

Static meta-programming



Václav Pech

NPRG014 2020/2021

<http://www.vaclavpech.eu>

@vaclav_pech

Last time agenda

Dynamic meta-programming



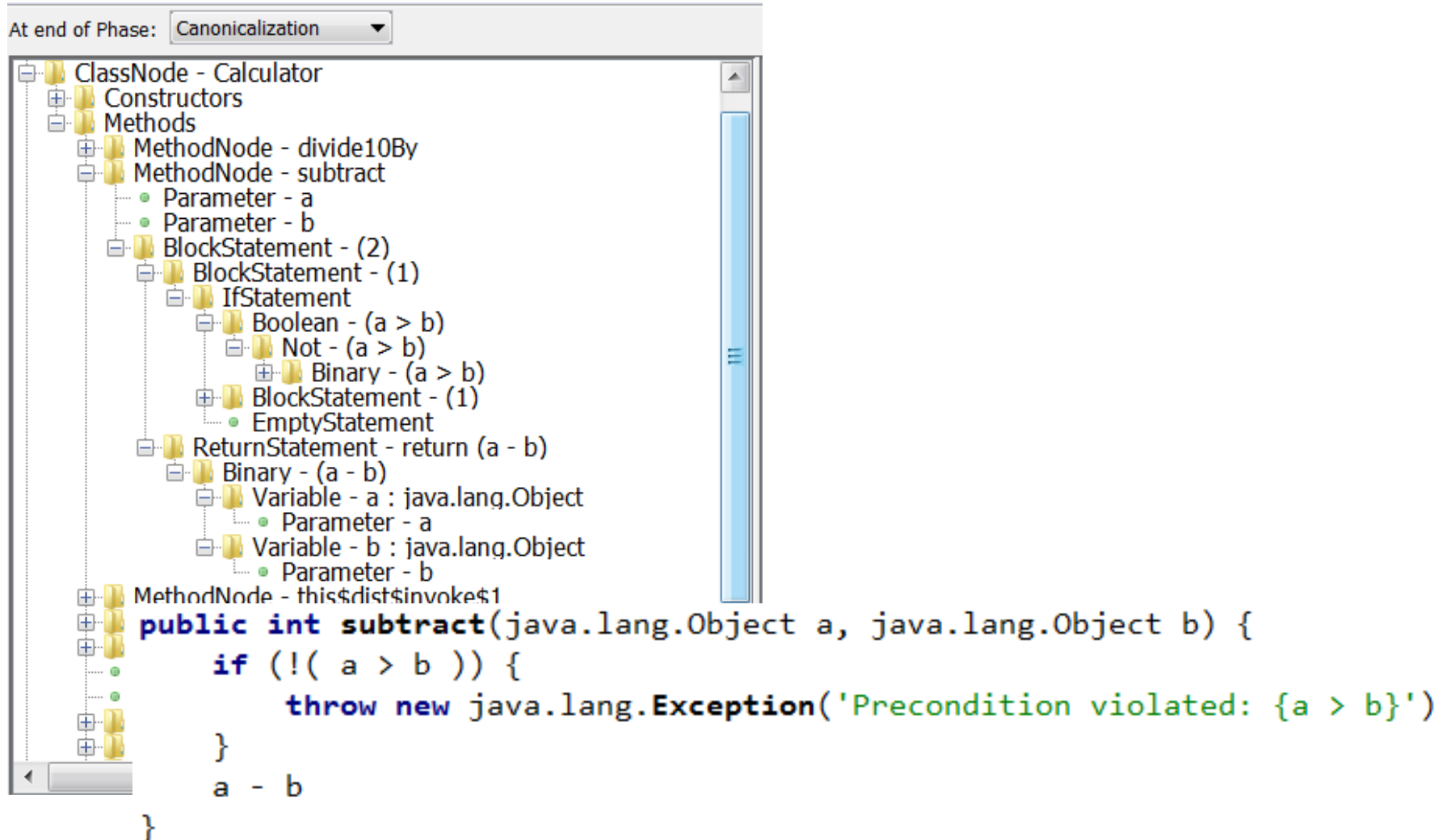
Domain-specific languages

Builders

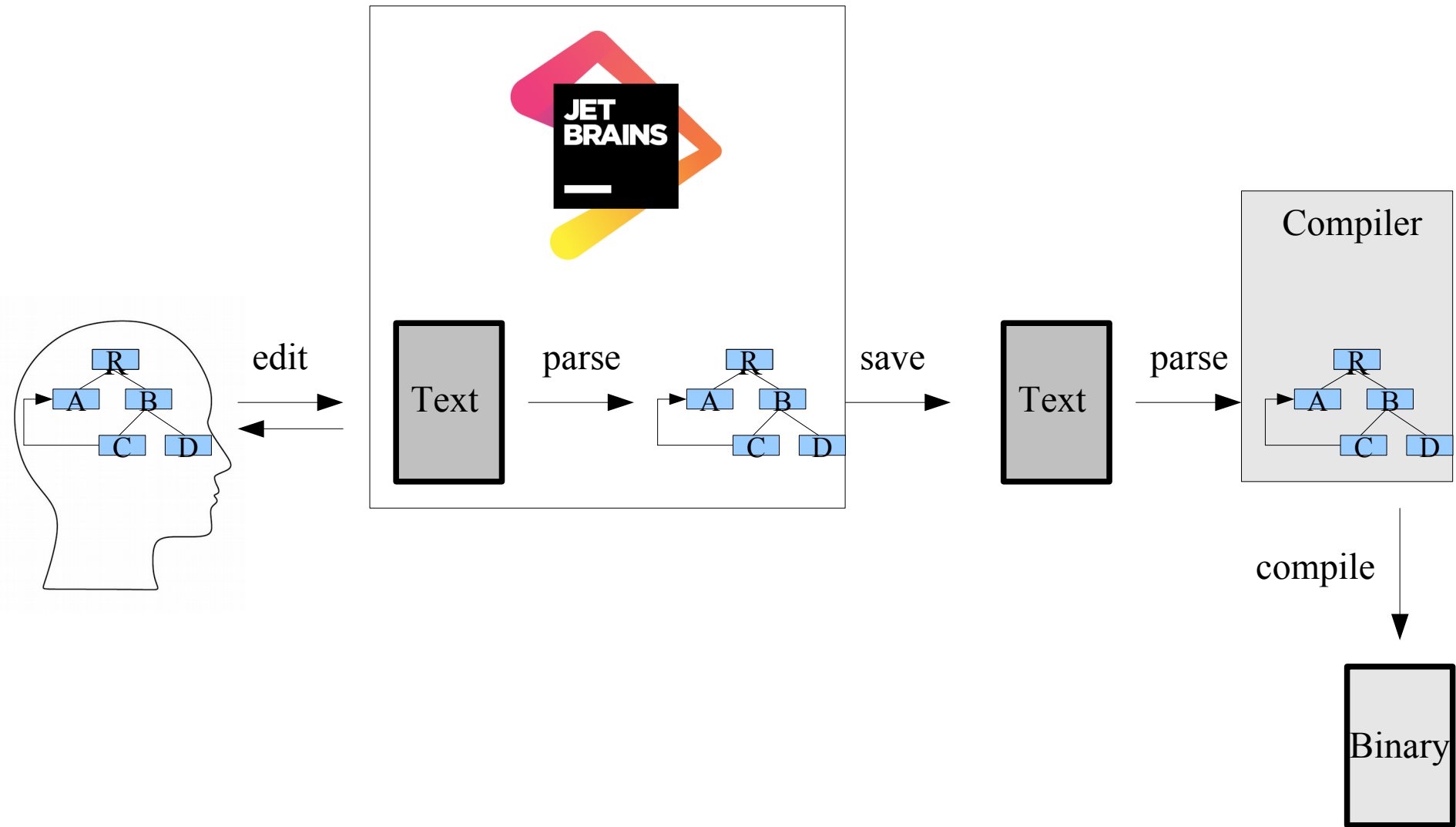
Part 5

Static meta-programming

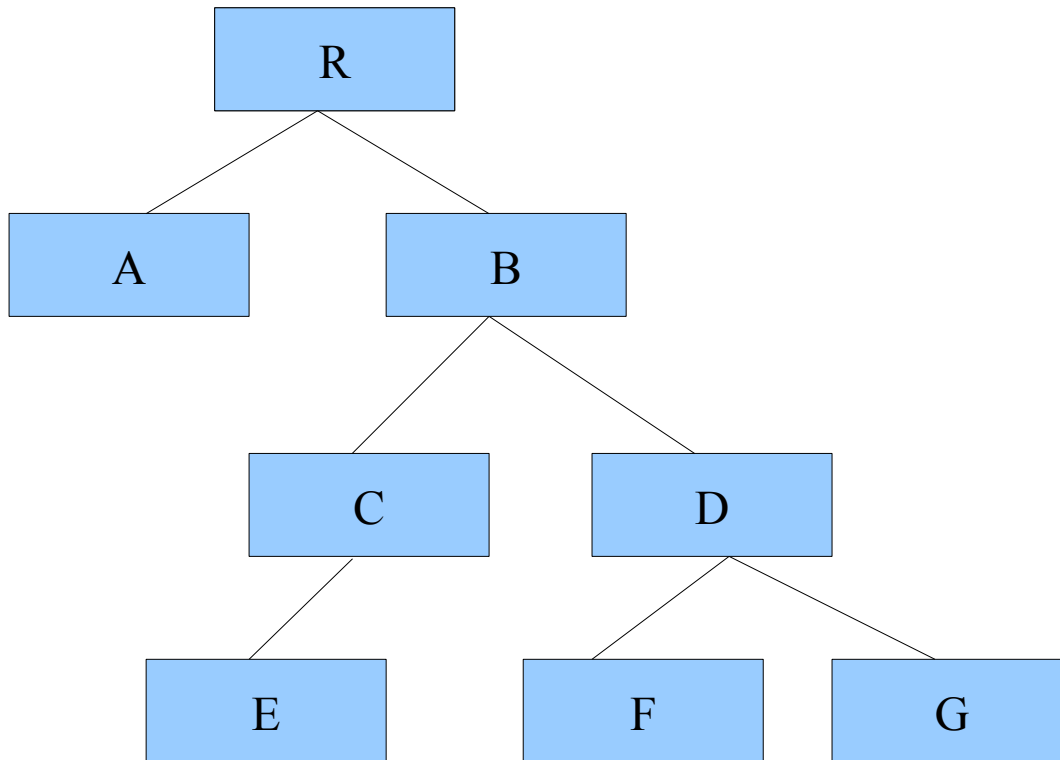
AST



Programming

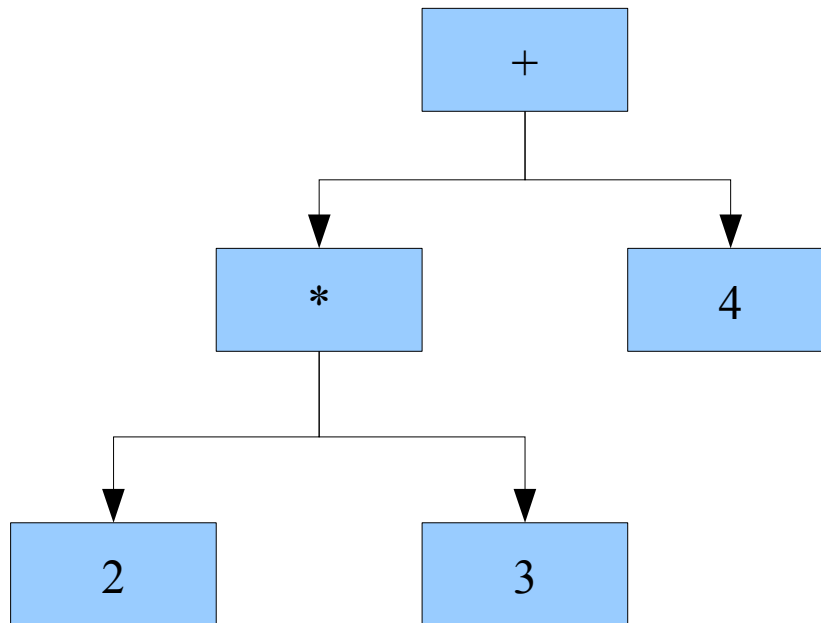


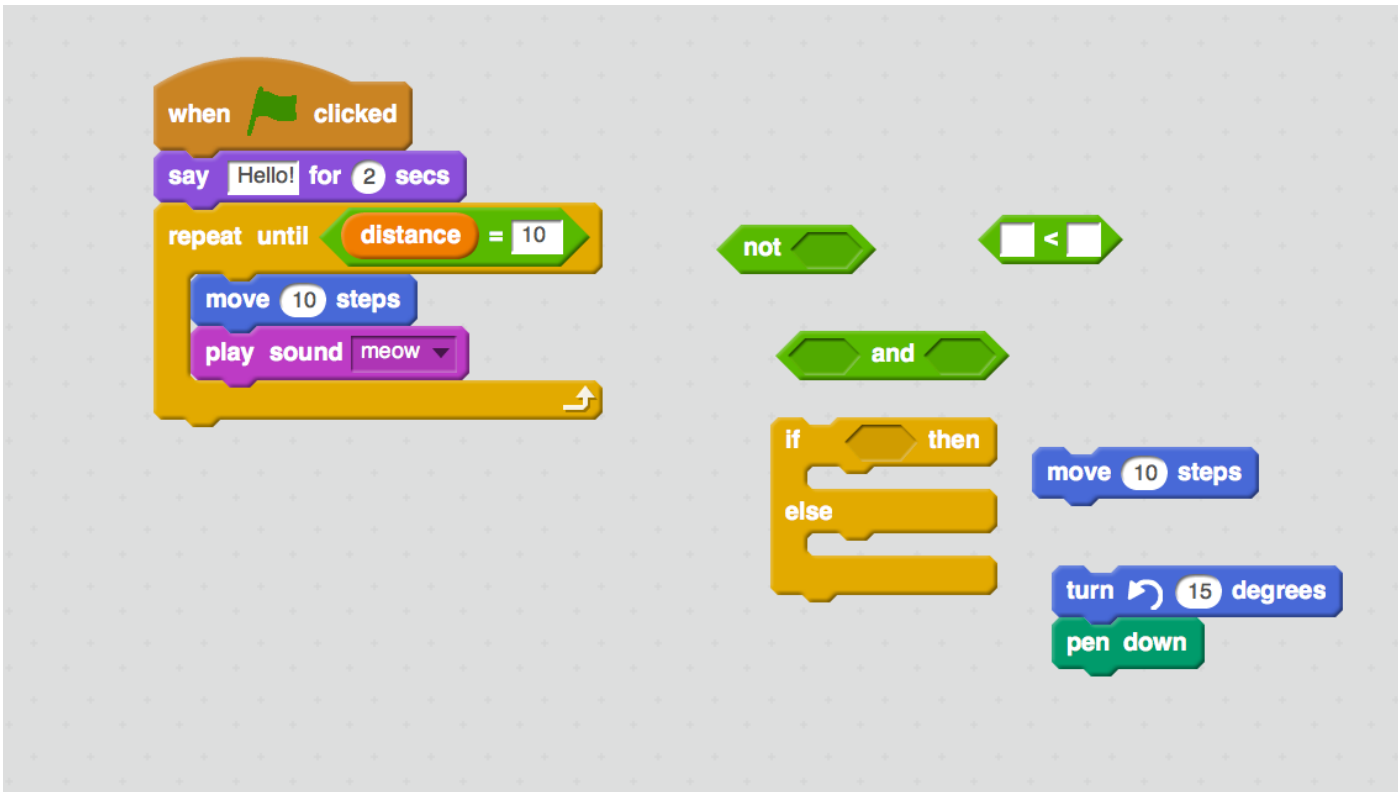
Programs are trees



Lisp (1958)

`(+ (* 2 3) 4)`






```
public class Demo {
```

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

```
    public static void main(string[] args) {
```

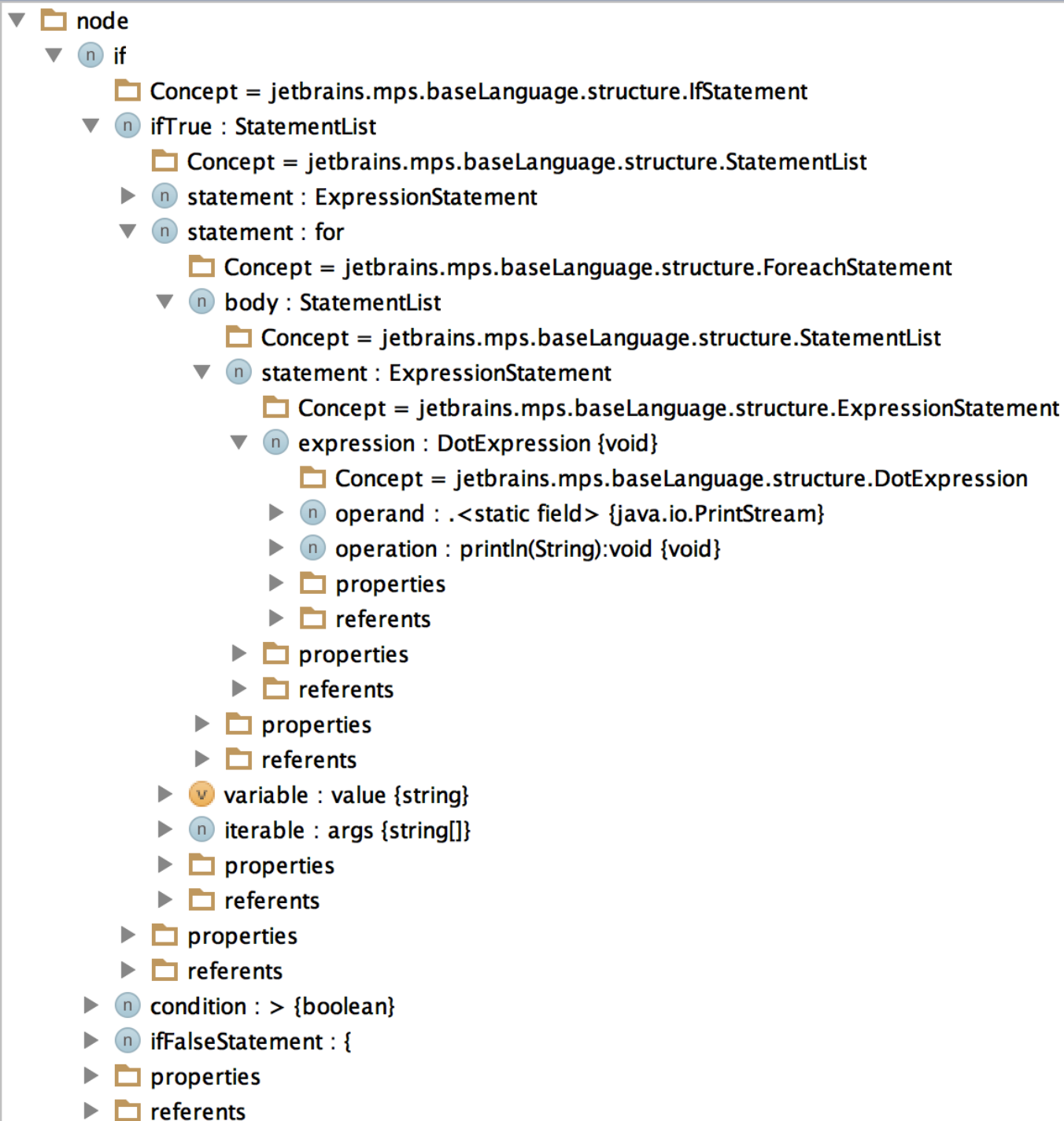
```
        System.out.println("Application started");
```



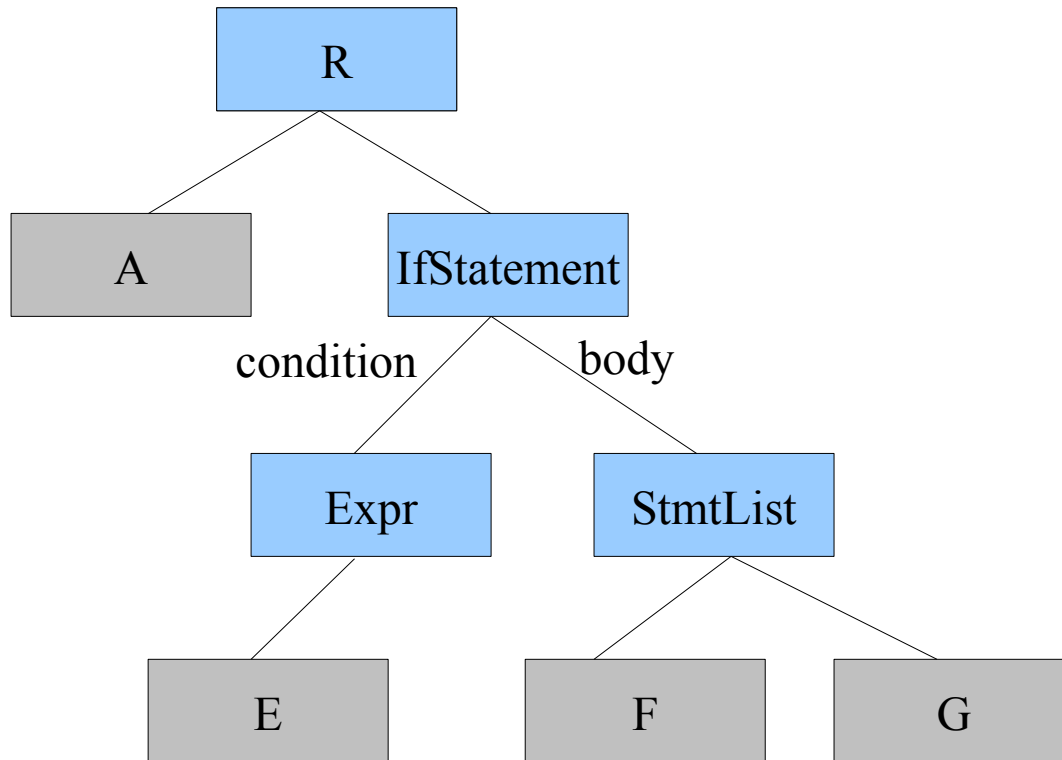
```
        if (args.length > 0) {  
            System.out.println("Supplied arguments");  
            for (string value : args) {  
                System.out.println("Argument: " + value);  
            }  
        } else {  
            System.out.println("No arguments provided");  
        }
```

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

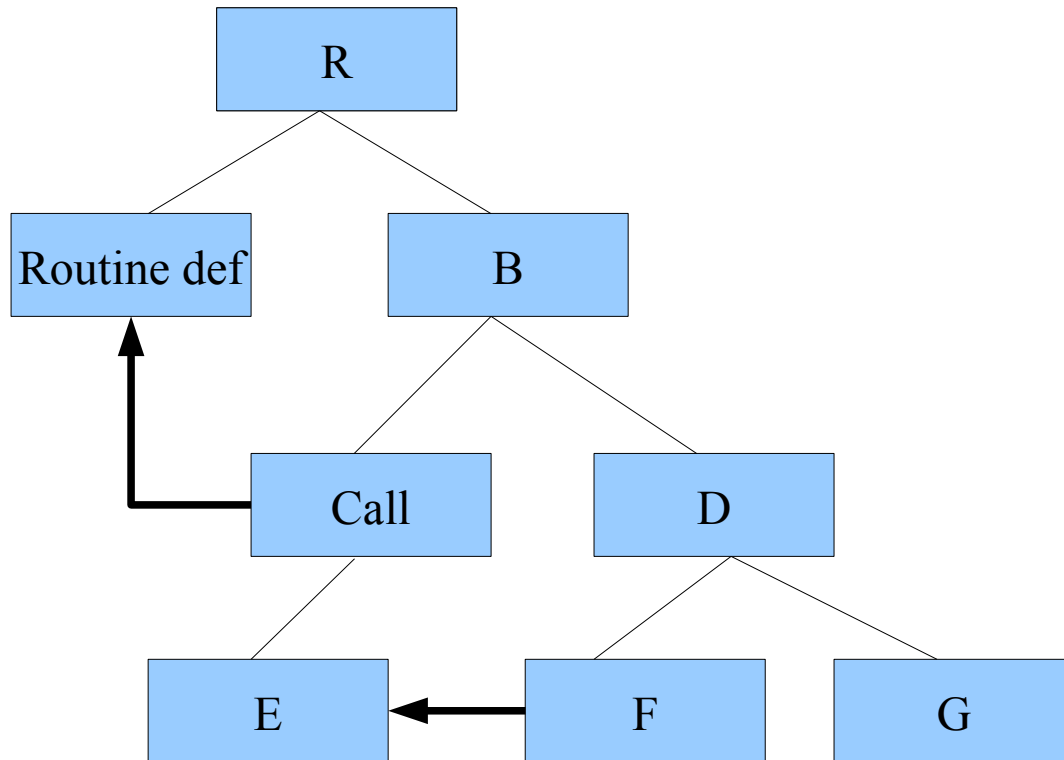
```
}
```



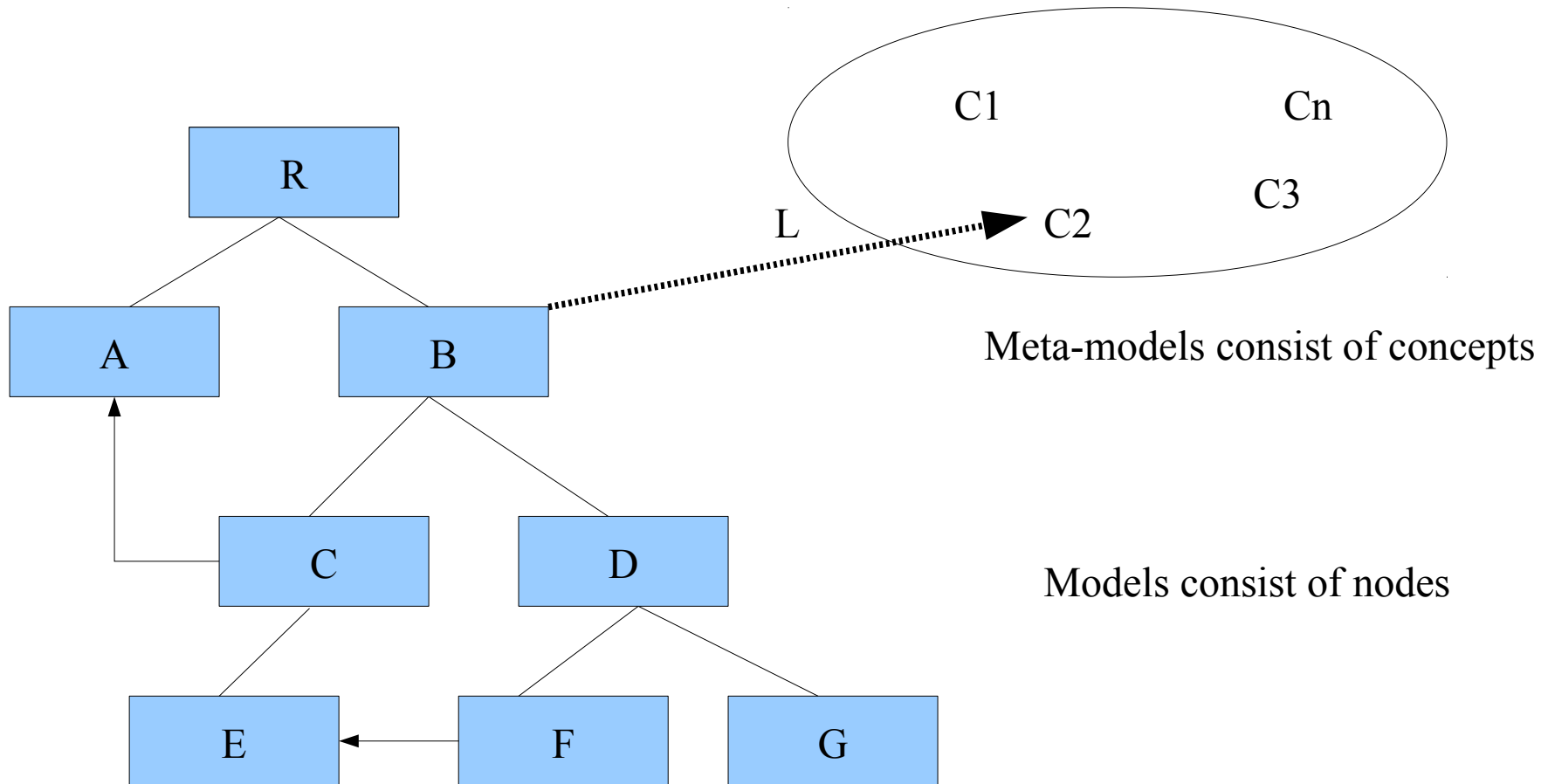
Children have roles



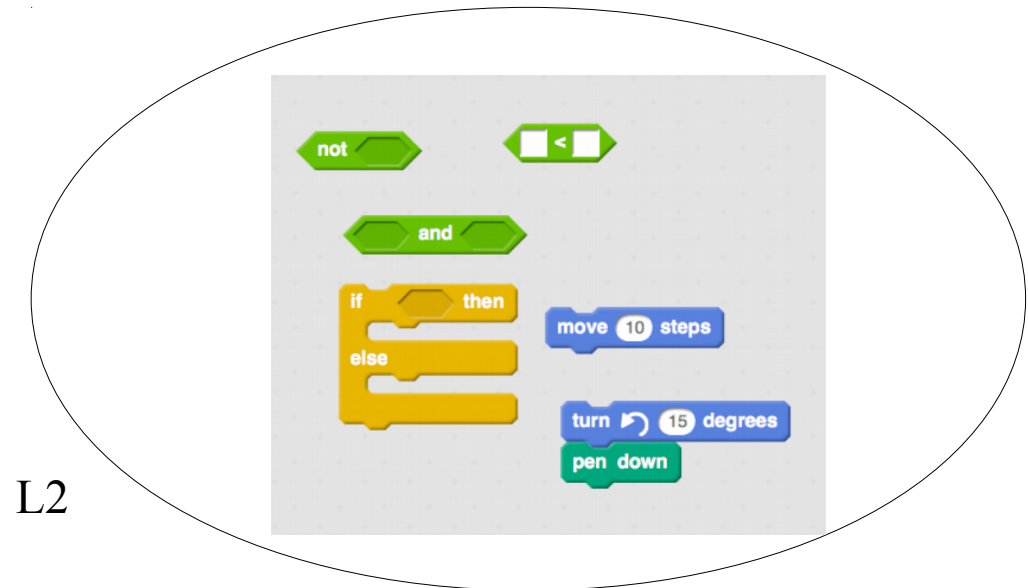
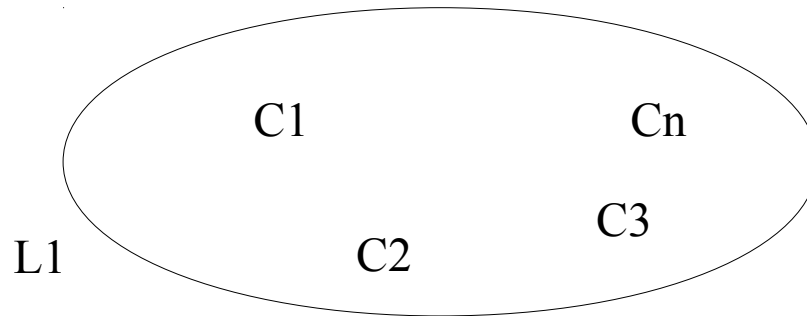
References cross the tree

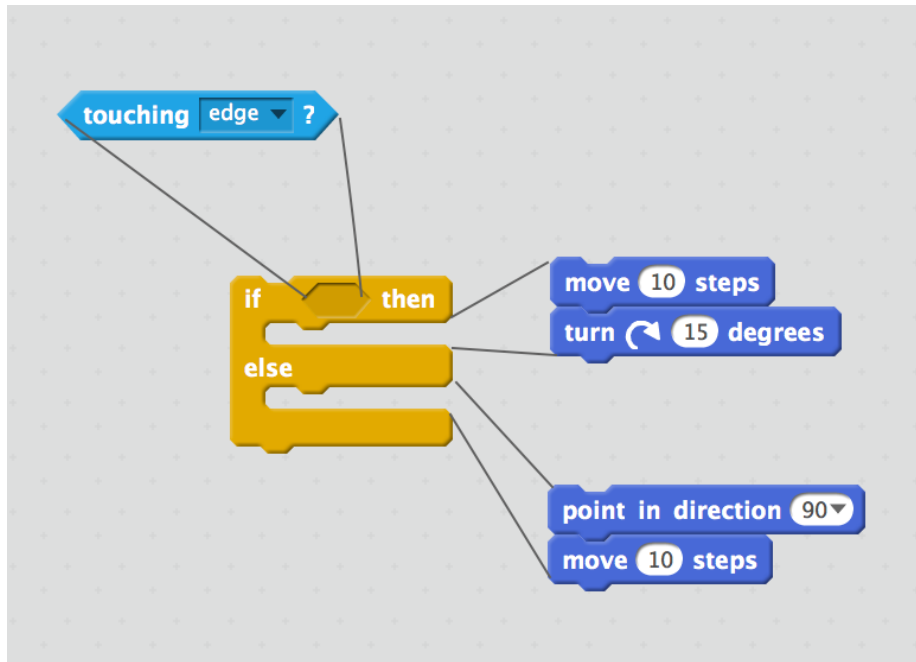


Programs and Languages



Languages are sets of concepts





```
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.codehaus.mojo
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

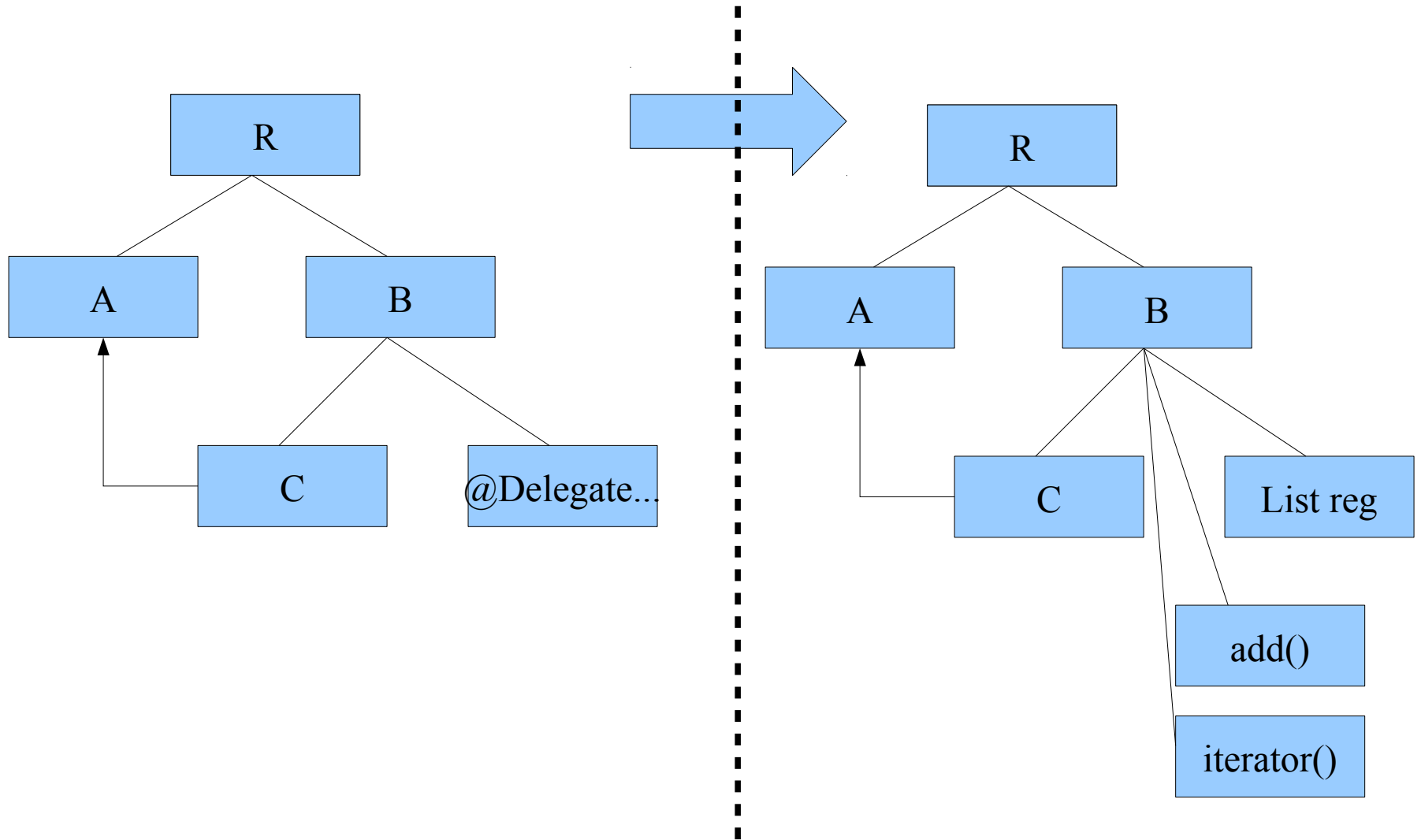
- Extending IDEs
- External DSLs
- Internal DSLs in modern languages
 - Groovy AST transformations
 - Scala macros
 - Lisp, Clojure macros
 - Lombok

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/coenig2/>