Static meta-programming

Václav Pech

NPRG014 2020/2021

http://www.vaclavpech.eu

@vaclav_pech

Last time agenda

Dynamic meta-programming

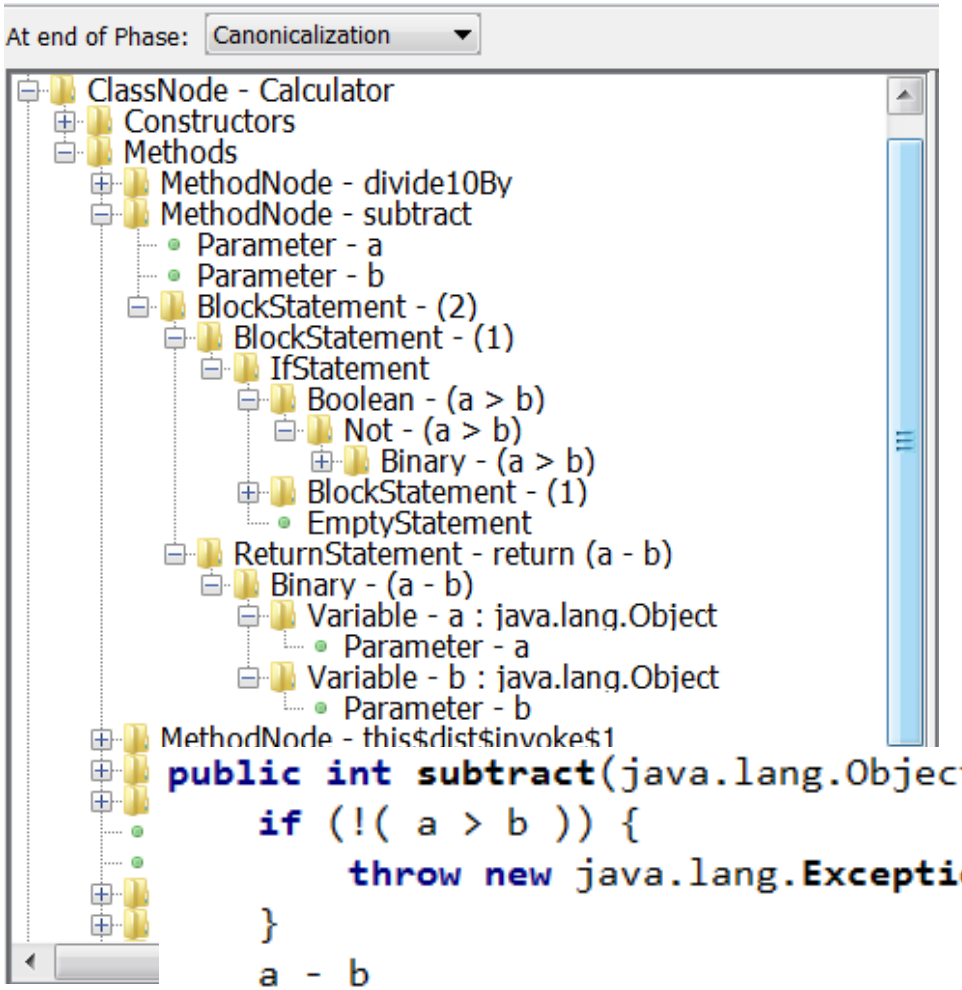
Domain-specific languages

Builders

Part 5

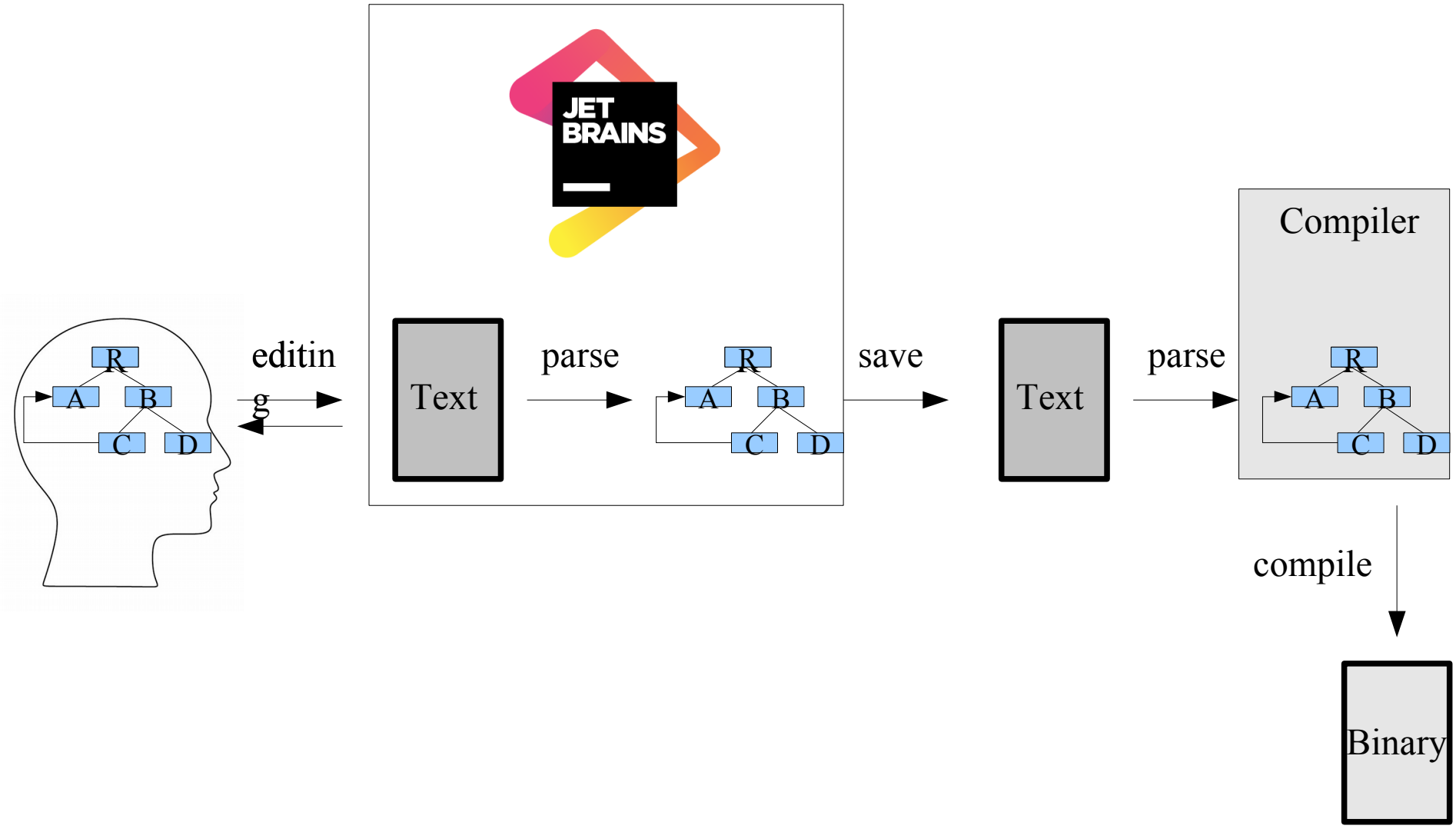
Static meta-programming

AST

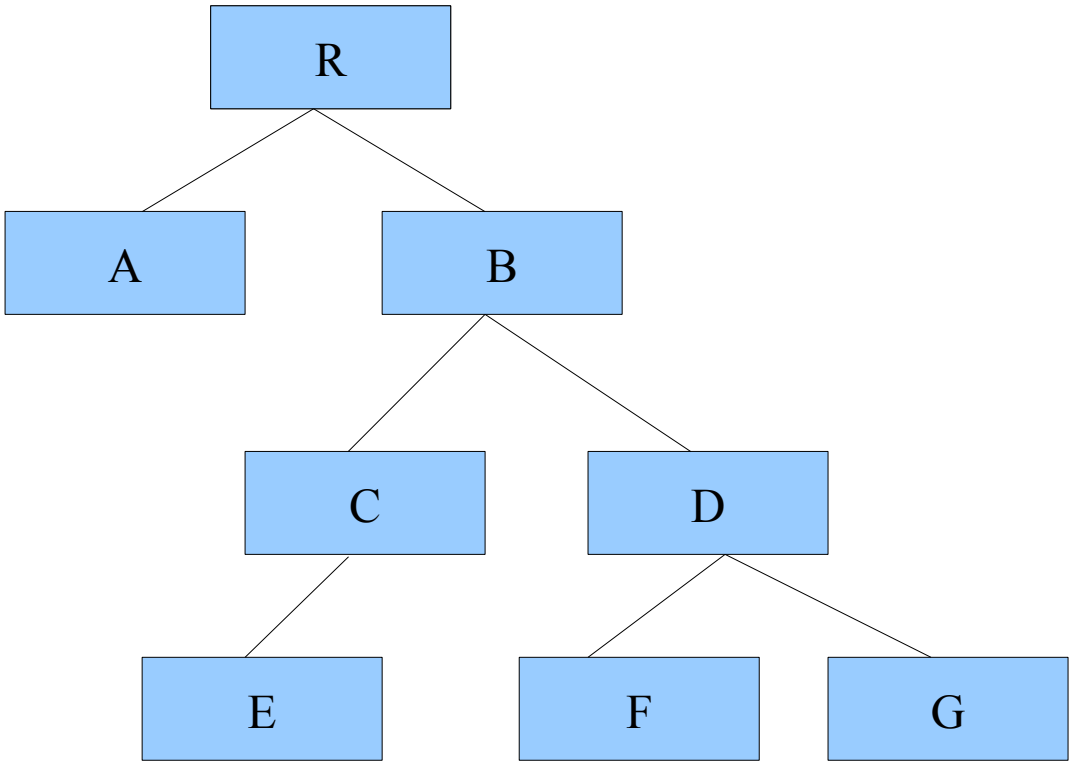



```
public int subtract(java.lang.Object a, java.lang.Object b) {
    if (!( a > b )) {
        throw new java.lang.Exception('Precondition violated: {a > b}')
    }
    a - b
}
```

Programming

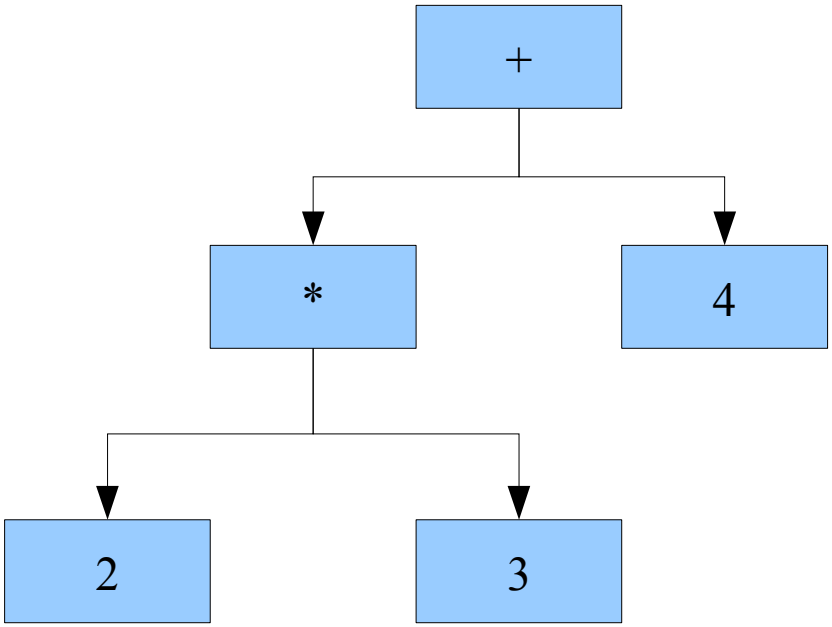


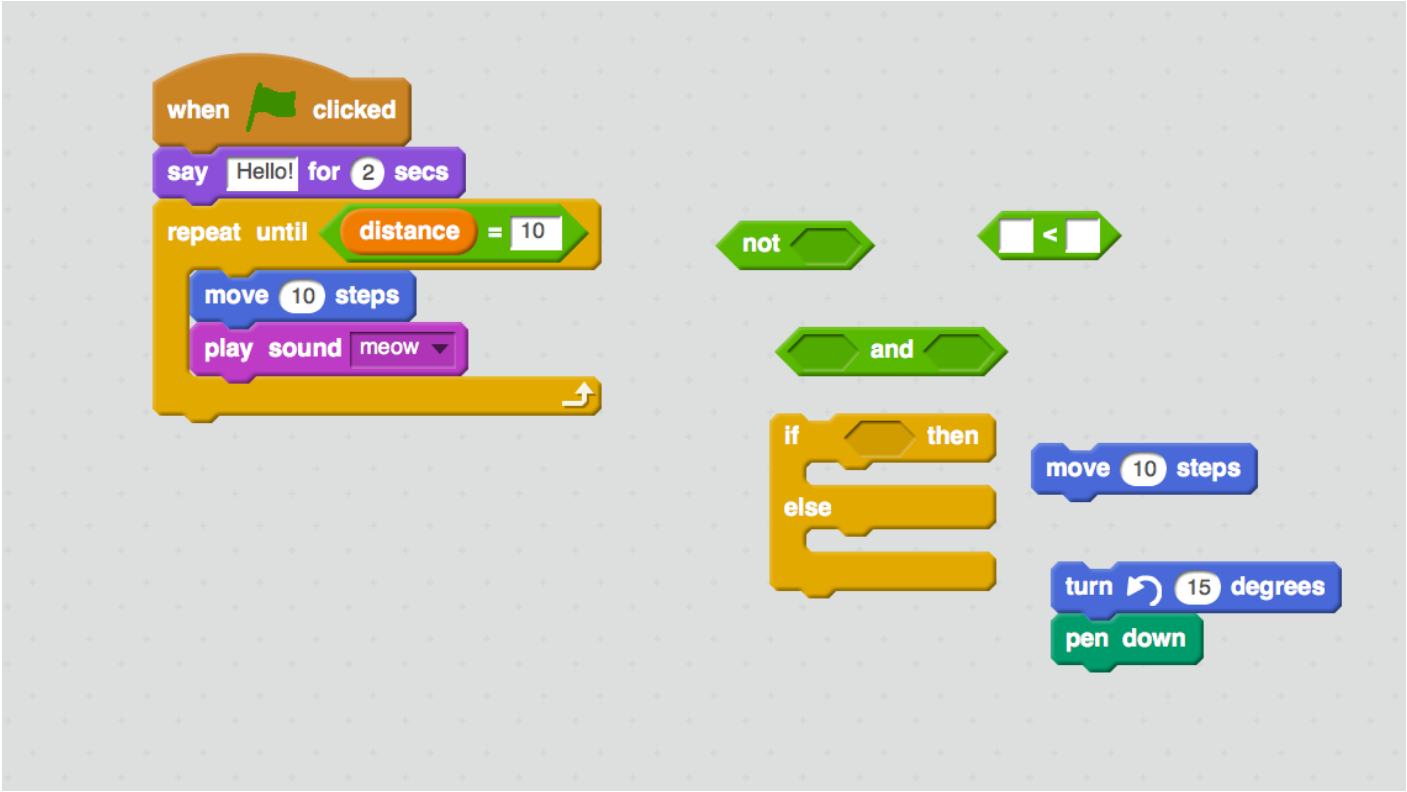
Programs are trees



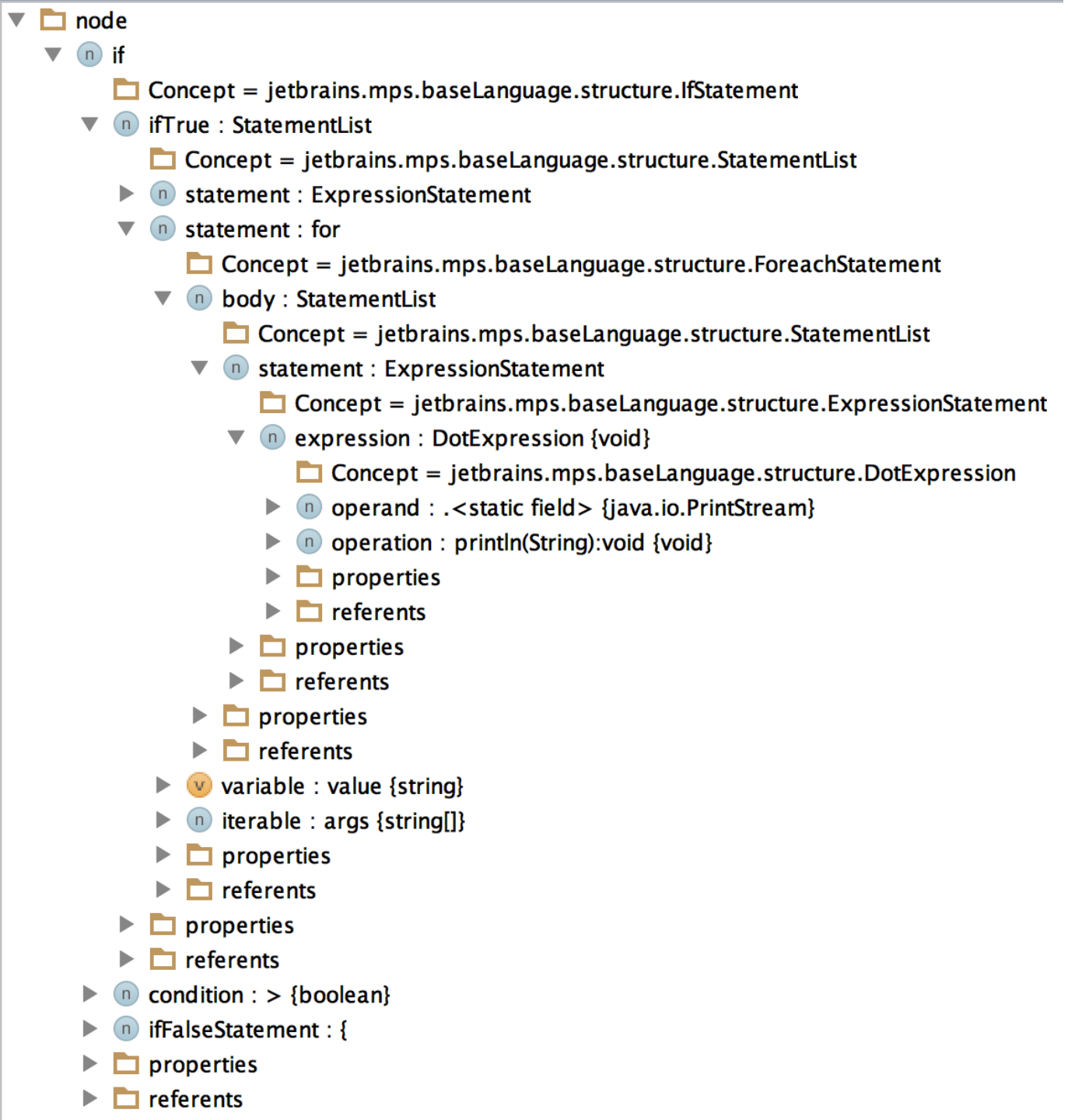
Lisp (1958)

(+ (* 2 3) 4)

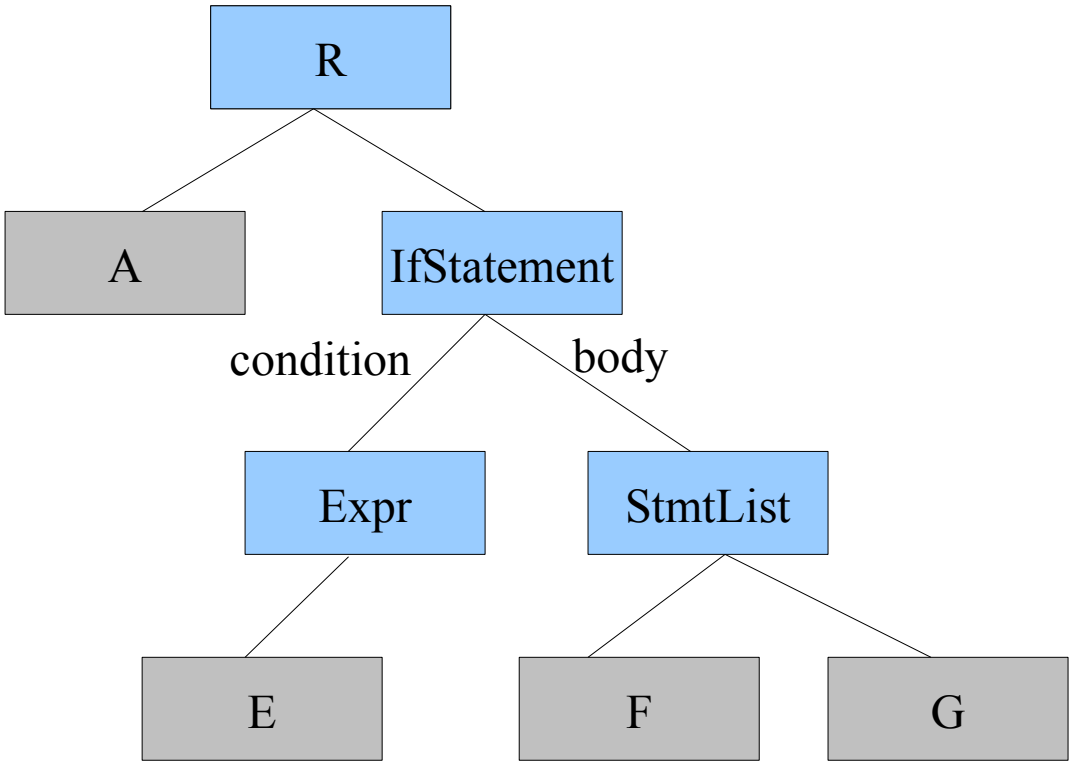



when clicked
say Hello! for 2 secs
repeat until distance = 10
move 10 steps
play sound meow
not
<
and
if then
else
move 10 steps
turn 15 degrees
pen down

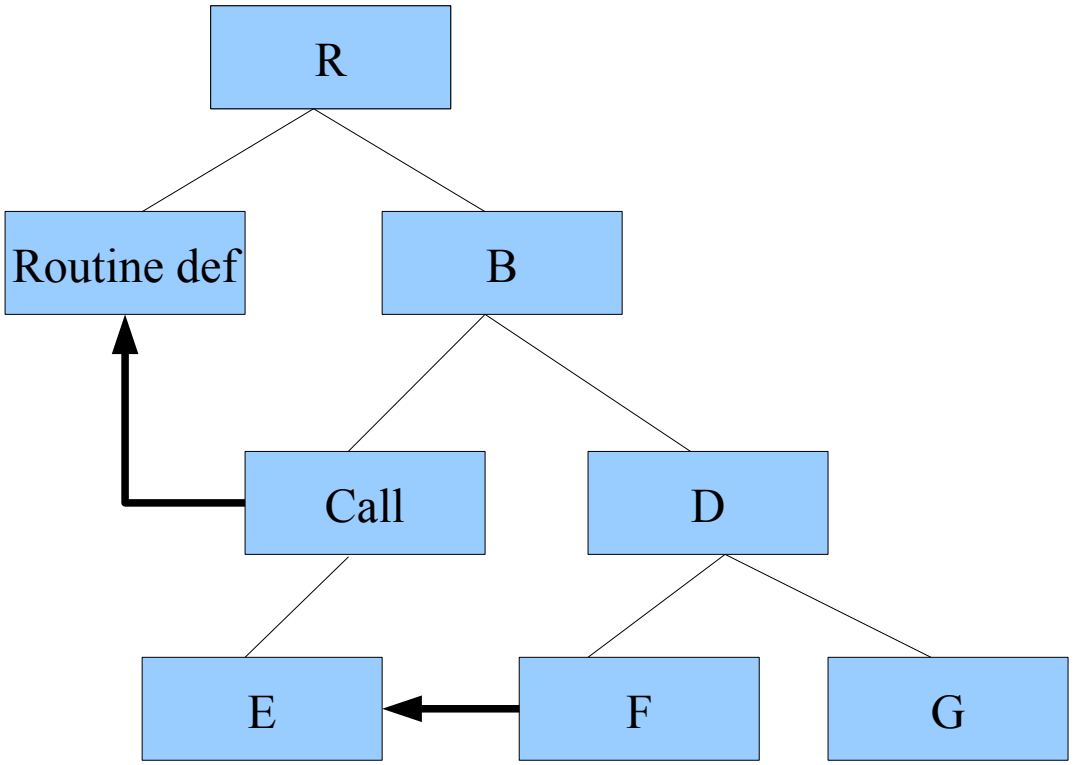
```java
public class Demo {

  private static void foo() {
    System.out.println("Foo called");
  }

  public static void main(string[] args) {

    System.out.println("Application started");

    if (args.length > 0) {
      System.out.println("Supplied arguments");
      for (string value : args) {
        System.out.println("Argument: " + value);
      }
    } else {
      System.out.println("No arguments provided");
    }

    foo();
    System.out.println("Application completed");
  }

}
```


node
if
Concept = jetbrains.mps.baseLanguage.structure.IfStatement
ifTrue : StatementList
Concept = jetbrains.mps.baseLanguage.structure.StatementList
statement : ExpressionStatement
statement : for
Concept = jetbrains.mps.baseLanguage.structure.ForeachStatement
body : StatementList
Concept = jetbrains.mps.baseLanguage.structure.StatementList
statement : ExpressionStatement
Concept = jetbrains.mps.baseLanguage.structure.ExpressionStatement
expression : DotExpression {void}
Concept = jetbrains.mps.baseLanguage.structure.DotExpression
operand : .<static field> {java.io.PrintStream}
operation : println(String):void {void}
properties
referents
properties
referents
properties
referents
variable : value {string}
iterable : args {string[]}
properties
referents
properties
referents
condition : > {boolean}
ifFalseStatement : {
properties
referents

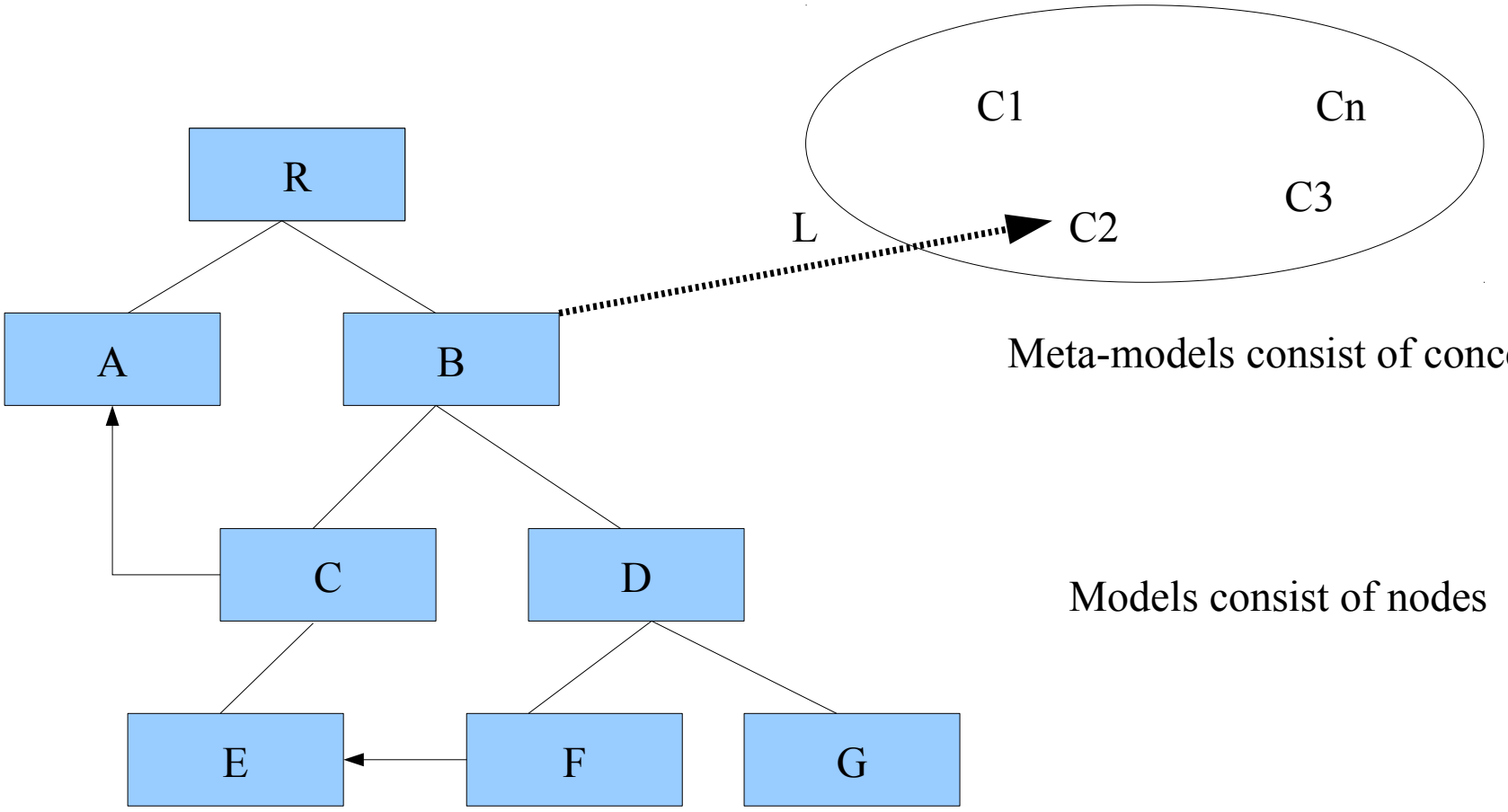
Children have roles



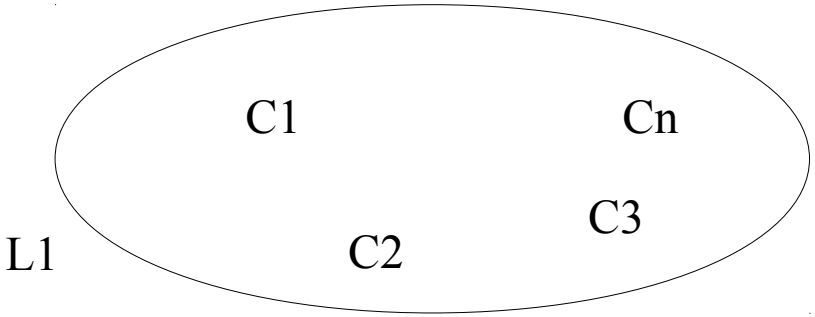
References cross the tree



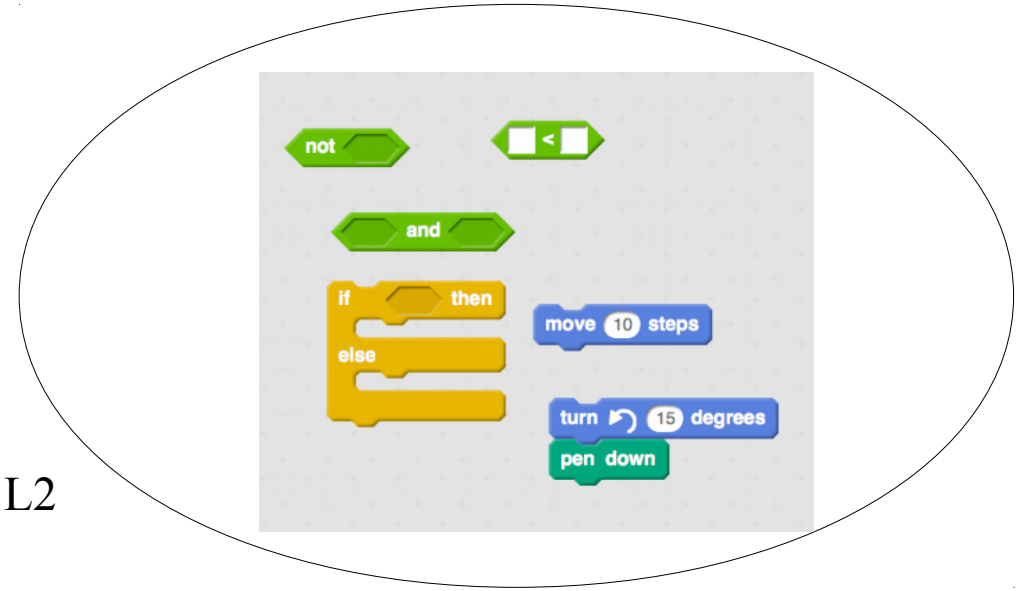
Programs and Languages



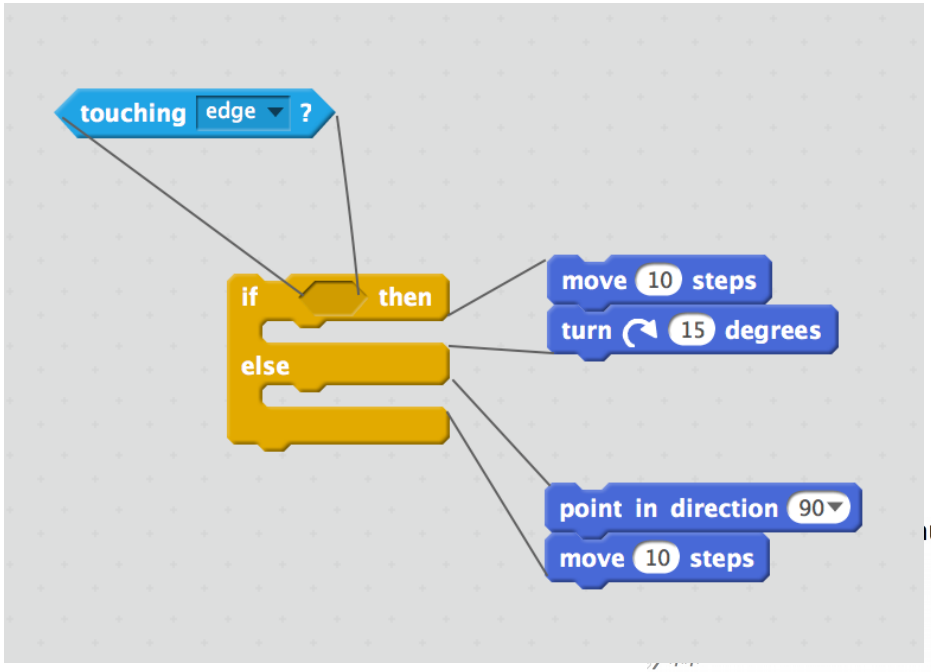
Languages are sets of concepts



L1



L2




```
us.groovy.ast.stmt;

 * Represents an if (condition) { ... } else { ... } statement in Groovy
 *
 * @author <a href="mailto:james@coredevelopers.net">James Strachan</a>
 * @version $Revision$
 */
public class IfStatement extends Statement {

    private BooleanExpression booleanExpression;
    private Statement ifBlock;
    private Statement elseBlock;


    public IfStatement(BooleanExpression booleanExpression, Statement ifBlock,
        this.booleanExpression = booleanExpression;
        this.ifBlock = ifBlock;
        this.elseBlock = elseBlock;
    }
```

The Node

```
public class ASTNode {

    private int lineNumber = -1;
    private int columnNumber = -1;
    private int lastLineNumber = -1;
    private int lastColumnNumber = -1;
    private ListHashMap metaDataMap = null;

    public void visit(GroovyCodeVisitor visitor) {
        throw new RuntimeException("No visit() method implemented for class: "
    }
```

```
public class TernaryExpression extends Expression {

    private BooleanExpression booleanExpression;
    private Expression trueExpression;
    private Expression falseExpression;
```

```
public class ElvisOperatorExpression extends TernaryExpression {

    public ElvisOperatorExpression(Expression base, Expression falseExpression) {
        super(getBool(base), base, falseExpression);
    }
```

```
public class ForStatement extends Statement implements LoopingStatement {
    public static final Parameter FOR_LOOP_DUMMY = new Parameter(ClassHelp

    private Parameter variable;
    private Expression collectionExpression;
    private Statement loopBlock;
    private VariableScope scope;
```

```
public class MethodNode extends AnnotatedNode implements Opcodes {

    public static final String SCRIPT_BODY_METHOD_KEY = "org.codeha
    private final String name;
    private int modifiers;
    private boolean syntheticPublic;
    private ClassNode returnType;
    private Parameter[] parameters;
    private boolean hasDefaultValue = false;
    private Statement code;
    private boolean dynamicReturnType;
    private VariableScope variableScope;
    private final ClassNode[] exceptions;
    private final boolean staticConstructor;

    // type spec for generics
    private GenericsType[] genericsTypes = null;
    private boolean hasDefault;

    // cached data
    String typeDescriptor;
```

Visitor pattern

Separate class hierarchies from their processing

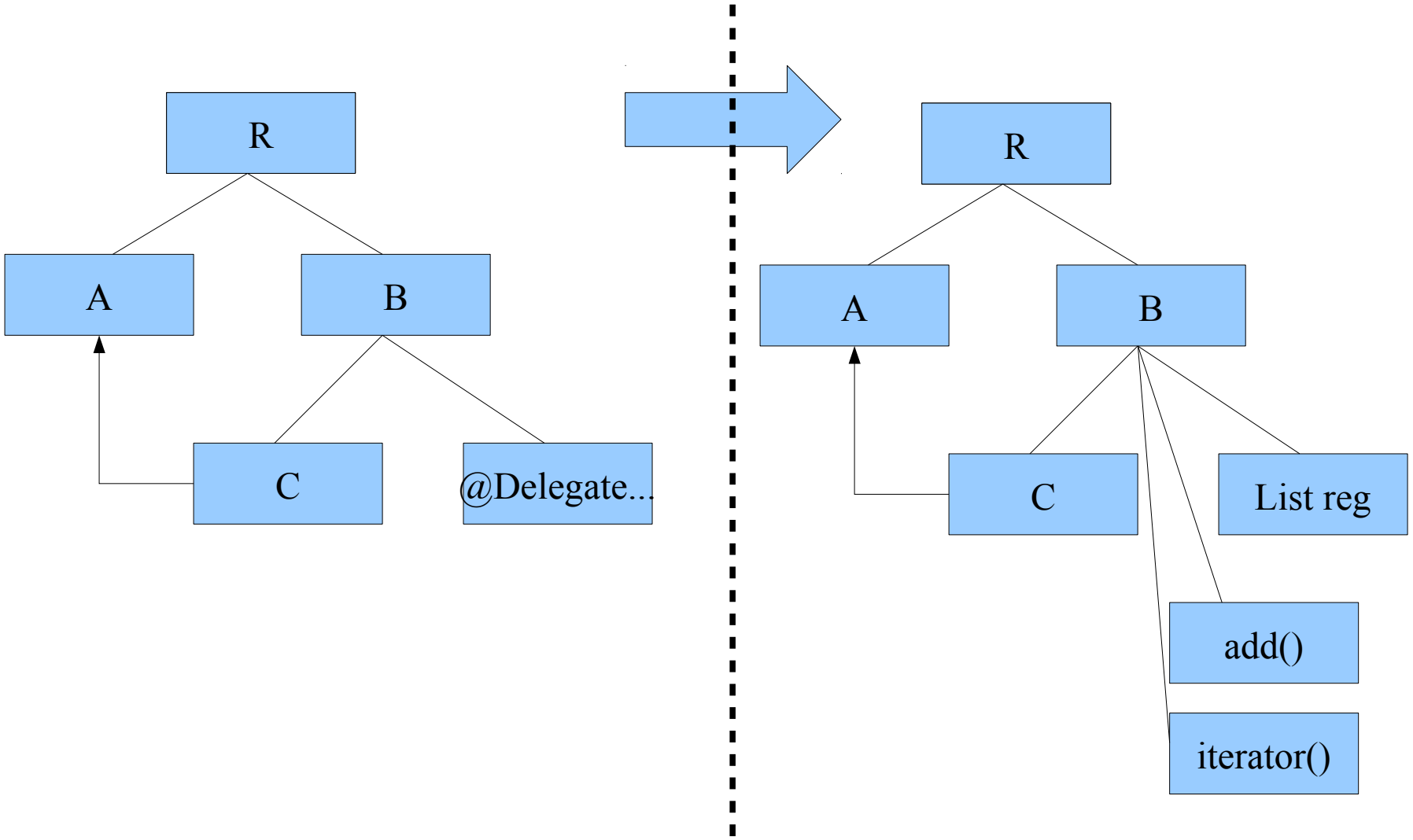
There's no life without trees

- Extending IDEs
- External DSLs
- Internal DSLs in modern languages
  - Groovy AST transformations
  - Scala macros
  - Lisp, Clojure macros
  - Lombok

AST Transformations

```
class Registrations {
    @Delegate List items = []
}

def people = new Registrations()
people.addAll(["Joe", "Dave"])
assert ["Dave", "Joe"] == people.reverse()
```

Ast transformation



@Delegate, @Immutable, @Singleton

@Lazy

@TupleConstructor

@InheritConstructors

@Canonical

@ToString

@EqualsAndHashCode

@Log, @Log4j, @Commons

@Synchronized

@WithReadLock

@WithWriteLock

@AutoClone, @AutoExternalize

...

Type-checking/Static

@TypeChecked, @CompileStatic

```
@TypeChecked
String test(Object val) {
    if (val instanceof String) {
        val.toUpperCase()
    } else if (val instanceof Number) {
        val.intValue() * 2
    }
}
```

Creating AST Transformations

```
new AstBuilder()
                    .buildFromString()
                    .buildFromCode()
                    .buildFromSpec()
```

```
.buildFromString ('''
                    Integer.parseInt("$param")
''')
```

```
.buildFromCode (
                    Integer.parseInt("$param")
)
```

```
.buildFromSpec {
    method('convertToNumber', ACC_PUBLIC, Integer) {
            parameters { parameter 'parameter': String.class }
            exceptions {}
            block {
                returnStatement {
                    staticMethodCall(Integer, "parseInt") {
                        argumentList {
                            variable "parameter"
                        }
        }   }   }   }   }
```

Macro

```
return macro(CompilePhase.SEMANTIC_ANALYSIS, true) {
    return java.security.MessageDigest
            .getInstance('MD5')
            .digest($v { fieldVar }.getBytes())
            .encodeHex()
            .toString()
}
```

Macro

```
@Override
Expression transform(Expression exp) {
    Expression ref = macro { 1 + 1 }

    if (ASTMatcher.matches(ref, exp)) {
        return macro { 3 }
    }

    return super.transform(exp)
}
```

Summary

AST transforms for Java programmers

vaclav@vaclavpech.eu

References

http://groovy-lang.org

http://grails.org

http://groovyconsole.appspot.com/

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