Anatomy of a full-stack Scala/Scala.js Web App

Intro to Self

- Previous at **Dropbox**
- Currently at **Bright Technology**, a Data-Science/Scala consultancy
  - We do training and consulting projects around **Python**/**Numpy**/**Scipy**, **Scala** & related tech
  - Built the Fluent Code Browser www.fluentcode.com
- Contributor to **Scala.js**, author of **Ammonite**, **FastParse**, **Scalatags**, ...
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Agenda

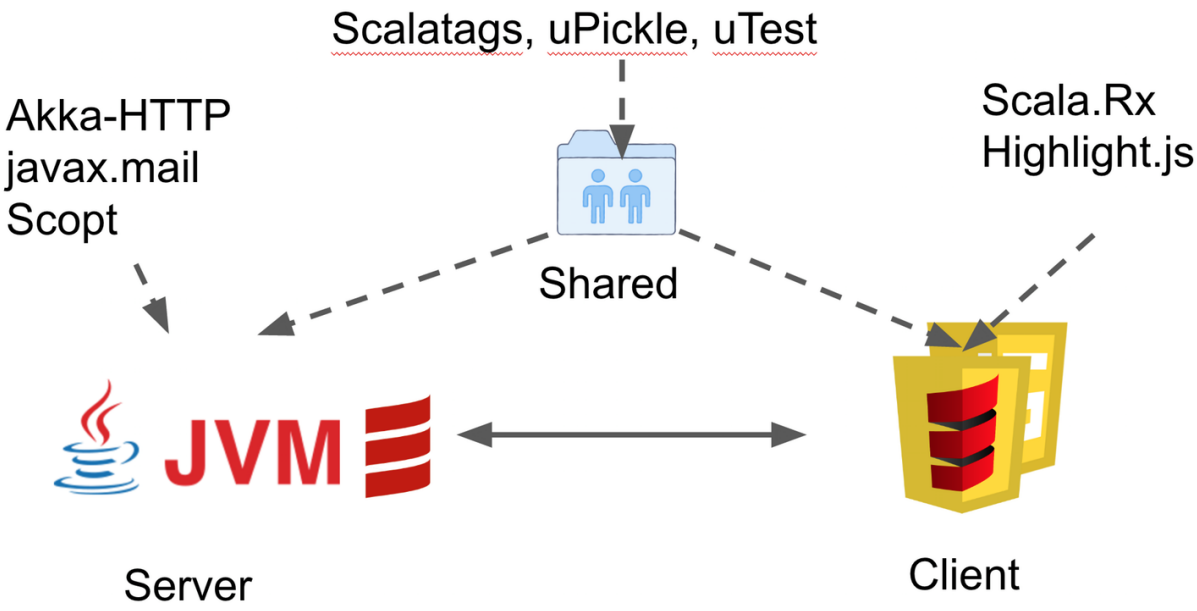
- Deep dive into how a Scala/Scala.js projects ends up looking
- Not meant to be a "prep talk" or inspirational
- Full of nitty-gritty details

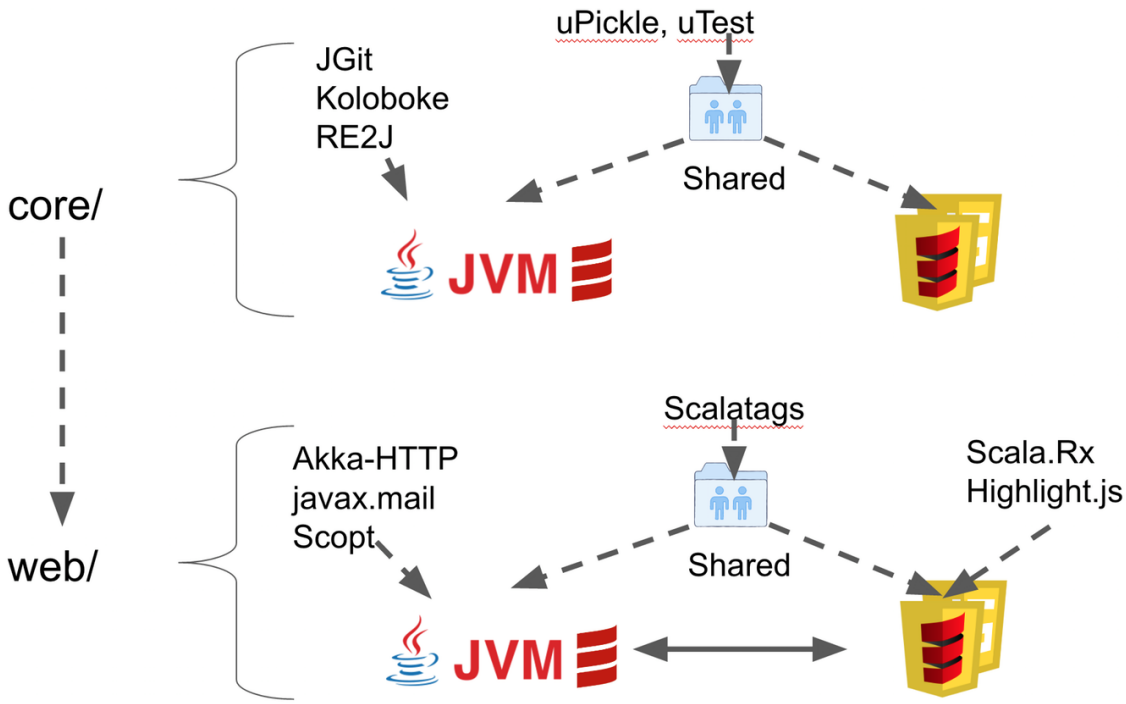
Intro to the Fluent Code Browser

- demo.fluentcode.com
- Blazing-fast online repository browser and search engine
- Works on repositories of all sizes, up to millions of lines of code
- Read-only view, background indexing
- Three person project, two engineers

Fluent Architecture

- Isomorphic Scala/Scala.js
  - 6500LOC JVM, 5500LOC JS, 2200LOC Shared
  - Akka-HTTP
  - Autowire/uPickle Ajax Routes
- Single-process
  - "Stateless" web-controller layer
  - Multiple background threads mirroring and indexing repositories


Scalatags, uPickle, uTest
Akka-HTTP
javax.mail
Scopt
Scala.Rx
Highlight.js
Shared
JVM
Server
Client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javax.mail
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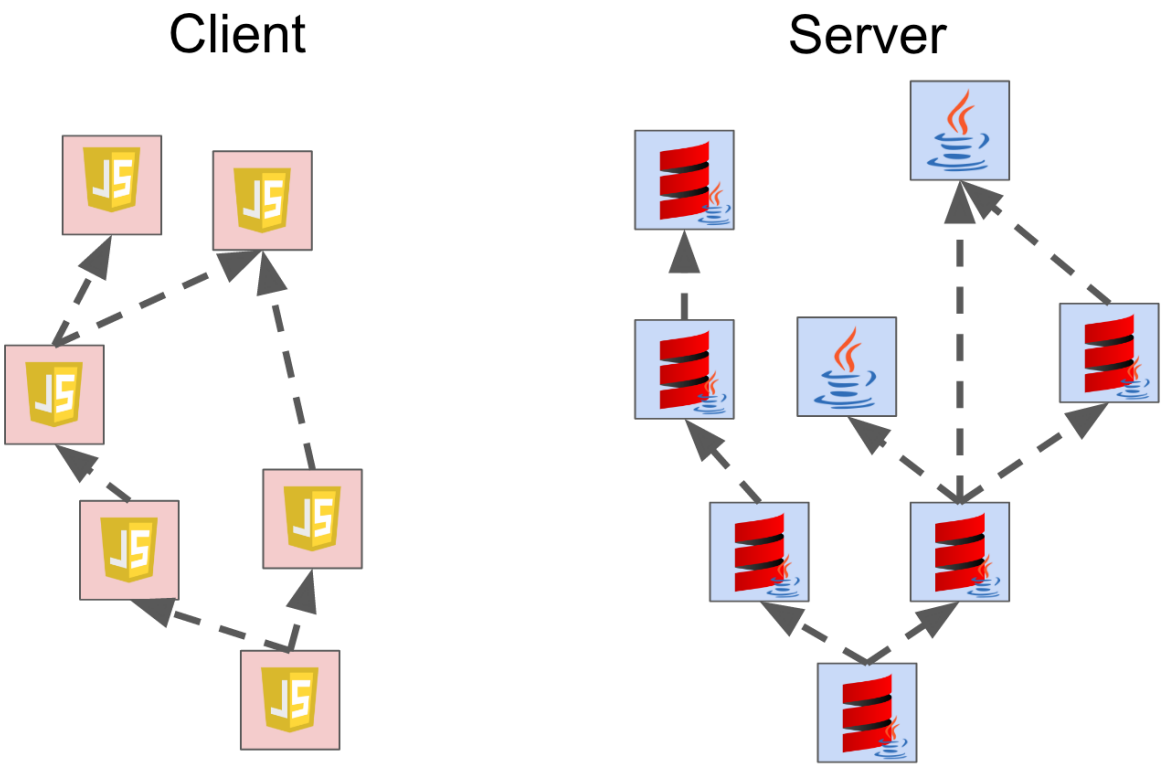
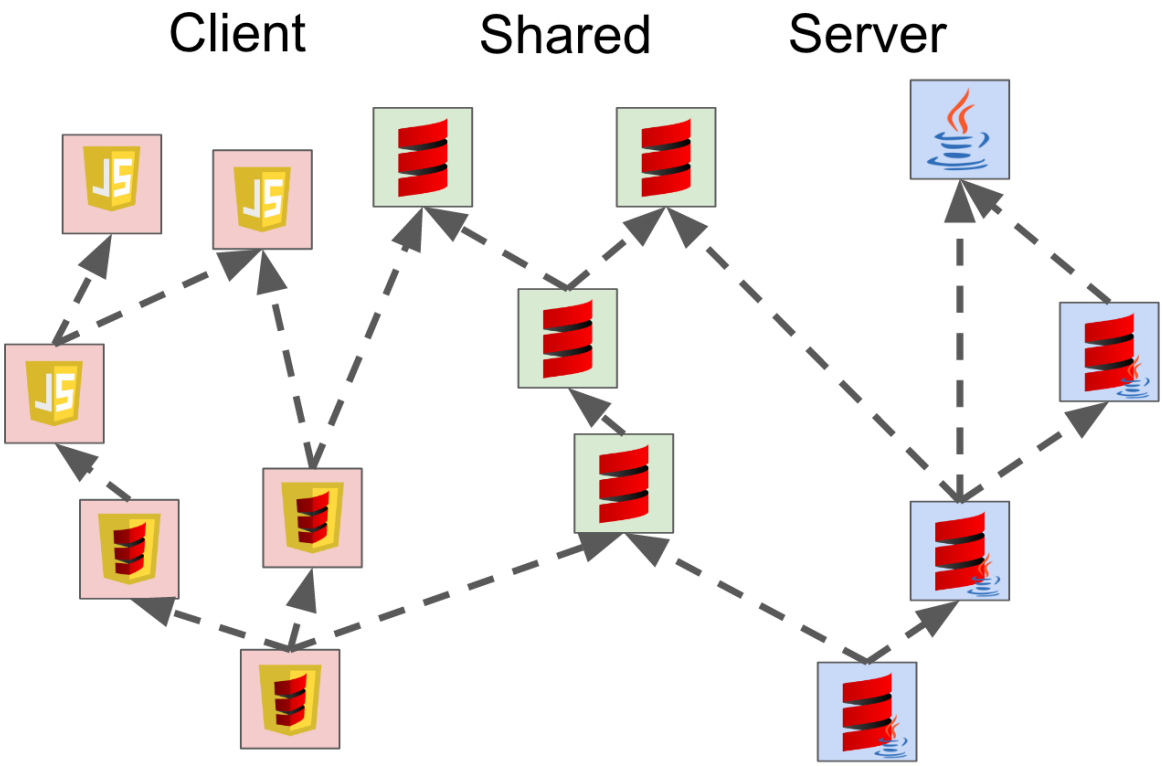
Scalatags
Shared
Scala.Rx
Highlight.js
JVM





Shared Code

Constants

Colors

```
object Colors {

```

```
  val sidePane = "#212121"
  val browsePane = "#2b2b2b"
  val topPane = "#424242"

  ...
}
```

Misc

```
object Constants{
  val gitIdLength = 12

  val searchResultBatchSize = 100
  val searchResultPauseSize = 500
  ...
}
```

Data Structures

FileTree

```
case class FileTree[+T](name: String,
                        value: T,
                        children: IndexedSeq[FileTree[T]]){
  ...
}
```

CommitId

```
case class CommitId(w1: Int, w2: Int, w3: Int, w4: Int, w5: Int){
  override def toString = {
    val dst = new Array[Char](40)
    CommitId.formatHexChar(dst, 0, w1)
    ...
    new String(dst)
  }
}
```

Helper Functions

```
def prettyMillisDelta(millisDelta: Long) = {
  val second = 1000L
  val minute = second * 60
  ...
  if(millisDelta / year > 1) millisDelta / year + " years ago"
```

```
  else if(millisDelta / year == 1) "1 year ago"
  else if(millisDelta / month > 1) millisDelta / month + " months ago"
  ...
}
```

Scalatags HTML Templates

Standard Icons

```
def devopsIcon(name: String) = {
  span(
    cls := s"devicons devicons-$name",
    styles.Base.devopIconStyle
  )
}
```

Standard Tables

```
def wrappingTable(tableHead: Option[Frag], contents: Frag*) = {
  table(
    cls := "table",
    tableLayout.fixed,
    styles.Base.normalTxt
  )(
    tableHead,
    tbody(contents)
  )
}
```

Wildly Different code

- Backend web server
- Frontend GUI

Backend

- Split into Stateless and Stateful code
- Stateless code is your typical web front-end: controllers, templates, etc.
  - No mutable state
  - Pure-ish functional
- Stateful code dealing with cloning/indexing git repos lives in repo-manager threads
  - Some mutable state
  - No global state
- Lives in same process for simplicity; could easily be split into separate workers

Pure-ish Functional Controller Code

```scala
def fetchPreview(filePath: GitPath, commitId: String) = {
  val commit = resolveIndexed(commitId)
  gitApi.queryFileOrFolder(commit, filePath) match{
    case Some(Left(objectId)) =>
      val lines = gitApi.open(objectId).lines.toArray
      PreviewResult.File(lines)
    case Some(Right(_)) => PreviewResult.Folder(...)
    case None => ???
  }
}
```

Stateful Background Indexer

```scala
var lastVersion = "..."
var currentIndex: Option[Index] = None
while(true){
  pullRepo()
  val newVersion = currentVersion()
  if (newVersion == lastVersion) sleep()
  else{
    currentIndex = reIndex()
    lastVersion = currentVersion
  }
}
```

Frontend

- Lots of globals
- Lots of mutation via the DOM; currently not using React or other frameworks
- Decomposed hierarchically into Views

Lots of globals:

- Global click handler to close popups when you click somewhere else
- Global resize handler to make sure we only respond to resize events once
- Global Highlight.js lang-pack downloader & cache
- Modeled as top-level `object`s with mutable state
- Intrinsic global state in DOM

WindowResize

```scala
object WindowResize {
  def register(f: () => Unit) = ...
  def handle(e: dom.Event) = {
    val allElements = dom.document.getElementsByClassName("resize-callbac
k-cls")
    for(k <- allElements) k.asInstanceOf[js.Dynamic].resizeCallback()
```

```
  }
  dom.window.addEventListener("resize", handle _)
}
```

Lots of mutation via the DOM; currently not using React or other frameworks

- Scala.Rx for simple "keep-things-in-sync" mutations
- Manual mangling for more ad-hoc mutations

```
def initCanvas(graphCanvas: dom.html.Canvas) = {
  graphCanvas.style.display = "block"
  graphCanvas.style.width = slice.pixelWidth.toString
  graphCanvas.height = (24 * dom.window.devicePixelRatio).toInt
  graphCanvas.style.height = 24.toString
}
```

Decomposed hierarchically into Views

```
trait View extends scalatags.jsdom.Frag{
  val view: dom.Node
}
class TreeView(...) extends View {...}
class LargeListView(...) extends View {...}
class DropdownInput(...) extends View {...}
```

Breakdown

	Server	Shared	Client
Lines	6,500	2,200	5,500
Code	• Akka-HTTP • JGit • Koloboke Collections • java.io, java.nio	• Constants • Data-structures • Helper Functions • HTML Templates • CSS Stylesheets	• Scala.Rx • Highlight.js • DOM interactions
Structure	Stateless controllers • Pure-ish functional Stateful workers • Long-lived • Lots of file IO	• A grab-bag of standalone pieces of code	• A hierarchy of stateful `Views` • Lots of references to third-part Javascript APIs

Performance Optimizations

- Both front-end and back-end are optimized to work well with large repos
- Back-end indexing must fit in memory and not take too long to create
- Front-end must lazy-load data and lazy-display UI to avoid crashing browser

Interesting back-end data-structures

- `Aggregator[T]`: specialized `mutable.Buffer`, reduces memory needed to store indices

```
class Aggregator[@specialized(Int, Long) T: ClassTag](initialSize: Int = 1) {
  // Can't be `private` because it makes `@specialized` explode
  protected[this] var data = new Array[T](initialSize)
  protected[this] var length0 = 0
  def length = length0
  def apply(i: Int) = data(i)
  def append(i: T) = {
    if (length >= data.length) {
      val newData = new Array[T](data.length * 3 / 2 + 1)
      System.arraycopy(data, 0, newData, 0, length)
      data = newData
    }
    data(length) = i
    length0 += 1
  }
}
```

Interesting front-end abstractions

- `FetcherLite`: Batching downloader
  - Call `.get(i: Int): Future[T]`
  - Pre-fetches items from `i-N` to `i+N` and caches them
  - Returns them instantly if asked for later

```
abstract class FetcherLite[T]{
  def fetchBatch(startCommitIndex: Int): Future[IndexedSeq[T]]
  var totalCount = rx.Var(0)
  var currentlyFetching = false
  var fetchQueue = List.empty[(Int, Promise[T])]
  var lastFetch: Option[(Int, IndexedSeq[T])] = None

  def get(commitIndex: Int): Future[T] = lastFetch match{
    case Some((lastStartIndex, lastFetchedCommits))
      if lastStartIndex <= commitIndex
      && commitIndex < lastStartIndex + lastFetchedCommits.length =>
      Future.successful(lastFetchedCommits(commitIndex - lastStartIndex))
```

```
13
14      case _ =>
15        val promise = Promise[T]()
16        fetchQueue = (commitIndex -> promise) :: fetchQueue
17        kickOffFetchIfNecessary()
18        promise.future
19    }
```

Final Thoughts

- Scala.js Benefits
- Scala.js Limitations

Scala.js Benefits

- Saves you from dealing with Javascript
- Use Scala to type-check front-end, especially with Autowire
- Use Scala to abstract common code patterns
- Share common code between back-end and front-end
- Shared libraries e.g. Scalatags/uPickle/autowire
- Easy for Scala programmers to pick up
  - Other engineer who joined project had zero front-end experience
  - Was able to start making useful contributions in a few days

Scala.js Limitations

- Very different coding style for backend vs backend, despite same language
  - Stateless vs heavily Stateful
  - No Globals vs lots of Globals
  - "Principled" 3rd party APIs vs YOLO 3rd party APIs
- Still need to write Front-end code, which is inherently hard/messy
  - Swing/AWT/QT/etc. aren't any better!
  - Still need to set up your own conventions/architecture/framework to keep things sane
  - Or use a third-party framework: React.js, Vue.js, Angular.js, Diode, ...

Conclusion

- Scala.js largely solves the problem of **Javascript** being complicated
- Scala.js *doesn't* solve the problem of **front-end UI** being complicated

- Scala/Scala.js largely avoids **incidental** differences in client/server code
- Scala/Scala.js *doesn't* avoid **intrinsic** differences in client/server code

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