

# Dynamic meta-programming and Domain-specific languages



**Václav Pech**

*NPRG014 2023/2024*

<http://www.vaclavpech.eu>

@vaclav\_pech

# Last time agenda

Scripting

Functional programming

- Groovy syntax and interoperability
- Language dynamism



# Agenda for today

- Dynamic meta-programming
- Builders
- Domain specific languages

# Review

Groovy syntax and interoperability

# 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
```

# 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)
```

# Closure scope

owner

delegate

this

# 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
```



# Review

## Scripting

# Scripting

Evaluate custom Groovy code

**At run-time!!!**

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

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

# Review

Functional programming

# 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

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

# Part 1

Dynamic meta-programming

# Agenda

Dynamic dispatch

Dynamic cast

Dynamic object creation

Categories

Meta-programming



# Method call dispatch

Static - the target method is decided at compile-time

Dynamic - the target method is decided at run-time

# Static dispatch

At compile-time using the compile-time type of the arguments

```
def calculate(String value)
```

```
def calculate(Integer value)
```

```
def calculate(Object value)
```

```
Object v = 10;
```

```
calculate(v); //Which method to call?
```

# Dynamic dispatch

At run-time using the run-time type of the arguments

```
def calculate(String value)
```

```
def calculate(Integer value)
```

```
def calculate(Object value)
```

```
Object v = 10;
```

```
calculate(v); //Which method to call?
```

# Dynamic object creation

```
Runnable r = {println 'Asynchronous'} as Runnable
```

# Dynamic object creation

## *Duck-typing*

```
Calculator c = [ add : {a, b, → a + b},  
                multiply : {a, b → a * b},  
                increment : {it + 1}  
              ] as Calculator
```

```
assert 6 == c.multiply(2, 3)
```

# Traits

```
trait Flying {  
    void fly() {println "I am flying!"}  
}
```

```
trait Quacking {  
    void quack() {println "Quack!"}  
}
```

```
class Duck implements Flying, Quacking {}
```

# Traits

- Componentisation of the design
- Generalized delegation
- Stackable
- Can be specified as argument types

# Category (extension methods)

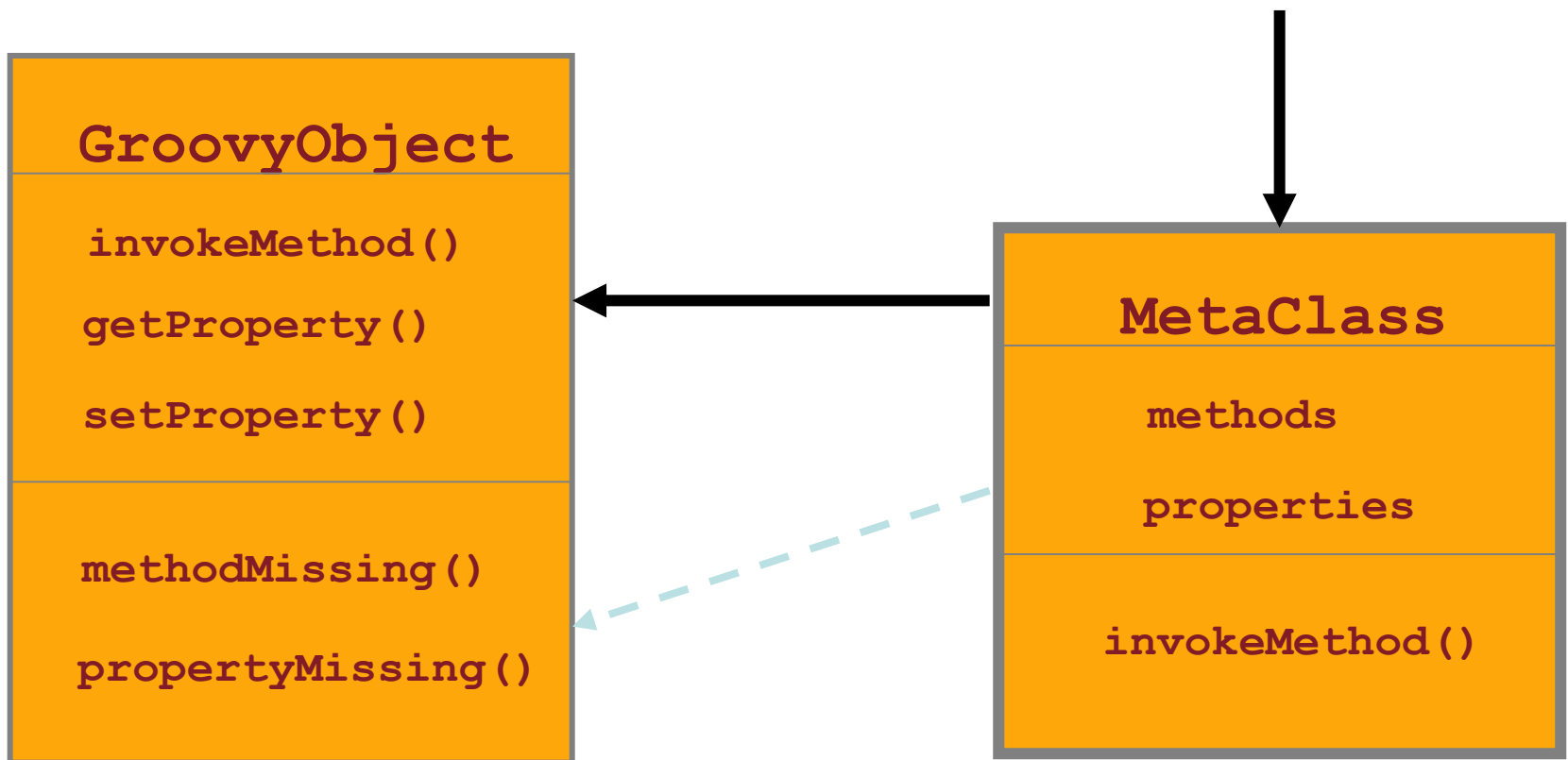
```
StringUtils.countMatches(myString, 'Groovy')
```

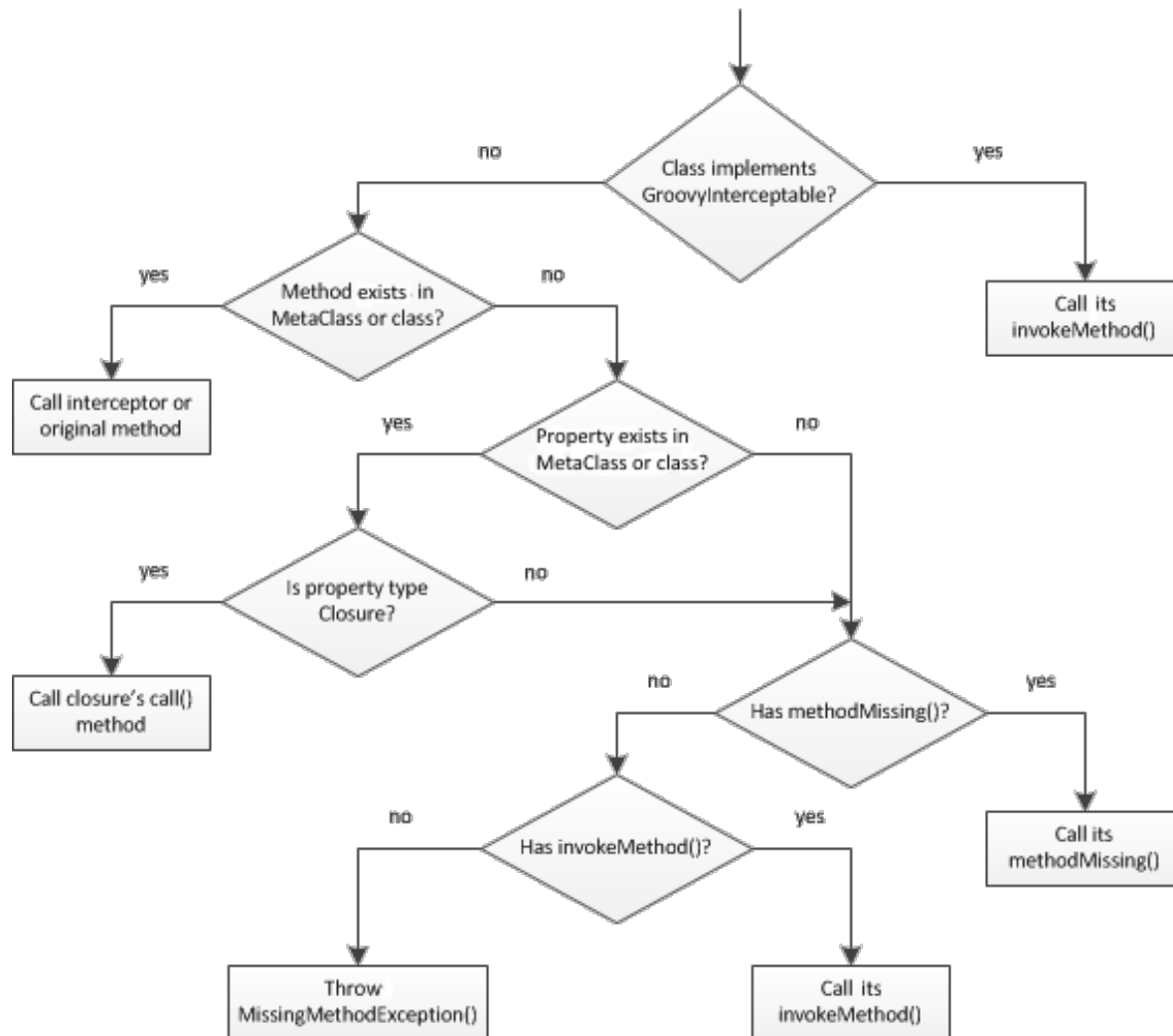


```
use(StringUtils) {  
    myString.countMatches('Groovy')  
}
```



# Dynamic method invocation





# Querying objects' methods

`o.respondsTo()`

`o.hasProperty()`

`o.metaClass.getMetaMethod(name, args)`

`o.metaClass.getMetaProperty(name)`

# Part 4

## Domain Specific Languages

# BDD - Spock

```
class DataDriven extends Specification {  
    def "maximum of two numbers"() {  
        expect:  
        Math.max(a, b) == c  
        where:  
        a | b | c  
        7 | 3 | 7  
        4 | 5 | 5  
        9 | 9 | 9  
    }  
}
```

# DSL

- Limited purpose language
- Targeted to a particular domain
- Friendlier API to a framework
  - External
    - SQL, HTML, CSS, ...
  - Internal

# Gradle

```
apply plugin: 'kotlin-android'

apply plugin: 'kotlin-android-extensions'

android {
    compileSdkVersion 28
    defaultConfig {
        applicationId "com.example.myapplication"
        minSdkVersion 16
        targetSdkVersion 28
        versionCode 1
        versionName "1.0"
        testInstrumentationRunner "androidx.test.runner.AndroidJUnitRunner"
    }
    buildTypes {
        release {
            minifyEnabled false
            proguardFiles getDefaultProguardFile('proguard-android-optimize.txt'), 'proguard-rules.pro'
        }
    }
}

dependencies {
    implementation fileTree(dir: 'libs', include: ['*.jar'])
    implementation "org.jetbrains.kotlin:kotlin-stdlib-jdk7:$kotlin_version"
    implementation 'androidx.appcompat:appcompat:1.0.2'
    implementation 'androidx.core:core-ktx:1.0.2'
    implementation 'androidx.constraintlayout:constraintlayout:1.1.3'
    implementation 'com.google.android.material:material:1.0.0'
    testImplementation 'junit:junit:4.12'
    androidTestImplementation 'androidx.test:runner:1.1.1'
    androidTestImplementation 'androidx.test.espresso:espresso-core:3.1.1'
}
```

```
File.metaClass.div = { path ->  
    new File(delegate, path)  
}
```



```
File.metaClass.div = { path ->  
    new File(delegate, path)  
}
```

```
def file = new File(".")/'test'/'hello'/'file.txt'
```

# DSL – Date manipulation

```
use (org.codehaus.groovy.runtime.TimeCategory) {  
    println "Tomorrow: ${1.day.from.today}"  
    println "A week ago: ${1.week.ago}"  
    println "Date: ${1.month.ago + 1.week + 2.hours - 5.minutes}"  
    println "Date ${1.month + 10.days}.ago"  
}
```

# DSL – Hibernate criteria

```
def participants = Participant.createCriteria().list {  
    gt('age', age)  
    or{  
        eq('interest', 'Java')  
        eq('interest', 'Groovy')  
    }  
    jug {  
        ilike('country', 'de')  
    }  
    order('lastName', 'asc')  
}
```

# DSL – Account manipulation

```
Money money = new Money(amount: 350, currency: 'eur')  
getAccount('Account1').withdraw money  
getAccount('Account3').deposit money
```



```
"Account1" >> 350.eur >> "Account3"
```

order cake with plums and apples  
and cream to "Malostranske namesti"

```
order(cake) .with(plums) .and(apples)  
 .and(cream) .to("Malostranske namesti")
```

# Builders

## Construct hierarchies

- html, xml, json, swing, configuration
- objects
- db queries
- ...

# Builders - GAnt

```
ant.sequential {  
    myDir = "target/AntTest/"  
    mkdir(dir: myDir)  
    copy(todir: myDir) {  
        fileset(dir: "src/test") {  
            include(name: "**/*.groovy")  
        }  
    }  
    List dirs = ['core', 'lib', 'engine', 'gui', 'db']  
    for(String currentDir:dirs) {  
        String targetDir="target/$currentDir"  
        mkdir(dir:targetDir)
```



# Cli Builder

```
def cli = new CliBuilder (usage:'simpleHtmlServer -p PORT -d DIRECTORY')
cli.with {
  h longOpt:'help', 'Usage information'
  p longOpt:'port',argName:'port', args:1, type:Number.class,'Default is 8080'
  d longOpt:'dir', argName:'directory', args:1, 'Default is .'
}

def opts = cli.parse(args)
if(!opts) return
if(opts.help) {
  cli.usage()
  return
}
```

# Builders – Spring config

```
dataSource(BasicDataSource) {  
    driverClassName = "org.hsqldb.jdbcDriver"  
    url = "jdbc:hsqldb:mem:shopDB"  
}  
  
sessionFactory(ConfigurableLocalSessionFactoryBean) {  
    dataSource = dataSource  
    hibernateProperties = ["hibernate.hbm2ddl.auto": "create-drop",  
        "hibernate.show_sql": true]  
}  
  
calculator(demo.shop.CalculatorImpl) {bean ->  
    bean.singleton = true  
    bean.autowire = 'byType'  
}
```

# Summary



Dynamic method call dispatch

Dynamic object creation

Builders

Traits

Categories

Dynamic DSLs

# References

<http://groovy-lang.org>

<http://grails.org>

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

<http://www.manning.com/coenig2/>