

Model Management in Xtend (second part)

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Material

<http://mathieuacher.com/teaching/MDE/>

foo1.videogen

```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"  
optional videoseq v2 "v2folder/v2.mp4"  
alternatives v3 {  
  videoseq v31 "v3/seq1.mp4"  
  videoseq v32 "v3/seq1.mp4"  
  videoseq v33 "v3/seq1.mp4"  
}  
alternatives v4 {  
  videoseq v41 "v4/seq1.mp4"  
  videoseq v42 "v4/seq1.mp4"  
}  
mandatory videoseq v5 "https://www.youtube.com/watch?v=eZKx-S0LiNQ"
```

#1 How to design, create, and support dedicated languages (DSLs)?



#2 How to transform models/programs?

#3 How to manage variability/variants?

#4 How do frameworks internally work?



Plan

- Model Management in a nutshell
 - Loading, serializing, transforming models
- Xtend
 - Java 10, cheatsheet
 - Advanced features: extension methods, active annotations, template expressions
 - **Xtend: behind the magic (Xtext+MDE)**
- Model Management + Xtend
 - Model transformations
 - @Aspect annotation
 - Xtend + Xtext (breathing life into DSLs)

Xtend is
implemented using
MDE principles

```
package fr.inria.k3
```

```
class FooA {
```

```
  //
```

```
}
```

Model

platform:/resource/FooActiveAnnotation/src/fr/inria/k3/FooA.xtend

- ▼ Xtend File fr.inria.k3
 - ▼ Xtend Class FooA
 - ◆ Xtend Type Declaration
 - ▼ Jvm Generic Type FooA
 - ◆ Jvm Unknown Type Reference java.lang.Object
 - ◆ Jvm Constructor FooA

<https://github.com/eclipse/xtext/blob/master/plugins/org.eclipse.xtext/src/org/eclipse/xtext/Xtext.xtext>

```
grammar org.eclipse.xtend.core.Xtend with org.eclipse.xtext.xbase.annotations.XbaseWithAnnotations

import "http://www.eclipse.org/xtend"
import "http://www.eclipse.org/xtext/xbase/Xbase" as xbase
import "http://www.eclipse.org/xtext/xbase/Xtype" as xtype
import "http://www.eclipse.org/Xtext/Xbase/XAnnotations" as annotations
import "http://www.eclipse.org/xtext/common/JavaVMTypes" as types

File returns XtendFile :
  ('package' package=QualifiedName ';'?)?
  importSection=XImportSection?
  (xtendTypes+=Type)*
;

Type returns XtendTypeDeclaration :
  {XtendTypeDeclaration} annotations+=XAnnotation*
  (
    {XtendClass.annotationInfo = current}
    modifiers+=CommonModifier*
    'class' name=ValidID ('<' typeParameters+=JvmTypeParameter (',' typeParameters+=JvmTypeParameter)* '>')?
    ("extends" extends=JvmParameterizedTypeReference)?
    ('implements' implements+=JvmParameterizedTypeReference (',' implements+=JvmParameterizedTypeReference)*)? '{'
      (members+=Member)*
    '}'
  |
    {XtendInterface.annotationInfo = current}
    modifiers+=CommonModifier*
    'interface' name=ValidID ('<' typeParameters+=JvmTypeParameter (',' typeParameters+=JvmTypeParameter)* '>')?
    ('extends' extends+=JvmParameterizedTypeReference (',' extends+=JvmParameterizedTypeReference)*)? '{'
      (members+=Member)*
    '}'
  |
    {XtendEnum.annotationInfo = current}
    modifiers+=CommonModifier*
    'enum' name=ValidID '{'
      (members+=XtendEnumLiteral (',' members+=XtendEnumLiteral)*)? ';'
    '}'
  |
    {XtendAnnotationType.annotationInfo = current}
    modifiers+=CommonModifier*
    'annotation' name=ValidID '{'
      (members+=AnnotationField)*
    '}'
  )
;
```

The logo for xtext, featuring the word "xtext" in a bold, black, sans-serif font. The letter "x" is stylized with a blue-to-purple gradient and a shadow effect, giving it a three-dimensional appearance. The "t" is also in black and has a similar shadow effect.

```
public class XtendCompiler extends XbaseCompiler {
```

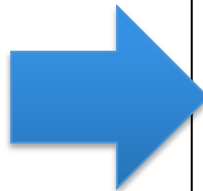
```
@Override
```

```
public void acceptForLoop(JvmFormalParameter parameter, @Nullable XExpression expression) {  
    currentAppendable = null;  
    super.acceptForLoop(parameter, expression);  
    if (expression == null)  
        throw new IllegalArgumentException("expression may not be null");  
    RichStringForLoop forLoop = (RichStringForLoop) expression.eContainer();  
    forStack.add(forLoop);  
    appendable.newLine();  
    pushAppendable(forLoop);  
    appendable.append("{").increaseIndentation();  
  
    ITreeAppendable debugAppendable = appendable.trace(forLoop, true);  
    internalToJavaStatement(expression, debugAppendable, true);  
    String variableName = null;  
    if (forLoop.getBefore() != null || forLoop.getSeparator() != null || forLoop.getAfter() != null) {  
        variableName = debugAppendable.declareSyntheticVariable(forLoop, "_hasElements");  
        debugAppendable.newLine();  
        debugAppendable.append("boolean ");  
        debugAppendable.append(variableName);  
        debugAppendable.append(" = false;");  
    }  
    debugAppendable.newLine();  
    debugAppendable.append("for(final ");  
    JvmTypeReference paramType = getTypeProvider().getTypeForIdentifiable(parameter);  
    serialize(paramType, parameter, debugAppendable);  
    debugAppendable.append(" ");  
    String loopParam = debugAppendable.declareVariable(parameter, parameter.getName());  
    debugAppendable.append(loopParam);  
    debugAppendable.append(" : ");  
    internalToJavaExpression(expression, debugAppendable);  
    debugAppendable.append(") {").increaseIndentation();  
}
```


Xtend to Java

```
HelloWorld.xtend  HelloWorld.java ✕
1 package fr.inria.k3;
2
3 import org.eclipse.xtext.xbase.lib.InputOutput;
4
5 @SuppressWarnings("all")
6 public class HelloWorld {
7     public static void main(final String[] args) {
8         InputOutput.<String>println("HW");
9     }
10 }
11
```

```
package fr.inria.k3
@Singleton
class GUIWindow {
    int x ;
    int y ;
}
```



```
public final class GUIWindow {
    private GUIWindow() {
        // singleton
    }

    private int x;

    private int y;

    private final static GUIWindow INSTANCE = new GUIWindow();

    public static GUIWindow getINSTANCE() {
        return INSTANCE;
    }
}
```

#1 Model Transformations

(importance, taxonomy, and some techniques -- templates, visitors, annotation processors)

#2 Xtend

(A general purpose language with advanced features and an illustration on how to transform models in practice)

<http://docs.oracle.com/javase/6/docs/technotes/guides/language/annotations.html>

<http://docs.oracle.com/javase/tutorial/java/annotations/>

<http://techblog.troyweb.com/index.php/2012/05/switching-annotation-preprocessors-for-jpa-meta-model-generation-in-eclipse/>

<http://blog.jonasbandi.net/2011/09/using-jpa-metamodel-annotation.html>

<http://mojo.codehaus.org/apt-maven-plugin/>

Plan

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- Xtend
 - Java 10, cheatsheet
 - **Advanced features: extension methods, active annotations, template expressions**
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Contract

- Practical foundations of model management
- Learning and understanding Java 10 (aka Xtend)
 - advanced features of a general GPL, implementation of a sophisticated language using MDE
- Model transformations
 - Model-to-Text
 - Model-to-Model
- **Metaprogramming**
 - Revisit annotations (e.g., as in JPA or many frameworks)
- DSLs and model management: all together (Xtext + Xtend)

Active Annotations

(a practical way to transform your
data, programs, models)

Do You know Java Annotations ?



JUnit



@Override

@SuppressWarnings



Guice (pronounced 'juice') is a lightweight dependency injection framework for Java 5 and above, brought to you by Google.

JUnit

```
package com.vogella.junit.first;

import org.junit.runner.RunWith;
import org.junit.runners.Suite;
import org.junit.runners.Suite.SuiteClasses;

@RunWith(Suite.class)
@SuiteClasses({ MyClassTest.class, MySecondClassTest.class })
public class AllTests {

}
```

```
public class MyClassTest {

    @BeforeClass
    public static void testSetup() {
    }

    @AfterClass
    public static void testCleanup() {
        // Teardown for data used by the unit tests
    }

    @Test(expected = IllegalArgumentException.class)
    public void testExceptionIsThrown() {
        MyClass tester = new MyClass();
        tester.multiply(1000, 5);
    }

    @Test
    public void testMultiply() {
        MyClass tester = new MyClass();
        assertEquals("10 x 5 must be 50", 50, tester.multiply(10, 5));
    }
}
```

Annotations (JUnit 4)

<code>@Test</code> <code>public void</code> <code>method()</code>	The <code>@Test</code> annotation identifies a method as a test method.
<code>@Test (expected =</code> <code>Exception.class)</code>	Fails, if the method does not throw the named exception.
<code>@Test(timeout=100)</code>	Fails, if the method takes longer than 100 milliseconds.
<code>@Before</code> <code>public void</code> <code>method()</code>	This method is executed before each test. It is used to can prepare the test environment (e.g. read input data, initialize the class).
<code>@After</code> <code>public void</code> <code>method()</code>	This method is executed after each test. It is used to cleanup the test environment (e.g. delete temporary data, restore defaults). It can also save memory by cleaning up expensive memory structures.
<code>@BeforeClass</code> <code>public static void</code> <code>method()</code>	This method is executed once, before the start of all tests. It is used to perform time intensive activities, for example to connect to a database. Methods annotated with this annotation need to be defined as <code>static</code> to work with JUnit.
<code>@AfterClass</code> <code>public static void</code> <code>method()</code>	This method is executed once, after all tests have been finished. It is used to perform clean-up activities, for example to disconnect from a database. Methods annotated with this annotation need to be defined as <code>static</code> to work with JUnit.

http://www.vogella.com/articles/JUnit/article.html#usingjunit_annotations



JAXB

Java

Annotations

```
@XmlRootElement  
public class Customer {
```

```
    String name;  
    int age;  
    int id;
```

```
    public String getName() {  
        return name;  
    }
```

```
    @XmlElement  
    public void setName(String name) {  
        this.name = name;  
    }
```

```
    public int getAge() {  
        return age;  
    }
```

```
    @XmlElement  
    public void setAge(int age) {  
        this.age = age;  
    }
```

```
    public int getId() {  
        return id;  
    }
```

```
    @XmlAttribute  
    public void setId(int id) {  
        this.id = id;  
    }
```

```
Customer customer = new Customer();  
customer.setId(100);  
customer.setName("mkyong");  
customer.setAge(29);
```



```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>  
<customer id="100">  
    <age>29</age>  
    <name>mkyong</name>  
</customer>
```



2.2.1. Marking a POJO as persistent entity

Every persistent POJO class is an entity and is declared using the `@Entity` annotation (at the class level):

```
@Entity
public class Flight implements Serializable {
    Long id;

    @Id
    public Long getId() { return id; }

    public void setId(Long id) { this.id = id; }
}
```

`@Entity` declares the class as an entity (i.e. a persistent POJO class), `@Id` declares the identifier property of this entity. The other mapping declarations are implicit. The class `Flight` is mapped to the `Flight` table, using the column `id` as its primary key column.

```
@Entity
class MedicalHistory implements Serializable {
    @Id @OneToOne
    @JoinColumn(name = "person_id")
    Person patient;
}

@Entity
public class Person implements Serializable {
    @Id @GeneratedValue Integer id;
}
```

Javadoc

(old fashion, not real annotations)

```
/**
 * Returns an Image object that can then be painted on the screen.
 * The url argument must specify an absolute {@link URL}. The name
 * argument is a specifier that is relative to the url argument.
 * <p>
 * This method always returns immediately, whether or not the
 * image exists. When this applet attempts to draw the image on
 * the screen, the data will be loaded. The graphics primitives
 * that draw the image will incrementally paint on the screen.
 *
 * @param url an absolute URL giving the base location of the image
 * @param name the location of the image, relative to the url argument
 * @return the image at the specified URL
 * @see Image
 */
public Image getImage(URL url, String name) {
    try {
        return getImage(new URL(url, name));
    } catch (MalformedURLException e) {
        return null;
    }
}
```

Disclaimer

- @AhaMoment
- @BossMadeMeDoIt
- @HandsOff
- @IAmAwesome
- @LegacySucks

Enforceable

- @CantTouchThis
- @ImaLetYouFinishBut

Literary Verse (new subcategory)

- @Burma Shave
- @Clerihew
- @DoubleDactyl
- @Haiku (moved to this subcategory)
- @Limerick
- @Sonnet

Remarks

- @Fail
- @OhNoYouDidnt
- @RTFM
- @Win



The Google Annotations Gallery is an exciting new Java open source library that provides a rich set of annotations for developers to express themselves.

Do you find the standard Java annotations dry and lackluster? Have you ever resorted to leaving messages to fellow developers with the `@Deprecated` annotation? Wouldn't you rather leave a `@LOL` or `@Facepalm` instead?

Not only can you leave expressive remarks in your code, you can use these annotations to draw attention to your poetic endeavors. How many times have you written a palindromic or synecdochal line of code and wished you could annotate it for future readers to admire? Look no further than `@Palindrome` and `@Synecdoche`.

But wait, there's more. The Google Annotations Gallery comes complete with dynamic bytecode instrumentation. By using the `gag-agent.jar` Java agent, you can have your annotations behavior-enforced at runtime. For example, if you want to ensure that a method parameter is non-zero, try `@ThisHadBetterNotBe(Property.ZERO)`. Want to completely inhibit a method's implementation? Try `@Noop`.

Annotations for...

- Documentation
 - Javadoc like
- Information to the Compiler
 - Suppress warnings, error detections
- Generation
 - Code (Java, SQL, etc.)
 - Configuration files (e.g., XML-like)
- Runtime processing

⇒ **Transformation of programs, datas, models**

⇒ You can define your own

Annotations: How does it work?



org.junit

Annotation Type Test

```
@Retention(value=RUNTIME)
@Target(value=METHOD)
public @interface Test
```

The `Test` annotation tells JUnit that the `public void` method to which it is applied, if no exceptions are thrown, the test is assumed to have succeeded.

A simple test looks like this:

```
public class Example {
    @Test
    public void method() {
        org.junit.Assert.assertTrue( new ArrayList().isEmpty() );
    }
}
```

The `Test` annotation supports two optional parameters. The first, `expected`

```
@Test(expected=IndexOutOfBoundsException.class) public void method() {
    new ArrayList<Object>().get(1);
}
```

The second optional parameter, `timeout`, causes a test to fail if it takes longer than the specified time.

```
@Test(timeout=100) public void infinity() {
    while(true);
}
```


Annotations: How does it work?



GitHub, Inc. [US]

<https://github.com/junit-team/junit/blob/master/src/main/java/org/junit/Test.java>

```
60 @Retention(RetentionPolicy.RUNTIME)
61 @Target({ElementType.METHOD})
62 public @interface Test {
63
64     /**
65      * Default empty exception
66      */
67     static class None extends Throwable {
68         private static final long serialVersionUID = 1L;
69
70         private None() {
71         }
72     }
73
74     /**
75      * Optionally specify <code>expected</code>, a Throwable, to cause a
76      * and only if an exception of the specified class is thrown by the
77      */
78     Class<? extends Throwable> expected() default None.class;
79
80     /**
81      * Optionally specify <code>timeout</code> in milliseconds to cause
82      * takes longer than that number of milliseconds.
83      * <p>
84      * <b>THREAD SAFETY WARNING:</b> Test methods with a timeout parameter
85      * thread which runs the fixture's @Before and @After methods. This
86      * code that is not thread safe when compared to the same test method
87      * <b>Consider using the {@link org.junit.rules.Timeout} rule instead
88      * same thread as the fixture's @Before and @After methods.
89      * </p>
90      */
91     long timeout() default 0L;
92 }
```

Java Build Path

Source | Projects | Libraries | Order and Export

JARs and class folders on the build path:

- ▶ JRE System Library [JavaSE-1.6]
- ▶ JUnit 4



```
package com.vogella.junit.first;

import org.junit.runner.RunWith;
import org.junit.runners.Suite;
import org.junit.runners.Suite.SuiteClasses;

@RunWith(Suite.class)
@SuiteClasses({ MyClassTest.class, MySecondClassTest.class })
public class AllTests {

}
```

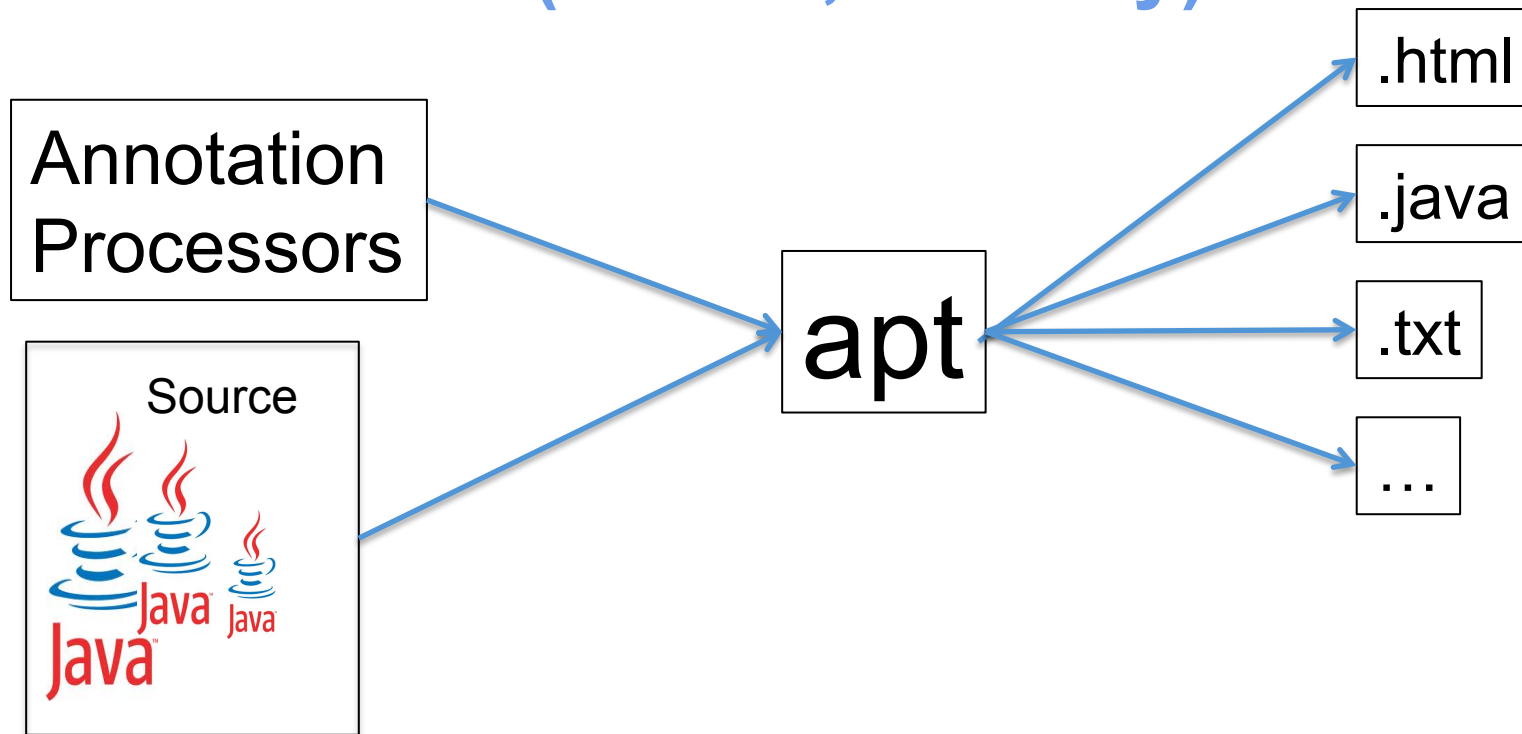


Transformation of Java code



JUnit 4 test runner interface showing a successful test run. The status bar indicates "Finished after 0,01 seconds". The test results show "Runs: 1/1", "Errors: 0", and "Failures: 0". A green progress bar is visible. The test name is "fr.inria.k3.SingletonTest [Runner: JUnit 4] (0,000 s)" and the test method is "test1 (0,000 s)".

Annotations and Transformations (Java 5, old way)



← → ↻ docs.oracle.com/javase/1.5.0/docs/guide/apt/GettingStarted.html



Getting Started with the Annotation Processing Tool (apt)

What is apt?

The command-line utility `apt`, annotation processing tool, finds and executes *annotation processors* based on the annotations present in the set of specified source files being examined. The annotation

Annotations and Transformations (Java 5, old way)

Annotation Processors

apt

```
/*
 * This class is used to run an annotation processor that lists class
 * names. The functionality of the processor is analogous to the
 * ListClass doclet in the Doclet Overview.
 */
public class ListClassApf implements AnnotationProcessorFactory {
    // Process any set of annotations
    private static final Collection<String> supportedAnnotations
        = unmodifiableCollection(Arrays.asList("*"));

    // No supported options
    private static final Collection<String> supportedOptions = emptySet();

    public Collection<String> supportedAnnotationTypes() {
        return supportedAnnotations;
    }

    public Collection<String> supportedOptions() {
        return supportedOptions;
    }

    public AnnotationProcessor getProcessorFor(
        Set<AnnotationTypeDeclaration> atds,
        AnnotationProcessorEnvironment env) {
        return new ListClassAp(env);
    }

    private static class ListClassAp implements AnnotationProcessor {
        private final AnnotationProcessorEnvironment env;
        ListClassAp(AnnotationProcessorEnvironment env) {
            this.env = env;
        }

        public void process() {
            for (TypeDeclaration typeDecl : env.getSpecifiedTypeDeclarations())
                typeDecl.accept(getDeclarationScanner(new ListClassVisitor(),
                    NO_OP));
        }

        private static class ListClassVisitor extends SimpleDeclarationVisitor {
            public void visitClassDeclaration(ClassDeclaration d) {
                System.out.println(d.getQualifiedName());
            }
        }
    }
}
```

The apt Command Line

In addition to its own options, the apt tool accepts all of the command-line options accepted by javac.

The apt specific options are:

- s *dir*
Specify the directory root under which processor-generated source files will be placed.
- nocompile
Do not compile source files to class files.
- print
Print out textual representation of specified types; perform no annotation processing.
- A[*key[=val]*]
Options to pass to annotation processors -- these are not interpreted by apt directly.
- factorypath *path*
Specify where to find annotation processor factories; if this option is used, the classpath is ignored.
- factory *classname*
Name of AnnotationProcessorFactory to use; bypasses default discovery procedure.

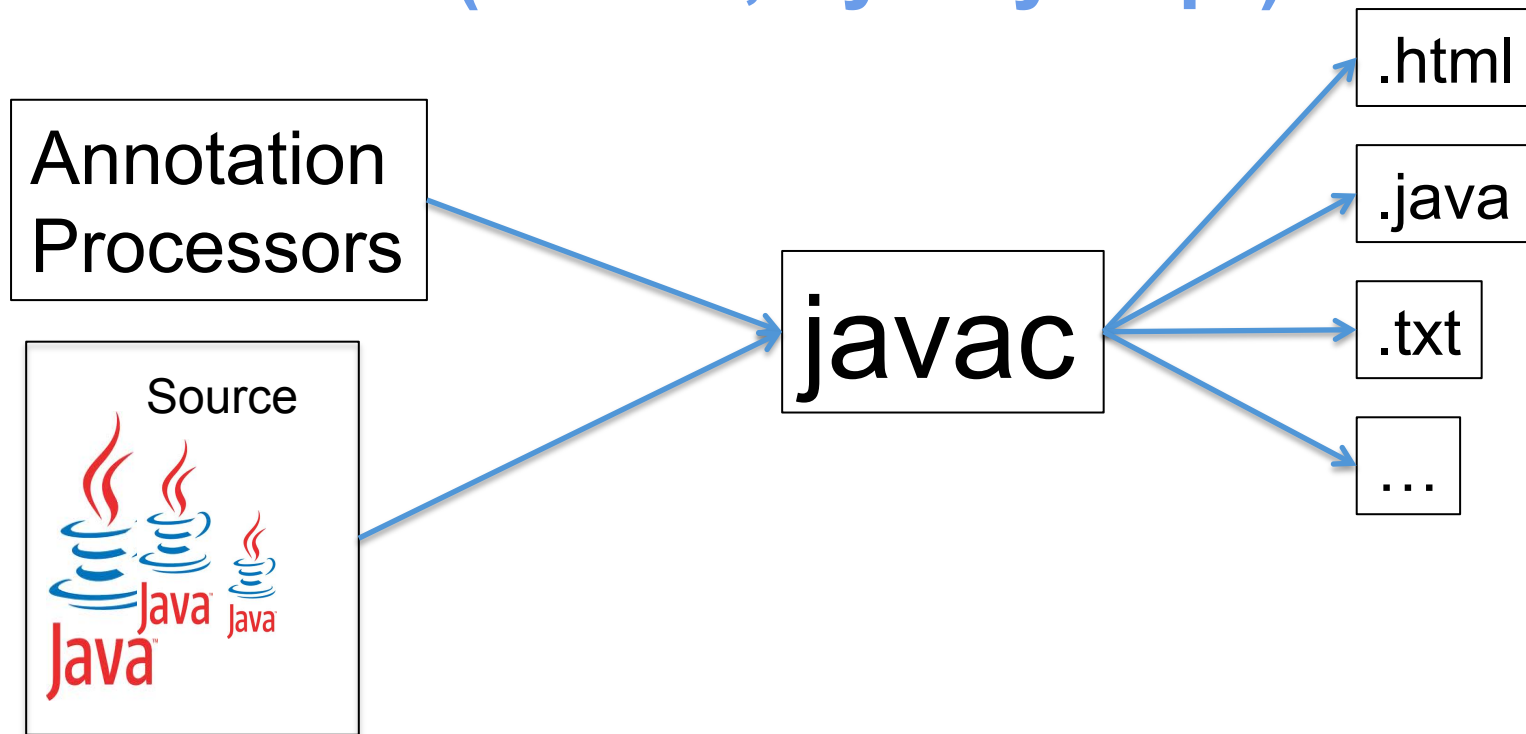
How apt shares some of javac's options:

- d *dir*
Specify where to place processor and javac generated class files.
- cp *path* or -classpath *path*
Specify where to find user class files and annotation processor factories. If -factory is used, this option is ignored.

There are a few apt hidden options that may be useful for debugging:

- XListAnnotationTypes
List found annotation types
- XListDeclarations
List specified and included declarations
- XPrintAptRounds
Print information about initial and recursive apt rounds
- XPrintFactoryInfo
Print information about which annotations a factory is asked to process

Annotations and Transformations (Java 6, bye bye apt)



Integrated into the Java compiler (javac)
New API: Pluggable Annotation Processing

Annotations and Transformations (Java 6, bye bye apt)

Annotation

```
Proc import java.util.*;
import javax.annotation.processing.*;
import javax.lang.model.*;
import javax.lang.model.element.*;

@SupportedAnnotationTypes(value= {"*"})
@SupportedSourceVersion(SourceVersion.RELEASE_6)

public class TestAnnotationProcessor extends AbstractProcessor {

    @Override
    public boolean process(
        Set<?> extends TypeElement> annotations, RoundEnvironment roundEnv){

        for (TypeElement element : annotations){
            System.out.println(element.getQualifiedName());
        }
        return true;
    }
}
```

.html

iava

javac -processor ...

Alternative: Java Reflection

```
import java.lang.annotation.Documented;
import java.lang.annotation.Retention;
import java.lang.annotation.RetentionPolicy;

@Documented
@Retention(RetentionPolicy.RUNTIME)
public @interface Todo {

    public enum Importance {
        MINEURE, IMPORTANT, MAJEUR, CRITIQUE
    };

    Importance importance() default Importance.MINEURE;

    String[] description();

    String assigneA();

    String dateAssignment();
}
```

<http://www.jmdoudoux.fr/java/dej/chap-annotations.htm#annotations-7>

```
@Todo(importance = Importance.CRITIQUE,
      description = "Corriger le bug dans le calcul",
      assigneA = "JMD",
      dateAssignment = "11-11-2007")
public class TestInstrospectionAnnotation {

    public static void main(
        String[] args) {
        Todo todo = null;

        // traitement annotation sur la classe
        Class classe = TestInstrospectionAnnotation.class;
        todo = (Todo) classe.getAnnotation(Todo.class);
        if (todo != null) {
            System.out.println("classe "+classe.getName());
            System.out.println(" ["+todo.importance()+"]" (" "+todo.assigneA()+
                " le "+todo.dateAssignment()+")");
            for(String desc : todo.description()) {
                System.out.println("    _ "+desc);
            }
        }

        // traitement annotation sur les méthodes de la classe
        for(Method m : TestInstrospectionAnnotation.class.getMethods()) {
            todo = (Todo) m.getAnnotation(Todo.class);
            if (todo != null) {
                System.out.println("methode "+m.getName());
                System.out.println(" ["+todo.importance()+"]" (" "+todo.assigneA()+
                    " le "+todo.dateAssignment()+")");
                for(String desc : todo.description()) {
                    System.out.println("    _ "+desc);
                }
            }
        }
    }

    @Todo(importance = Importance.MAJEUR,
          description = "Implementer la methode",
          assigneA = "JMD",
          dateAssignment = "11-11-2007")
    public void methode1() {

    }

    @Todo(importance = Importance.MINEURE,
          description = {"Completer la methode", "Ameliorer les logs"},
          assigneA = "JMD",
          dateAssignment = "12-11-2007")
    public void methode2() {

    }
}
```

You can define your own annotations

- Specification
 - At the Class, Field, Method level
 - Annotations can be combined
 - Annotations can have parameters
- Transformation (compilation)
 - Introspection
 - Compiler (javac/apt) and definition of « processors »
- Widely used
 - Generation, verification, etc.

Back to Xtend

- Active Annotations
 - Facilities to specify Annotations and their treatment (API)
 - Seamless integration in the IDE
 - On-the-fly compilation to Java allows proper type checking and auto-completion

Example

```
package fr.inria.k3  
  
@Singleton  
class GUIWindow {  
  
    int x ;  
    int y ;  
  
}
```

Example

```
package fr.inria.k3
```

```
@Singleton
```

```
class GUIWindow {
```

```
    int x ;
```

```
    int y ;
```

```
}
```

```
public final class GUIWindow {
```

```
    private GUIWindow() {
```

```
        // singleton
```

```
    }
```

```
    private int x;
```

```
    private int y;
```

```
    private final static GUIWindow INSTANCE = new GUIWindow();
```

```
    public static GUIWindow getINSTANCE() {
```

```
        return INSTANCE;
```

```
    }
```

```
}
```

```
package fr.inria.k3
```

```
@Singleton  
class GUIWindow {
```

```
    int x ;  
    int y ;
```

```
}
```

```
public final class GUIWindow {  
    private GUIWindow() {  
        // singleton  
    }  
  
    private int x;  
    private int y;  
  
    private final static GUIWindow INSTANCE = new GUIWindow();  
  
    public static GUIWindow getInstance() {  
        return INSTANCE;  
    }  
}
```

```
class SingletonProcessor extends AbstractClassProcessor {
```

```
    override doTransform(MutableClassDeclaration annotatedClass, extension TransformationContext context) {
```

```
        annotatedClass.final = true
```

```
        if (annotatedClass.declaredConstructors.size > 1)  
            annotatedClass.addError("More than one constructor is defined")
```

```
        val constructor = annotatedClass.declaredConstructors.head  
        if (constructor.parameters.size > 0)  
            constructor.addError("Constructor has arguments")
```

```
        if (constructor.body == null) {
```

```
            // no constructor defined in the annotated class  
            constructor.visibility = Visibility::PRIVATE  
            constructor.body = ["// singleton"]
```

```
        } else {  
            if (constructor.visibility != Visibility::PRIVATE)  
                constructor.addError("Constructor is not private")
```

```
        }
```

```
        annotatedClass.addField('INSTANCE') [  
            visibility = Visibility::PRIVATE  
            static = true  
            final = true  
            type = annotatedClass.newTypeReference  
            initializer = [  
                "new «annotatedClass.simpleName»()"
```

```
            ]  
  
        annotatedClass.addMethod('getInstance') [  
            visibility = Visibility::PUBLIC  
            static = true  
            returnType = annotatedClass.newTypeReference  
            body = [  
                "return INSTANCE;"
```

```
        ]  
    }
```

Example (2)

```
package fr.inria.k3  
  
@Extract  
class ExtractA {  
  
}
```

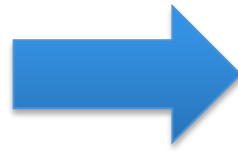
```
package fr.inria.k3;  
  
import fr.inria.k3.Extract;..  
  
@Extract  
@SuppressWarnings("all")  
public class ExtractA implements ExtractAInterface {  
}
```

```
package fr.inria.k3
```

```
@Extract
```

```
class ExtractA {
```

```
}
```



```
package fr.inria.k3;
```

```
import fr.inria.k3.Extract;..
```

```
@Extract
```

```
@SuppressWarnings("all")
```

```
public class ExtractA implements ExtractAInterface {  
}
```

```
/**  
 * Extracts an interface for all locally declared public methods.  
 */  
@Target(ElementType.TYPE)  
@Active(ExtractProcessor)  
annotation Extract {}  
  
class ExtractProcessor extends AbstractClassProcessor {  
  
    override doRegisterGlobals(ClassDeclaration annotatedClass, RegisterGlobalsContext context) {  
        context.registerInterface(annotatedClass.interfaceName)  
    }  
  
    def getInterfaceName(ClassDeclaration annotatedClass) {  
        annotatedClass.qualifiedName+"Interface"  
    }  
  
    override doTransform(MutableClassDeclaration annotatedClass, extension TransformationContext context) {  
        val interfaceType = findInterface(annotatedClass.interfaceName)  
  
        // add the interface to the list of implemented interfaces  
        annotatedClass.implementedInterfaces = annotatedClass.implementedInterfaces + #[interfaceType.newTypeReference]  
  
        // add the public methods to the interface  
        for (method : annotatedClass.declaredMethods) {  
            if (method.visibility == Visibility.PUBLIC) {  
                interfaceType.addMethod(method.simpleName) [  
                    docComment = method.docComment  
                    returnType = method.returnType  
                    for (p : method.parameters) {  
                        addParameter(p.simpleName, p.type)  
                    }  
                    exceptions = method.exceptions  
                ]  
            }  
        }  
    }  
}
```

Predefined Annotations

```
@Singleton
class SingletonA {

    @Property
    int a = 13 ;

    @Property
    int b ;

    @Property
    String c ;

}
```

```
@Singleton
@SuppressWarnings("all")
public final class SingletonA {
    private SingletonA() {
        // singleton
    }

    private int _a = 13;

    public int getA() {
        return this._a;
    }

    public void setA(final int a) {
        this._a = a;
    }

    private int _b;

    public int getB() {
        return this._b;
    }

    public void setB(final int b) {
        this._b = b;
    }

    private String _c;

    public String getC() {
        return this._c;
    }

    public void setC(final String c) {
        this._c = c;
    }

    private final static SingletonA INSTANCE = new SingletonA();

    public static SingletonA getINSTANCE() {
        return INSTANCE;
    }
}
```

Plan

- Model Management in a nutshell
 - Loading, serializing, transforming models
- Xtend
 - Java 10, cheatsheet
 - Advanced features: extension methods, active annotations, template expressions
 - Xtend: behind the magic (Xtext+MDE)
- Model Management + Xtend
 - Model transformations
 - @Aspect annotation
 - Xtend + Xtext (breathing life into DSLs)

Contract

- Practical foundations of model management
- Learning and understanding Java 10 (aka Xtend)
 - advanced features of a general GPL, implementation of a sophisticated language using MDE
- **Model transformations**
 - Model-to-Text
 - Model-to-Model
- **Metaprogramming**
 - Revisit annotations (e.g., as in JPA or many frameworks)
- **DSLs and model management: all together (Xtext + Xtend)**

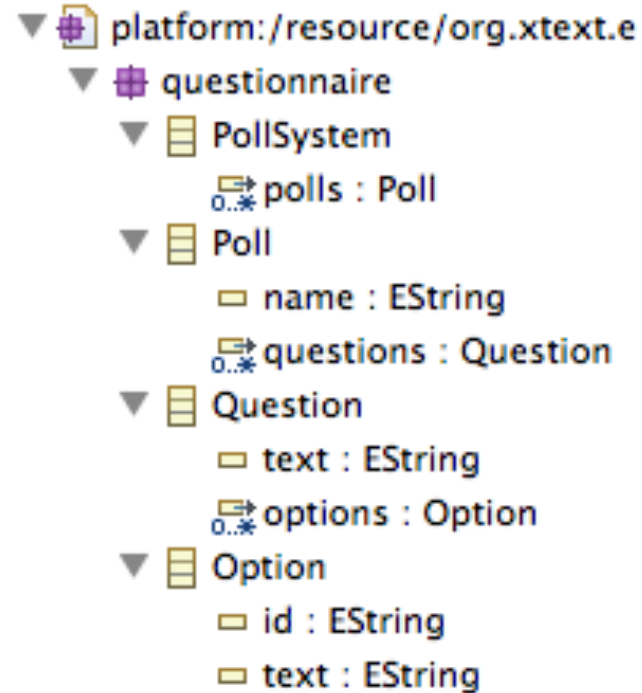
Visitors, EMF, and Xtend

(key to M2M or M2T:
iterate
over the model)

```

PollSystem {
  Poll Quality {
    Question q1 {
      "Value the user experience"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
    Question q2 {
      "Value the layout"
      options {
        A : "It was not easy to locate elements"
        B : "I didn't realize"
        C : "It was easy to locate elements"
      }
    }
  }
  Poll Performance {
    Question q1 {
      "Value the time response"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
  }
}

```



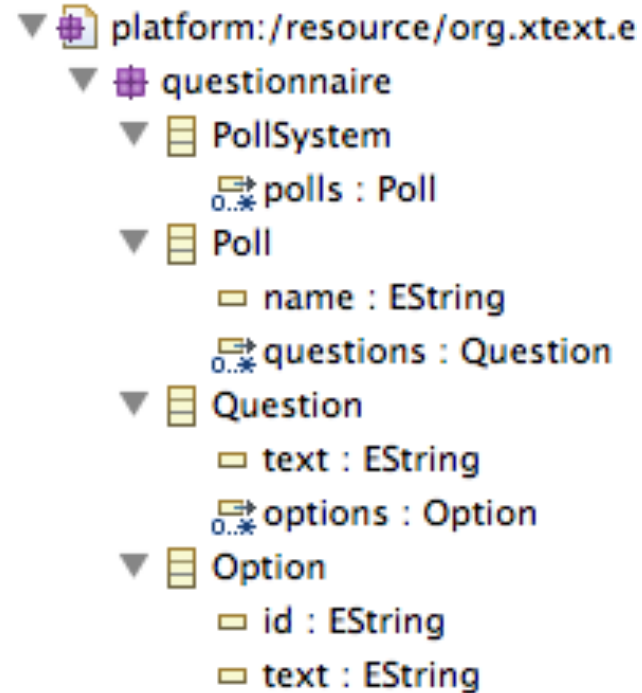
We already give examples of transformation, defined over the metamodel...

Common point: the need to visit the model (graph)

```

PollSystem {
  Poll Quality {
    Question q1 {
      "Value the user experience"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
    Question q2 {
      "Value the layout"
      options {
        A : "It was not easy to locate elements"
        B : "I didn't realize"
        C : "It was easy to locate elements"
      }
    }
  }
  Poll Performance {
    Question q1 {
      "Value the time response"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
  }
}

```



Visit the model (graph)

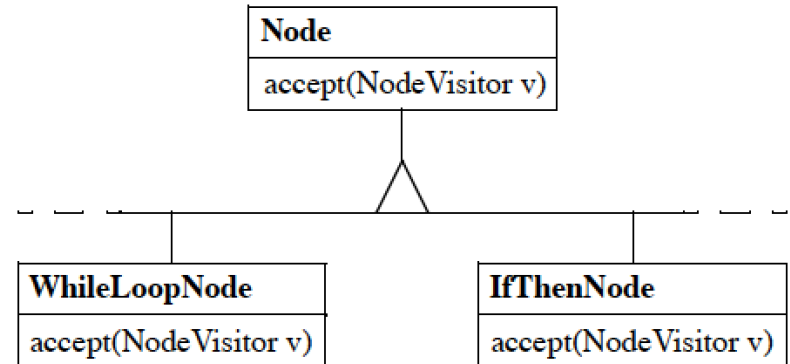
Possible solution: a series of casts (lots of if-statements and traversal loops)

Visitor Pattern

separating an algorithm from an object structure on which it operates

```
public class WhileLoopNode extends Node {
    protected Node condition, body;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitWhileLoop(this);
    }
}

public class IfThenNode extends Node {
    protected Node condition, thenBranch;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitIfThen(this);
    }
}
```



```
public abstract class NodeVisitor {
    /* ... */
    public abstract void visitWhileLoop(WhileLoopNode n);
    public abstract void visitIfThen(IfThenNode n);
}

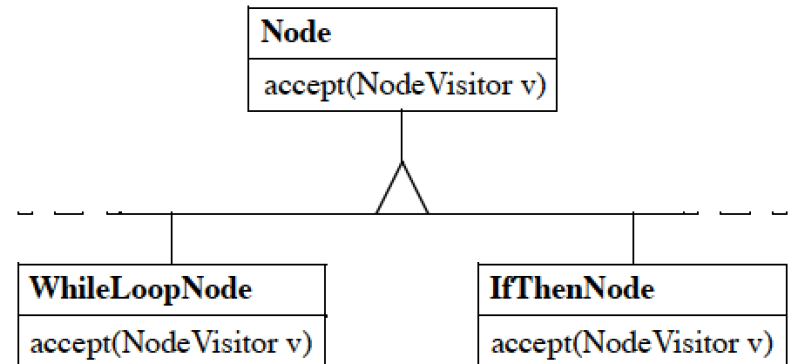
public class TypeCheckingVisitor extends NodeVisitor {
    /* ... */
    public void visitWhileLoop(WhileLoopNode n) { n.getCondition().accept(this); /* ... */ }
    public void visitIfThen(IfThenNode n) { /* ... */ }
}
```

new operations can be added modularly, without needing to edit any of the Node subclasses: the programmer simply defines a new NodeVisitor subclass containing methods for visiting each class in the Node hierarchy.

Visitor Pattern (problems)

```
public class WhileLoopNode extends Node {
    protected Node condition, body;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitWhileLoop(this);
    }
}

public class IfThenNode extends Node {
    protected Node condition, thenBranch;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitIfThen(this);
    }
}
```



```
public abstract class NodeVisitor {
    /* ... */
    public abstract void visitWhileLoop(WhileLoopNode n);
    public abstract void visitIfThen(IfThenNode n);
}

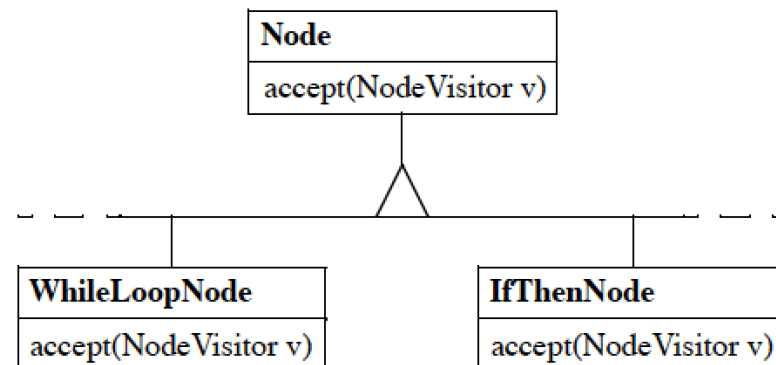
public class TypeCheckingVisitor extends NodeVisitor {
    /* ... */
    public void visitWhileLoop(WhileLoopNode n) { n.getCondition().accept(this); /* ... */ }
    public void visitIfThen(IfThenNode n) { /* ... */ }
}
```

#1 stylized double-dispatching code is tedious to write and prone to error.

Visitor Pattern (problems)

```
public class WhileLoopNode extends Node {
    protected Node condition, body;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitWhileLoop(this);
    }
}

public class IfThenNode extends Node {
    protected Node condition, thenBranch;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitIfThen(this);
    }
}
```



```
public abstract class NodeVisitor {
    /* ... */
    public abstract void visitWhileLoop(WhileLoopNode n);
    public abstract void visitIfThen(IfThenNode n);
}

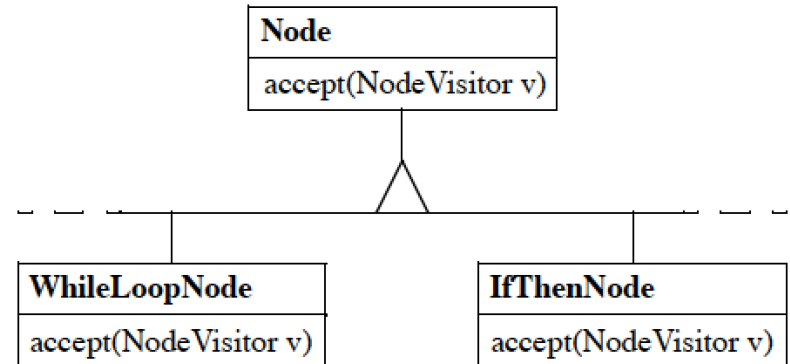
public class TypeCheckingVisitor extends NodeVisitor {
    /* ... */
    public void visitWhileLoop(WhileLoopNode n) { n.getCondition().accept(this); /* ... */ }
    public void visitIfThen(IfThenNode n) { /* ... */ }
}
```

#2 the need for the Visitor pattern must be anticipated ahead of time, when the Node class is first implemented

Visitor Pattern (problems)

```
public class WhileLoopNode extends Node {
    protected Node condition, body;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitWhileLoop(this);
    }
}

public class IfThenNode extends Node {
    protected Node condition, thenBranch;
    /* ... */
    public void accept(NodeVisitor v) {
        v.visitIfThen(this);
    }
}
```

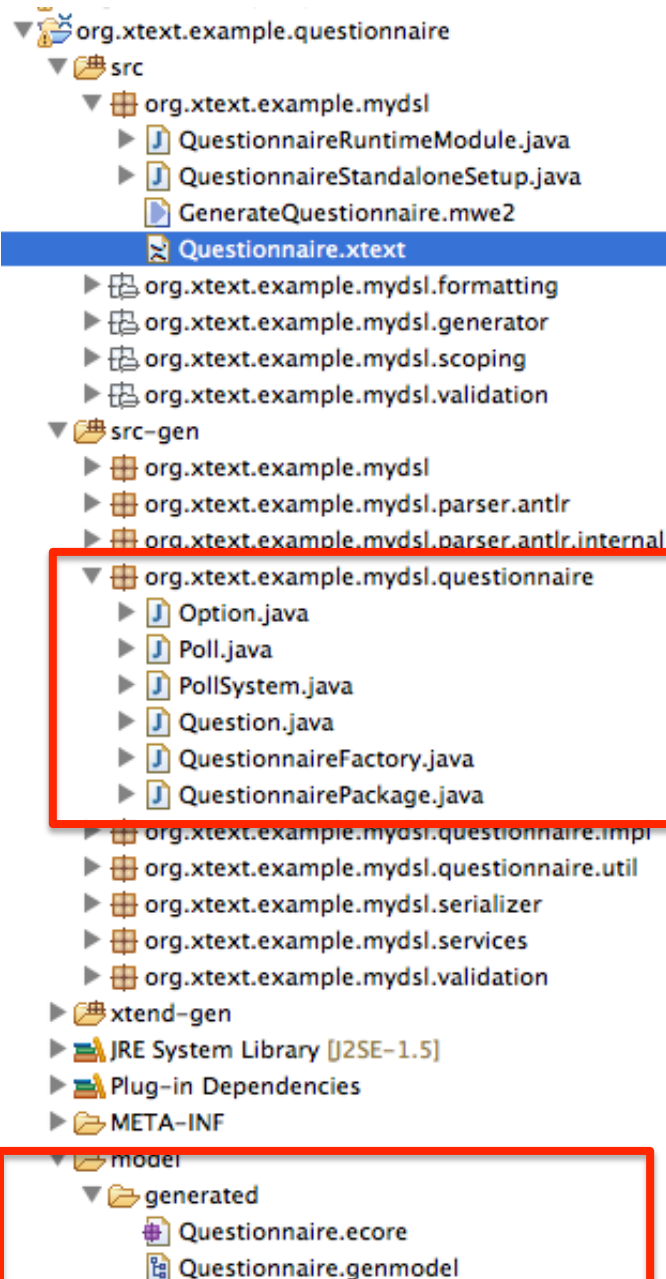


```
public abstract class NodeVisitor {
    /* ... */
    public abstract void visitWhileLoop(WhileLoopNode n);
    public abstract void visitIfThen(IfThenNode n);
}

public class TypeCheckingVisitor extends NodeVisitor {
    /* ... */
    public void visitWhileLoop(WhileLoopNode n) { n.getCondition().accept(this); /* ... */ }
    public void visitIfThen(IfThenNode n) { /* ... */ }
}
```

#3 class hierarchy evolution (e.g., new Node subclass) forces us to rewrite NodeVisitor

Visitor Pattern (impact of the problem)



```
Questionnaire.xtext
```

```
grammar org.xtext.example.mydsl.Questionnaire with org.eclipse.xtext.common.Terminals

generate questionnaire "http://www.xtext.org/example/mydsl/Questionnaire"

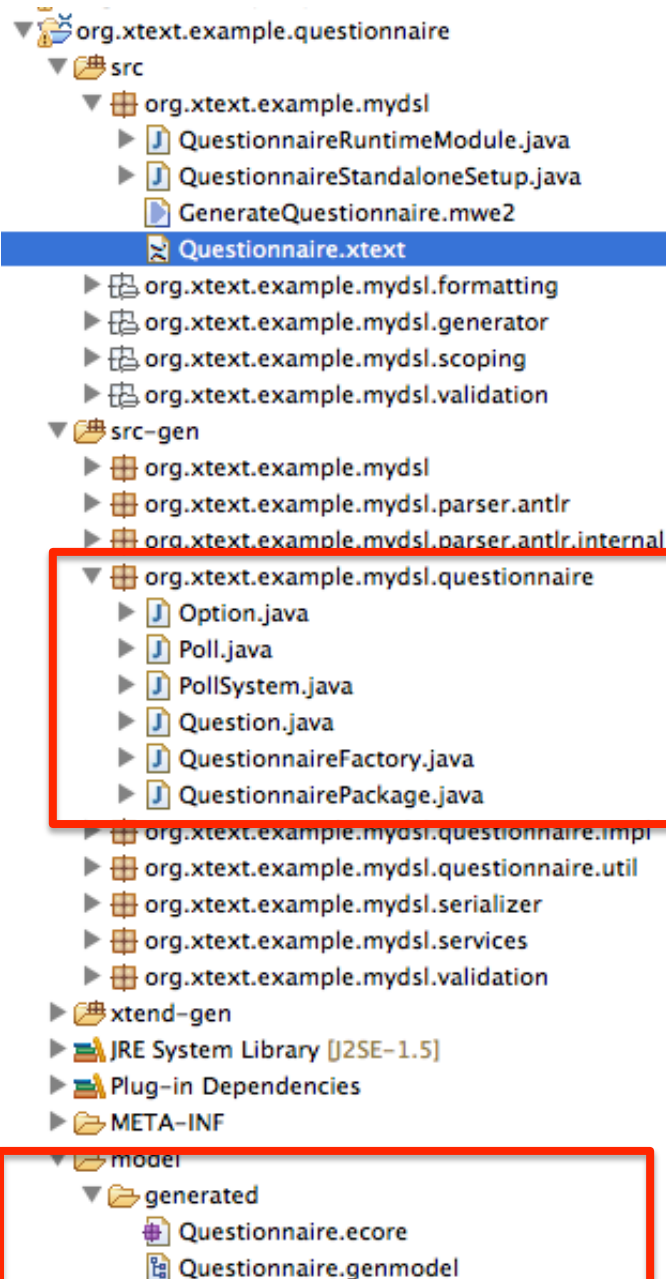
PollSystem:
    'PollSystem' '{' polls+=Poll+ '}';

Poll:
    'Poll' name=ID '{' questions+=Question+ '}';

Question : 'Question' ID? '{' text=STRING 'options' options+=Option+ '}';

Option : id=ID ':' text=STRING ;
```

Visitor Pattern (impact of the problem)



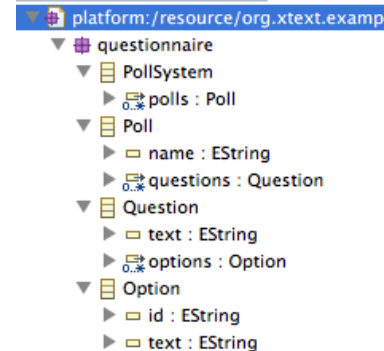
```
public interface Question extends EObject
{
    /**
     * Returns the value of the
     * <!-- begin-user-doc -->
     * <p>
     * If the meaning of the '<er
     * there really should be mo
     * </p>
     * <!-- end-user-doc -->
     * @return the value of the
     * @see #setText(String)
     * @see org.xtext.example.mydsl.questionnaire.QuestionnairePackage#getQuestion_Text()
     * @model
     * @generated
     */
    String getText();

    /**
     * Sets the value of the '{@link org.xtext.example.mydsl.questionnaire.Question#getText <em>
     * <!-- begin-user-doc -->
     * <!-- end-user-doc -->
     * @param value the new value of the '<em>Text</em>' attribute.
     * @see #getText()
     * @generated
     */
    void setText(String value);
}
```

No accept method

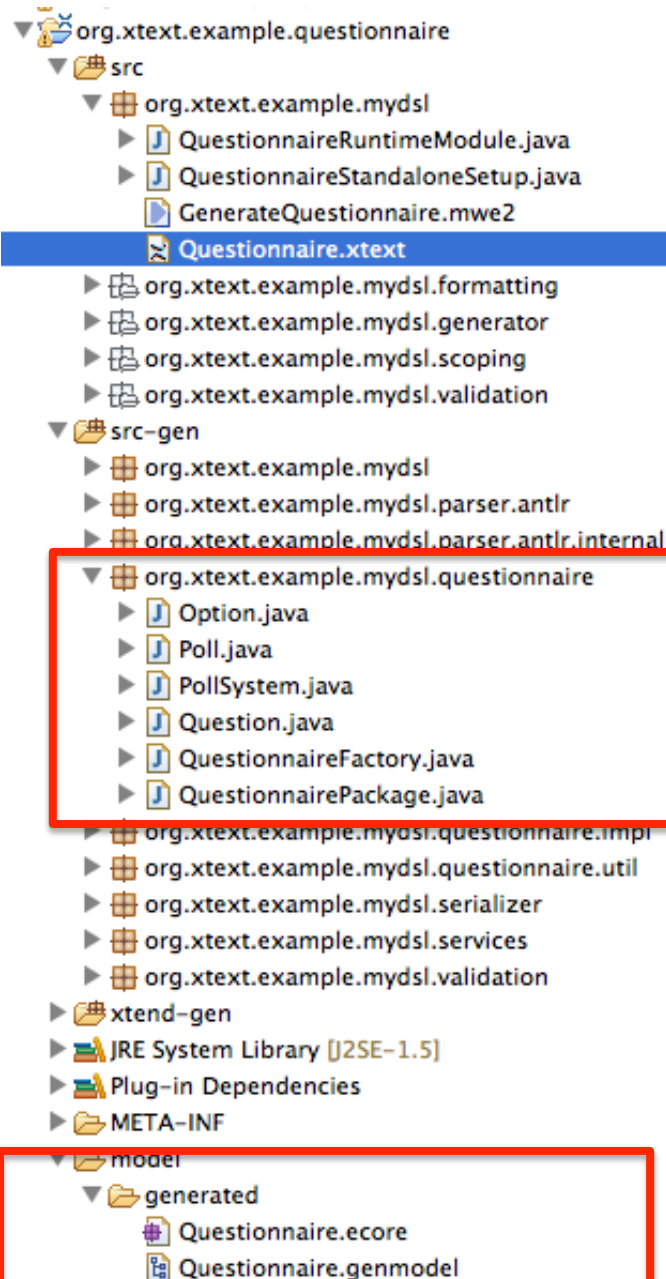
The Outline view on the right shows the structure of the `org.xtext.example.mydsl.questionnaire` package, specifically the `Question` interface. The methods listed are:

- `getText() : String`
- `setText(String) : void`
- `getOptions() : EList<Option>`



Visitor Pattern (impact of the problem)

Handcrafted code?



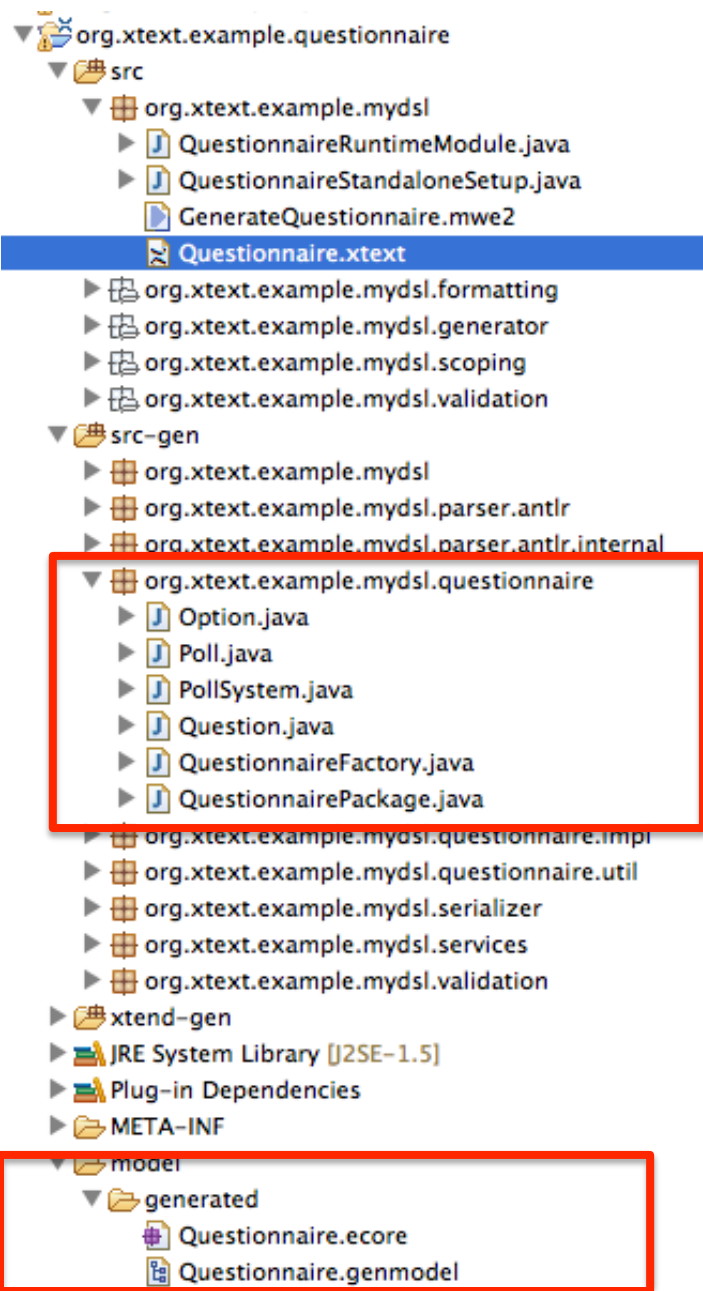
```
public interface Question extends EObject
{
    public void accept(QuestionnaireVisitor vis) ;
}
```

Visitor Pattern (impact of the problem)

⇒ **Manual**
⇒ **Some classes are not
concerned by the visit...**

```
public interface Question extends EObject  
{  
  
    public void accept(QuestionnaireVisitor vis);  
}
```

⇒ **If Xtext Grammar changes,
you can restart again**



Visitor Pattern (requirements)

#1 stylized double-dispatching code is tedious to write and prone to error.

Automation

#2 the need for the Visitor pattern must be anticipated ahead of time, when the Node class is first implemented

No accept method

Violation of open/close principle: no way

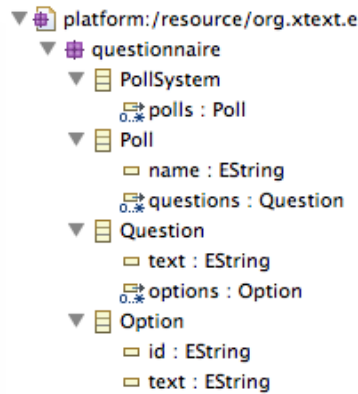
#3 class hierarchy evolution (e.g., new Node subclass) forces us to (completely) rewrite NodeVisitor

Automation

```

PollSystem {
  Poll Quality {
    Question q1 {
      "Value the user experience"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
    Question q2 {
      "Value the layout"
      options {
        A : "It was not easy to locate elements"
        B : "I didn't realize"
        C : "It was easy to locate elements"
      }
    }
  }
  Poll Performance {
    Question q1 {
      "Value the time response"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
  }
}

```



Possible solution (1): « *Switch » generated by... EMF

org.xtext.example.mydsl.questionnaire.util

QuestionnaireSwitch<T>

- ◆ S modelPackage : QuestionnairePackage
- C QuestionnaireSwitch()
- ◆ ▲ isSwitchFor(EPackage) : boolean
- ◆ ▲ doSwitch(int, EObject) : T
- casePollSystem(PollSystem) : T
- casePoll(Poll) : T
- caseQuestion(Question) : T
- caseOption(Option) : T
- ▲ defaultCase(EObject) : T

```

/**
 * The switch that delegates to the <code>createXXX</code> methods.
 * <!-- begin-user-doc -->
 * <!-- end-user-doc -->
 * @generated
 */
protected QuestionnaireSwitch<Adapter> modelSwitch =
  new QuestionnaireSwitch<Adapter>()
  {
    @Override
    public Adapter casePollSystem(PollSystem object)
    {
      return createPollSystemAdapter();
    }
    @Override
    public Adapter casePoll(Poll object)
    {
      return createPollAdapter();
    }
    @Override
    public Adapter caseQuestion(Question object)
    {
      return createQuestionAdapter();
    }
    @Override
    public Adapter caseOption(Option object)
    {
      return createOptionAdapter();
    }
    @Override
    public Adapter defaultCase(EObject object)
    {
      return createEObjectAdapter();
    }
  };

```

```

PollSystem {
  Poll Quality {
    Question q1 {
      "Value the user experience"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
    Question q2 {
      "Value the layout"
      options {
        A : "It was not easy to locate elements"
        B : "I didn't realize"
        C : "It was easy to locate elements"
      }
    }
  }
  Poll Performance {
    Question q1 {
      "Value the time response"
      options {
        A : "Bad"
        B : "Fair"
        C : "Good"
      }
    }
  }
}

```

```

platform:/resource/org.xtext.e
└─ questionnaire
   └─ PollSystem
      └─ polls : Poll
         └─ Poll
            └─ name : EString
               └─ questions : Question
                  └─ Question
                     └─ text : EString
                        └─ options : Option
                           └─ Option
                              └─ id : EString
                                 └─ text : EString

```

Possible solution (2): Extension Methods of Xtend

```

def foo(PollSystem sys, Context c) {
  // treatment
}

```

```
pollSystem.foo (new Context)
```

Context (classical with the Visitor)

Can be seen as a way to avoid a (very) long list of parameters and record the « state » of the visit

@Aspect

(Active Annotations
for implementing Visitors)


```
class A {  
    def boolean testReplacement() {  
        return false  
    }  
}
```

Weaving methods

AspectA can handle a context in a proper way

```
@Aspect(className=typeof(A))  
abstract class AspectA {  
    def String foo() {  
        return "A"  
    }  
  
    abstract def String foofoo()  
}
```

```
@Test  
def void testA() {  
    val l = new A  
    l.foofoo  
}
```

```
override def doTransform(List<? extends MutableClassDeclaration> classes, extension TransformationContext context) {
```

```
    //Method name_parameterLengths,  
    val Map<MutableClassDeclaration, List<MutableClassDeclaration>> superclass = new HashMap<MutableClassDeclaration, Li  
    val Map<MutableMethodDeclaration, Set<MutableMethodDeclaration>> dispatchmethod = new HashMap<MutableMethodDeclarati  
    init_superclass(classes, context, superclass)  
    init_dispatchmethod(superclass, dispatchmethod, context)
```

```
    for (clazz : classes) {
```

```
        //var List<String> inheritList1 = new ArrayList<String>() //sortByClassInheritance(clazz)
```

```
        var List<MutableClassDeclaration> listRes = sortByClassInheritance(clazz, classes, context)  
        val List<String> inheritList = new ArrayList<String>()  
        listRes.forEach[c| inheritList.add(c.simpleName)]  
        listResMap.put(clazz, listRes)  
        //sortByClassInheritance(clazz, inheritList1, context)
```

```
        /*val StringBuffer Log = new StringBuffer  
        Log.append("before ")  
        inheritList.forEach[ s | Log.append(" " + s)]  
        Log.append("\n after ")  
        inheritList1.forEach[ s | Log.append(" " + s)]  
        */  
        //clazz.addError(Log.toString)
```

```
        var className = clazz.annotations.findFirst[getValue('className') != null].getValue('className')  
        //addError(clazz, className.class.toString)
```

```
        //var simpleNameF = className.eClass.EAllStructuralFeatures.findFirst[name == "simpleName"]  
        //val className = className.eGet(simpleNameF) as String  
        val className = className.class.getMethod("getSimpleName").invoke(className) as String  
        //var identF = className.eClass.getEAllStructuralFeatures().findFirst[name == "identifier"]  
        //val identifier = className.eGet(identF) as String  
        val identifier = className.class.getMethod("getIdentifier").invoke(className) as String  
        val Map<MutableMethodDeclaration, String> bodies = new HashMap<MutableMethodDeclaration, String>()
```

```
        //clazz.addError(className)  
        //MOVE non static fields  
        fields_processing(context, clazz, className, identifier, bodies)
```

```
        //Transform method to static  
        methods_processing(clazz, context, identifier, bodies, dispatchmethod, inheritList, className)
```

```
        aspectContextMaker(context, clazz, className, identifier)
```

```
    }
```

<https://github.com/diverse-project/k3/blob/master/k3-al/fr.inria.diverse.k3.al.annotationprocessor/src/main/java/fr/inria/diverse/k3/al/annotationprocessor/Aspect.xtend>