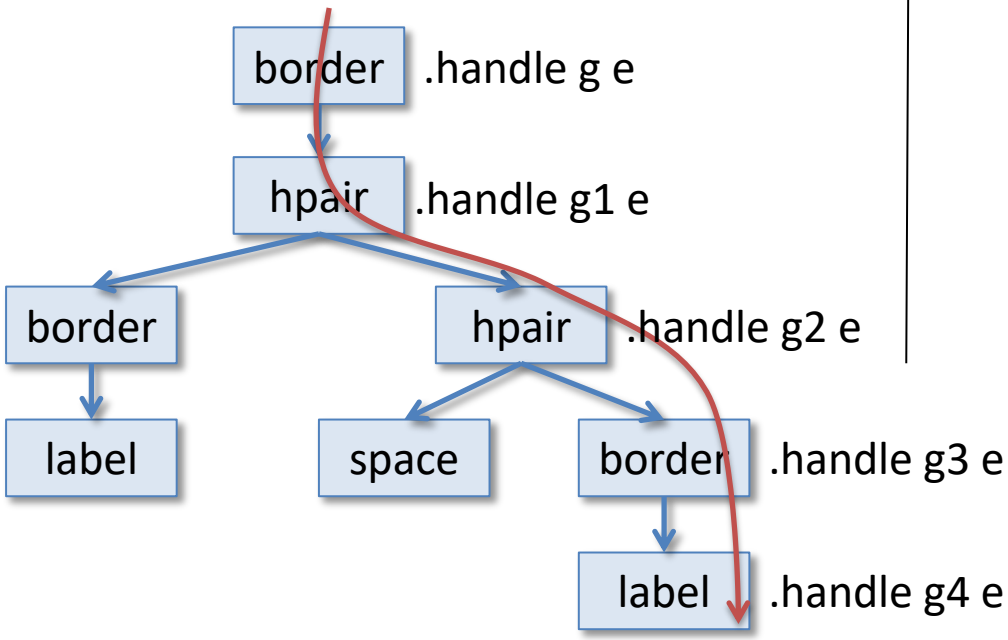
widget.mli

```
type widget = {
  repaint : Gctx.gctx -> unit;
  size    : unit -> Gctx.dimension;
  handle  : Gctx.gctx -> Gctx.event -> unit
}
```

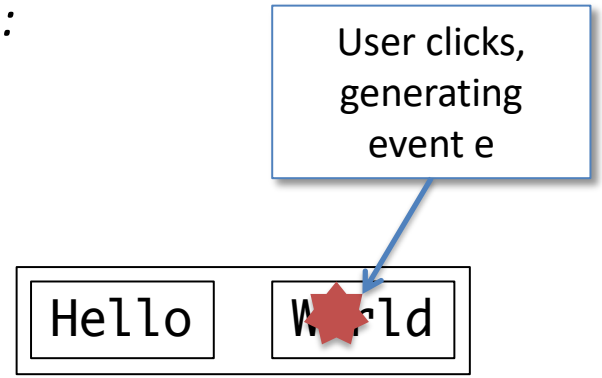
- Widgets now have a “method” for handling events
  - The eventloop waits for an event and then gives it to the root widget
  - The widgets forward the event down the tree, according to the position of the event

Event-handling: Containers

Container widgets propagate events to their children:



Widget tree



On the screen

Routing events through container widgets

Event Handling: Routing

- When a container widget handles an event, it passes the event to the appropriate child
- The Gctx.gctx must be translated so that the child can interpret the event in its own local coordinates.

widget.ml

```
let border (w:widget):widget =
  { repaint = …;
    size = …;
    handle = (fun (g:Gctx.gctx) (e:Gctx.event) ->
        w.handle (Gctx.translate g (2,2)) e);
  }
```

Consider routing an event through an hpair widget constructed as shown. The event will always be propagated either to w1 or w2.

```
let hp = hpair w1 w2
```

True

False

Consider routing an event through an hpair widget constructed by:

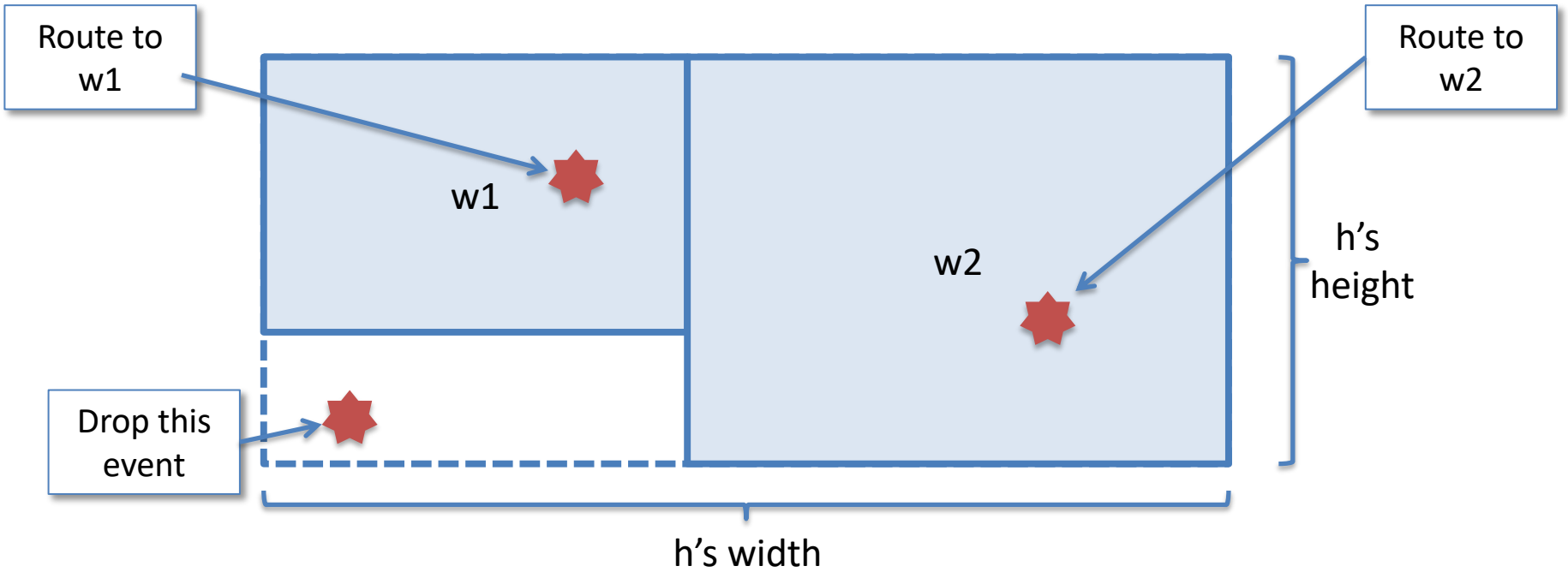
```
let hp = hpair w1 w2
```

The event will always be propagated either to w1 or w2.

1. True
2. False

Answer: False

Routing events through hpair widgets



- There are three cases for routing in an hpair.
- An event in the "empty area" should not be sent to either w1 or w2.

Routing events through hpair widgets

- The event handler of an hpair must check to see whether the event should be handled by the left or right widget.
  - Check the event's coordinates against the *size* of the left widget
  - If the event is within the left widget, let it handle the event
  - Otherwise check the event's coordinates against the right child's
  - If the right child gets the event, don't forget to translate its coordinates

```
handle =
 (fun (g:Gctx.gctx) (e:Gctx.event) ->
   if event_within g e (w1.size ())
   then w1.handle g e
   else
   let g = (Gctx.translate g (fst (w1.size ()), 0)) in
     if event_within g e (w2.size ())
     then w2.handle g e
     else ())
```

Stateful Widgets

How can widgets react to events?

(not very useful first stab at a)

A stateful label Widget

```
let label (s: string) : widget =
  let r = { contents = s } in
  { repaint = (fun (g: Gctx.gctx) ->
                 Gctx.draw_string g (0,0) r.contents);
    handle  = (fun _ _ -> ());
    size    = (fun () -> Gctx.text_size r.contents)
  }
```

- The label object can make its string mutable. The methods can refer to this mutable string.
- But how can we change this string in response to an event?

A stateful `label` Widget

widget.ml

```
type label_controller = { set_label: string -> unit }

let label (s: string) : widget * label_controller =
  let r = { contents = s } in
    ({ repaint = (fun (g: Gctx.gctx) ->
                  Gctx.draw_string g (0,0) r.contents);
       handle  = (fun _ _ -> ());
       size    = (fun () -> Gctx.text_size r.contents)
     }
    ,
    { set_label = fun (s: string) -> r.contents <- s })
```

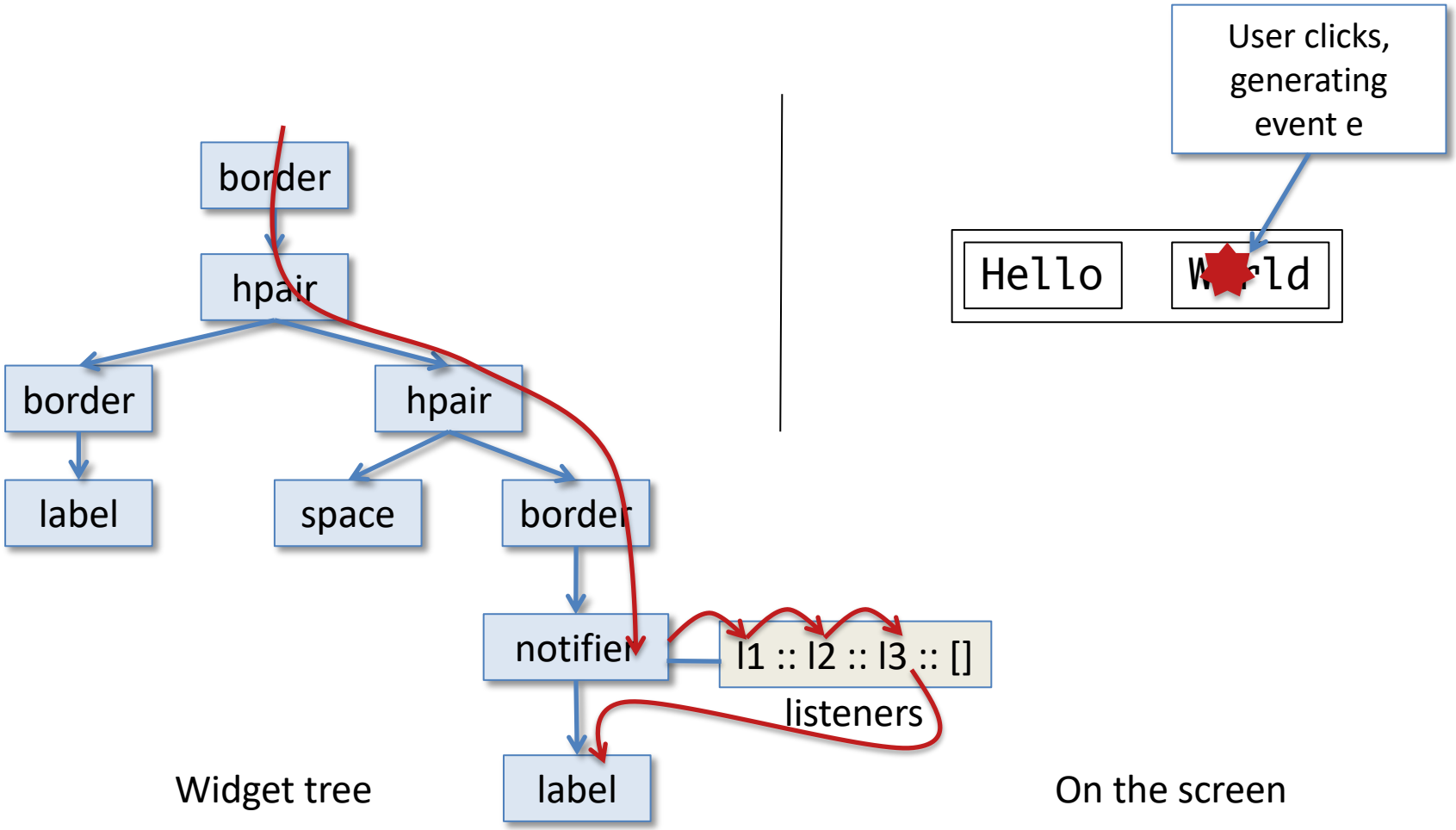
- A label consists of two parts: the widget and its controller
- A *controller* gives access to the shared state.
  - Here, the `label_controller` object returned by `label` provides a way to set the label string

See notifierdemo.ml

(distributed with the homework)

EVENT LISTENERS

Listeners and Notifiers Pictorially



Handling multiple event types

- Problem: *Widgets may want to react to many different events*
- Example: Button
  - button click: changes the state of the paint program and button label
  - mouse movement: tooltip? highlight?
  - key press: provide keyboard access to the button functionality?
- These reactions should be independent
  - Each sort of event handled by a different *event listener* (i.e. a first-class function)
  - Reactive widgets may have *several* listeners to handle a triggered event
  - Listeners react in sequence, all have a chance to see the event
- Solution: notifier

True or False: One can use a notifier and label to create a button that toggles the states of two separte lightbulb canvases.

True or False: One can use a notifier and label to create a button that toggles the states of *two* separate lightbulb canvases.

Answer: True

Listeners

widget.ml

```
type event_listener = Gctx.gctx -> Gctx.event -> unit

(* Performs an action upon receiving a mouse click. *)
let mouseclick_listener (action: unit -> unit)
                        : event_listener =
  fun (g:Gctx.gctx) (e: Gctx.event) ->
    if Gctx.event_type e = Gctx.MouseDown
    then action ()
```

Notifiers

- A *notifier* is a container widget that adds event listeners to a node in the widget hierarchy
  - Note: this way of structuring event listeners is based on Java's Swing Library design (we use Swing terminology).
- *Event listeners* "eavesdrop" on the events flowing through the notifier
  - The event listeners are stored in a list
  - They react in order
  - Then the event is passed down to the child widget
- Event listeners can be added by using a notifier_controller

Notifiers and Notifier Controllers

widget.ml

```
type notifier_controller =
     { add_listener : event_listener -> unit }

let notifier (w: widget) : widget * notifier_controller =
  let listeners = { contents = [] } in
  { repaint = w.repaint;
    size    = w.size
    handle  =
      (fun (g: Gctx.gctx) (e: Gctx.event) ->
          List.iter (fun h -> h g e) listeners.contents;
          w.handle g e);
  },
  { add_event_listener =
      fun (newl: event_listener) ->
          listeners.contents <-
                 newl :: listeners.contents
  }
```

Loop through the list of listeners, allowing each one to process the event. Then pass the event to the child.

The notifier_controller allows new listeners to be added to the list.

Buttons (at last!)

widget.ml

```
(* A text button *)
let button (s: string) : widget
                       * label_controller
                       * notifier_controller =
  let (w, lc)  = label s in
  let (w', nc) = notifier w in
    (w', lc, nc)
```

- A button widget is just a label wrapped in a notifier
- Add a mouseclick_listener to the button using the notifier_controller
- (For aesthetic purposes, we could also put a border around the label widget.)

onoff.ml — changing state on a button click

DEMO: ONOFF