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Experiences with Scala Across the College-Level Curriculum

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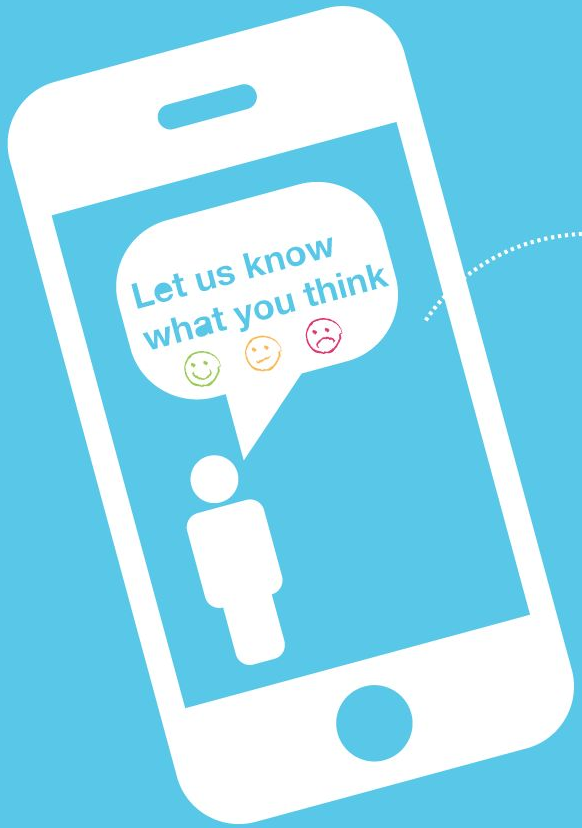

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Scala Days app
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Motivation

- Colleges and universities (we) produce talent.
- Industry (you) “consumes” talent.
- This could be a match made in heaven!
- Where do we stand with respect to *Scala* talent?
- We’ll share our side of the story.
- Then you’ll get to share yours!

Context: the Higher Ed landscape

- Pre-college: CS for All
  - CS Principles AP/CS0 - Python
  - CS AP/CS1 - Java
- Community colleges (2y)
- 4y colleges and universities
  - Wide spectrum btw. teaching and research
  - What can they offer?
  - Which are the best match?

Us in the Higher Ed landscape 3

Loyola: private not-for-profit, 16,000 students

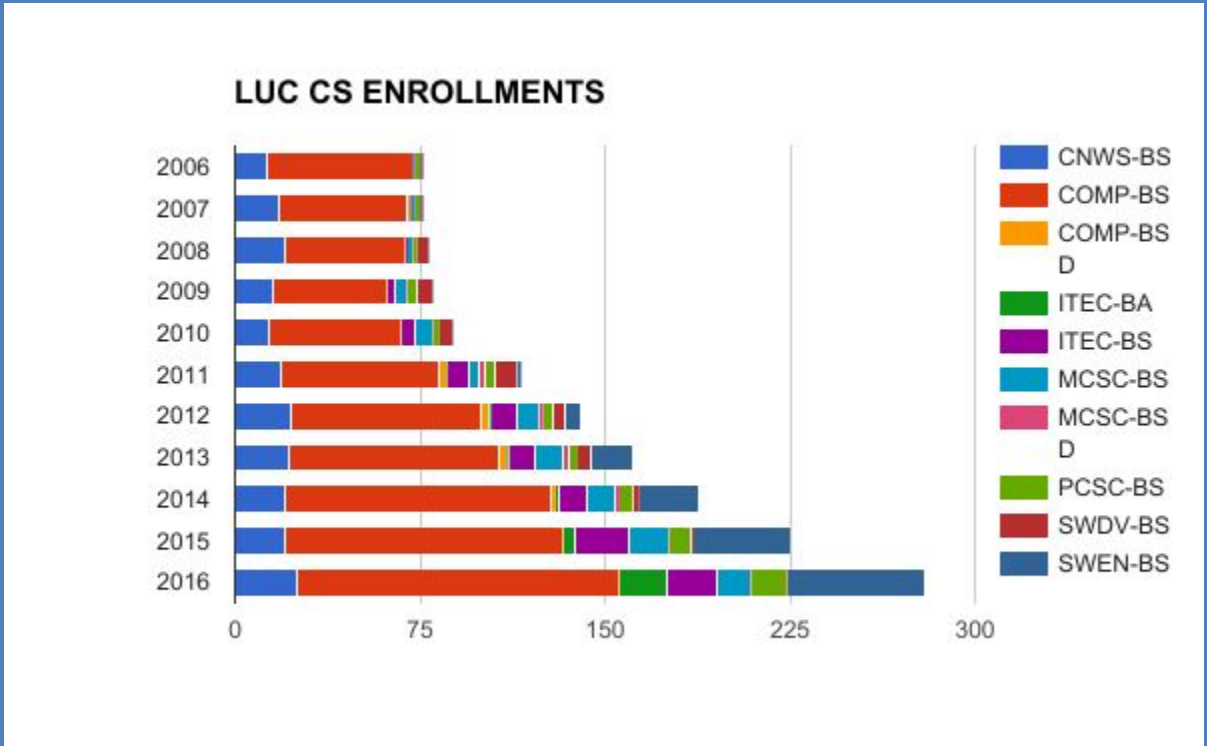
- Doctoral Universities: Higher Research Activity (“R2”)
- BS and MS in CS, SE, IT, BIOI; BS in Cybersecurity
- Producing about 60 BS and 80 MS per year

Trinity: private non-profit, 2,500 students

- Master's Colleges & Universities: Small Programs
- BS in CS
- Producing 15-30 BS per year

Us: senior faculty with 16-25 years post-PhD experience

Us in the Higher Ed landscape 2



Us in the Higher Ed Landscape 1

Does this scale (out)?

Portfolio of Scala-based courses 2

Using Scala since 2010 across these courses:

- CS1, CS2
- Intermediate OO Development
- Theory (and Practice) of Programming Languages
- Advanced OO Development
- Server Side Software Development
- Web Services Programming
- Independent study/directed research

https://github.com/LoyolaChicagoCode/?q=scala

Portfolio of Scala-based courses 1

For each course, we will show

- functional and nonfunctional objectives
- role of Scala
- examples
- what worked and what needs improvement
- current status: how regularly offered, using Scala or not

CS1: Intro Programming for CS/SE Majors 3

Functional objectives

- Solve simple symbolic and numeric problems programmatically

Nonfunctional objectives

- Proficiency in a programming language
- Values, constants, variables, and types
- Branching, iteration, control abstraction (functions)

Role of Scala: like a statically typed scripting language

CS1: Intro Programming for CS/SE Majors 2

```
for (i <- 1 to 100) {
  if (i % 3 == 0) print("fizz")
  if (i % 5 == 0) print("buzz")
  if (i % 3 != 0 && i % 5 != 0) print(i)
  println()
}
```

Can also use pattern matching to set up a decision table but first-year students might find this less clear.

CS1: Intro Programming for CS/SE Majors 1

Reflection

+ Scala worked like a statically typed Python without Java's warts
+ (Lightweight) functions first
+ Unlike Java, supports structural typing, not only nominal
- IO, `readInt` and `readLine` now require an import
- Various other complications and lost opportunities

Status

- Loyola: Scala: one-time pilot in fall 2015, Java: active/regular
- Trinity: Scala - active as a regular offering

CS2: Intro Data Structures

Functional objectives

- (Mostly linear) data structures
- Searching and sorting algorithms
- A bit of parallelism

Nonfunctional objectives

- Using an OO language to provide abstract data types
- Appreciation of performance and speedup on multicore HW

Role of Scala: largely as a better Java, works well *after Scala in CS1*

Status: Trinity: Scala active, regular offering; Loyola: Java or C++

Intermediate OO Development 3

Functional objectives

- Custom domain models + recursive behaviors
- Interactive/GUI applications

Nonfunctional objectives

- Design and architectural patterns, separation of concerns
- Event-based programming and background activities
- Testing, including event-based/concurrent systems
- Some experience with Android
- Initial exposure to CI/CD

Intermediate OO Development 2

```
override def start() = { // in ticking clock
  timer = new Timer
  timer.schedule(new TimerTask {
    override def run() = listener.onTick() // fire event
  }, /*initial delay*/ DELAY, /*periodic delay*/ DELAY)
}

private object RUNNING extends StopwatchState { // in state machine
  override def onStartStop() = { actionStop() ; goToState(STOPPED) }
  override def onTick()      = { actionInc() ; goToState(RUNNING) }
  override def updateView()  = updateUIRuntime()
}

val model: StopwatchModel = new ConcreteStopwatchModelFacade {
  lazy val listener = MainActivity.this // inject Android activity
```

Intermediate OO Development 1

Reflection

+ Better, more concise Java
+ Very versatile, multi-paradigm
- Steep learning curve for some
- Considerable friction with Android development (ProGuard)

Status - Loyola

- Scala: one-time graduate-level *online* pilot in fall 2014
- Java: active, five sections per year including summer

Theory (and Practice) of Programming Languages 7

Functional objectives

- Efficient Unix-like stdin-stdout pipes
- Custom domain models + recursive behaviors
- Lexers, parsers, interpreters

Nonfunctional objectives

- Understand the programming language design space
- Build and use increasingly powerful abstractions
- Separation of concerns in software design, e.g.
  - structure, content, traversal, processing

Theory (and Practice) of Programming Languages 6

Role of Scala

- Thin cake *idiom* for simple dependency injection
- Algebraic data types
- Higher-order functions
- Higher-kinded types

Theory (and Practice) of Programming Languages 5

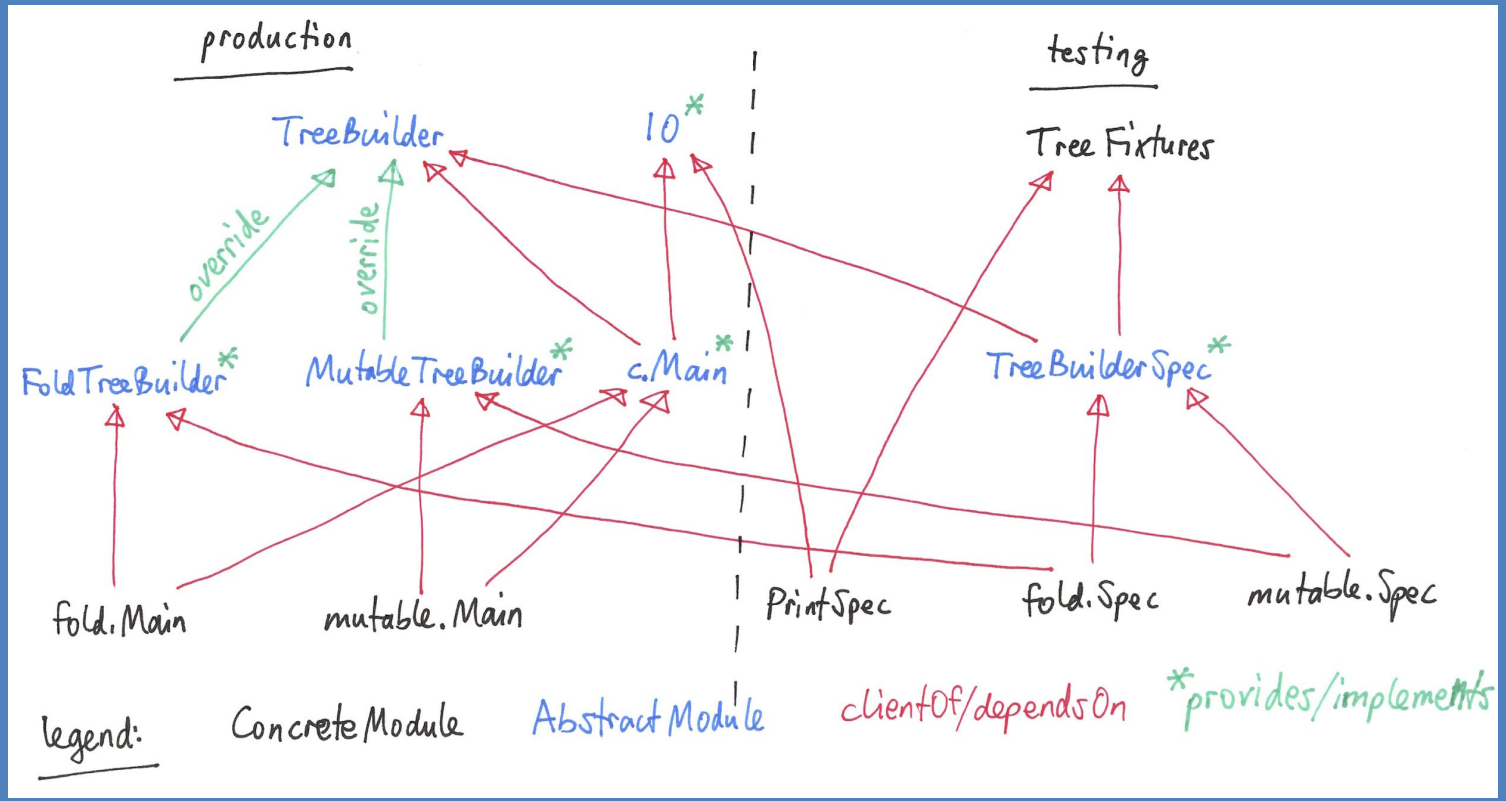
```
trait TreeBuilder { … } // SUT-abstraction/contract
trait IO { … } // provider
trait Main extends App with IO with TreeBuilder { … } // hybrid
trait FoldTreeBuilder extends TreeBuilder { … } // SUT-provider

object FMain extends Main with FoldTreeBuilder // DI - no body!

abstract class Spec
  extends WordSpec with TreeBuilder { … } // hybrid

class FSpec extends Spec with FoldTreeBuilder // DI - no body!
```

Theory (and Practice) of Programming Languages 4



Theory (and Practice) of Programming Languages 3

```
// data = structure + content

sealed trait ExprF[A]
case class Constant[A](value: Int) extends ExprF[A]
case class Plus[A](left: A, right: A) extends ExprF[A]

…
object exprFFunctor extends Functor[ExprF] { // scalaz
  def map[A, B](fa: ExprF[A])(f: A => B): ExprF[B] = fa match {
    case Constant(v) => Constant[B](v)
    case Plus(l, r)  => Plus(f(l), f(r))
    …
type Expr = Fix[ExprF] // Matryoshka
```

Theory (and Practice) of Programming Languages 2

```
// behavior = traversal + processing

val evaluate: Algebra[ExprF, Int] = { // processing
  case Constant(c) => c
  case Plus(l, r)  => l + r
  …


assert { (fixtures.complex1 cata evaluate) == -1 }
// cata (generalized fold provided by Fix[F]): traversal

functor.laws[ExprF]
```

Theory (and Practice) of Programming Languages 1

Reflection

+ Multi-paradigm lang: imperative, OO, functional, concurrent
+ Powerful value and type abstractions
- Steep learning curve for many
- JVM ignores `SIGPIPE` => can't write composable Unix tools

Status - Loyola

- Active, taught in Scala every spring semester since 2013 to 15-25 students (70-80% undergrad)
- U: alternative to Operating Systems, G: elective

Advanced OO Development

Objectives: depends on who teaches it!

- (1) Enterprise computing focus vs.
- (2) Modeling and simulation

Nonfunctional objectives

- (1) Architecture, ORM
- (2) Architecture, concurrency/actors

Role of Scala: (2) powerful abstractions and support for actors

Status - Loyola: in Scala 2x before 2012, then back to Java

Server-Side App Development

```
object Application extends Controller {
  def guess(value: Long) = Action { implicit request => …
    val model = previousModel.guess(value.toInt)
    if (model.comparison == 0)
      Ok(views.html.right(guessForm, model))
    else
  …
```

Objectives: multi-tier, human-centric app design/ implementation

Role of Scala: architecture/frameworks, better Java

Loyola: Scala/Play 2x bef. 2012, then back to Java, now suspended*

Trinity: active using Scala and Play

*alt. course: full-stack JS

Web Services Programming

```
class ClickcounterServiceActor
  extends Actor with RedisRepositoryProvider {
  …
  path("increment") {
    post {
      updateIt(_.value + 1, "counter at max, cannot increment")
  …
```

Objectives: REST API design and implementation

Role of Scala: architecture/libraries, concurrency, scalability

Status - Loyola: Scala/spray 2x before 2012, then back to Java

How can we make “it” happen? 4

“it” = scaling *out* the talent production

Some observations:

- We have trouble finding Scala talent ourselves…
- How many instructors fully understand functional programming?
- Need to identify “the hook”: for what courses is Scala a/the *compelling* choice?
- Can we add Scala support to Processing as an onramp?

How can we make “it” happen? 3

Can we convince an entire (education) community that Scala is a compelling choice for each of these areas?

- Full-stack web
- Web front end, preferably isomorphic
- High-scalability server-side
- Mobile
- Systems
- Embedded
- Data analytics

How can we make “it” happen? 2

Can we convince an entire (education) community that Scala is a compelling choice for each of these areas? Lots of competition!

- Full-stack web: JavaScript, Python, Java, Scala/Scala.js
- Web front end, preferably isomorphic: JavaScript, Elm, Scala.js
- High-scalability server-side: Java, Scala
- Mobile: Java, Kotlin, Swift, JavaScript, C#/Xamarin
- Systems: Go, Rust, Scala native, nim?
- Embedded: Go, Rust, Erlang/Elixir, JavaScript, Scala native?, nim?
- Data analytics: lightweight - Python, R; high-performance - Spark

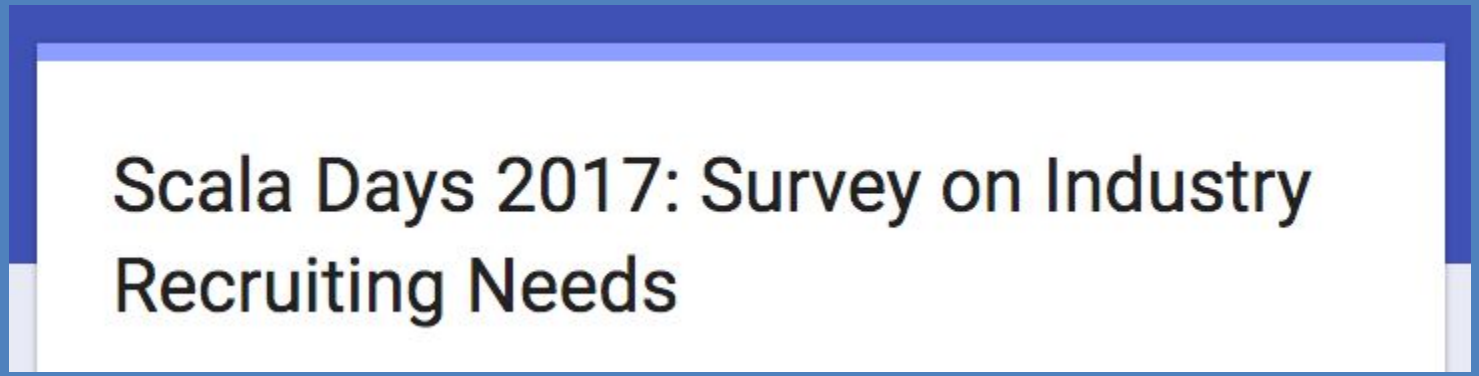
How can we make “it” happen? 1

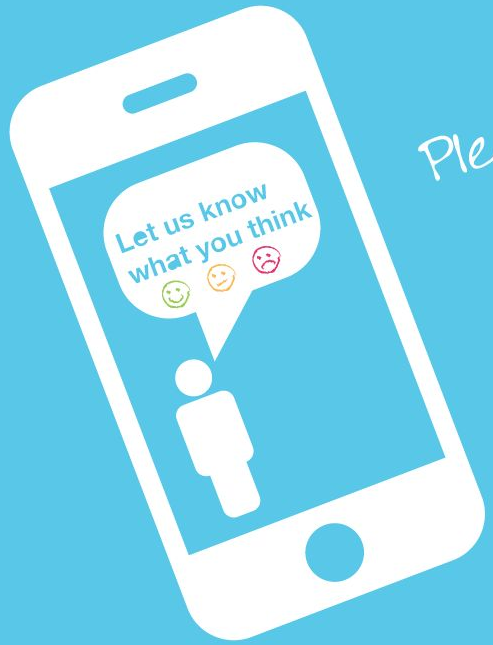
To make it scale out, we need a *multiplier effect*. Some ideas:

- Building out the community
- Working with educators across the whole spectrum
  - Scala workshops at CS edu conferences, e.g., ours @ SIGCSE
  - ambassador program?
  - internships?
- Including the batteries, curate the choices, include exemplars
  “C_AN” - Comprehensive _ Archive Network
- Stepping up support for lightweight data analytics (CSV, JSON) to compete with R, Python

Conclusion: We need your input

http://bit.ly/lucscalasurvey





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