

Concurrency and Actors

Lecture Question

Task: Create an Actor class that tracks a single Int

- In a package named actors create a class named StringActor that extends Actor
- Create the following case class/objects that will be used as messages
 - A case class named Append that takes a String in its constructor
 - A case object named GetValue
 - A case class named Value that takes a String in its constructor
- The StringActor class must:
 - Take a String in its constructor. This will be the initial String that it will store
 - When it receives an Append message, append its value to the end of the currently stored String
 - When it receives a GetValue message, sends its current value back to the sender in a Value message

Concurrency

- Most programs we've written execute code sequentially
- Each statement of code is executed in the order they are written
- Can have control flow to decide which statements are executed and in which order
- **What if we want multiple pieces of code to execute at the same time?**

Concurrency

- We've written 2 types of concurrent software already
- In CSE115, you wrote a web server
 - What if 2 users are visiting your site at the same time?
 - Server waits for requests and handles them as they are received
 - You provide callback functions that are called when a request arrives
- In CSE116, we saw GUIs on each HW assignment
 - GUI runs an update loop to display the current state of the software
 - GUI simultaneously listens for user inputs
 - You provide listener classes with a method that is called when the user takes an action

Concurrency

- For both web servers and GUIs
 - We used libraries that hid the concurrency
- What if we want to write concurrent code that is not part of a web server or GUI?
- We'll see how to write concurrent programs using actors

Concurrency - Actors

- The Akka library
 - Add to pom.xml and install
- Akka uses actors for concurrency
- We create and instantiate actor classes and each actor runs concurrently
- Actors are based on a message passing system
 - Multiple actors run in the same program at the same time
 - Actors pass messages to share information
 - Write code that executes in reaction to a message
 - Messages are case classes or case objects

Concurrency - Actors

- Receiving a message is an event
- **Event-Based Architecture**
 - Write code that is executed when an event occurs
 - Create events that cause code to run

Case Class/Object

- Case class
 - A different type of class in Scala
 - Primarily used to store values provided through its constructor
 - Typically have no body
 - Are compared by value, not reference
- Case object
 - Used when no values are stored (no constructor)
 - Can be used to signal that an event has occurred

```
case class BuyEquipment(equipmentID: String)
case object Setup
```


Concurrency - Actors

- To define an Actor
 - Extend the Actor class
 - Implement the receive method to define how the Actor responds to different message types

```
import akka.actor._

case object CustomMessageType
case class AnotherMessageType(message: String)

class MyActor extends Actor {

  def receive: Receive = {
    case CustomMessageType => // do something
    case received: AnotherMessageType => received.message // do something
  }

}
```

Concurrency - Actors

- Messages are instances of case classes or case objects
- Use a case statement to make decisions based on the type of the message
- If the message is a case class, declare a variable to access its values

```
import akka.actor._

case object CustomMessageType
case class AnotherMessageType(message: String)

class MyActor extends Actor {

  def receive: Receive = {
    case CustomMessageType => // do something
    case received: AnotherMessageType => received.message // do something
  }

}
```

Concurrency - Actors

- Create an actor and add it to actor system
 - The actor is now running concurrently with your program
- Send messages using the ! method

```
object CounterTest extends App {  
  val system = ActorSystem("FirstSystem")  
  
  val actor = system.actorOf(Props(classOf[MyActor]))  
  
  actor ! CustomMessageType  
  actor ! AnotherMessageType  
}
```

Concurrency - Actors

- Cannot create an Actor using the new keyword
- Use Props (part of the Akka library) and pass the class as an argument

```
object CounterTest extends App {  
  val system = ActorSystem("FirstSystem")  
  
  val actor = system.actorOf(Props(classOf[MyActor]))  
  
  actor ! CustomMessageType  
  actor ! AnotherMessageType  
}
```

Concurrency - Actors

- If your Actor class takes a constructor parameters pass them in the Props call

```
class MyActor(n: Int) extends Actor {  
  
  def receive: Receive = {  
    case CustomMessage => // do something  
    case r: AnotherMessageType => r.message // do something  
  }  
  
}
```

```
object CounterTest extends App {  
  val system = ActorSystem("FirstSystem")  
  
  val actor = system.actorOf(Props(classOf[MyActor], 10))  
  
  actor ! CustomMessageType  
  actor ! AnotherMessageType  
}
```

Counting Example

Actors - Counting Example

- Create an Actor class that counts down from 20 as fast as it can
- Send the actor a Start message to start the countdown
- Start is a case object
- We'll create 3 of these actors and watch them count down concurrently

Actors - Counting Example

- 4 different message types
 - All are case objects
- Start - Tells a Counter to start its countdown
- IsDone - Sent to a Counter to ask if it's done or not
- Done - Sent from Counter to indicate that it is done counting
- NotDone - Sent from Counter to indicate that it is not done counting

```
case object Start
case object IsDone
case object Done
case object NotDone
```

```
class Counter(name: String) extends Actor {

  var n = 0

  def countdown(): Unit = {
    if (n >= 0) {
      println(this.name + " - " + n)
      n -= 1
      countdown()
    } else {
      println(this.name + " finished")
    }
  }

  def receive: Receive = {
    case Start =>
      this.n = 20
      countdown()
    case IsDone =>
      if (n <= 0) {
        sender() ! Done
      } else {
        sender() ! NotDone
      }
  }
}
```


Actors - Counting Example

- We define actors just like any other class
- Can have constructor, variables, methods
- This class:
 - Takes a String in the constructor
 - Initializes a variable n to 0
 - Has a countdown method to start a countdown and print the progress along the way

```
case object Start
case object IsDone
case object Done
case object NotDone
```

```
class Counter(name: String) extends Actor {

  var n = 0

  def countdown(): Unit = {
    if (n >= 0) {
      println(this.name + " - " + n)
      n -= 1
      countdown()
    } else {
      println(this.name + " finished")
    }
  }

  def receive: Receive = {
    case Start =>
      this.n = 20
      countdown()
    case IsDone =>
      if (n <= 0) {
        sender() ! Done
      } else {
        sender() ! NotDone
      }
  }
}
```

Actors - Counting Example

- Since we extend Actor, we must implement Receive
- Use case syntax to react differently to different message types
- Whenever this actor receives a message of type Start, it resets its counter to 20 and starts a countdown

```
case object Start
case object IsDone
case object Done
case object NotDone
```

```
class Counter(name: String) extends Actor {

  var n = 0

  def countdown(): Unit = {
    if (n >= 0) {
      println(this.name + " - " + n)
      n -= 1
      countdown()
    } else {
      println(this.name + " finished")
    }
  }

  def receive: Receive = {
    case Start =>
      this.n = 20
      countdown()
    case IsDone =>
      if (n <= 0) {
        sender() ! Done
      } else {
        sender() ! NotDone
      }
  }
}
```

Actors - Counting Example

- When this actor receives a message of type IsDone
- Uses the sender() method to send a message back to whatever actor sent the message
- Send Done or NotDone based on the status of the countdown
- In this way, actors can communicate by passing messages

```
case object Start
case object IsDone
case object Done
case object NotDone
```

```
class Counter(name: String) extends Actor {

  var n = 0

  def countdown(): Unit = {
    if (n >= 0) {
      println(this.name + " - " + n)
      n -= 1
      countdown()
    } else {
      println(this.name + " finished")
    }
  }

  def receive: Receive = {
    case Start =>
      this.n = 20
      countdown()
    case IsDone =>
      if (n <= 0) {
        sender() ! Done
      } else {
        sender() ! NotDone
      }
  }
}
```

Actors - Counting Example

- To use the Actor we'll create 3 objects of this type with different names
- Send each Actor the Start message so they count down

```
class Counter(name: String) extends Actor {  
  
  ...  
  
  def receive: Receive = {  
    case Start =>  
      this.n = 20  
      countDown()  
  }  
}
```

```
object CounterTest extends App {  
  val system = ActorSystem("CountingSystem")  
  
  val one = system.actorOf(Props(classOf[Counter], "1"))  
  val two = system.actorOf(Props(classOf[Counter], "2"))  
  val three = system.actorOf(Props(classOf[Counter], "3"))  
  
  one ! Start  
  two ! Start  
  three ! Start  
}
```

Actors - Counting Example

- All three counters countdown concurrently
- No way to know which will finish first

```
class Counter(name: String) extends Actor {  
  
  ...  
  
  def receive: Receive = {  
    case Start =>  
      this.n = 20  
      countDown()  
  }  
}
```

```
object CounterTest extends App {  
  val system = ActorSystem("CountingSystem")  
  
  val one = system.actorOf(Props(classOf[Counter], "1"))  
  val two = system.actorOf(Props(classOf[Counter], "2"))  
  val three = system.actorOf(Props(classOf[Counter], "3"))  
  
  one ! Start  
  two ! Start  
  three ! Start  
}
```

Counter Demo

Actors - Counting Example

- Let's create another Actor that will communicate with the three counters
- This actor will "ask" each counter if it's done or not
- Once all counters are done, it will print a message to the screen

```
class Supervisor(counters: List[ActorRef]) extends Actor {  
  
  var total: Int = counters.size  
  var completed: List[ActorRef] = List()  
  
  def receive: Receive = {  
    case Update =>  
      counters.foreach((actor: ActorRef) => actor ! IsDone)  
    case Done =>  
      if(!completed.contains(sender())){  
        completed ::= sender()  
        if (completed.size == this.total) {  
          println("All counters complete")  
        }  
      }  
    case NotDone =>  
      println("A counter is not done yet")  
  
  }  
}
```

Actors - Counting Example

- Use the ActorRef class to send messages to other actors
 - sender() returns the ActorRef of the sender of a message

```
class Supervisor(counters: List[ActorRef]) extends Actor {  
  
  var total: Int = counters.size  
  var completed: List[ActorRef] = List()  
  
  def receive: Receive = {  
    case Update =>  
      counters.foreach((actor: ActorRef) => actor ! IsDone)  
    case Done =>  
      if(!completed.contains(sender())){  
        completed ::= sender()  
        if (completed.size == this.total) {  
          println("All counters complete")  
        }  
      }  
    case NotDone =>  
      println("A counter is not done yet")  
  
  }  
}
```


Actors - Counting Example

- Add the supervisor to the system and have it update twice per second
- Use a scheduler to repeatedly send a message

```
object CounterTest extends App {  
  val system = ActorSystem("CountingSystem")  
  
  import system.dispatcher  
  
  val one = system.actorOf(Props(classOf[Counter], "1"))  
  val two = system.actorOf(Props(classOf[Counter], "2"))  
  val three = system.actorOf(Props(classOf[Counter], "3"))  
  
  val supervisor = system.actorOf(Props(classOf[Supervisor], List(one, two, three)))  
  
  one ! Start  
  two ! Start  
  three ! Start  
  
  system.scheduler.schedule(0.milliseconds, 500.milliseconds, supervisor, Update)  
}
```

Supervisor Counter Demo

Lecture Question

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 - When it receives a GetValue message, sends its current value back to the sender in a Value message