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: GUls

Possible programs:

• Can click?
• Find a label
• Read screen
Representing GUls

- 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 : 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 GUls

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

```
(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

```scheme
(define guil
  (vertical
    (horizontal
      (label "Pick a fruit:"
        (choice '("Apple" "Banana" "Coconut")
          0))
      (horizontal
        (button "Ok" false)
        (button "Cancel" true)))))
```
; 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 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
  ○ 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”:

```scheme
; 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

Hello

I Hello

2 Ok 2 Cancel

Ok Cancel

))
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:

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

\[
\text{(show-depth \text{\color{red}Ok} \text{\color{red}Cancel} \rightarrow ... 0 \text{\color{red}Ok} ... 0 \text{\color{red}Cancel} ...)
\]
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...
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))

Show Depth
Programming With Lists

Sometimes you can use `map`, `ormap`, `for/list`, etc.

```scheme
; 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 \texttt{map, ormap, for/list, etc.}

\begin{verbatim}
; 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)
\end{verbatim}

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

\begin{verbatim}
; A list-of-string is either
;  - empty
;  - (cons string list-of-string)
\end{verbatim}
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) ...]]))
; 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))])))