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WEB3D 2012 - 17th International Conference
on 3D Web Technology

Model-Driven Iterative Development of 3D Web-Applications Using SSIML, X3D and JavaScript

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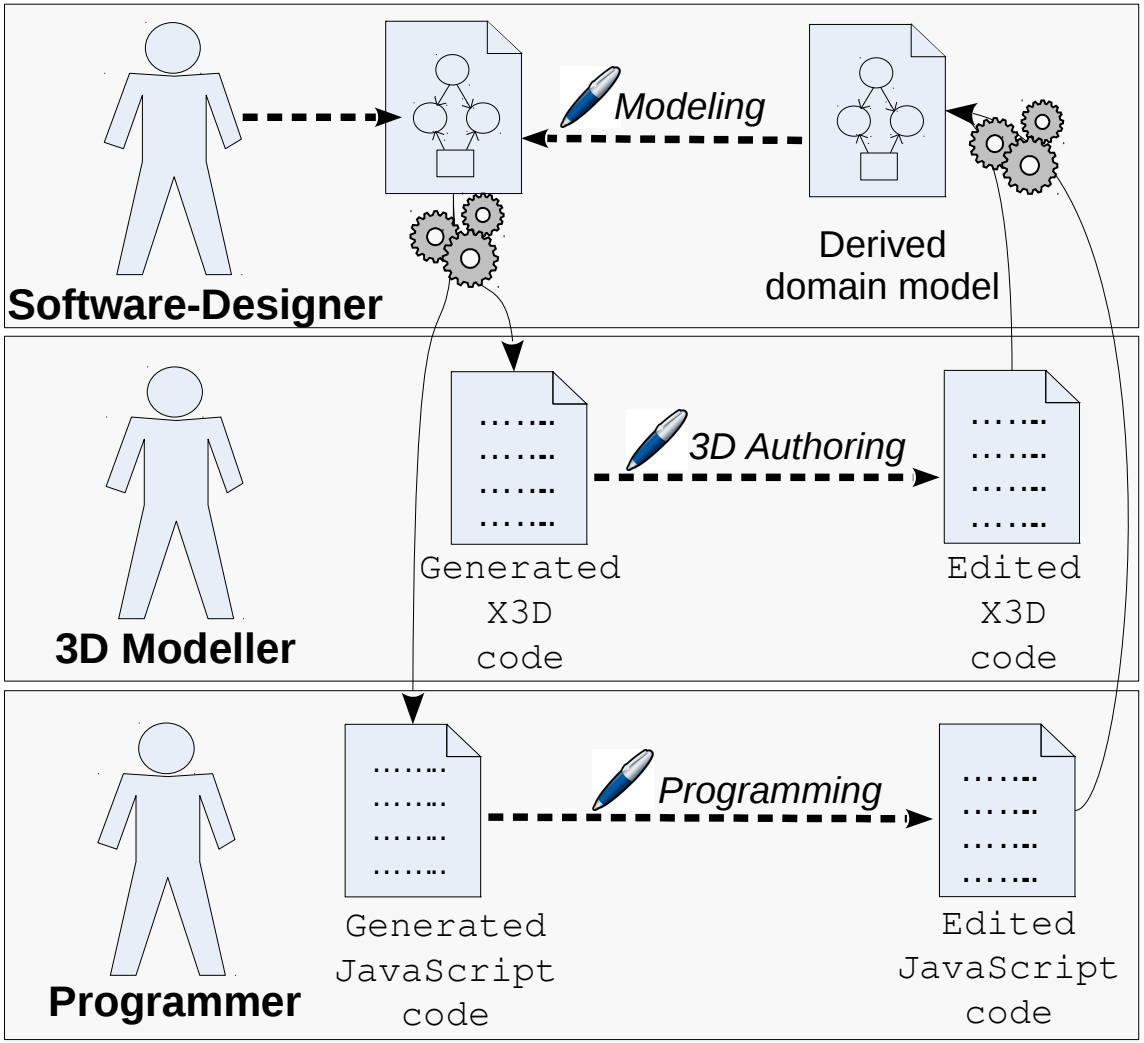
1.1 Preliminaries: Motivation

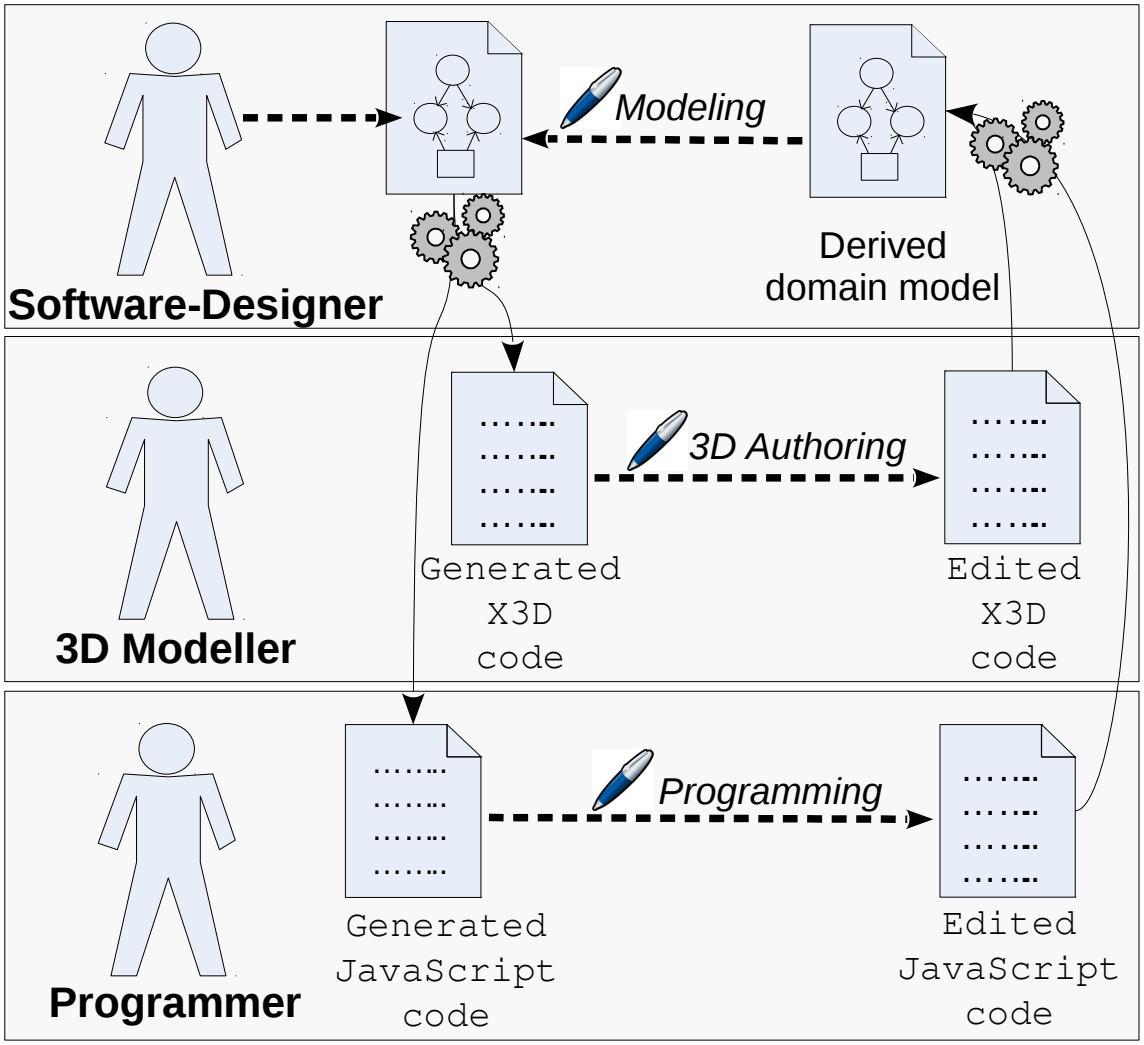
- **Application logic** and **3D content** → **two** different developer groups: 3D modelers, programmers
- E. g. X3D and JavaScript
- Traditionally: code-centric and **iterative** development



1.1 Preliminaries: Motivation

- **Iterative** development
- Improvements with **model-driven** engineering [1] :
  - communication aid
  - contract
  - code generation
  - ➔ **concurrent development**

→ **Round-trip engineering** [2]



$\sum$

Forward engineering

Reverse engineering

Preserve modifications

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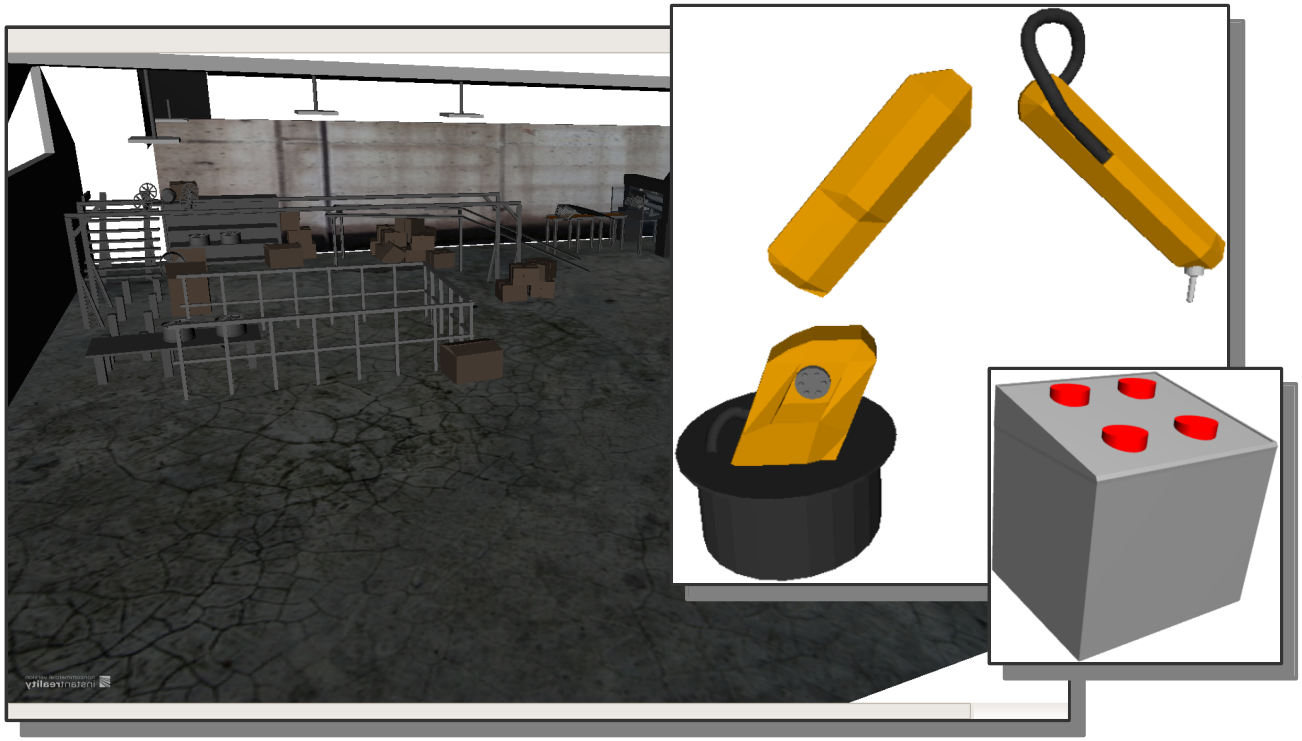
1.2 Preliminaries: Running example

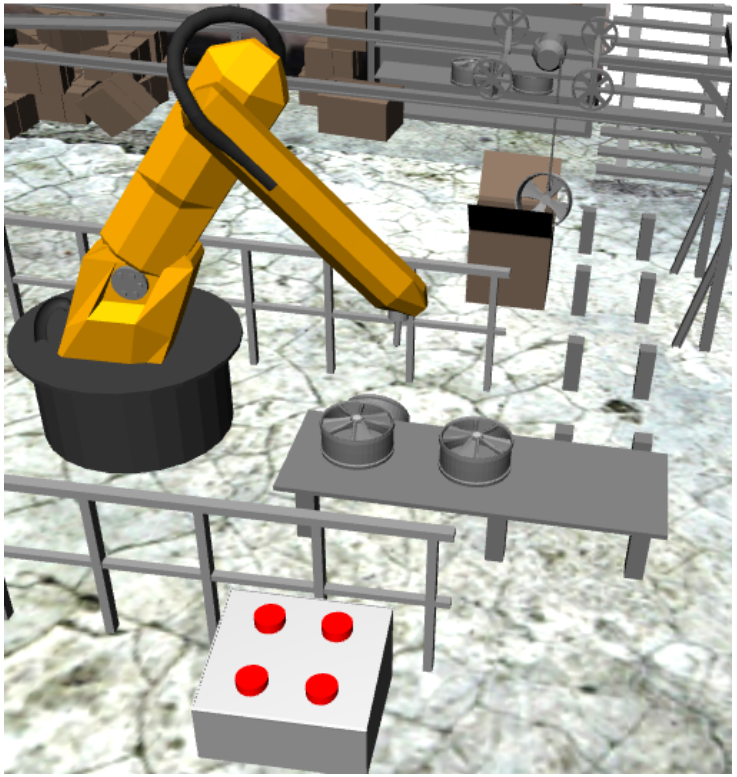
- **3D content** and **application code** → multiple target languages (TL): X3D/ X3DOM, JavaScript
- Example application:

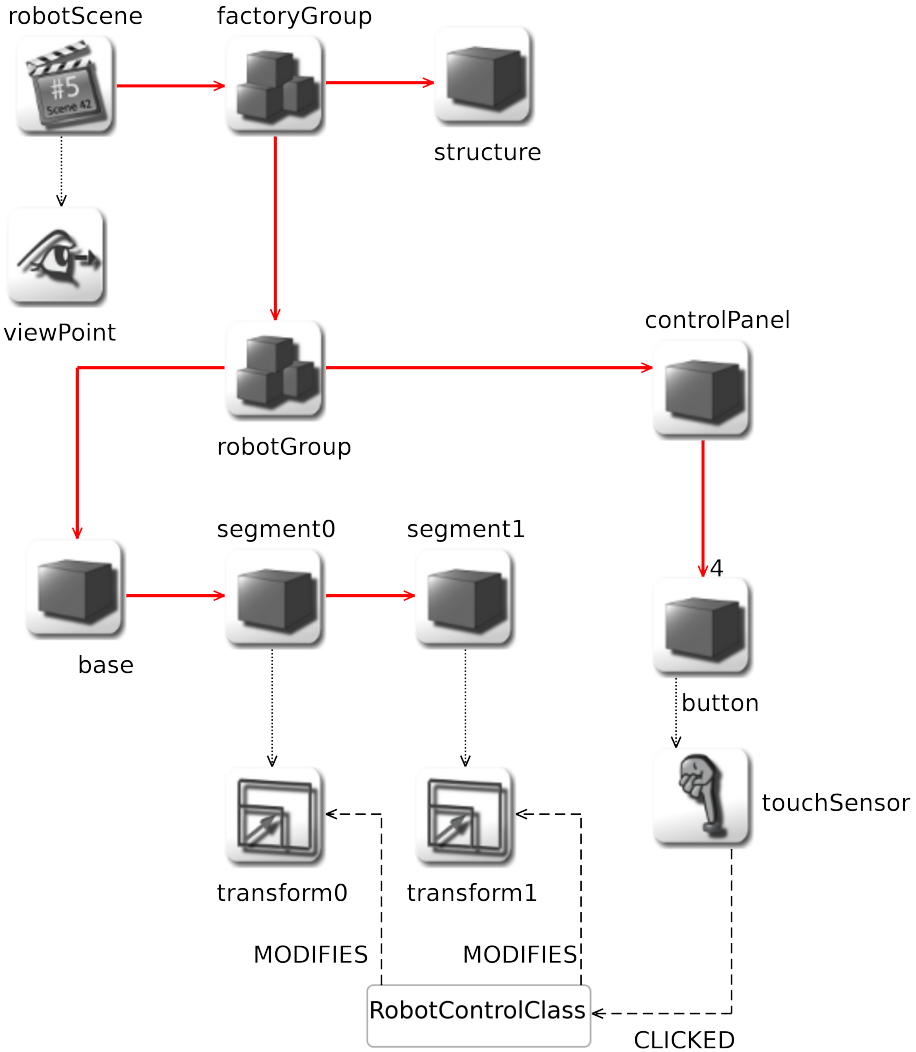


```
window.onload = init;

function RobotControlClass( ) {
    var transform1 = document.querySelector( '[DE
    var transform0 = document.querySelector( '[DE

    this.button0_CLICKED = function( obj ) {
        var rot = transform0.getAttribute("rotati
        var angle = parseFloat(rot.split(" ")[3],
        angle += 0.04;
        transform0.setAttribute("rotation", "1 0
    }
    this.button1_CLICKED = function( obj ) {
    var angle = parseFloat(transform0.getAttribut
        angle -= 0.04;
        transform0.setAttribute("rotation", "1 0
    }
    this.button2_CLICKED = function( obj ) {
        var angle = parseFloat(transform1.getAttr
        angle += 0.04;
        transform1.setAttribute("rotation", "1 0
    }

    this.button3_CLICKED = function( obj ) {
        var angle = parseFloat(transform1.getAttr
        angle -= 0.04;
        transform1.setAttribute("rotation", "1 0
    }
```

1.2 Preliminaries: MDE for 3D applications

- Graphical domain specific language: SSIML (*Scene Structure and Integration Modeling Language*) [1]
- **Scene graph** and **application components** at high grade of abstraction





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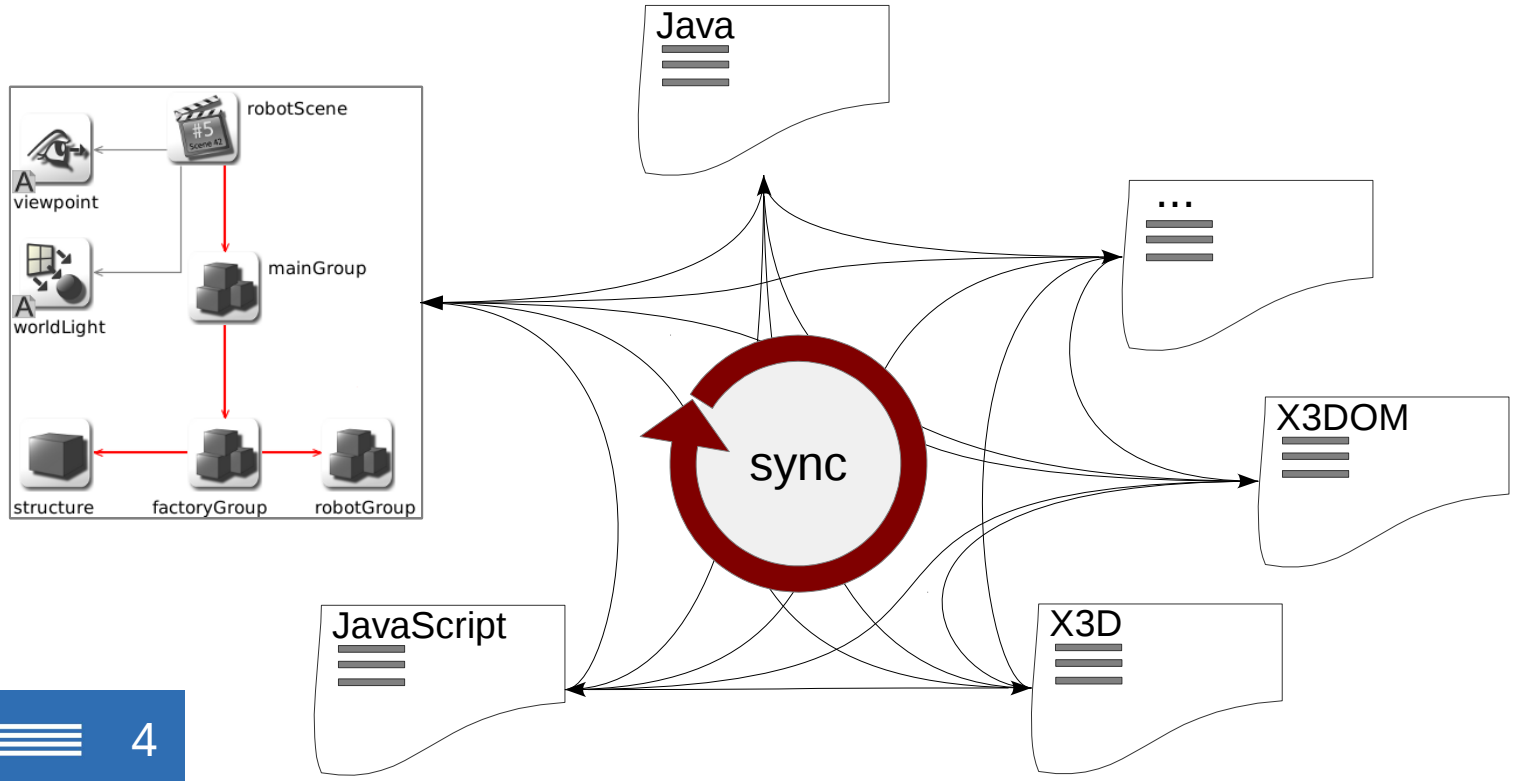
2.1 Roundtrip3D: Requirements

- Different **granularity** of model and code
- **Heterogeneous** target languages with different **scope**
- Common methods in RTE tools:
  - Model and code **stored separately**
  - Model **derived** from source code

➔ **Synchronization issue** between code bases and model



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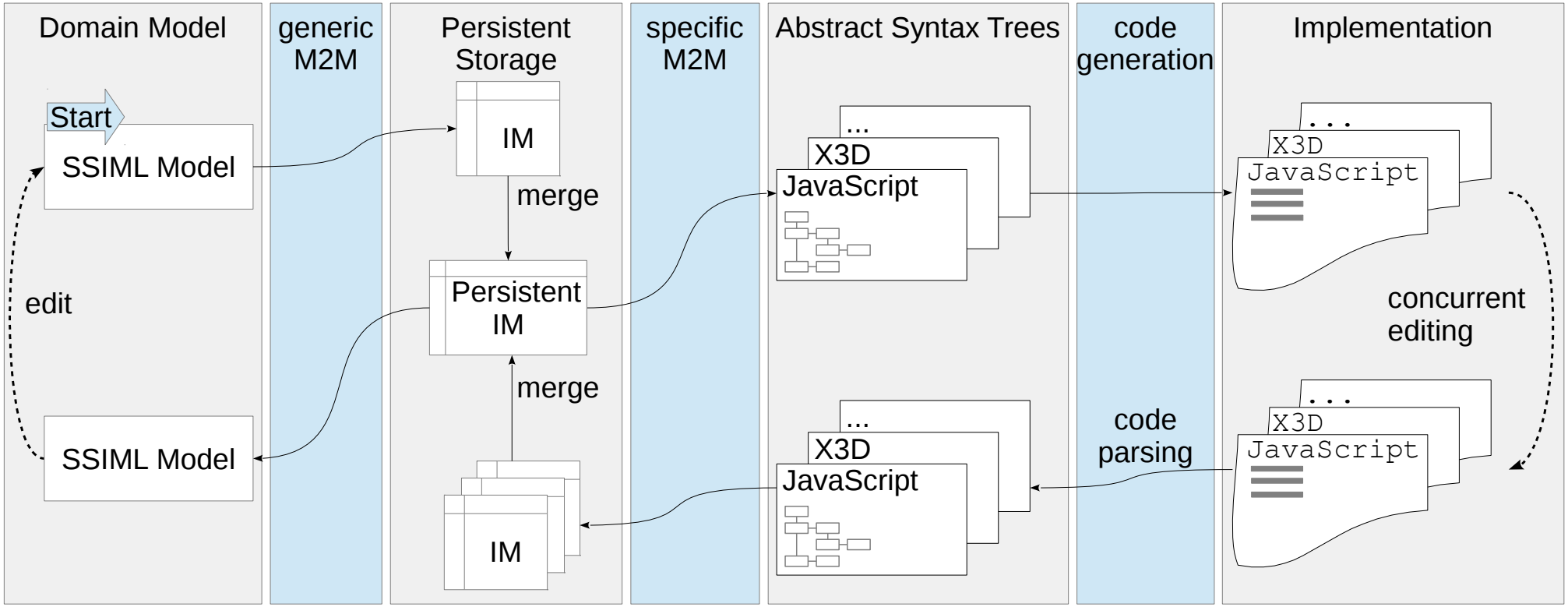
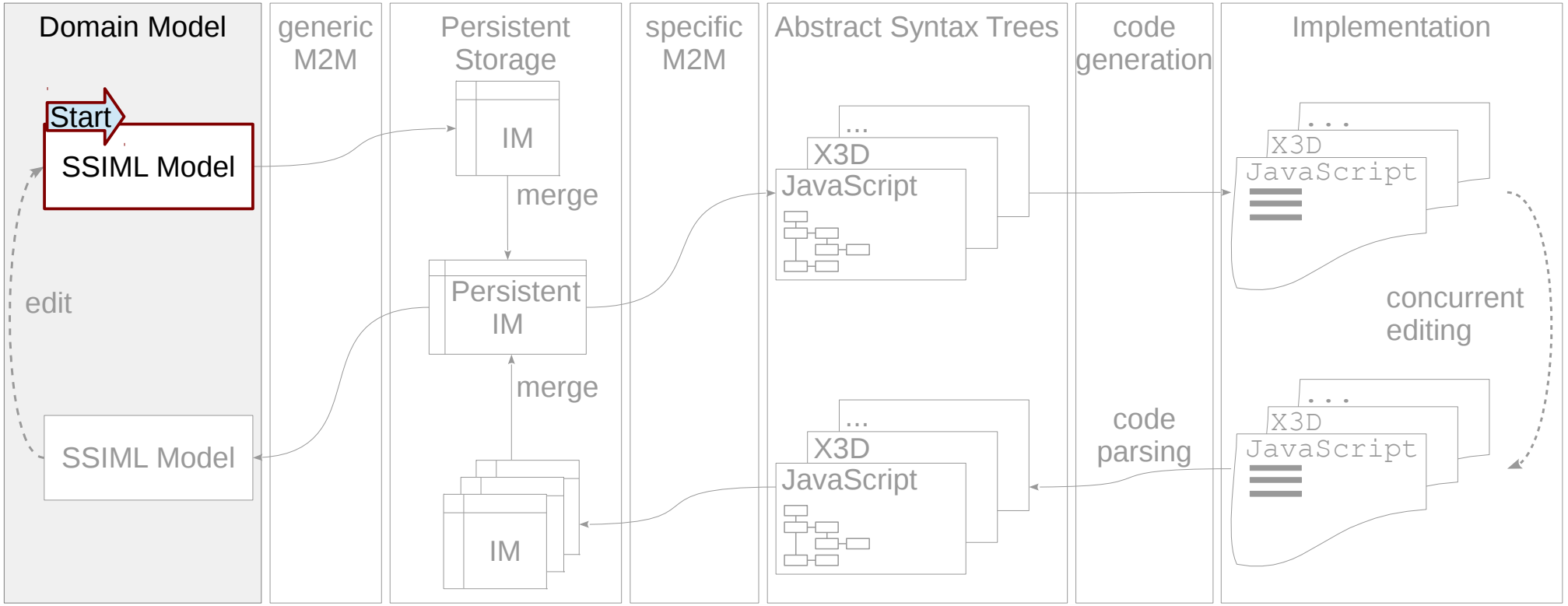
2.2 Roundtrip3D: Overview RTE Approach

- One common **intermediate** representation for languages and model
- Managable transformations:
  - **Multi-tiered** approach
    - **Task specific** transformation languages



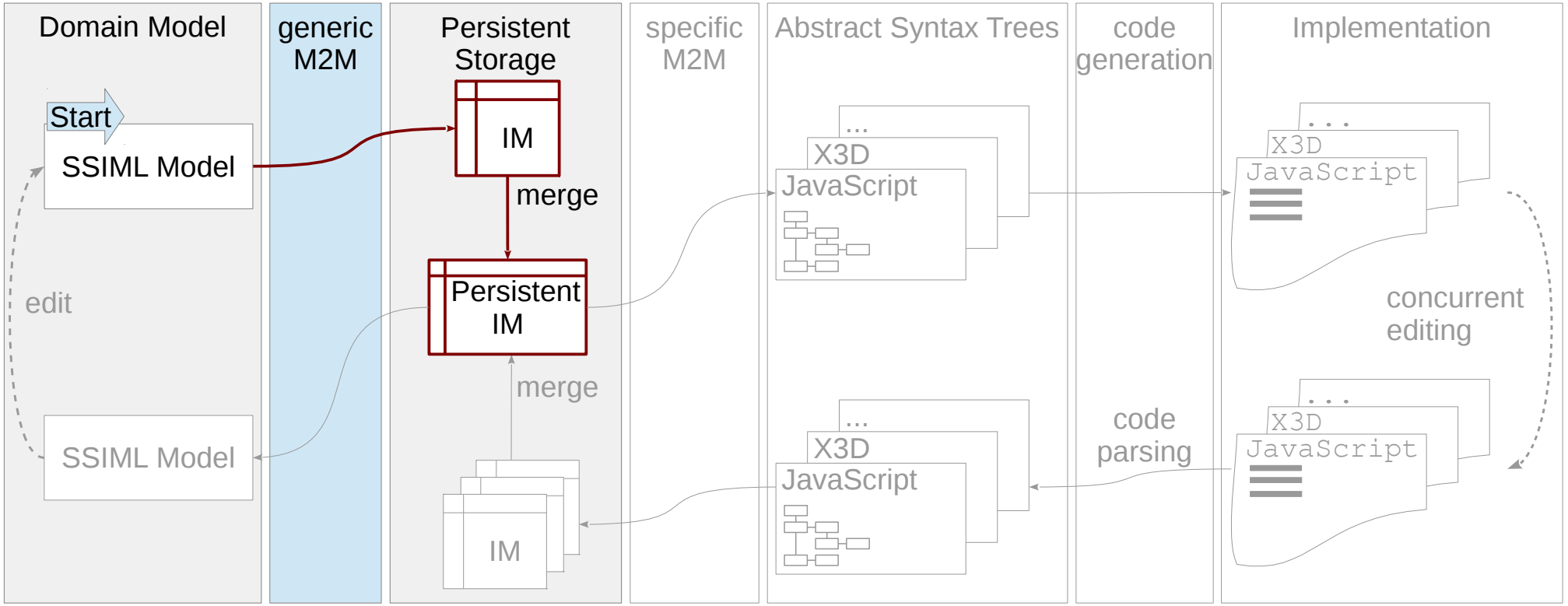
2.2 Roundtrip3D: Overview RTE Approach

- Modeling 3D applications with SSIML



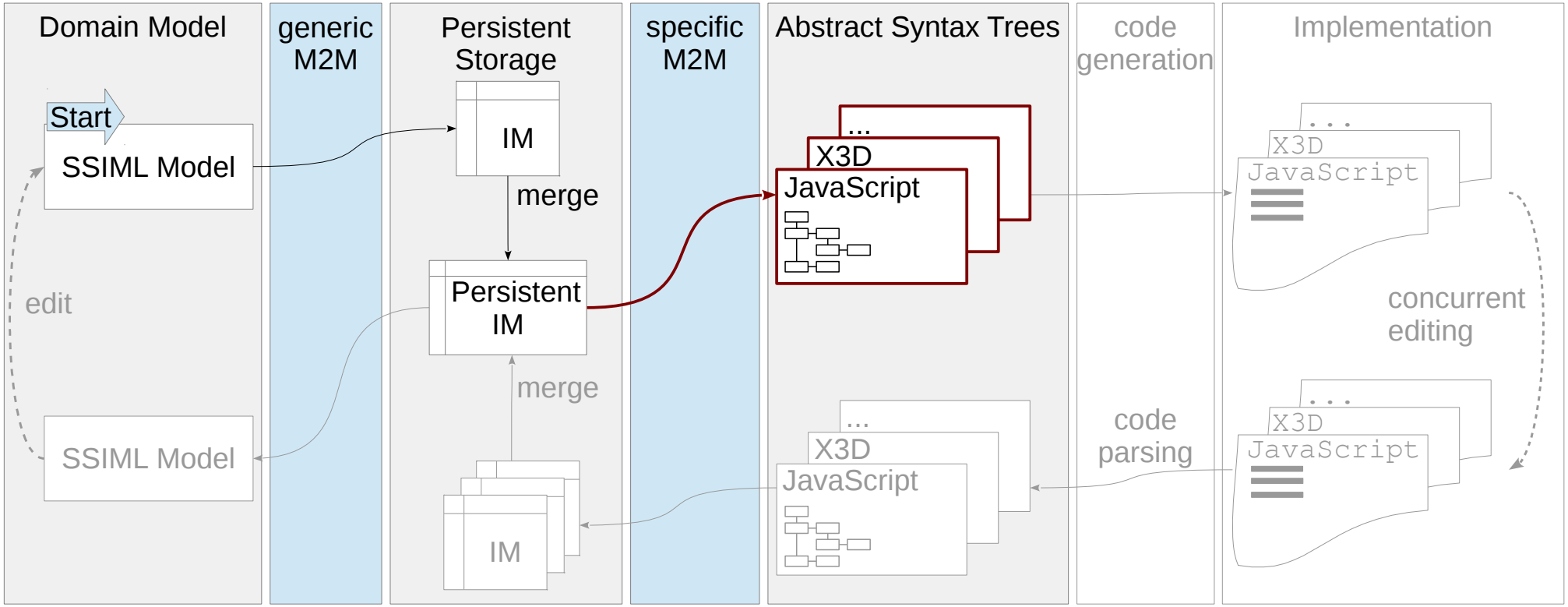
2.2 Roundtrip3D: Overview RTE Approach

- Model-based generic storage in an intermediate model (IM)
- (Merge intermediate model with persistent intermediate model from previous iterations)?



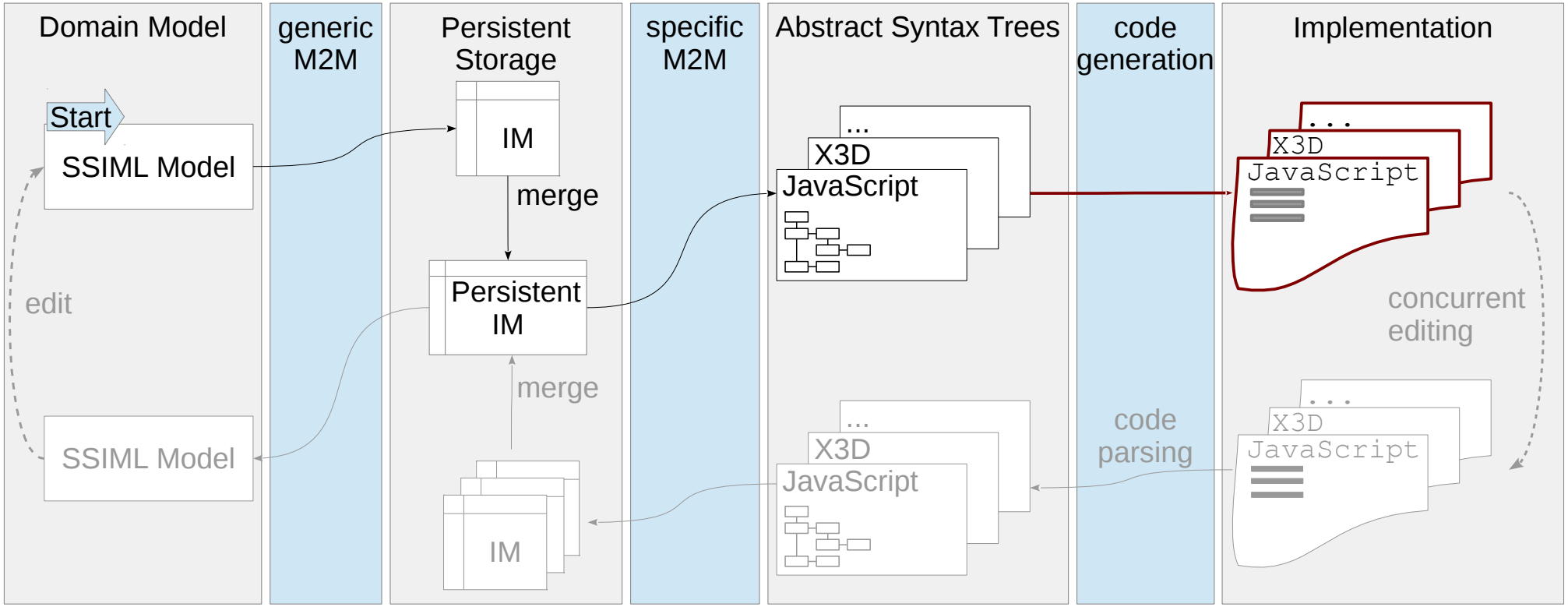
2.2 Roundtrip3D: Overview RTE Approach

- Build abstract syntax trees (ASTs) from intermediate model



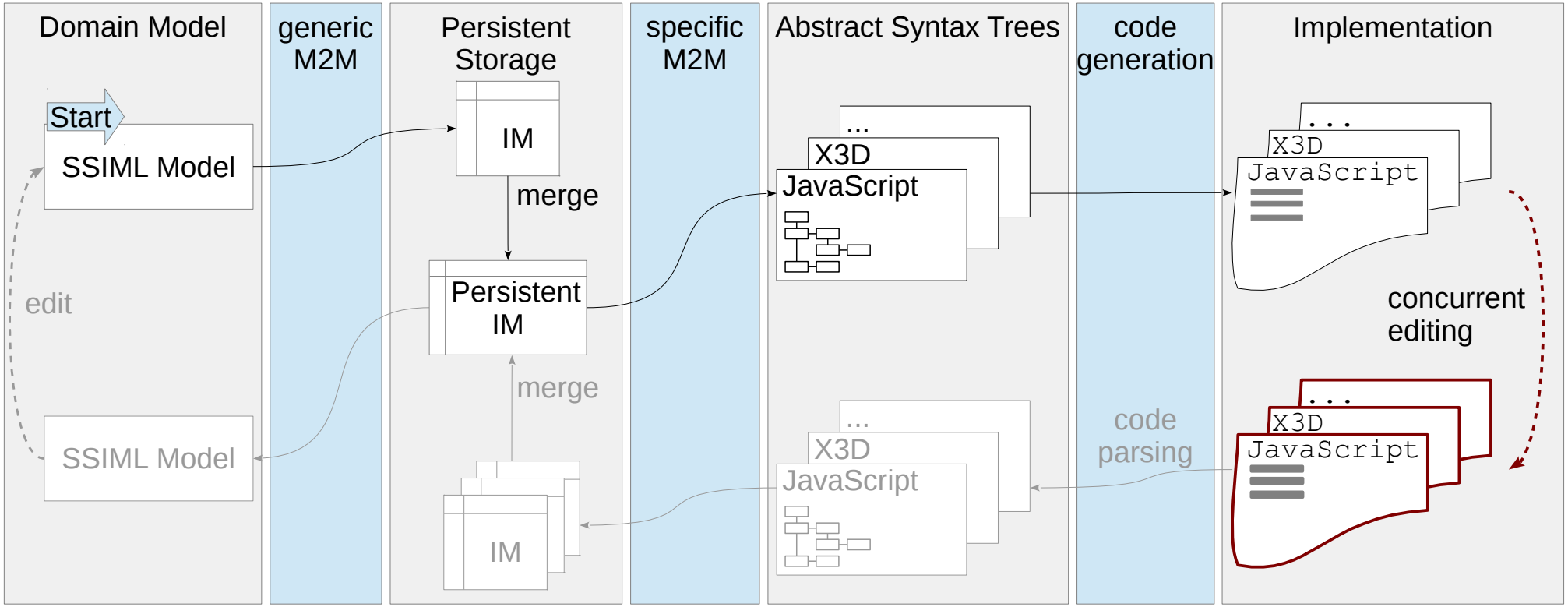
2.2 Roundtrip3D: Overview RTE Approach

- Code generation for each target language from abstract syntax trees



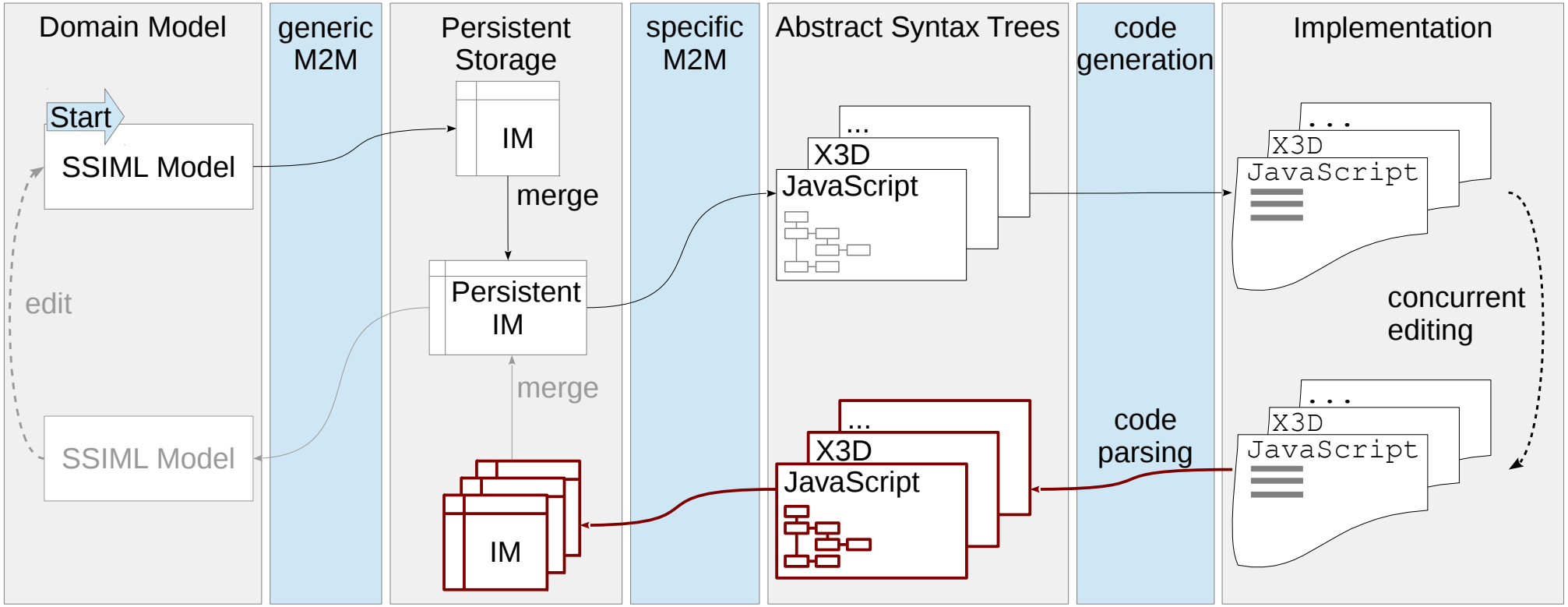
2.2 Roundtrip3D: Overview RTE Approach

- **Concurrent** editing of code bases, i. e. 3D design and implementation of application logic



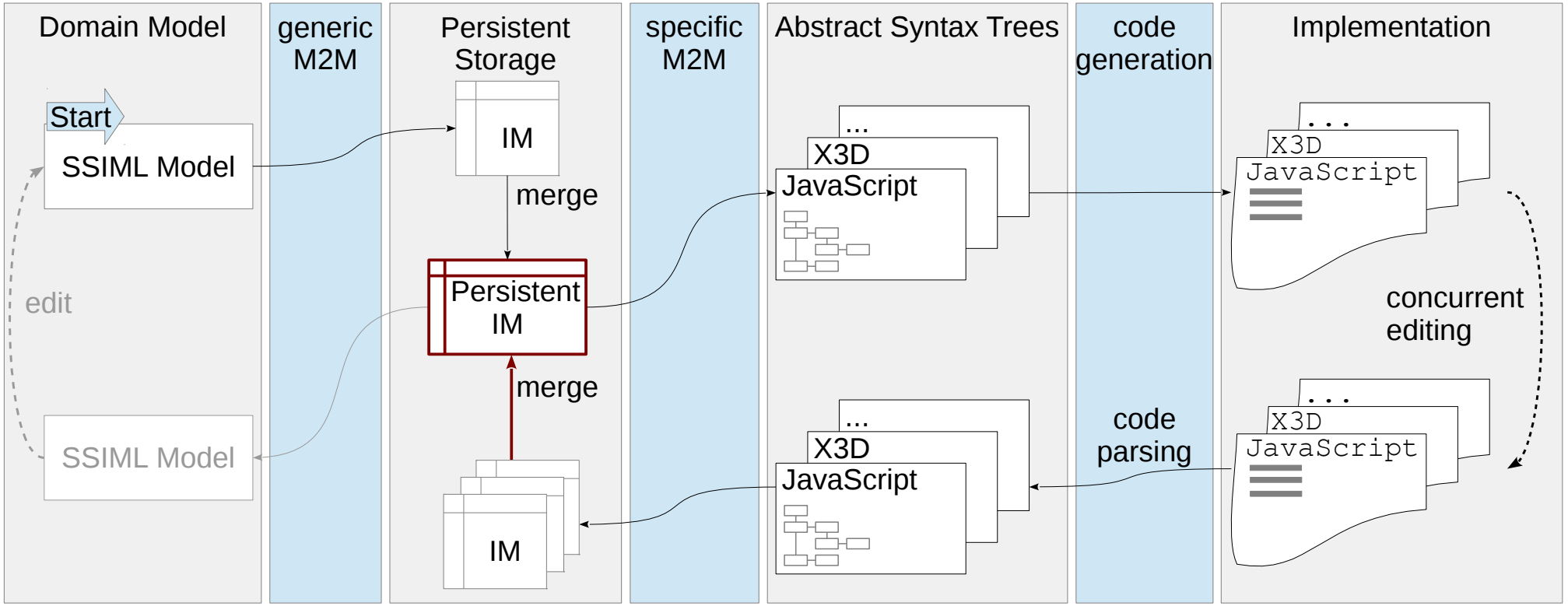
2.2 Roundtrip3D: Overview RTE Approach

- Reverse steps: Code parsing, built abstract syntax trees
- Transformation of each abstract syntax tree to intermediate model



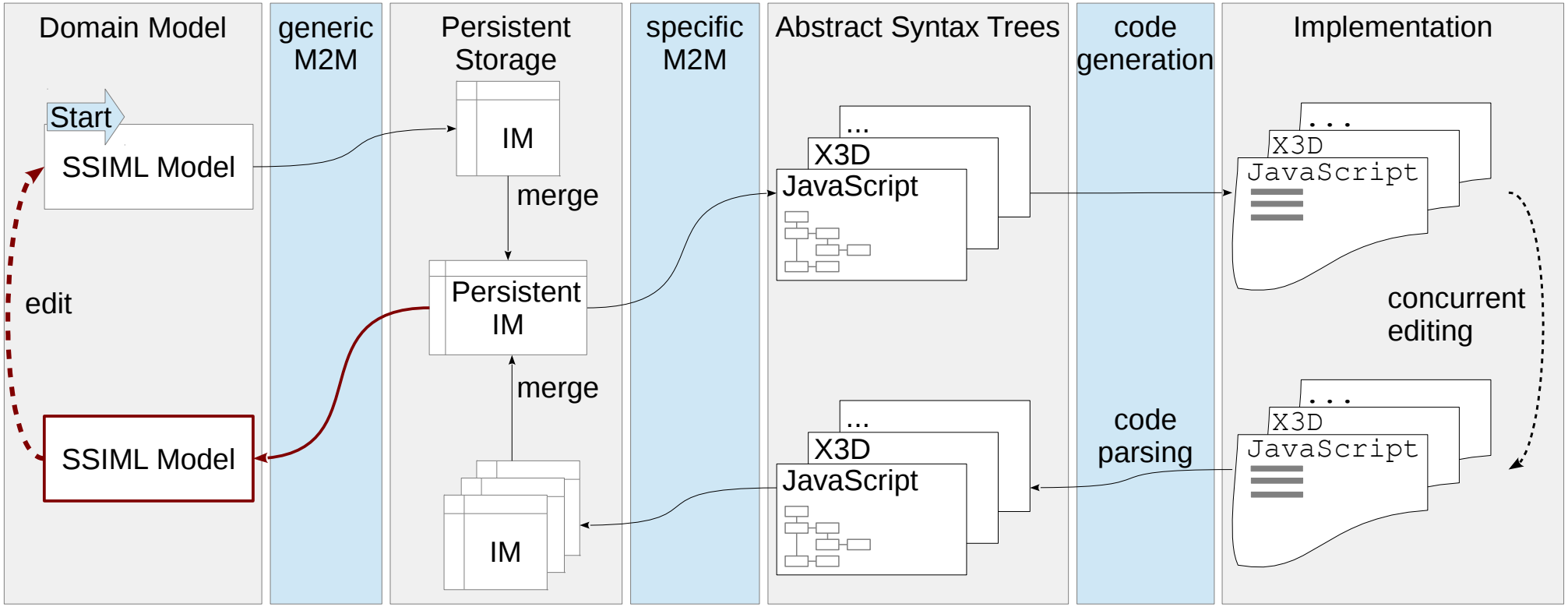
2.2 Roundtrip3D: Overview RTE Approach

- Sequentially merge derived intermediate model with persistent one



2.2 Roundtrip3D: Overview RTE Approach

- Derive domain model → modify
- Next forward iteration: Complete source code re-generation from persistent intermediate model



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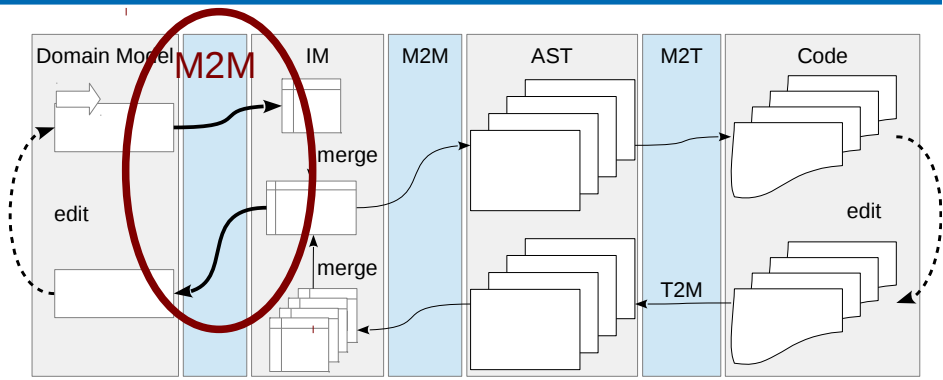
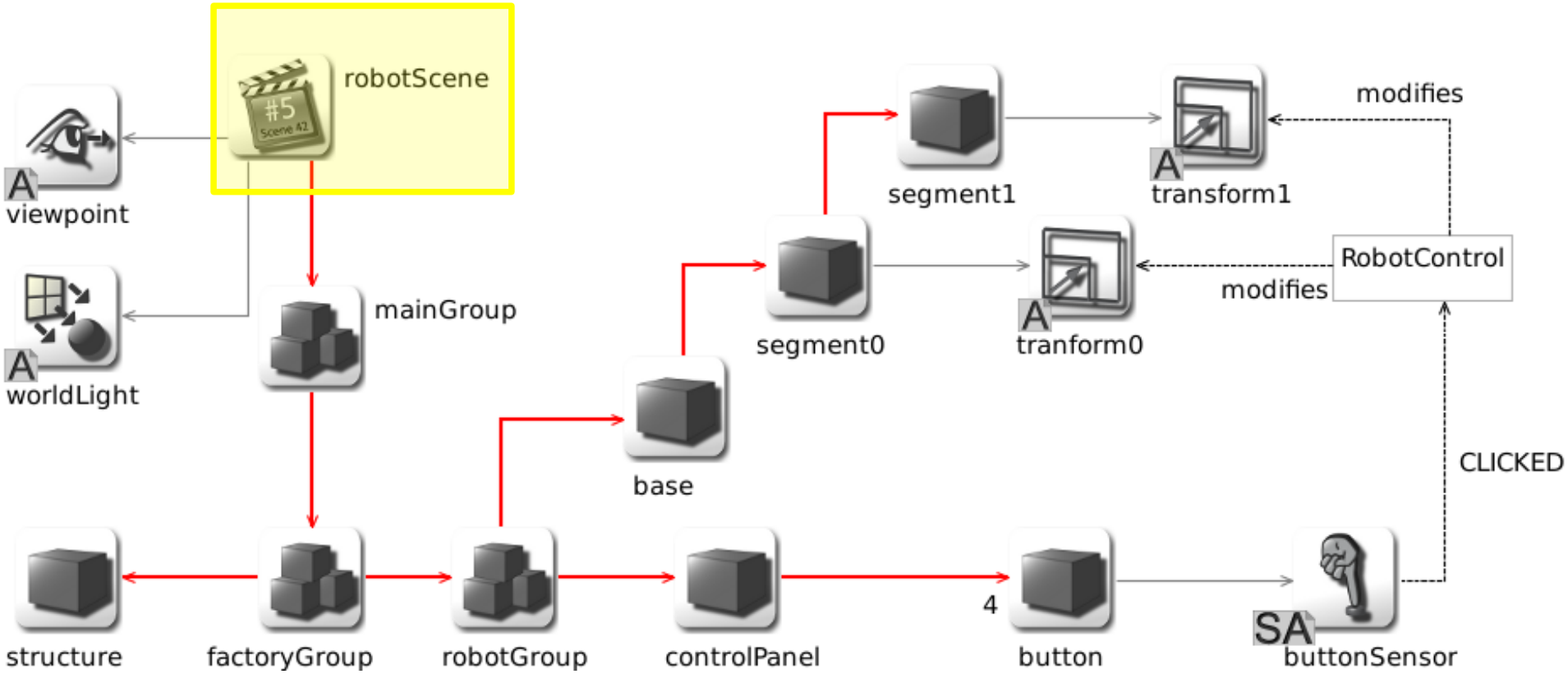
2.3 Roundtrip3D: SSIML → Intermediate model

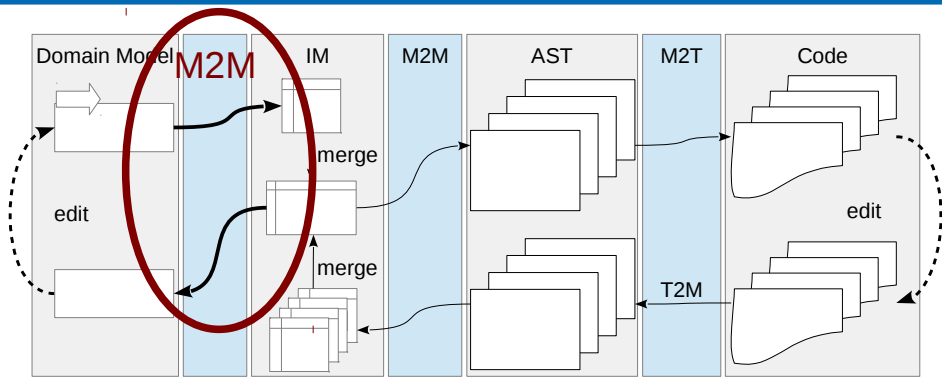
- Generic transformations, with Java
- EMF reflective API





2.3 Roundtrip3D: SSIML → Intermediate model

- Generic transformations, with Java
- EMF reflective API

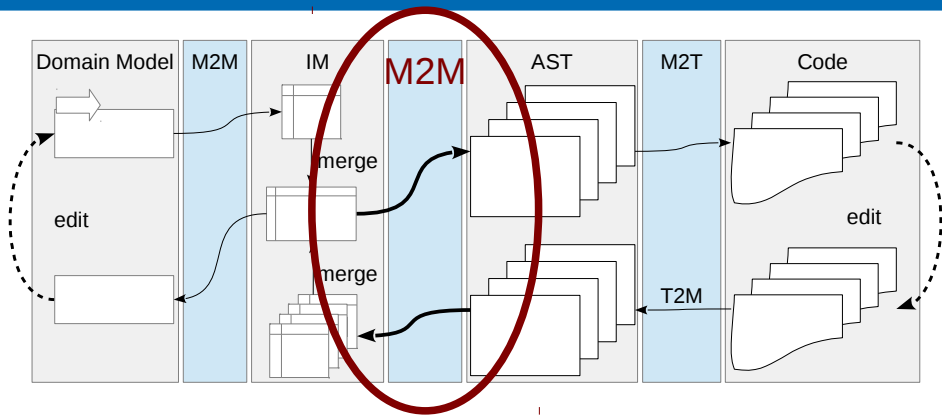


- SSIML Model
  - Value Access Relationship
  - Touch Sensor Event Relationship
  - Value Access Relationship
  - Value Access Relationship
  - Application Class RobotControl
  - Scene robotScene
  - Group factoryGroup
  - Object structure
  - Primary Parent Child Relationship
  - Group robotGroup
  - Primary Parent Child Relationship
  - Object base
  - Object segment0
  - Object segment1

- Model
  - Object ValueAccessRelationship
  - Object TouchSensorEventRelationship
  - Object ValueAccessRelationship
  - Object ValueAccessRelationship
  - Object ApplicationClass
  - Object Scene
    - Attribute id
    - Attribute name
    - Attribute model
    - Attribute attributes
    - Attribute childContent
  - Object Group
  - Object Object

2.3 Roundtrip3D: Intermediate model ↔ AST

- Rule based, hybrid transformation language
- External mapping model [4]



- Mapping Model SSIML to X3D
  - Source Element SSIMLModel
    - Target Element X3D
  - Source Element Group
    - Target Element Group
  - Source Element Transformation
    - Target Element Transform
  - Source Element Object
    - Target Element Inline

+

- Model
  - Object Transformation
    - Attribute id
    - Attribute name
    - Attribute angleAxis
    - Attribute scale
    - Attribute translation
    - Attribute model
    - Attribute owner
    - Attribute actionSources
    - Attribute successor
    - Attribute predecessor
  - Object Scene
  - Object Group
  - Object Object

+

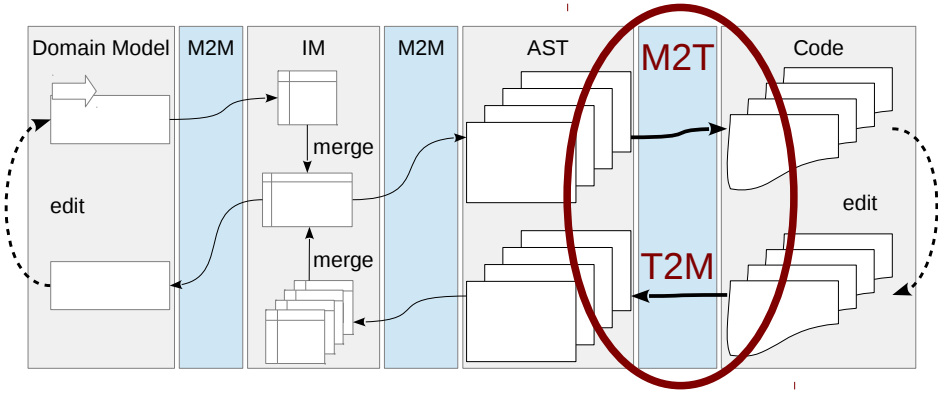
```
rule SSIML_Node_to_X3D_Node
    transform source : IM!IntermetiateObject
    to target : Any
{
    ...
    target.name = source.getMapping();
    target.id   = source ...;
    ...
}
```

- X3D X3D
  - X3D Attribute version
  - X3D Attribute profile
  - Scene Scene
    - Transform Transform
      - X3D Attribute DEF
      - X3D Attribute translation
      - X3D Attribute rotation
      - X3D Attribute scale
      - X3D Attribute center
      - X3D Attribute scaleOrientation
    - Group Group
      - X3D Attribute DEF
      - Transform Transform
      - Transform Transform
    - Viewpoint Viewpoint
      - X3D Attribute DEF
      - X3D Attribute position
      - X3D Attribute orientation

2.3 Roundtrip3D: Code serialization and parsing

- Grammar for each target language
- Coarse granularity of grammar and meta model [8]

➔ Derive code serializers and parsers



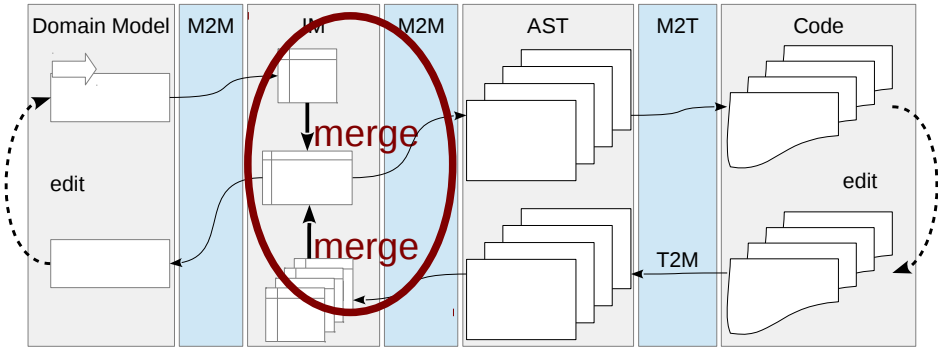
X3D code skeleton

```
<X3D version="3.0" profile="Immersive">
 <Scene>
  <Transform DEF="generatedTransform1" translation="0 0 0"
   rotation="0 0 1 0" scale="1 1 1" center="0 0 0"
   scaleOrientation="0 0 1 0">
   <Group DEF="factoryGroup">
    <Transform DEF="generatedTransform2" translation="0 0 0"
     rotation="0 0 1 0" scale="1 1 1" center="0 0 0"
     scaleOrientation="0 0 1 0">
     <Inline DEF="structure" url="factory.x3d">
     </Inline>
    </Transform>
    ...
      <Inline DEF="button0" url="button.x3d">
      </Inline>
    ...
  </Viewpoint>
 </Scene>
</X3D>
```

JavaScript code skeleton

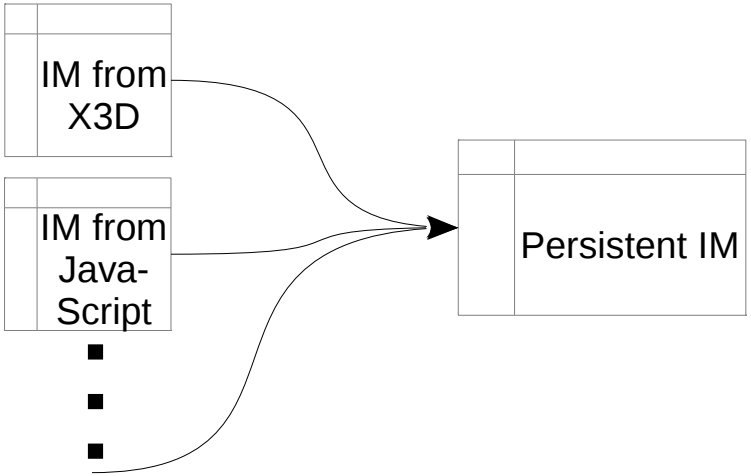
```
/**
 * @id: ApplicationClass 381af861-5437-403d-9293-d3807e441005
 */
function RobotControlClass( ) {
    ...
    var transform0 = document.querySelector( '[DEF="transform0"]' );

    this.button0_CLICKED = function( obj ) {
    }
    ...
}

/**
 * @id: Init 1218cda5-76ca-438f-9b49-4c68219a0637
 */
function init( ) {

    var robotControlClass = new RobotControlClass( );

    document.querySelector( '[DEF="button0"]' )
        .addEventListener( "click", robotControlClass.button0_CLICKED );
    ...
}
```

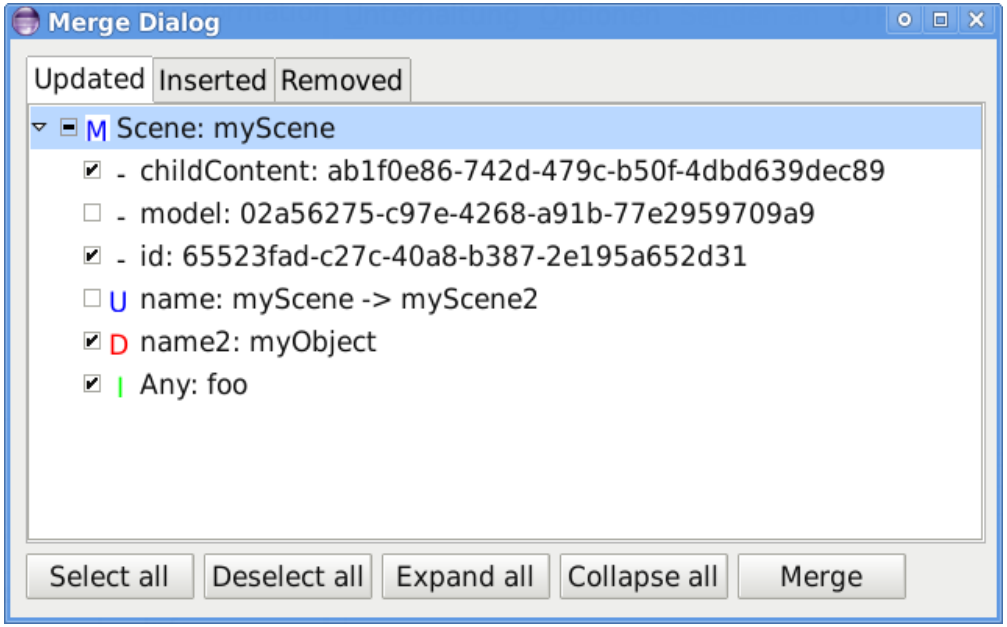
2.4 Roundtrip3D: Model merging



- **Synchronize** relevant elements between model and code
- **Preserve** manually developed source code

1. Comparison: Operations: Update, Insert, Delete (, Move) [5]
2. Conformance checking
3. Interactive merging: **one** merge algorithm
4. Reconciliation





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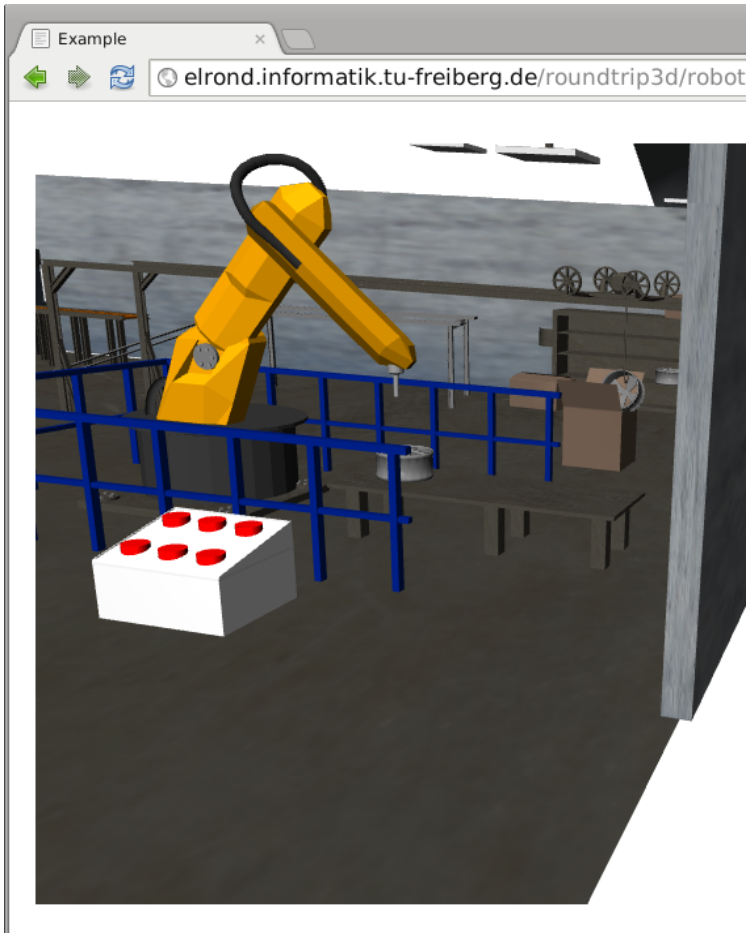
3.1 Conclusion: Summary

- Eclipse based graphical model editor
- Forward & reverse engineering (X3D/ X3DOM, JavaScript) with respect to **non-simultaneous** development process
- Common intermediate representation and **one** merge algorithm to overcome **synchronization issue**



http://elrond.informatik.tu-freiberg.de/roundtrip3d/robot

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3.2 Conclusion: Outlook

- Tree diff algorithms to avoid IDs
- Integrate Augmented Reality (Android devices, Java)
- Integrate C.A.V.E. like systems (C++)

Questions

Thank You!

mail: lenk@informatik.tu-freiberg.de

References

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[3] FIGUEROA , P., GREEN , M., AND HOOVER , H. J. 2002. Intml: a description language for vr applications. In Web3D '02: Proceedings of the seventh international conference on 3D Web technology, ACM, New York, NY, USA, 53–58.

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[5] CHAWATHE, S.S., RAJARAMAN, A., GARCIA-MOLINA, H., WIDOM, J.: Change detection in hierarchically structured information. SIGMOD Rec. 25, 493–504 (June 1996)

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Lecture Notes in Computer Science, vol. 5095, pp. 1–16. Springer (2008)

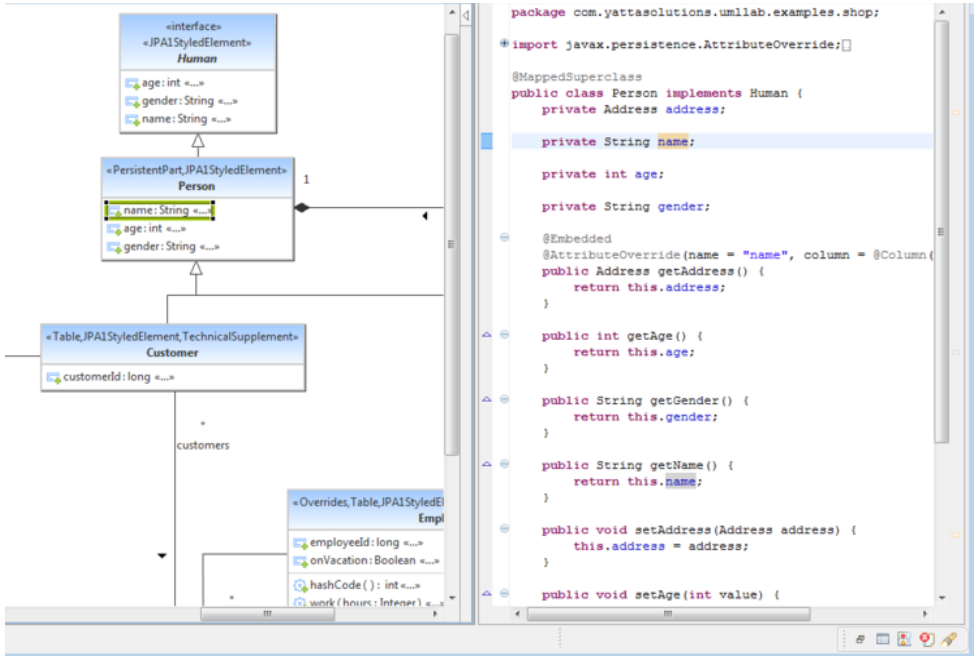
[7] OLDEVIK, J.: MOFScript Eclipse Plug-In: Metamodel-Based Code Generation. In: Proceedings of the Eclipse Technology eXchange workshop (eTX) (2006)

[8] JONES, J.: Abstract syntax tree implementation idioms. Pattern Languages of Program Design (2003), proceedings of the 10th Conference on Pattern Languages of Programs (PLoP2003)

Backup: Related work

Round-trip tools:

- Exist for 'ordinary' software
- E. g. UML Lab, Together, …
- Simultaneous editing; provide different views



source: http://www.uml-lab.com/de/uml-lab

Tools for high level 3D development:

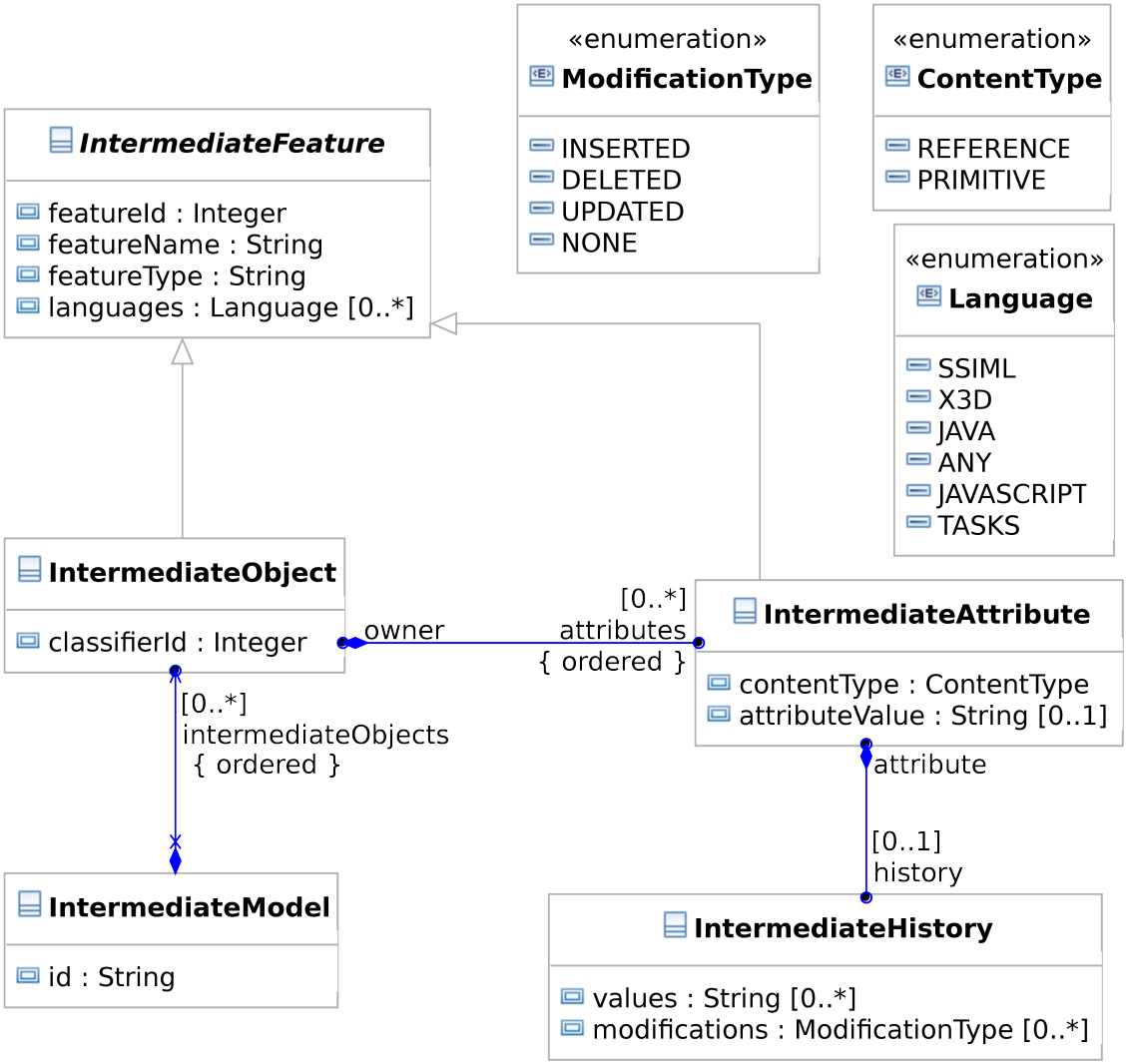
- High level dev. hardly supported
- Simplify programming task
- Rapid prototyping
- E. g. InTML [3] : describe different input devices, output devices, virtual objects, and 3D interaction techniques at high level, XML-based

- Traditionally: Active code generation (code weaving, protected regions) [6, 7]

Backup: Intermediate Model

Model based storage

- Common methods:
  1. Store model and code separately
     - Redundancy
     - Synchronization through domain model; restrictions
  2. Completely derive model from code (render code)
     - Synchronize between TL
     - Many merge processes
- Intermediate model contains data and meta data



Backup: Eclipse Framework and Editor

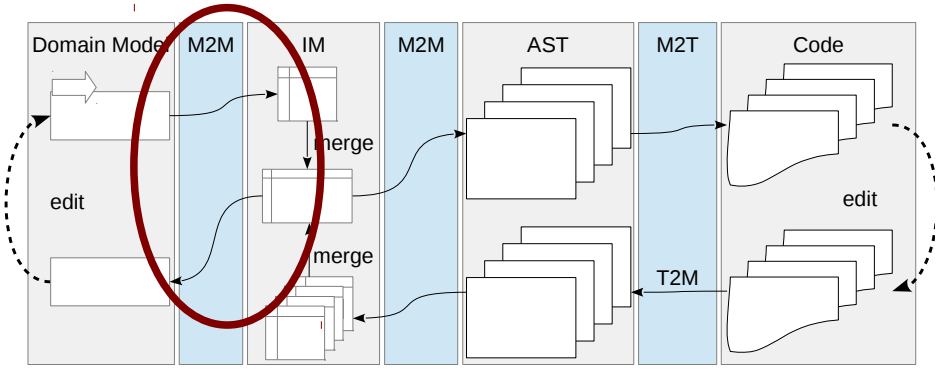
Eclipse Modeling Tools:

- (Meta-) Modeling of DSLs: Eclipse Modeling Framework (EMF)
- Graphical DSLs: Graphical Modeling Framework (GMF)
- (Graphical) model editor: ~120t effective lines of code
- Model validation: Object Constraint Language (OCL)
- Model transformations (M2M): ETL, (ATL, QVT)
- Code generation (M2T): JET, Xpand, (MOFScript)
- Generation of code parsers and serializers (M2T, T2M): Xtext
- Change detection, model merging and resolving conflicts: ECL, EML, ETL

Backup: SSIML ↔ IM (XMI)

M2M: SSIML ↔ Intermediate model:

- Generic transformations, with Java
- EMF reflective API




```
<?xml version="1.0" encoding="UTF-8"?>
<ssiml:SSIMLModel xmi:version="2.0" xmlns:xmi:
  <interrelations xsi:type="ssiml:ValueAccess
  <interrelations xsi:type="ssiml:TouchSensor
  <interrelations xsi:type="ssiml:ValueAccess
  <applicationElements xsi:type="ssiml:Applic
  <elements xsi:type="ssiml:Scene"
    id="a52a010e-596c-4437-99b6-6bef63d338ef"
    name="robotScene"
    attributes="//@elements.23"
    childContent="//@elements.21"/>
  <elements xsi:type="ssiml:Group" id="404ed.
  <elements xsi:type="ssiml:Object" id="4a31
  <elements xsi:type="ssiml:PrimaryParentChil
  <elements xsi:type="ssiml:Group" id="8bf539
  <elements xsi:type="ssiml:PrimaryParentChil
  <elements xsi:type="ssiml:Object" id="3e162
  <elements xsi:type="ssiml:Object" id="4e3af
```

```
<intermediateObjects featureId="6"
  featureName="elements" featureType="Scene" classifierId="83">
  <languages>SSIML</languages>
  <attributes featureId="0" featureName="id"
    featureType="java.lang.String" contentType="PRIMITIVE"
    attributeValue="a52a010e-596c-4437-99b6-6bef63d338ef">
    <languages>SSIML</languages>
  </attributes>
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    <languages>SSIML</languages>
  </attributes>
  <attributes featureId="1" featureName="model" featureType="ER
    <languages>SSIML</languages>
  </attributes>
  <attributes featureId="4" featureName="attributes" featureTyp
    <languages>SSIML</languages>
  </attributes>
  <attributes featureId="6" featureName="childContent" featureT
    <languages>SSIML</languages>
  </attributes>
</intermediateObjects>
```