Sockets

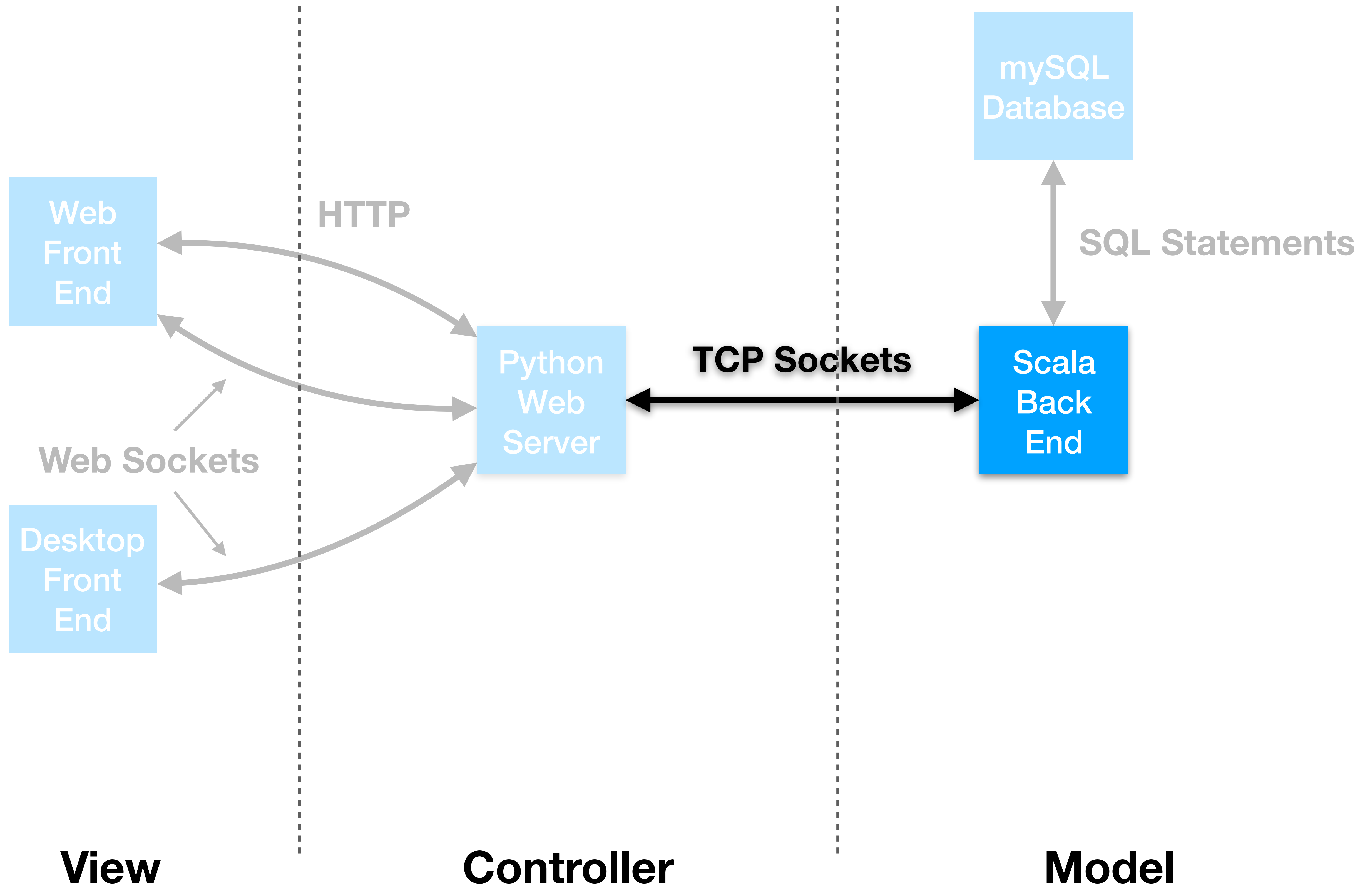
Lecture Question

Task: Write a Scala program that functions as a TCP socket server

- Create a class named concurrency.LectureServer that extends Actor
- concurrency.LectureServer opens a socket server on localhost port 8000 and listens for connections and messages
- The server responds to all messages by sending "ACK" to the sender

* This question will be open until midnight

CSE116 - End Game



Sockets

- Two-way communicate between programs

- Send byte strings
  - Hardware only handles bits/bytes 0/1
  - Whenever a value leaves your program it bust be converted to bits/bytes

Sockets

- Server-Client model
  - Server opens a socket and listens for connections
  - Client connects to a server socket

- Once connected, client and server can send byte strings to each other

Socket Server

Socket Server

- Let's work through the code

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Create a case class that takes a parameter

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
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      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
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      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Extend Actor and implement receive to react to messages

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
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      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Additional import needed for sockets

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
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      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Listen for connections on port 8000

```scala
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
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      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- We'll store references to each connection in a Set

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
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      println("Client Disconnected: " + sender())
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Set does not allow duplicates and can remove by value

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- A Bound message is received when Bind is ready

```scala
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- A Connected message is received when a client connects

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Insert the new client to our set

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Send message to the client to complete the connection

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
      sender() ! Register(self)
    case PeerClosed =>
      println("Client Disconnected: " + sender())
      this.clients = this.clients - sender()
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Use this Actor to handle messages from this client

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
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      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Could defer to another ActorRef to send the client elsewhere

```scala
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
      this.clients = this.clients + sender()
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- PeerClosed message received when client disconnects

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Received message received when a client sends a message

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
    case c: Connected =>
      println("Client Connected: " + c.remoteAddress)
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      println("Client Disconnected: " + sender())
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      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Received has a variable "data" of type ByteString

```
case class SendToClients(message: String)

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  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

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      println("Received: " + r.data.utf8String)
    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Convert from bytes to a utf-8 string and print the message

```scala
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    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- We'll send the server SendToClients messages

```scala
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
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    case send: SendToClients =>
      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Server

- Server broadcasts the message to all connected clients

```
case class SendToClients(message: String)

class SocketServer extends Actor {

  import Tcp._
  import context.system

  IO(Tcp) ! Bind(self, new InetSocketAddress("localhost", 8000))

  var clients: Set[ActorRef] = Set()

  override def receive: Receive = {
    case b: Bound => println("Listening on port: " + b.localAddress.getPort)
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      println("Sending: " + send.message)
      this.clients.foreach((client: ActorRef) => client ! Write(ByteString(send.message)))
  }

}
```

Socket Client

Socket Client

- New case class to store message to send to the server

```scala
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
      this.server = sender()
      this.server ! Register(self)
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- When created, connect to the provided ip/port

```
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
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    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- Create variable that will store the server ActorRef

```scala
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
      this.server = sender()
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- Connected and Received same as server

```scala
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
      this.server = sender()
      this.server ! Register(self)
    case r: Received =>
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    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- Before sending message to server, check if we've connected

```
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
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    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- Concurrency Concern: Might receive a SendToServer message before connection is complete

```
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
      this.server = sender()
      this.server ! Register(self)
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Socket Client

- Concurrency Concern: Could lose messages if not careful!

```
case class SendToServer(message: String)

class SocketClient(remote: InetSocketAddress) extends Actor {

  import akka.io.Tcp._
  import context.system

  IO(Tcp) ! Connect(remote)

  var server: ActorRef = _

  override def receive: Receive = {
    case c: Connected =>
      println("Connected to: " + remote)
      this.server = sender()
      this.server ! Register(self)
    case r: Received =>
      println("Received: " + r.data.utf8String)
    case send: SendToServer =>
      println("Sending: " + send.message)
      if (server != null) {
        this.server ! Write(ByteString(send.message))
      }
  }

}
```

Lecture Question

Task: Write a Scala program that functions as a TCP socket server

- Create a class named concurrency.LectureServer that extends Actor
- concurrency.LectureServer opens a socket server on localhost port 8000 and listens for connections and messages
- The server responds to all messages by sending "ACK" to the sender

* This question will be open until midnight