

NPRG014 – 2021 plan

4th Oct - Groovy (FP, scripting) (VP)

18th Oct - Groovy (dynamism, meta-programming) (VP)

25th Oct - Groovy (DSL) (VP)

1st Nov - Concurrency (VP)

8th Nov – Bytecode, Scala (TB)

15th Nov - Scala (TB)

22nd Nov - Scala (TB)

29rd Nov - Scala (TB)

6th Dec - Prototype-based languages - IO (TB)

13th Dec - Prototype-based languages - JavaScript, TypeScript (TB)

Criteria

A homework assignment will be given at each lecture

A solution to each homework must be submitted through the university system **by the start of the following lecture**

Submit **at least 8** out of 10 correctly implemented homeworks

Repository

<https://github.com/d3scomp/NPRG014>

Clone and then checkout before each lecture

<https://github.com/d3scomp/NPRG014.git>

Language dynamism, scripting and functional programming



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Today's agenda

Scripting

Functional programming

- Groovy syntax and interoperability
- Language dynamism

Groovy



A JVM programming language

- Dynamic
- Dynamically-typed
- Scripting
- Object-oriented
- Building on Java syntax



Flat learning curve

Concise, readable and expressive syntax, easy to learn for Java developers



Smooth Java integration

Seamlessly and transparently integrates and interoperates with Java and any third-party libraries



Vibrant and rich ecosystem

Web development, reactive applications, concurrency / asynchronous / parallelism library, test frameworks, build tools, code analysis, GUI building



Powerful features

Closures, builders, runtime & compile-time meta-programming, functional programming, type inference, and static compilation



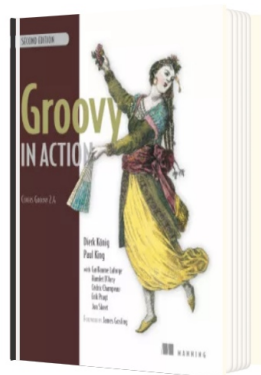
Domain-Specific Languages

Flexible & malleable syntax, advanced integration & customization mechanisms, to integrate readable business rules in your applications



Scripting and testing glue

Great for writing concise and maintainable tests, and for all your build and automation tasks



The 7 usage patterns

- Super Glue
- Liquid Heart
- Keyhole Surgery
- Smart Configuration
- Unlimited Openness
- House-Elf Scripts
- Prototype



Examples in Groovy

canoo

They all use Apache Groovy!



Part 1

Groovy syntax and interoperability

Interoperability

Groovy and *Java* can **implement**, **extend**, **refer** and **call** each other at will.

Groovy sources compile into *.class* files

IDEs provide cross-reference support

Java

```
public class Person {  
    private final String name;  
    public Person(String name) {  
        this.name = name;  
    }  
    public String getName() {  
        return name;  
    }  
}
```

Groovy

```
public class Person {  
    private final String name;  
    public Person(String name) {  
        this.name = name;  
    }  
    public String getName() {  
        return name;  
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Groovy

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Groovy

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Groovy

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class Person {  
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    public String getName() {  
        name  
    }  
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```

Groovy

```
class Person {  
    final String name  
    Person(String name) {  
        this.name = name  
    }  
}
```

Groovy

```
class Person {  
    final String name  
    Person(String name) {  
        this.name = name  
    }  
}
```

Groovy is Java

```
class Person {  
    final String name  
}
```

Variables, constants, params

String a

def a – a re-assignable variable

final a – a constant value

Intuitiveness

Equality `a == b`

Identity `a.is(b)`

() sometimes optional: `println 'Joe'`

String interpolation

```
final s = 'Hi Joe'
```

```
final s = "Hi Dave"
```

```
final s = "Hi $name"
```

```
final s = "Hi ${user.name}"
```

```
final s = """Hi Dave,
```

```
How are you?
```

```
""")
```

Numbers and primitive types

15 - integer

15G - BigInteger

1.5 - BigDecimal

1.5d - Double

All values are objects: 5.upto(10)

Clever boxing and unboxing

Properties

```
class City {  
    String name  
    int size  
    boolean capital = false  
}
```

```
City c1 = new City(name: 'Praha', size: 1200000, capital: true)
```

```
City c2 = new City(name: 'Písek', size: 25000)
```

```
print c1.name
```

```
c2.size = 25001
```

Power assert

assert 5 == customer.score

Exception thrown

17.2.2012 12:30:12 org.codehaus.groovy.runtime.StackTraceUtils sanitize

WARNING: Sanitizing stacktrace:

Assertion failed:

assert 5 == customer.score

```
  |   |   |
  |   |   4
  | [score:4]
false
```

Closures

Closure multiply = {**int** a, **int** b -> **return** a * b}

Closures

Closure multiply = {**int** a, **int** b -> a * b}

Closures

Closure multiply = $\{a, b \rightarrow a * b\}$

Closures – implicit parameter

```
def triple1 = {int number -> number * 3}
```

```
def triple2 = {number -> number * 3}
```

```
def triple3 = {it * 3}
```


Groovy is functional

```
def multiply = {a, b -> a * b}  
def double = multiply.curry(2)  
def triple = multiply.curry(3)
```

```
assert 4 == multiply(2, 2)  
assert 8 == double(4)  
assert 6 == triple(2)
```

Currying vs. Partial application

def multiply = {a, b \rightarrow a * b}

def partial = multiply.curry(3)

def curried1 = {x \rightarrow {y \rightarrow multiply(x, y)}}

def curried2 = {x \rightarrow multiply.curry(x)}

Memoize

```
def func = {a → longComputation(a)}
```

```
def fastFunc = func.memoize()
```

Closure scope

owner

delegate

this

closure.resolveStrategy =

DELEGATE_FIRST / OWNER_FIRST

DELEGATE_ONLY / OWNER_ONLY

Collections

```
final emptyList = []
```

```
final list = [1, 2, 3, 4, 5]
```

```
final emptyMap = [:]
```

```
final capitals = [cz : 'Prague', uk : 'London']
```

```
final list = [1, 2, 3, 4, 5] as LinkedList
```

```
final emptyMap = [:] as ConcurrentHashMap
```

Collections API

```
(1..10).each {println it}  
2.step(10, 2) {println it}
```

```
(10..20).findAll{it%2==0}  
    .collect {3*it}  
    .inject(0){acc, v -> acc + v}
```

map, filter, and reduce explained with emoji 🤔

```
map([🐮, 🍌, 🐔, 🌽], cook)  
=> [🍔, 🍟, 🍗, 🍿]
```

```
filter([🍔, 🍟, 🍗, 🍿], isVegetarian)  
=> [🍟, 🍿]
```

```
reduce([🍔, 🍟, 🍗, 🍿], eat)  
=> 🤩
```

(Not exhaustive) list

each (aka for loop)

collect (aka map)

inject (aka reduce)

findAll (aka filter)

sum, size, findFirst, grep, groupBy

any, every, min, max, ...

Some more operators

```
['Java', 'Groovy']*.toUpperCase()
```

```
customer?.shippingAddress?.street
```

```
return user.locale ?: defaultLocale
```

GDK = JDK + FUN

- `java.util.Collection`
 - `each()`, `find()`, `join()`, `min()`, `max()` ...
- `java.lang.Object`
 - `any()`, `every()`, `print()`, `invokeMethod()`, ...
- `java.lang.Number`
 - `plus()`, `minus()`, `power()`, `upto()`, `times()`, ...

Tip: Ask *DefaultGroovyMethods* for help

Syntax enhancements

- Dynamic (duck) typing – optional!
- GDK
- Syntax enhancements
 - Properties, Named parameters
 - Closures
 - Collections and maps
 - Operator overloading
 - ...

List comprehension (Python)

```
odd = [x for x in range(0, 100) if x % 2 != 0]
```

```
squares = [x*x for x in odd]
```

Generators (Python)

```
def fibonacci():  
    a = 0  
    b = 1  
    yield b  
    while True:  
        a, b = b, a + b  
        yield b  
  
allFibs = fibonacci()
```

Part 2

Scripting

Agenda

- Scripting
- Script engine customization
- Grabbing libraries

Scripting

Evaluate custom Groovy code

At run-time!!!

```
new GroovyShell().evaluate('println Hi!')
```

<http://groovyconsole.appspot.com/>

Script customization

CompilerConfiguration

CompilationCustomizer

ImportCustomizer

ASTCustomizer

SecureASTCustomizer

Functors

Dealing with wrapped data

$\text{map}: ([A], f: A \rightarrow B) \rightarrow [B]$

$\text{map}: (\text{Maybe}\langle A \rangle, f: A \rightarrow B) \rightarrow \text{Maybe}\langle B \rangle$

Functors are *mappable* (they have a **map** operation)

Monoids

Aggregating data and operations

Monoids

Aggregating data and operations

- A set of elements
- An operation that combines two elements
- An 'id' element neutral with respect to the operation
- Closure of the set with respect to the operation

$$1. \ a + id = id + a = a$$

$$2. \ (a + b) + c = a + (b + c)$$

$$3. \ a \in M \ \& \ b \in M \Rightarrow a+b \in M$$

Monoids

Reducible – any set of elements from a monoid can be reduced into a single value

reduce: $([A], f: (A, A) \rightarrow A) \rightarrow A$

Monoids

class Customer {name, address, orders}

vs.

class CustData {orders, totalAmount}

Monoids

class Customer {name, address, orders}

not a monoid

vs.

class CustData {orders, totalAmount}

a monoid

Monoids

class Customer {name, address, orders}

not a monoid

transform

vs.

class CustData {orders, totalAmount}

a monoid

Reduce vs. Fold

m.reduce {*v1*, *v2* \rightarrow *v1* + *v2*}

m.foldLeft(0) {*acc*, *v* \rightarrow *acc* + *v*}

Composing functions

$f: A \rightarrow B$

$g: B \rightarrow C$

$f \gg g: A \rightarrow C$

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$f: A \rightarrow B$

$g: B \rightarrow C$

$f \gg g: A \rightarrow C$

```
def f = {String s → s.size()}
```

```
def g = {Integer i → i%2==0 ? true : false}
```

```
def h = f >> g
```

Composing functions

$f: A \rightarrow B$

$g: B \rightarrow C$

$f \gg g: A \rightarrow C$

Not a monoid

Endofunctors

$f: A \rightarrow A$

with composition ($>>$) and an **id()** function
form a monoid

`[f1, f2, f3, f4, f5, ...].reduce(id, >>)`

Other monoids of functions

Elements: $f: \text{String} \rightarrow \text{Boolean}$

Other monoids of functions

Elements: $f: \text{String} \rightarrow \text{Boolean}$

`id()` – returns *true/false*

Operation: logical AND/OR

Summary

Groovy syntax

Scripting

Functional programming

- closures
- functors (map)
- monoids (reduce)

References

<http://groovy-lang.org>

<http://grails.org>

<http://groovyconsole.appspot.com/>

<http://www.manning.com/koenig2/>