

How to Design Programs

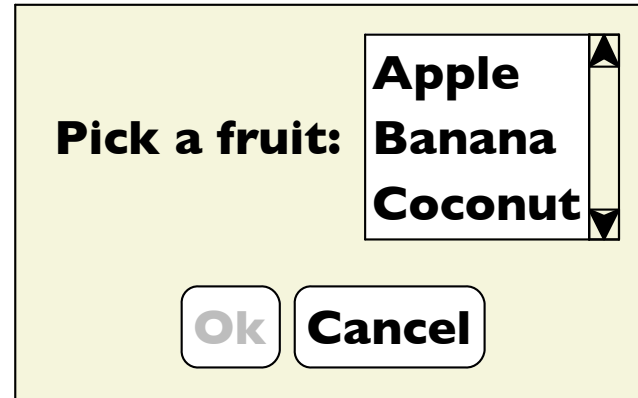
How to (in Scheme):

- represent data
 - variants
 - trees and lists
- write functions that process the data

See also

<http://www.htdp.org/>

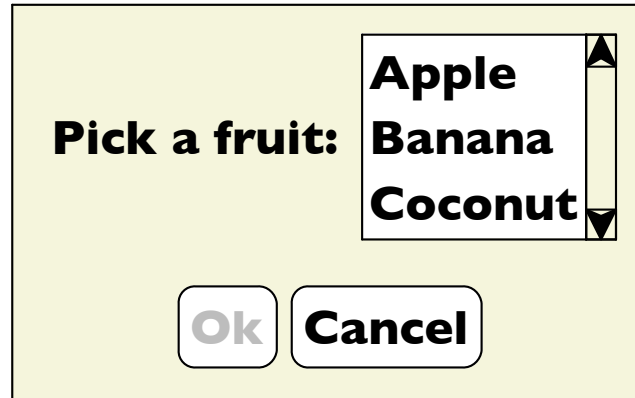
Running Example: GUIs



Possible programs:

- Can click?
- Find a label
- Read screen

Representing GUIs



- labels
 - a label string
- buttons
 - a label string
 - enabled state
- lists
 - a list of choice strings
 - selected item

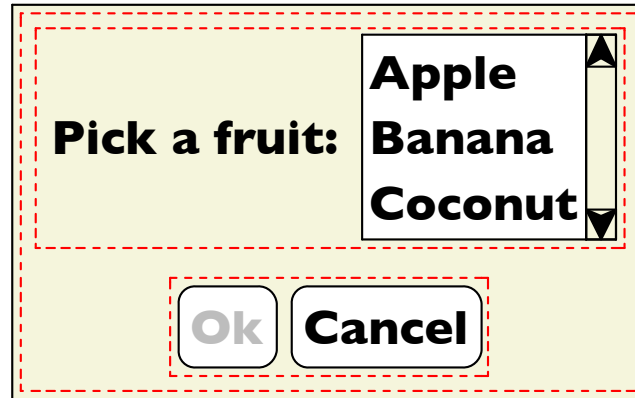
```
(define-type GUI  
  [label (text string?)]  
  [button (text string?)  
          (enabled? boolean?)]  
  [choice (items (listof string?))  
          (selected integer?)])
```

Read Screen

```
; read-screen : GUI -> list-of-string
(define (read-screen g)
  (type-case GUI g
    [label (t) (list t)]
    [button (t e?) (list t)]
    [choice (i s) i]))

(test (read-screen (label "Hi"))
      ' ("Hi"))
(test (read-screen (button "Ok" true))
      ' ("Ok"))
(test (read-screen (choice ' ("Apple" "Banana") 0))
      ' ("Apple" "Banana"))
```

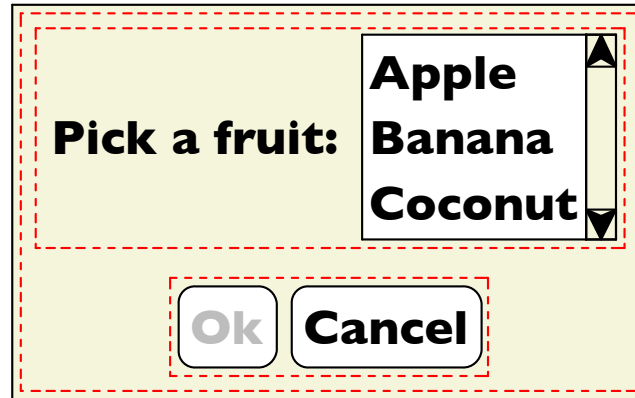
Assemblings GUIs



- label
- buttons
- lists
- vertical stacking
 - two sub-GUIs
- horizontal stacking
 - two sub-GUIs

```
(define-type GUI
  [label (text string?)]
  [button (text string?)
          (enabled? boolean?)]
  [choice (items (listof string?))
          (selected integer?)]
  [vertical (top GUI?)
            (bottom GUI?)]
  [horizontal (left GUI?)
              (right GUI?)])
```

Assemblings GUIs



- label
 - buttons
 - lists
 - vertical stacking
 - two sub-GUIs
 - horizontal stacking
 - two sub-GUIs
- ```
(define gui
 (vertical
 (horizontal
 (label "Pick a fruit:")
 (choice '("Apple" "Banana" "Coconut")
 0))
 (horizontal
 (button "Ok" false)
 (button "Cancel" true))))
```

# Read Screen

```
; read-screen : GUI -> list-of-string
(define (read-screen g)
 (type-case GUI g
 [label (t) (list t)]
 [button (t e?) (list t)]
 [choice (i s) i]
 [vertical (t b) (append (read-screen t)
 (read-screen b))]
 [horizontal (l r) (append (read-screen l)
 (read-screen r))]))

; ... earlier test cases ...
(test guil
 '("Pick a fruit:"
 "Apple" "Banana" "Coconut"
 "Ok" "Cancel"))
```

# Function and Data Shapes Match

```
(define-type GUI
 [label (text string?)]
 [button (text string?)
 (enabled? boolean?)]
 [choice (items (listof string?))
 (selected integer?)]
 [vertical (top GUI?)
 (bottom GUI?)]
 [horizontal (left GUI?)
 (right GUI?)])
```

```
(define (read-screen g)
 (type-case GUI g
 [label (t) (list t)]
 [button (t e?) (list t)]
 [choice (i s) i]
 [vertical (t b) (append (read-screen t)
 (read-screen b))]
 [horizontal (l r) (append (read-screen l)
 (read-screen r))]))
```



# Design Steps

- Determine the representation
  - **define-type**
- Write examples
  - **test**
- Create a template for the implementation
  - **type-case** plus natural recursion,  
**check shape!**
- Finish implementation case-by-case
  - *the is usually the interesting part*
- Run tests

# Enable Button

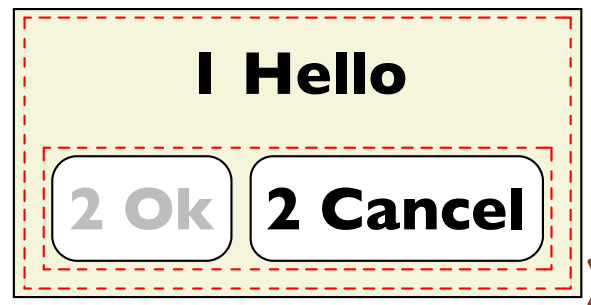
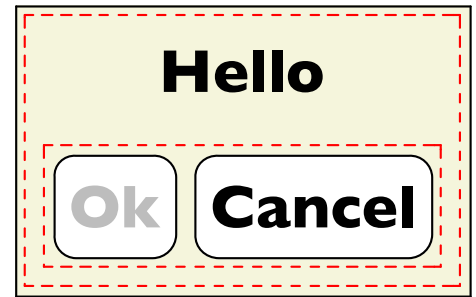
The **name** argument is “along for the ride”:

```
; enable-button : GUI string -> GUI
(define (enable-button g name)
 (type-case GUI g
 [label (t) g]
 [button (t e?) (cond
 [(equal? t name) (button t true)]
 [else g])])
 [choice (i s) g]
 [vertical (t b) (vertical (enable-button t name)
 (enable-button b name))]
 [horizontal (l r) (horizontal (enable-button l name)
 (enable-button r name))]))

...
(test (enable-button guil "Ok")
 (vertical
 (horizontal (label "Pick a fruit:")
 (choice '("Apple" "Banana" "Coconut") 0))
 (horizontal (button "Ok" true)
 (button "Cancel" true))))
```

# Show Depth

(test (show-depth



# Show Depth

Template:

```
(define (show-depth g)
 (type-case GUI g
 [label (t) ...]
 [button (t e?) ...]
 [choice (i s) ...]
 [vertical (t b) ... (show-depth t)
 ... (show-depth b) ...]
 [horizontal (l r) ... (show-depth l)
 ... (show-depth r) ...]))
```

# Show Depth

Template:





```
(define (show-depth g)
 (type-case GUI g
 [label (t) ...]
 [button (t e?) ...]
 [choice (i s) ...]
 [vertical (t b) ... (show-depth t)
 ... (show-depth b) ...]
 [horizontal (l r) ... (show-depth l)
 ... (show-depth r) ...]))
```

(show-depth **Ok**) → **0 Ok**

# Show Depth

Template:

```
(define (show-depth g)
 (type-case GUI g
 [label (t) ...]
 [button (t e?) ...]
 [choice (i s) ...]
 [vertical (t b) ... (show-depth t)
 ... (show-depth b) ...]
 [horizontal (l r) ... (show-depth l)
 ... (show-depth r) ...]))
```

(show-depth  ) → ...  ...  ...

# Show Depth

Template:

```
(define (show-depth g)
 (type-case GUI g
 [label (t) ...]
 [button (t e?) ...]
 [choice (i s) ...]
 [vertical (t b) ... (show-depth t)
 ... (show-depth b) ...]
 [horizontal (l r) ... (show-depth l)
 ... (show-depth r) ...]))
```

recursion results don't have the right labels...

# Show Depth

The `n` argument is an *accumulator*:

```
; show-depth-at : GUI num -> GUI
(define (show-depth-at g n)
 (type-case GUI g
 [label (t) (label (prefix n t))]
 [button (t e?) (button (prefix n t) e?)]
 [choice (i s) g]
 [vertical (t b) (vertical (show-depth-at t (+ n 1))
 (show-depth-at b (+ n 1)))]
 [horizontal (l r) (horizontal (show-depth-at l (+ n 1))
 (show-depth-at r (+ n 1)))]))

; show-depth : GUI -> GUI
(define (show-depth g)
 (show-depth-at g 0))
```



# Programming With Lists

Sometimes you can use `map`, `ormap`, etc.

```
; has-label? : list-of-string string -> bool
(define (has-label? l s)
 (ormap (lambda (e) (string=? e s)) l))
```

```
(test (has-label? empty "Banana") false)
(test (has-label? ' ("Apple" "Banana") "Banana")
 true)
```

# Programming With Lists

Sometimes you can use `map`, `ormap`, etc.

```
; has-label? : list-of-string string -> bool
(define (has-label? l s)
 (ormap (lambda (e) (string=? e s)) l))

(test (has-label? empty "Banana") false)
(test (has-label? ' ("Apple" "Banana") "Banana")
 true)
```

Otherwise, the general design process works for programs on lists using the following data definition:

```
; A list-of-string is either
; - empty
; - (cons string list-of-string)
```

# Programming With Lists

```
; A list-of-string is either
; - empty
; - (cons string list-of-string)
```

```
; has-label? : list-of-string string -> bool
```

```
(define (has-label? l s)
 (cond
 [(empty? l) ...]
 [(cons? l) ... (first l)
 ... (has-label? (rest l) s) ...]))
```

# Programming With Lists

```
; A list-of-string is either
; - empty
; - (cons string list-of-string)

; has-label? : list-of-string string -> bool
(define (has-label? l s)
 (cond
 [(empty? l) false]
 [(cons? l) (or (string=? (first l) s)
 (has-label? (rest l) s))]))
```