Generalizing Similar Functions

CS 5010 Program Design Paradigms
“Bootcamp”
Lesson 6.1
The goal of generalization is to avoid having to repeat code, whether the code is identical or slightly different.

In this sequence of lessons, you will learn how to do this, starting with very simple situations, then covering more and more complex situations.
Slogans for Generalization

• Never write the same code twice
  – Don’t repeat yourself
  – Single Point of Control
    • fix each bug only once
    • easier maintenance, modification

• Copy and Paste is bad practice

• Also known as: Refactoring
Module Outline

• Generalizing a constant to a variable
• Generalizing over functions
• Using prepackaged generalizations: map, foldr, etc.
Learning Objectives for this Lesson

• By the end of this lesson, you should be able to
  – recognize when two functions differ only by a constant
  – rewrite the two functions using a single more general function
  – test your new function definitions
Imagine the following:

• Your boss comes to you and asks you to write a function called `find-dog`.
• You follow the design recipe, write the code, and test it.
• Your boss and you are both happy.
• Here’s what you wrote:
find-dog

;; find-dog : StringList -> Boolean
;; GIVEN: a list of strings
;; RETURNS: true iff "dog" is in the given list.
;; STRATEGY: Use template for StringList on los
(define (find-dog los)
  (cond
   [(empty? los) false]
   [else (or
     [(string=? (first los) "dog")
      (find-dog (rest los))]]))

(check-equal? (find-dog (list "cat" "dog" "weasel")) true)
(check-equal? (find-dog (list "cat" "elephant" "weasel")) false)
The story continues

• The next morning, your boss comes to you and asks you to write `find-cat`.
• You follow the design recipe, write the code, and test it.
• Here’s what you wrote:
find-cat

;; find-cat : StringList -> Boolean
;; GIVEN: a list of strings
;; RETURNS: true iff "cat" is in the given list.
;; STRATEGY: Use template for StringList on los
(define (find-cat los)
  (cond
   [(empty? los) false]
   [else (or
      (string=? (first los) "cat")
      (find-cat (rest los)))]))

(check-equal? (find-cat (list "cat" "dog" "weasel")) true)
(check-equal? (find-cat (list "elephant" "weasel")) false)
A lot of repeated work there!

- Your boss is happy, but you are less happy; what if the next day, he asks you to write `find-elephant`?
- You feel like you are wasting a lot of time!
- Let’s see just how alike these functions were.
These functions are very similar:

```scheme
(define (find-dog los)
  (cond
    [(empty? los) false]
    [else
      (or
        (string=? (first los) "dog")
        (find-dog (rest los))))]))

(define (find-cat los)
  (cond
    [(empty? los) false]
    [else
      (or
        (string=? (first los) "cat")
        (find-cat (rest los))))]))
```

The only differences between the functions are their names, and the fact that one refers to “dog” and the other refers to “cat”.
So generalize them by adding an argument

;; find-animal : StringList String -> Boolean
;; returns true iff the given string is in the given list of strings.

(define (find-animal los str)
  (cond
   [(empty? los) false]
   [else (or
          (string=? (first los) str)
          (find-animal (rest los) str))]]

(check-expect
 (find-animal (list "cat" "elephant" "weasel") "elephant")
 true)
(check-expect
 (find-animal (list "cat" "elephant" "weasel") "beaver")
 false)

Nothing mysterious here!
What did we do here?

- If two functions differ only in a few places, add extra arguments for those places.
- `find-dog` and `find-cat` can be generalized to get `find-animal`. We replace a constant, like "dog" or "cat" with an argument, here `str`.
- Moving common code to a single function with some extra arguments is what is often called "refactoring".
Generalization

• Both functions were special cases of a more general function.
• The more general function takes extra arguments that express the differences.
• The arguments "specialize" the function.
• Must make sure that we can to specialize back to our original functions:
Confirm that the original functions can still be expressed.

(define (find-dog los)
  (find-animal los "dog"))

(define (find-cat los)
  (find-animal los "cat"))

(define (find-elephant los)
  (find-animal los "elephant"))

find-elephant is now a one-liner. Yay!
What's the strategy?

;; STRATEGY: Use template for StringList on los
(define (find-animal los str)
  (cond
   [(empty? los) false]
   [else (or
     (string=? (first los) str)
     (find-animal (rest los) str))]]))

We could describe this as "call a simpler function", but it seems more accurate to describe this as calling a more general function.

In this function we are still using the template.

;; STRATEGY: Call a more general function
(define (find-dog los)
  (find-animal los "dog"))

Don't get all anxious about the difference.

We could describe this as calling a more general function.
How to test the new definitions

• To test the new definitions, comment out the old definitions. This can be accomplished by using the Racket menu item for "comment out with semicolons".

• An entire parenthesized expression can also be commented out by prefixing it with #; (see the Help Desk for details).

• Do NOT use the Racket menu item "comment out in a box"—the result will be that your Racket file is converted to a form that is no longer plain text, and will not be viewable with ordinary tools (text editors, web browsers, etc.).
Your file should now look like this:

```scheme
#;(define (find-dog los) ...)
#;(define (find-cat los) ...)

(define (find-animal los str) ...)
(define (find-dog los)
  (find-animal los "dog"))
```

The old definitions are commented out.

find-dog now refers to the new definition.
Now your old tests should work WITHOUT CHANGE

(check-equal?
  (find-dog (list "cat" "dog" "weasel"))
  true)
(check-equal?
  (find-dog (list "cat" "elephant" "weasel"))
  false)
(check-equal?
  (find-cat (list "cat" "dog" "weasel"))
  true)
(check-equal?
  (find-cat (list "elephant" "weasel"))
  false)

The new definitions of **find-dog** and **find-cat** are the only ones visible, so these are now testing the new definitions.
Another Example: Pizza!

;; Data Definitions:

;; A Topping is a String.

;; A Pizza is represented as a list of Toppings
;; INTERP: a pizza is a list of toppings, listed from top to bottom

;; pizza-fn : Pizza -> ??
;; (define (pizza-fn p)
;; (cond
;; [(empty? p) ...]
;; [else (... (first p)
;; (pizza-fn (rest p)))]))

;; Examples:
(define plain-pizza empty)
(define cheese-pizza (list "cheese"))
(define anchovies-cheese-pizza (list "anchovies" "cheese"))

The toppings are listed in a certain order, so we must explain the order in the interpretation.
replace-all-anchovies-with-onions

;; replace-all-anchovies-with-onions
;;   : Pizza -> Pizza
;; GIVEN: a pizza
;; RETURNS: a pizza like the given pizza, but with
;; onions in place of each layer of anchovies
(define (replace-all-anchovies-with-onions p)
  (cond
   [(empty? p) empty]
   [else (if (string=? (first p) "anchovies")
            (cons "onions"
                  (replace-all-anchovies-with-onions
                   (rest p)))
            (cons (first p)
                  (replace-all-anchovies-with-onions
                   (rest p))))])))
Opportunities for Generalization

We can generalize over onions to get replace-all-anchovies.

```r
;; replace-all-anchovies
;;   : Pizza Topping -> Pizza
;; GIVEN: A pizza and a topping
;; RETURNS: a pizza like the given pizza, but
;; with all anchovies replaced by the given
;; topping.
```
Opportunities for Generalization

Generalize over anchovies to get replace-topping.

;;; replace-topping
;;; : Pizza Topping Topping -> Pizza
;;; GIVEN: a pizza and two toppings
;;; RETURNS: a pizza like the given one, but
;;; with all instances of the first topping
;;; replaced by the second one.
Summary

• Functions will sometimes differ only in choice of data items.
• Functions can be generalized by adding new argument(s) for the differences.
• No magic here, but we will do the same thing in more interesting ways in the following lessons.
• Confirm the original functions work before generalizing.
• Test functions by renaming the originals and running the same tests.
Next Steps

• Study 06-1-1-find-dog.rkt and 06-1-2-pizza.rkt in the examples folder.
• If you have questions about this lesson, ask them on the Discussion Board
• Do Guided Practice 6.1
• Go on to the next lesson.