

Dynamic meta-programming and Domain-specific languages



Václav Pech

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<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

Today's agenda

You will learn:

How the dynamic dispatch mechanism works

How to utilize it to alter the run-time behavior of a class

What are builders and how to build them

How to create text-like DSLs

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/>

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?

Type coercion

Implicit

Runnable r = {println 'Asynchronous'}

Integer i = '42'

Explicit

def f = '3.14' as Float

def s = [1, 2, 3] as Set

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

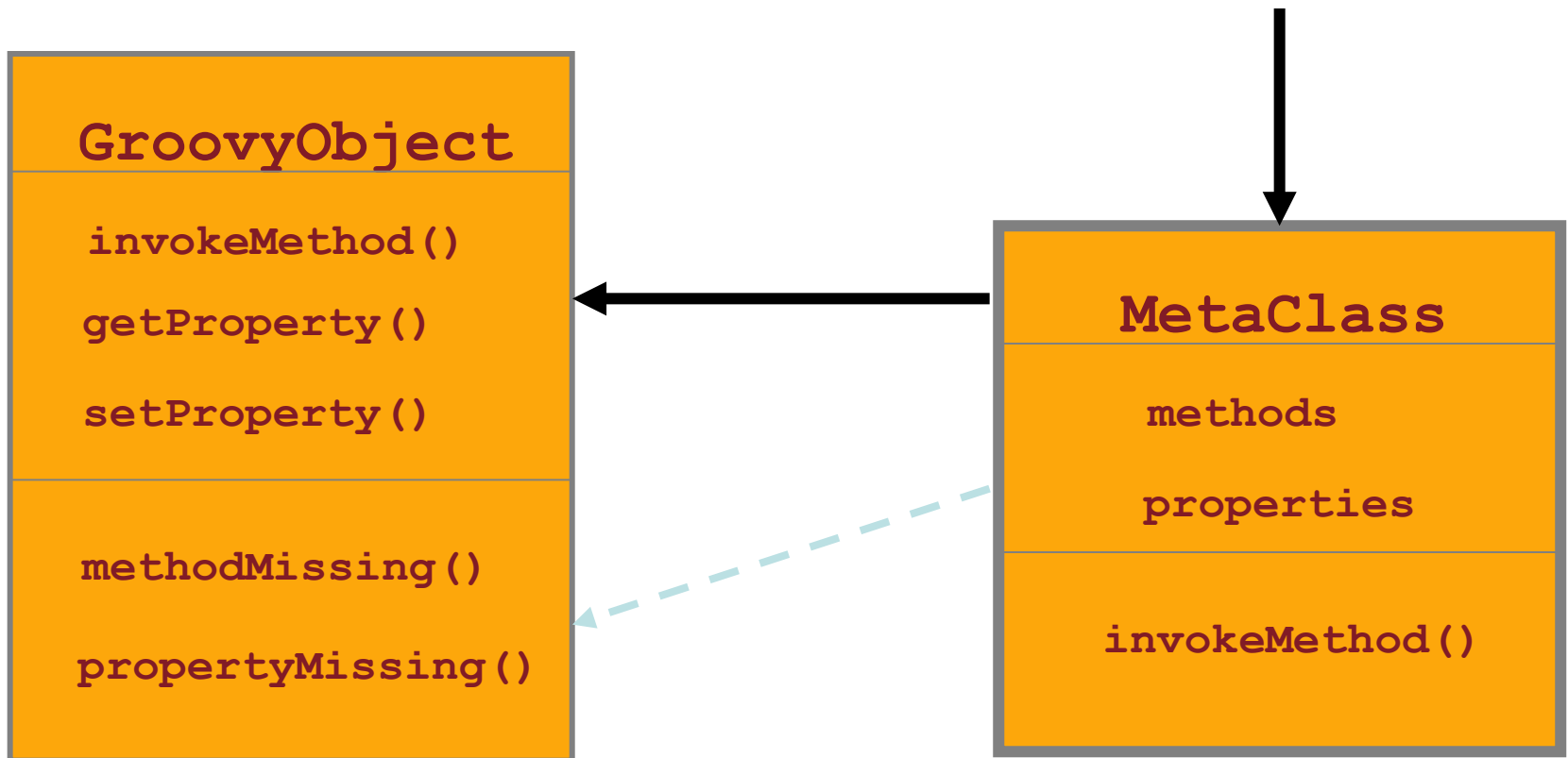
Category (extension methods)

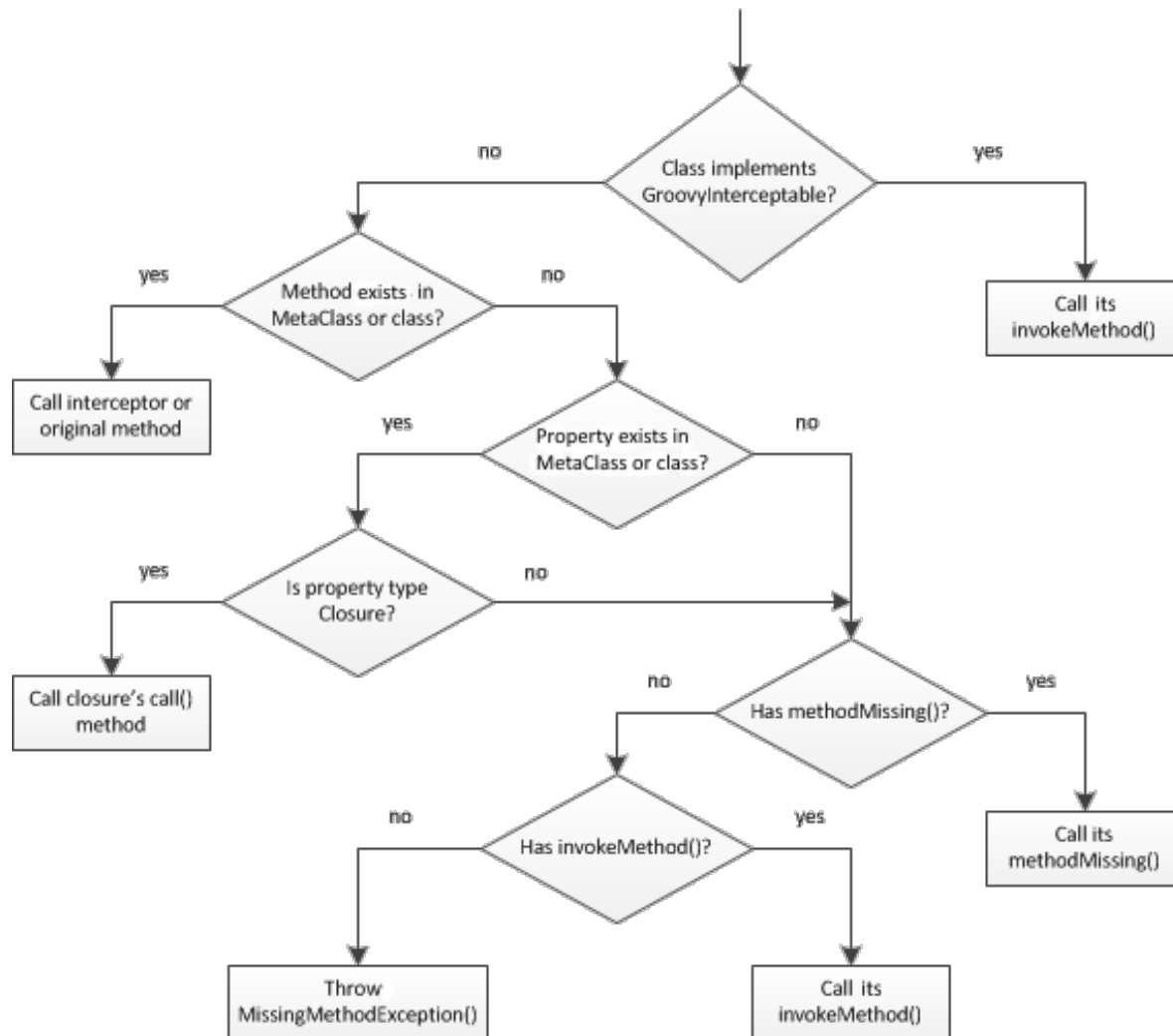
```
StringUtils.countMatches(myString, 'Groovy')
```



```
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  
    }  
}
```

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'
}
```

DSL

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

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"
```

Why DSLs

Domain expressiveness – code closely matches domain concepts, improving readability.

Reduced boilerplate – conciseness compared to general-purpose language constructs.

Improved communication – shared language between developers and domain experts.

Higher abstraction – hides low-level details, focusing on "what" not "how."

Consistency & correctness – enforces domain-specific rules directly in syntax.

Rapid prototyping – easier experimentation with domain models and solutions.

Integration leverage – benefits from host language tooling (IDE, debuggers, libraries).

Easier maintenance – domain logic is explicit, reducing cognitive load over time.

Example – file access DSL

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

Example – file access DSL

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

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

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)
```

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'  
}
```

JSON Builder

```
def builder = new JsonBuilder()
builder {
  model "gpt-5"
  messages([
    [role: "system", content: "You are a helpful assistant."],
    [role: "user", content: "Explain JsonBuilder in Groovy."]
  ])
  max_tokens 200
  temperature 0.7
}
```


Summary



Dynamic method call dispatch

Dynamic object creation

Builders

Traits

Categories

Dynamic DSLs

References

<http://groovy-lang.org>

<http://grails.org>

<https://martinfowler.com/books/dsl.html>