

How to Design Programs

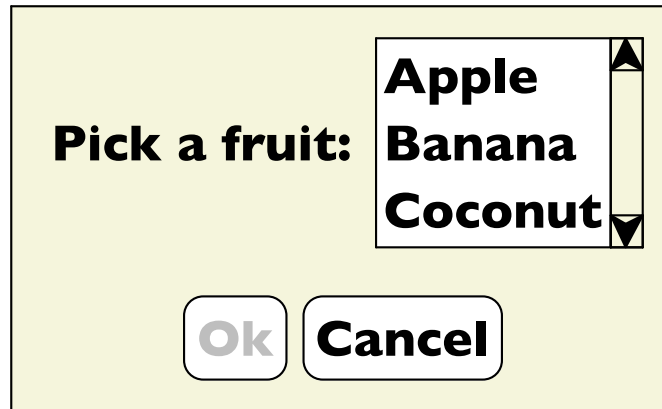
How to (in Racket):

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

See also

`http://www.htdp.org/`

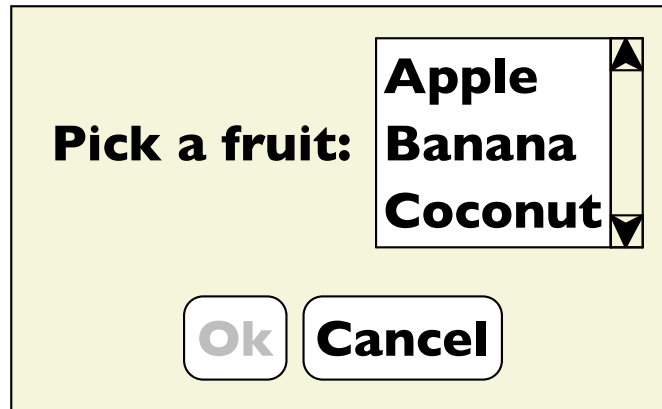
Running Example: GUIs



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 (read-screen gui1)
      ('("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
 - usually the interesting part, but good test cases make it less interesting (i.e., easier!)
- Run tests

Enable Button

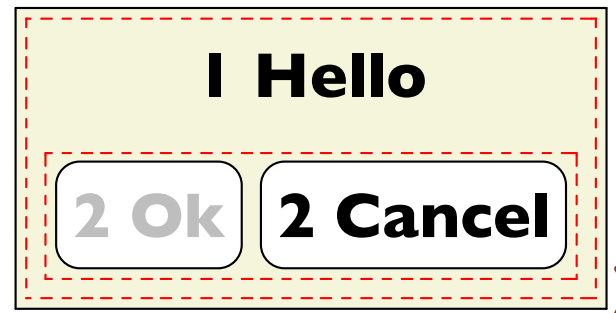
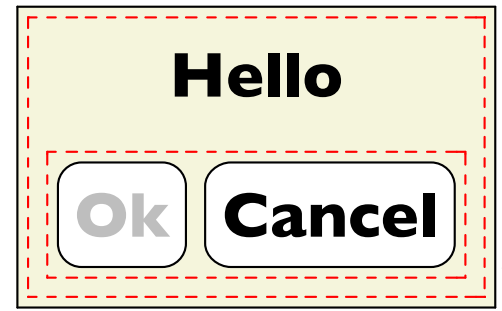
The **name** argument is “along for the ride”:

```
; 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 gui1 "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`, `for/list`, 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`, `for/list`, 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))]))
```

Programming With Lists

For lists (and other built-in data), there are also loops. Read more in the documentation, but here's how you can write `has-label?` more succinctly using lists:

```
(define (has-label? l desired-s)
  (for/or ([actual-s (in-list l)])
    (equal? desired-s
             actual-s)))
```