Statically-typed Class-based languages (Scala)

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CHARLES UNIVERSITY IN PRAGUE

faculty of mathematics and physics

Scala

- Statically-typed language
- Compiles to bytecode
- Modern concepts

- Example: E01

Semicolon inference

- A line ending is treated as a semicolon unless one of the following conditions is true:
  - The line in question ends in a word that would not be legal as the end of a statement, such as a period or an infix operator.
  - The next line begins with a word that cannot start a statement.
  - The line ends while inside parentheses (...) or brackets [...], because these cannot contain multiple statements anyway.

Static vs. dynamic typing

- Target function is determined
  - at compile time – static typing
  - at runtime – dynamic typing

- Example: E02

- Decompiled – DynamicTypingMain

Classes vs. objects

- Scala does not have static method
- Instead it features a singleton object
  - Defines a class and a singleton instance

- Example: E03

- Decompiled – AppLogger, Logger

Type inference

- Types can be omitted – they are inferred automatically
  - At compile time

- Example: E04

Type Hierarchy

- Everything is an object
  - primitive data types behind the scene (boxing/unboxing)
- Compiler optimizes the use of primitive types
  - a primitive type is used if possible

Companion object

- A class and object may have the same name
  - Must be defined in the same source
- Then the class and object may access each others private fields
- Example: E05

Constructors

- One primary constructor
  - class parameters
  - can invoke superclass constructor
- Auxiliary constructors
  - must invoke the primary constructor (as the first one)
  - must not invoke superclass constructor

Operators

- Scala allows almost arbitrary method names (including operators)
- A method may be called without a dot
- Prefix operators have special names

- Example: E06

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Flexibility in Identifiers and Operators

- Alphanumeric identifier
  - starts with letter or underscore
- Operator identifier
  - an operator character belongs to the Unicode set of mathematical symbols(Sm) or other symbols(So), or to the 7-bit ASCII characters that are not letters, digits
  - any sequence of them
- Mixed identifier
  - e.g. unary_- to denote a prefix operator
- Literal identifier
  - with backticks (e.g. `class`) to avoid clashes with reserved words, etc.

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Operator precedences

- Operator precedence determined by the first character
  - Only if the operator ends with “=“, the last character is used

(all other special characters)
* / %
\+ −
:
= !
< >
&
^
|
(all letters)
(all assignment operators)

Implicit conversions

- Scala allows specifying functions that are applied automatically to make the code correct
  - conversion to the type of the argument or to the type of the receiver
  - must be in current scope or source or target type scope
  - scalac -Xprint:typer mocha.scala
    - program after implicits added and fully-qualified types substituted

- Example: E07 + H1

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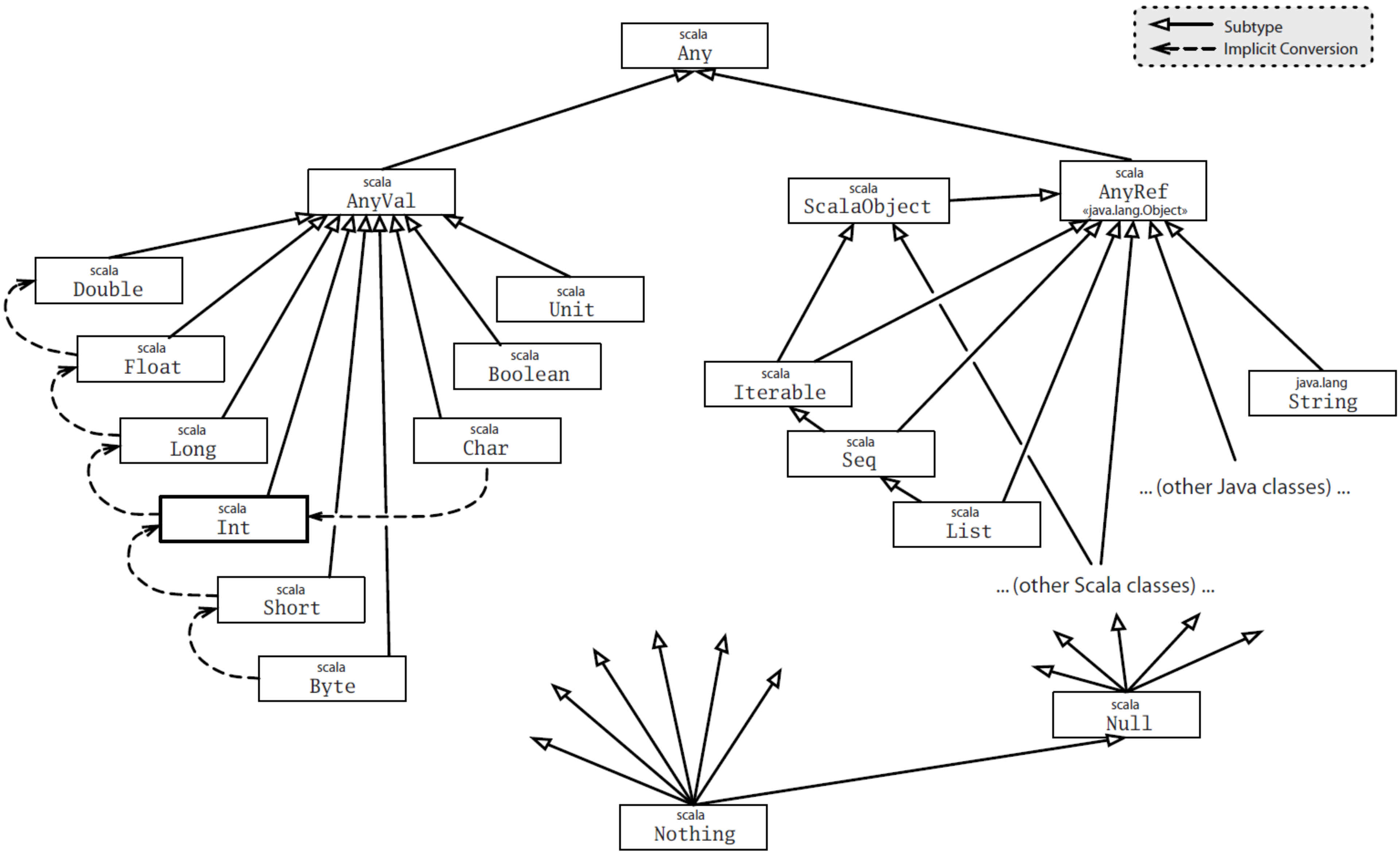
Rich wrappers

- Implicit conversions used to implement so called Rich wrappers
  - Similar to extension methods in C#
- Standard library contains rich types for the basic ones
  - E.g. RichInt – defines methods to, until, …

Type Hierarchy



Null and Nothing types

- **null** is singleton instance of Null
  - can be assigned to any AnyRef

- Nothing is a subtype of everything
  - Can be assigned to anything, but does not have any instance

```
def doesNotReturn(): Nothing = {
  throw new Exception
}
```

Nothing in Use I

```
def fail(msg: String): Nothing = {
      println(msg)
      sys.exit(1)
}

val y = if (x != null) x else fail("$&#@!")
```

Nothing in Use II

```
class Option[+A] {
  def isEmpty
  def get: A
}

case class Some[+A](x: A) extends Option[A] {
  def isEmpty = false
  def get = x
}


case object None extends Option[Nothing] {
  def isEmpty = true
  def get = throw new NoSuchElementException()
}
```

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Equality

- Overloading of operator “==“ is used to implement equality
- Reference equality is tested by functions eq and ne

```
val s1 = "Hello"
val s2 = "World"
println("1: " + (s1 + s2 == s1 + s2)) // true
println("2: " + (s1 + s2 eq s1 + s2)) // false
```

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Basic Types + Symbol Literals

- Types are pretty much the same as in Java
- Symbol literals
  - Similar to constant strings, but represented as instances of class Symbol
  - Possible to compare them by reference
- Example: E08

String interpolation

- String interpolation implemented by rewriting code at compile time
- Standard interpolators
  - s – interpolator

```
val name = "reader"
println(s"Hello, $name!")
```

  - raw – interpolator

```
println(raw"No\\\\escape!") // prints: No\\\\escape!
```

  - f – interpolator (printf-like formatter)

```
f"${math.Pi}%.5f"
```

- Custom interpolators can be defined
- Example: E09

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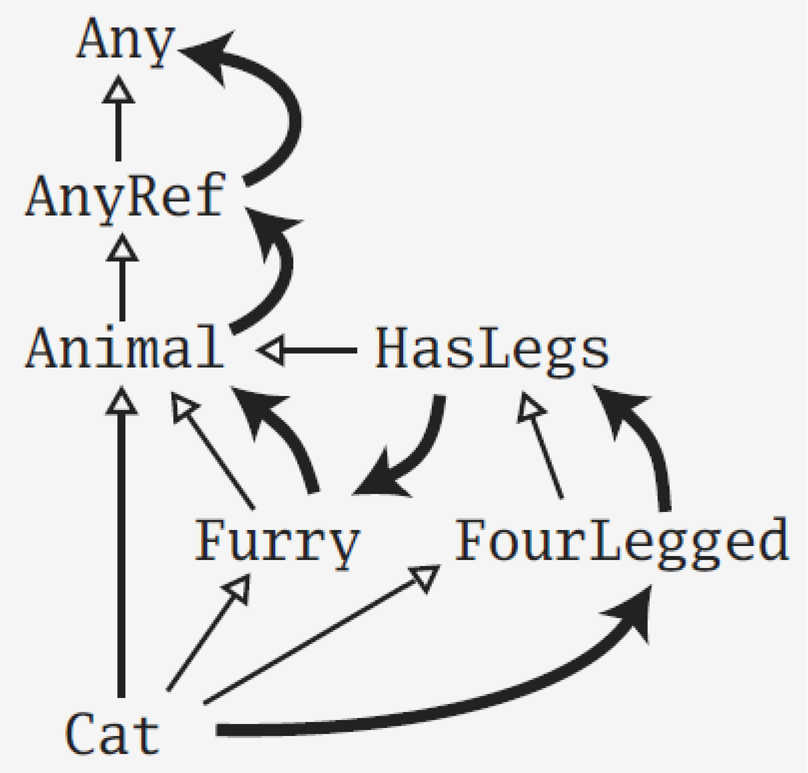
Traits

- Scala does not have interfaces
  - It has something stronger – mixins (called traits)
- A trait is like an interface, but allows for defining methods and variables
- Example: E10

Linearization

- As opposed to multiple inheritance, traits do not suffer from the diamond problem
- This is because the semantics of super is determined only when the final type is defined
- Example: E11



Composing Traits

- Composition of traits can be used to address the same problem as Dependency injection addresses
  - “Cake pattern”
- Example: E12 + test

Scala – Java interoperability

- trait T
  - interface T – method declarations
  - class T$class – method implementations
- class C extends T
  - instance methods of C
  - delegate methods to methods of T$class
- object C
  - static methods in C
    - delegate to methods of C$.MODULE
  - class C$
    - instance methods of C
    - static field C$.MODULE of type C (the singleton instance)
- Example: E13

Type parameterization

- Each class and method may be parameterized by a type
- Lower and upper bounds
- Example: E14

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Instance private data

- The mutable state in a class typically prevents the covariance/contravariance
- Why?
- Example (covariance): E15
- Example (contravariance): E16

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Path dependent types

- Nested traits/classes are specific to the instance of the outer class
- This makes types different based on the instance they are tied with
  - Though this is a runtime property, it can be with some effort checked statically
- Example: E17

Abstract types

- What about if we want methods in a subclass to specialize method parameters?
- Example: E18 + H2

Structural subtyping

- It is possible to specify only properties of a type
- Example: E19

First-class functions

- Functions are first-class citizens
- May be passed as parameters
- Anonymous functions, …
- Anonymous functions are instances of classes
  - Function1, Function2, …
- Example: E20

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Tail recursion

- The compiler can do simple tail recursion
  - If the return value of a function is a recursive call to the function itself
- Example: E21

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