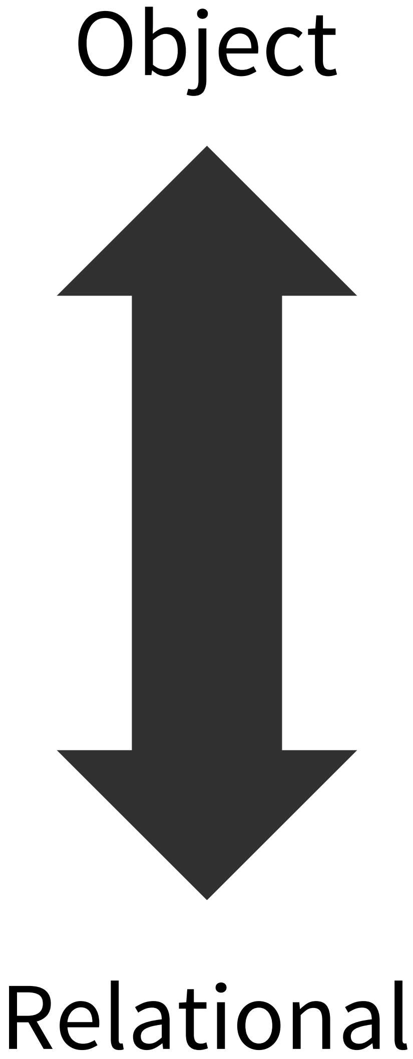
Introduction to Slick 2.1 and 2.2

Stefan Zeiger

Typesafe

Object-Relational Mapping



Object

Relational

Object

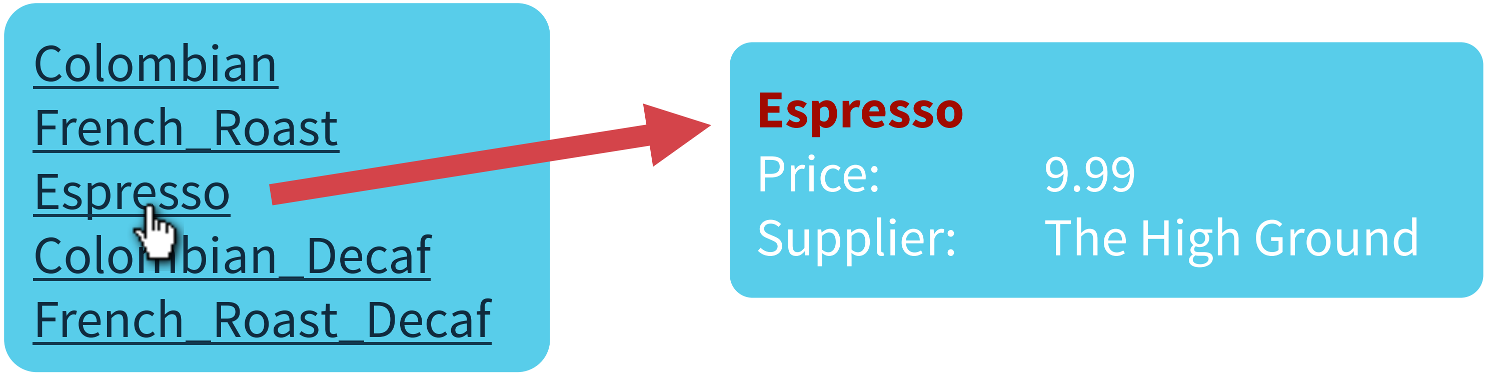
Impedance Mismatch

Relational

Concepts

Object-Oriented	Relational
Identity	No Identity
State	Transactional State
Behavior	No Behavior
Encapsulation	No Encapsulation

Laziness



Colombian
French_Roast
Espresso
Colombian_Decaf
French_Roast_Decaf

Espresso
Price: 9.99
Supplier: The High Ground

```
select NAME
from COFFEES
```

```
select c.NAME, c.PRICE, s.NAME
from COFFEES c
join SUPPLIERS s
  on c.SUP_ID = s.SUP_ID
where c.NAME = ?
```

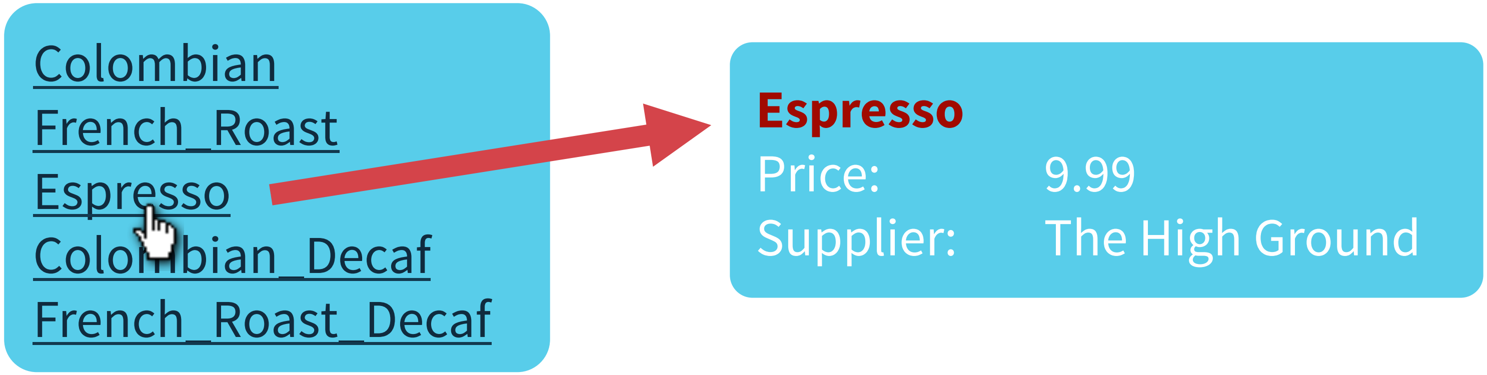
Laziness

Colombian	7.99
French_Roast	8.99
Espresso	9.99
Colombian_Decaf	8.99
French_Roast_Decaf	9.99

```
def getAllCoffees(): Seq[Coffee] = …

def printLinks(s: Seq[Coffee]) {
  for(c <- s) println(c.name + c.price)
}
```

Laziness



Colombian
French_Roast
Espresso
Colombian_Decaf
French_Roast_Decaf

Espresso
Price: 9.99
Supplier: The High Ground

```
def printDetails(c: Coffee) {
  println(c.name)
  println("Price: " + c.price)
  println("Supplier: " + c.supplier.name)
}
```

Level of Abstraction

	Object Oriented	Relational
Data Organization	High	Low
Data Flow	Low	High

Functional Relational Mapping

Relational Model

- Relation
- Attribute
- Tuple
- Relation Value
- Relation Variable

COFFEES		
NAME : String	**PRICE** : Double	**SUP_ID** : Int
Colombian	7.99	101
French_ Roast	8.99	49
Espresso	9.99	150

Relational Model

- **Relation**
- Attribute
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COFFEES

NAME	PRICE	SUP_ID
: String	: Double	: Int
Colombian	7.99	101
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COFFEES

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Espresso	9.99	150

Mapped to Scala

- Relation
- Attribute
- Tuple
- Relation Value
- Relation Variable

```scala
case class Coffee(
  name: String,
  supplierId: Int,
  price: Double
)

val coffees = Set(
  Coffee("Colombian",   101, 7.99),
  Coffee("French_Roast", 49, 8.99),
  Coffee("Espresso",    150, 9.99)
)
```

Mapped to Scala

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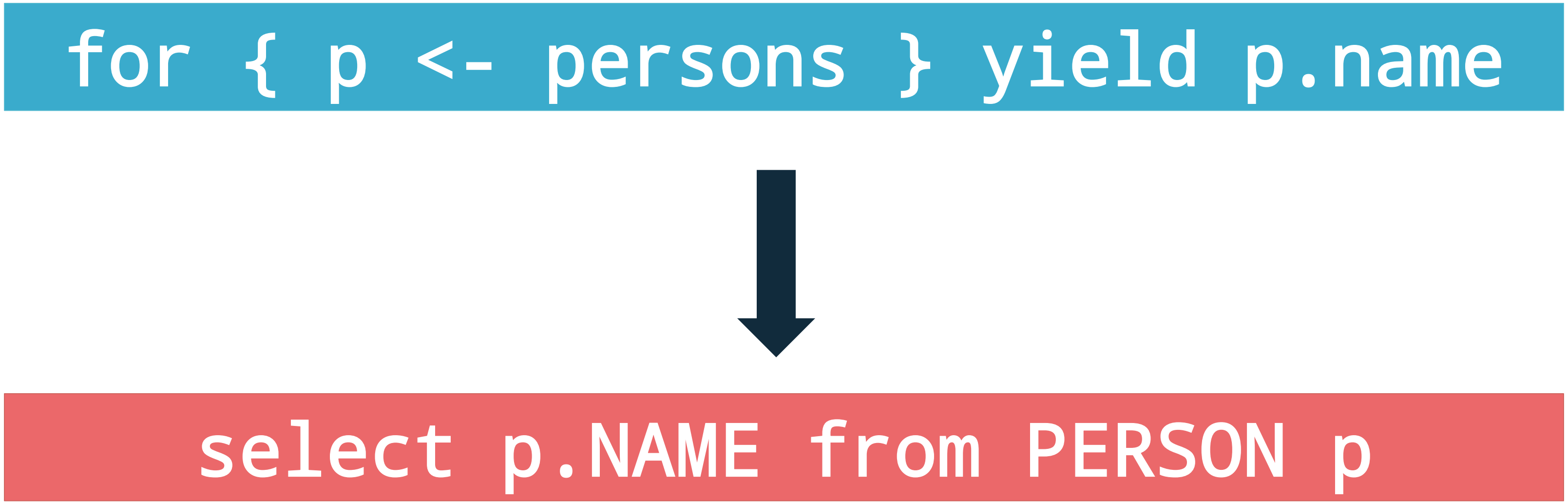
  Coffee("Espresso",     150, 9.99)
)
```

Write Database Code in Scala



```
for { p <- persons } yield p.name
```

```
select p.NAME from PERSON p
```

```
(for {
      p <- persons.filter(_.age < 20) ++
           persons.filter(_.age >= 50)
           if p.name.startsWith("A")
} yield p).groupBy(_.age).map { case (age, ps) =>
  (age, ps.length)
}
```

```
select x2.x3, count(1) from (
  select * from (
    select x4."NAME" as x5, x4."AGE" as x3
      from "PERSON" x4 where x4."AGE" < 20
    union all select x6."NAME" as x5, x6."AGE" as x3
      from "PERSON" x6 where x6."AGE" >= 50
    ) x7 where x7.x5 like 'A%' escape '^'
  ) x2
group by x2.x3
```

Functional Relational Mapping

- Embraces the relational model
- Prevents impedance mismatch

```
class Suppliers ... extends
    Table[(Int, String, String)](... "SUPPLIERS")

sup.filter(_.id < 2) ++ sup.filter(_.id > 5)
```

Functional Relational Mapping

- Embraces the relational model
- Prevents impedance mismatch
- Composable Queries

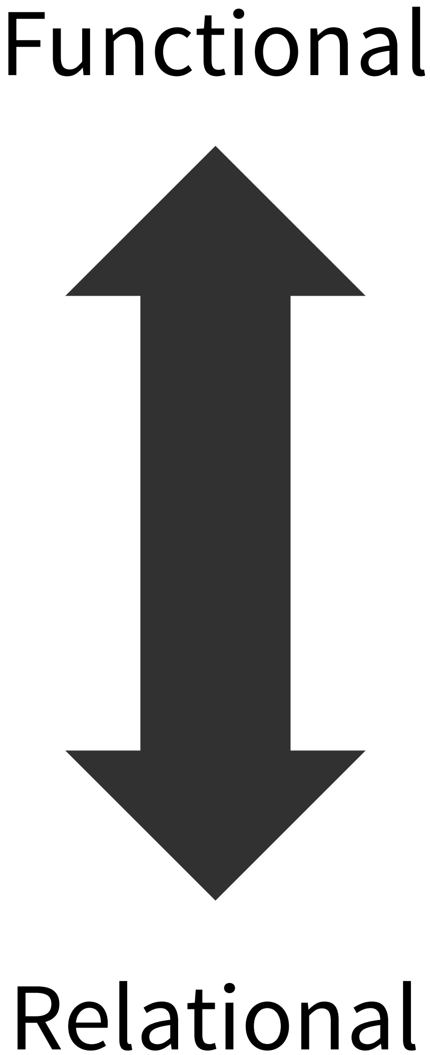
```
def f(id1: Int, id2: Int) =
  sup.filter(_.id < id1) ++ sup.filter(_.id > id2)

val q = f(2, 5).map(_.name)
```

Functional Relational Mapping

- Embraces the relational model
- Prevents impedance mismatch
- Composable Queries
- Explicit control over statement execution

```
val result = q.run
```



Functional

Relational

Functional

Relational

Slick

Slick

Scala Language Integrated Connection Kit

- Database query and access library for Scala
- Successor of ScalaQuery
- Developed at Typesafe and EPFL
- Open Source

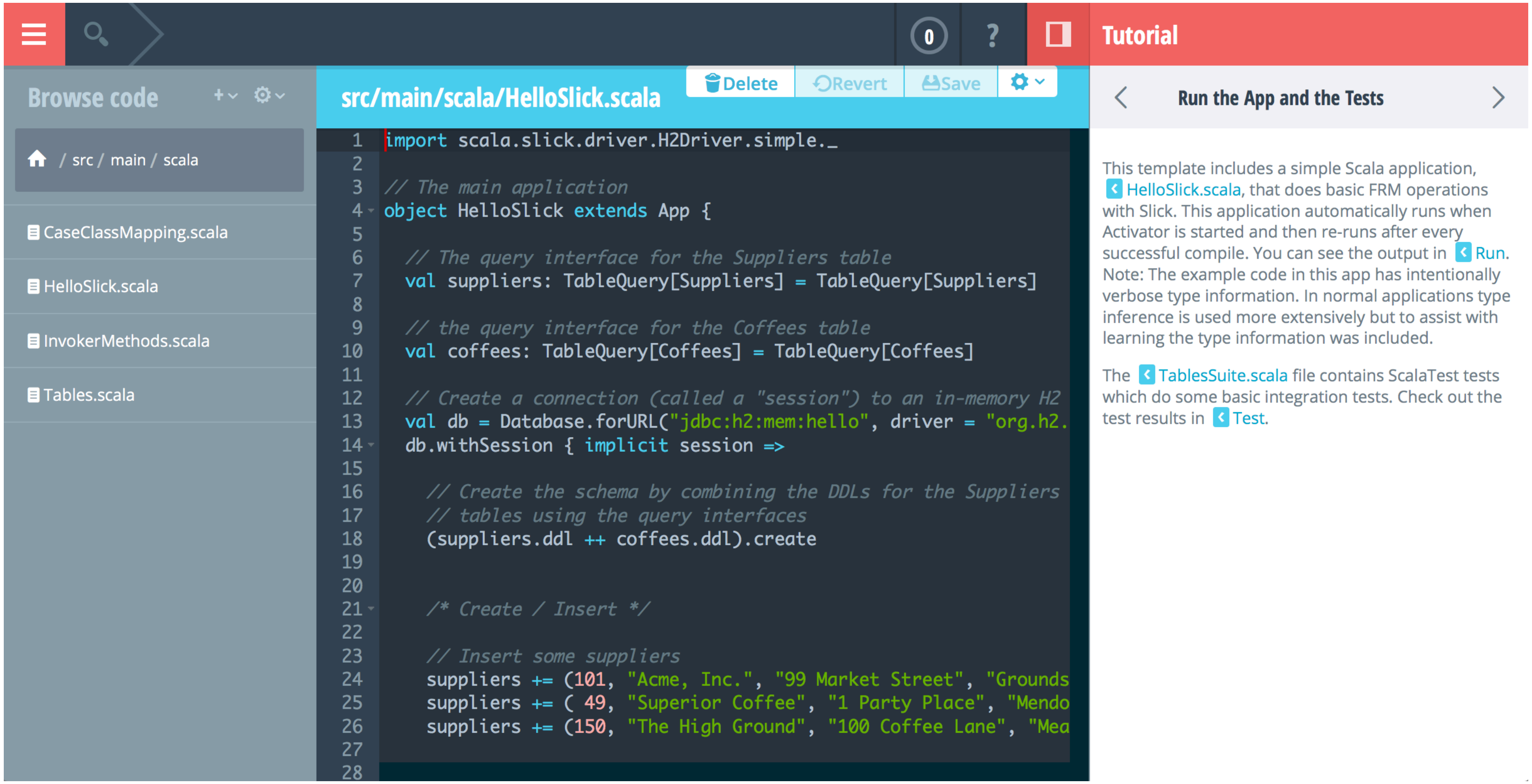
Supported Databases

- **Slick**
  - PostgreSQL
  - MySQL
  - H2
  - Hsqldb
  - Derby / JavaDB
  - SQLite
  - Access

- **Slick Extensions**
  - Oracle
  - DB2
  - SQL Server

Closed source, with commercial support by Typesafe

Getting Started with Activator



```
import scala.slick.driver.H2Driver.simple._

// The main application
object HelloSlick extends App {

  // The query interface for the Suppliers table
  val suppliers: TableQuery[Suppliers] = TableQuery[Suppliers]

  // the query interface for the Coffees table
  val coffees: TableQuery[Coffees] = TableQuery[Coffees]

  // Create a connection (called a "session") to an in-memory H2
  val db = Database.forURL("jdbc:h2:mem:hello", driver = "org.h2.
  db.withSession { implicit session =>

    // Create the schema by combining the DDLs for the Suppliers
    // tables using the query interfaces
    (suppliers.ddl ++ coffees.ddl).create


    /* Create / Insert */

    // Insert some suppliers
    suppliers += (101, "Acme, Inc.", "99 Market Street", "Grounds
    suppliers += ( 49, "Superior Coffee", "1 Party Place", "Mendo
    suppliers += (150, "The High Ground", "100 Coffee Lane", "Mea

```

This template includes a simple Scala application, HelloSlick.scala, that does basic FRM operations with Slick. This application automatically runs when Activator is started and then re-runs after every successful compile. You can see the output in Run. Note: The example code in this app has intentionally verbose type information. In normal applications type inference is used more extensively but to assist with learning the type information was included.

The TablesSuite.scala file contains ScalaTest tests which do some basic integration tests. Check out the test results in Test.

http://typesafe.com/activator

Schema Definition

Table Definition

```
class Suppliers(tag: Tag) extends
    Table[(Int, String, String)](tag, "SUPPLIERS") {
  def id = column[Int]("SUP_ID",
                       O.PrimaryKey, O.AutoInc)
  def name = column[String]("NAME")
  def city = column[String]("CITY")
  def * = (id, name, city)
}

val suppliers = TableQuery[Suppliers]
```

Custom Row Types

```
case class Supplier(id: Int, name: String,
  city: String)

class Suppliers(tag: Tag) extends
    Table[ Supplier            ](tag, "SUPPLIERS") {
  def id = column[Int]("SUP_ID",
                       O.PrimaryKey, O.AutoInc)
  def name = column[String]("NAME")
  def city = column[String]("CITY")
  def * = (id, name, city) <>
    (Supplier.tupled, Supplier.unapply)
}

val suppliers = TableQuery[Suppliers]
```

Custom Column Types

```
class SupplierId(val value: Int) extends AnyVal

case class Supplier(id: SupplierId, name: String,
  city: String)

implicit val supplierIdType = MappedColumnType.base
  [SupplierId, Int](_.value, new SupplierId(_))

class Suppliers(tag: Tag) extends
    Table[Supplier](tag, "SUPPLIERS") {
  def id = column[SupplierId]("SUP_ID", ...)
  ...
}
```

Custom Column Types

```
class SupplierId(val value: Int) extends MappedTo[Int]

case class Supplier(id: SupplierId, name: String,
  city: String)




class Suppliers(tag: Tag) extends
    Table[Supplier](tag, "SUPPLIERS") {
  def id = column[SupplierId]("SUP_ID", ...)
  ...
}
```

Foreign Keys

```
class Coffees(tag: Tag) extends Table[
    (String, SupplierId, Double)](tag, "COFFEES") {
  def name = column[String]("NAME", O.PrimaryKey)
  def supID = column[SupplierId]("SUP_ID")
  def price = column[Double]("PRICE")
  def * = (name, supID, price)
  def supplier =
    foreignKey("SUP_FK", supID, suppliers)(_.id)
}

val coffees = TableQuery[Coffees]
```

Code Generator

- Reverse-engineer an existing database schema
- Create table definitions and case classes
- Customizable
- Easy to embed in sbt build

Data Manipulation

Session Management

```
import scala.slick.driver.H2Driver.simple._

val db = Database.forURL("jdbc:h2:mem:test1",
                    driver = "org.h2.Driver")

db.withSession { implicit session =>
  // Use the session:
  val result = myQuery.run
}
```

Creating Tables and Inserting Data

```scala
val suppliers = new ArrayBuffer[Supplier]
val coffees = new ArrayBuffer[(String, SupplierId, Double)]
```

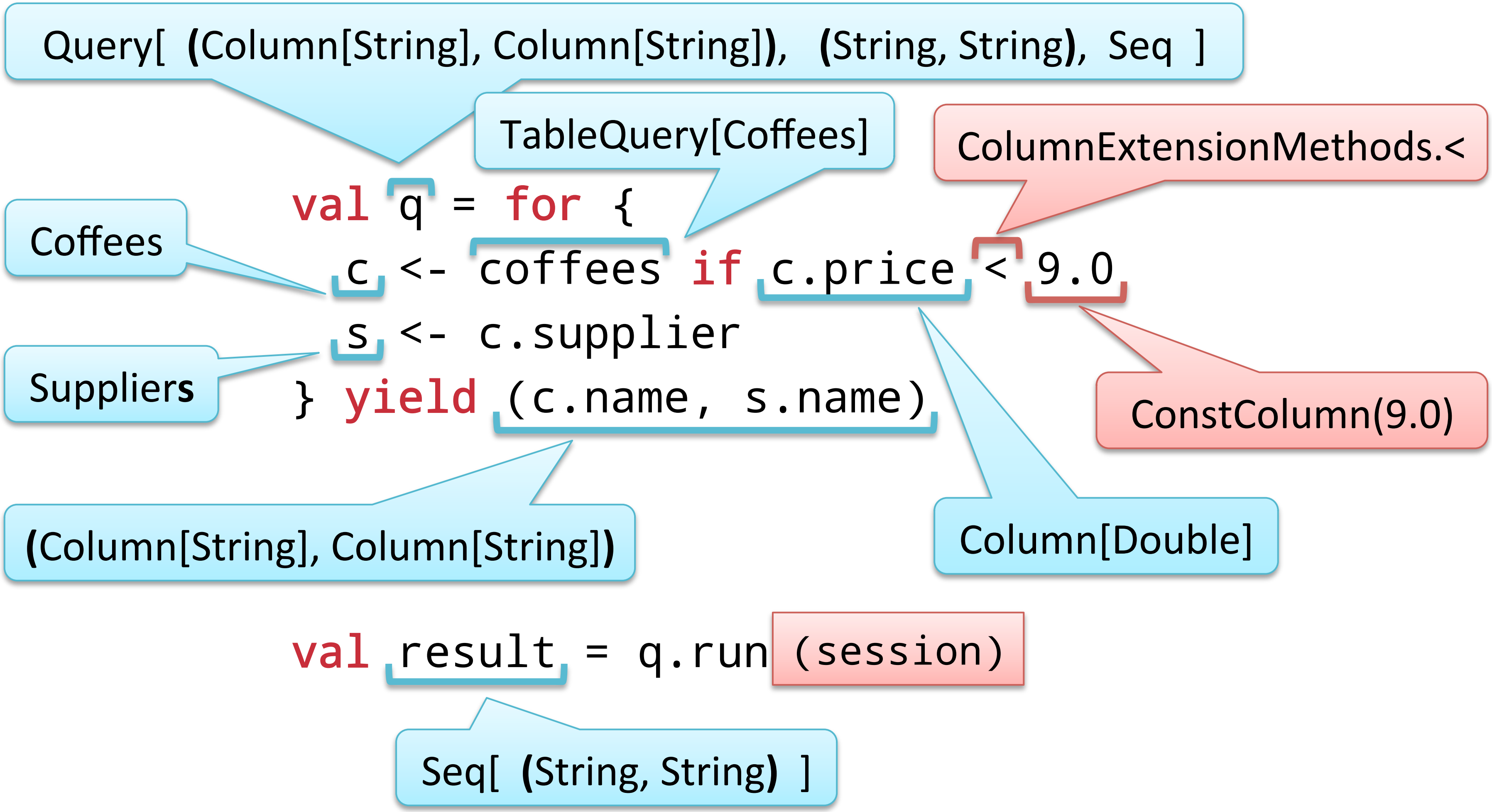
```scala
suppliers += Supplier(si1, "Acme, Inc.", "Groundsville")
suppliers += Supplier(si2, "Superior Coffee", "Mendocino")
suppliers += Supplier(si3, "The High Ground", "Meadows")

coffees ++= Seq(
  ("Colombian",          si1, 7.99),
  ("French_Roast",       si2, 8.99),
  ("Espresso",           si3, 9.99),
  ("Colombian_Decaf",    si1, 8.99),
  ("French_Roast_Decaf", si2, 9.99)
)
```

Auto-Generated Keys

```
val ins = suppliers.map(s => (s.name, s.city))
  returning suppliers.map(_.id)

val si1 = ins += ("Acme, Inc.", "Groundsville")
val si2 = ins += ("Superior Coffee", "Mendocino")
val si3 = ins += ("The High Ground", "Meadows")

coffees ++= Seq(
  ("Colombian",          si1, 7.99),
  ("French_Roast",       si2, 8.99),
  ("Espresso",           si3, 9.99),
  ("Colombian_Decaf",    si1, 8.99),
  ("French_Roast_Decaf", si2, 9.99)
)
```

Querying

Queries



```
val q = for {
  c <- coffees if c.price < 9.0
  s <- c.supplier
} yield (c.name, s.name)

val result = q.run (session)
```

Query[(Column[String], Column[String]), (String, String), Seq]

TableQuery[Coffees]

ColumnExtensionMethods.<

Coffees

Suppliers

ConstColumn(9.0)

(Column[String], Column[String])

Column[Double]

Seq[(String, String)]

Nullable Columns

- We don't like *null* in Scala!
- ...but the database likes them

```
class Coffees(tag: Tag) extends Table[
    (String, Option[SupplierId], Double)](tag, "COFFEES") {
  def name = column[String]("NAME", O.PrimaryKey)
  def supID = column[Option[SupplierId]]("SUP_ID")
  def price = column[Double]("PRICE")
  def * = (name, supID, price)
  def supplier =
    foreignKey("SUP_FK", supID.?, suppliers)(_.id)
}
```

Nullable Columns

- We don't like *null* in Scala!
- ...but the database likes them

```
coffees.map(_.price).max : Column[Option[Double]]
```

Plain SQL

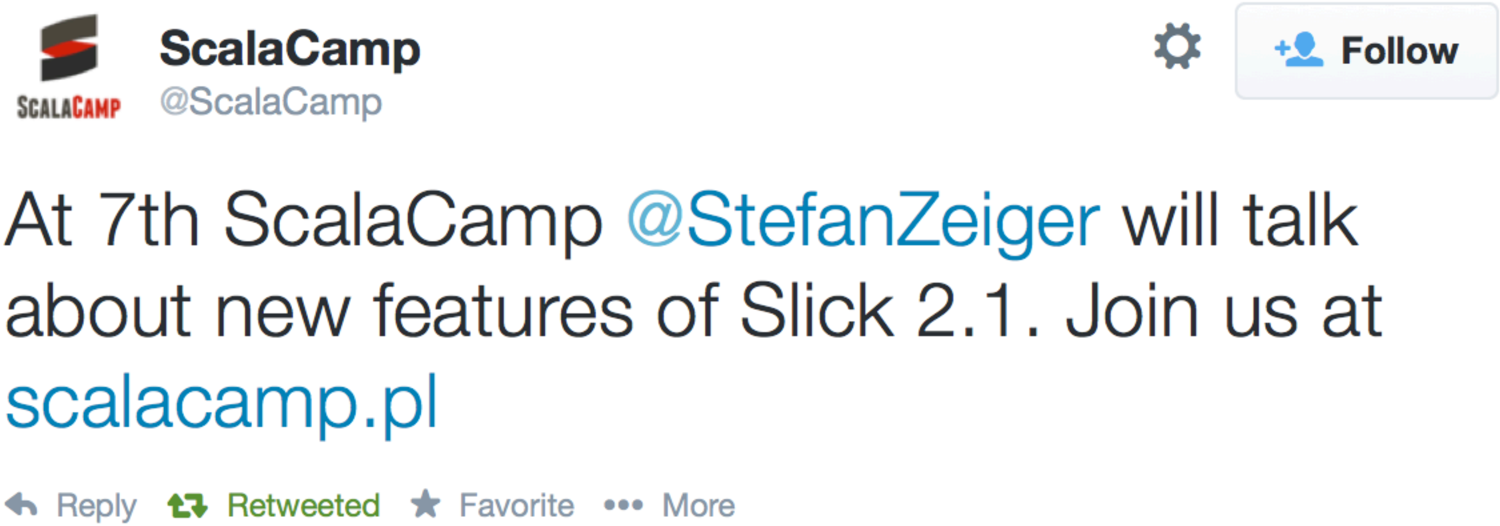
JDBC

```
def personsMatching(pattern: String)(conn: Connection) = {
  val st = conn.prepareStatement(
    "select id, name from person where name like ?")
  try {
    st.setString(1, pattern)
    val rs = st.executeQuery()
    try {
      val b = new ListBuffer[(Int, String)]
      while(rs.next)
        b.append((rs.getInt(1), rs.getString(2)))
      b.toList
    } finally rs.close()
  } finally st.close()
}
```

Slick: Plain SQL Queries

```
def personsMatching(pattern: String)(implicit s: Session) =
  sql"select id, name from person where name like $pattern"
    .as[(Int, String)].list
```

Slick 2.1



ScalaCamp
@ScalaCamp

At 7th ScalaCamp @StefanZeiger will talk about new features of Slick 2.1. Join us at scalacamp.pl

Documentation

- New user manual chapters
  - Coming from ORM to Slick
  - Coming from SQL to Slick
- Activator Templates
  - Replacing *slick-examples* and other sample projects
  - Per major version
- More comprehensive API docs

Outer Join Emulation

- Full Outer Join → Left Outer Join + Union All
- Right Outer Join → Left Outer Join
- Left Outer Join → Inner Join + Union All

```
ts outerJoin ts on (_.id === _.id)
```

```
select s2.s21, s3.s22
from (select s23."id" as s21 from "t" s23) s2
  full outer join (select s24."id" as s22 from "t" s24) s3
  on s2.s21 = s3.s22
```

Outer Join Emulation

```
select s21.s41, s21.s42
from (
  select s27.s43 as s41, s27.s44 as s42 from (
    select s2.s45 as s43, s3.s46 as s44
    from (select s53."id" as s45 from "t" s53) s2
      inner join (select s54."id" as s46 from "t" s54) s3
      on s2.s45 = s3.s46
    union all select s55."id" as s43, null as s44
    from "t" s55
    where not exists(select s57."id" from "t" s57 where s55."id" = s57."id")
  ) s27
  union all select null as s41, s59."id" as s42
  from "t" s59
  where not exists(select s61."id" from "t" s61 where s61."id" = s59."id")
) s21
```

Compiled Pagination Operators

- Overloaded for *ConstColumn*
- Values known at query execution time

```
Compiled { (d: ConstColumn[Long], t: ConstColumn[Long]) =>
  ids.sortBy(_.id).drop(d).take(t)
}
```

H2

- CompiledStatement

```
select s6."id" from (select s13."id" as "id" from
"ids_compiled" s13 order by s13."id" limit ? offset ?) s6
```

Compiled Pagination Operators

- Overloaded for *ConstColumn*
- Values known at query execution time

Derby

- `ParameterSwitch`
  - `[<function1>(...) == 0]: CompiledStatement`

    ```
    select s6."id" from (select s13."id" as "id" from
    "ids_compiled" s13 where 1=0 order by s13."id") s6
    ```

  - `default: CompiledStatement`

    ```
    select s6."id" from (select s13."id" as "id" from
    "ids_compiled" s13 order by s13."id" offset ? row
    fetch next ? row only) s6
    ```

Fast Path Result Converters

- Remove Boxing and Allocation Overhead

```
case class A(var a: Int, var b: Int, var c: Int)

class ARow ... extends Table ... {
  ...
  def proj = (i, io.get, io.getOrElse(-1))
}

// Standard converters
val q1 =  as.map(a => a.proj <> (A.tupled, A.unapply))

q1.foreach { a => ... }
```

Fast Path Result Converters

- Remove Boxing and Allocation Overhead

```
// Fast path
val q2 = as.map(a => a.proj <> (A.tupled, A.unapply)
  fastPath(new FastPath(_) {
    val (a, b, c) =
      (next[Int], next[Int], next[Int])
    override def read(r: Reader) = new A(
      a.read(r), b.read(r), c.read(r))
  })
)
```

Fast Path Result Converters

- Remove Boxing and Allocation Overhead

```
// Allocation-free fast path
val sharedA = new A(0, 0, 0)
val q3 = as.map(a => a.proj <> (A.tupled, A.unapply)
  fastPath(new FastPath(_) {
    val (a, b, c) =
      (next[Int], next[Int], next[Int])
    override def read(r: Reader) = {
      sharedA.a = a.read(r)
      sharedA.b = b.read(r)
      sharedA.c = c.read(r)
      sharedA
    }
  })
)
```

Insert or Update

- Longest standing feature request (issue #6) with most upvotes
- Uses native database support (*UPSERT*, *MERGE*) where possible
- Based on primary key comparison

```
ts += (1, "a")

ts insertOrUpdate (2, "b")
```

CaseClassShape

- Easily support monomorphic record types

```
case class B(a: Int, b: String)
case class LiftedB(a: Column[Int], b: Column[String])
implicit object BShape extends CaseClassShape(LiftedB.tupled, B.tupled)

class BRow(tag: Tag) extends Table[B](tag, "shape_b") {
  def id = column[Int]("id", O.PrimaryKey)
  def s = column[String]("s")
  def * = LiftedB(id, s)
}
val bs = TableQuery[BRow]

bs += B(1, "a")

val q3 = for {
  LiftedB(id, s) <- bs if id == 1
} yield LiftedB(id, s ++ s)
```

Collection Type Constructors

- Type constructor propagated through *Query*
- Used with *Executor* API (.run)

```
val xs = TableQuery[X]  // Query[X, ..., Seq]

xs.run // Seq[...]

val q = xs.to[Set] // Query[X, ..., Set]

q.take(10).run // Set[...]
```

- Long-term goal: Remove old *Invoker* API (.list, .first, .iterator, ...)

Other

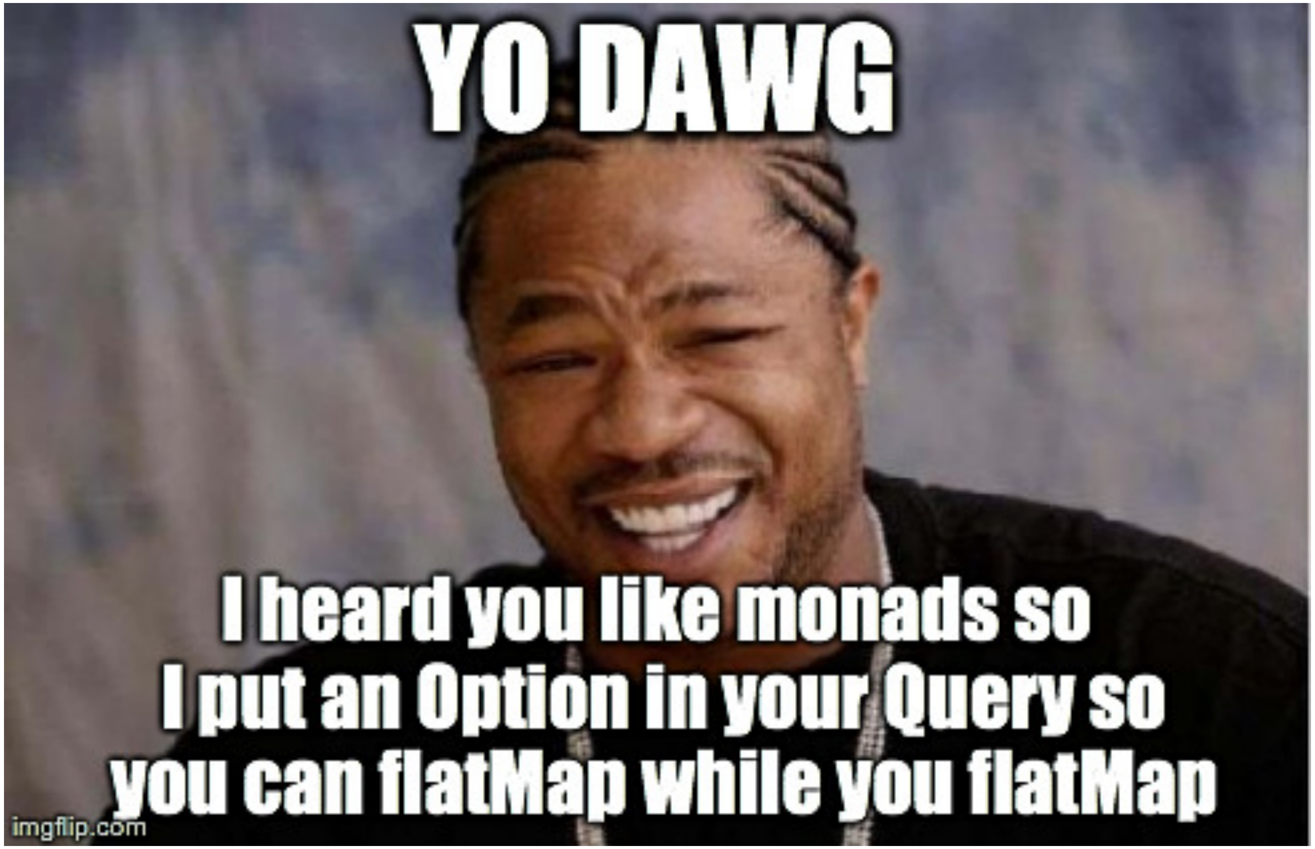
- Typesafe Config (*Database.forConfig*)
- OSGi Support
- More String methods in queries (e.g. *substring)*
- Pre-Compiled Inserts
- More flexible TestKit
- More stable and flexible schema reverse engineering and code generator

Slick 2.2

Reactive Slick

- Asynchronous execution
  - ***Futures*** for scalar / fully materialized results
  - ***Reactive Streams*** for streaming results
- Revamped API for synchronous execution
- Integrated connection pool support
  - Asynchronous execution on top of JDBC
  - Based on connection pool and automatically configured thread pool
- New API for composing database actions (*I/O monad*)
  - Prevent leaking / expired *Session* objects
  - Blocking-agnostic composition of actions

Nested and Multi-Column Options


YO DAWG
I heard you like monads so
I put an Option in your Query so
you can flatMap while you flatMap
imgflip.com

Nested and Multi-Column Options

- Lift to Option: **Rep.Some**
- Generate lifted *None* value: **Rep.None**
- Extension methods: **fold, flatMap, map, flatten, filter, getOrElse, isEmpty, isDefined, nonEmpty**
- Not for column definitions
- No **get** method for non-primitive Options

Outer Joins

- Non-primitive Options are the correct representation of outer join results

```scala
case class Data(a: Int, b: String)
class Row(name: String)(tag: Tag)
  extends Table[Data](tag, name) {
  def a = column[Int]("a")
  def b = column[String]("b")
  def * = (a, b) <> (Data.tupled, Data.unapply)
}
val xs = TableQuery(new Row("xs")(_))
val ys = TableQuery(new Row("ys")(_))

val q1 = xs join ys on (_.b === _.b)

q1.run // Seq[(Data, Data)]
```

Outer Joins

- Non-primitive Options are the correct representation of outer join results

```scala
val q2 = xs leftJoin ys on (_.b === _.b)
```

Option[Data]

```scala
q2.run // Seq[(Data, Data)]
```

Outer Joins

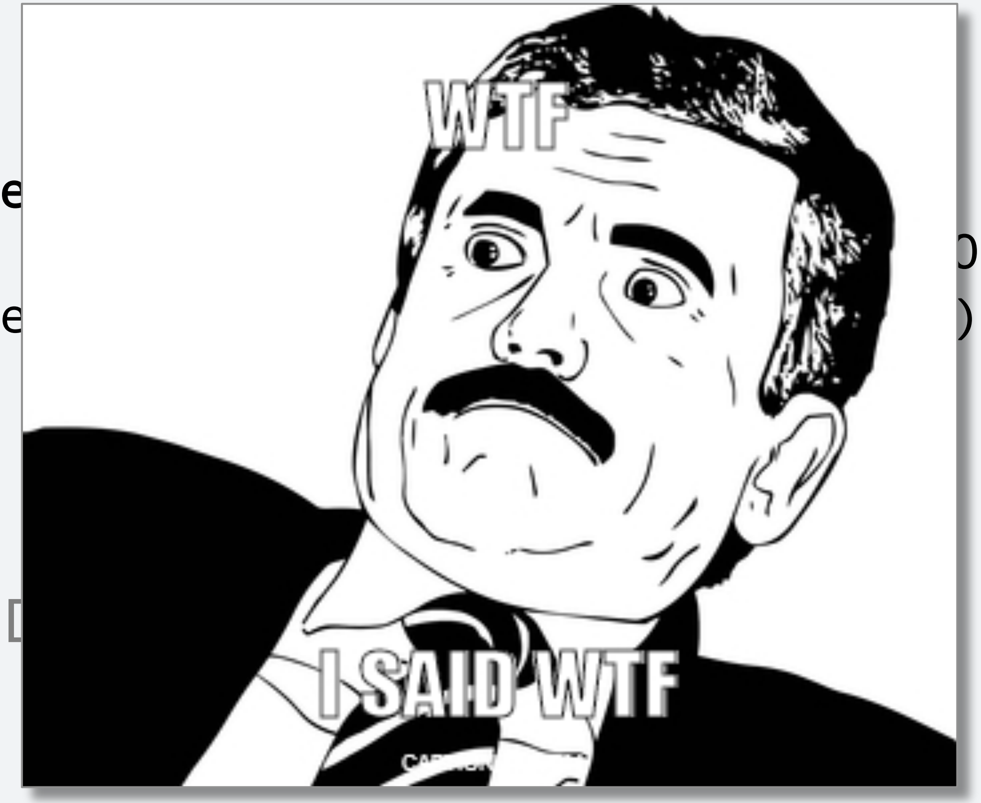
- Non-primitive Options are the correct representation of outer join results

```
val q2 = xs leftJoin ys on (_.b === _.b) map {
  case (x, y) => (x, (y.a.?, y.b.?).shaped.<>[Option[Data]] ({
    case (Some(a), Some(b)) => Some(Data(a, b))
    case _ => None
  }, { case _ => ??? } ))
}

q2.run // Seq[(Data, Option[Data])]
```

Outer Joins

- Non-primitive Options are the correct representation of outer join results

```
val q2 = xs le
  case (x, y)                               Option[Data]] ({
    case (Some                              )
    case _ =>
  }, { case _
}

q2.run // Seq[
```



Outer Joins

- Non-primitive Options are the correct representation of outer join results

```
val q3 = xs joinLeft ys on (_.b === _.b)

q3.run // Seq[(Data, Option[Data])]
```

Statically Checked Plain SQL

- Let the database server type-check Plain SQL queries when compiling your Scala code
- Automatically infer return types

```scala
def personsMatching(pattern: String)(implicit s: Session) =
  sql"select id, name from person where name like $pattern"
    .as[(Int, String)].list
```

Statically Checked Plain SQL

- Let the database server type-check Plain SQL queries when compiling your Scala code
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```
def personsMatching(pattern: String)(implicit s: Session) =
 tsql"select id, name from person where name like $pattern"
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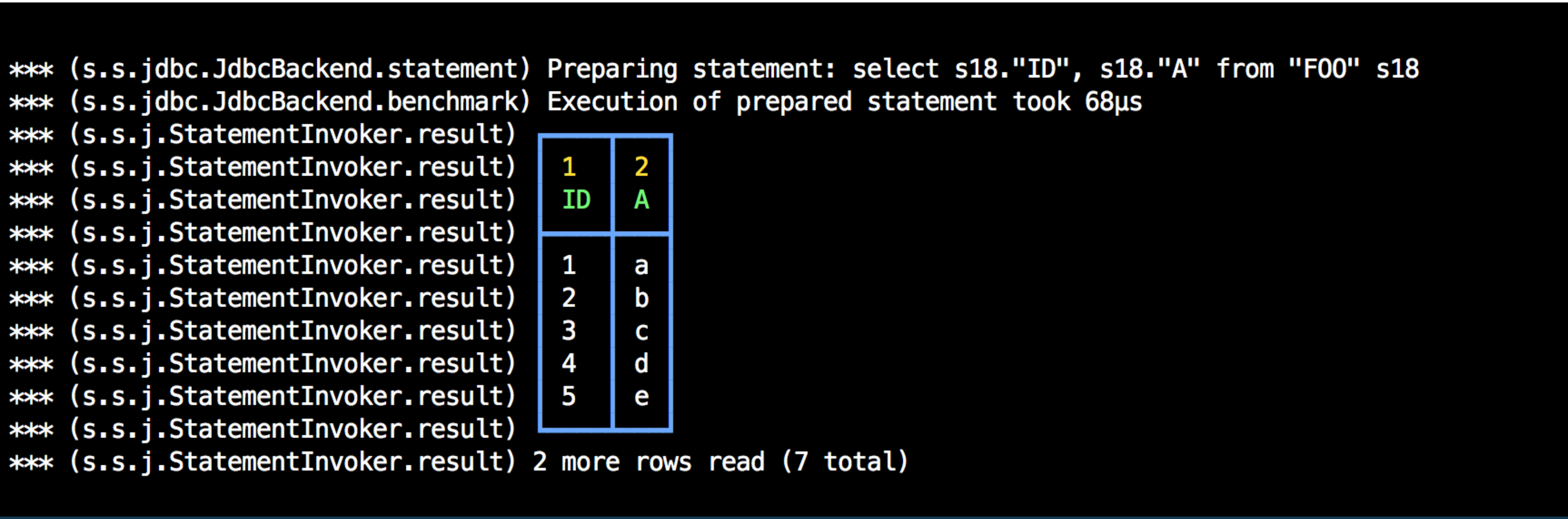
Logging

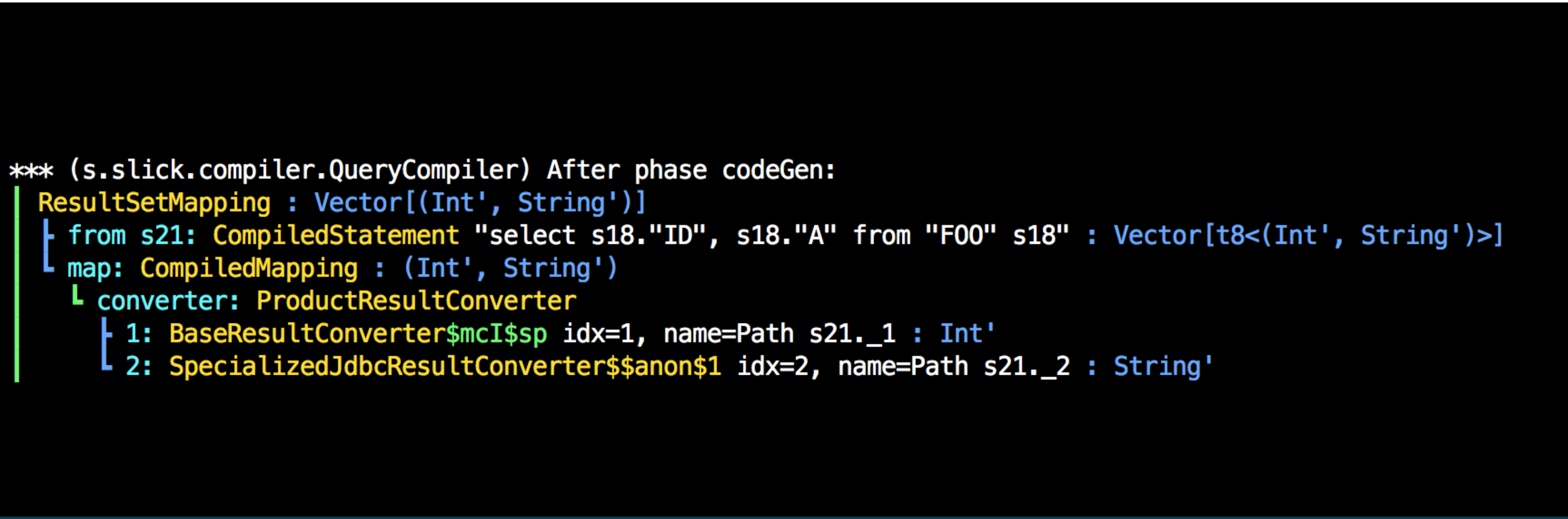
- Result Set Summaries, Statements, Execution Times
- ANSI Colors and Unicode Symbols
- Configured via Typesafe Config (application.conf)



```
*** (s.s.jdbc.JdbcBackend.statement) Preparing statement: select s18."ID", s18."A" from "FOO" s18
*** (s.s.jdbc.JdbcBackend.benchmark) Execution of prepared statement took 68µs
*** (s.s.j.StatementInvoker.result) ┌────┬───┐
*** (s.s.j.StatementInvoker.result) │ 1  │ 2 │
*** (s.s.j.StatementInvoker.result) │ ID │ A │
*** (s.s.j.StatementInvoker.result) ├────┼───┤
*** (s.s.j.StatementInvoker.result) │ 1  │ a │
*** (s.s.j.StatementInvoker.result) │ 2  │ b │
*** (s.s.j.StatementInvoker.result) │ 3  │ c │
*** (s.s.j.StatementInvoker.result) │ 4  │ d │
*** (s.s.j.StatementInvoker.result) │ 5  │ e │
*** (s.s.j.StatementInvoker.result) └────┴───┘
*** (s.s.j.StatementInvoker.result) 2 more rows read (7 total)
```

Logging

- Result Set Summaries, Statements, Execution Times
- ANSI Colors and Unicode Symbols
- Configured via Typesafe Config (application.conf)



```
*** (s.slick.compiler.QueryCompiler) After phase codeGen:
┃ ResultSetMapping : Vector[(Int', String')]
┃ ┣ from s21: CompiledStatement "select s18."ID", s18."A" from "FOO" s18" : Vector[t8<(Int', String')>]
┃ ┗ map: CompiledMapping : (Int', String')
┃   ┗ converter: ProductResultConverter
┃     ┣ 1: BaseResultConverter$mcI$sp idx=1, name=Path s21._1 : Int'
┃     ┗ 2: SpecializedJdbcResultConverter$$anon$1 idx=2, name=Path s21._2 : String'
```

slick.typesafe.com

@StefanZeiger

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