CMSC 330: Organization of Programming Languages

Array, Hashes, Code Blocks, Equality

Arrays and Hashes

- Ruby data structures are typically constructed from Arrays and Hashes
  - Built-in syntax for both
  - Each has a rich set of standard library methods
  - They are integrated/used by methods of other classes

Array

- Arrays of objects are instances of class Array
  - Arrays may be heterogeneous

    a = [1, "foo", 2.14]
- C-like syntax for accessing elements
  - indexed from 0
  - return nil if no element at given index

```
irb(main):001:0> b = []; b[0] = 0; b[0]
 => 0
irb(main):002:0> b[1]  # no element at this index
 => nil
```

Arrays Grow and Shrink

- Arrays are growable
  - Increase in size automatically as you access elements

```
irb(main):001:0> b = []; b[0] = 0; b[5] = 0; b
 => [0, nil, nil, nil, nil, 0]
```

  - [ ] is the empty array, same as Array.new
- Arrays can also shrink
  - Contents shift left when you delete elements

```
a = [1, 2, 3, 4, 5]
a.delete_at(3)          # delete at position 3; a = [1,2,3,5]
a.delete(2)             # delete element = 2; a = [1,3,5]
```

Iterating Through Arrays

- It's easy to iterate over an array with while
  - length method returns array's current length

```
a = [1,2,3,4,5]
i = 0
while i < a.length
  puts a[i]
  i = i + 1
end
```

- Looping through elements of an array is common
  - We'll see a better way soon, using code blocks

Arrays as Stacks and Queues

- Arrays can model stacks and queues

```
a = [1, 2, 3]
a.push("a")      # a = [1, 2, 3, "a"]
x = a.pop        # x = "a"
a.unshift("b")   # a = ["b", 1, 2, 3]
y = a.shift      # y = "b"
```

Note that `push`, `pop`, `shift`, and `unshift` all permanently modify the array

Hash

- A hash acts like an associative array
  - Elements can be indexed by *any kind* of values
  - Every Ruby object can be used as a hash key, because the Object class has a hash method

- Elements are referred to like array elements

```
italy = Hash.new
italy["population"] = 58103033
italy["continent"] = "europe"
italy[1861] = "independence"
pop = italy["population"] # pop is 58103033
planet = italy["planet"]  # planet is nil
```

Hash methods

- new(o) returns hash whose default value is o
  - h = Hash.new("fish"); h["go"] # returns "fish"
- values returns array of a hash's values
- keys returns an array of a hash's keys
- delete(k) deletes mapping with key k
- has_key?(k) is true if mapping with key k present
  - has_value?(v) is similar
- Two objects refer to the same hash key when their hash value is identical and the two objects are eql? to each other.

Hash creation

Convenient syntax for creating literal hashes

- Use { key => value, ... } to create hash table

```
credits = {
   "cmsc131" => 4,
   "cmsc330" => 3,
}

x = credits["cmsc330"]   # x now 3
credits["cmsc311"] = 3
```

- Use { } for the empty hash

Quiz 1: What is the output

```
a = {}
a[“foo”] = 1
print a[“foo”]
print a[“bar”]
```

A. 1
B. 1nil
C. Error
D. foobar

Quiz 1: What is the output

```
a = {}
a[“foo”] = 1
print a[“foo”]
print a[“bar”]
```

A. 1
B. 1nil
C. Error
D. foobar

Quiz 2: What is the output

```
a = {}
a[”Spade”] = [ ]
a[“Spade”][“Club”] = “Heart”
puts a[“Spade”][“Club”]
```

A. Heart
B. [ ]
C. Error
D. { }

Quiz 2: What is the output

```
a = {}
a["Spade"] = [ ]
a["Spade"]["Club"] = "Heart"
puts a["Spade"]["Club"]
```

A. Heart
B. [ ]
C. Error
D. { }

Quiz 3: What is the output

```
a = {}
a[1] = "foo"
print a[0]
```

A. Error
B. nil
C. foo
D. Nothing is printed.

Quiz 3: What is the output

```
a = {}
a[1] = "foo"
print a[0]
```

A. Error
B. nil
C. foo
D. Nothing is printed.

Code Blocks

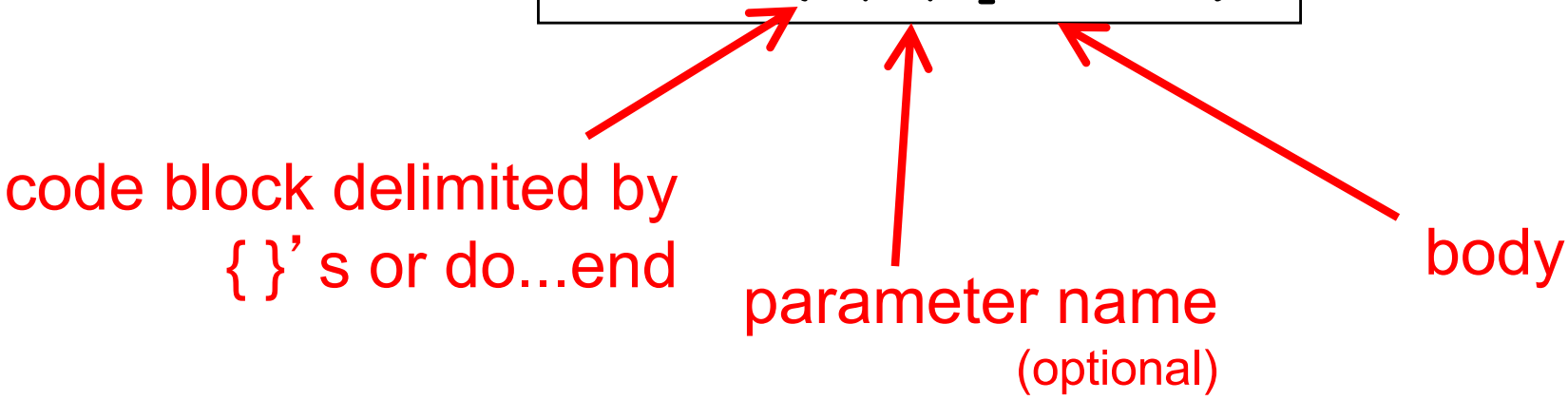
- A code block is a piece of code that is invoked by another piece of code

- Code blocks are useful for encapsulating repetitive computations

Array Iteration with Code Blocks

- The Array class has an each method
  - Takes a code block as an argument

```
a = [1,2,3,4,5]
a.each { |x| puts x }
```



More Examples of Code Block Usage

- Sum up the elements of an array

```
a = [1,2,3,4,5]
sum = 0
a.each { |x| sum = sum + x }
printf("sum is %d\n", sum)
```

- Print out each segment of the string as divided up by commas (commas are printed trailing each segment)
  - Can use any delimiter

```
s = "Student,Sally,099112233,A"
s.split(',').each { |x| puts x }
```

("delimiter" = symbol used to denote boundaries)

Yet More Examples of Code Blocks

```
3.times { puts "hello"; puts "goodbye" }
5.upto(10) { |x| puts(x + 1) }
[1,2,3,4,5].find { |y| y % 2 == 0 }
[5,4,3].collect { |x| -x }
```

- n.times runs code block n times
- n.upto(m) runs code block for integers n..m
- a.find returns first element x of array such that the block returns true for x
- a.collect applies block to each element of array and returns new array (a.collect! modifies the original)

Still Another Example of Code Blocks

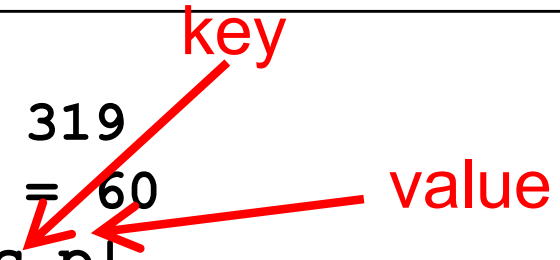
```
File.open("test.txt", "r") do |f|
  f.readlines.each { |line| puts line }
end
```

alternative syntax: do … end instead of { … }

- open method takes code block with file argument
  - File automatically closed after block executed
- readlines reads all lines from a file and returns an array of the lines read
  - Use each to iterate
- Can do something similar on strings directly:
- "r1\nr2\n\nr4".each_line { |rec| puts rec }
  - Apply code block to each newline-separated substring

Code Blocks for Hashes

```
population = {}
population["USA"] = 319
population["Italy"] = 60
population.each { |c,p|
  puts "population of #{c} is #{p} million"
}
```



- Can iterate over keys and values separately

```
population.keys.each { |k|
    print "key: ", k, " value: ", population[k]
  }
popluation.values.each { |v|
    print "value: ", v
  }
```

Default_proc for Hashes

- If Hash::new was invoked with a block, return that block, otherwise return nil.

```
h = Hash.new {|h,k| h[k] = k*k }
h.default_proc   #=> #<Proc:0x401b3d08@-:1>
h[2]
h.inspect     => "{2=>4}"


p = h.default_proc
a = []
p.call(a, 2)
a             #=> [nil, nil, 4]
```

Using Yield To Call Code Blocks

- Any method can be called with a code block
  - Inside the method, the block is called with yield
- After the code block completes
  - Control returns to the caller after the yield instruction

```
def countx(x)
  for i in (1..x)
     puts i
     yield
  end
end

countx(4) { puts "foo" }
```

```
1
foo
2
foo
3
foo
4
foo
```

So What Are Code Blocks?

- A code block is just a special kind of method
  - { |y| x = y + 1; puts x } is almost the same as
  - def m(y) x = y + 1; puts x end
- The each method takes a code block as a parameter
  - This is called higher-order programming
    - In other words, methods take other methods as arguments
    - We'll see a lot more of this in OCaml
- We'll see other library classes with each methods
  - And other methods that take code blocks as arguments
  - As we saw, your methods can use code blocks too!

Ranges

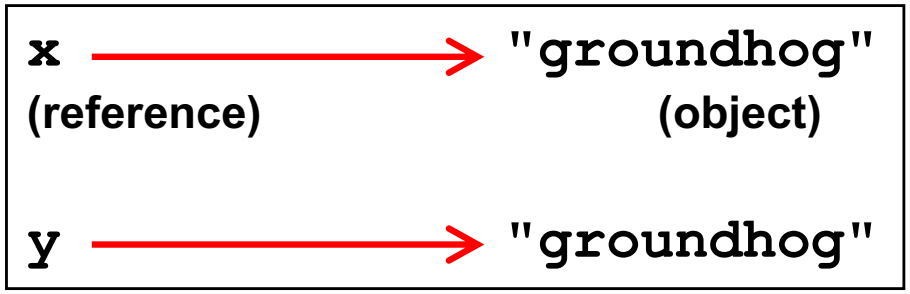
- 1..3 is an object of class Range
  - Integers between 1 and 3 inclusively
- 1…3 also has class Range
  - Integers between 1 and 3 *but not including 3 itself*.
- Not just for integers
  - 'a'..'z' represents the range of letters 'a' to 'z'
  - 1.3…2.7 is the *continuous* range [1.3,2.7)
    - (1.3…2.7).include? 2.0 # => true
- Discrete ranges offer the each method to iterate
  - And can convert to an array via to_a; e.g., (1..2).to_a

Object Copy vs. Reference Copy

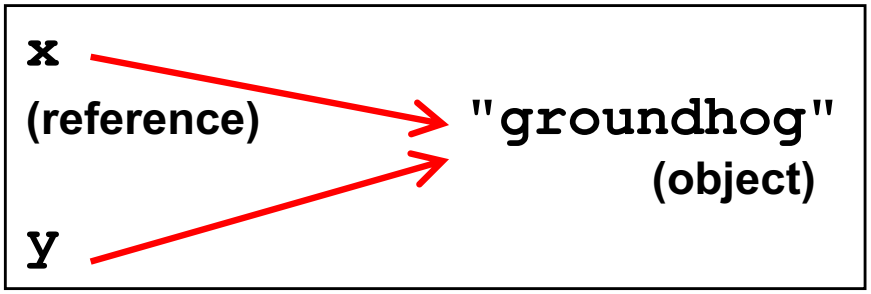
- Consider the following code
  - Assume an object/reference model like Java or Ruby
    - Or even two pointers pointing to the same structure

```
x = "groundhog" ; y = x
```

- Which of these occur?



Object copy



Reference copy

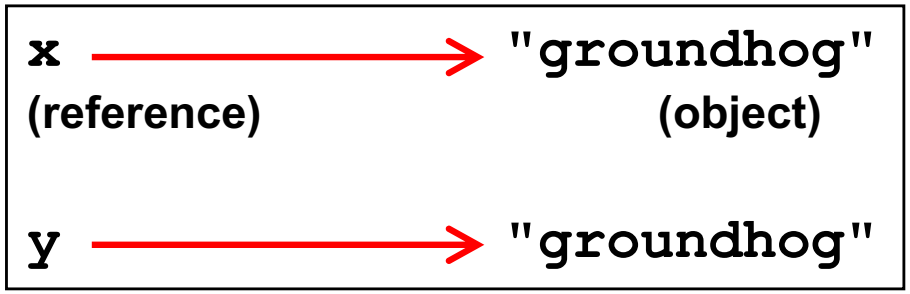
Object Copy vs. Reference Copy (cont.)

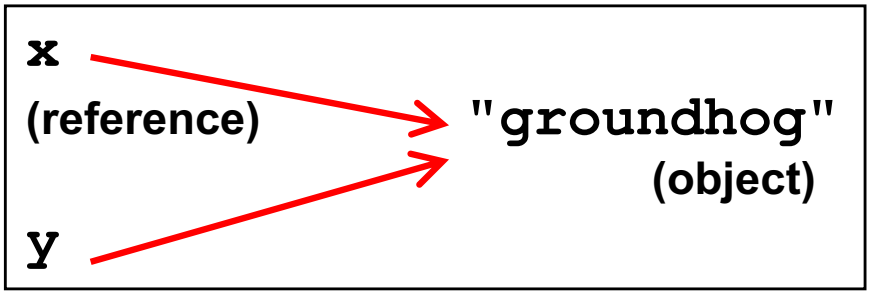
- For
```
x = "groundhog" ; y = x
```
  - Ruby and Java would both do a reference copy

- But for
```
x = "groundhog"
y = String.new(x)
```
  - Ruby would cause an object copy
  - Unnecessary in Java since Strings are immutable

Physical vs. Structural Equality

- Consider these cases again:





- If we compare x and y, what is compared?
  - The references, or the contents of the objects they point to?
- If references are compared (physical equality) the first would return false but the second true
- If objects are compared both would return true

String Equality

- In Java, x == y is physical equality, always
  - Compares references, not string contents
- In Ruby, x == y for strings uses structural equality
  - Compares contents, not references
  - == is a method that can be overridden in Ruby!
  - To check physical equality, use the equal? method
    - Inherited from the Object class
- It's always important to know whether you're doing a reference or object copy
  - And physical or structural comparison

Comparing Equality

Language	Physical equality	Structural equality
Java	**a == b**	**a.equals(b)**
C	**a == b**	***a == *b**
Ruby	**a.equal?(b)**	**a == b**
Ocaml	**a == b**	**a = b**
Python	**a is b**	**a == b**
Scheme	**(eq? a b)**	**(equal? a b)**
Visual Basic .NET	**a Is b**	**a = b**

Summary

- Scripting languages
- Ruby language
  - Implicit variable declarations
  - Dynamic typing
  - Many control statements
  - Classes & objects
  - Strings