CSE 413
Programming Languages & Implementation

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Ruby Containers, Blocks, and Procs
The Plan

• Ruby container data structures
• Blocks and control structures (iterators, etc.)
• Blocks and first-class closures

• Later:
  – Duck typing
  – Inheritance
  – Modules and mixins
Containers in Ruby

• Like most scripting languages, Ruby provides very general container classes
• Two major kinds
  – Arrays: ordered by position
  – Hashes: collections of <key, value> pairs
    • Often known as associative arrays, maps, or dictionaries
    • Unordered
Ruby Arrays

- Instances of class **Array**
- Create with an array literal, or **Array.new**
  ```ruby
  words = [ "how", "now", "brown", "cow" ]
  stuff = [ "thing", 413, nil ]
  seq = Array.new
  ```
- Indexed with [ ] operator, 0-origin; negative indices count from right
  ```ruby
  words[0]  stuff[2]  words[-2]
  seq[1] = "something"
  ```
Ruby Hashes

• Instances of class `Hash`
• Create with an hash literal, or `Hash.new`

```ruby
pets = { "spot"=>"dog","puff"=>"cat" }
tbl = Hash.new
```
• Indexed with `[ ]` operator

```ruby
pets["puff"]   pets["fido"]
pets["cheeta"] = "monkey"
```
– Can use almost anything as key type; can use anything as element type
Containers and Iterators

• All containers respond to the message “each”, executing a block of code for each item in the container

```ruby
words.each { puts "another word" }
words.each { |w| puts w }
```
Blocks

• A block is a sequence of statements surrounded by 
  \{ \ldots \} or do \ldots end
• Blocks must appear immediately following the 
  method call that executes them, on the same line
• Blocks may have 1 or more parameters at the 
  beginning surrounded by | \ldots |
  – Initialized by the method that runs (executes, 
    “calls”) the block
Blocks as Closures

• Blocks can access variables in surrounding scopes

```plaintext
wordlist = ""
words.each { |w| wordlist = wordlist + w + " " }
```

– These are almost, but not quite, first-class closures (some differences in scope rules compared to Racket)
More Block Uses

- Besides iterating through containers, blocks are used in many other contexts

```ruby
3.times { puts "hello" }

n = 0
100.times { | k | n += k }
puts "sum of 0 + ... + 99 is " + n
```
Block Execution

- Any method call can be followed by a block. The block is executed by the method – when depends on the method
- A block is executed in the context of the method call
  - Block has access to variables at the call location
  - Return in a block returns from surrounding method(!)

```ruby
def search(x, words)
  words.each { |w| if x==w then return end }
  puts "not found"
end
```
yield

- Any method call can be followed by a trailing block. A method “calls” the block with a `yield` statement.

```ruby
def repeat
  yield
  yield
end
repeat { puts "hello" }
```

Output:

```
hello
hello
```
yield with arguments

- If the block has parameters, use expressions with yield to pass arguments

```python
def xvii
    yield 17
end
xvii { | n | puts n+1 }
```

- This is exactly how an iterator works
Blocks are “second-class”

- Blocks (and methods) are not objects in Ruby – i.e., not things that can be passed around as first-class values
- All a method can do with a block is `yield` to it (i.e., call it)
  - Can’t return it, store it in an object, etc.
  - But can also turn blocks into real closures (next slide)
First-class closures

• Implicit block arguments and yield are often sufficient
• But when you want a closure that can be returned, stored, passed as an argument:
  – The built-in Proc class
  – Lambda method of Object takes a block and makes a Proc
  – Instances of Proc have a call method that can be used to execute them
Creating Procs: examples

- Create a Proc object explicitly

```ruby
p = Proc.new { |x, y| x+y }
...
p.call(x,y)
```

- Use Object’s `lambda` method

```ruby
is_positive = lambda { |x| x > 0 }
```
Procs vs. Lambdas

• A Proc is a block wrapped in an object – and behaves just like a block
  – In particular, a return in a Proc will return from the *surrounding* method where the Proc’s closure was created
    • Error if that method has already terminated
• A Lambda is more like a method
  – Return just exits from the lambda