Model Management
in Xtend
(first part)

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istic Informatique Électronique

Material

https://github.com/acherm/teaching-MDE-IL1718

Plan

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

Contract

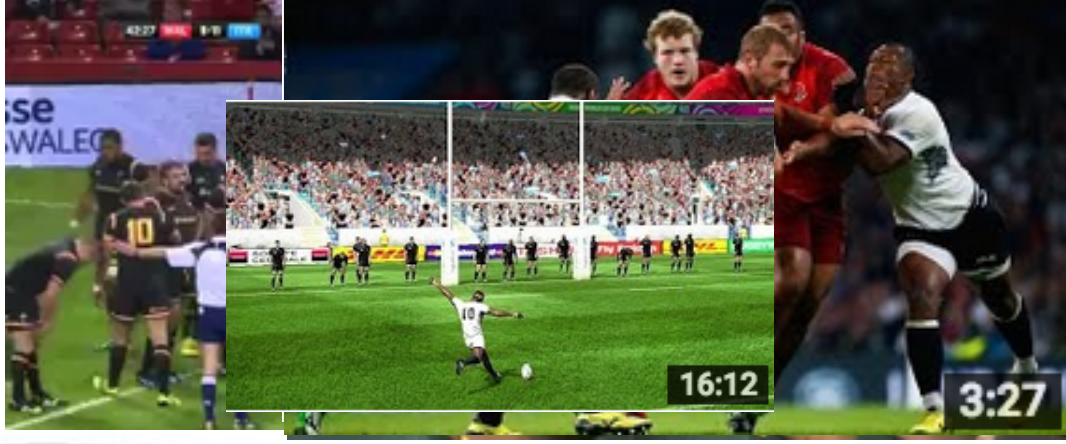
- Practical foundations of model management
- Learning and understanding Java 10 (aka Xtend)
  - advanced features of a general GPL, implementation of a sophisticated language using MDE
- Model transformations
  - Model-to-Text
  - Model-to-Model
- Metaprogramming
  - Revisit annotations (e.g., as in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

Model Management

Scenarios

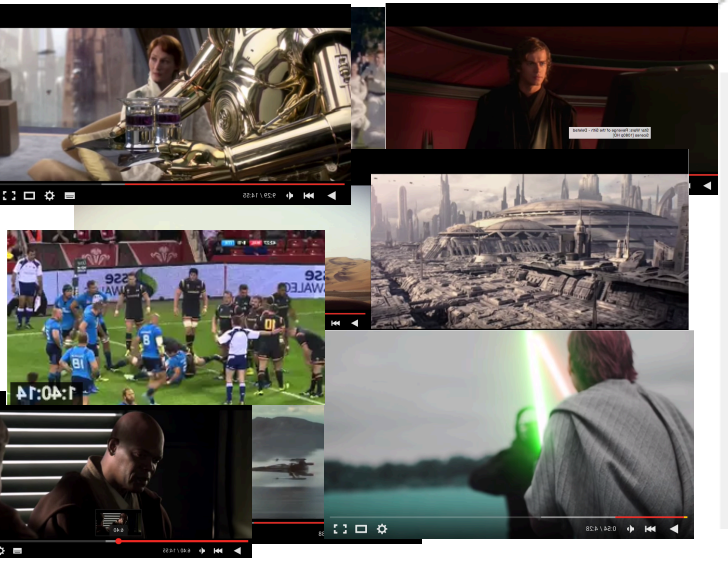
Generator ~ composition of video sequences

video variants



Generator
~ composition of video sequences

video variants



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 {
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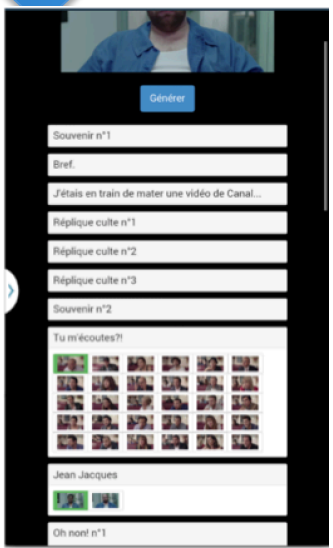
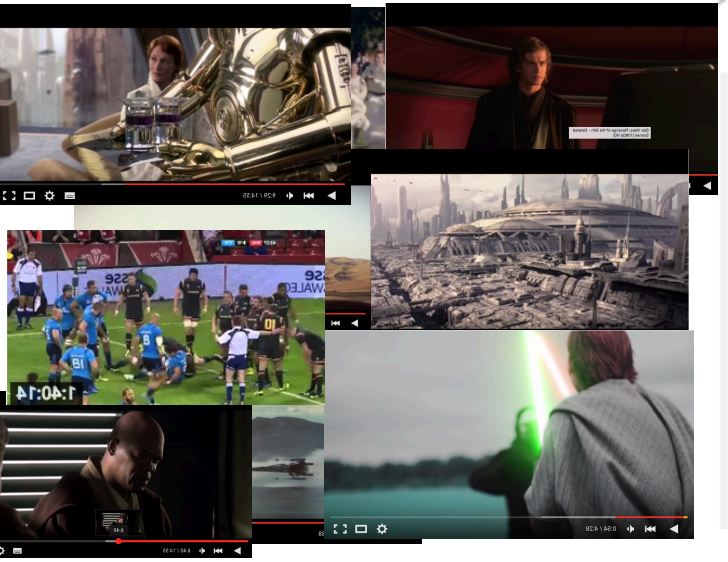
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

Website/online

- Random generation
- Configurator
- Game
- …





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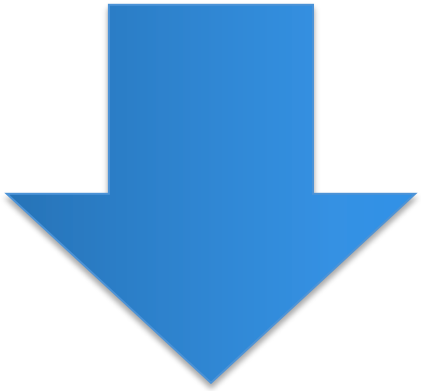

#1 How to design, create, and support dedicated languages (DSLs)?

#2 How to transform models/ programs?

#3 How to manage variability/variants?

#4 How do frameworks internally work?

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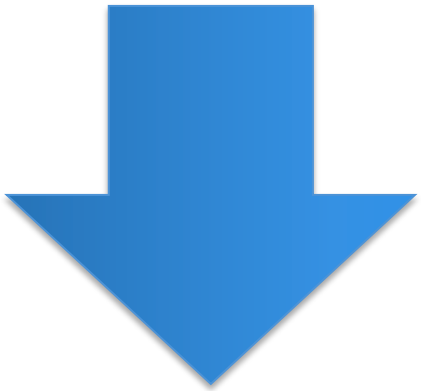

model-to-text

```
# this is a comment
file ‘v3/seq1.avi'
file '/path/to/video2.avi'
file '/path/to/video3.avi'
```

FFmpeg

foo1.videogen

```
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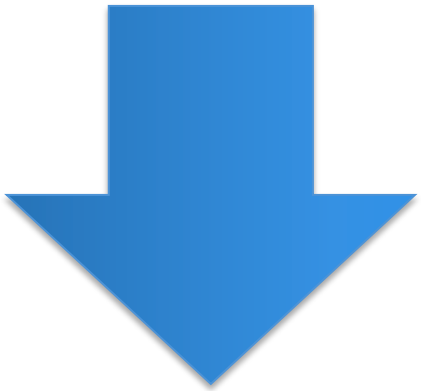

model-to-text

.m3u

```
v3/seq1.avi
/path/to/video2.avi
/path/to/video3.avi
```

foo1.videogen

```
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optional videoseq v2 "v2folder/v2.mp4"
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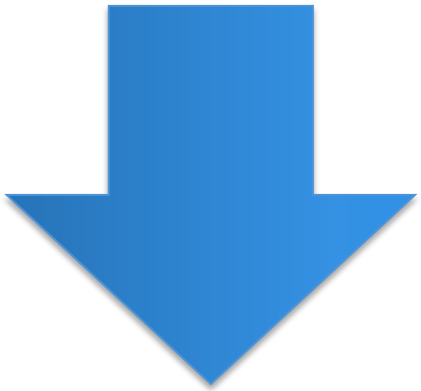

model-to-text

.m3u
(extended)

```
#EXTM3U
#EXT-X-DISCONTINUITY
#EXTINF:3
resources/videos/vp0-logo/logo_start.ts
#EXT-X-DISCONTINUITY
#EXTINF:12
resources/videos/vp1-QR/QR05_1.ts
#EXT-X-DISCONTINUITY
#EXTINF:2
resources/videos/vp2-intro-fluide-glacial/
EtPendantCeTempsLaEn1975_processed.ts
```

foo1.videogen

```
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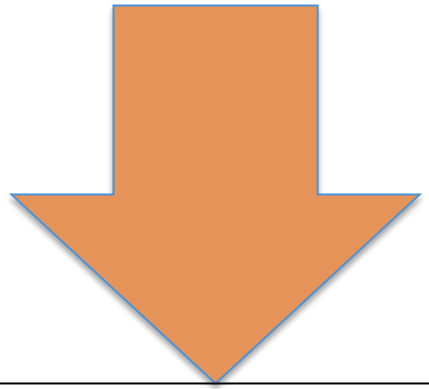
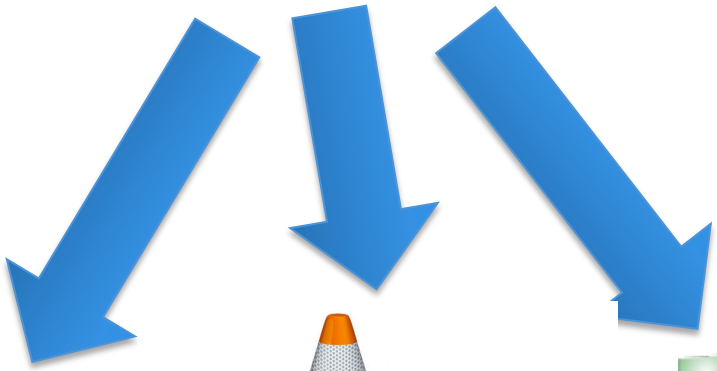


model-to-model

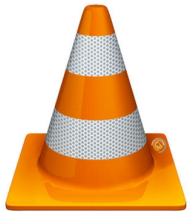
playlist metamodel

playlist model



model-to-text

flowplayer flash



FFmpeg

foo1.videogen

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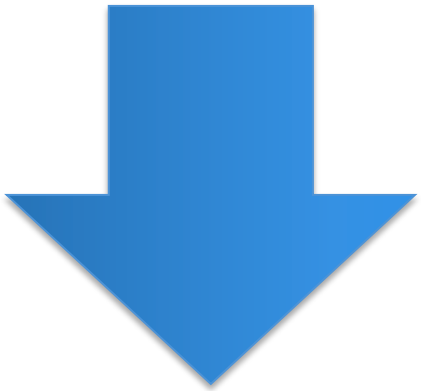
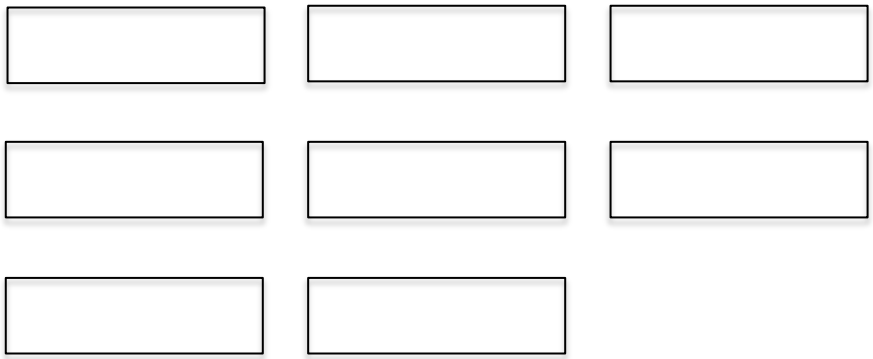


model-to-*

FFmpeg

Thumbnails (vignettes) of each video sequence (e.g., PGN format)



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model-to-*

FFmpeg

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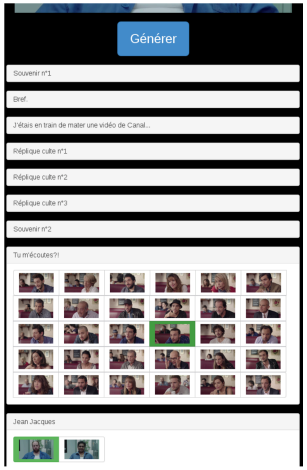

HTML JS CSS

foo1.videogen

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model-to-*

FFmpeg

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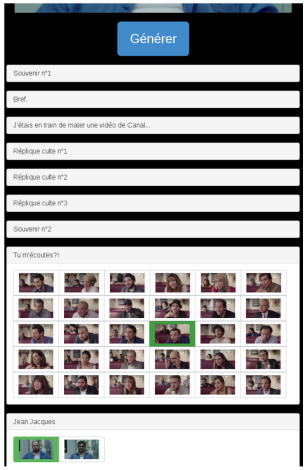


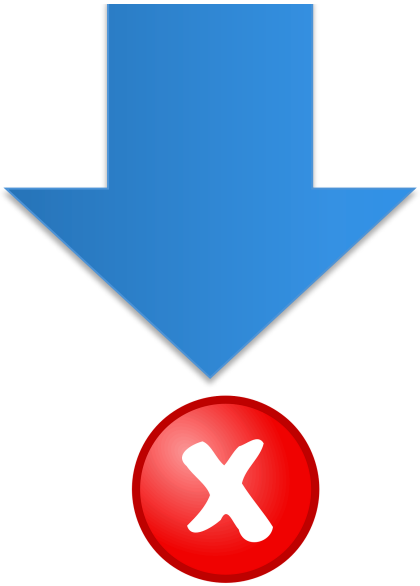
foo1.videogen

```
VideoGen {

    mandatory videoseq v1 "V1/v1.mp4"
    optional videoseq v2 "v2folder/v2.mp4" {
        probability 25
    }
    alternatives v3 {
        videoseq v31 "v3/seq1.mp4" {
            duration 12
            probability 25
            description "a"
        }
        videoseq v31 "v3/seq2.mp4"
        videoseq v32 "v3/seq3.mp4"
    }

    alternatives v4 {
        videoseq v41 "v4/seq1.mp4"
        videoseq v42 "v4/seq2.mp4"
    }
    mandatory videoseq v5 "v5.mp4"

    optional videoseq v8 "v8.avi"
    alternatives v9 {
        videoseq v81 "V81.avi"
    }
}
```



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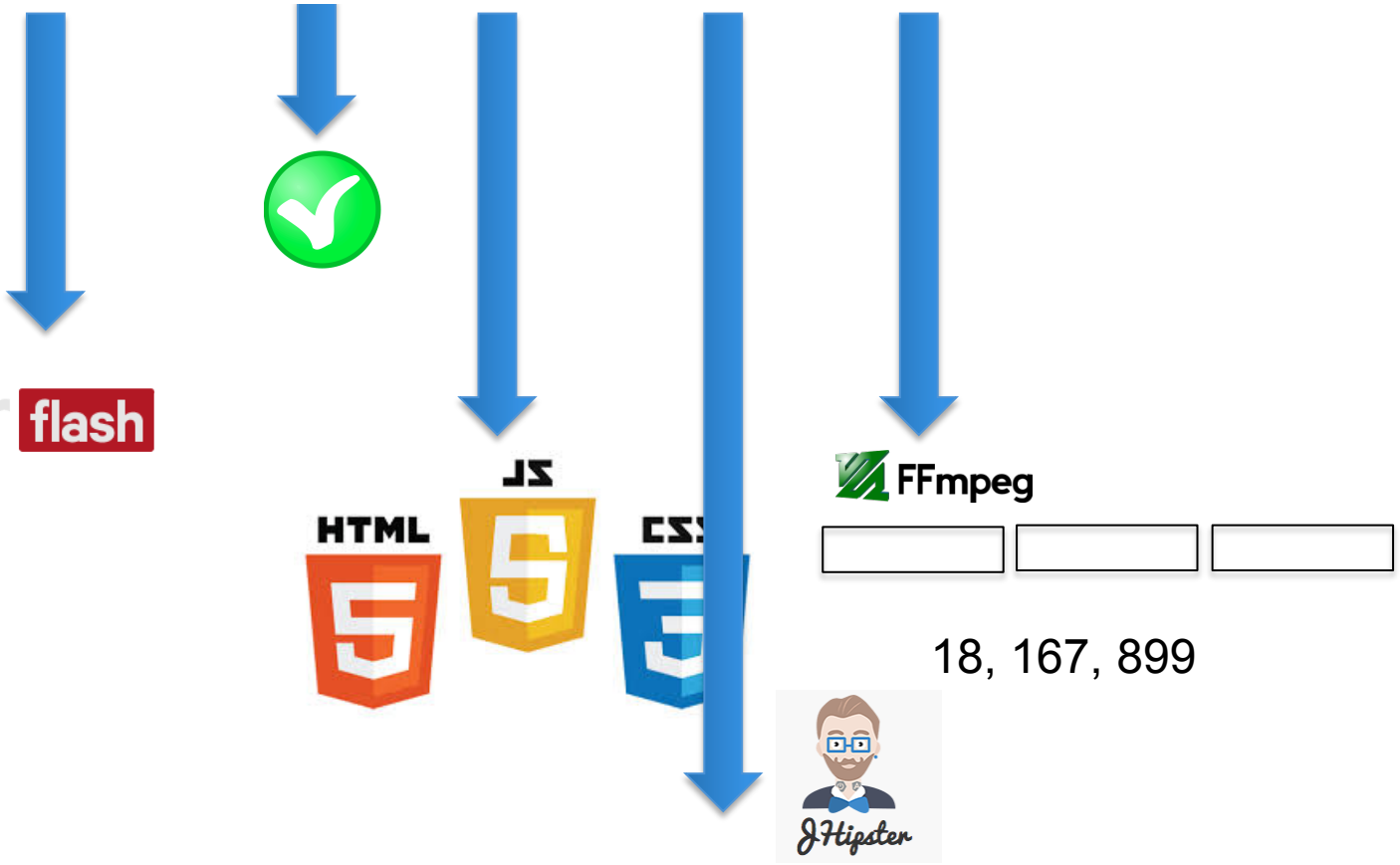

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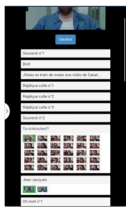
```

Website/online

- **Random generation**
- **Configurator**
- **Game**
- **…**



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```

Feature model: another model for modeling “features” of your Web site (eg ability to save the video; mode=generation with frequencies)

Website/online

- **Random generation**
- **Configurator**
- **Game**
- **…**

Model Transformations

Taxonomy + Examples

Abstraction Gap

Transformation is the key

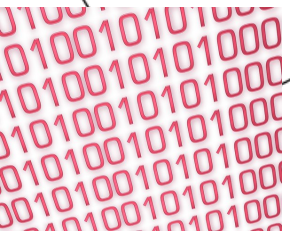
Problem space

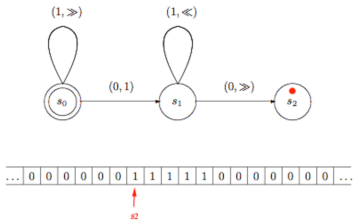
domain–specific language

Transformation

Solution space

implementation language



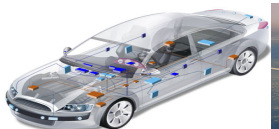


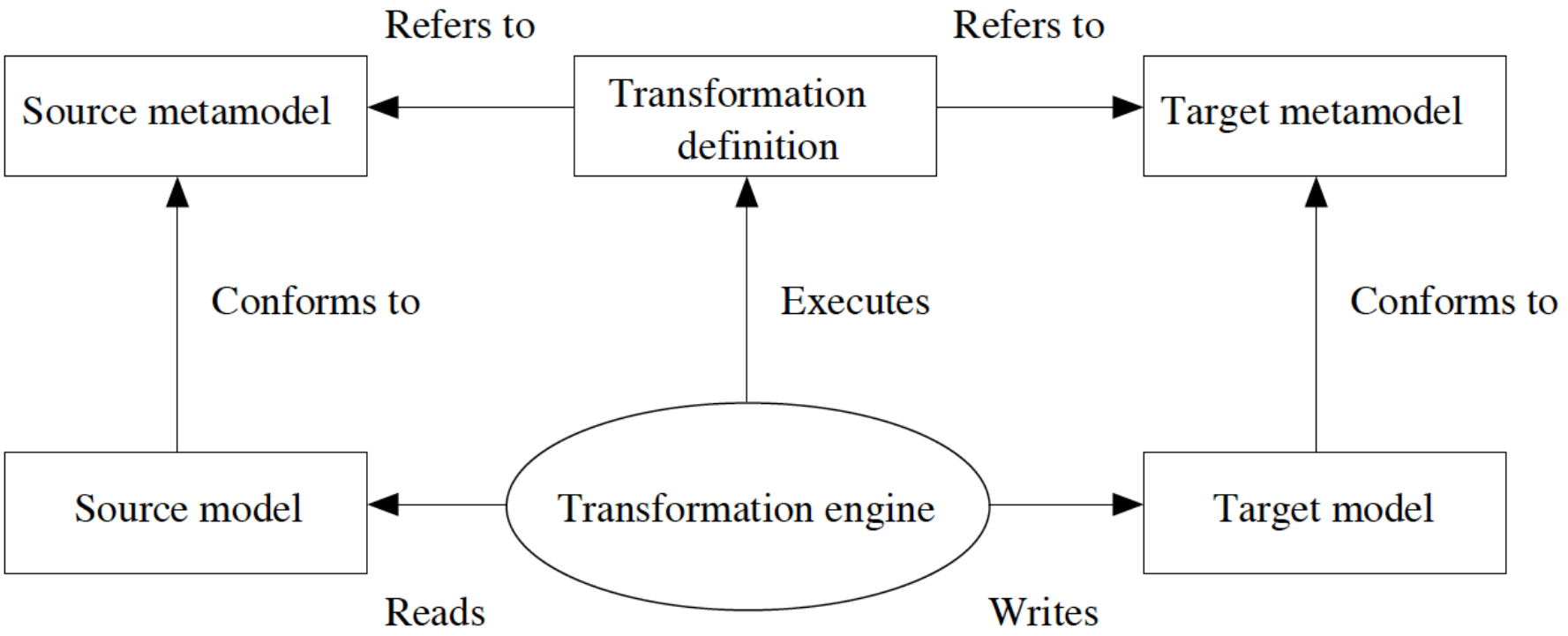
orange™

android

Google

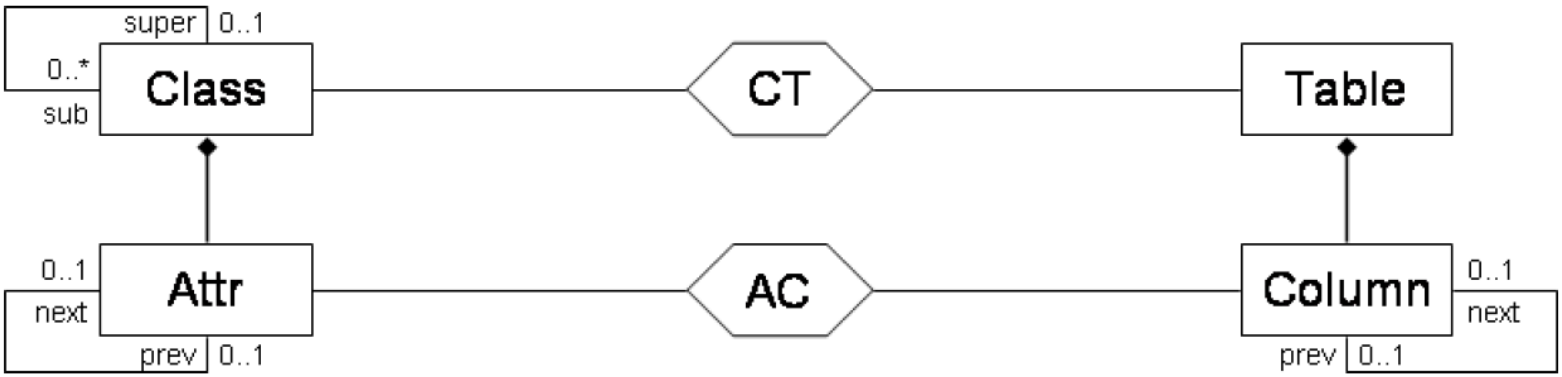
twitter



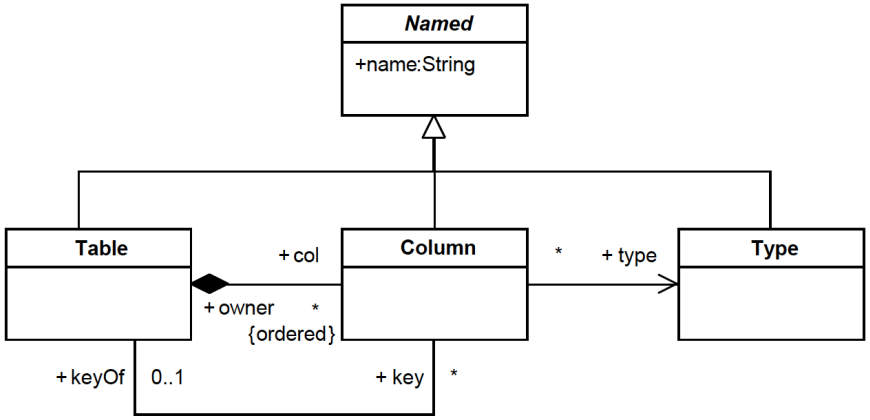

Refers to
Refers to
Source metamodel
Transformation definition
Target metamodel
Conforms to
Executes
Conforms to
Source model
Transformation engine
Target model
Reads
Writes

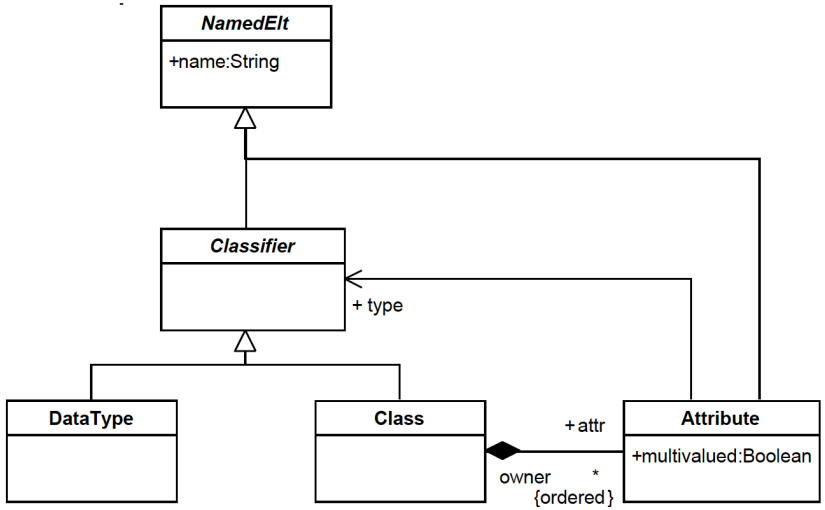
Andy Schürr, Felix Klar “15 Years of Triple Graph Grammars.” ICGT 2008

(decalarative; bi-directionnal; model-to-model)



ATL (http://www.eclipse.org/atl/atlTransformations/)






```
rule Class2Table {
    from                        -- source pattern
        c : Class!Class
    to                          -- target pattern
        t : Relational!Table
}
```

Feature-Based Survey of Model Transformation Approaches

Krzysztof Czarnecki
University of Waterloo
Waterloo, Canada

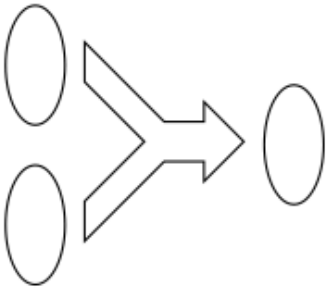
Simon Helsen
SAP AG
Walldorf, Germany

March 15, 2006

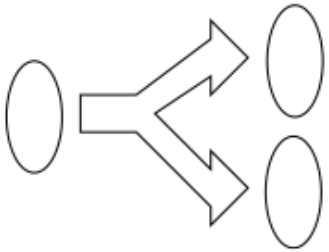
Overview of Generative Software Development

Krzysztof Czarnecki

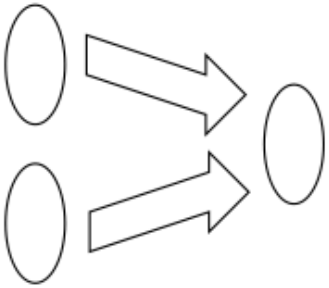
a. Chaining of mappings



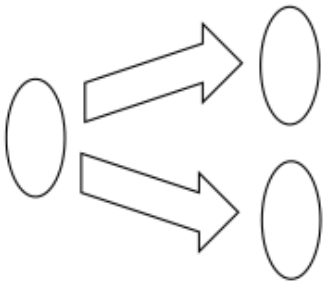
b. Multiple problem spaces



c. Multiple solution spaces



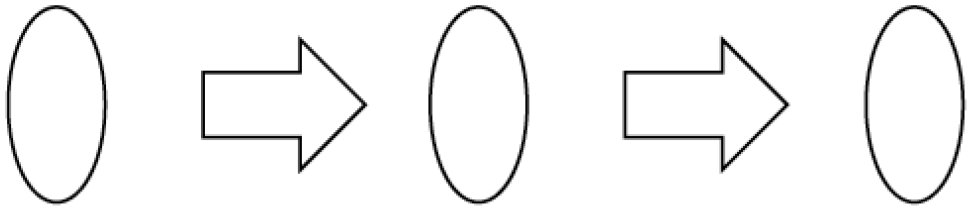
d. Alternative problem spaces



e. Alternative solution spaces

One step/stage transformation

hardly the case



a. Chaining of mappings

flowplayer flash

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"
```

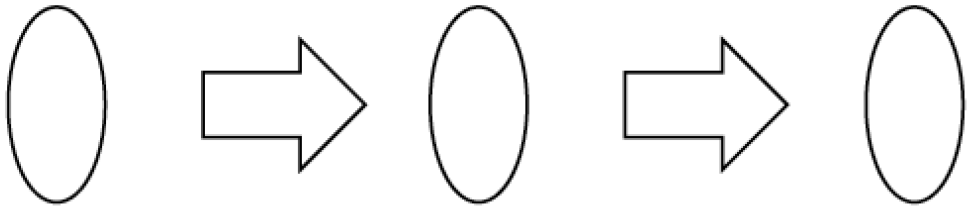
Playlist model

```
#EXTM3U
#EXT-X-DISCONTINUITY
#EXTINF:3
resources/videos/vp0-logo/logo_start.ts
#EXT-X-DISCONTINUITY
#EXTINF:12
resources/videos/vp1-QR/QR05_1.ts
#EXT-X-DISCONTINUITY
#EXTINF:2
resources/videos/vp2-intro-fluide-glacial/
EtPendantCeTempsLaEn1975_processed.ts
```

.m3u (extended)

One step/stage transformation

hardly the case



a. Chaining of mappings

flowplayer flash

```
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"
```

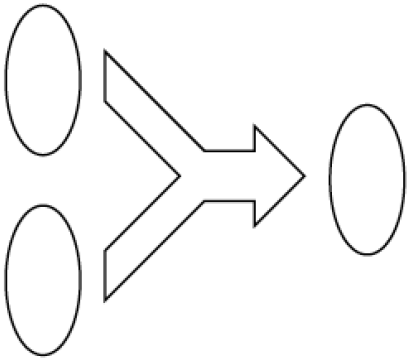
FFmpeg

Playlist model

```
#EXTM3U
#EXT-X-DISCONTINUITY
#EXTINF:3
resources/videos/vp0-logo/logo_start.ts
#EXT-X-DISCONTINUITY
#EXTINF:12
resources/videos/vp1-QR/QR05_1.ts
#EXT-X-DISCONTINUITY
#EXTINF:2
resources/videos/vp2-intro-fluide-glacial/
EtPendantCeTempsLaEn1975_processed.ts
```

.m3u (extended)

Problem space
Combination of expertises/aspects/DSLs

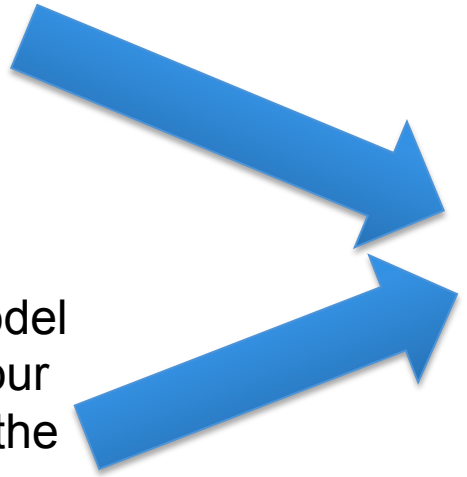


b. Multiple problem spaces

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"
}

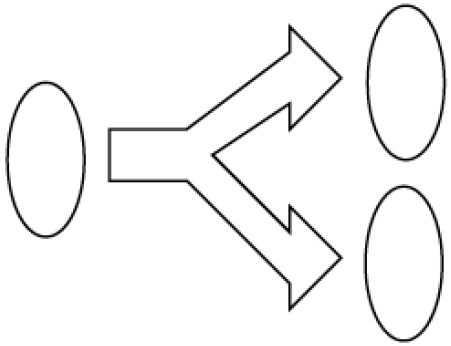
alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```



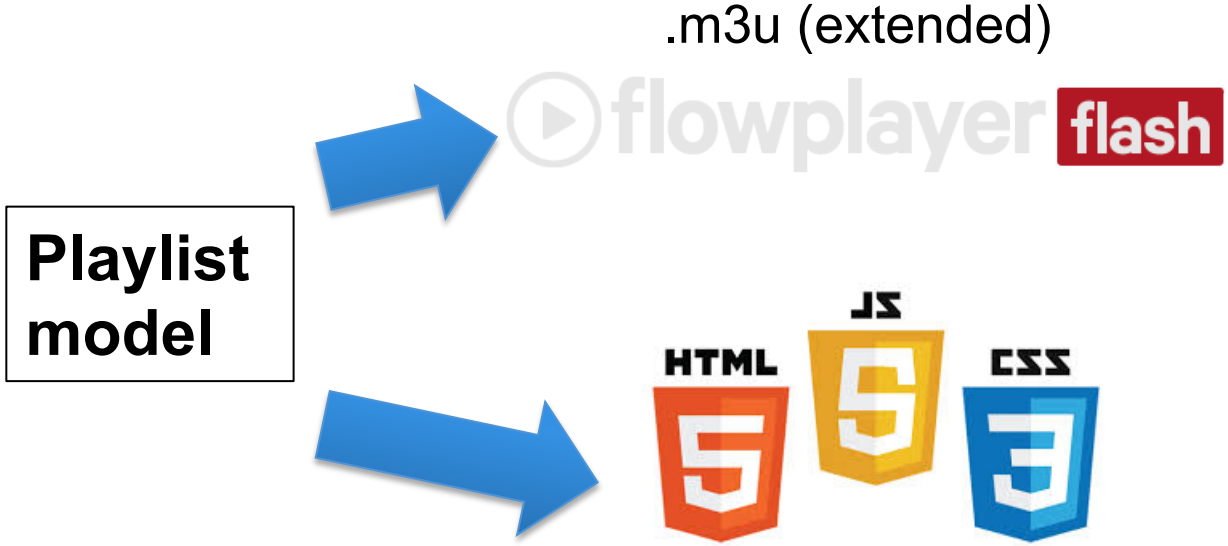
Feature model: another model for modeling “features” of your Web site (eg ability to save the video; mode=generation with frequencies)

Solution space

Different targets (e.g., technological platforms)

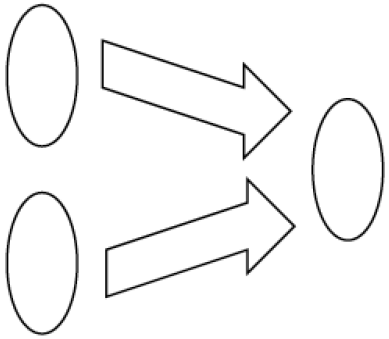


c. Multiple solution spaces



Problem space

e.g., different concrete syntaxes



d. Alternative problem spaces

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"
}

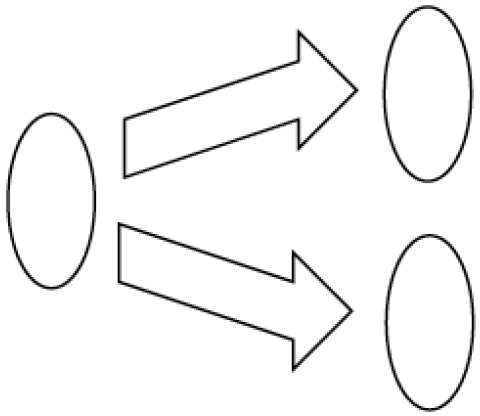
alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```

Video Variants

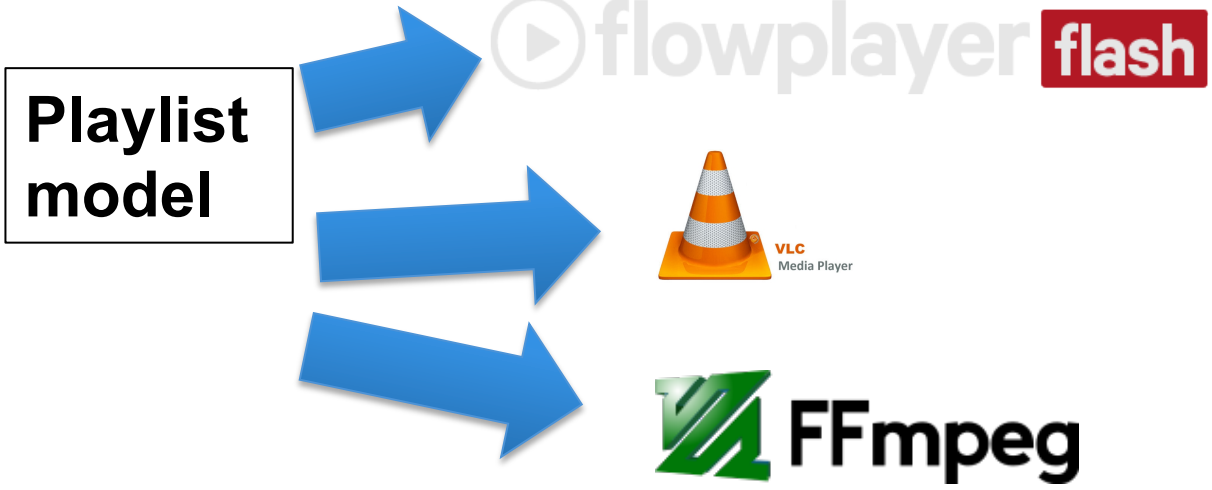
Feature Model (see next courses)

Solution space

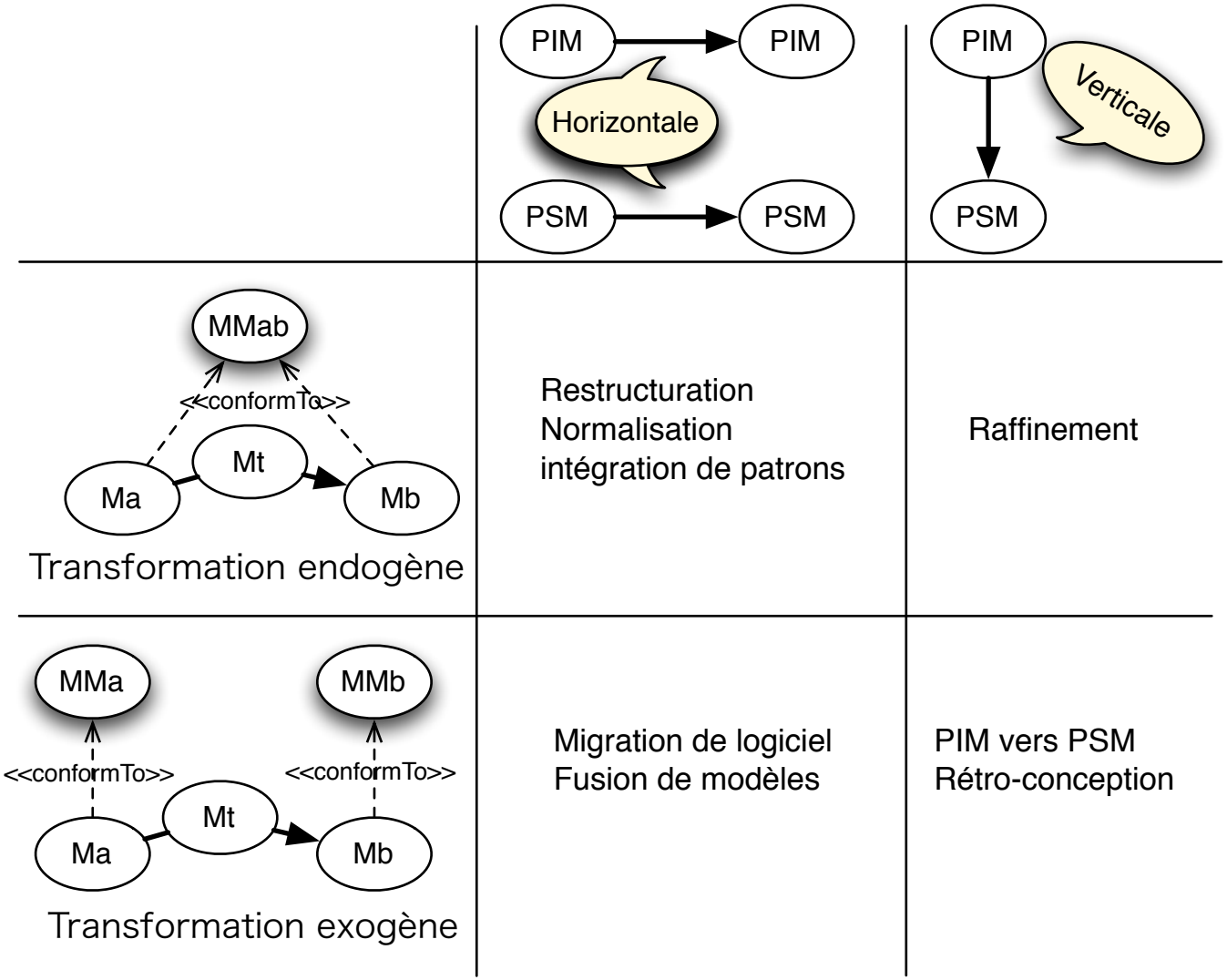
Different targets (e.g., technological platforms)



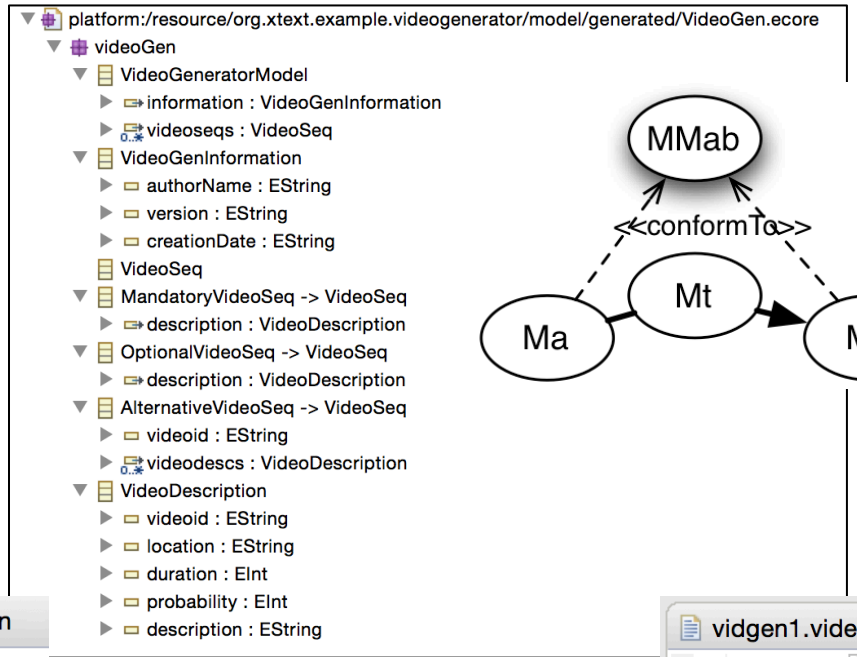
e. Alternative solution spaces



Model Transformation: Taxonomy



Endogeneous Transformation



vidgen1.videogen | vidgen1-bis.videogen

```
VideoGen {

    mandatory videoseq "V1/v1.mp4"
    optional videoseq "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```

vidgen1.videogen | vidgen1-bis.videogen

VideoGen1/vidgen1-bis.videogen

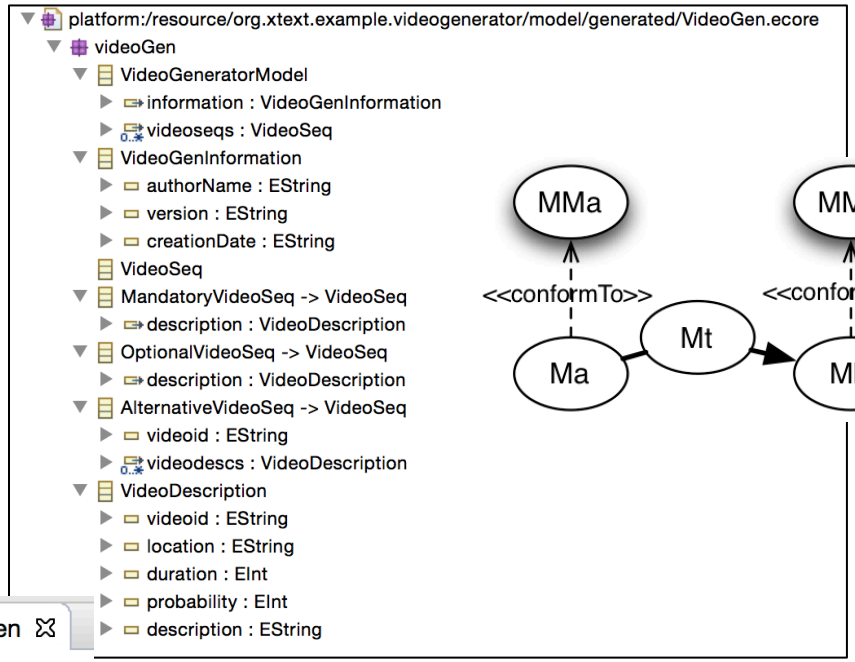
```
VideoGen {
    mandatory videoseq v0 "V1/v1.mp4"
    optional videoseq v1 "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq v2 "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```

Exogeneous Transformation

(metamodel)



vidgen1.videogen | vidgen1-bis.videogen

```
VideoGen {
    VideoGen1/vidgen1-bis.videogen
    mandatory videoseq v0 "v1/v1.mp4"
    optional videoseq v1 "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq v2 "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

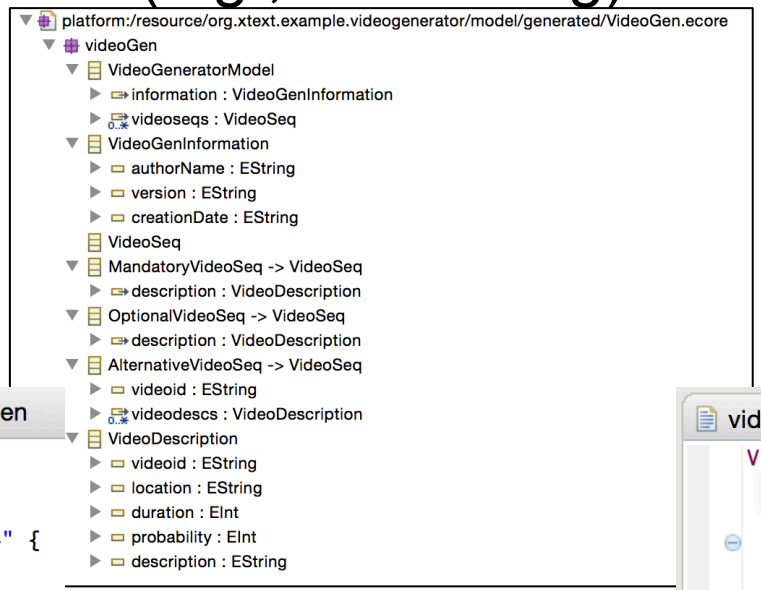
    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```

```
<ul>
<li>v0</li>
<li>v1</li>
<li>vid3</li>
<ul>
<li>v2</li>
<li>vid31</li>
<li>vid32</li>
</ul>
<li>vid4</li>
<ul>
<li>vid41</li>
<li>vid42</li>
</ul>
<li>vid5</li>
<li>vid8</li>
<li>vid9</li>
<ul>
<li>vid81</li>
</ul>
</ul>
```

Vertical Transformation

source and target models reside at the same abstraction level (e.g., refactoring)



vidgen1.videogen | vidgen1-bis.videogen

```
VideoGen {

    mandatory videoseq "V1/v1.mp4"
    optional videoseq "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```

vidgen1.videogen | vidgen1-bis.videogen

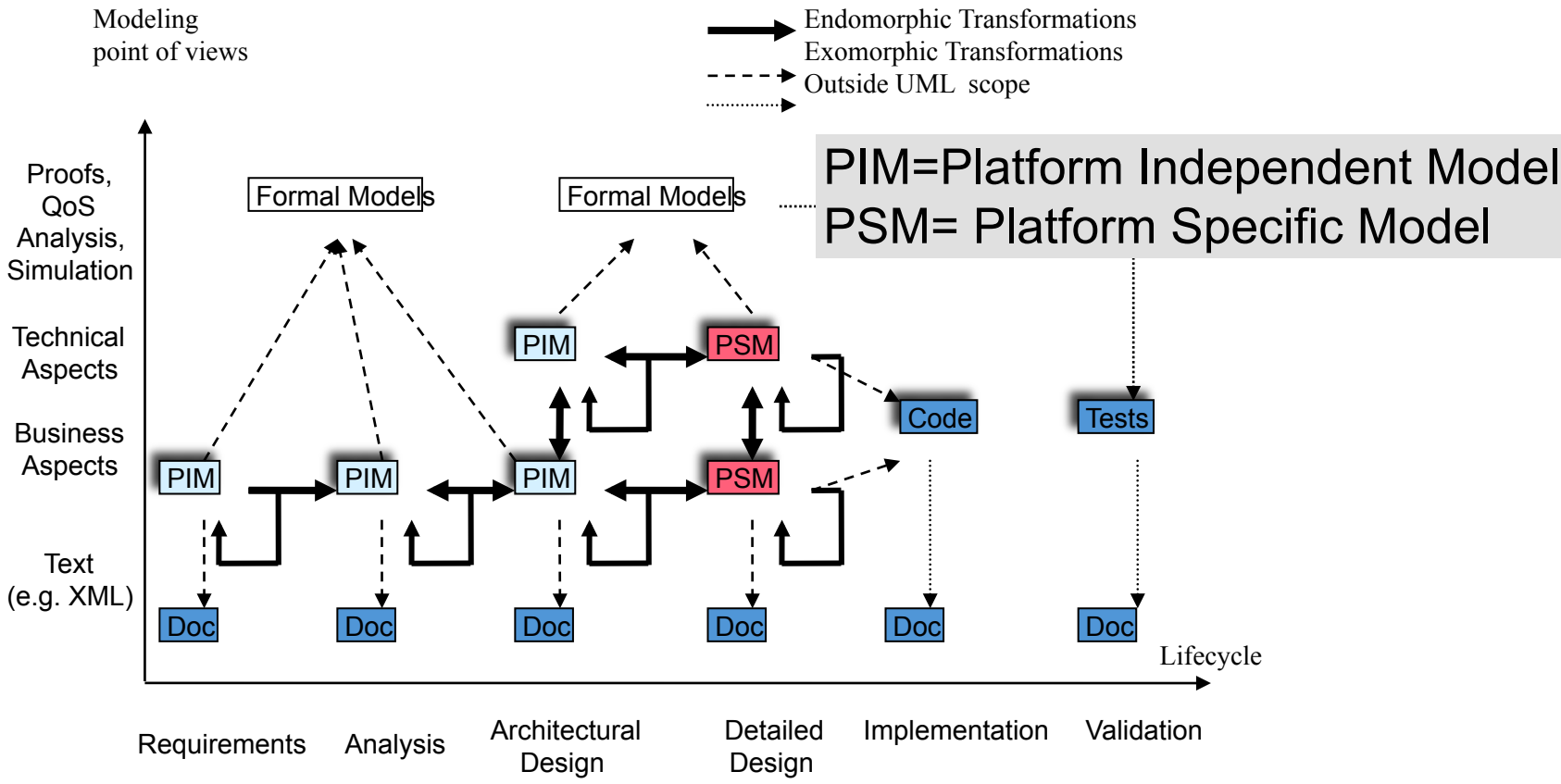
```
VideoGen {
    VideoGen1/vidgen1-bis.videogen
    mandatory videoseq v0 "V1/v1.mp4"
    optional videoseq v1 "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq v2 "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```

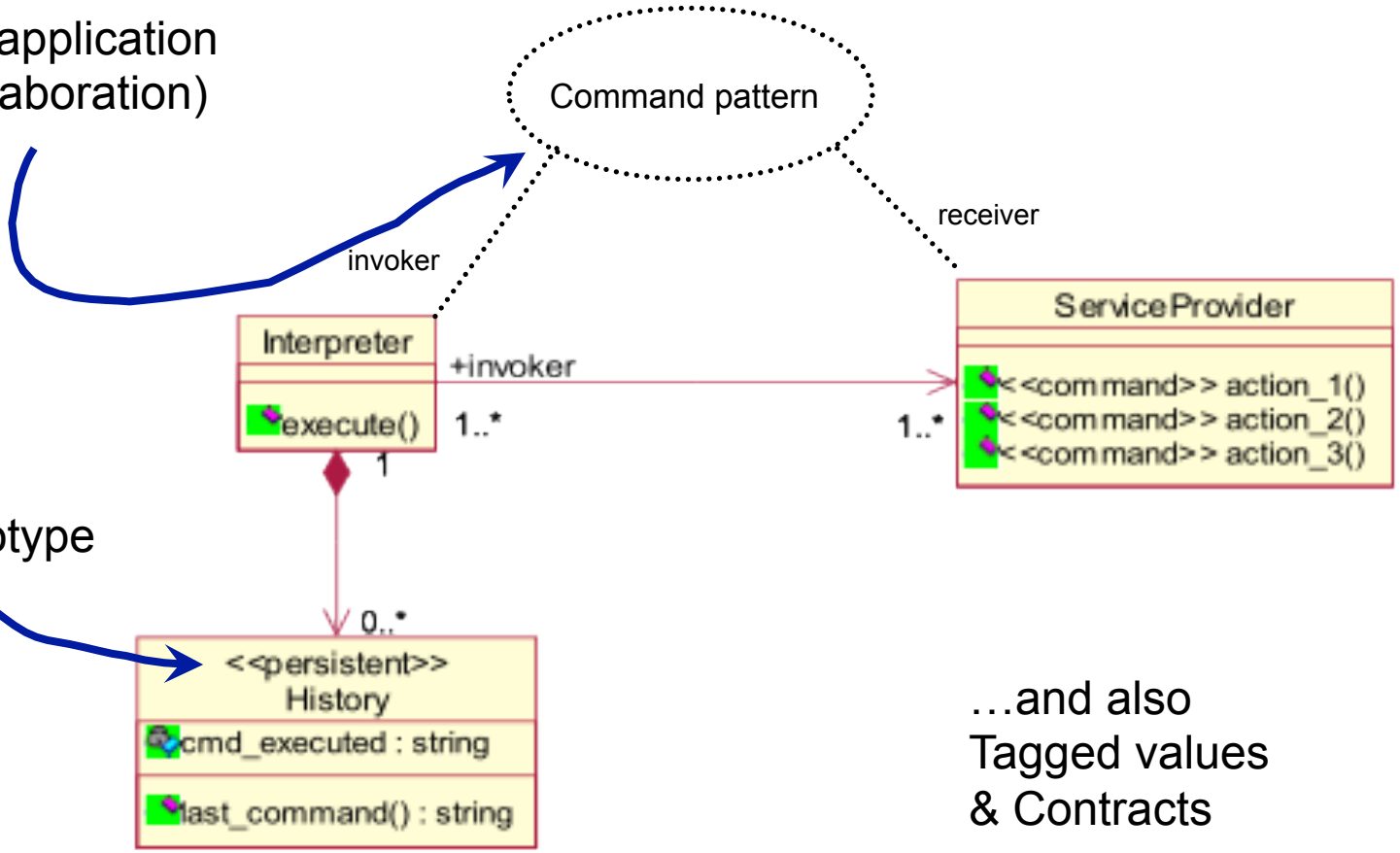
Chaining of Transformations

Back to the first courses



Embedding implicit semantics into a model

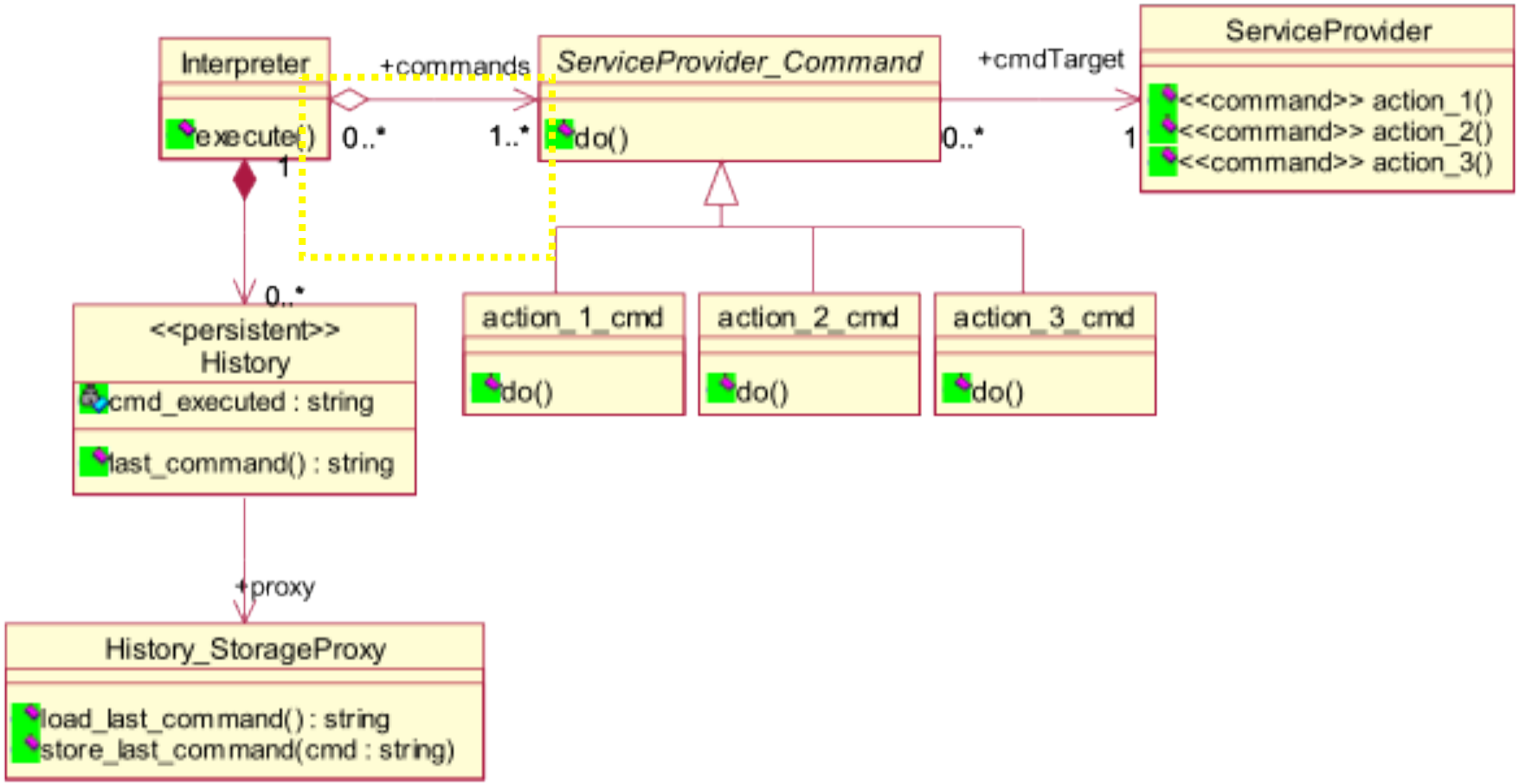
Design pattern application
(parametric collaboration)



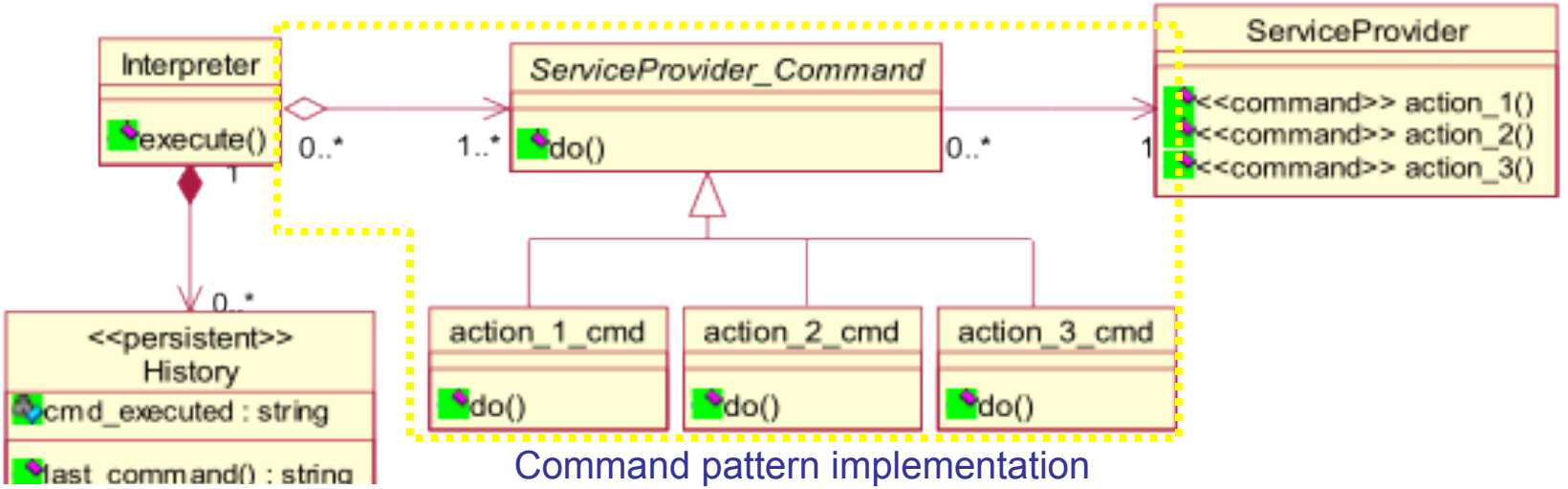
Element stereotype

…and also
Tagged values
& Contracts

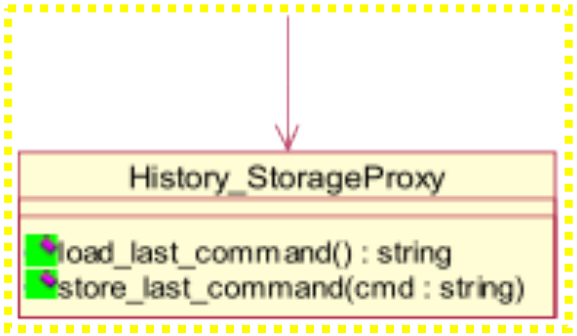
…and the result we want...



How To:
Automatic Model Transformations



Command pattern implementation



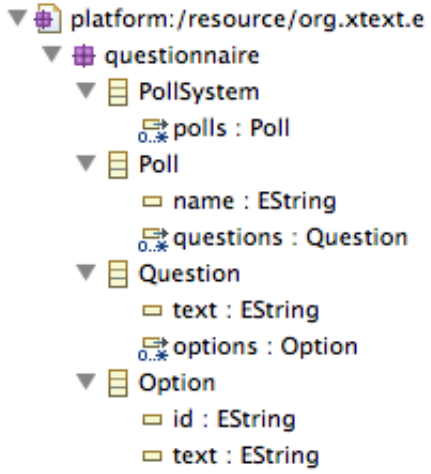
Persitence implementation

In some domains (e.g.; RT systems)
transformations can get more complex
than initial model!
=> must be managed with sound SE principles

Quizz Time

Characterize the following model transformations

Endogeneous? Exogeneous?
Vertical? Horizontal?
Model-to-text? Model-to-Model?



foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                    b : "B"
                    c : "C"
                    d : "D"

        }

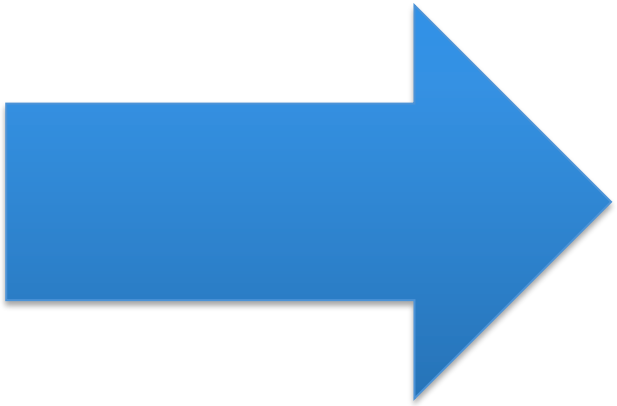
    }

    Poll poll2 {

        Question D {
            "What is D ?"
            options
                    e : "E"
                    f : "F"

        }

    }
}
```



foo1.q | foo2.q

```
PollSystem {

    Poll poll1_poll {

        Question {
            "What is A ?"
            options
                    b : "B"
                    c : "C"
                    d : "D"

        }

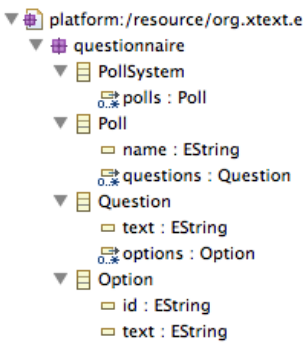
    }

    Poll poll2_poll {

        Question {
            "What is D ?"
            options
                    e : "E"
                    f : "F"

        }

    }
}
```



foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                    b : "B"
                    c : "C"
                    d : "D"

        }

    }

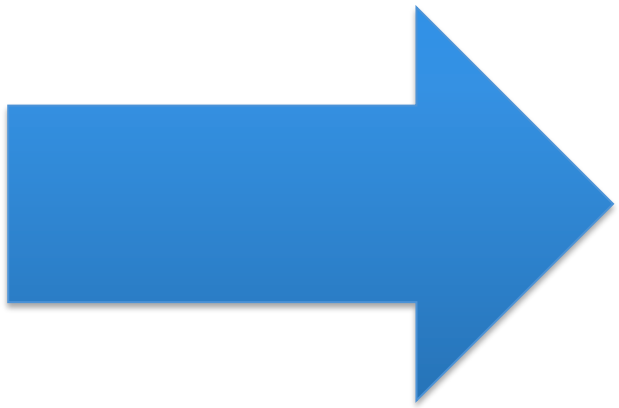
    Poll poll2 {

        Question D {
            "What is D ?"
            options
                    e : "E"
                    f : "F"

        }

    }

}
```



poll1

What is A ?

- B
- C
- D

poll2

What is D ?

- E
- F

Xtend

A possible solution
for
model management

Effective Model Management

- How to load/serialize a model?
- How to visit, analyze and transform models?
- You can do it in Java (EMF API)

- We arbitrarily choose 

  - Java 10, interesting « features »
  - Integration within Eclipse ecosystem (incl. Xtext) and facilities to manage models
  - An example of a sophisticated language

Before going into details of Xtend…

- Recap of the scenarios
  - Text-to-Model
  - Model(s)-to-Model transformation
  - Metamodels as a « bridge » between techologies
  - Model-to-Text
- The solution of some of the « scenarios »
  - Just to give an overview of Xtend capabilities
  - To give a more practical/concrete view of some of the previous scenarios

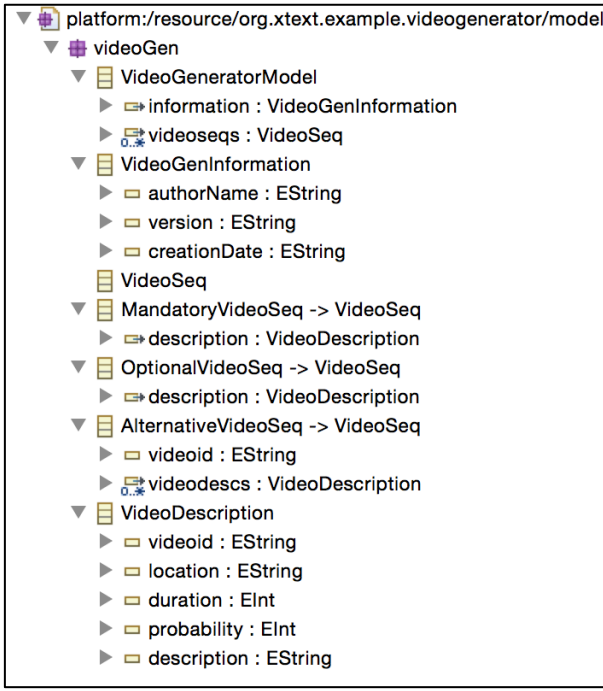
```
def loadVideoGenerator(URI uri) {
    new VideoGenStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as VideoGeneratorModel
}
```

```
def saveVideoGenerator(URI uri, VideoGeneratorModel pollS) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(pollS);
    rs.save(new HashMap());
}
```

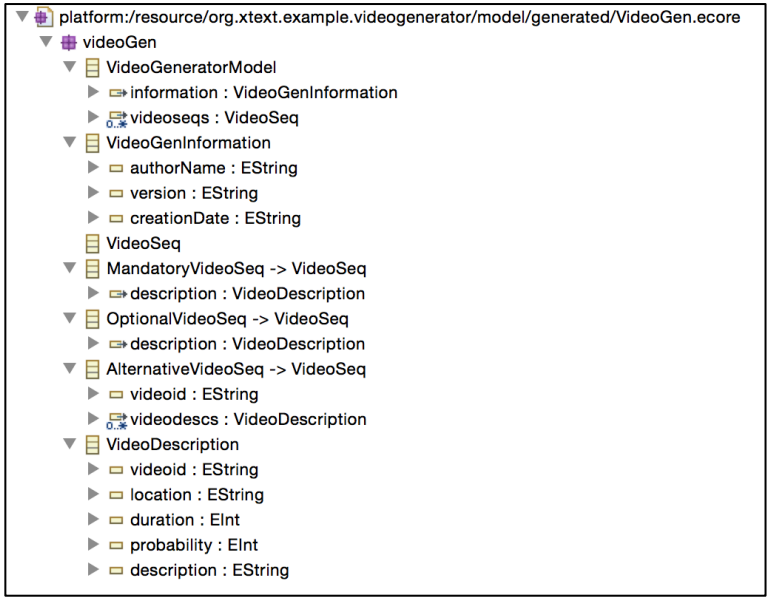
```
@Test
def test1() {
    // loading
    var videoGen = loadVideoGenerator(URI.createURI("foo2.videogen"))
    assertNotNull(videoGen)
    assertEquals(3, videoGen.videoseqs.size)
    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    videoGen.videoseqs.forEach[videoseq |
        if (videoseq instanceof MandatoryVideoSeq) {
            val desc = (videoseq as MandatoryVideoSeq).description
            if(desc.videoid.isNullOrEmpty)  desc.videoid = genID()
        }
        else if (videoseq instanceof OptionalVideoSeq) {
            val desc = (videoseq as OptionalVideoSeq).description
            if(desc.videoid.isNullOrEmpty) desc.videoid = genID()
        }
        else {
            val altvid = (videoseq as AlternativeVideoSeq)
            if(altvid.videoid.isNullOrEmpty) altvid.videoid = genID()
            for (vdesc : altvid.videodescs) {
                if(vdesc.videoid.isNullOrEmpty) vdesc.videoid = genID()
            }
        }
    ]
// serializing
saveVideoGenerator(URI.createURI("foo2bis.xmi"), videoGen)
saveVideoGenerator(URI.createURI("foo2bis.videogen"), videoGen)
```

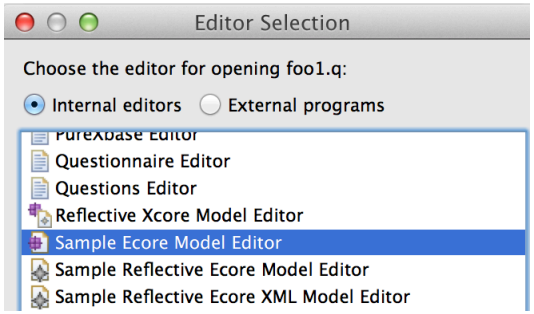
foo2.videogen

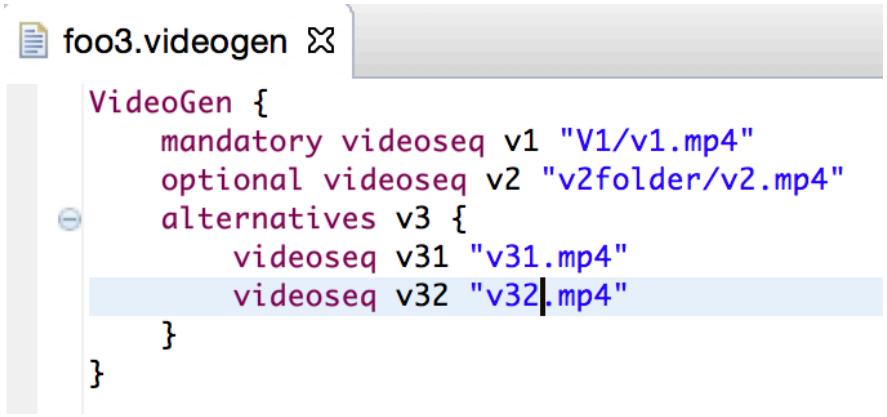
```
VideoGen {
    mandatory videoseq v1 "V1/v1.mp4"
    optional videoseq v2 "v2folder/v2.mp4"
    alternatives v3 {
        videoseq v31 "v31.mp4"
        videoseq v32 "v32.mp4"
    }
}
```

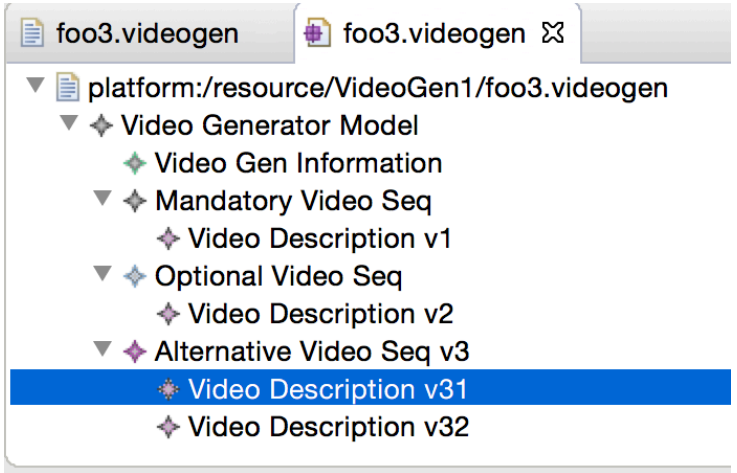


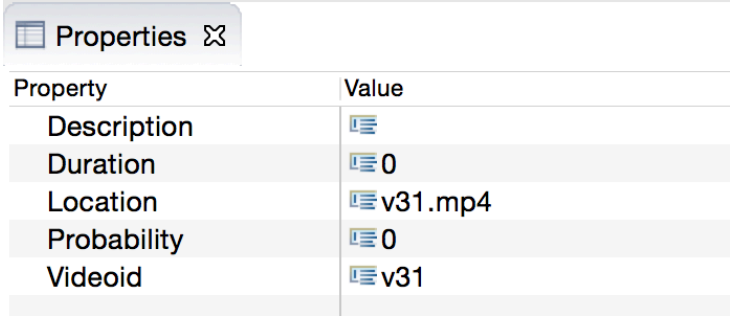
Loading Models (1)



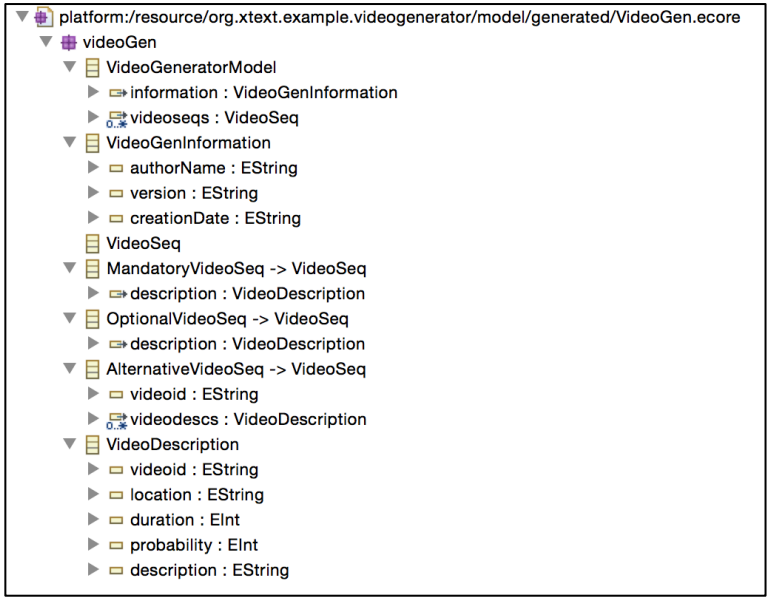








Loading Models (2)

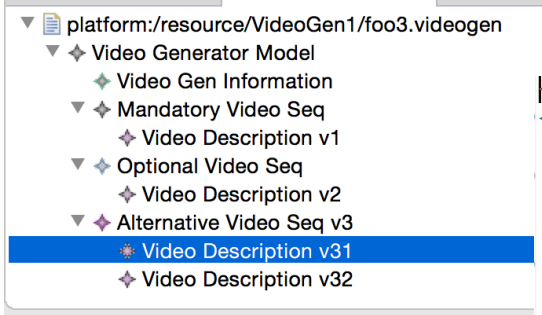


Persistence of Models in XMI (XML Metadata Interchange)

foo3.videogen

```
VideoGen {
    mandatory videoseq v1 "V1/v1.mp4"
    optional videoseq v2 "v2folder/v2.mp4"
    alternatives v3 {
        videoseq v31 "v31.mp4"
        videoseq v32 "v32.mp4"
    }
}
```

foo3.videogen | foo3.videogen



Properties

Property	Value
Description	
Duration	0
Location	v31.mp4
Probability	0
Videoid	v31

```
<?xml version="1.0" encoding="ASCII"?>
<videoGen:VideoGeneratorModel xmi:version="2.0" xmlns:xmi="htt
  <information/>
  <videoseqs xsi:type="videoGen:MandatoryVideoSeq">
    <description videoid="v1" location="V1/v1.mp4"/>
  </videoseqs>
  <videoseqs xsi:type="videoGen:OptionalVideoSeq">
    <description videoid="v2" location="v2folder/v2.mp4"/>
  </videoseqs>
  <videoseqs xsi:type="videoGen:AlternativeVideoSeq" videoid="
    <videodescs videoid="v31" location="v31.mp4"/>
    <videodescs videoid="v32" location="v32.mp4"/>
  </videoseqs>
</videoGen:VideoGeneratorModel>
```

```
def loadPollSystem(URI uri) {
    new QuestionnaireStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as PollSystem
}
```

```
def savePollSystem(URI uri, PollSystem pollS) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(pollS);
    rs.save(new HashMap());
}
```

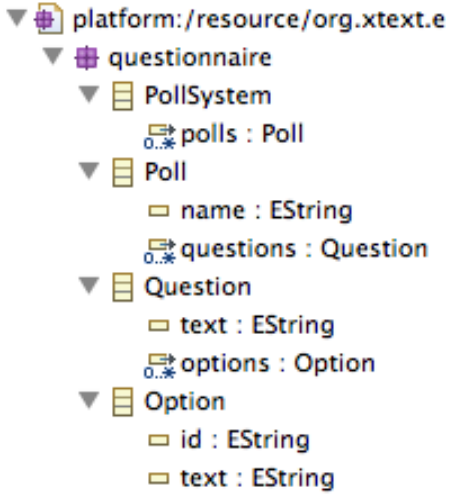
```
@Test
def test1() {

    // loading
    var pollS = loadPollSystem(URI.createURI("foo1.q"))
    assertNotNull(pollS)
    assertEquals(2, pollS.polls.size)

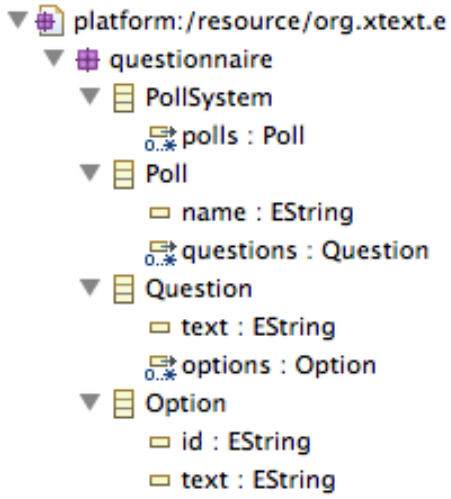
    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    pollS.polls.forEach[p | p.name = p.name + "_poll"]

    // serializing
    savePollSystem(URI.createURI("foo2.q"), pollS)

}
```



Loading Models (1)



foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                b : "B"
                c : "C"
                d : "D"

        }

    }

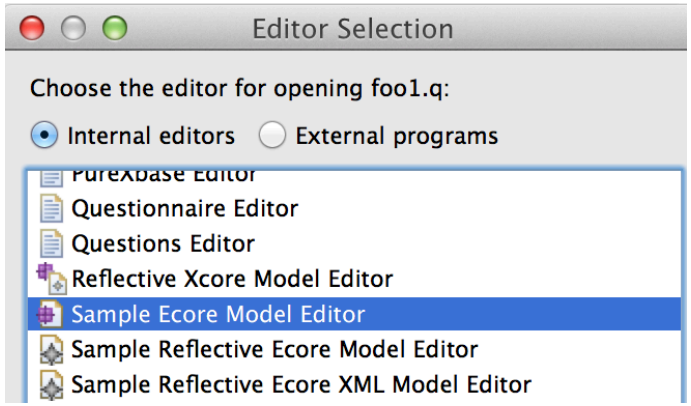
    Poll poll2 {

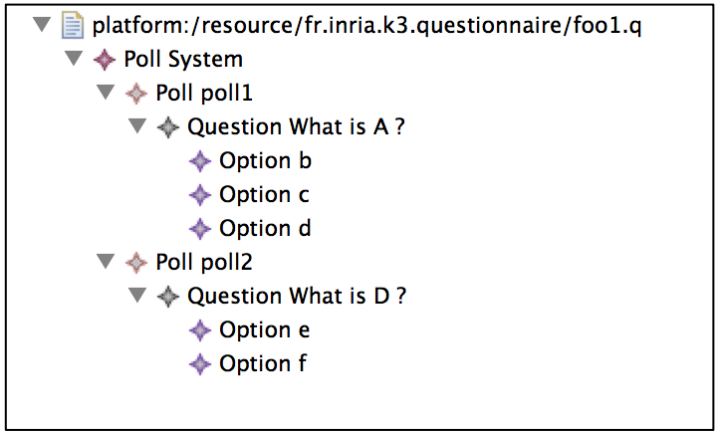
        Question D {
            "What is D ?"
            options
                e : "E"
                f : "F"

        }

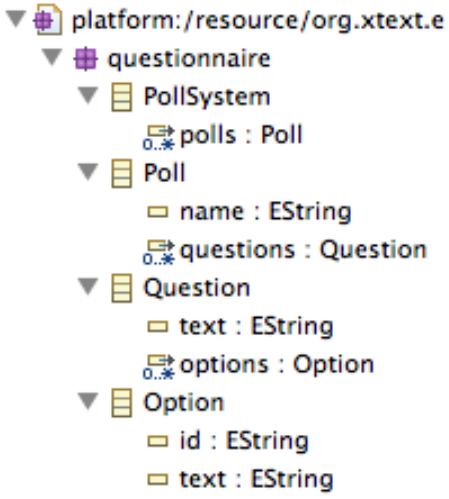
    }

}
```





Loading Models (2)



foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                b : "B"
                c : "C"
                d : "D"

        }

    }

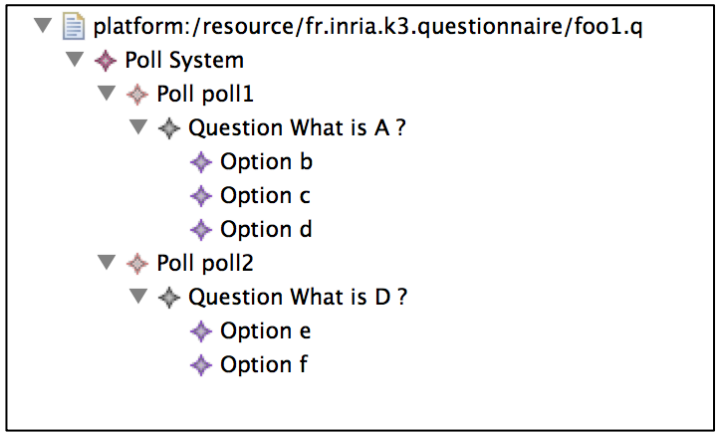
    Poll poll2 {

        Question D {
            "What is D ?"
            options
                e : "E"
                f : "F"

        }

    }

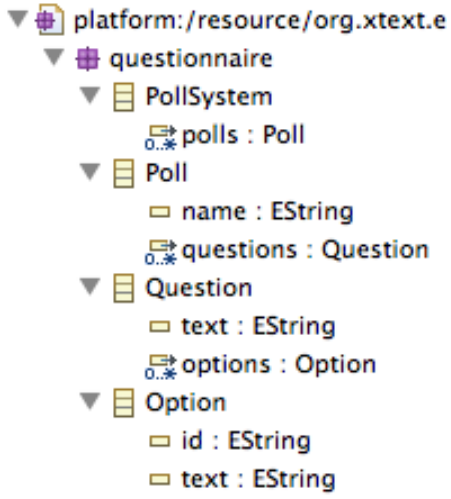
}
```



XMI

```
<?xml version="1.0" encoding="ASCII"?>
<questionnaire:PollSystem xmi:version="2.0"
xmlns:xmi="http://www.omg.org/XMI"
xmlns:questionnaire="http://www.xtext.org/example/mya
  <polls name="poll1">
    <questions text="What is A ?">
      <options id="b" text="B"/>
      <options id="c" text="C"/>
      <options id="d" text="D"/>
    </questions>
  </polls>
  <polls name="poll2">
    <questions text="What is D ?">
      <options id="e" text="E"/>
      <options id="f" text="F"/>
    </questions>
  </polls>
</questionnaire:PollSystem>
```

Loading Models (3)



foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                    b : "B"
                    c : "C"
                    d : "D"

        }

    }

    Poll poll2 {

        Question D {
            "What is D ?"
            options
                    e : "E"
                    f : "F"

        }

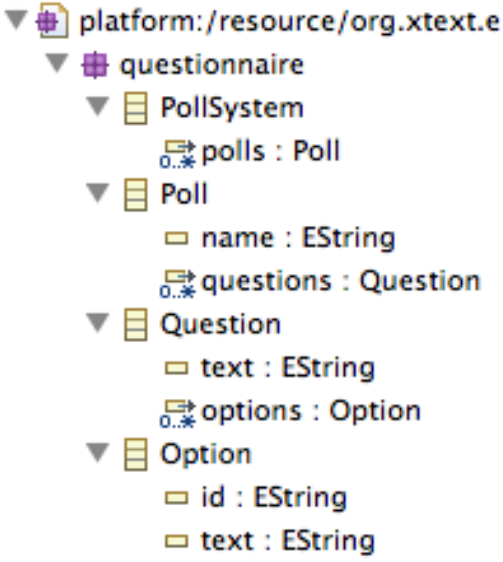
    }

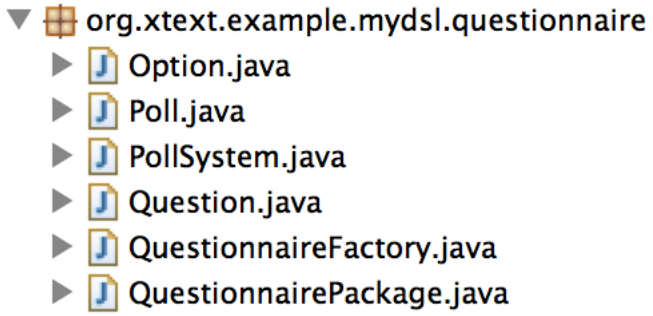
}
```

Persistence of Models in XMI (XML Metadata Interchange)

```
<?xml version="1.0" encoding="ASCII"?>
<questionnaire:PollSystem xmi:version="2.0"
xmlns:xmi="http://www.omg.org/XMI"
xmlns:questionnaire="http://www.xtext.org/example/mydsl/Questionnaire">
  <polls name="poll1">
    <questions text="What is A ?">
      <options id="b" text="B"/>
      <options id="c" text="C"/>
      <options id="d" text="D"/>
    </questions>
  </polls>
  <polls name="poll2">
    <questions text="What is D ?">
      <options id="e" text="E"/>
      <options id="f" text="F"/>
    </questions>
  </polls>
</questionnaire:PollSystem>
```

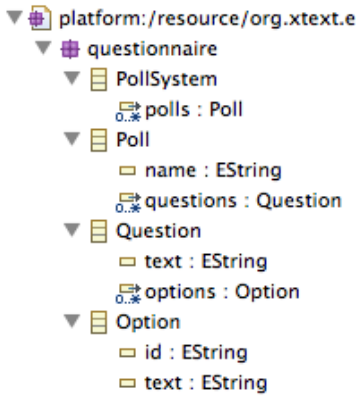
Meta(models) and Java

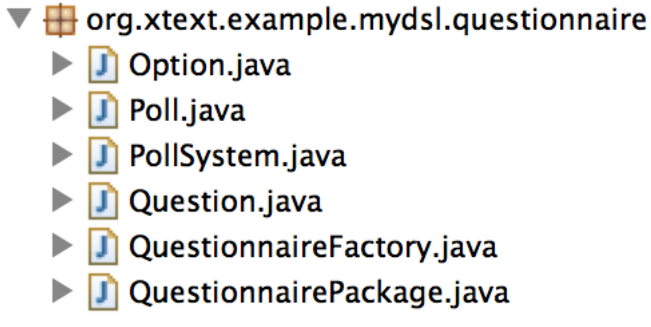





```java
public interface Poll extends EObject
{
  /**
   * Returns the value of the '<em><b>Name</b></em>' attribute.
   * <!-- begin-user-doc -->
   * <p>
   * If the meaning of the '<em>Name</em>' attribute isn't clear,
   * there really should be more of a description here...
   * </p>
   * <!-- end-user-doc -->
   * @return the value of the '<em>Name</em>' attribute.
   * @see #setName(String)
   * @see org.xtext.example.mydsl.questionnaire.QuestionnairePackage#getPoll_Name()
   * @model
   * @generated
   */
  String getName();

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

  /**
   * Returns the value of the '<em><b>Questions</b></em>' containment reference list.
   * The list contents are of type {@link org.xtext.example.mydsl.questionnaire.Question}.
   * <!-- begin-user-doc -->
   * <p>
   * If the meaning of the '<em>Questions</em>' containment reference list isn't clear,
   * there really should be more of a description here...
   * </p>
   * <!-- end-user-doc -->
   * @return the value of the '<em>Questions</em>' containment reference list.
   * @see org.xtext.example.mydsl.questionnaire.QuestionnairePackage#getPoll_Questions()
   * @model containment="true"
   * @generated
   */
  EList<Question> getQuestions();

} // Poll
```

Meta(models) and Java





```
public interface Poll extends EObject
{
  /**
   * Returns the value of the '<em><b>Name</b></em>' attribute.
   * <!-- begin-user-doc -->
   * <p>
   * If the meaning of the '<em>Name</em>' attribute isn't clear,
   * there really should be more of a description here...
   * </p>
   * <!-- end-user-doc -->
   * @return the value of the '<em>Name</em>' attribute.
   * @see #setName(String)
   * @see org.xtext.example.mydsl.questionnaire.QuestionnairePackage#getPoll_Name()
   * @model
   * @generated
   */
  String getName();

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

  /**
   * Returns the value of the '<em><b>Questions</b></em>' containment reference list.
   * The list contents are of type {@link org.xtext.example.mydsl.questionnaire.Question}.
   * <!-- begin-user-doc -->
   * <p>
   * If the meaning of the '<em>Questions</em>' containment reference list isn't clear,
   * there really should be more of a description here...
   * </p>
   * <!-- end-user-doc -->
   * @return the value of the '<em>Questions</em>' containment reference list.
   * @see org.xtext.example.mydsl.questionnaire.QuestionnairePackage#getPoll_Questions()
   * @model containment="true"
   * @generated
   */
  EList<Question> getQuestions();

} // Poll
```

```
foo1.q
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                b : "B"
                c : "C"
                d : "D"

        }

    }

    Poll poll2 {

        Question D {
            "What is D ?"
            options
                e : "E"
                f : "F"

        }

    }

}
```

« Eclipse Modeling Framework (EMF) runtime support to produce a set of Java classes for the model »

http://eclipsesource.com/blogs/tutorials/emf-tutorial/

Ecore Model

Java Code

Code generation

EPackage
EClass
EAttribute
EReference

Package
Class
Attribute
Reference

foo1.q

```
PollSystem {

    Poll poll1 {

        Question A {
            "What is A ?"
            options
                b : "B"
                c : "C"
                d : "D"

        }

    }

    Poll poll2 {

        Question D {
            "What is D ?"
            options
                e : "E"
                f : "F"

        }

    }

}
```

```
def loadPollSystem(URI uri) {
    new QuestionnaireStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as PollSystem
}

def savePollSystem(URI uri, PollSystem poll5) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(poll5);
    rs.save(new HashMap());
}

@Test
def test1() {

    // loading
    var poll5 = loadPollSystem(URI.createURI("foo1.q"))
    assertNotNull(poll5)
    assertEquals(2, poll5.polls.size)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    poll5.polls.forEach[p | p.name = p.name + "_poll"]

    // serializing
    savePollSystem(URI.createURI("foo2.q"), poll5)

}
```

foo1.q foo2.q

```
PollSystem {

    Poll poll1_poll {

        Question {
            "What is A ?"
            options
                b : "B"
                c : "C"
                d : "D"

        }

    }

    Poll poll2_poll {

        Question {
            "What is D ?"
            options
                e : "E"
                f : "F"

        }

    }

}
```

Questionnaire MM (ecore)

Questionnaire MM (ecore)

Questionnaire Model 1 (xmi)

Questionnaire Model 2 (xmi)

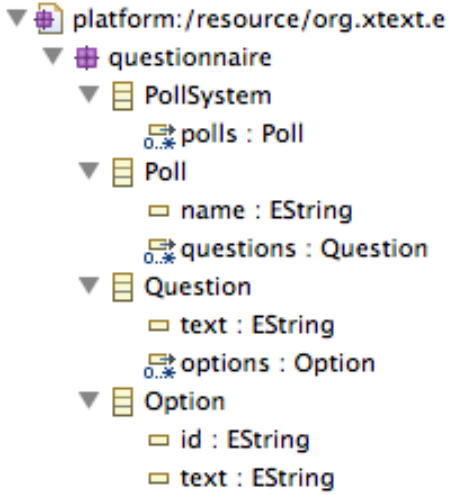
```
PollSystem {
    Poll Quality {
        Question q1 {
            "Value the user experience"
            options {
                A : "Bad"
                B : "Fair"
                C : "Good"
            }
        }
        Question q2 {
            "Value the layout"
            options {
                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"
            }
        }
    }
}
```

```
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"
            }
        }
    }
}
```

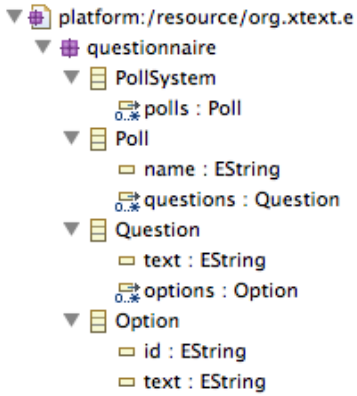
```
def loadPollSystem(URI uri) {
    new QuestionnaireStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as PollSystem
}
```

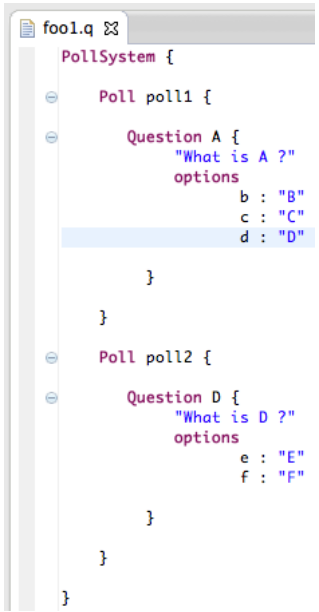
```
def savePollSystem(URI uri, PollSystem pollS) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(pollS);
    rs.save(new HashMap());
}
```

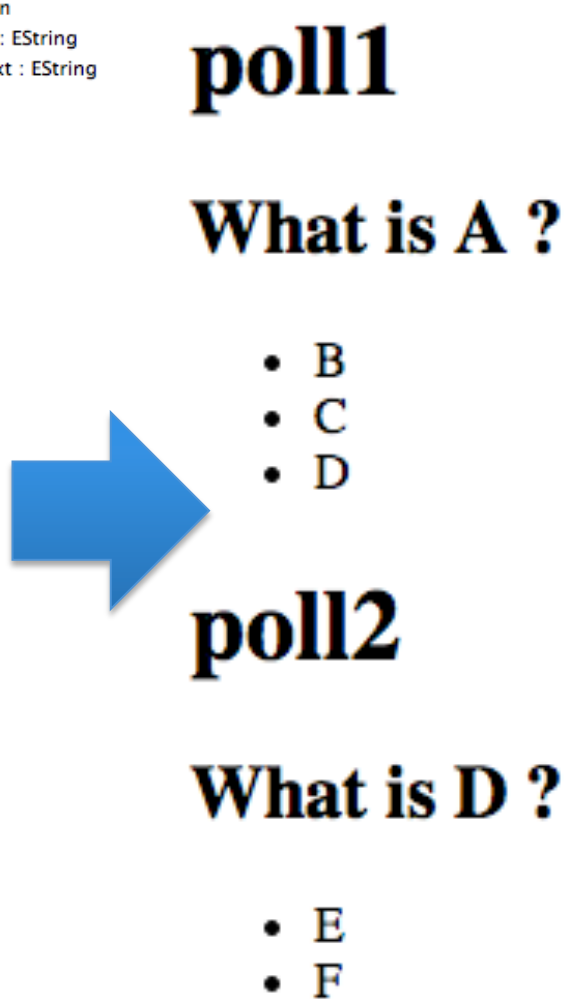
```
@Test
def test1() {

    // loading
    var pollS = loadPollSystem(URI.createURI("foo1.q"))
    assertNotNull(pollS)
    assertEquals(2, pollS.polls.size)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    pollS.polls.forEach[p | p.name = p.name + "_poll"]

    // serializing
    savePollSystem(URI.createURI("foo2.q"), pollS)

}
```



```
@Test
def test2() {

// loading
var pollS = loadPollSystem(URI.createURI("foo1.q"))

// MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
var html = toPolls(pollS.polls)
assertNotNull(html)

// serializing (note: we could type check the HTML
// with Xtext by specifying the grammar for instance)
val fw = new FileWriter("foo1.html")
fw.write(html.toString)
fw.close


}

def toPolls(List<Poll> polls) '''
  <html>
    <body>
      «FOR p : polls»
        «IF p.name != null»
          <h1>«p.name»</h1>
        «ENDIF»
        «FOR q : p.questions»
        <p>
            <h2>«q.text»</h2>
            <ul>
             «FOR o : q.options»
             <li>«o.text»</li>
             «ENDFOR»
            </ul>
        </p>
        «ENDFOR»
      «ENDFOR»
    </body>
  </html>
'''
```







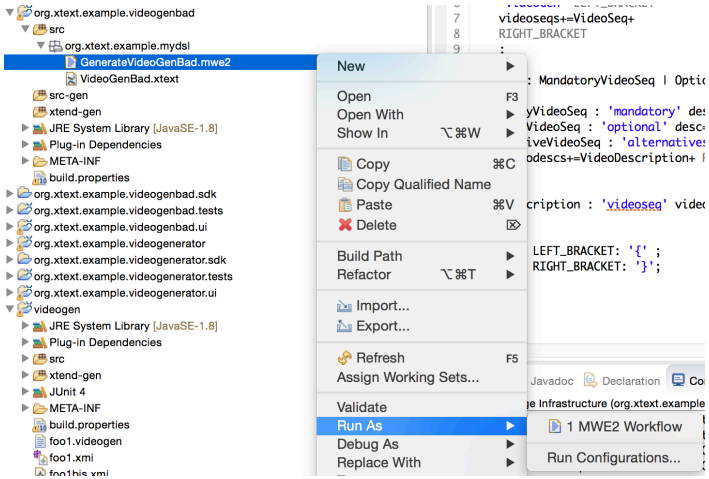
Contract

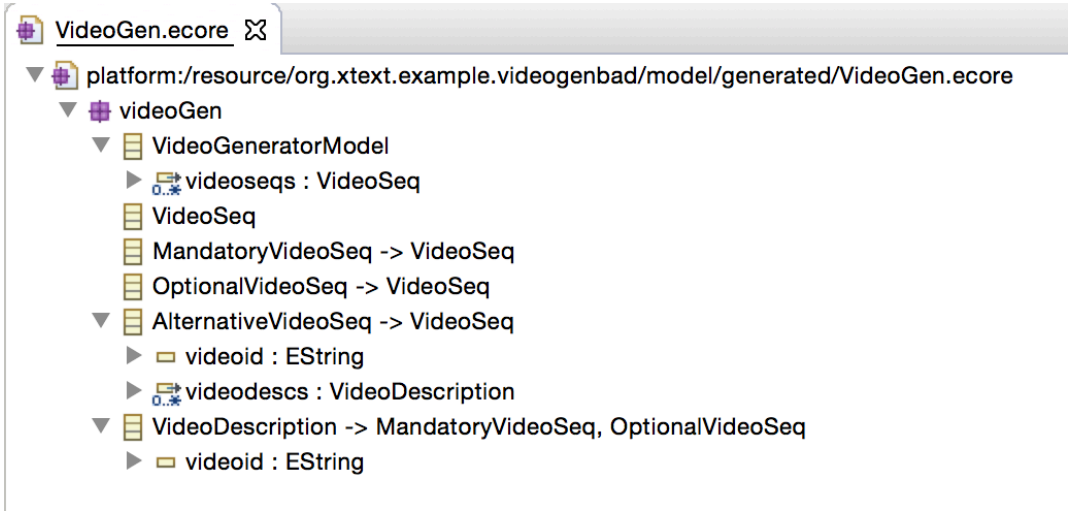
- Practical foundations of model management
- Learning and understanding Java 10 (aka Xtend)
  - advanced features of a general GPL, implementation of a sophisticated language using MDE
- Model transformations
  - Model-to-Text
  - Model-to-Model
- Metaprogramming
  - Revisit annotations (e.g., as in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

What are the problems with this Xtext grammar?

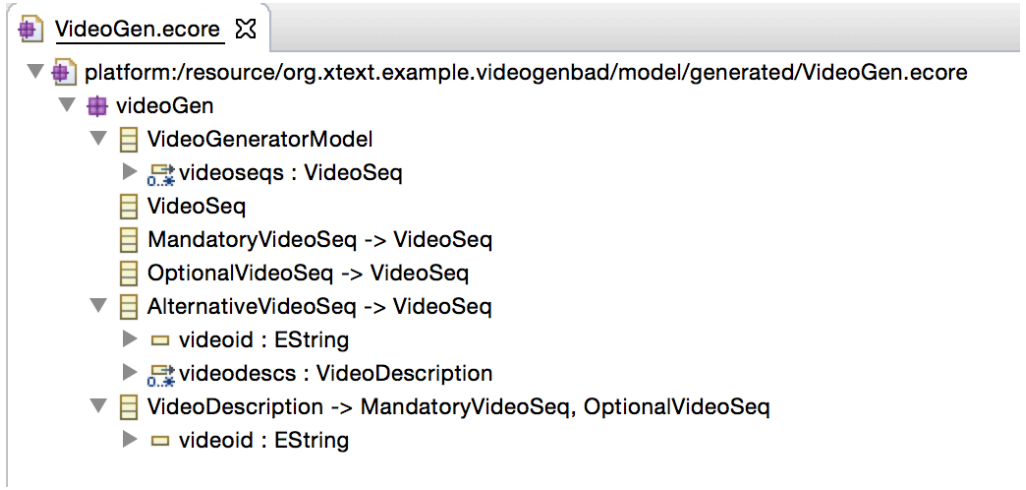
```
grammar org.xtext.example.mydsl.VideoGen with org.eclipse.xtext.common.Terminals

generate videoGen "http://www.xtext.org/example/mydsl/VideoGen"

VideoGeneratorModel:
    'VideoGen' LEFT_BRACKET
    videoseqs+=VideoSeq+
    RIGHT_BRACKET
    ;

VideoSeq: MandatoryVideoSeq | OptionalVideoSeq | AlternativeVideoSeq ;

MandatoryVideoSeq : 'mandatory' VideoDescription;
OptionalVideoSeq : 'optional' VideoDescription;
AlternativeVideoSeq : 'alternatives' (videoid=ID)? LEFT_BRACKET
    videodescs+=VideoDescription+ RIGHT_BRACKET
;

VideoDescription : 'videoseq' videoid=ID STRING
    ;

terminal LEFT_BRACKET: '{' ;
terminal RIGHT_BRACKET: '}';
```

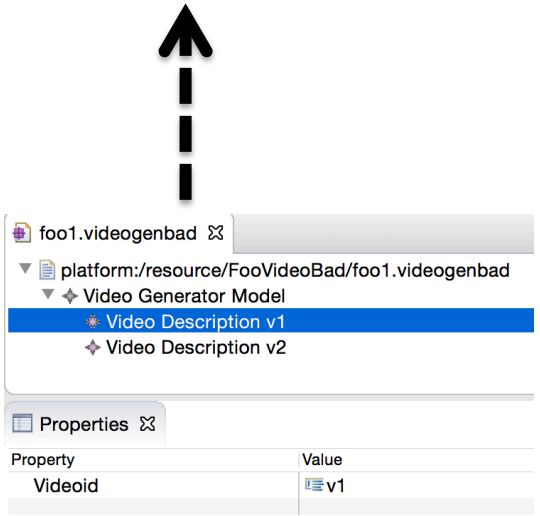
```
grammar org.xtext.example.mydsl.VideoGen with org.eclipse.xtext.common.Terminals

generate videoGen "http://www.xtext.org/example/mydsl/VideoGen"

VideoGeneratorModel:
    'VideoGen' LEFT_BRACKET
    videoseqs+=VideoSeq+
    RIGHT_BRACKET
    ;

VideoSeq: MandatoryVideoSeq | OptionalVideoSeq | AlternativeVideoSeq ;

MandatoryVideoSeq : 'mandatory' VideoDescription;
OptionalVideoSeq : 'optional' VideoDescription;
AlternativeVideoSeq : 'alternatives' (videoid=ID)? LEFT_BRACKET
    videodescs+=VideoDescription+ RIGHT_BRACKET
;

VideoDescription : 'videoseq' videoid=ID STRING
    ;

terminal LEFT_BRACKET: '{' ;
terminal RIGHT_BRACKET: '}';
```





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

generate videoGen "http://www.xtext.org/example/mydsl/VideoGen"

VideoGeneratorModel:
    'VideoGen' LEFT_BRACKET
    videoseqs+=VideoSeq+
    RIGHT_BRACKET
    ;

VideoSeq: MandatoryVideoSeq | OptionalVideoSeq | AlternativeVideoSeq ;

MandatoryVideoSeq : 'mandatory' VideoDescription;
OptionalVideoSeq : 'optional' VideoDescription;
AlternativeVideoSeq : 'alternatives' (videoid=ID)? LEFT_BRACKET
    videodescs+=VideoDescription+ RIGHT_BRACKET
;

VideoDescription : 'videoseq' videoid=ID STRING
    ;

terminal LEFT_BRACKET: '{' ;
terminal RIGHT_BRACKET: '}';
```





foo1.videogenbad

```
VideoGen {
    mandatory videoseq v1 "v1.avi"
    optional videoseq v2 "v2.mp4"
}
```

VideoGen.ecore

- platform:/resource/org.xtext.example.videogenbad/model/generated/VideoGen.ecore
  - videoGen
    - VideoGeneratorModel
      - videoseqs : VideoSeq
      - VideoSeq
      - MandatoryVideoSeq -> VideoSeq
      - OptionalVideoSeq -> VideoSeq
      - AlternativeVideoSeq -> VideoSeq
        - videoid : EString
        - videodescs : VideoDescription
      - VideoDescription -> MandatoryVideoSeq, OptionalVideoSeq
        - videoid : EString

```
def loadVideoGenerator(URI uri) {
    new VideoGenStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as VideoGeneratorModel
}


@Test
def test1() {

    // loading
    var videoGen = loadVideoGenerator(URI.createURI("foo1.videogenbad"))
    assertNotNull(videoGen)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    assertEquals(2, videoGen.videoseqs.size)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    videoGen.videoseqs.forEach[videoseq |
        if (videoseq instanceof MandatoryVideoSeq) {
            val desc = (videoseq as MandatoryVideoSeq).description
            // ...
        }
    ]
```

The method description is undefined….

foo1.videogenbad

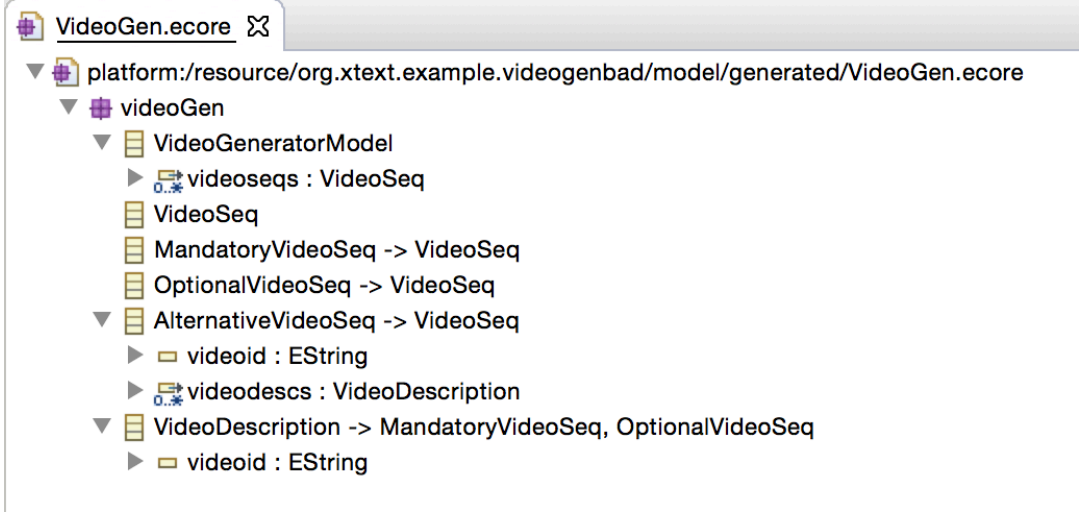
```
VideoGen {
    mandatory videoseq v1 "v1.avi"
    optional videoseq v2 "v2.mp4"
}
```

VideoGen.ecore

- platform:/resource/org.xtext.example.videogenbad/model/generated/VideoGen.ecore
  - videoGen
    - VideoGeneratorModel
      - videoseqs : VideoSeq
      - VideoSeq
      - MandatoryVideoSeq -> VideoSeq
      - OptionalVideoSeq -> VideoSeq
      - AlternativeVideoSeq -> VideoSeq
        - videoid : EString
        - videodescs : VideoDescription
      - VideoDescription -> MandatoryVideoSeq, OptionalVideoSeq
        - videoid : EString

```
def loadVideoGenerator(URI uri) {
    new VideoGenStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as VideoGeneratorModel
}


@Test
def test1() {

    // loading
    var videoGen = loadVideoGenerator(URI.createURI("foo1.videogenbad"))
    assertNotNull(videoGen)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    assertEquals(2, videoGen.videoseqs.size)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    videoGen.videoseqs.forEach[videoseq |
        if (videoseq instanceof MandatoryVideoSeq) {
            val desc = (videoseq as MandatoryVideoSeq).description
            // ...
        }
    ]
```

The method description is undefined….




```java
/**
package org.xtext.example.mydsl.videoGen;


/**
 * <!-- begin-user-doc -->
 * A representation of the model object '<em><b>Mandatory Video Seq</b></em>'.
 * <!-- end-user-doc -->
 *
 *
 * @see org.xtext.example.mydsl.videoGen.VideoGenPackage#getMandatoryVideoSeq()
 * @model
 * @generated
 */
public interface MandatoryVideoSeq extends VideoSeq
{
} // MandatoryVideoSeq

```

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

generate videoGen "http://www.xtext.org/example/mydsl/VideoGen"

VideoGeneratorModel:
    'VideoGen' LEFT_BRACKET
    videoseqs+=VideoSeq+
    RIGHT_BRACKET
    ;

VideoSeq: MandatoryVideoSeq | OptionalVideoSeq | AlternativeVideoSeq ;

MandatoryVideoSeq : 'mandatory' VideoDescription;
OptionalVideoSeq : 'optional' VideoDescription;
AlternativeVideoSeq : 'alternatives' (videoid=ID)? LEFT_BRACKET
    videodescs+=VideoDescription+ RIGHT_BRACKET
;

VideoDescription : 'videoseq' videoid=ID STRING
    ;

terminal LEFT_BRACKET: '{' ;
terminal RIGHT_BRACKET: '}';
```

deoGen.ecore

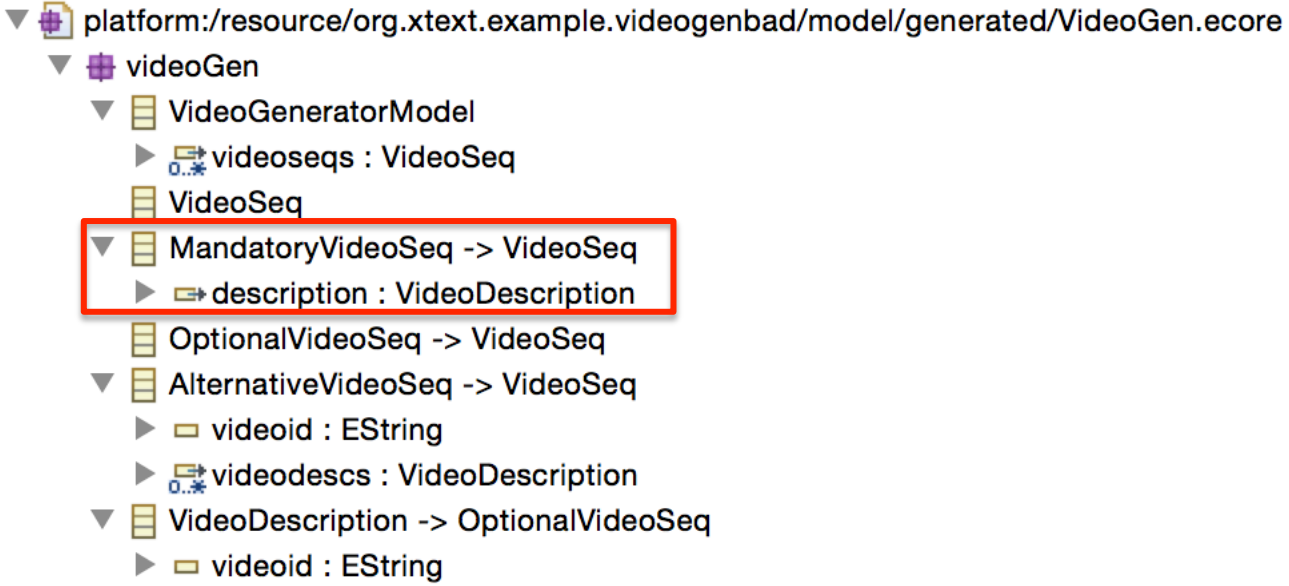
platform:/resource/org.xtext.example.videogenbad/model/generated/VideoGen.ecc

- videoGen
  - VideoGeneratorModel
    - videoseqs : VideoSeq
    - VideoSeq
    - MandatoryVideoSeq -> VideoSeq
    - OptionalVideoSeq -> VideoSeq
    - AlternativeVideoSeq -> VideoSeq
      - videoid : EString
      - videodescs : VideoDescription
    - VideoDescription -> MandatoryVideoSeq, OptionalVideoSeq
      - videoid : EString

```
1  /**
3  package org.xtext.example.mydsl.videoGen;
4
5
6  /**
7   * <!-- begin-user-doc -->
8   * A representation of the model object '<em><b>Mandatory Video Seq</b></em>'.
9   * <!-- end-user-doc -->
10  *
11  *
12  * @see org.xtext.example.mydsl.videoGen.VideoGenPackage#getMandatoryVideoSeq()
13  * @model
14  * @generated
15  */
16 public interface MandatoryVideoSeq extends VideoSeq
17 {
18 } // MandatoryVideoSeq
19
```

Fixing the grammar

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

generate videoGen "http://www.xtext.org/example/mydsl/VideoGen"

VideoGeneratorModel:
    'VideoGen' LEFT_BRACKET
    videoseqs+=VideoSeq+
    RIGHT_BRACKET
    ;

VideoSeq: MandatoryVideoSeq | OptionalVideoSeq | AlternativeVideoSeq ;

MandatoryVideoSeq : 'mandatory' description=VideoDescription;
OptionalVideoSeq : 'optional' VideoDescription;
AlternativeVideoSeq : 'alternatives' (videoid=ID)? LEFT_BRACKET
    videodescs+=VideoDescription+ RIGHT_BRACKET
;

VideoDescription : 'videoseq' videoid=ID STRING
    ;

terminal LEFT_BRACKET: '{' ;
terminal RIGHT_BRACKET: '}';
```




```java
/**
 */
package org.xtext.example.mydsl.videoGen;


/**
 * <!-- begin-user-doc -->
 * A representation of the model object '<em><b>Mandatory Video Seq</b></em>'.
 * <!-- end-user-doc -->
 *
 * <p>
 * The following features are supported:
 * </p>
 * <ul>
 *   <li>{@link org.xtext.example.mydsl.videoGen.MandatoryVideoSeq#getDescription <em>Description</em>}</li>
 * </ul>
 *
 * @see org.xtext.example.mydsl.videoGen.VideoGenPackage#getMandatoryVideoSeq()
 * @model
 * @generated
 */
public interface MandatoryVideoSeq extends VideoSeq
{
  /**
   * Returns the value of the '<em><b>Description</b></em>' containment reference.
   * <!-- begin-user-doc -->
   * <p>
   * If the meaning of the '<em>Description</em>' containment reference isn't clear,
   * there really should be more of a description here...
   * </p>
   * <!-- end-user-doc -->
   * @return the value of the '<em>Description</em>' containment reference.
   * @see #setDescription(VideoDescription)
   * @see org.xtext.example.mydsl.videoGen.VideoGenPackage#getMandatoryVideoSeq_Description()
   * @model containment="true"
   * @generated
   */
  VideoDescription getDescription();

  /**
   * Sets the value of the '{@link org.xtext.example.mydsl.videoGen.MandatoryVideoSeq#getDescription <em>Description</em>}' containment reference.
   * <!-- begin-user-doc -->
   * <!-- end-user-doc -->
   * @param value the new value of the '<em>Description</em>' containment reference.
   * @see #getDescription()
   * @generated
   */
  void setDescription(VideoDescription value);

} // MandatoryVideoSeq
```

```
// loading
var videoGen = loadVideoGenerator(URI.createURI("foo1.videogenbad"))
assertNotNull(videoGen)

// MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
assertEquals(2, videoGen.videoseqs.size)

// MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
videoGen.videoseqs.forEach[videoseq |
    if (videoseq instanceof MandatoryVideoSeq) {
        val desc = (videoseq as MandatoryVideoSeq).description
        // ...
    }
]
```

Grammar and Metamodel

- Model transformations are defined on top of metamodel constructs
- **Co-design** of grammar and metamodel
  - Grammar defines the syntax
  - Metamodel defines the structure
  - Xtext facilitates the metamodel design with
    - Default rules for inferring the metamodel from the grammar
    - Facilities to parameterize the inference
- Some transformations may be difficult to express. In this case two possible attitudes:
  - Revise the Xtext grammar and the underlying metamodel
  - Design another metamodel (from scrath) and write a model-to-model transformation

Plan

- Model Management in a nutshell
  - Loading, serializing, transforming models: scenarios
  - Taxonomy
  - Model transformation in Xtend
- Xtend: a case study for GPL/DSL, MDE, and model transformation
  - Advanced features: extension methods, active annotations, template expressions
  - Xtend: behing the magic (Xtext+MDE)
  - Xtend + Xtext (breathing life into DSLs)
  - @Aspect annotation

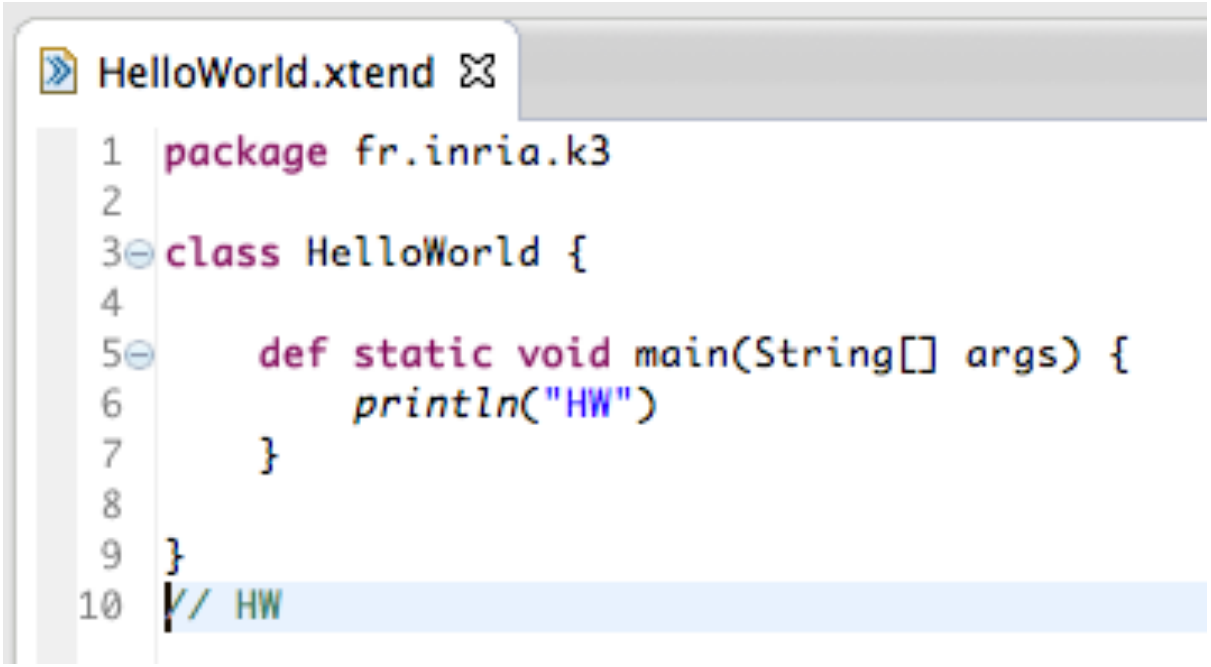
Contract

- Practical foundations of model management
- Model transformations
  - Model-to-Text
  - Model-to-Model
  - Metaprogramming
- DSLs and model management: all together (Xtext + Xtend)

Xtend

The Basics
(~ Java cheatsheet)

Hello World


HelloWorld.xtend
1 package fr.inria.k3
2
3 class HelloWorld {
4
5 def static void main(String[] args) {
6 println("HW")
7 }
8
9 }
10 // HW

Semi-colon is optional (within class, methods, etc.)

```
1  package fr.inria.k3.fields
2
3  class MyFielder {
4
5    int count = 1
6    static boolean debug = false
7    var name = 'Foo'            // type String is inferred
8    val UNIVERSAL_ANSWER = 42 // final field with inferred type int
9    // ...
10   public int count2 = 2 ;
11
12 }
13
```

Package Declaration

HelloWorld.xtend

```
1  package fr.inria.k3
2
3  class HelloWorld {
4
5      def static void main(String[] args) {
6          println("HW")
7      }
8
9  }
10 // HW
```

Semi-colon ‘;’ is optional

HelloWorld.xtend | HelloWorld.java | PackageExploder.xtend

```
1  package fr.inria.k3.^def
2
3  class PackageExploder {
4
5  }
```

‘^’ for avoiding keyword conflicts

Methods

```
1  package fr.inria.k3.methods
2
3  class FooMethod {
4
5      def foo1() {
6          "A"
7      }
8
9      def foo2() {
10         6 + 3
11     }
12
13     def private foo3() {
14         6 + 3
15     }
16
17     def public foo4() {
18         foo3() * 8
19     }
20 }
21
22 class FooMethodUses {
23
24     def fooUse() {
25         new FooMethod().foo1
26         new FooMethod().foo3()
27
28
29
30         new FooMethod().f
31
32
33     }
34
35 }
```

```
foo1 : String - FooMethod.foo1()
foo2 : int - FooMethod.foo2()
foo4 : int - FooMethod.foo4()
```

By default: visibility conditions set to public

HelloWorld.xtend

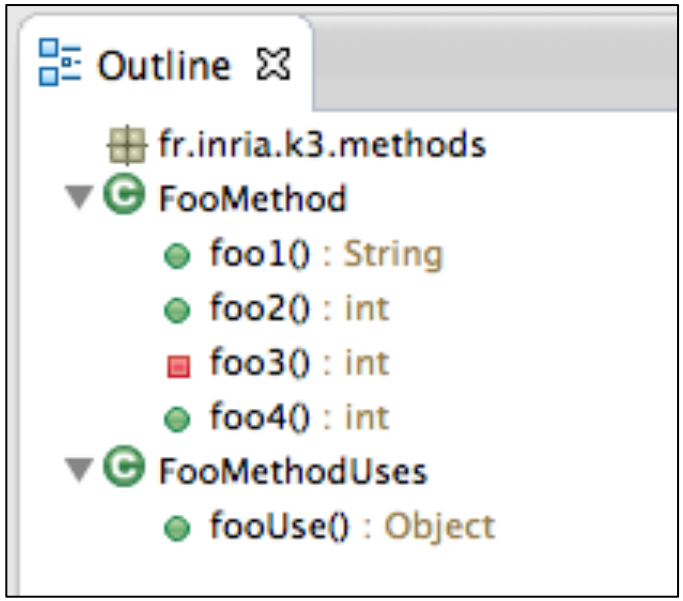
```
1  package fr.inria.k3
2
3  class HelloWorld {
4
5      def static void main(String[] args) {
6          println("HW")
7      }
8
9  }
10 // HW
```

Methods

```
1  package fr.inria.k3.methods
2
3  class FooMethod {
4
5      def foo1() {
6          "A"
7      }
8
9      def foo2() {
10         6 + 3
11     }
12
13     def private foo3() {
14         6 + 3
15     }
16
17     def public foo4() {
18         foo3() * 8
19     }
20 }
21
22 class FooMethodUses {
23
24     def fooUse() {
25         new FooMethod().foo1
26         new FooMethod().foo3()
27
28
29
30         new FooMethod().f
31
32
33     }
34
35 }
```

```
foo1 : String - FooMethod.foo1()
foo2 : int - FooMethod.foo2()
foo4 : int - FooMethod.foo4()
```

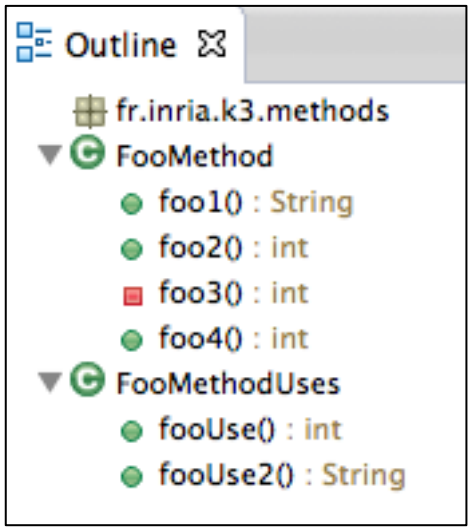
Type inference (return type)



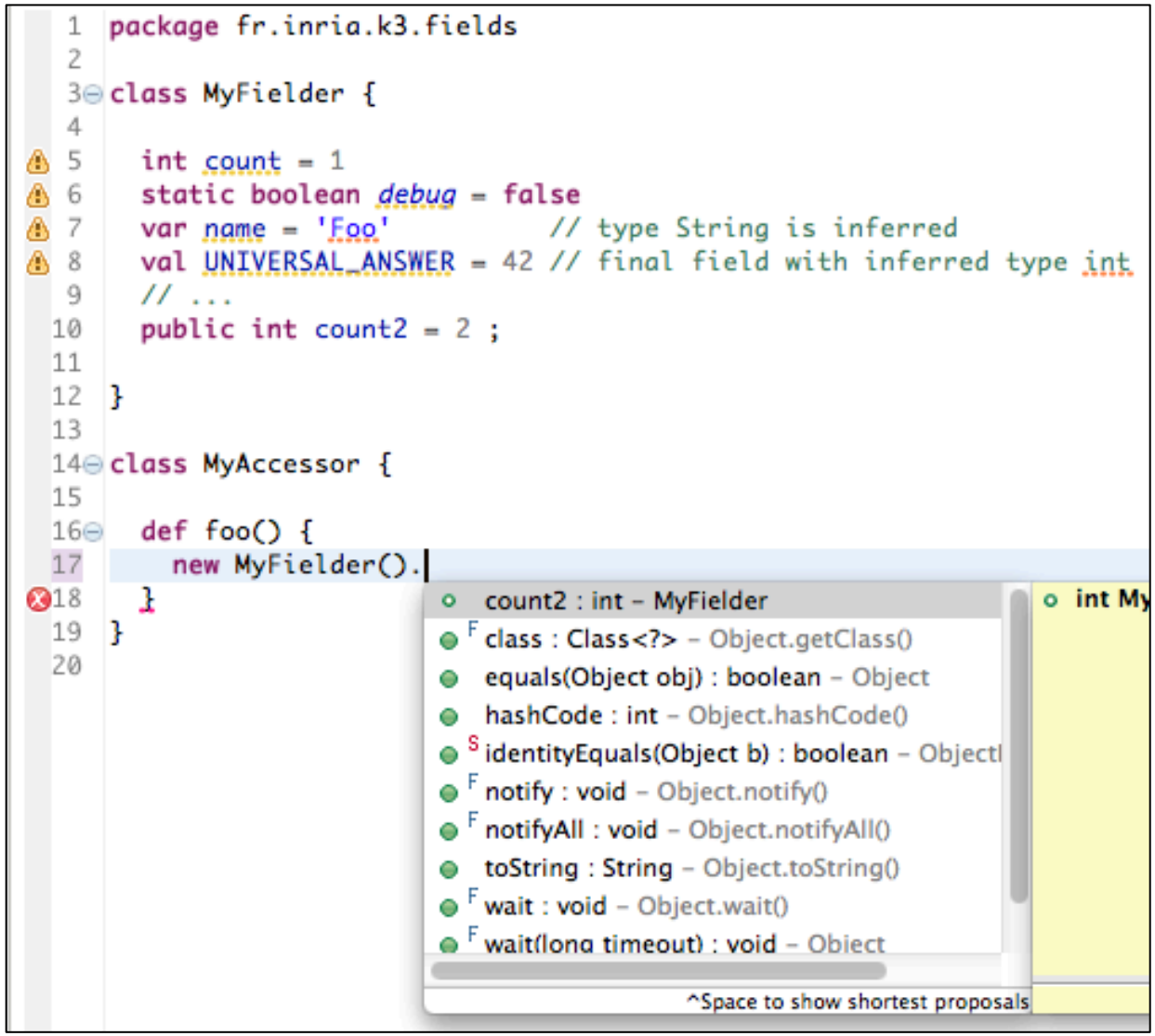
Method Calling

You can ommit parentheses

```
33    def fooUse2() {
34        3.toString
35        "4".length
36        new FooMethod().foo1
37        new FooMethod().foo1()
38        new FooMethod().foo1 + 3.toString
39
40    }
```



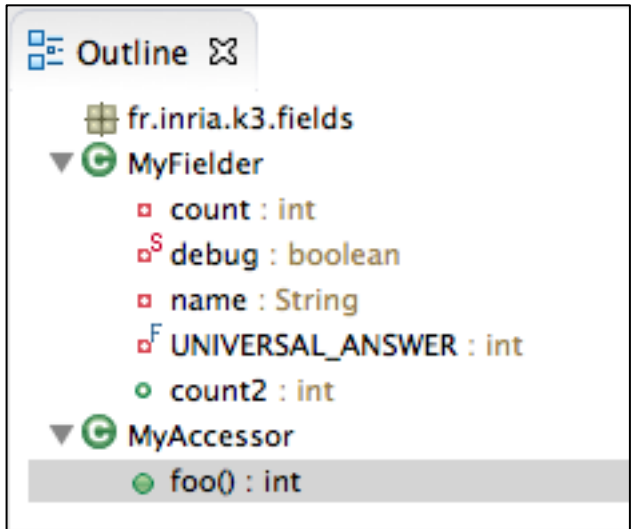
Fields



By default: visibility conditions set to private

Fields

```
1  package fr.inria.k3.fields
2
3  class MyFielder {
4
5    int count = 1
6    static boolean debug = false
7    var name = 'Foo'           // type String is inferred
8    val UNIVERSAL_ANSWER = 42 // final field with inferred type int
9    // ...
10   public int count2 = 2 ;
11
12 }
13
```



primitive types of Java (int, boolean, etc) with autoboxing

var: type inference

val: constant, « final » in Java

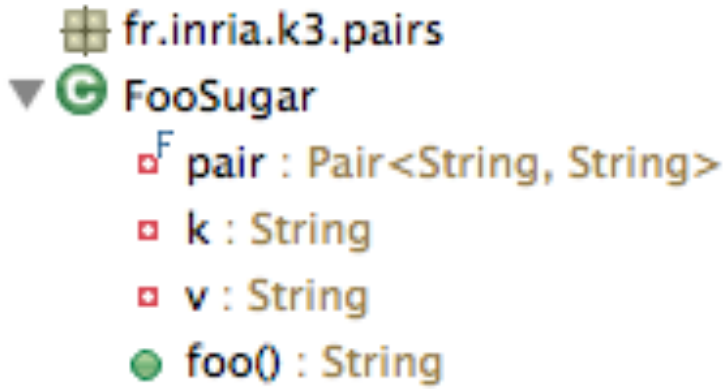
Static Methods (::)

```
1  package fr.inria.k3.stat
2
3  import java.util.Collections
4
5  class FooStati {
6
7
8      static var colors = newArrayList(46, 76, 89, 53)
9
10
11     def static void main(String... args) {
12         println("B " + colors)
13         Collections::sort(colors)
14         println("A " + colors)
15
16         colors.add(45)
17         println("A " + colors)
18
19     }
20 }
```

```
B [46, 76, 89, 53]
A [46, 53, 76, 89]
A [46, 53, 76, 89, 45]
```

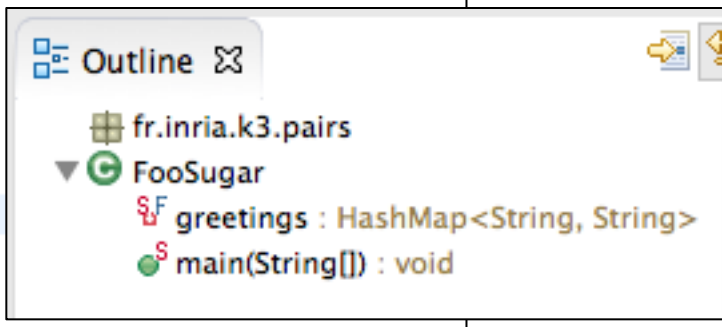
Pairs

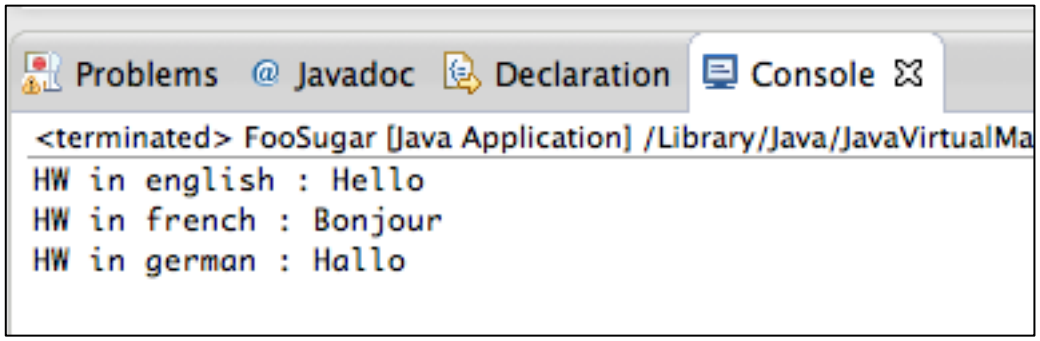
```
1  package fr.inria.k3.pairs
2
3  class FooSugar {
4
5      // syntactic sugar
6      val pair = "spain" -> "italy"
7      var k = pair.key
8      var v = pair.value
9
10     def foo() {
11
12         println("key=" + k + " value=" + v)
13
14     }
15 }
```



Pairs

```
1  package fr.inria.k3.pairs
2
3  class FooSugar {
4
5
6      static val greetings = newHashMap(
7      "german"  -> "Hallo",
8      "english" -> "Hello",
9      "french" -> "Bonjour"
10     )
11
12     def static main(String... args) {
13         greetings.forEach[key, value | println("HW in " + key + " : " + value)]
14
15     }
16 }
```





Immutable data structure

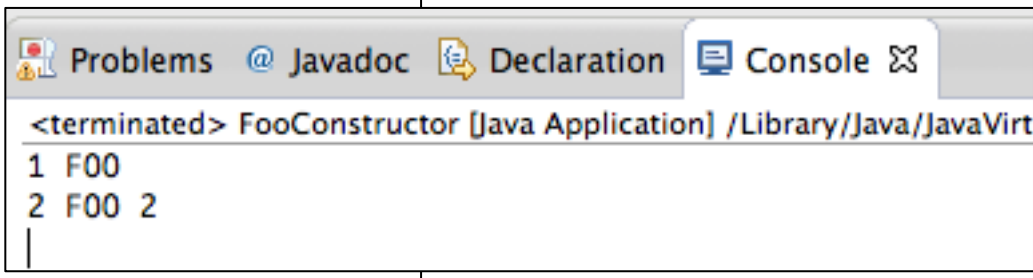
```
1  package fr.inria.k3.stat
2
3  import java.util.Collections
4
5  class FooStati {
6
7
8      static var colors = #[46, 76, 89, 53] // newArrayList(46, 76, 89, 53)
9
10
11     def static void main(String... args) {
12         println("B " + colors)
13         Collections::sort(colors)
14         println("A " + colors)
15
16         colors.add(45)
17         println("A " + colors)
18
19     }
20 }
```

```
<terminated> FooStati [Java Application] /Library/Java/JavaVirtualMachines/jdk1.7.0_13.jdk/Contents/H
B [46, 76, 89, 53]
Exception in thread "main" java.lang.UnsupportedOperationException
        at java.util.Collections$UnmodifiableList$1.set(Collections.java:1244)
        at java.util.Collections.sort(Collections.java:159)
        at fr.inria.k3.stat.FooStati.main(FooStati.java:15)
```

Constructor

Default visibility: public

```
1  package fr.inria.k3.classes
2
3  class FooConstructor {
4
5      var String l
6
7      new() {
8          this("FOO")
9      }
10
11     new (String v) {
12         l = v
13     }
14
15
16     override toString() {
17         l
18     }
19
20     def static void main (String... args) {
21         println("1 " + new FooConstructor())
22         println("2 " + new FooConstructor("FOO 2"))
23     }
24 }
```



override keyword: mandatory

Cast and Type

```
1  package fr.inria.k3.types
2
3  class FooTypes {
4
5      static val Object obj = "a string"
6      // static val String s = obj
7      static val String s = obj as String // cast
8
9      def static void main(String... args) {
10         println(typeof(String) + "") // String.class
11         println("\t" + s + "\n")
12
13     }
14 }
```

Extension Methods…

« … allow to add new methods to existing types without modifying them. »

```
def removeVowels (String s){
  s.replaceAll("[aeiouAEIOU]", "")
}
```

We can call this method either like in Java:

```
removeVowels("Hello")
```

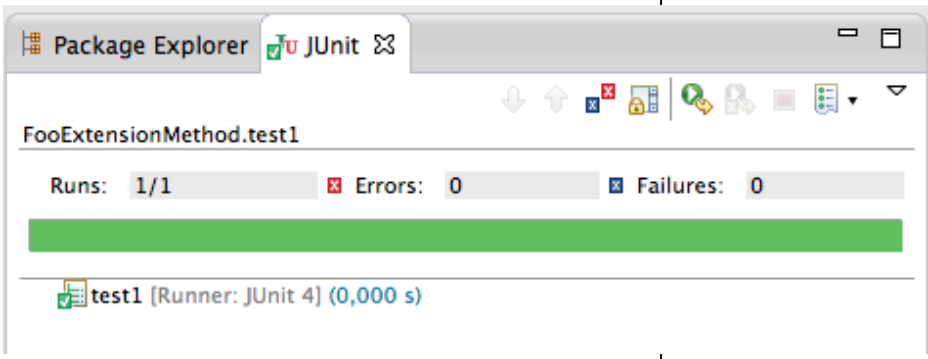
or as an extension method of String:

```
"Hello".removeVowels
```

The first parameter of a method can either be passed in after opening the parentheses or before the method call

Extension Method (local)

```
1  package fr.inria.k3.methods
2
3  import org.junit.Test
4  import static org.junit.Assert.*
5
6  class FooExtensionMethod {
7
8
9      def removeVowels (String s){
10         s.replaceAll("[aeiouAEIOU]", "")
11     }
12
13     def foo() {
14         "HelloWorld".removeVowels
15     }
16
17     @Test
18     def test1() {
19         assertEquals("HllWrld", new FooExtensionMethod().foo)
20     }
21 }
```



Extension Method (library)

```
1  package fr.inria.k3.methods
2
3  import org.junit.Test
4
5  import static org.junit.Assert.*
6
7  class FooExtensionLibrary {
8
9      var listOfStrings = #["A", "b", "c", "D", "e"]
10
11     def foo() {
12         var String h = "hello".toFirstUpper // calls StringExtensions.toFirstUpper(String)
13         listOfStrings.map[ toUpperCase ] // calls ListExtensions.<T, R>map(List<T> list, Function<? super T, ? extends R> mapFunction)
14
15     }
16
17     @Test
18     def test1() {
19         assertEquals("C", new FooExtensionLibrary().foo.get(2))
20     }
21 }
```

```
/**
 * Returns a list that performs the given {@code transformation} for each element of {@code original} when
 * requested. The mapping is done lazily. That is, subsequent iterations of the elements in the list will
 * repeatedly apply the transformation. The returned list is a transformed view of {@code original}; changes to
 * {@code original} will be reflected in the returned list and vice versa (e.g. invocations of {@link List#remove(int)}).
 *
 *
 * @param original
 *            the original list. May not be <code>null</code>.
 * @param transformation
 *            the transformation. May not be <code>null</code>.
 * @return a list that effectively contains the results of the transformation. Never <code>null</code>.
 */
@Pure
public static <T, R> List<R> map(List<T> original, Function1<? super T, ? extends R> transformation) {
    return Lists.transform(original, new FunctionDelegate<T, R>(transformation));
}
```

```
public class ListExtensions {
```

Extension Method (library)

```
1  package fr.inria.k3.methods
2
3  import org.junit.Test
4
5  import static org.junit.Assert.*
6
7  class FooExtensionLibrary {
8
9      var listOfStrings = #["A", "b", "c", "D", "e"]
10
11     def foo() {
12         var String h = "hello".toFirstUpper // calls StringExtensions.toFirstUpper(String)
13         listOfStrings.map[ toUpperCase ] // calls ListExtensions.<T, R>map(List<T> list, Function<? super T, ? extends R> mapFunction)
14
15     }
16
17     @Test
18     def test1() {
19         assertEquals("C", new FooExtensionLibrary().foo.get(2))
20     }
21 }
```

```
/**
 * Returns the {@link String} {@code s} with an {@link Character#isUpperCase(char) upper case} first character. This
 * function is null-safe.
 *
 * @param s
 *            the string that should get an upper case first character. May be <code>null</code>.
 * @return the {@link String} {@code s} with an upper case first character or <code>null</code> if the input
 *         {@link String} {@code s} was <code>null</code>.
 */
@Pure
public static String toFirstUpper(String s) {
    if (s == null || s.length() == 0)
        return s;
    if (Character.isUpperCase(s.charAt(0)))
        return s;
    if (s.length() == 1)
        return s.toUpperCase();
    return s.substring(0, 1).toUpperCase() + s.substring(1);
}
```

```
public class StringExtensions {
```

Lambda Expression
(Java 8 will support it)

Anonymous classes can be found everywhere in Java code…

```
1.  // Java Code!
2.  final JTextField textField = new JTextField();
3.  textField.addActionListener(new ActionListener() {
4.    @Override
5.    public void actionPerformed(ActionEvent e) {
6.      textField.setText("Something happened!");
7.    }
8.  });
```

… And have always been the poor-man's replacement for lambda expressions in Java.

Lambda Expression
(Xtend answer)

Anonymous classes can be found everywhere in Java code…

```
1.  // Java Code!
2.  final JTextField textField = new JTextField();
3.  textField.addActionListener(new ActionListener() {
4.    @Override
5.    public void actionPerformed(ActionEvent e) {
6.      textField.setText("Something happened!");
7.    }
8.  });
```

No need to specify the type for e

```
1.  textField.addActionListener([ e |
2.    textField.text = "Something happened!"
3.  ])
```

You can even ommit e

```
1.  textField.addActionListener([
2.    textField.text = "Something happened!"
3.  ])
```

Lambda Expression

(Xtend answer, more impressive examples)

```
1.  Collections.sort(someStrings) [ a, b |
2.    a.length - b.length
3.  ]
```

Java 8:

```
shapes.forEach(s -> { s.setColor(RED); });
```

Xtend:

```
shapes.forEach[color = RED]
```

Java 8:

```
shapes.stream()
      .filter(s -> s.getColor() == BLUE)
      .forEach(s -> { s.setColor(RED); });
```

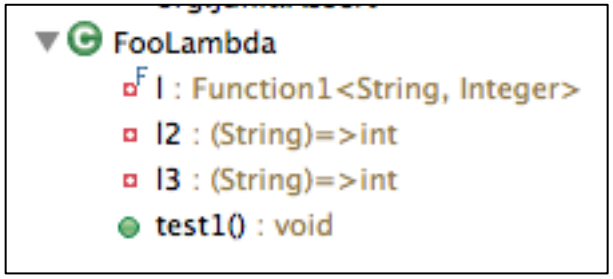
Xtend:

```
shapes.stream
      .filter[color == BLUE]
      .forEach[color = RED]
```

Lambda Expression

(Xtend answer, more impressive examples)

```
class FooLambda {

    val l = [String s | s.length]
    var (String)=>int l2 = [it.length] // it is a keyword for refering to the first parameter
    var (String)=>int l3 = [length] // we can even ommit it or the first parameter

    @Test
    def test1() {
        assertEquals(l.apply ("RRRR"), l2.apply("PPPP"))
        assertEquals(l2.apply ("RRRR"), l3.apply("PPPP"))
    }
}
```

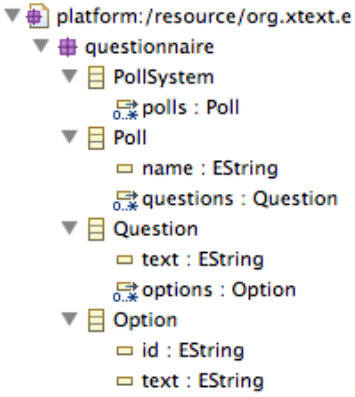


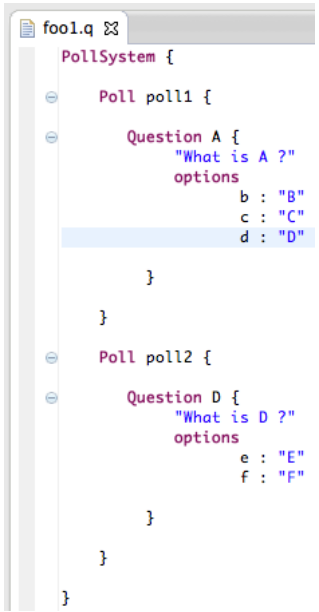
Templates

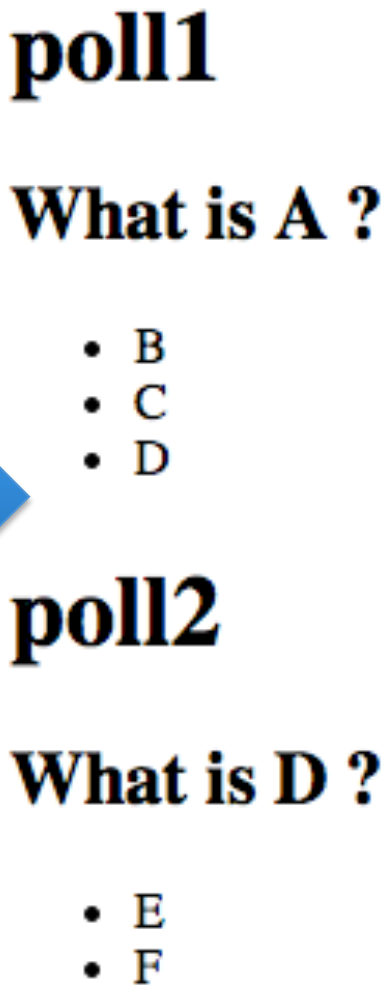
```
1  package fr.inria.k3.templates
2
3  import org.junit.Test
4  import static org.junit.Assert.*
5
6  class FooTempl {
7
8
9      def someHTML(String content) '''<html><body>«content»</body></html>'''
10
11
12     @Test
13     def test1() {
14         assertEquals("<html><body>HW</body></html>", someHTML('HW').toString)
15     }
16
17 }
```

Templates (2)

```
@Test
def test2() {

// loading
var pollS = loadPollSystem(URI.createURI("foo1.q"))

// MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
var html = toPolls(pollS.polls)
assertNotNull(html)

// serializing (note: we could type check the HTML
// with Xtext by specifying the grammar for instance)
val fw = new FileWriter("foo1.html")
fw.write(html.toString)
fw.close


}

def toPolls(List<Poll> polls) '''
  <html>
    <body>
      «FOR p : polls»
        «IF p.name != null»
          <h1>«p.name»</h1>
        «ENDIF»
        «FOR q : p.questions»
        <p>
            <h2>«q.text»</h2>
            <ul>
             «FOR o : q.options»
             <li>«o.text»</li>
             «ENDFOR»
            </ul>
        </p>
        «ENDFOR»
      «ENDFOR»
    </body>
  </html>
'''
```







Templates (3)

- You already experiment with web templating engines (JSP, Scala templates in Play!, Symfony templates, etc.)

```
    <h1>Exemple de page JSP</h1>
    <%-- Impression de variables --%>
    <p>Au moment de l'exécution de ce script, nous sommes le <%= date %>.</p>
    <p>Cette page a été affichée <%= nombreVisites %> fois !</p>
  </body>
</html>
```

- Alternatives exist in the modeling world
  - Multiple pre-defined and customizables generators

- Xtend: seamless integration into a general purpose language

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
```

Xtend to Java (2)

more after

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
```

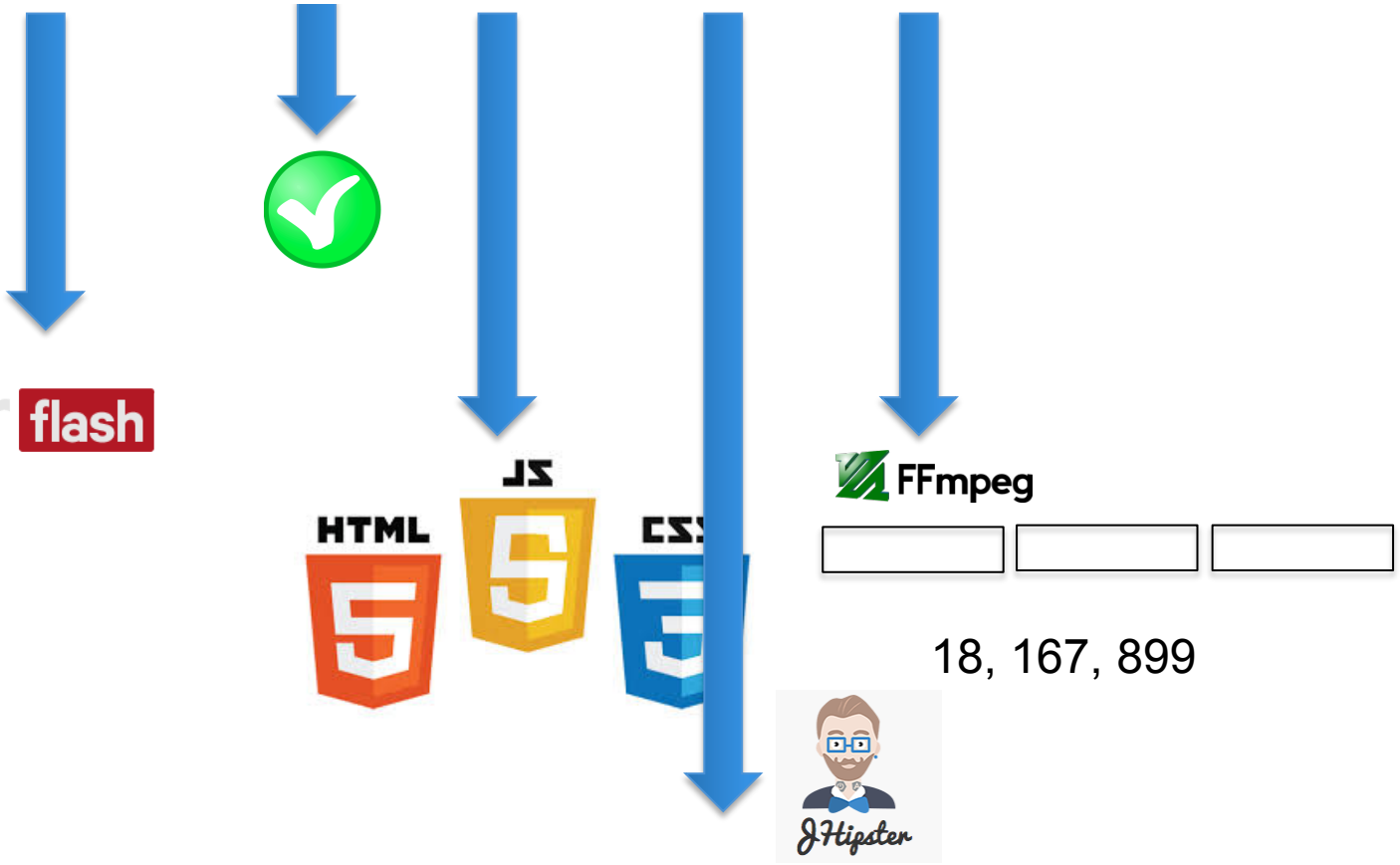
```
package org.eclipse.xtext.xbase.lib;

import com.google.common.annotations.GwtCompatible;

/**
 * Utilities to print information to the console.
 *
 * @author Sven Efftinge - Initial contribution and API
 */
@GwtCompatible public class InputOutput {

    /**
     * Prints a newline to standard out, by delegating directly to <code>System.out.println()</code>
     * @since 2.3
     */
    public static void println() {
        System.out.println();
    }
    /**
     * Prints the given {@code object} to {@link System#out System.out} and terminate the line. Useful to log partial
     * expressions to trap errors, e.g. the following is possible: <code>println(1 + println(2)) + 3</code>
     *
     * @param object
     *            the to-be-printed object
     * @return the printed object.
     */
    public static <T> T println(T object) {
        System.out.println(object);
        return object;
    }
```

Xtend/Xtext

Back to our scenarios

foo1.videogen

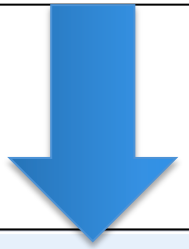
```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```



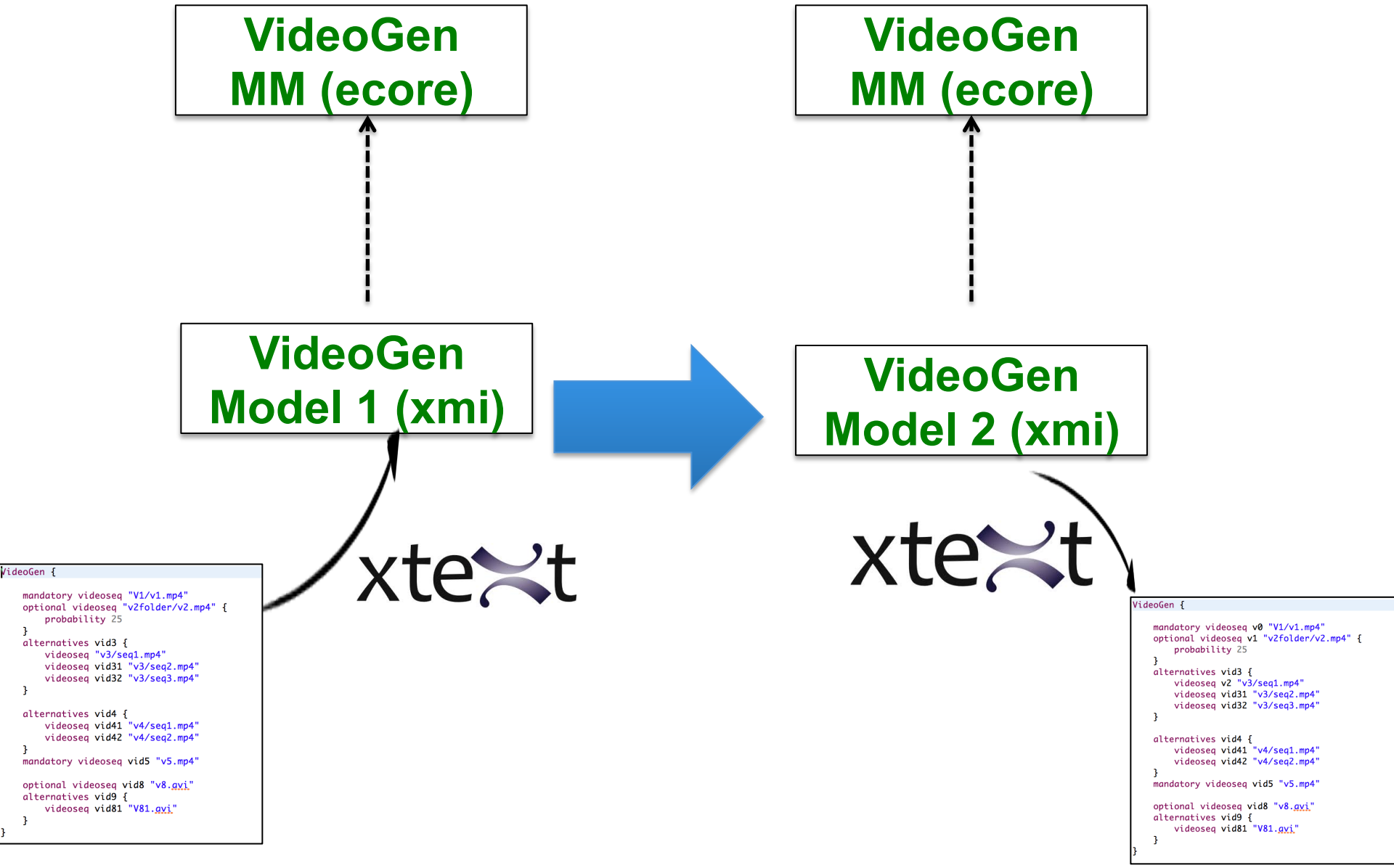
Refactoring

```
def loadVideoGenerator(URI uri) {
    new VideoGenStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as VideoGeneratorModel
}

def saveVideoGenerator(URI uri, VideoGeneratorModel pollS) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(pollS);
    rs.save(new HashMap());
}

@Test
def test1() {
    // loading
    var videoGen = loadVideoGenerator(URI.createURI("foo2.videogen"))
    assertNotNull(videoGen)
    assertEquals(3, videoGen.videoseqs.size)
    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    videoGen.videoseqs.forEach[videoseq |
        if (videoseq instanceof MandatoryVideoSeq) {
            val desc = (videoseq as MandatoryVideoSeq).description
            if(desc.videoid.isNullOrEmpty)  desc.videoid = genID()
        }
        else if (videoseq instanceof OptionalVideoSeq) {
            val desc = (videoseq as OptionalVideoSeq).description
            if(desc.videoid.isNullOrEmpty) desc.videoid = genID()
        }
        else {
            val altvid = (videoseq as AlternativeVideoSeq)
            if(altvid.videoid.isNullOrEmpty) altvid.videoid = genID()
            for (vdesc : altvid.videodescs) {
                if(vdesc.videoid.isNullOrEmpty) vdesc.videoid = genID()
            }
        }
    ]
// serializing
saveVideoGenerator(URI.createURI("foo2bis.xmi"), videoGen)
saveVideoGenerator(URI.createURI("foo2bis.videogen"), videoGen)
```

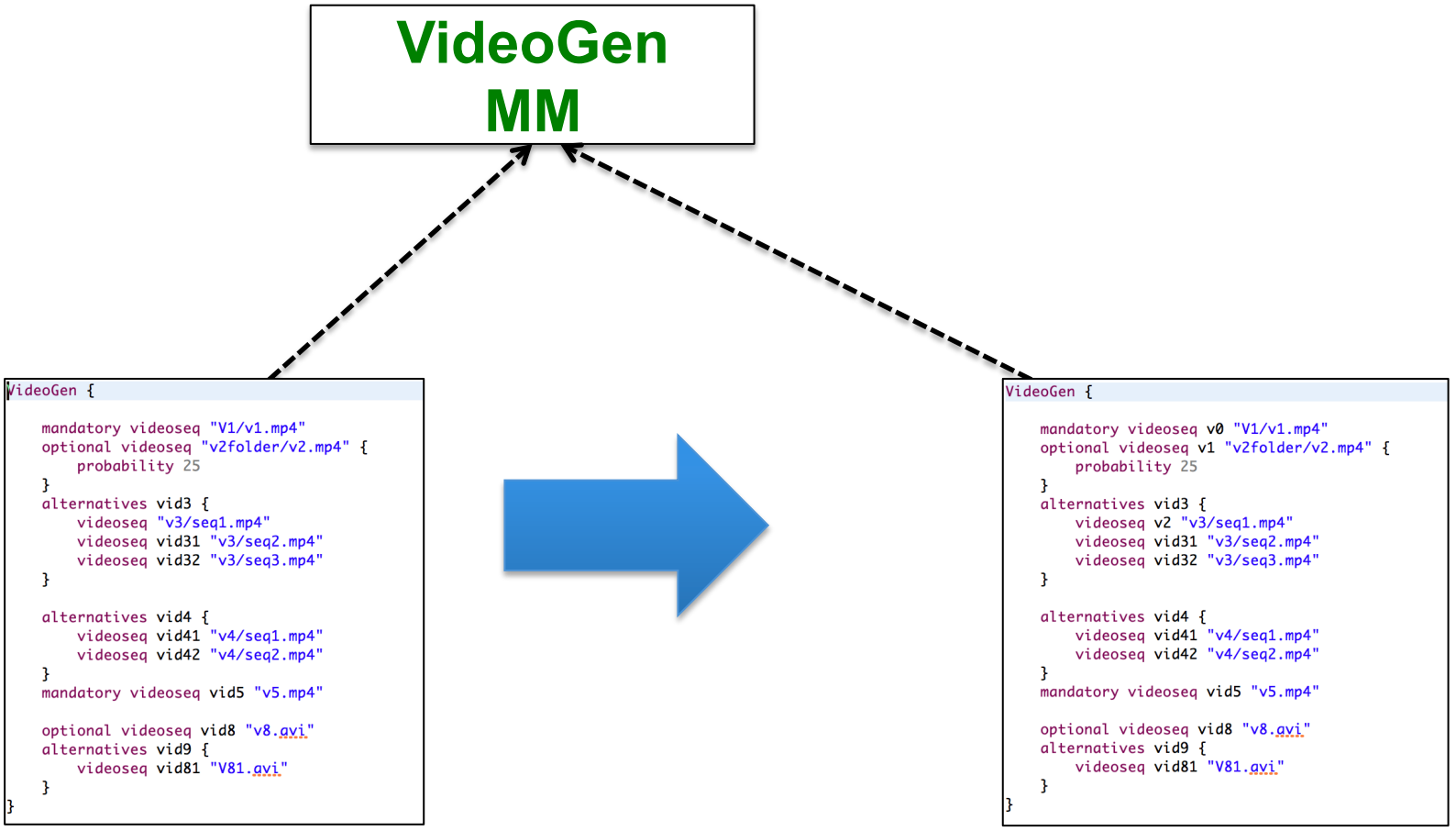
```
VideoGen {

    mandatory videoseq "V1/v1.mp4"
    optional videoseq "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```



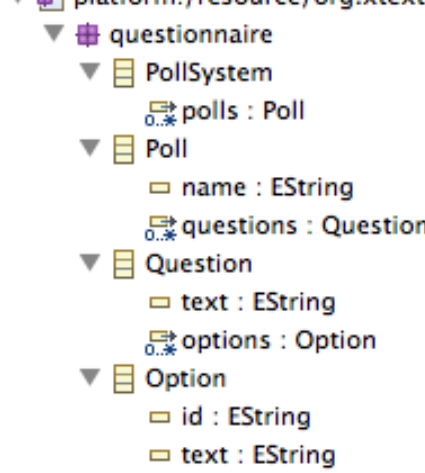
```
VideoGen {

    mandatory videoseq v0 "V1/v1.mp4"
    optional videoseq v1 "v2folder/v2.mp4" {
        probability 25
    }
    alternatives vid3 {
        videoseq v2 "v3/seq1.mp4"
        videoseq vid31 "v3/seq2.mp4"
        videoseq vid32 "v3/seq3.mp4"
    }

    alternatives vid4 {
        videoseq vid41 "v4/seq1.mp4"
        videoseq vid42 "v4/seq2.mp4"
    }
    mandatory videoseq vid5 "v5.mp4"

    optional videoseq vid8 "v8.avi"
    alternatives vid9 {
        videoseq vid81 "V81.avi"
    }
}
```


VideoGen
MM (ecore)
VideoGen
MM (ecore)
VideoGen
Model 1 (xmi)
VideoGen
Model 2 (xmi)
xtext
xtext
VideoGen {
mandatory videoseq "V1/v1.mp4"
optional videoseq "v2folder/v2.mp4" {
probability 25
}
alternatives vid3 {
videoseq "v3/seq1.mp4"
videoseq vid31 "v3/seq2.mp4"
videoseq vid32 "v3/seq3.mp4"
}
alternatives vid4 {
videoseq vid41 "v4/seq1.mp4"
videoseq vid42 "v4/seq2.mp4"
}
mandatory videoseq vid5 "v5.mp4"
optional videoseq vid8 "v8.avi"
alternatives vid9 {
videoseq vid81 "V81.avi"
}
}
VideoGen {
mandatory videoseq v0 "V1/v1.mp4"
optional videoseq v1 "v2folder/v2.mp4" {
probability 25
}
alternatives vid3 {
videoseq v2 "v3/seq1.mp4"
videoseq vid31 "v3/seq2.mp4"
videoseq vid32 "v3/seq3.mp4"
}
alternatives vid4 {
videoseq vid41 "v4/seq1.mp4"
videoseq vid42 "v4/seq2.mp4"
}
mandatory videoseq vid5 "v5.mp4"
optional videoseq vid8 "v8.avi"
alternatives vid9 {
videoseq vid81 "V81.avi"
}
}

Endogeneous Transformation



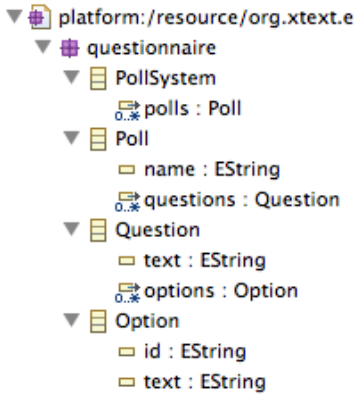
```
def loadPollSystem(URI uri) {
    new QuestionnaireStandaloneSetupGenerated().createInjectorAndDoEMFRegistration()
    var res = new ResourceSetImpl().getResource(uri, true);
    res.contents.get(0) as PollSystem
}

def savePollSystem(URI uri, PollSystem pollS) {
    var Resource rs = new ResourceSetImpl().createResource(uri);
    rs.getContents.add(pollS);
    rs.save(new HashMap());
}

@Test
def test1() {

    // loading
    var pollS = loadPollSystem(URI.createURI("foo1.q"))
    assertNotNull(pollS)
    assertEquals(2, pollS.polls.size)

    // MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
    pollS.polls.forEach[p | p.name = p.name + "_poll"]

    // serializing
    savePollSystem(URI.createURI("foo2.q"), pollS)

}
```

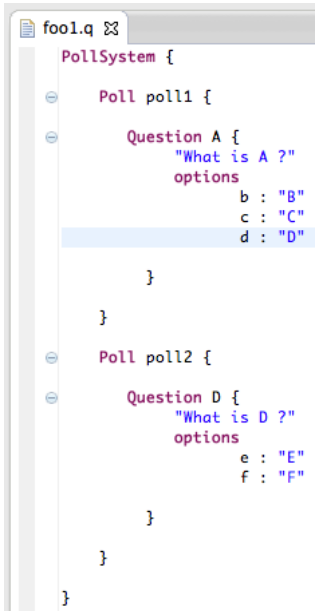


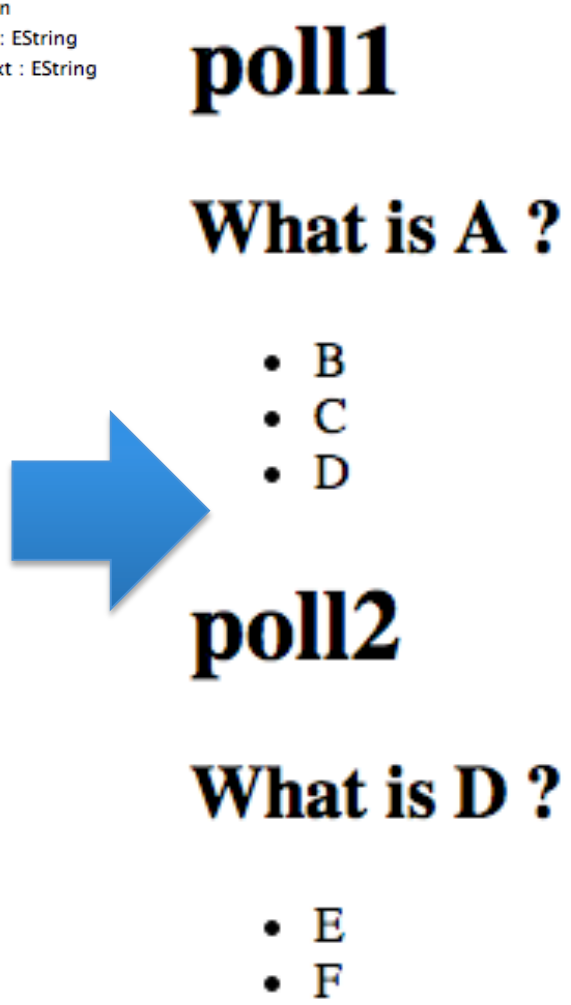
Templates

```
1  package fr.inria.k3.templates
2
3  import org.junit.Test
4  import static org.junit.Assert.*
5
6  class FooTempl {
7
8
9      def someHTML(String content) '''<html><body>«content»</body></html>'''
10
11
12     @Test
13     def test1() {
14         assertEquals("<html><body>HW</body></html>", someHTML('HW').toString)
15     }
16
17 }
```

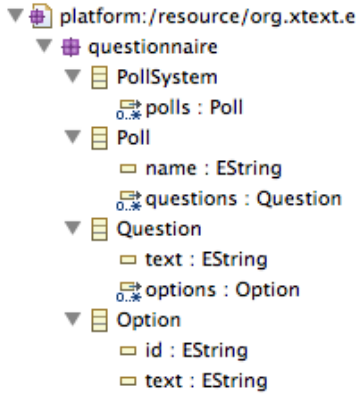
```
@Test
def test2() {

// loading
var pollS = loadPollSystem(URI.createURI("foo1.q"))

// MODEL MANAGEMENT (ANALYSIS, TRANSFORMATION)
var html = toPolls(pollS.polls)
assertNotNull(html)

// serializing (note: we could type check the HTML
// with Xtext by specifying the grammar for instance)
val fw = new FileWriter("foo1.html")
fw.write(html.toString)
fw.close


}

def toPolls(List<Poll> polls) '''
  <html>
    <body>
      «FOR p : polls»
        «IF p.name != null»
          <h1>«p.name»</h1>
        «ENDIF»
        «FOR q : p.questions»
        <p>
            <h2>«q.text»</h2>
            <ul>
             «FOR o : q.options»
             <li>«o.text»</li>
             «ENDFOR»
            </ul>
        </p>
        «ENDFOR»
      «ENDFOR»
    </body>
  </html>
'''
```





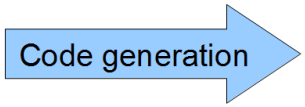


Facilities to create objects in a programmatic way



Ecore Model

Java Code



EPackage
EClass
EAttribute
EReference

Package
Class
Attribute
Reference

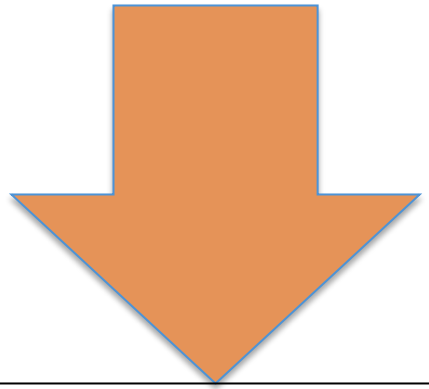
```
@Test
def test2() {

    var pollSystem = QuestionnaireFactory.eINSTANCE.createPollSystem ;
    var p1 = QuestionnaireFactory.eINSTANCE.createPoll() ;
    p1.setName("p1");
    pollSystem.polls.add(p1)
    //
```

Lab Sessions

Overview

foo1.videogen

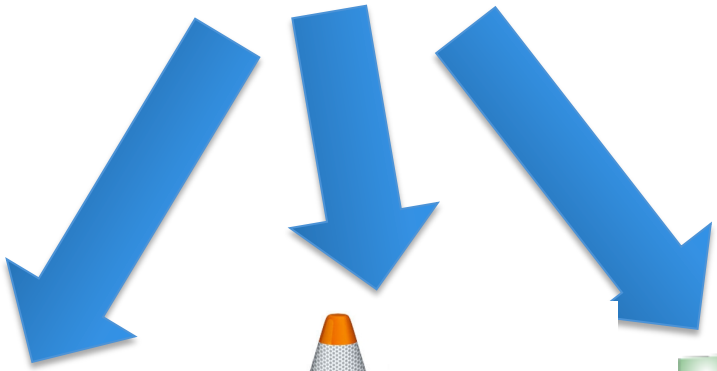
```
mandatory videoseq v1 "https://www.youtube.com/watch?v=PJNi1uYhV5w"
optional videoseq v2 "v2folder/v2.mp4"
alternatives v3 {
    videoseq v31 "v3/seq1.mp4"
    videoseq v32 "v3/seq1.mp4"
    videoseq v33 "v3/seq1.mp4"
}

alternatives v4 {
    videoseq v41 "v4/seq1.mp4"
    videoseq v42 "v4/seq1.mp4"
}
mandatory videoseq v5 "https://www.youtube.com/watch?v=ezKx-S0LiNQ"
```



model-to-model

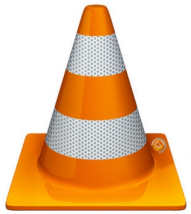
playlist metamodel

playlist model



model-to-text

flowplayer flash



FFmpeg

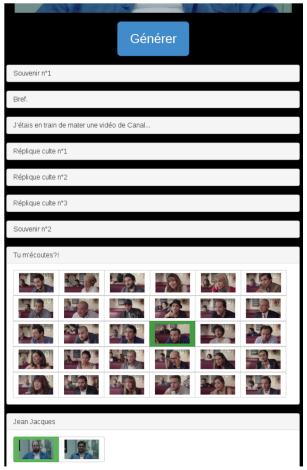
foo1.videogen

```
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"
```

model-to-*

FFmpeg

Thumbnails (vignettes) of each video sequence (e.g., PGN format)

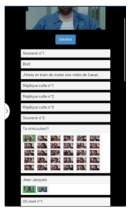


foo1.videogen

```
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"
```

Website/online

- **Random generation**
- **Configurator**
- **Game**
- **…**



Xtend

Advanced features (active annotation)
Model transformation in depth
MDE enables Xtend

http://www.eclipse.org/xtend/documentation.html
http://jnario.org/org/jnario/jnario/documentation/20FactsAboutXtendSpec.html
http://blog.efftinge.de/2012/12/java-8-vs-xtend.html
http://eclipsesource.com/blogs/tutorials/emf-tutorial/

Xtext.xtext?