Bootstrapping the Scala.js Ecosystem

Li Haoyi, Scala eXchange 7 Dec 2014

What is Scala.js

- Scala.js is a Scala -> Javascript compiler
- Write code in Scala, run in the browser
- *No more wallowing around in Javascript!*
    - No more fat-fingered typos making it to production
    - Good toolability/tool support
    - Strong, enforceable abstractions
    - Refactorability

Scala.js

```
object Example extends js.JSApp{
  def main() = {
    var x = 0
    while(x < 10) x += 3
    println(x)
    // 12
  }
}
```

```
ScalaJS.c.LExample$.prototype.main__V =
(function() {
  var x = 0;
  while ((x < 10)) {
    x = ((x + 3) | 0)
  };
  ScalaJS.m.s_Predef().println__O__V(x)
  // 12
});
```

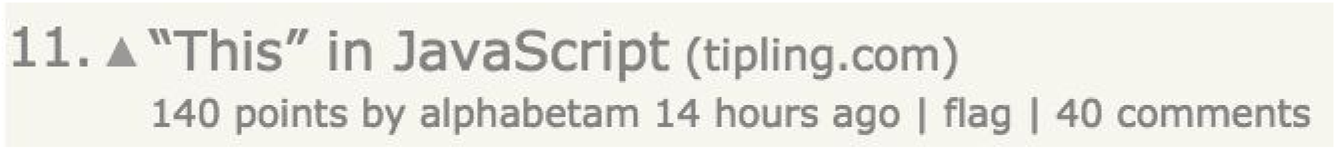
Problems faced in Web Dev

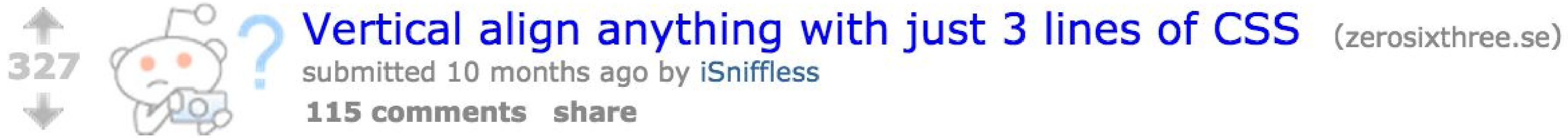
- Our proprietary algorithm is O(n log(n)) rather than O(n log(log(n))
- The machine-learning team can’t reliably predict this user’s click behavior
- Nobody knows why this code works and we are afraid to touch it

Problems faced in Web Dev

- ✘ ~~Our proprietary algorithm is O(n log(n)) rather than O(n log(log(n))~~
- ✘ ~~The machine-learning team can’t reliably predict this user’s click behavior~~
- ✔ Nobody knows why this code works and we are afraid to touch it

Javascript


11. ▲ "This" in JavaScript (tipling.com)
140 points by alphabetam 14 hours ago | flag | 40 comments


327 Vertical align anything with just 3 lines of CSS (zerosixthree.se)
submitted 10 months ago by iSniffless
115 comments share

Scala.js Today: the Tech

- Incremental compiles ~1s
- Dev executables ~ 1mb
- Deployed executables ~100-300kb, +5s
- Passes most of Scala’s own partest suite
- *As fast as Raw Javascript*

Scala.js Today: the Ecosystem

- Active Community
  - Mailing list ¾ as much traffic as scala-user
- >Dozen libraries available
  - Including Scalaz, Shapeless
- Mature platform
  - Incremental Compilation, IDE support, binary/backward-compatibility, ...

Live Demo

Client-Server Application

Cool Things

- DOM access is type-safe
- HTML generation is type-safe
- Ajax calls are type-safe
  - And Boilerplate-free!
- Hard to accidentally screw up

To Learn More...

- Hands-on Scala.js, talk @ PNWScala
    - Cool presentation I gave
- Hands-on Scala.js E-book
    - Lots of intro material on Scala.js
- http://www.scala-js.org/
    - Main Website

Scala.js 14 Months Ago: Tech

- Dev turnaround: 30s
- Dev executables: ~20mb
- Deployable executables: 800kb, +100s
- *No Tests*
- >10x slower than Raw Javascript

Scala.js 14 Months Ago: Ecosystem

- No community
    - 2-3 people on the mailing list
- No libraries
- No tooling

Fancy
Demo

Scala.js

$$\begin{tikzcd} \text{Scala.js} \arrow[r] & ??? \arrow[r] & \textit{Fancy Demo} \end{tikzcd}$$

Let’s talk about

The Tech

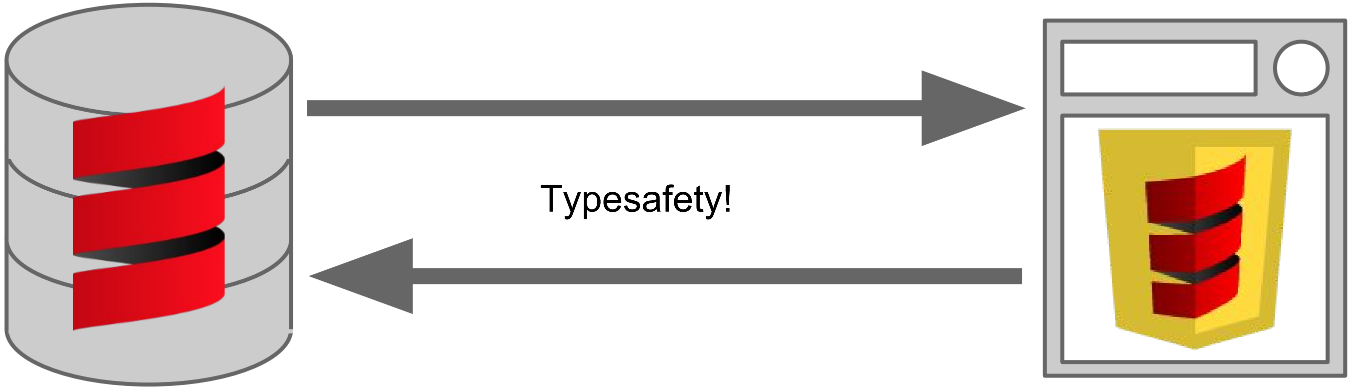
The Ecosystem

Let’s talk about

✘ ~~The Tech~~

✔ The Ecosystem

Fancy Demo



Things We Need

✔ Web Server (Spray)

JavaScript APIs

HTML Generation

Things We Need

✔ Web Server (Spray)

JavaScript APIs

HTML Generation

JavaScript APIs

- Can access them dynamically
  - Annoying and unsafe
- Support for typed interop facades available
  - But no such facades written
- Tool to import typescript defs as facades
  - But it doesn't work all the time

Can access them dynamically

```
import js.Dynamic.global

global.JSON.parse("[1, 2, 3]")

// [1, 2, 3]
```

Can access them dynamically

```
import js.Dynamic.global
global.JSON.parse("[1, 2, 3]")
// [1, 2, 3]

global.JSON.pasre("[1, 2, 3]")
// TypeError: undefined is not a function

global.JSN.parse("[1, 2, 3]")
// ReferenceError: JSN is not defined
```

Support for typed interop facades

```
object JSON extends js.Object {
  def parse(text: String): Dynamic = native
}

JSON.parse("[1, 2, 3]")
// [1, 2, 3]

JSON.pasre("[1, 2, 3]")
// Compile error: value pasre is not a member of object JSON
```

TypeScript => Scala

```
interface StyleSheet {
   disabled: bool;
   ownerNode: Node;
   parentStyleSheet: StyleSheet;
   media: MediaList;
   type: string;
   title: string;
}
```

```
class StyleSheet extends js.Object {
  def disabled: Boolean = native
  def ownerNode: Node =  native
  def parentStyleSheet: StyleSheet = native
  def media: MediaList = native
  def `type`: String = native
  def title: String = native
}
```

Doesn’t always work

- Buggy POC

- Scala & Typescript type-systems differ
  - e.g. Typescript has literal singleton types

- Solution: just fix it manually after

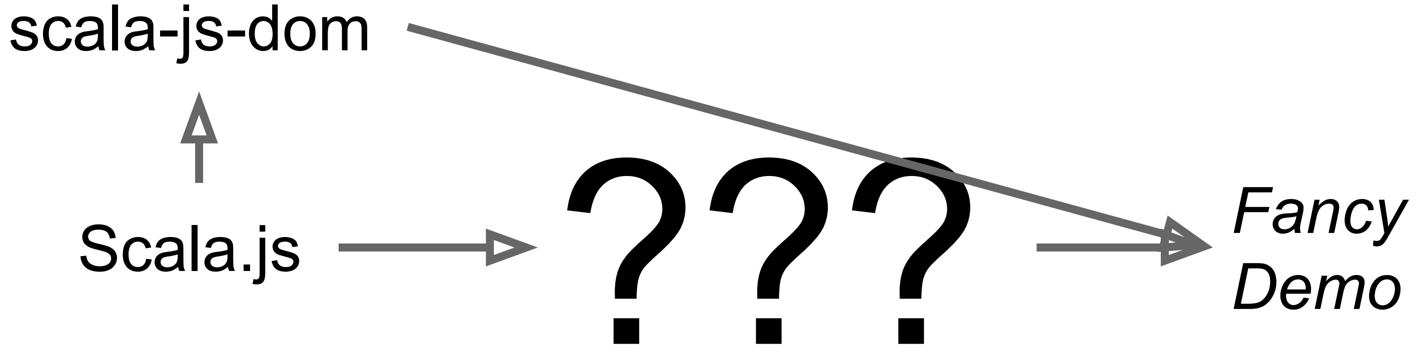
JavaScript APIs

- Batch import lib.d.ts from Typescript
- Manually fix up the things that don't work
- Publish compiled, *untested* facades to Maven Central as ***scala-js-dom***

- Total work: ~4 hrs

Scala-Js-Dom

```
libraryDependencies +=
  "org.scala-lang.modules.scalajs" %%% "scalajs-dom" % "0.6"
```


scala-js-dom
Scala.js
???
Fancy Demo

$$\begin{tikzcd}
 & \textit{scala-js-games} & & \\
\textit{Roll} & \text{scala-js-dom} \arrow[l] \arrow[u] \arrow[rrd] & & \\
 & \text{Scala.js} \arrow[u] \arrow[r] & ??? \arrow[r] & \textit{Fancy Demo}
\end{tikzcd}$$

Things We Need

✔ Web Server (Spray)

✔ JavaScript APIs (scala-js-dom)

<u>HTML Generation</u>

HTML Generation

- Games don't need HTML but websites do

- Options:
    - Cross-compile a Scala templating library
    - Write a wrapper for a JS templating library
    - Spend all day concatting strings

What didn't work

- Cross compiling Twirl, Scalate
  - Java dependencies
- Javascript templating libraries?
  - Won’t run on a Scala server
- Concatting strings
  - Just asking for XSS vulnerabilities

Cross compiling Scalate

```
<dependency>
    <groupId>javax.servlet</groupId>
    <artifactId>servlet-api</artifactId>
    <version>${servlet-api-version}</version>
</dependency>

<dependency>
    <groupId>com.sun.jersey</groupId>
    <artifactId>jersey-server</artifactId>
    <version>${jersey-version}</version>
</dependency>
```

Concatting Strings

```
document.innerHTML = "<h1>Hello " + name + "!</h1>"

...

name = "<script>alert('uve R pwnzed')</script>"
```

Scalatags

- Existing, Pure Scala library
- No separate template files to load
- *Zero* dependencies

Scalatags

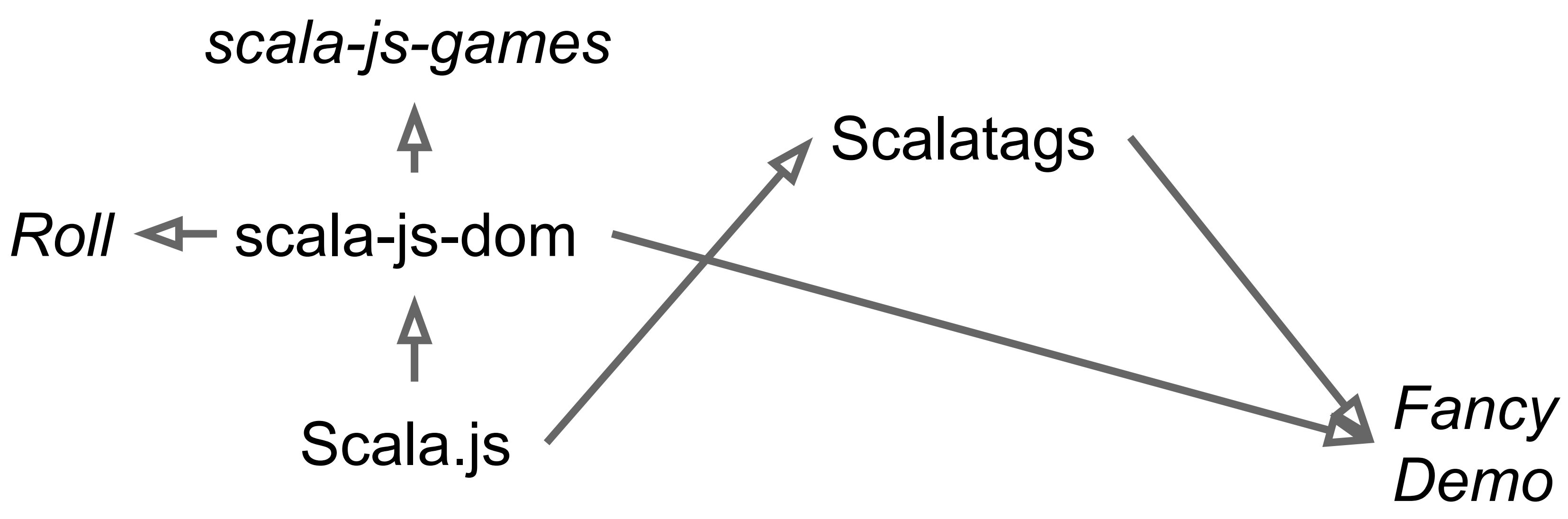
```scala
val frag = html(
  head(
    script(src:="..."),
    script("alert('Hello’)")
  ),
  body(
    div(
      h1(id:="title", "My title"),
      p("Paragraph of text")
    )
  )
)
```

```html
<html>
    <head>
        <script src="..."></script>
        <script>alert('Hello')</script>
    </head>
    <body>
        <div>
            <h1 id="title">My title</h1>
            <p>Paragraph of text</p>
        </div>
    </body>
</html>
```

Scalatags

```
// Scala.js
libraryDependencies +=
  "com.scalatags" %%% "scalatags" % "0.4.2"


// Scala-JVM
libraryDependencies +=
  "com.scalatags" %% "scalatags" % "0.4.2"
```


scala-js-games
Roll
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Scalatags
Scala.js
Fancy Demo

Things We Need

✔ Web Server (Spray)

✔ JavaScript APIs (scala-js-dom)

✔ HTML Generation (Scalatags)

What Next?

- We have HTML generation
- We have DOM APIs like XMLHttpRequest
- How do we make the Ajax calls typechecked?

Things We Need

✔ Web Server (Spray)

✔ JavaScript APIs (scala-js-dom)

✔ HTML Generation (Scalatags)

Type safe Ajax Routing

But Wait...

- Ajax calls involve Data
- Data needs to get sent between client & server
- Manually construction {JSON, XML, CSV} blobs sucks

Things We Need

✔ HTML Generation (Scalatags)

✔ Web Server (Spray)

✔ JavaScript APIs (scala-js-dom)

Type safe Ajax Routing

Data Serialization Library

Requirements

- No Reflection

- Pure Scala
  - No Java
  - No Javascript

- Handles case classes

Things that don't Work

- Java serialization (Java)
- Kryo (Reflection)
- Play Json (Jackson/Java/Reflection)
- Spray Json (no case classes)
- Scala-Pickling (Reflection)

- ...

Basic Difficulty

- How to serialize case classes without Reflection?
- Need some way of breaking alpha equivalence

Basic Difficulty

- How to serialize case classes without Reflection?
- Need some way of breaking alpha equivalence
- Macros!

Writing my own: uPickle

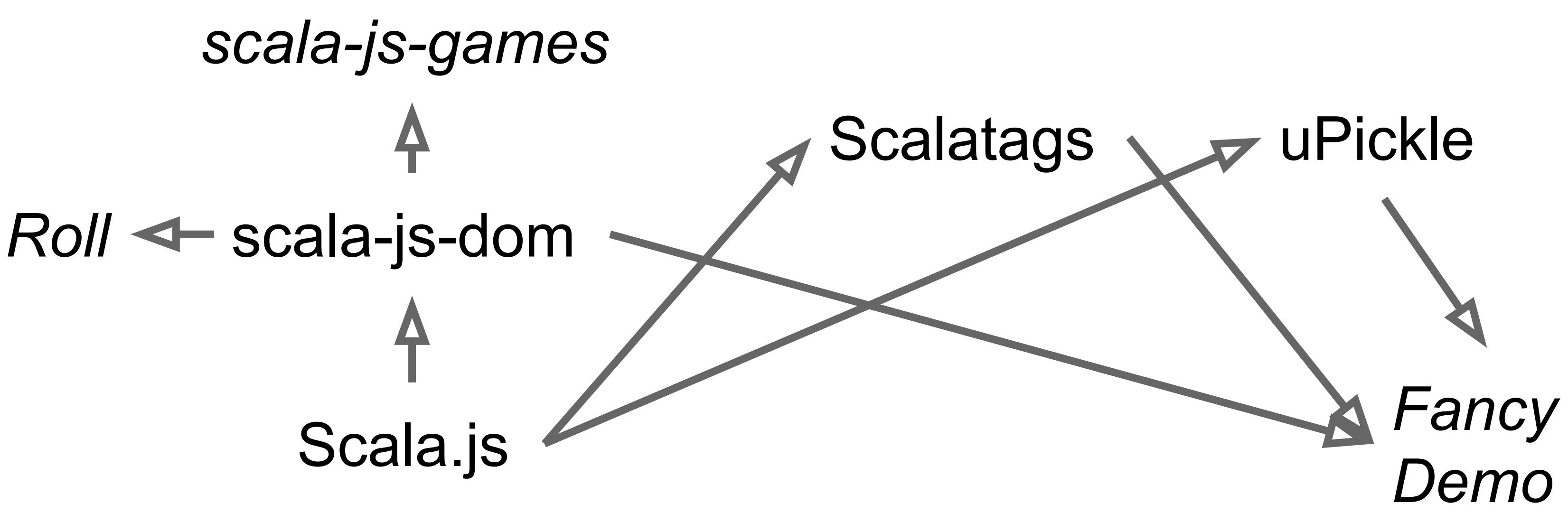
- Basically Spray JSON with a macro for case classes
- ~1000 LOC
- Initially a pure-Scala (shared) JSON parser
    - Now JSON.parse in Scala.js, Jawn in Scala-jVM

- That was easy

Scala-Js-Dom

```
libraryDependencies += "com.lihaoyi" %%% "upickle" % "0.2.5"
```

```
libraryDependencies += "com.lihaoyi" %% "upickle" % "0.2.5"
```


scala-js-games
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uPickle
Fancy Demo

But wait...

- It cross compiles, but how do we know it works?

- For that matter, how do we know that Scalatags works?

Testing Options on Scala.js

- Blind Faith
- Manual Testing
- Jasmine

How Scalatags was tested

https://github.com/scala-js/scala-js/issues/96

...

For scalatags, this basically involved copying and pasting the body of the unit tests into a separate project, `optimizeJSing`, and opening up my `index.html` in chrome to verify manually that it continues to do the right thing.

...

Things We Need

HTML Generation (Scalatags)

Web Server (Spray)

JavaScript APIs (scala-js-dom)

Type safe Ajax Routing

Data Serialization Library (uPickle)

Testing Framework

We need a Test Suite

- Manual testing libraries via C&Ping to example projects doesn't scale

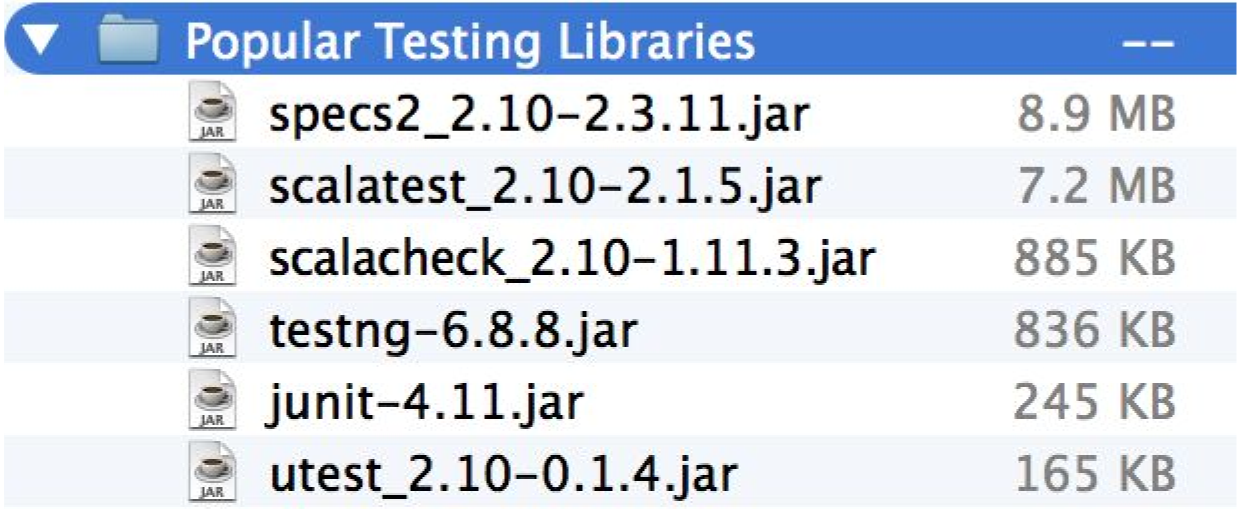
- We already have one!
    - But it uses ScalaTest and only runs on Scala-JVM

What if...

We cross compile ScalaTest?

We cross-compile some subset of ScalaTest?

Find some other testing library?



Popular Testing Libraries	--
specs2_2.10-2.3.11.jar	8.9 MB
scalatest_2.10-2.1.5.jar	7.2 MB
scalacheck_2.10-1.11.3.jar	885 KB
testng-6.8.8.jar	836 KB
junit-4.11.jar	245 KB
utest_2.10-0.1.4.jar	165 KB

Problem: ScalaTest is huuuge

```java
@Retention(RetentionPolicy.RUNTIME)
@Target(ElementType.TYPE)
public @interface Finders {
    String[] value();
}
```

Problem: ScalaTest uses Java sources

```scala
val fieldOption =
  objectWithProperty.getClass.getFields.find(isFieldToAccess)

val methodOption =
  objectWithProperty.getClass.getMethods.find(isMethodToInvoke)

val getMethodOption =
  objectWithProperty.getClass.getMethods.find(isGetMethodToInvoke)
```

Problem: ScalaTest uses tons of Reflection

What if...

We cross compile ScalaTest?

<u>We cross-compile some subset of ScalaTest?</u>

Find some other testing library?

It Works!

```scala
package org.scalatest
import scala.scalajs.test.JasmineTest

class FreeSpec extends JasmineTest {
  implicit class SuperString(s: String){
    def in(thunk: => Unit) = {
      it(s)(thunk)
    }
    def -(thunk: => Unit) = {
      describe(s)(thunk)
    }
  }
}
```

```scala
package scalatags
import org.scalatest._
class BasicTests extends FreeSpec{
  "basic tag creation" in {
    assert(a.toString === "<a/>")
    assert(html.toString === "<html/>")
    ...
  }
  ...
}
```

But...

- Super sketchy
  - What if the semantics differ?
- Only supports a *very* narrow subset of the API
  - Probably exactly the subset I want
  - ...but not the subset someone else would want
  - Not obvious what this subset is

What if...

We cross compile ScalaTest?

We cross-compile some subset of ScalaTest?

Find some other testing library?

Find some other testing library?

- Specs2 had much of the same problem
- Scalacheck is much more special purpose
- JUnit, test-ng, etc. are all out because Java

What if...

We cross compile ScalaTest?

We cross-compile some subset of ScalaTest?

Find some other testing library?

<u>Writing my own</u>

Writing my own:

µTest 0.2.4

uTest (pronounced micro-test) is a lightweight testing library for Scala. Its key features are:

- Less than 1000 lines of code
- A fancy set of macro-powered asserts
- A unique execution model
- Integration with SBT
- Cross compiles to ScalaJS
- Parallel testing

uTest

```
package mytests
object MyTestSuite extends TestSuite{
  val tests = TestSuite{
    'myTest - {
      val a = 1
      val b = 2
      assert(a == b)
    }
  }
}
```

Writing my own: uTest

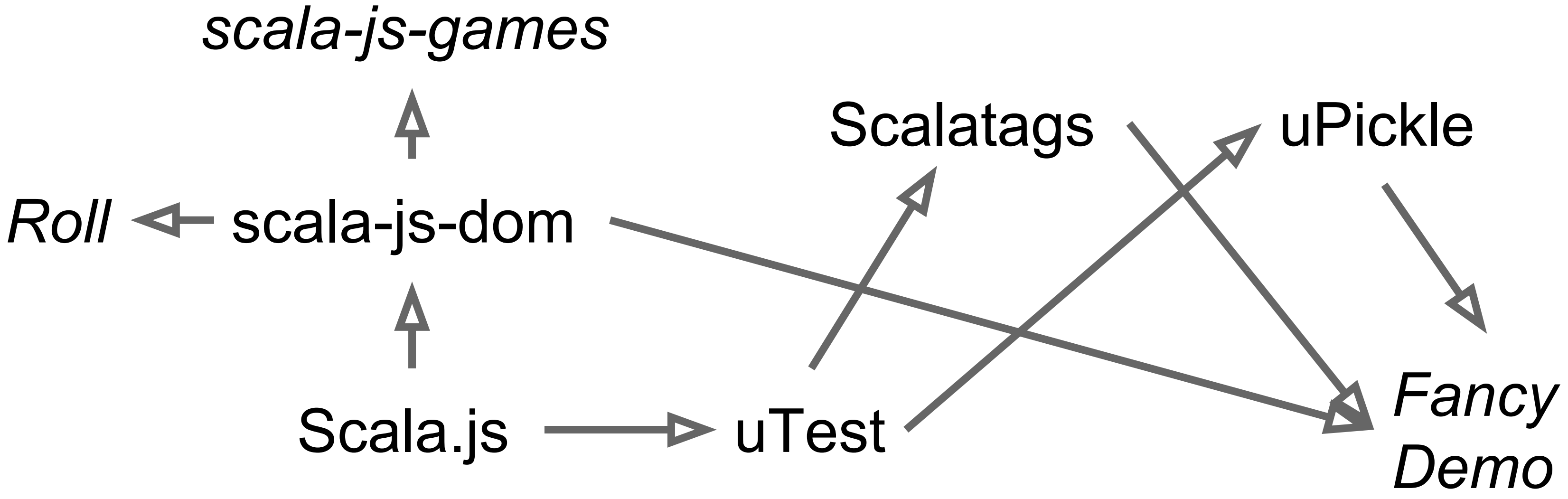
- Basically ScalaTest’s Freespec + 2-3 asserts
- Written once and cross compiled
- Leaves out all the misc. things I don't need
- ~1000 LOC

- That was easy

uTest

```
libraryDependencies += "com.lihaoyi" %%% "utest" % "0.2.4"

libraryDependencies += "com.lihaoyi" %% "utest" % "0.2.4"
```


scala-js-games
Scalatags
uPickle
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Scala.js
uTest

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<u>Type safe Ajax Routing</u>

✔ Data Serialization Library (uPickle)

✔ Testing Framework (uTest)

What's Routing All About

- Call some method in some file with some arguments, return some value

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- Call some method in some file with some arguments, return some value
- The rest of the features routing engines provide are purely cosmetic
- Don't need them for Ajax routes

Autowire: macro-based routing

```scala
trait Api{
  def endpoint(name: String, count: Int): Seq[String]
}

ajax[Api].endpoint("hello", 123).call(): Future[Seq[String]]
// becomes
ajax.makeRequest[Seq[String]](
  Seq("Api", "endpoint"),
  Map("name" -> ajax.write("hello"), "count" -> ajax.write(123))
)
```

Autowire: macro-based routing

```
router.route[Api](cont)
// becomes
{ case Request(Seq("Api", "endpoint"), args) =>
  router.write(cont.endpoint(
    router.read[String](args("name")),
    router.read[Int](args("count"))
  ))
  ...
}
```

Autowire: macro-based routing

```scala
// Shared
trait Api{
  def endpoint(name: String, count: Int): Seq[String]
}
// Server
router.route[Api](new Api{
  def endpoint(name: String, count: Int) = ...
})
// Client
ajax[Api].endpoint("hello", 123).call()
```

One place to get it right

- Actual transport layer is left up to you to implement
  - `ajax.read`, `ajax.write`, `ajax.makeRequest`
  - `router.read`, `router.write`
- If you mess up, things will fail at runtime
  - But only need to get it right once
  - After that, all Ajax calls will be safe
  - read and write calls are trivial using uPickle

Autowire: Safety!

```
ajax[haoyi.Controller].endpoin("hello", 123).call()
// Compile error: value endpoin is not a member of Controller

ajax[haoyi.Controller].endpoint("hello", "123").call()
// Compile error: type mismatch; found: String; required: Int

val x: Seq[String] =
    ajax[haoyi.Controller].endpoint("hello", 123).call()
// Compile error: type mismatch;
// found: Future[Seq[String]]
// required: Seq[String]
```

Autowire: Safety!

```
// OK
for(res <- ajax[haoyi.Controller].endpoint("hello", 123).call()){
  doStuff(res: Seq[String])
}
// OK
val future1 = ajax[haoyi.Controller].endpoint("hello", 123).call()
val future2 = ajax[haoyi.Controller].endpoint("你好", 888).call()
for (res1 <- future1; res2 <- future2){
  doStuff(res1, res2)
}
```

Autowire

- Type-safe, boilerplate-free RPCs calls between Client & Server
- Returns a Future[T], so impossible to mis-use
- Interestingly, *does not depend on uPickle*
  - Can be used on Scala-JVM with Kryo, pickling, etc.
- *435* LOC

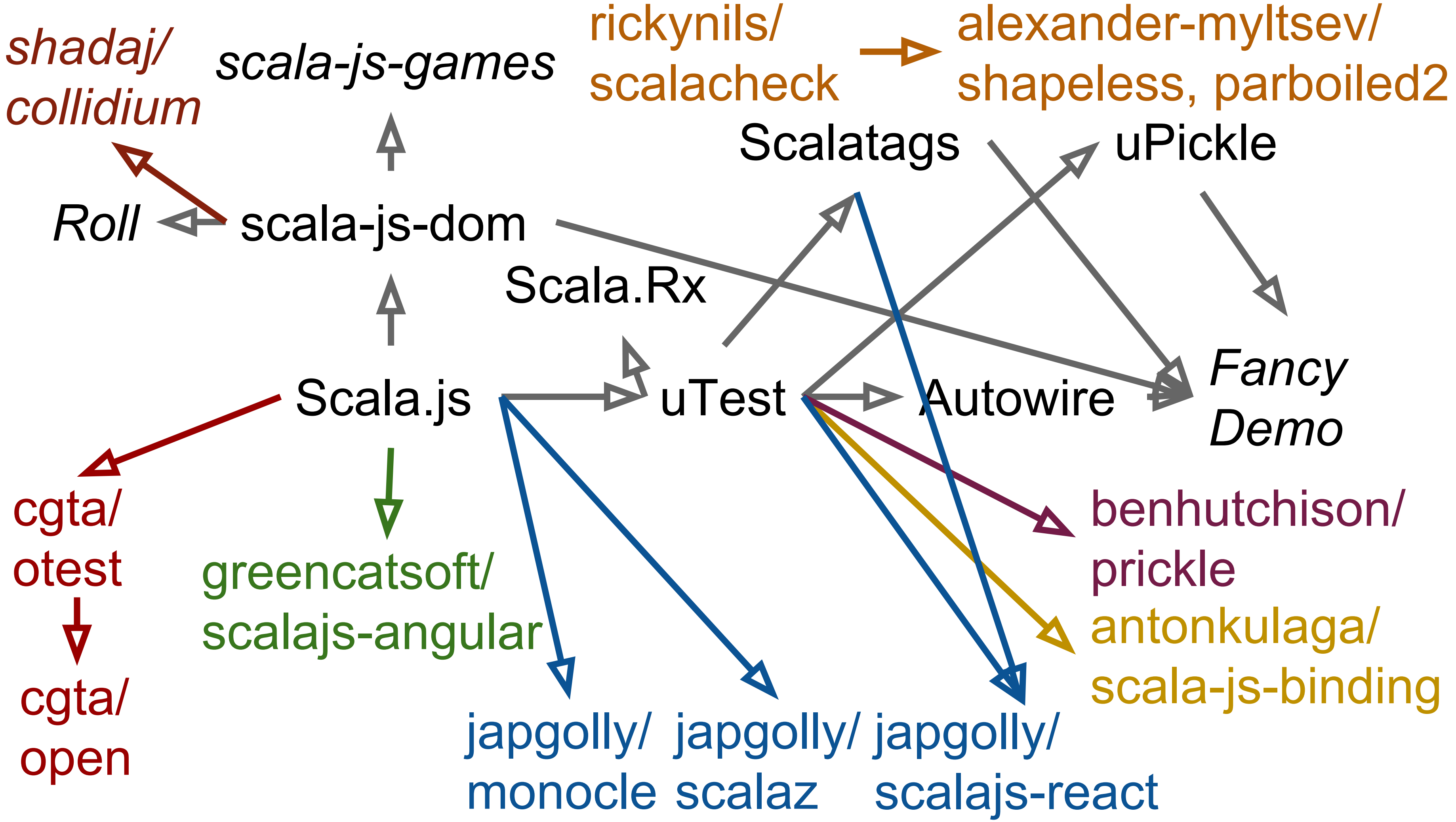
Autowire

```
libraryDependencies += "com.lihaoyi" %%% "autowire" % "0.2.3"

libraryDependencies += "com.lihaoyi" %% "autowire" % "0.2.3"
```

Things We Need

- ✔ Web Server (Spray)
- ✔ JavaScript APIs (scala-js-dom)
- ✔ HTML Generation (Scalatags)
- ✔ Type safe Ajax Routing (Autowire)
- ✔ Data Serialization Library (uPickle)
- ✔ Testing Framework (uTest)


shadaj/ collidium
scala-js-games
rickynils/ scalacheck
alexander-myltsev/ shapeless, parboiled2
Scalatags
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Roll
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Scala.Rx
Fancy Demo
Scala.js
uTest
Autowire
cgta/ otest
greencatsoft/ scalajs-angular
benhutchison/ prickle
antonkulaga/ scala-js-binding
cgta/ open
japgolly/ monocle
japgolly/ scalaz
japgolly/ scalajs-react

Properties of the Scala.js Ecosystem

- Roughly breaks down into *Javascript wrappers*, and *cross-built code*

- No BS, minimal-dependency libraries
  - BS dependencies don’t exist in Scala.js
  - Servlets, Reflection, Classloaders, etc.

- No large frameworks (yet?)

Moral of the story?

- It takes quite a lot of effort to go from "working compiler" to "cool demo"

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- Writing things yourself ain't so bad

Moral of the story?

- It takes quite a lot of effort to go from "working compiler" to "cool demo"
- Writing things yourself ain't so bad
- If you are trapped on a desert island with nothing but a compiler, first thing to build is a testing framework

Bootstrapping the Scala.js Ecosystem

Questions?

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    - Cool presentation I gave
- Hands-on Scala.js E-book
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