# Simplifying Asynchronous Code with SCALA ASYNC

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# THE PROBLEM

- Asynchronous code ubiquitous
  - Intrinsic to programming models like actors
  - Required for performance and scalability
    - See Doug Lea's talk at PhillyETE'13 [1]
- Problem: usually enforces an unnatural code style
- Async enables direct-style code while using efficient non-blocking APIs under the hood

[1] https://vimeo.com/65102395

# INSPIRATION

- Yes, we're avoiding NIH!
- Popular additions to C# and F#
- Our twist:
  - Don't change the Scala language
  - Async is "just" a macro

# THIS TALK

- Motivate Async
- Async Internals
- Conclusion

# GENTLE INTRO TO ASYNC

Async provides two constructs: async and await

```
async { <expr> }
```

- Declares block to be asynchronous
- Executes block asynchronously
- Returns future for the result of the block

# USING ASYNC

```
async {
  // some expensive computation without result
}

val future = async {
  // some expensive computation with result
}

def findAll[T](what: T => Boolean) = async {
  // find it all
}
```

"Asynchronous Method"

# AWAIT

Within an `async { }` block, `await` provides a *non-blocking* way to await the completion of a future

```
await(<expr>)
```

- Only valid within an `async { }` block
- Argument `<expr>` returns a future
- Suspends execution of the enclosing `async { }` block until argument future is completed

# USING AWAIT

```
val fut1 = future { 42 }
val fut2 = future { 84 }

async {
  println("computing...")
  val answer = await(fut1)
  println(s"found the answer: $answer")
}

val sum = async {
  await(fut1) + await(fut2)
}
```

# IN SHORT

```
def async[T](body: => T): Future[T]
```

```
def await[T](future: Future[T]): T
```

# PLAY FRAMEWORK EXAMPLE

```
val futureDOY: Future[Response] =
  WS.url("http://api.day-of-year/today").get
val futureDaysLeft: Future[Response] =
  WS.url("http://api.days-left/today").get

futureDOY.flatMap { doyResponse =>
  val dayOfYear = doyResponse.body
  futureDaysLeft.map { daysLeftResponse =>
    val daysLeft = daysLeftResponse.body
    Ok(s"$dayOfYear: $daysLeft days left!")
  }
}
```

# PLAY FRAMEWORK EXAMPLE

```
val futureDOY: Future[Response] =
  WS.url("http://api.day-of-year/today").get
val futureDaysLeft: Future[Response] =
  WS.url("http://api.days-left/today").get

for { doyResponse <- futureDOY
      dayOfYear = doyResponse.body
      daysLeftResponse <- futureDaysLeft
      daysLeft = daysLeftResponse.body
} yield Ok(s"$dayOfYear: $daysLeft days left!")
```

# PLAY FRAMEWORK EXAMPLE

```
val futureDOY: Future[Response] =
  WS.url("http://api.day-of-year/today").get
val futureDaysLeft: Future[Response] =
  WS.url("http://api.days-left/today").get

async {
  val dayOfYear = await(futureDOY).body
  val daysLeft  = await(futureDaysLeft).body
  Ok(s"$dayOfYear: $daysLeft days left!")
}
```

# ANOTHER EXAMPLE

```
def nameOfMonth(num: Int): Future[String] = ...
val date = """(\d+)/(\d+)""".r

async {
  await(futureDOY).body match {
    case date(month, day) =>
      Ok(s"It's ${await(nameOfMonth(month.toInt))}!")
    case _ =>
      NotFound("Not a date, mate!")
  }
}
```

# BACK TO USING FOR

```
def nameOfMonth(num: Int): Future[String] = ...
val date = """(\d+)/(\d+)""".r
for { doyResponse <- futureDOY
      dayOfYear = doyResponse.body
      response <- dayOfYear match {
        case date(month, day) =>
          for (name <- nameOfMonth(month.toInt))
            yield Ok(s"It's $name!")
        case _ =>
          Future.successful(NotFound("Not a..."))
      }
} yield response
```

# DIRECT STYLE

- Not forced to introduced names for intermediate results
- Control flow can be expressed naturally
  - Suspend within if-else, while, match, try-catch, ...

# USING AWAIT

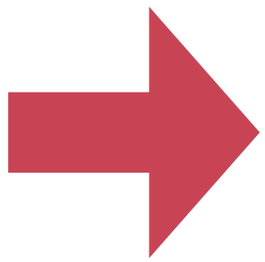
- Requires a directly-enclosing `async { }`
- Cannot use `await`
  - within closures
  - within local functions/classes/objects
  - within an argument to a by-name parameter

# REMEDY

- Existing combinators in Futures API can help!

```
def f(x: A): Future[B]
```

```
async {
  list.map(x =>
    await(f(x)).toString
  )
}
```



```
Future.sequence(
  list.map(x => async {
    await(f(x)).toString
  }))
```

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# INTERNALS OVERVIEW

- `async { }` is a macro
- `await` is a stub method
- Translation in two steps
  - Step 1: ANF transform (“introduce temporaries”)
  - Step 2: State machine transform

# DEBUGGING

- Stepping, setting breakpoints supported
- Similar trade-off as in for-comprehensions
  - Artifacts of expanded program visible
- More IDE support planned (e.g., show expanded code)

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# CONCLUSION

- Macro does a lot of hard work for you
- Generated code...
  - is non-blocking
  - spends a single class per async block
  - avoids boxing of intermediate results (which is more difficult with continuation closures)

# WHAT IS IT FOR?

- Play Framework
  - Pervasive use of futures (SIP-14)
  - Async perfect fit, out-of-the-box support
- Akka actors/futures integration
- Non-blocking I/O
- Connect to other asynchronous APIs
- Some uses of delimited continuations

# TAKEAWAY

```
def async[T](body: => T): Future[T]
```

```
def await[T](future: Future[T]): T
```

# ROADMAP

- New feature of Scala 2.11
- https://github.com/scala/async

# CREDITS:

- Jason Zaugg, Typesafe

- Philipp Haller, Typesafe

# PLUG:

the Fourth Annual Scala Workshop

# Scala2013

MONTPELLIER, FRANCE

July 2nd, 2013

co-located with ECOOP, ECMFA, and ECSA

http://lampwww.epfl.ch/~hmiller/scala2013/

# ASYNC VS. CPS PLUGIN

- Delimited continuations provided by CPS plugin can be used to implement async/await
- CPS plugin could support await within closures
- CPS-transformed code creates more closures (a closure is created at each suspension point)
- CPS plugin requires type annotations like `cpsParam[Int, String]`
- Error messages contain type annotations