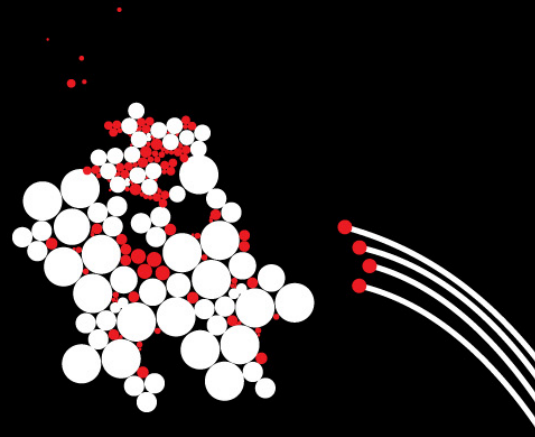
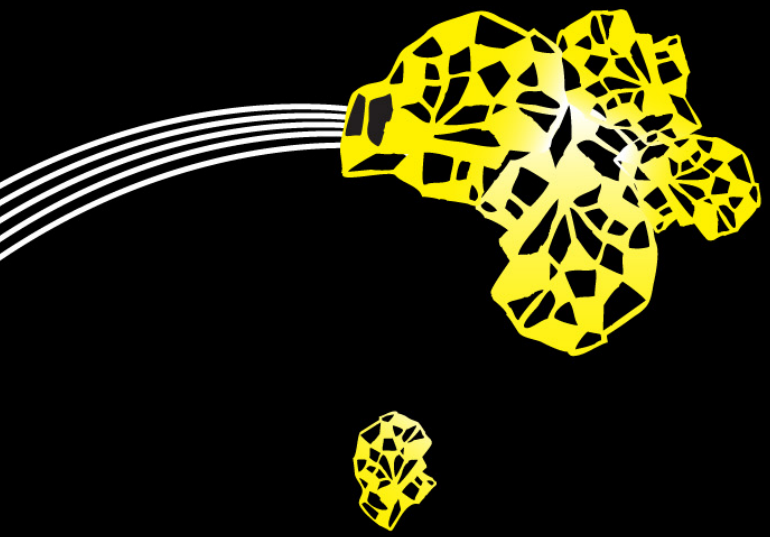
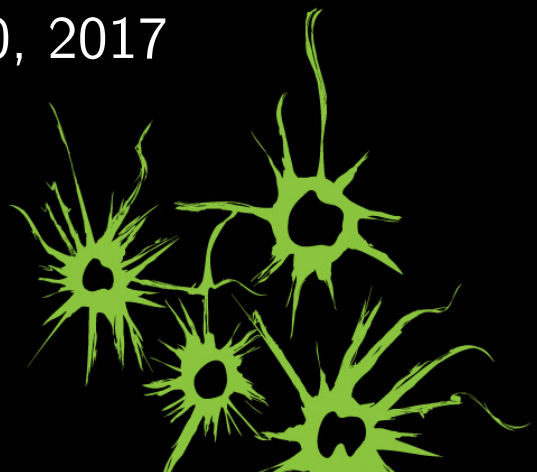
UNIVERSITY OF TWENTE.



Model Transformations applied to Process Calculi



Djurre van der Wal
Data61 (CSIRO), University of Twente
November 20, 2017



Process algebra

Process algebra
= Algebraic tool for describing agent interactions at a high level

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General-purpose	**Domain-specific**
Versatile. Available modeling tools. Large user-base.	Easy to learn and use. Domain rules apply automatically. No distracting supportive elements.

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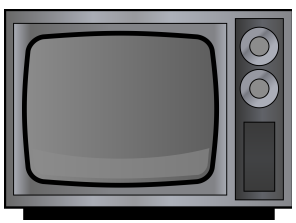
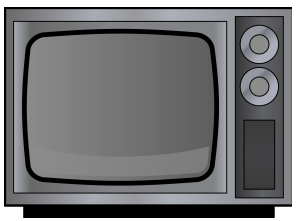
mCRL2 mini Common Representation Language 2
AWN Algebra for Wireless Networks

mCRL2 by example

```
Volume(v: Integer) =
    decVolume . Volume(v > 0 ? v - 1 : 0)
  + incVolume . Volume(v < 30 ? v + 1 : 30);
```



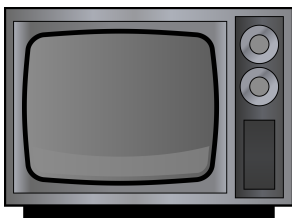
mCRL2 by example



```
Volume(v: Integer) =
    decVolume . Volume(v > 0 ? v - 1 : 0)
  + incVolume . Volume(v < 30 ? v + 1 : 30);

Channel(c: Integer) =
  sum n1:{0..9} . press(n1) .
    sum n2:{0..9} . press(n2) .
      Channel(n1 * 10 + n2);
```

mCRL2 by example



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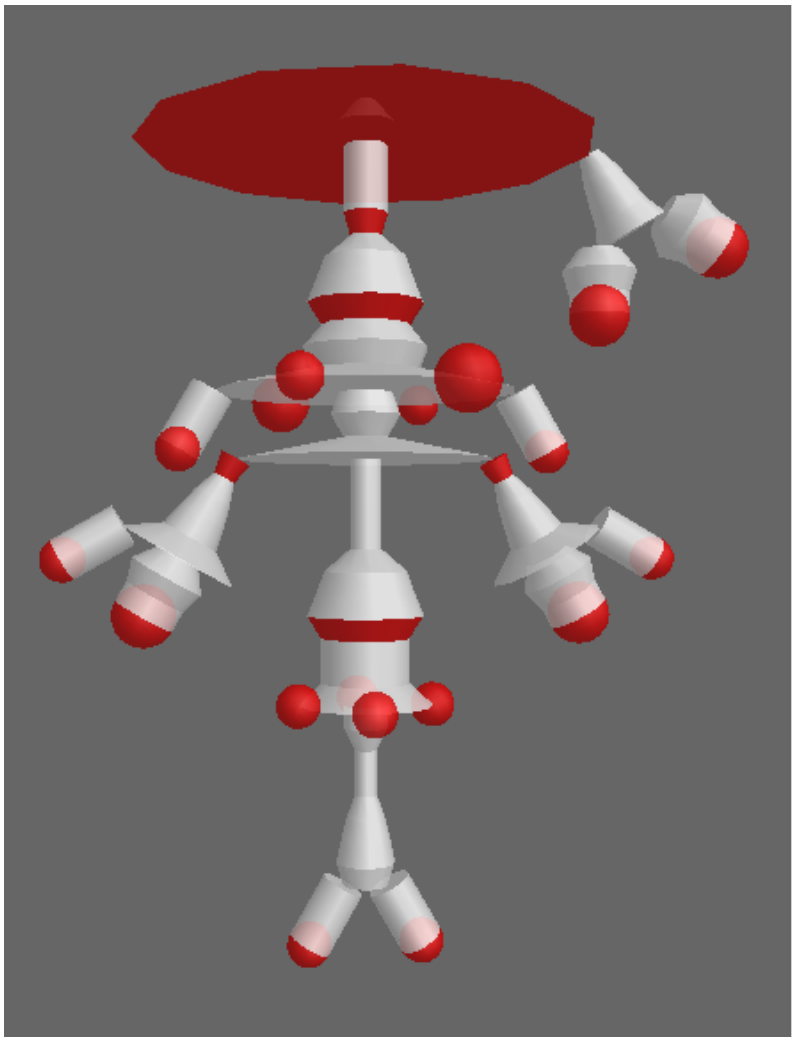
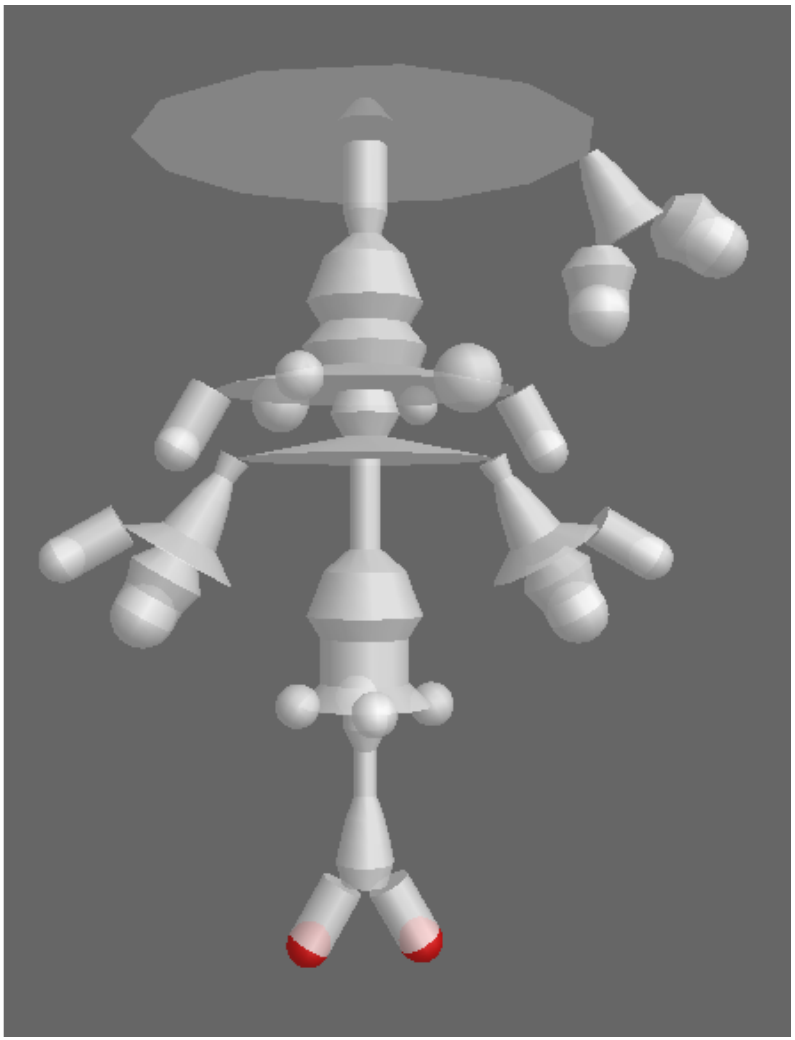
      Channel(n1 * 10 + n2);

TV = Channel(1) || Volume(15);
```

mCRL2 by example





AWN by example

```
RadioTower(m: Integer) =
  broadcast(Message(m)) . RadioTower(m + 1);
```

AWN by example

```
RadioTower(m: Integer) =
  broadcast(Message(m)) . RadioTower(m + 1);

Radio(last: Message) = receive(m) . Radio(m);
```

AWN by example

```
RadioTower(m: Integer) =
  broadcast(Message(m)) . RadioTower(m + 1);

Radio(last: Message) = receive(m) . Radio(m);

RadioNetwork = [ 1 : RadioTower(1) : { 2, 4 } ||
                 2 : Radio(null) : {} ||
                 3 : Radio(null) : {} ||
                 4 : Radio(null) : {} ];
```

Main goal

Make an automated translation from AWN to mCRL2.

From AWN to mCRL2

What would a typical implementation look like?

From AWN to mCRL2

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AWN text

From AWN to mCRL2

What would a typical implementation look like?

AWN text $\rightarrow$ AWN data

From AWN to mCRL2

What would a typical implementation look like?

AWN text $\rightarrow$ AWN data $\rightarrow$ mCRL2 data

From AWN to mCRL2

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AWN text $\rightarrow$ **AWN data** $\rightarrow$ **mCRL2 data** $\rightarrow$ **mCRL2 text**

From AWN to mCRL2

What would a typical implementation look like?

AWN text $\rightarrow$ **AWN data** $\rightarrow$ **mCRL2 data** $\rightarrow$ **mCRL2 text**

Model-driven engineering (=MDE):

- Distribute implementation over *(meta-)models*.
- Transform model to model as required.
- Use DSLs specialized for the type of transformation.
- Benefit from peripheral tools.

From AWN to mCRL2

What would a typical implementation look like?

AWN text $\rightarrow$ **AWN data** $\rightarrow$ **mCRL2 data** $\rightarrow$ **mCRL2 text**

Model-driven engineering (=MDE):

- Distribute implementation over *(meta-)models*.
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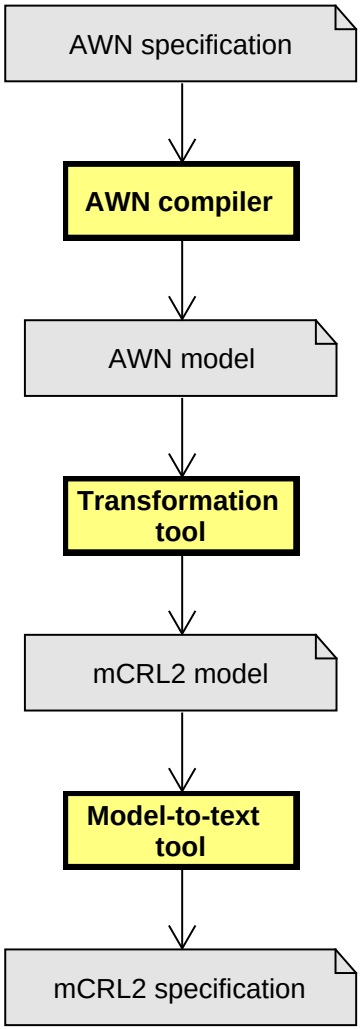
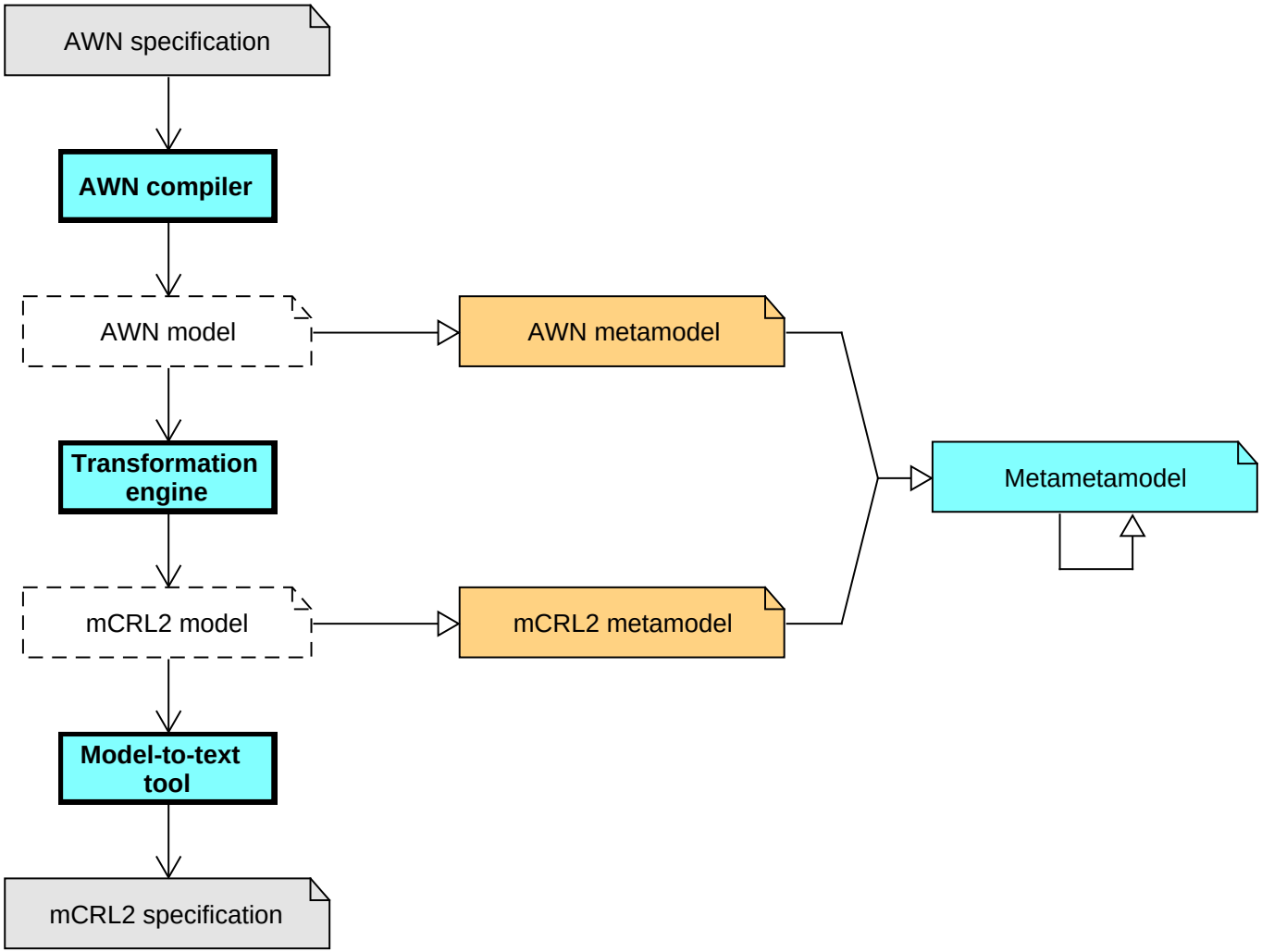
Model
= Bunch of related objects organized according to a metamodel

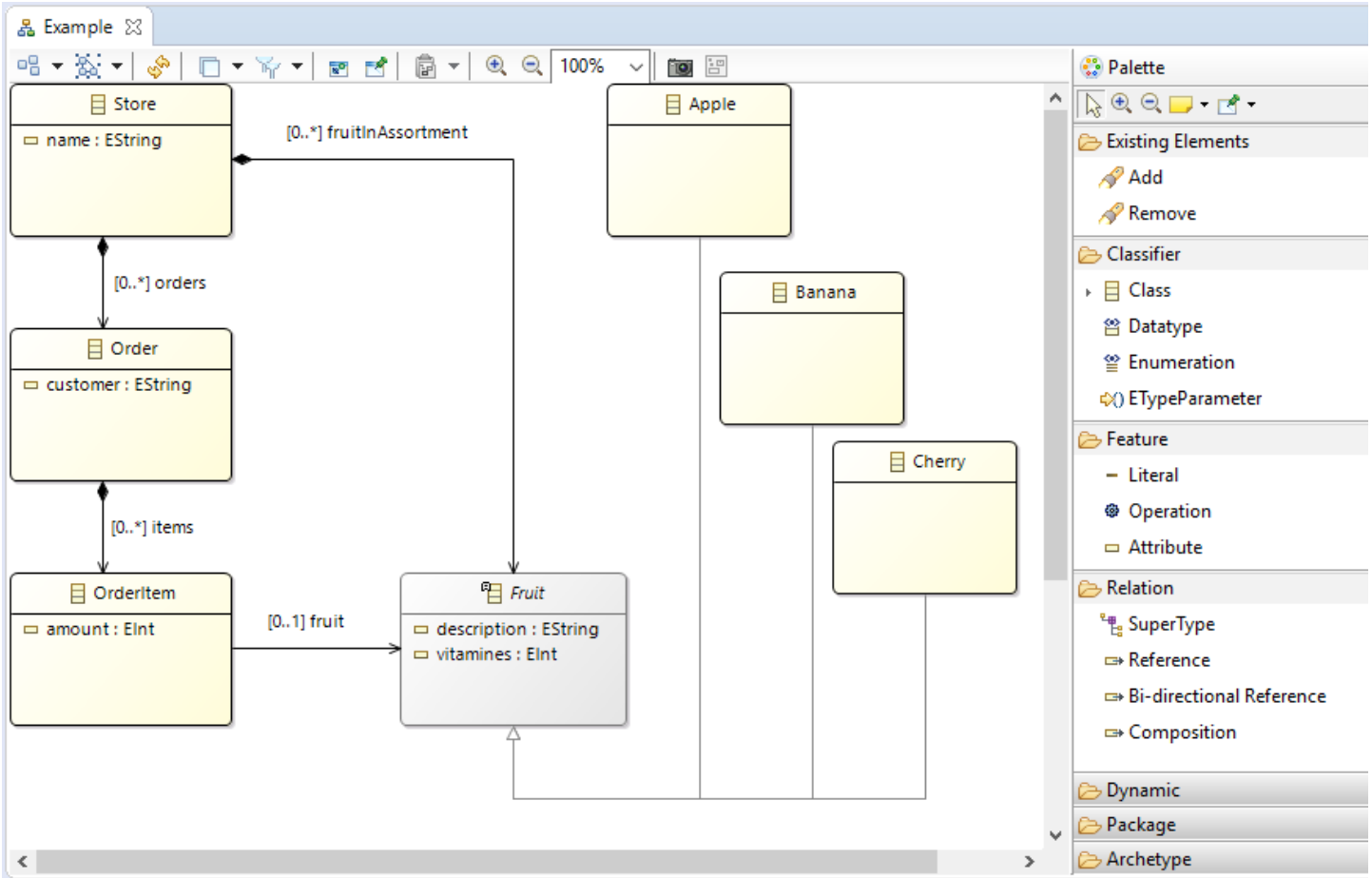
From AWN to mCRL2 using MDE



From AWN to mCRL2 using MDE



Edit metamodels



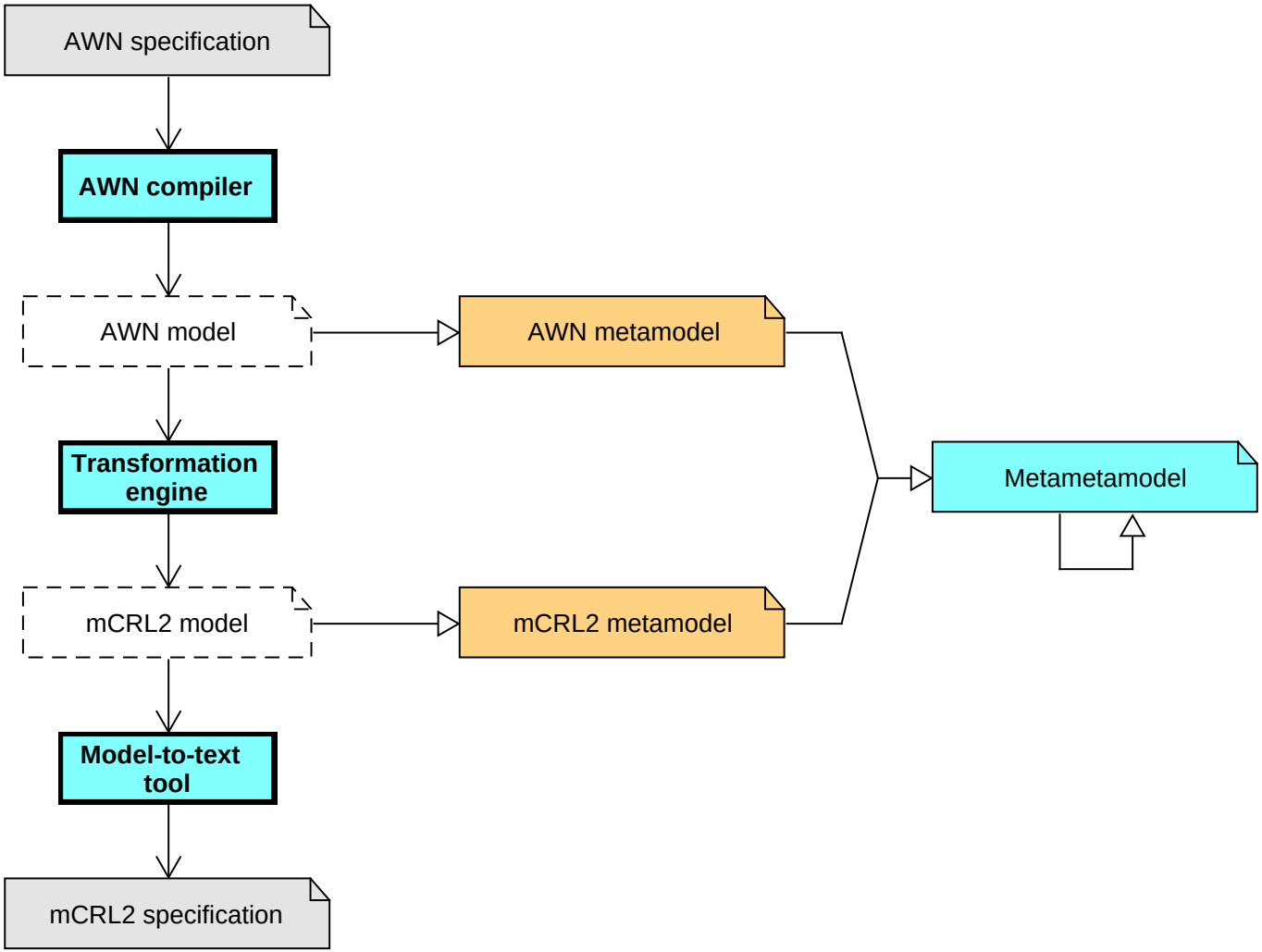
Edit metamodels

Example | Example.ecore

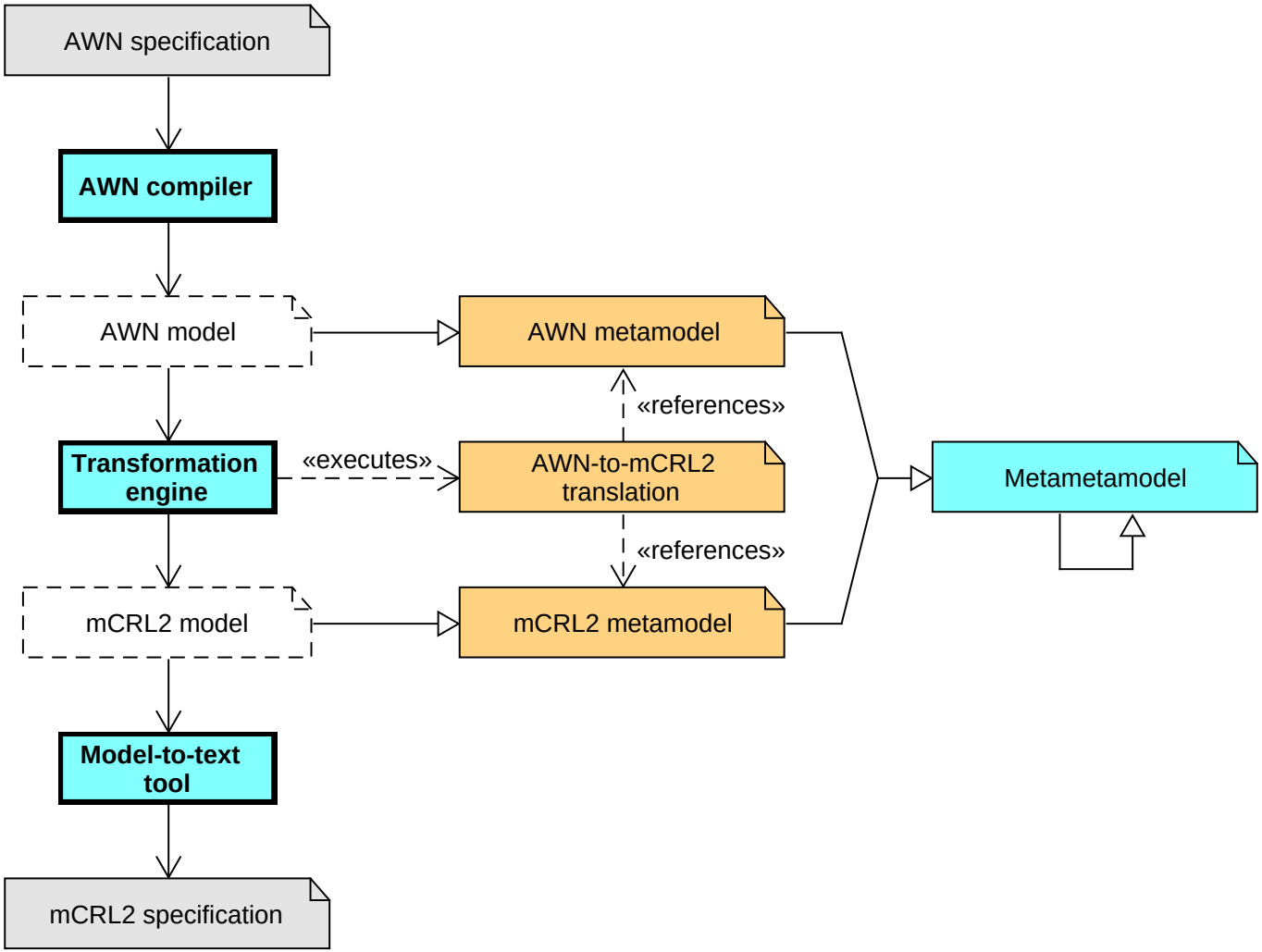
```
import ecore : 'http://www.eclipse.org/emf/2002/Ecore' ;

package Example
{
    abstract class Fruit
    {
        attribute description : String[?];
        attribute vitamines : ecore::EInt[?];
    }
    class Apple extends Fruit;
    class Banana extends Fruit;
    class Cherry extends Fruit;
    class OrderItem
    {
        attribute amount : ecore::EInt[?];
        property fruit : Fruit[?];
    }
    class Order
    {
        property items : OrderItem[*|1] { ordered composes };
        attribute customer : String[?];
    }
    class Store
    {
        property fruitInAssortment : Fruit[*|1] { ordered composes };
        property orders : Order[*|1] { ordered composes };
        attribute name : String[?];
    }
}
```

From AWN to mCRL2 using MDE



From AWN to mCRL2 using MDE



AWN to mCRL2 transformation

$T(p + q) = T(p) + T(q)$

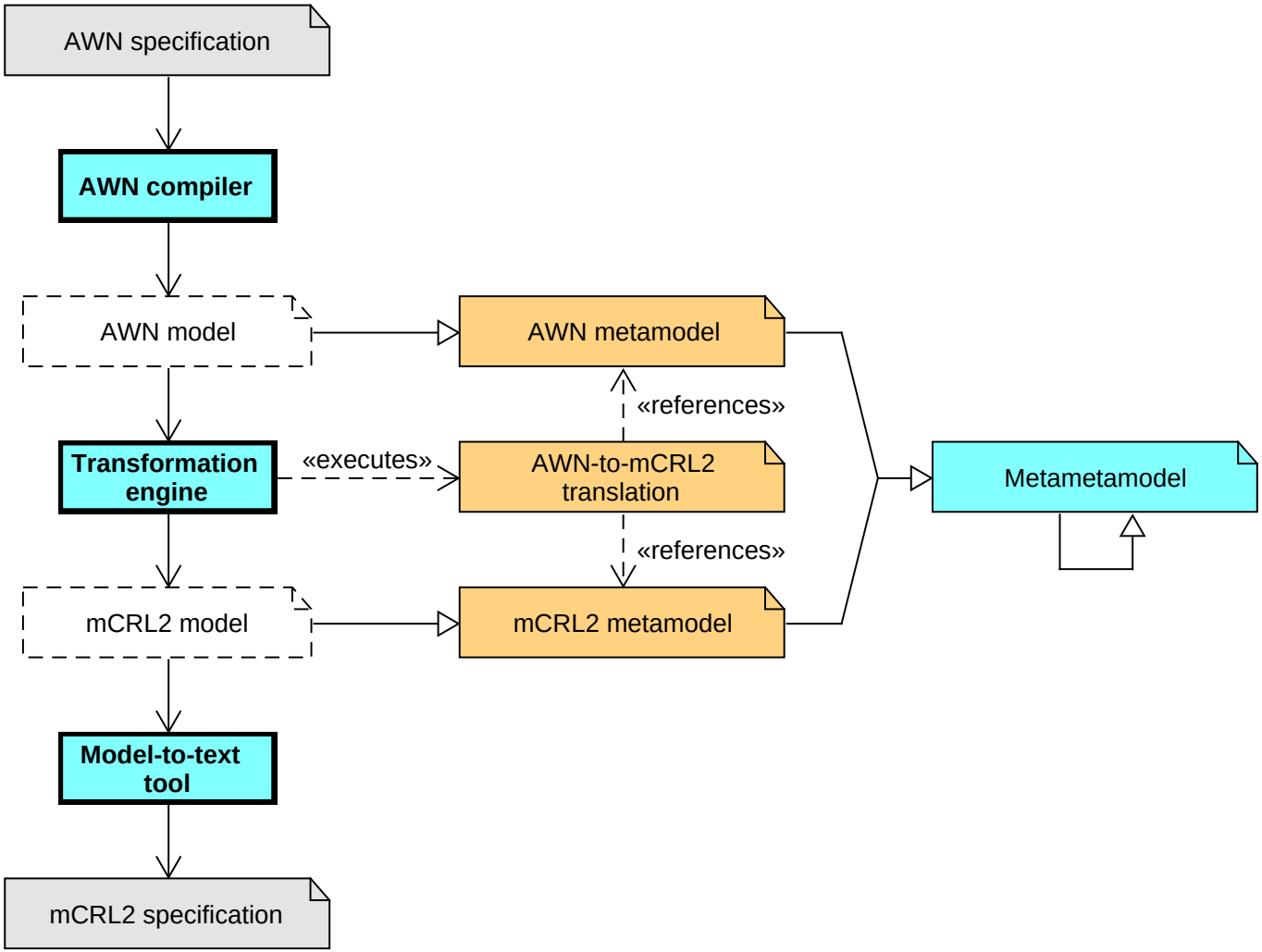
```
mapping AWN::Choice::transform() : MCRL2::Choice {
  lhs := self.lhs.map transform();
  rhs := self.rhs.map transform();
}
```

AWN to mCRL2 transformation

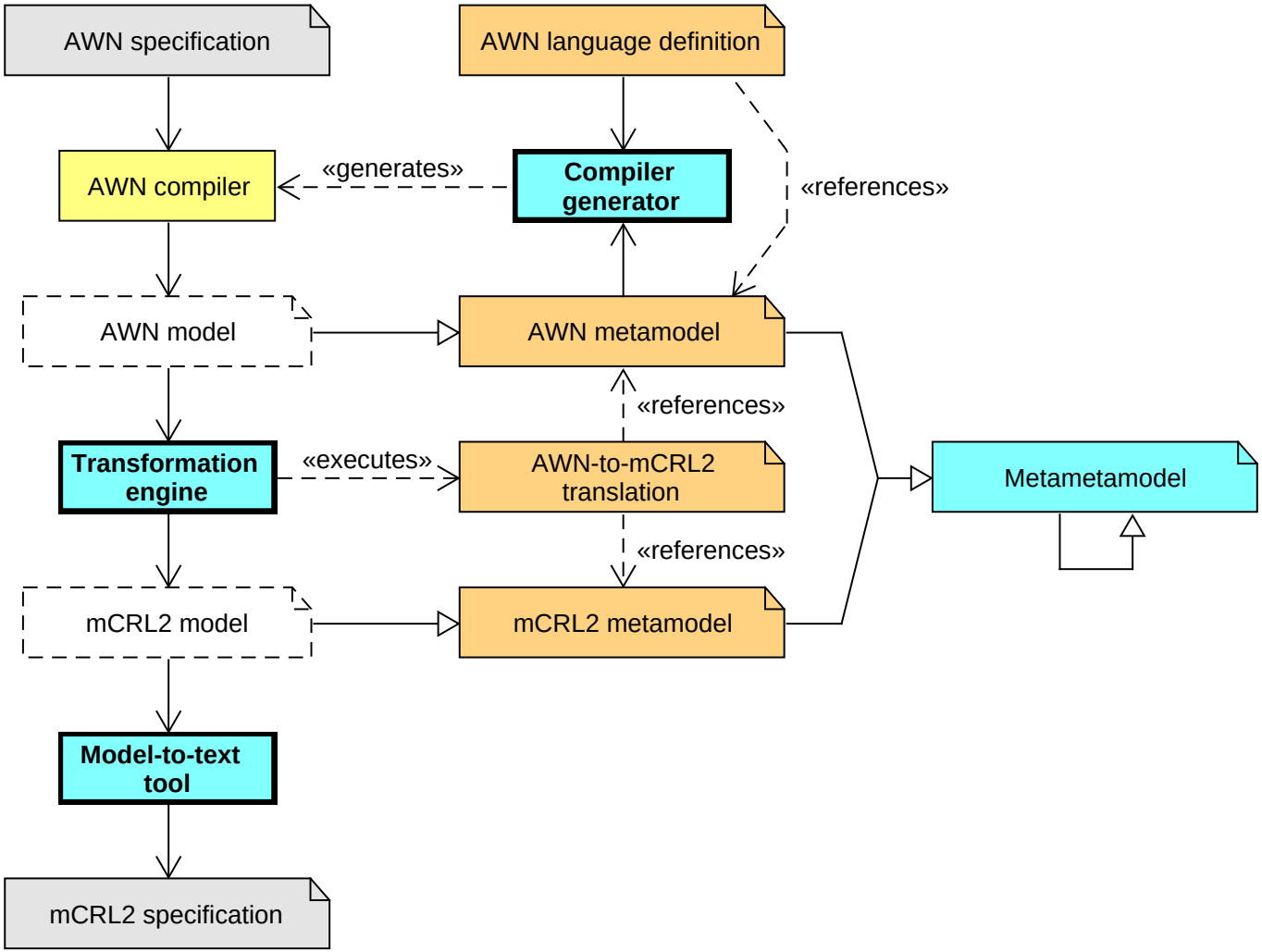
$T(\mathbf{broadcast}(msg).p) = \sum_{R \in \mathcal{P}(IP)} \mathbf{broadcast}(R, R, msg).T(p)$

```
mapping AWN::Broadcast::transform() : MCRL2::SumOperator {
  sumVariable := object MCRL2::Variable {
    name := "R";
    type := "Set(IP)";
  };
  p := object MCRL2::ActionExpr {
    action := object MCRL2::Action {
      name := "broadcast";
      params := Sequence {
        sumVariable.createReference(),
        sumVariable.createReference(),
        self.msg.map transform()
      };
    };
    p := self.p.map transform();
  };
}
```

From AWN to mCRL2 using MDE



From AWN to mCRL2 using MDE



AWN language definition

```
// automatically generated by Xtext
grammar csiro.data61.jawn.Jawn hidden(WS, ML_COMMENT, SL_COMMENT)

import "csiro/data61/jawn/rawASTModelDef"
import "http://www.eclipse.org/emf/2002/Ecore" as ecore

InputModelRoot returns Protocol:
    {Protocol}
    (wired?='wired' | 'wireless')? 'protocol' name=ID ';'
    ('message' '(' globalDefs+=MessageVariable (',' globalDefs+=MessageVariable)* ')' ';')?
    (
        globalDefs+=Constant
        | globalDefs+=NamedExprType
        | globalDefs+=Function
        | globalDefs+=Equation
        | globalDefs+=RegularProcess
        | globalDefs+=SimulationProcess
        | globalDefs+=ParallelProcess
        | networks+=Network
        | simulations+=SimulateInit
    )*
;

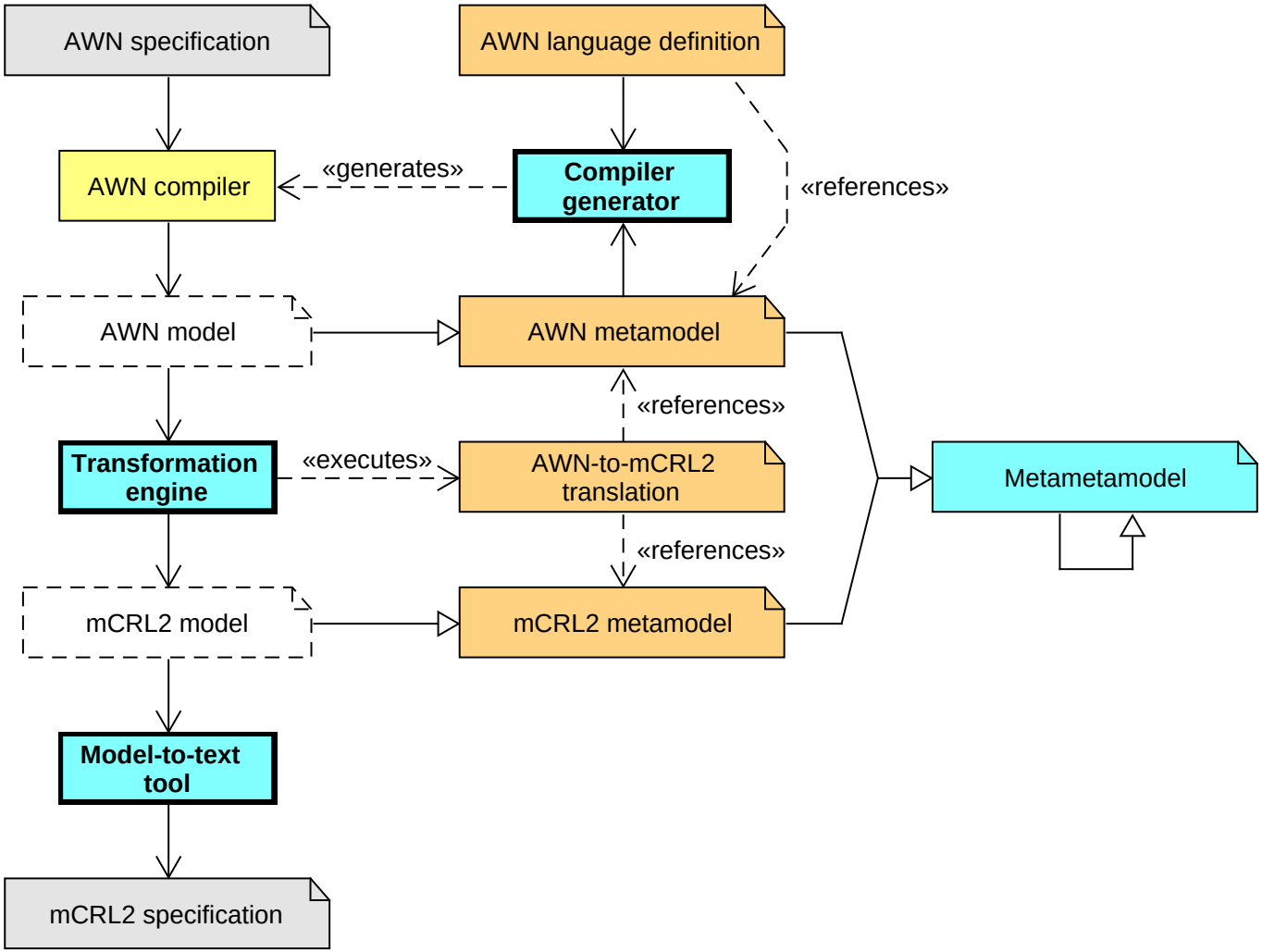
SimulateInit returns SimulationProcess:
    'simulate' {SimulationProcess} rootAction=Action ';'
;

Constant returns Constant:
    {Constant}
    'const' name=ID ':' type=ExprType ':=' expression=Expression ';'
;

MessageVariable returns MessageVariable:
    {MessageVariable}
    name=ID ':' type=ExprType
;

```

From AWN to mCRL2 using MDE



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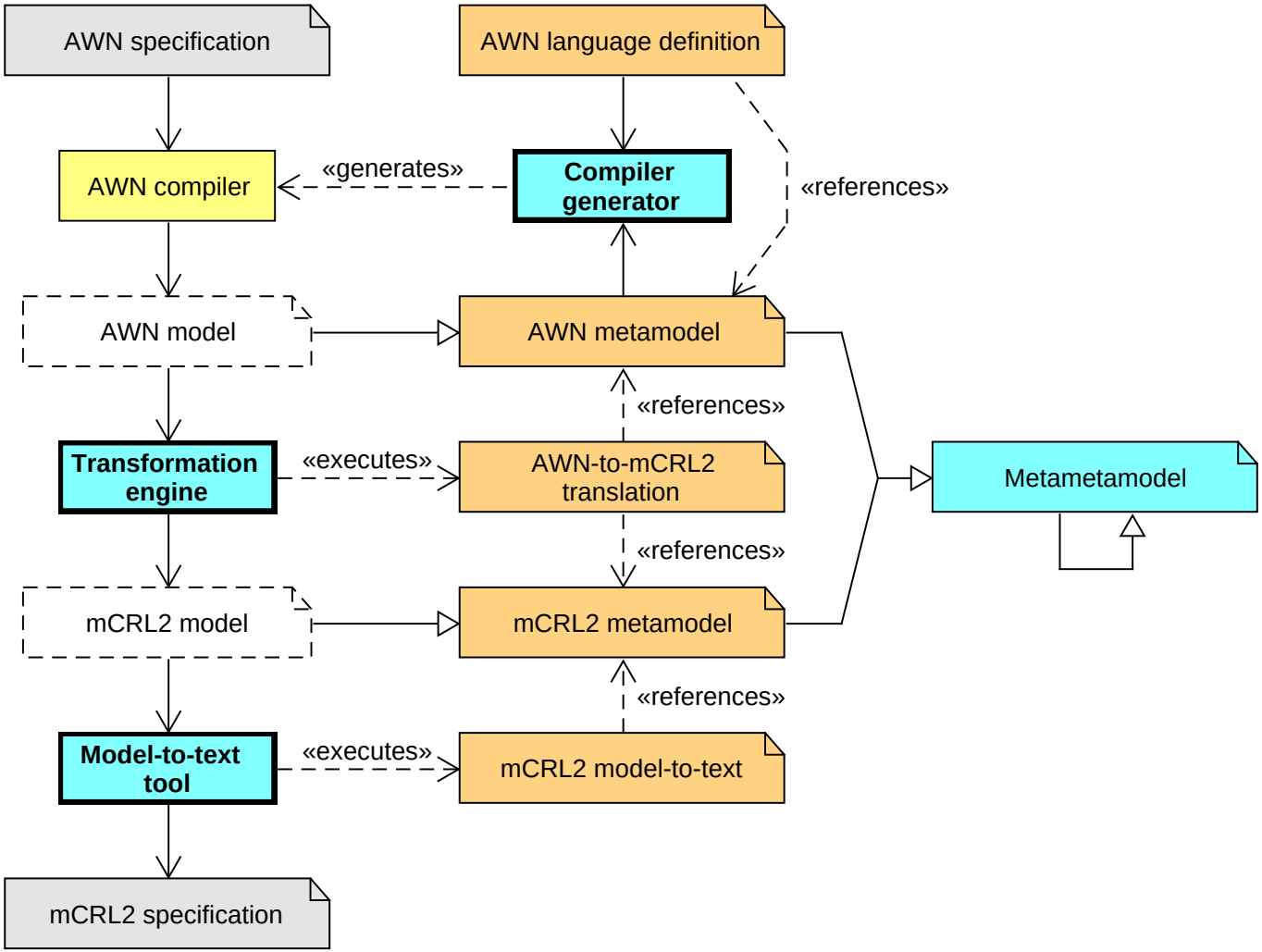


mCRL2 model-to-text

```
[comment encoding = UTF-8 /]
[module generate('http://www.eclipse.org/uml2/3.0.0/UML')/]

[template public generate(aClass : Class)]
[file (aClass.classFileName(), false)]
    package [aClass.containingPackages().name->sep('.')/]

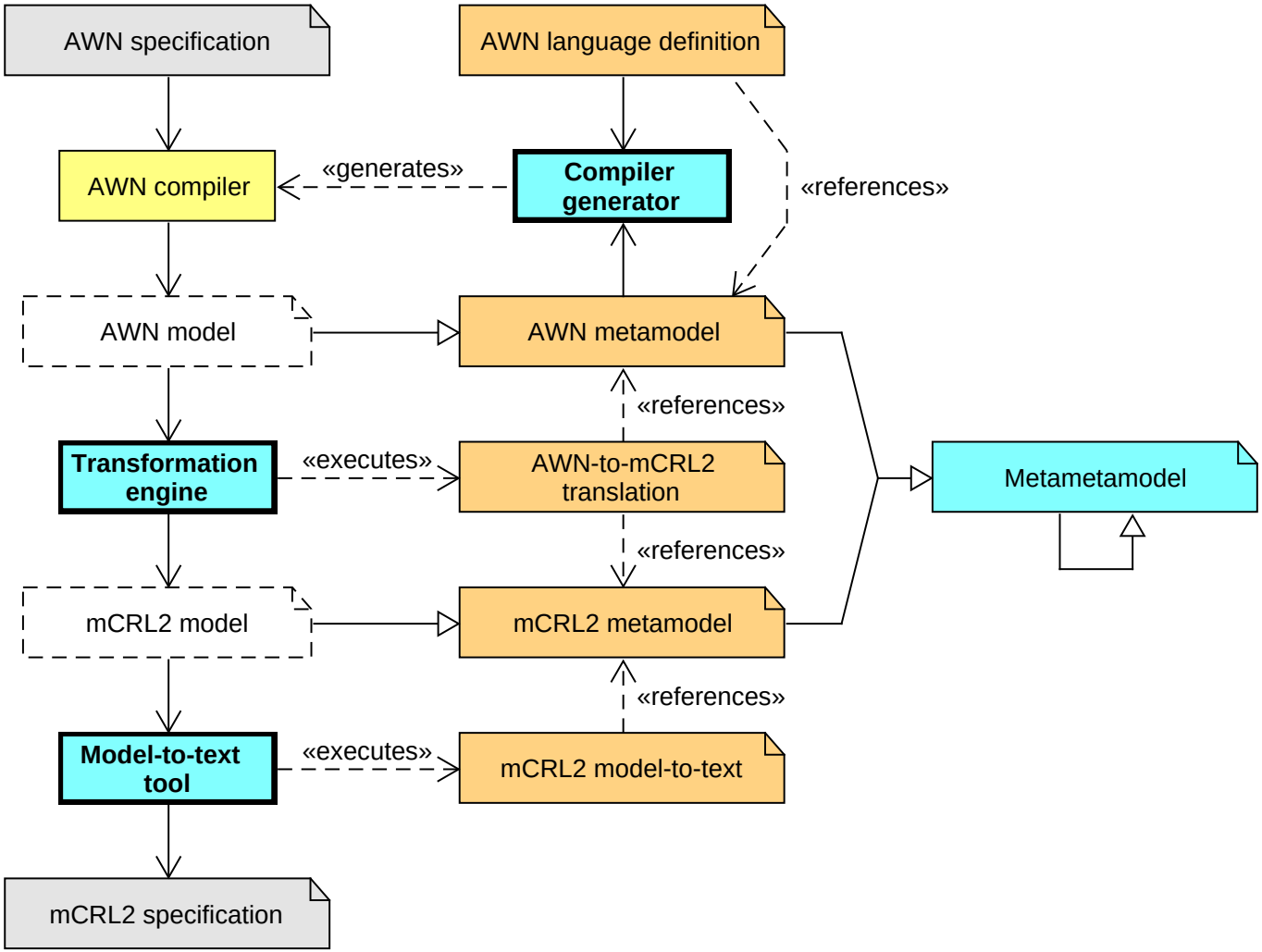
    // [protected ('imports')]
    // [/protected]

    public class [aClass.name.toUpperFirst()/] {
    [for (p: Property | aClass.attribute) separator('\n')]
        private [p.type.name/] [p.name/];
    [/for]

    [for (p: Property | aClass.attribute) separator('\n')]
        public [p.type.name/] get[p.name.toUpperFirst()/]() {
            return this.[p.name/];
        }
    [/for]

    [for (o: Operation | aClass.ownedOperation) separator('\n')]
        public [o.type.name/] [o.name/]() {
            // [protected (o.name)]
            // TODO should be implemented
            // [/protected]
        }
    [/for]
```

From AWN to mCRL2 using MDE



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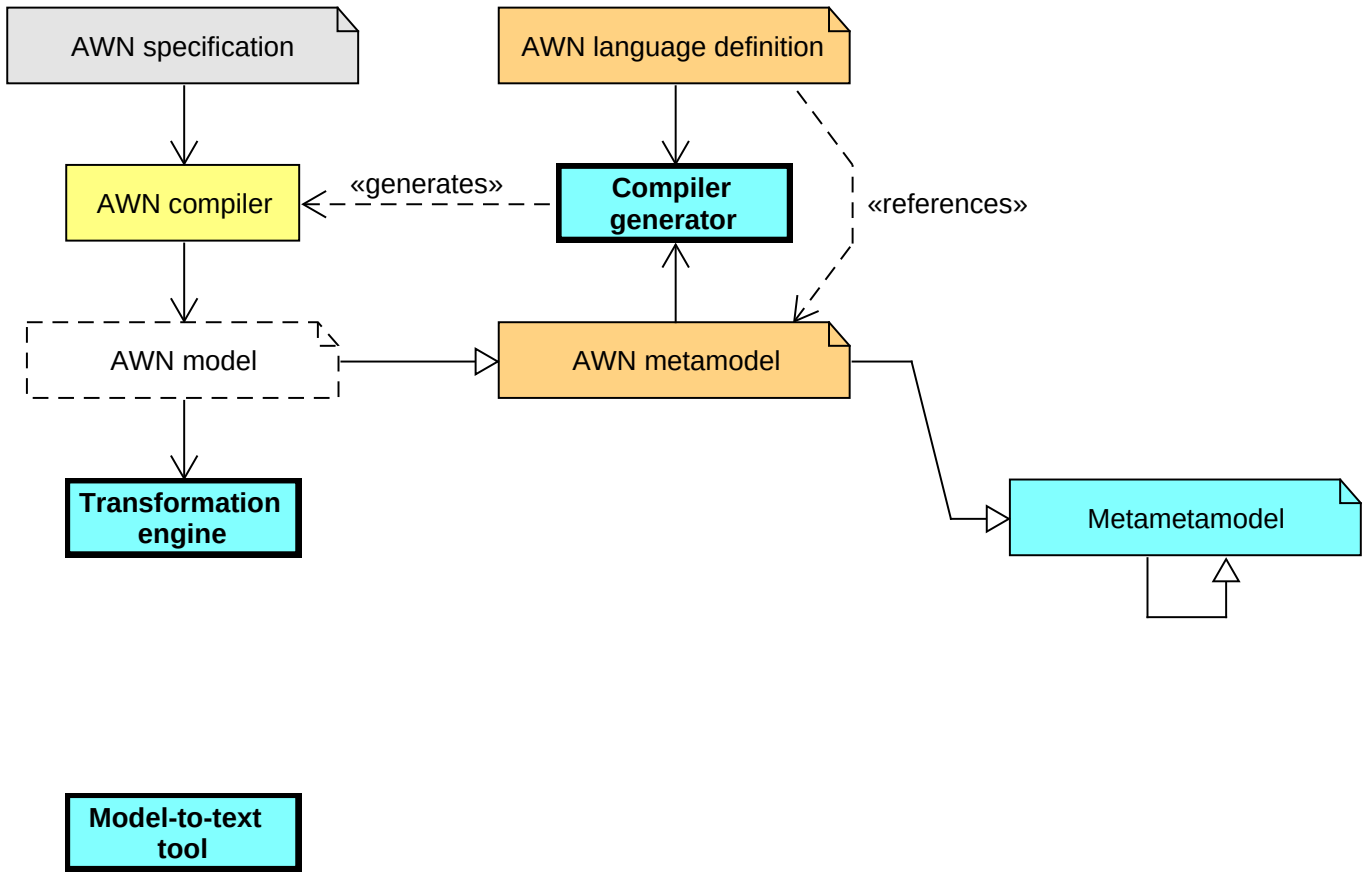

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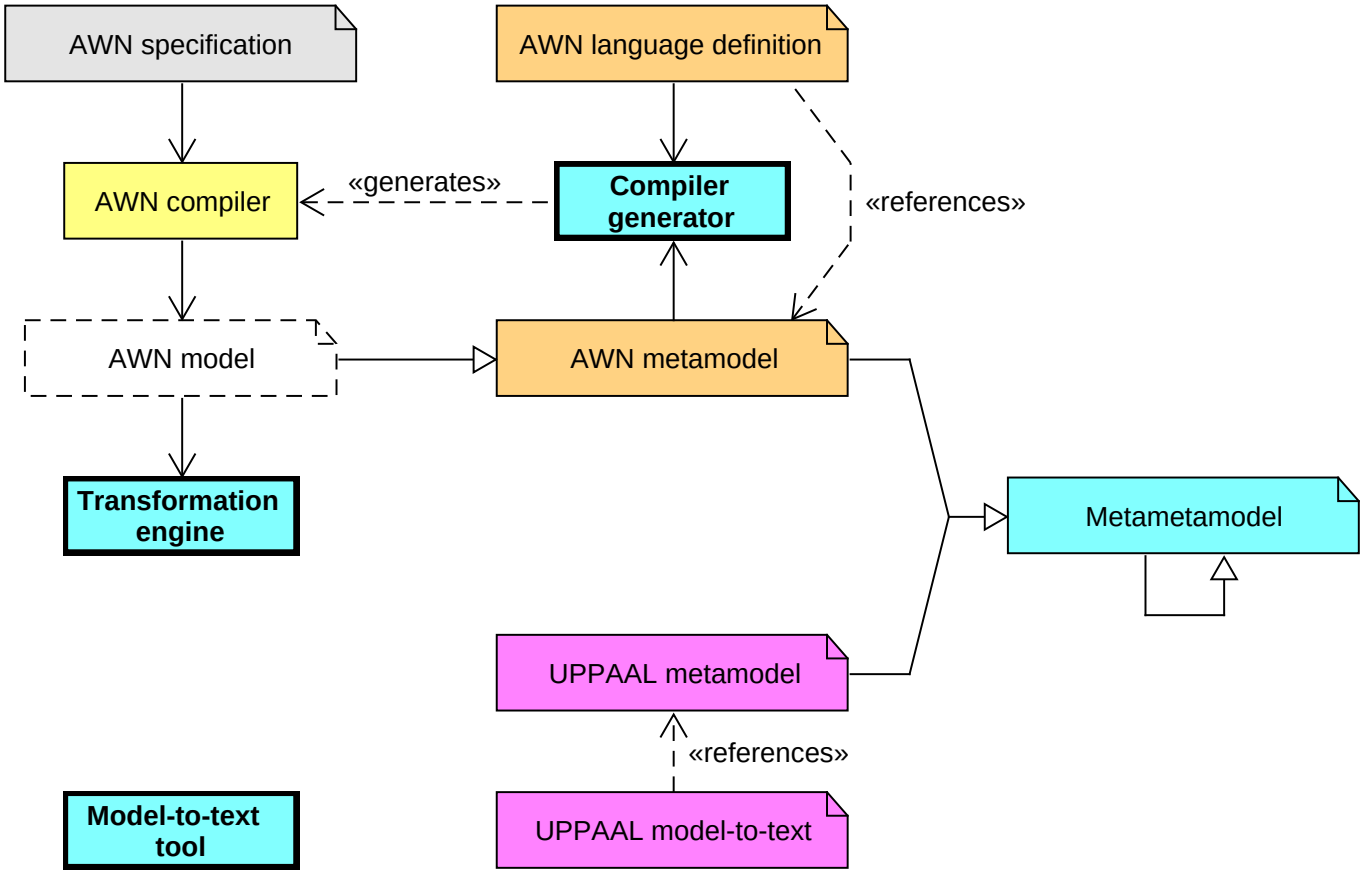

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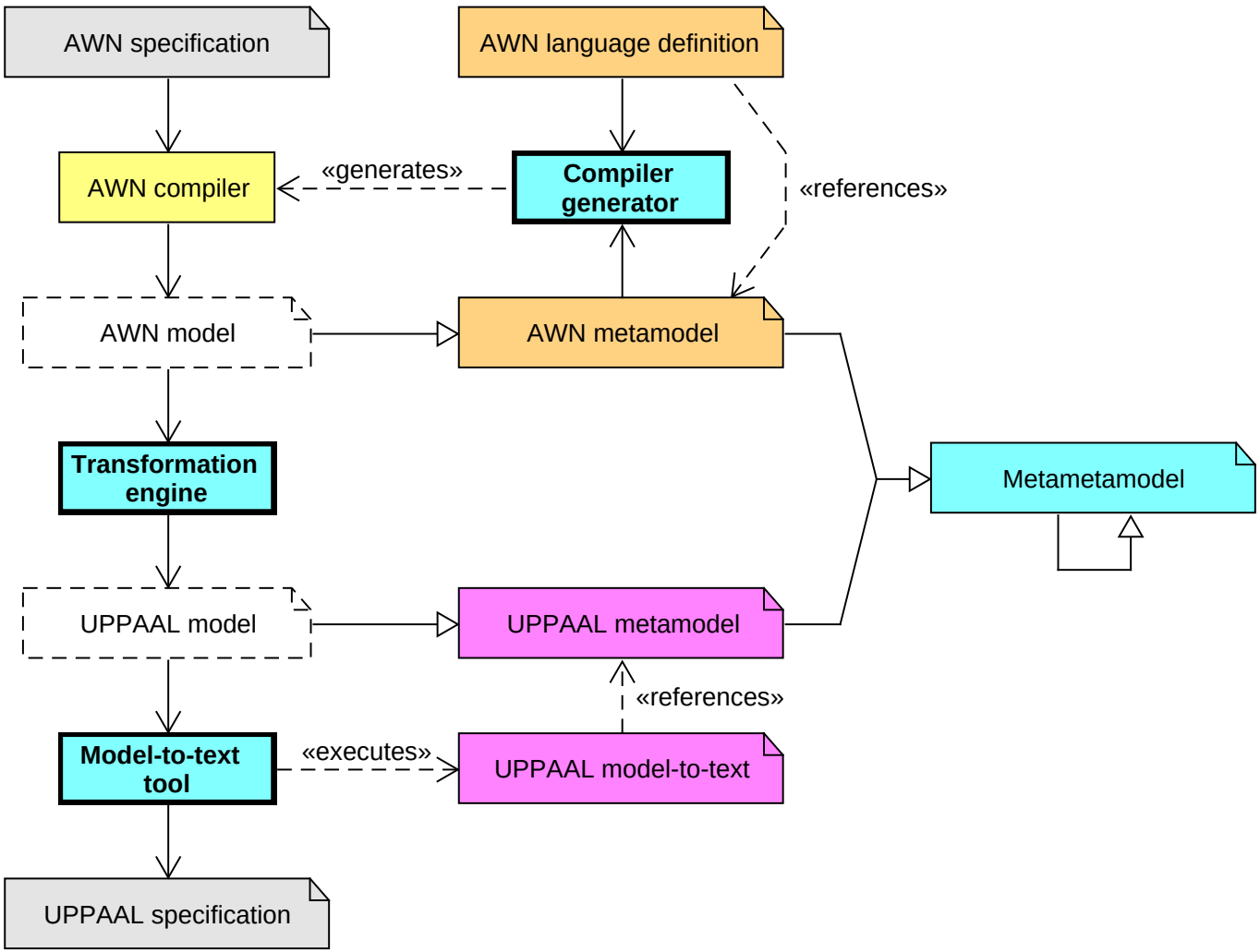

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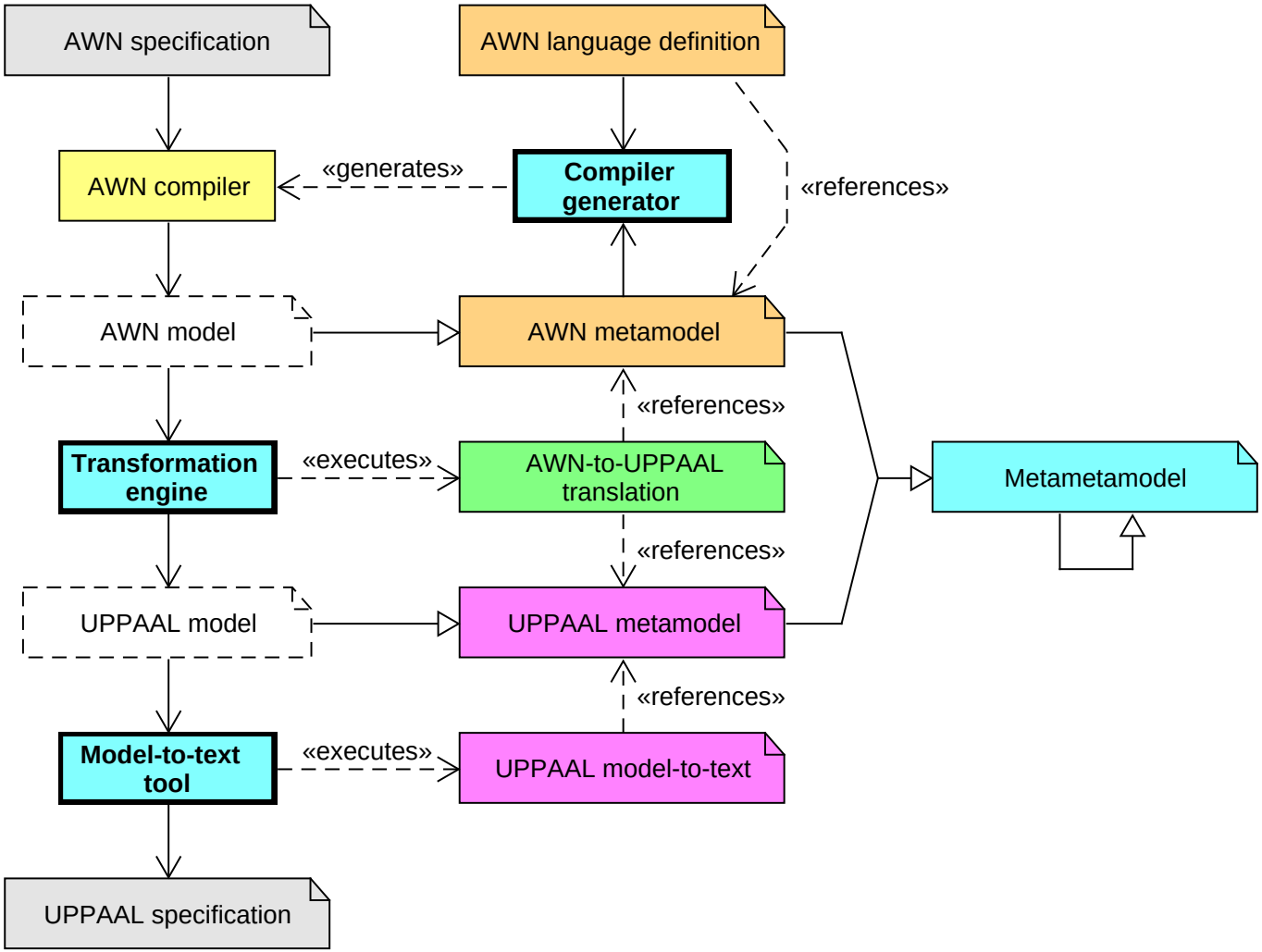

Advantages/Disadvantages

Advantages	**Disadvantages**
Fewer files required	Extra design efforts
Domain rules apply automatically	Knowledge of DSLs required
Peripheral tools available	
Improved interoperability	
Improved reusability	
Improved maintainability	

Future work

Tasks:

- Finish the translation from AWN to mCRL2.
- Prove validity of the translation.
- Automate the translation.
- Determine the suitability of MDE techniques in practice.

The project will take 6 months.