A QoS-aware Integrated Model Checking Environment for Developing and Validating DRE Applications

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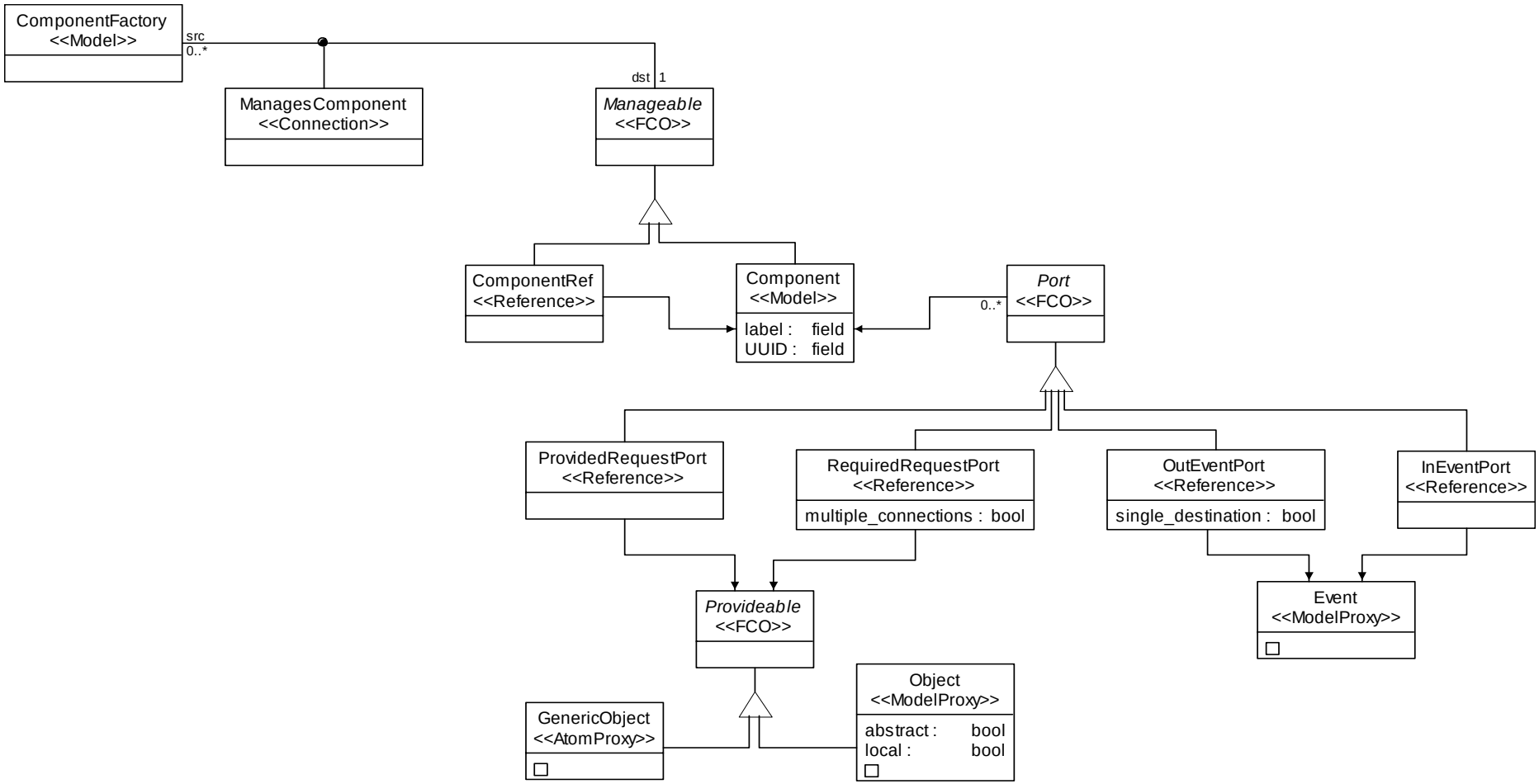
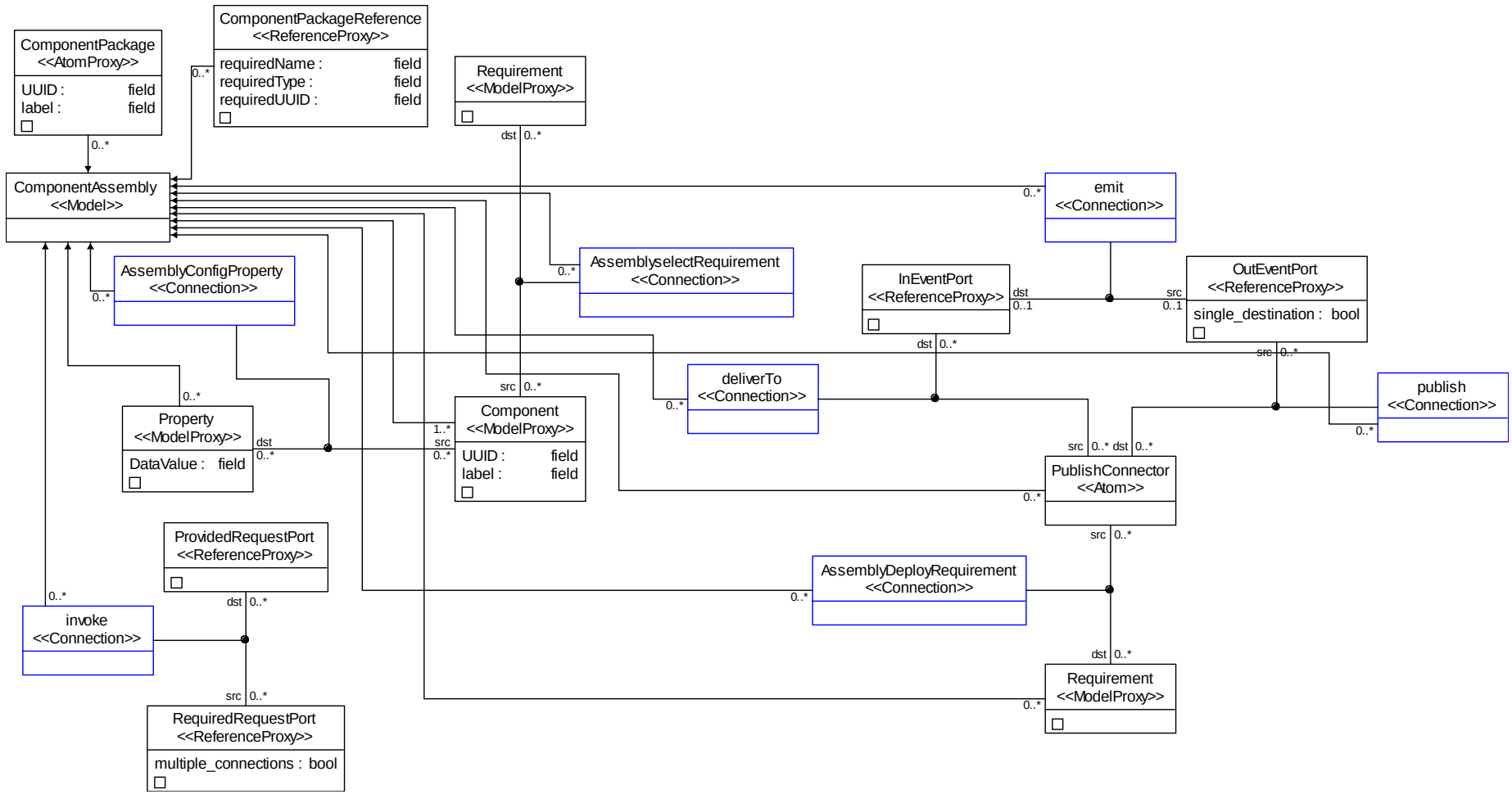
Platform Independent Component Modelling Language

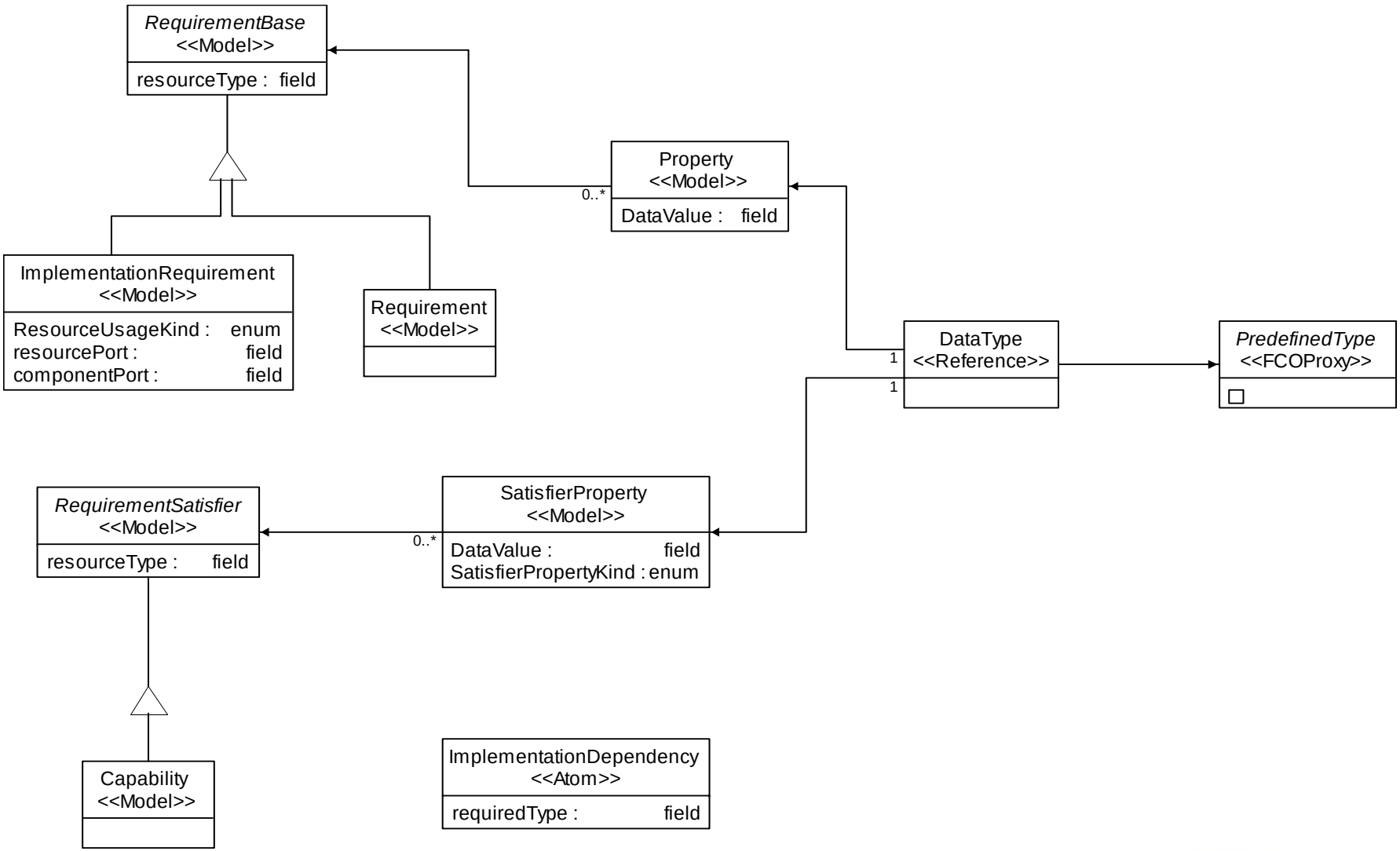
PICML Meta: Components



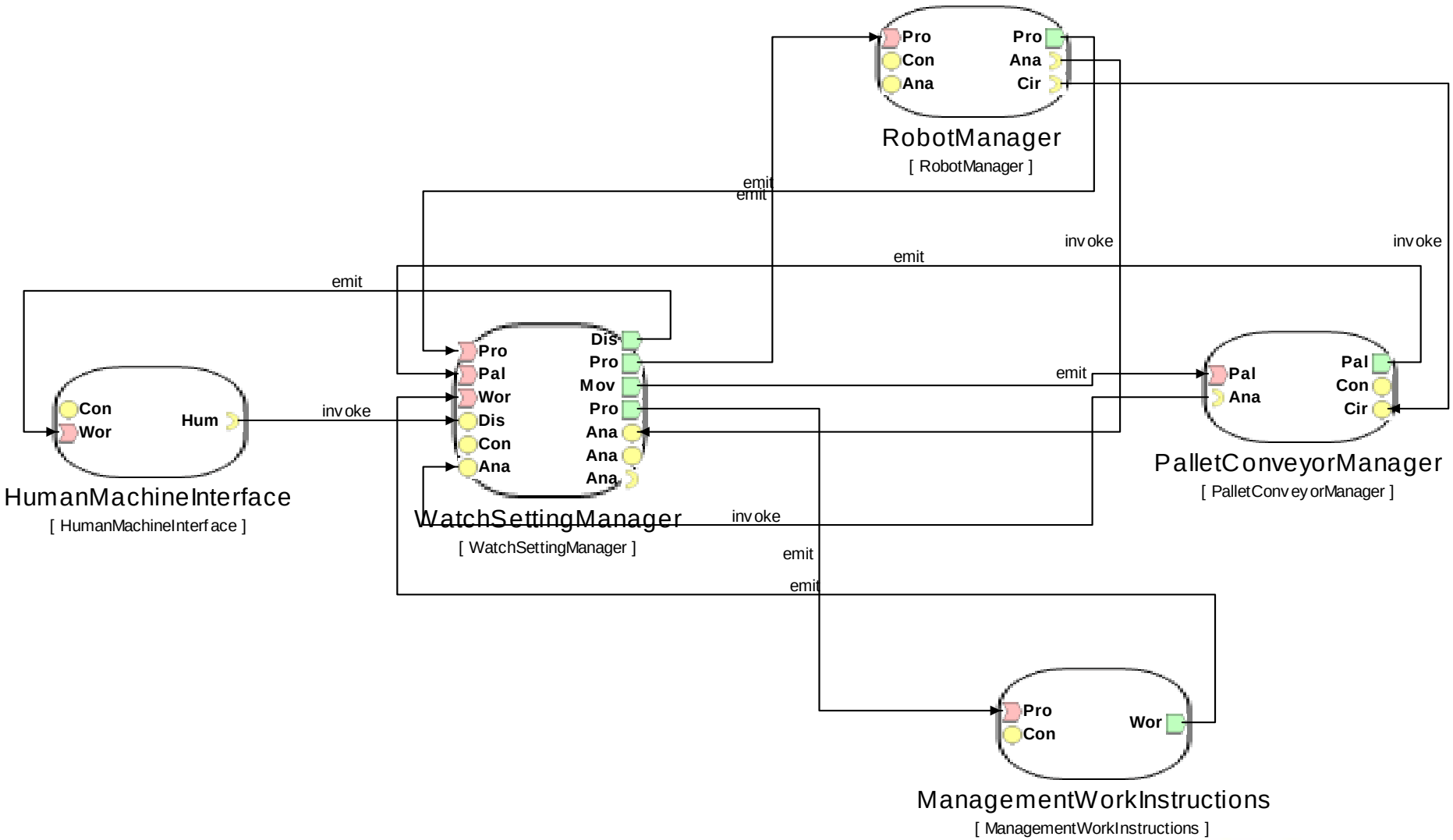
PICML Meta: Assemblies



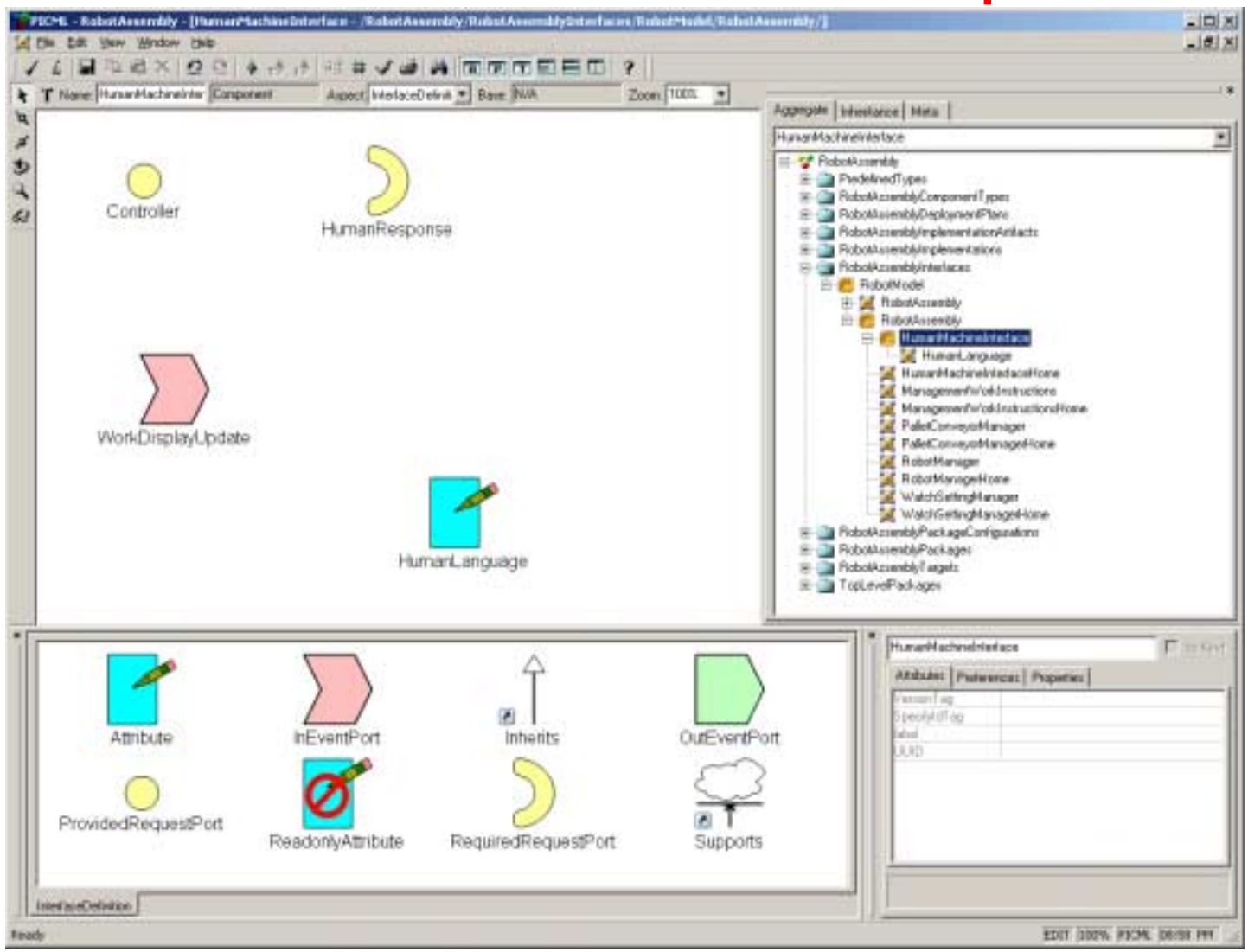
PICML Meta: Properties & Requirements



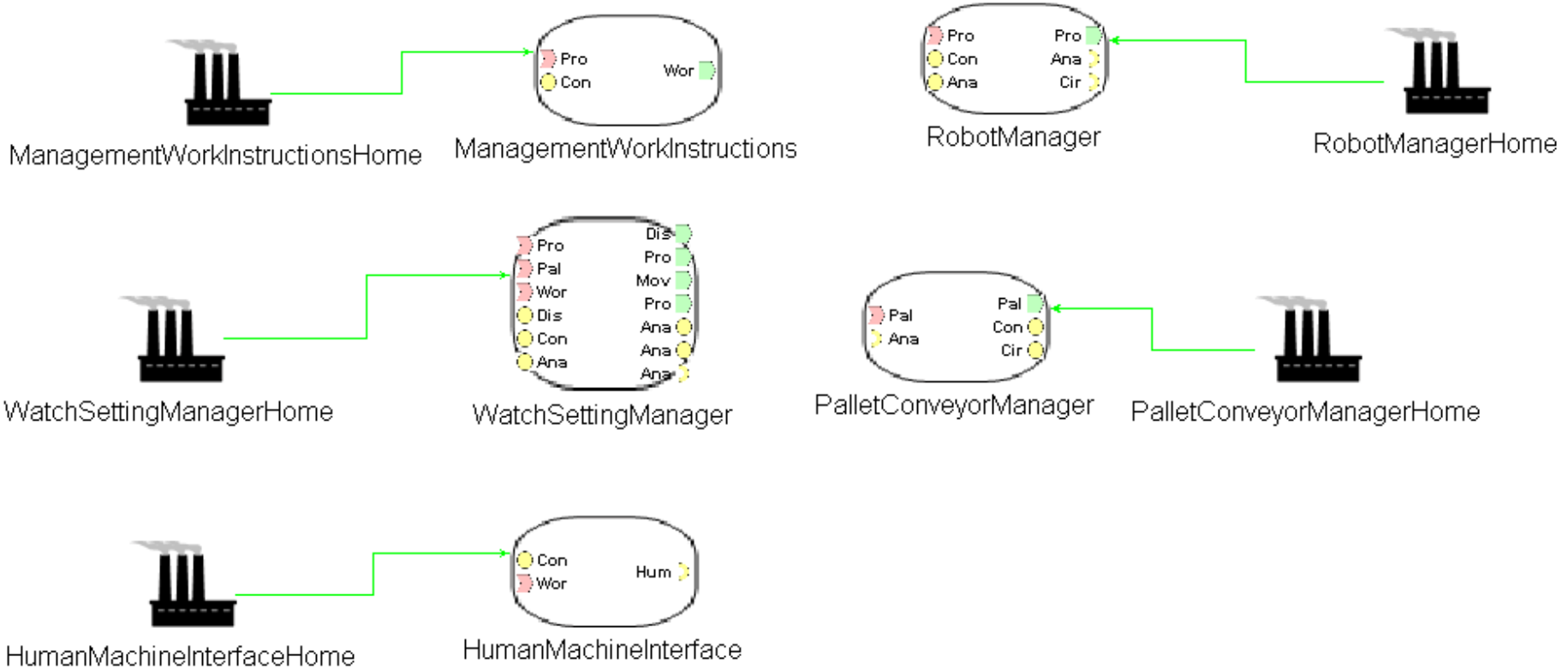
A PICML Instance: Robot - Assembly



PICML Instance: Robot–Component Def.

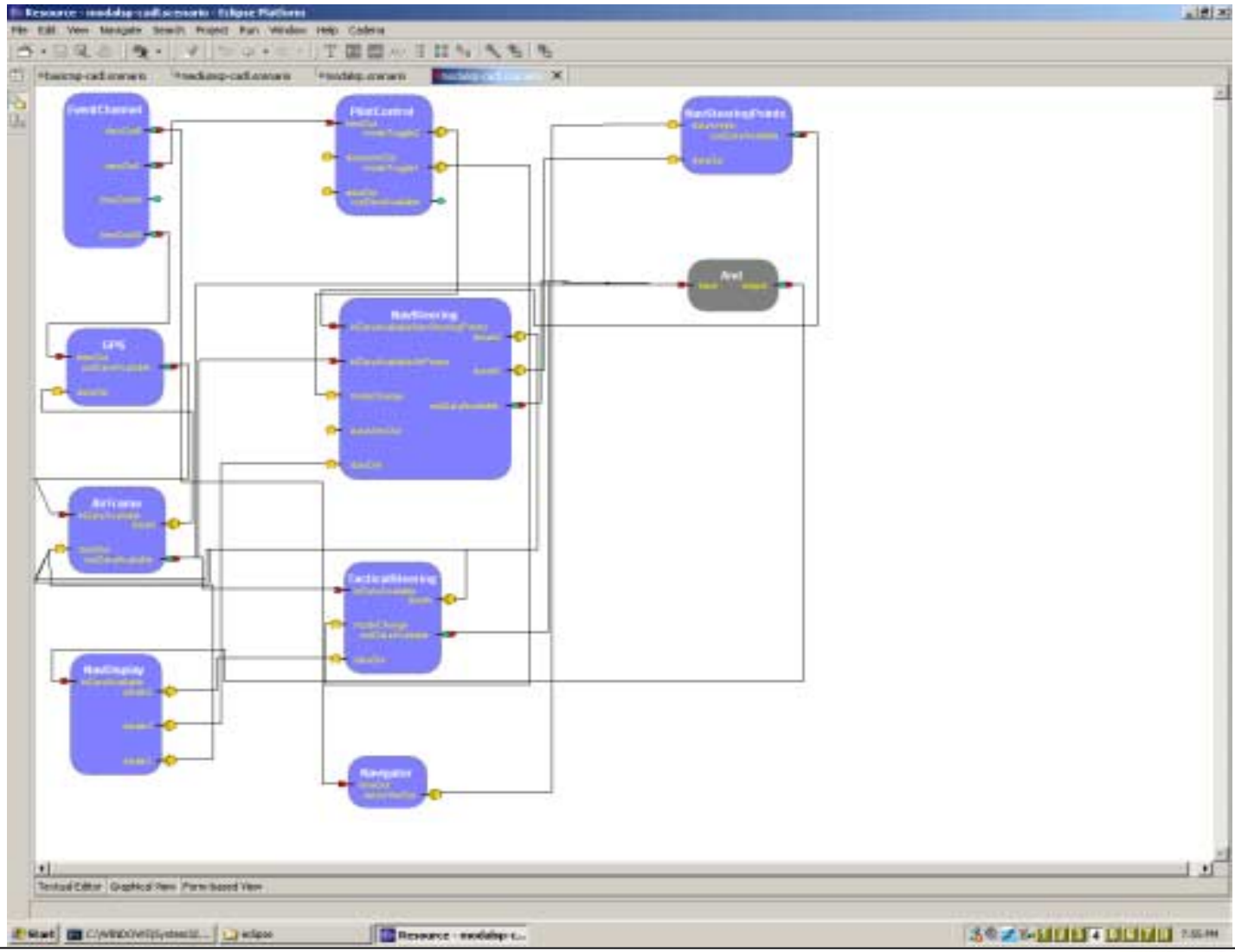


PICML Instance: Robot–ComponentHomes

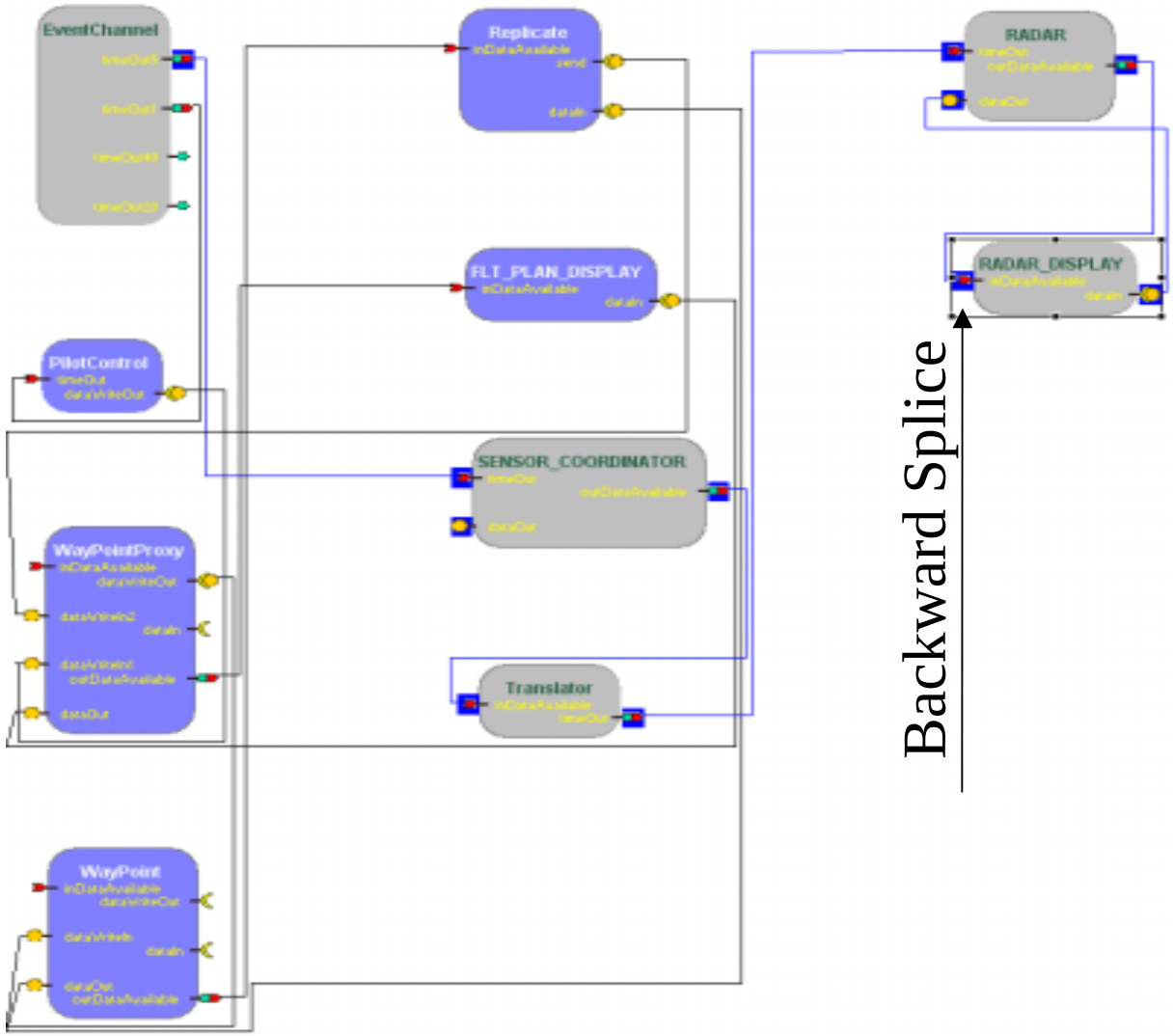


Cadena

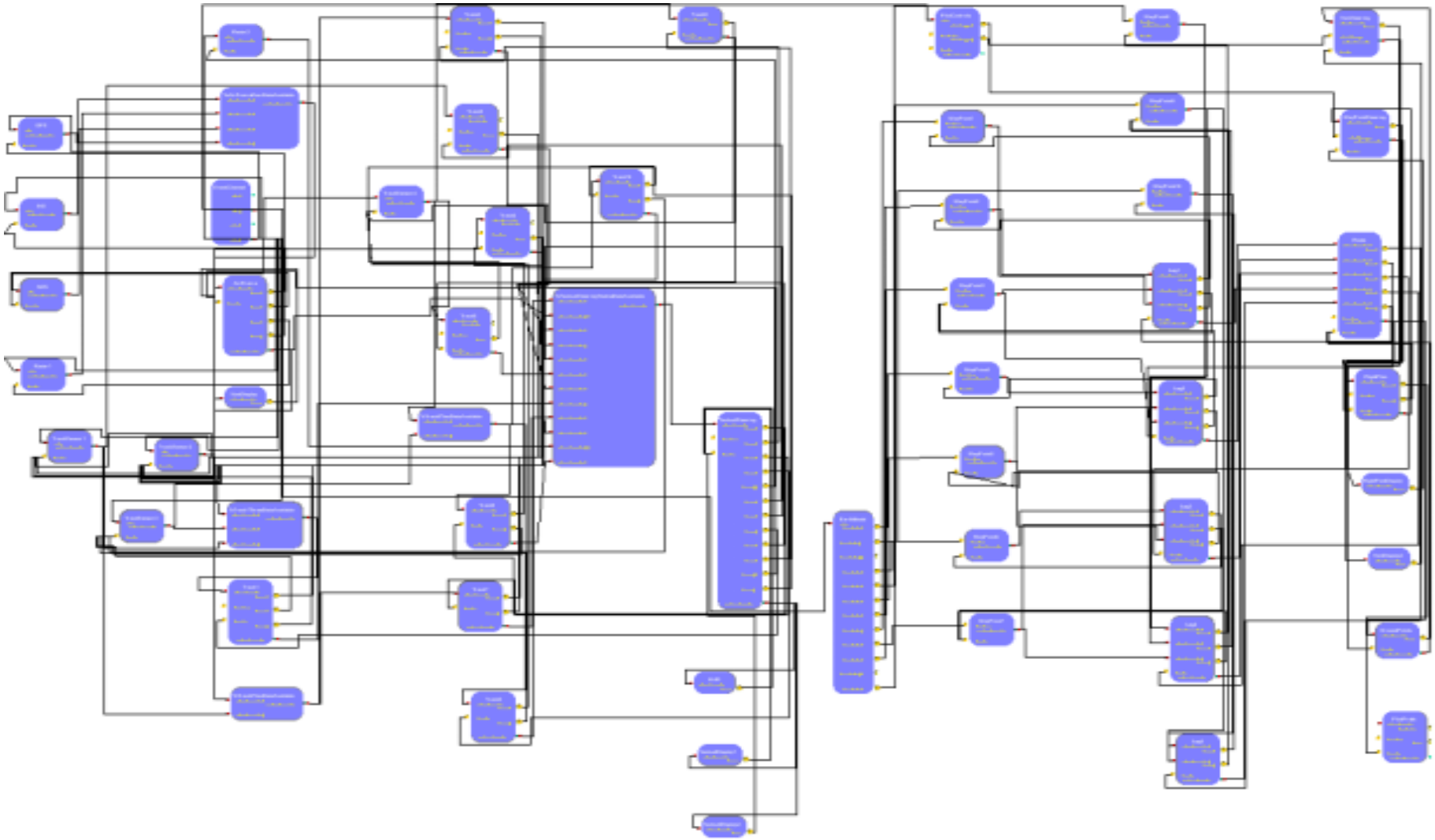
Cadena examples - ModalSP



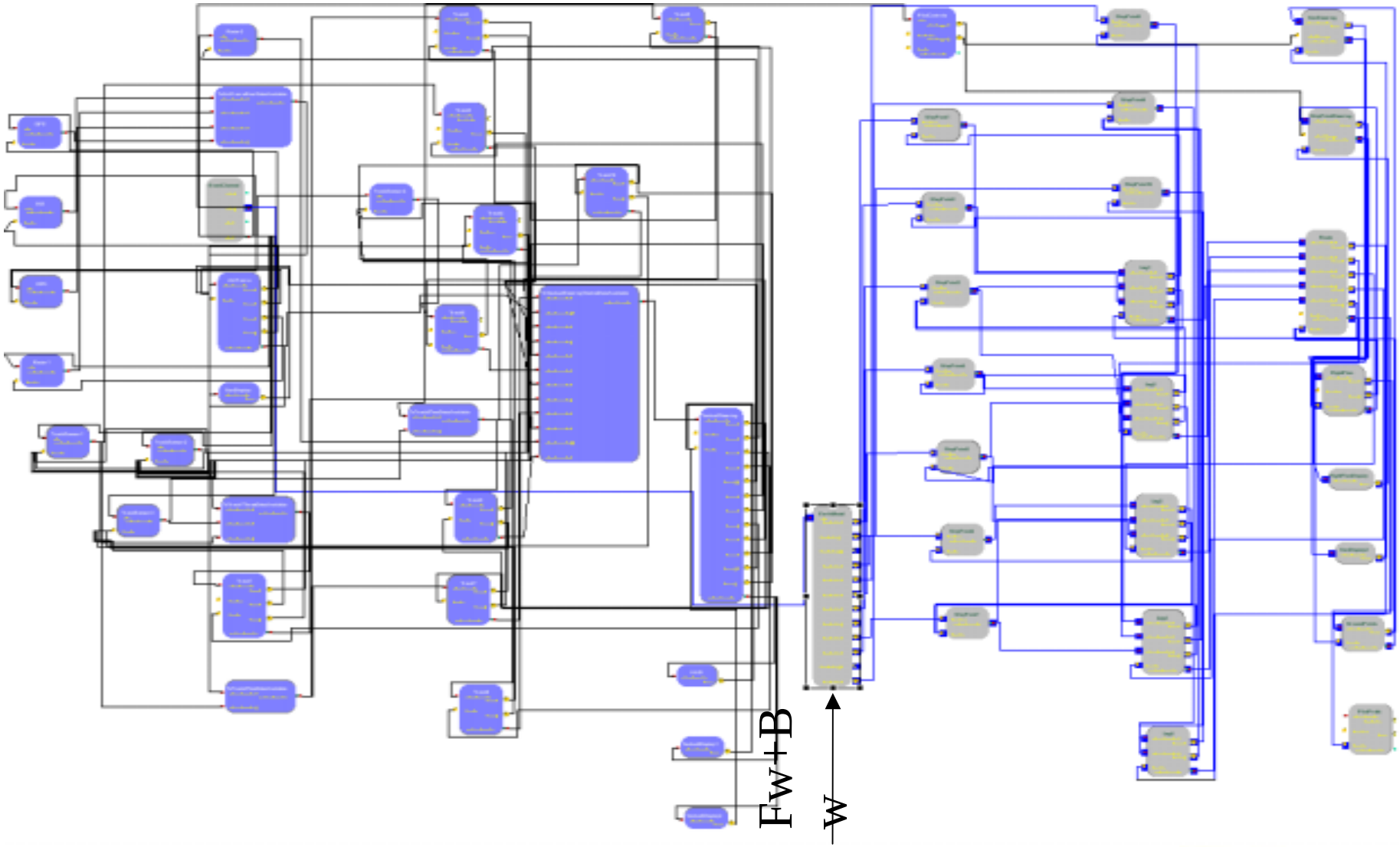
[MultirateMP] Backward Splice



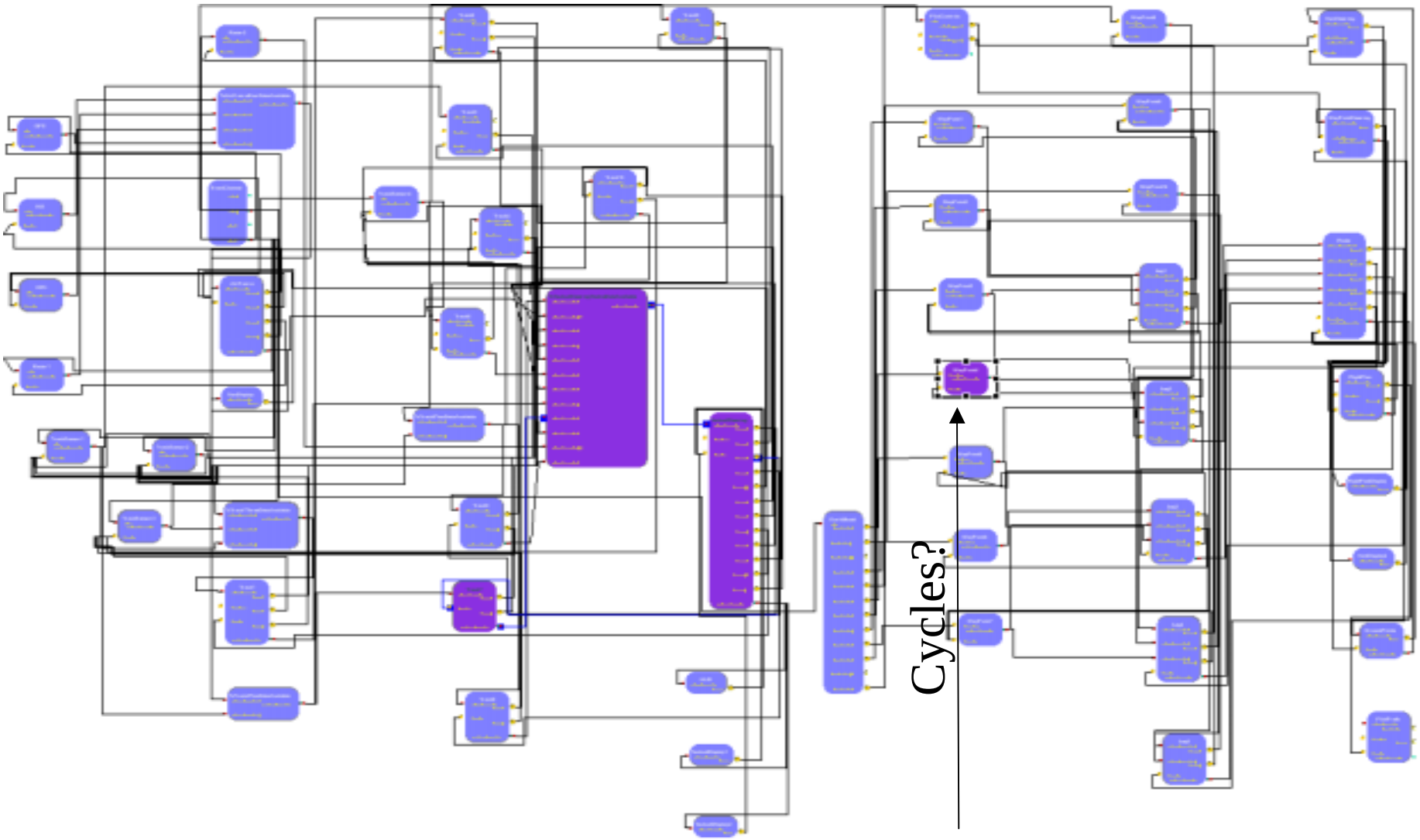
MediumSP



Forward + Backward splice



Cycle Detection



Incremental Specification

Increasing Effort & Strength of Verification

Specifications

port action dependencies

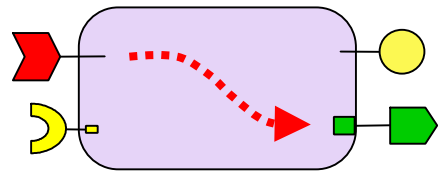
refinement

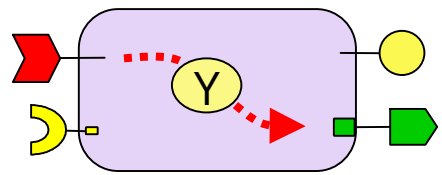
mode-based dependencies

refinement

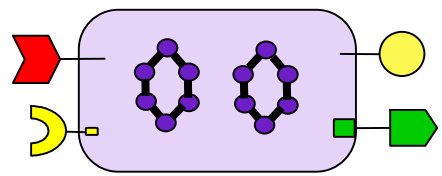
component transition semantics

Component Structure





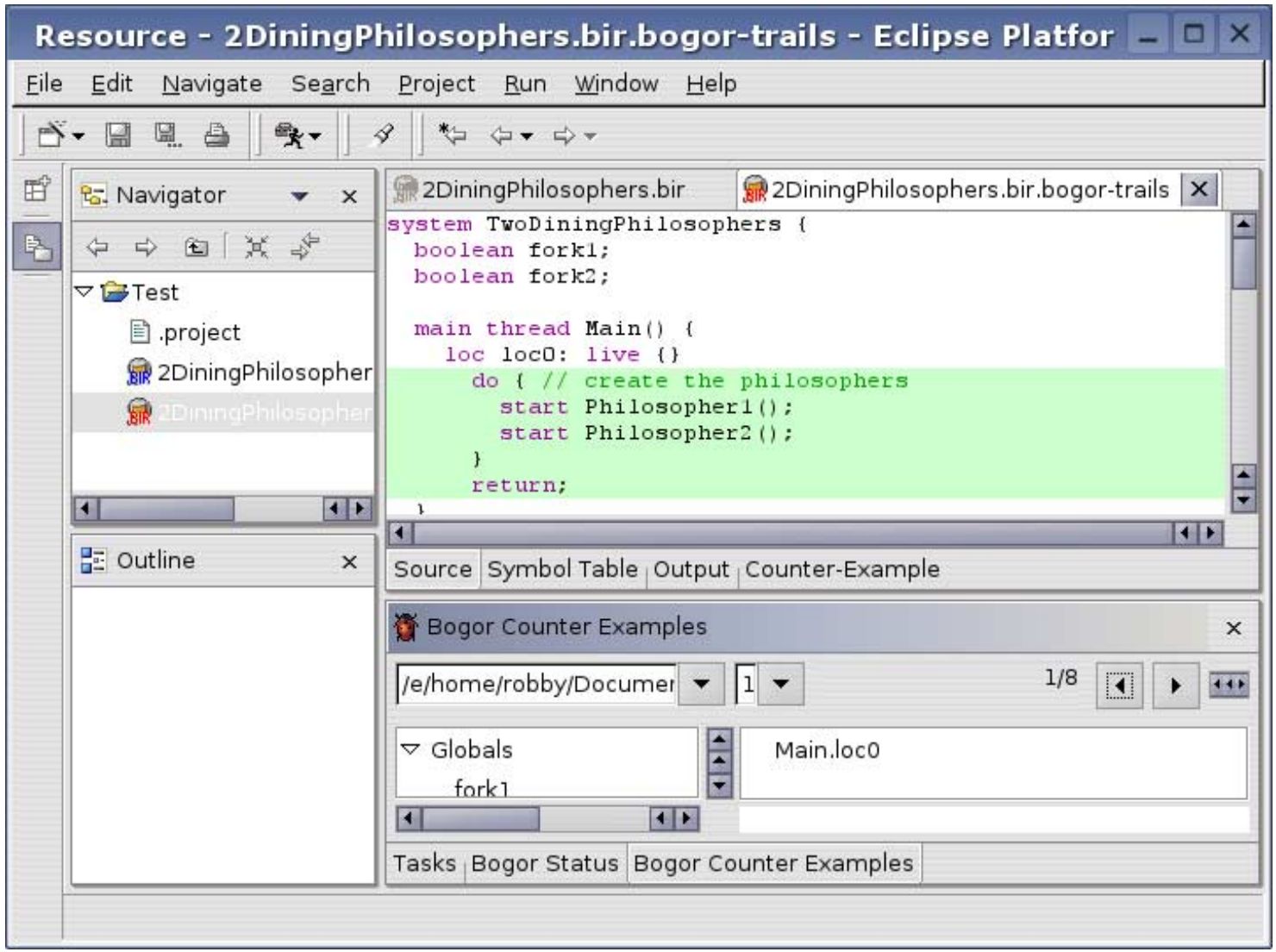
...only in mode Y



...state machines give abstract behavior

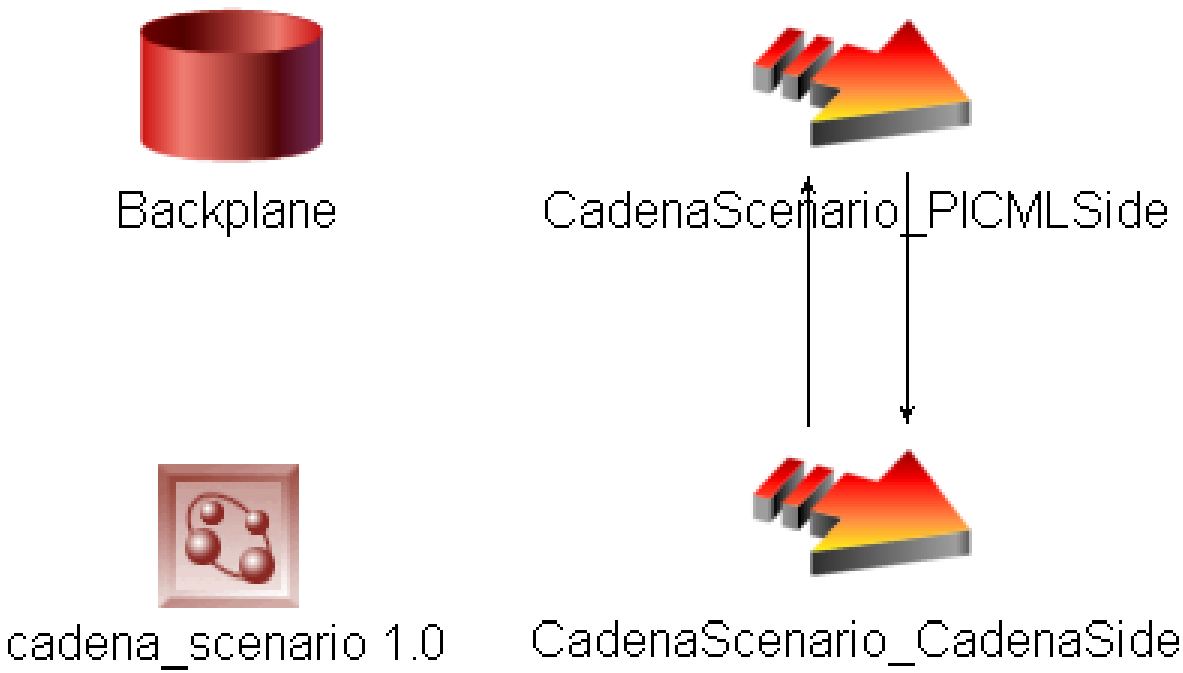
Bogor

Bogor example – 2 Dining Philosophers

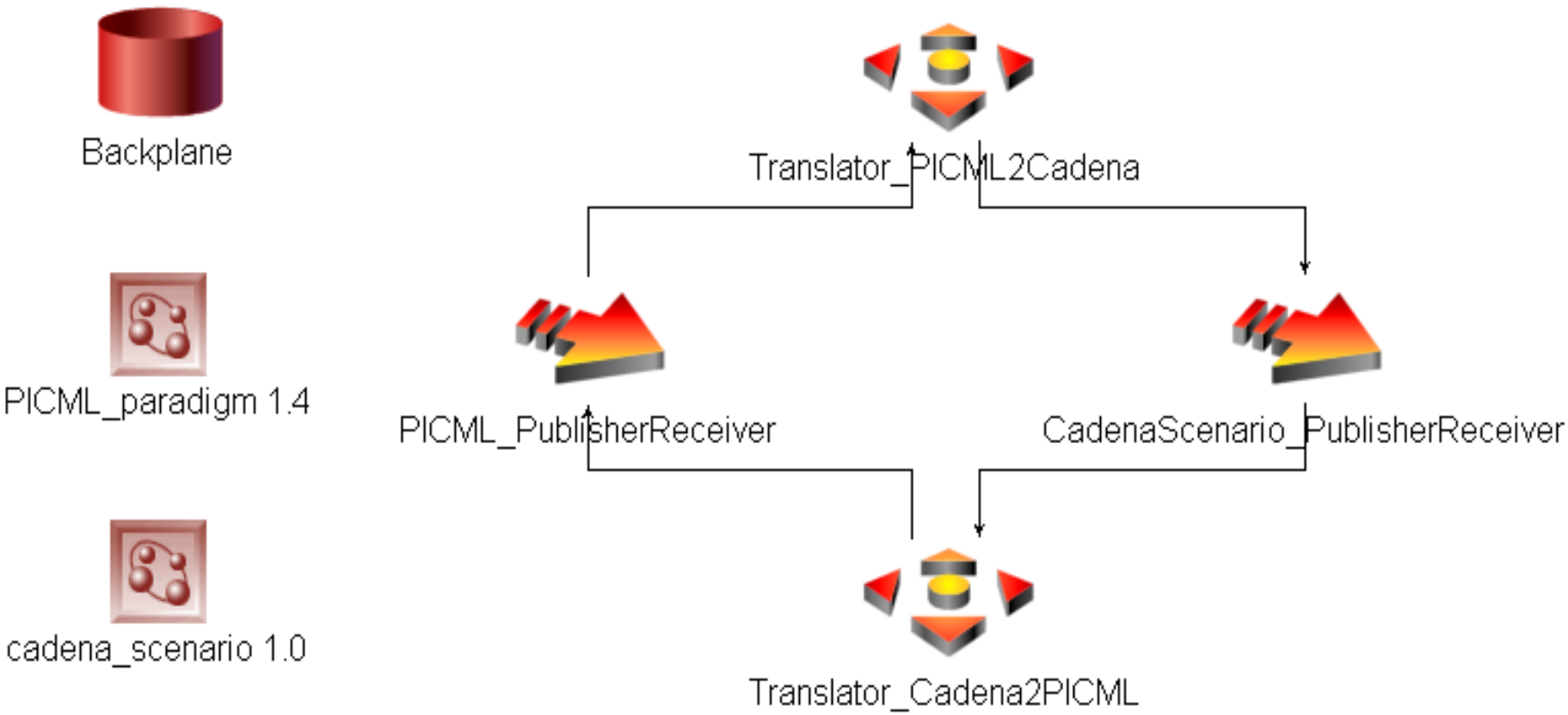


Open Tool Integration Framework

OTIF - Integration Workflow

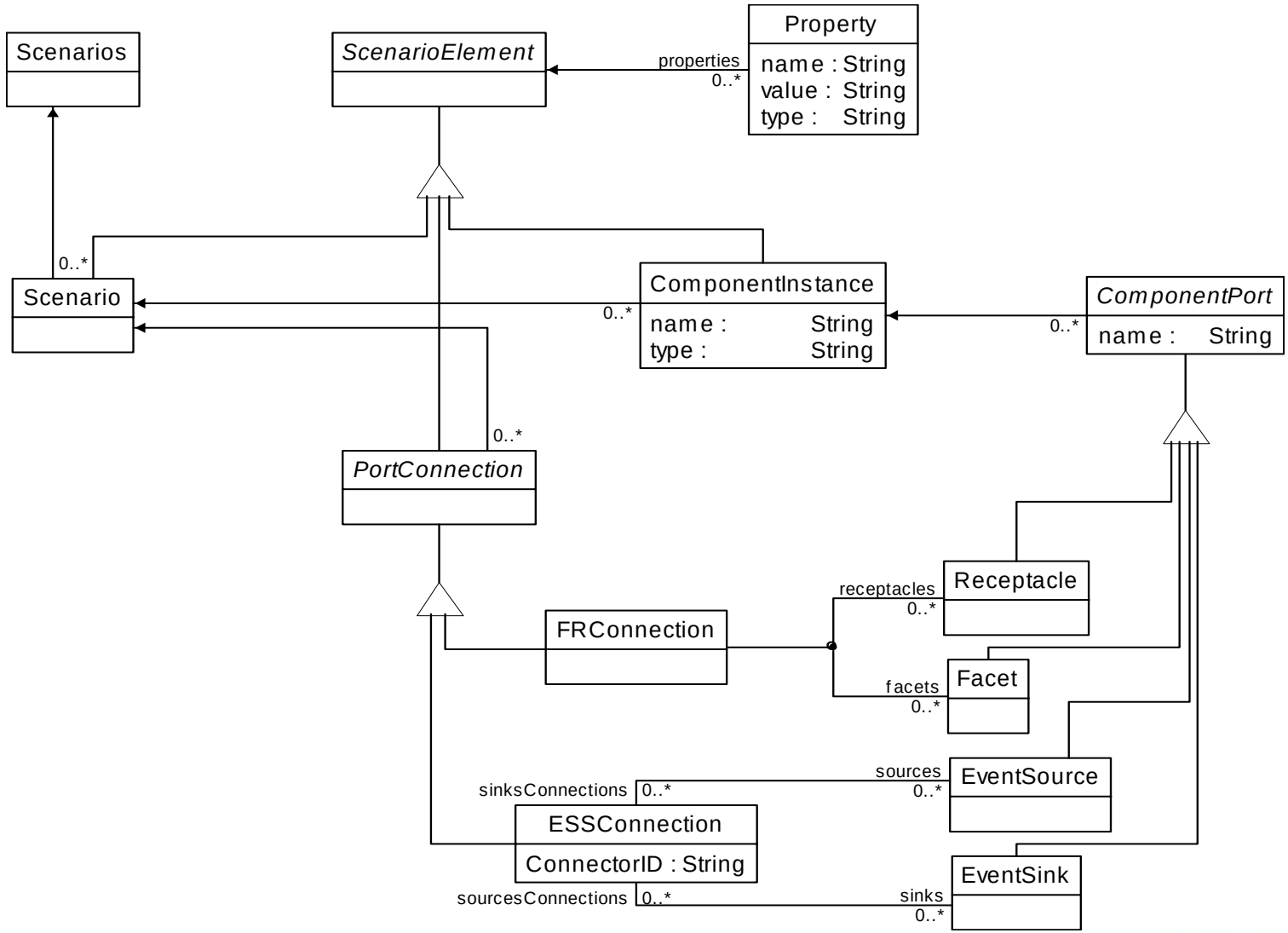


Future workflow



Interchange Format

CadenaScenario – UML meta



Generated Schema

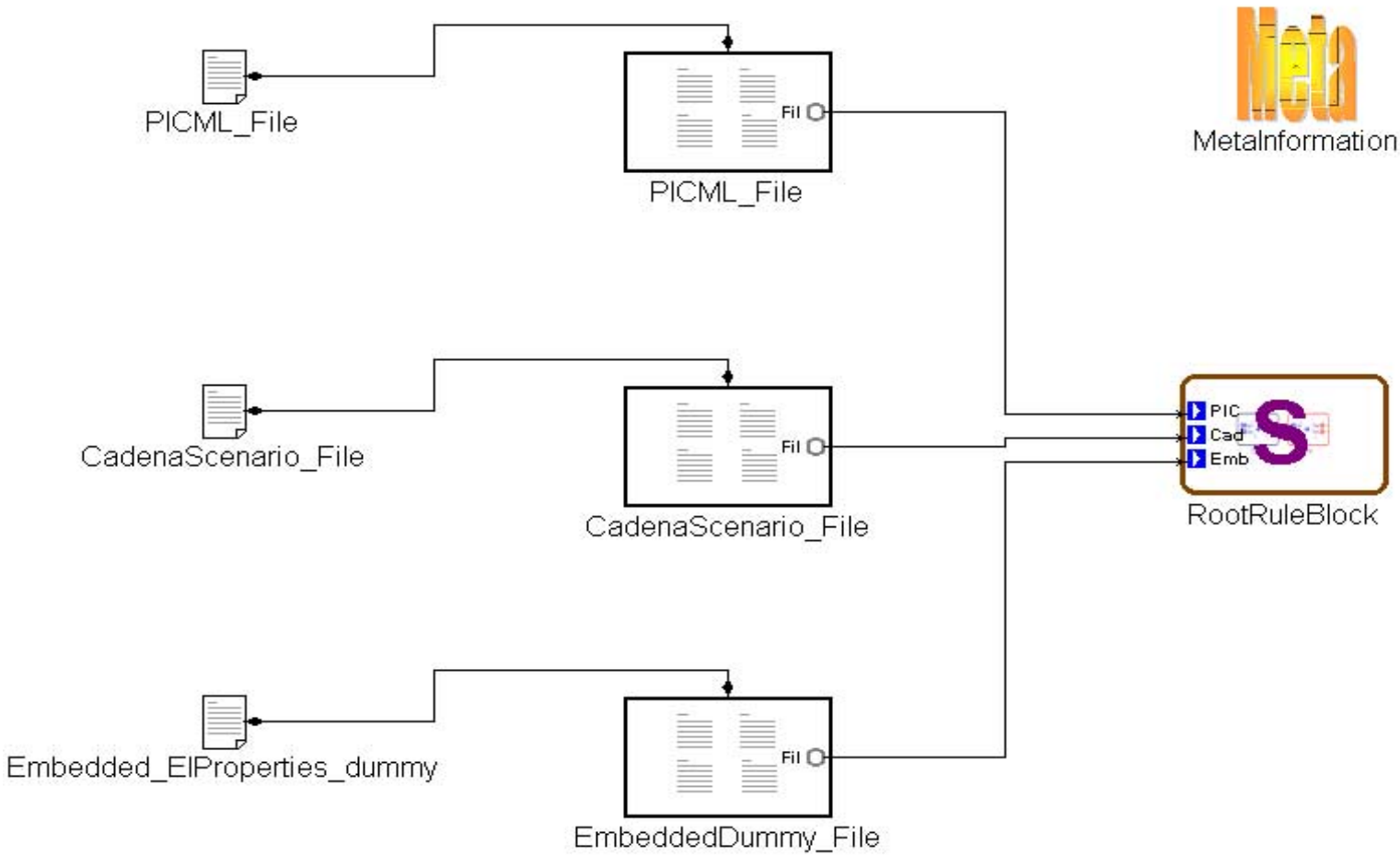
```
<?xml version="1.0" encoding="UTF-8" ?>
<?udm interface="cadena_scenario" version="1.00"?>
- <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
- <!--  generated on Mon Jun 14 01:27:17 2004
 -->
- <xsd:complexType name="ESSConnectionType">
- <xsd:sequence>
 <xsd:element name="Property" type="PropertyType" minOccurs="0"
maxOccurs="unbounded" />
 </xsd:sequence>
 <xsd:attribute name="ConnectorID" type="xsd:string" use="required"
/>
 <xsd:attribute name="sources" type="xsd:IDREFS" />
 <xsd:attribute name="sinks" type="xsd:IDREFS" />
 <xsd:attribute name="_id" type="xsd:ID" />
 <xsd:attribute name="_archetype" type="xsd:IDREF" />
 <xsd:attribute name="_derived" type="xsd:IDREFS" />
 <xsd:attribute name="_instances" type="xsd:IDREFS" />
 <xsd:attribute name="_desynched_atts" type="xsd:string" />
 <xsd:attribute name="_real_archetype" type="xsd:boolean" />
 <xsd:attribute name="_subtype" type="xsd:boolean" />
 </xsd:complexType>
- <xsd:complexType name="ScenariosType">
- <xsd:sequence>
 <xsd:element name="Scenario" type="ScenarioType" minOccurs="0"
maxOccurs="unbounded" />
 </xsd:sequence>
 <xsd:attribute name="_id" type="xsd:ID" />
 <xsd:attribute name="_archetype" type="xsd:IDREF" />
 <xsd:attribute name="_derived" type="xsd:IDREFS" />
 <xsd:attribute name="_instances" type="xsd:IDREFS" />
 <xsd:attribute name="_desynched_atts" type="xsd:string" />
 <xsd:attribute name="_real_archetype" type="xsd:boolean" />
 <xsd:attribute name="_subtype" type="xsd:boolean" />
 </xsd:complexType>
- <xsd:complexType name="FRConnectionType">
- <xsd:sequence>
 <xsd:element name="Property" type="PropertyType" minOccurs="0"
maxOccurs="unbounded" />
 </xsd:sequence>
 <xsd:attribute name="facets_end_" type="xsd:IDREF" />
 <xsd:attribute name="receptacles_end_" type="xsd:IDREF" />
 <xsd:attribute name="_id" type="xsd:ID" />
 <xsd:attribute name="_archetype" type="xsd:IDREF" />
 <xsd:attribute name="_derived" type="xsd:IDREFS" />
 <xsd:attribute name="_instances" type="xsd:IDREFS" />
 <xsd:attribute name="_desynched_atts" type="xsd:string" />
 <xsd:attribute name="_real_archetype" type="xsd:boolean" />
 <xsd:attribute name="_subtype" type="xsd:boolean" />
 </xsd:complexType>
- <xsd:complexType name="EventSinkType">
 <xsd:attribute name="name" type="xsd:string" use="required" />
 <xsd:attribute name="sourcesConnections" type="xsd:IDREFS" />
 <xsd:attribute name="_id" type="xsd:ID" />
 <xsd:attribute name="_archetype" type="xsd:IDREF" />
 <xsd:attribute name="_derived" type="xsd:IDREFS" />
 <xsd:attribute name="_instances" type="xsd:IDREFS" />
 <xsd:attribute name="_desynched_atts" type="xsd:string" />
 <xsd:attribute name="_real_archetype" type="xsd:boolean" />
 <xsd:attribute name="_subtype" type="xsd:boolean" />
 </xsd:complexType>
- <xsd:complexType name="EventSourceType">
 <xsd:attribute name="name" type="xsd:string" use="required" />
 <xsd:attribute name="sinksConnections" type="xsd:IDREFS" />
 <xsd:attribute name="_id" type="xsd:ID" />
 <xsd:attribute name="_archetype" type="xsd:IDREF" />
 <xsd:attribute name="_derived" type="xsd:IDREFS" />
 <xsd:attribute name="_instances" type="xsd:IDREFS" />
 <xsd:attribute name="_desynched_atts" type="xsd:string" />
[.....]
```

Robot Assembly – Equivalent XML

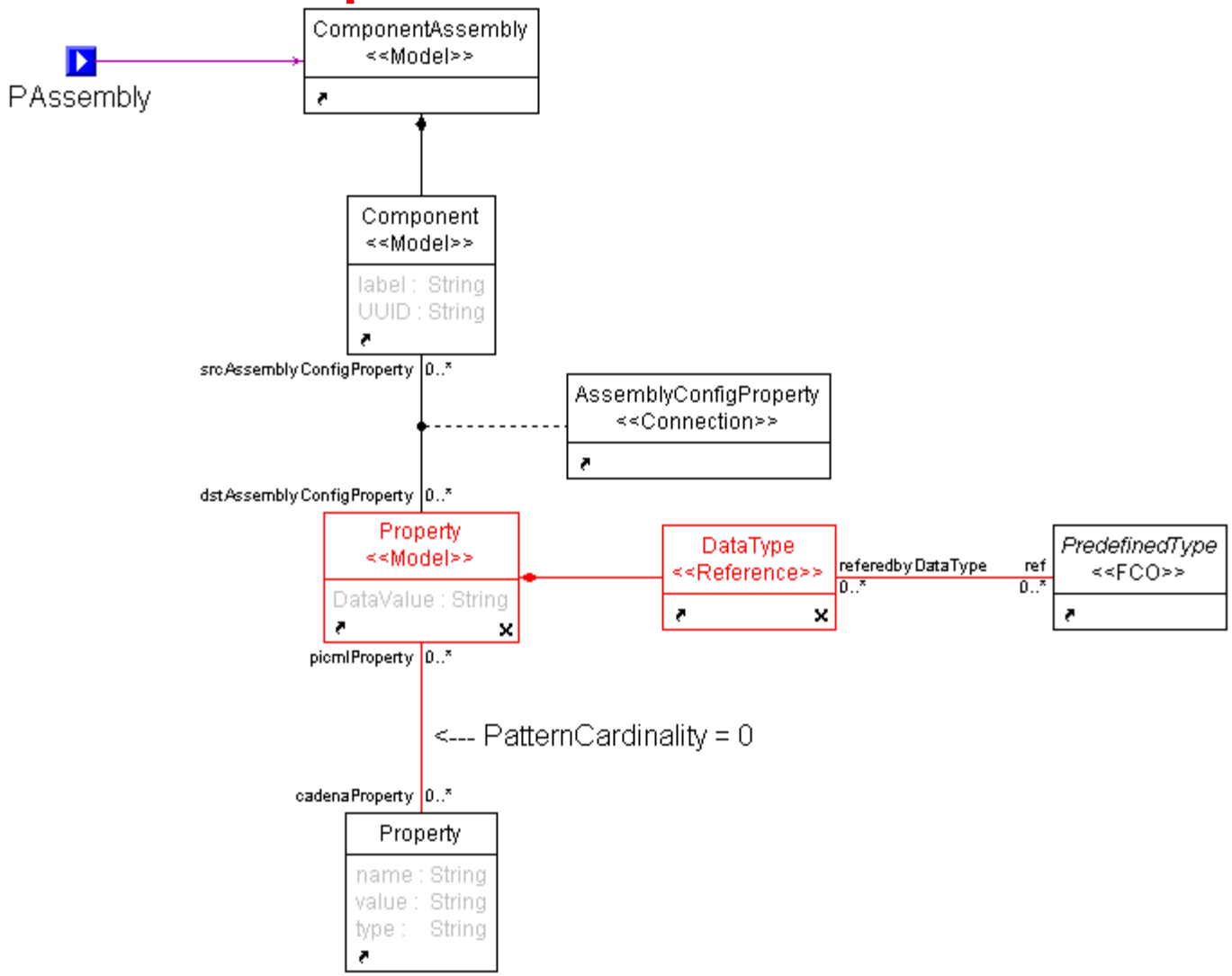
```
- <Scenarios xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="..\Udm\cadena_scenario.xsd">
- <Scenario>
- <ComponentInstance name="HumanMachineInterface" type="RobotAssembly/HumanMachineInterface">
  <EventSink _id="id18a4" name="WorkDisplayUpdate" sourcesConnections="id18a5" />
  <Facet name="AnalysisController" />
  <Facet name="Controller" />
  <Receptacle _id="id18a6" name="HumanResponse" facets="id18a7" />
  </ComponentInstance>
- <ComponentInstance name="ManagementWorkInstructions"
type="RobotAssembly/ManagementWorkInstructions">
  <EventSink _id="id18aa" name="ProductionReport" sourcesConnections="id18ab" />
  <EventSource _id="id18a8" name="WorkOrder" sinksConnections="id18a9" />
  <Facet name="Controller" />
  </ComponentInstance>
- <ComponentInstance name="WatchSettingManager" type="RobotAssembly/WatchSettingManager">
  <EventSink _id="id18b2" name="ProcessingStatus" sourcesConnections="id18b3" />
  <EventSink _id="id18b4" name="PalletStatus" sourcesConnections="id18b5" />
  <EventSink _id="id18b6" name="WorkOrder" sourcesConnections="id18a9" />
  <EventSource _id="id18ac" name="Display" sinksConnections="id18a5" />
  <EventSource _id="id18ad" name="ProductionControl" sinksConnections="id18ae" />
  <EventSource _id="id18af" name="MovePallet" sinksConnections="id18b0" />
  <EventSource _id="id18b1" name="ProductionReport" sinksConnections="id18ab" />
  <Facet name="AnalysisCalls" />
  <Facet _id="id18b7" name="DisplayResponse" receptacles="id18a7" />
  <Facet name="Controller" />
  <Facet _id="id18b8" name="AnalysisOne" receptacles="id18b9" />
  <Facet _id="id18ba" name="AnalysisTwo" receptacles="id18bb" />
  </ComponentInstance>
[.....................]
```

Cross-Meta Graph Transformation
A Model-To-Model driven approach

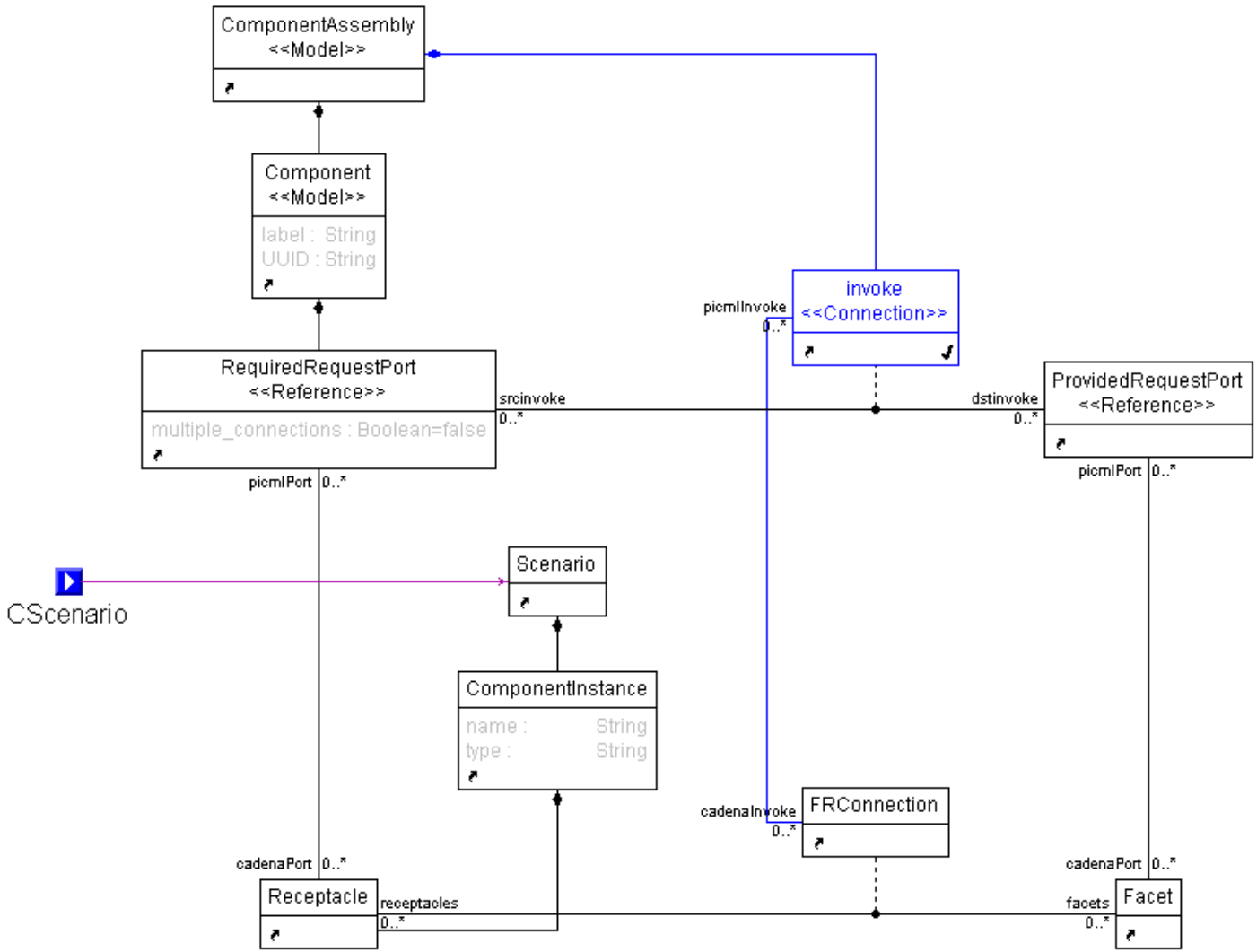
Graph Transformation
A Model-To-Model driven approach



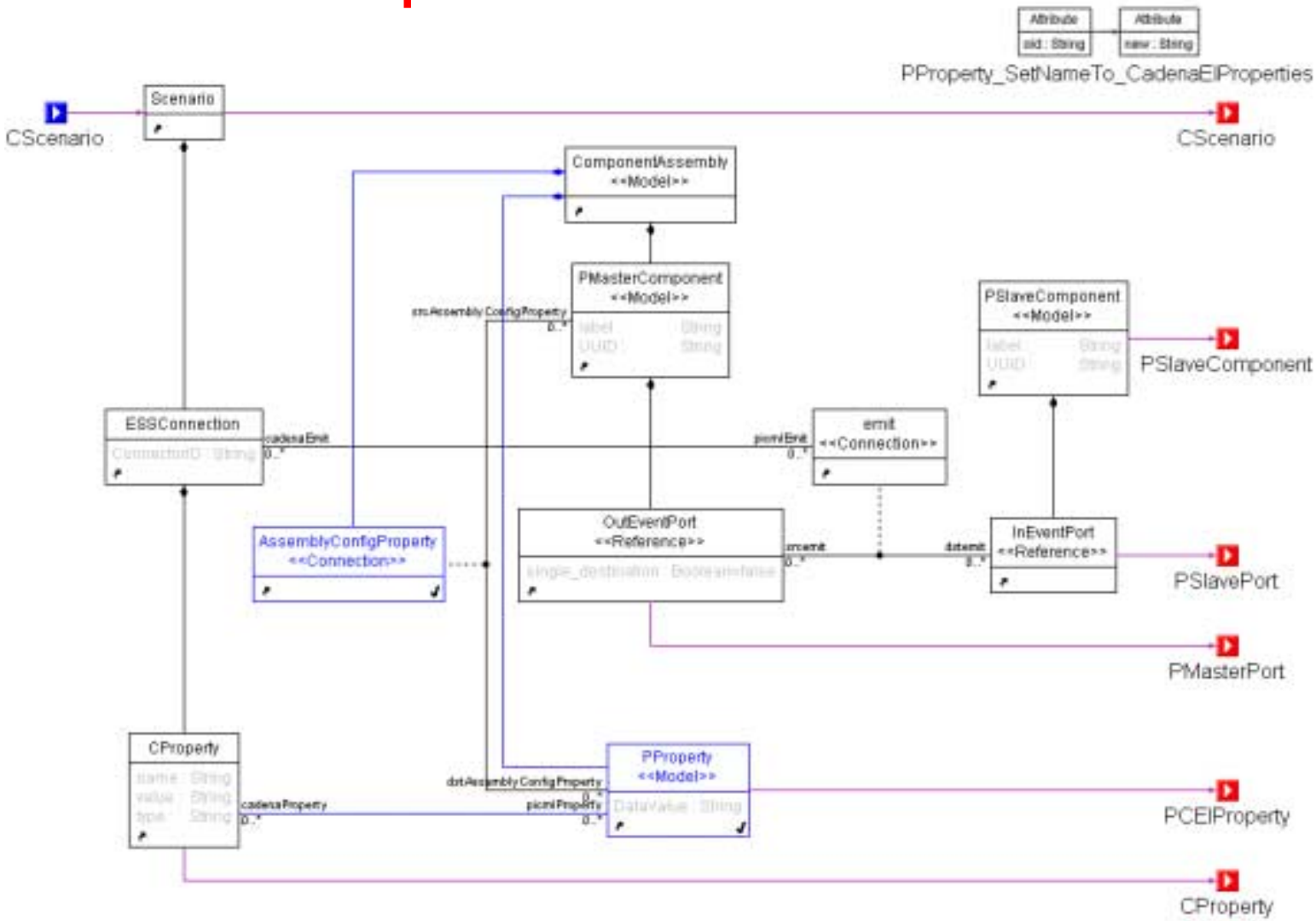
Graph Transformation



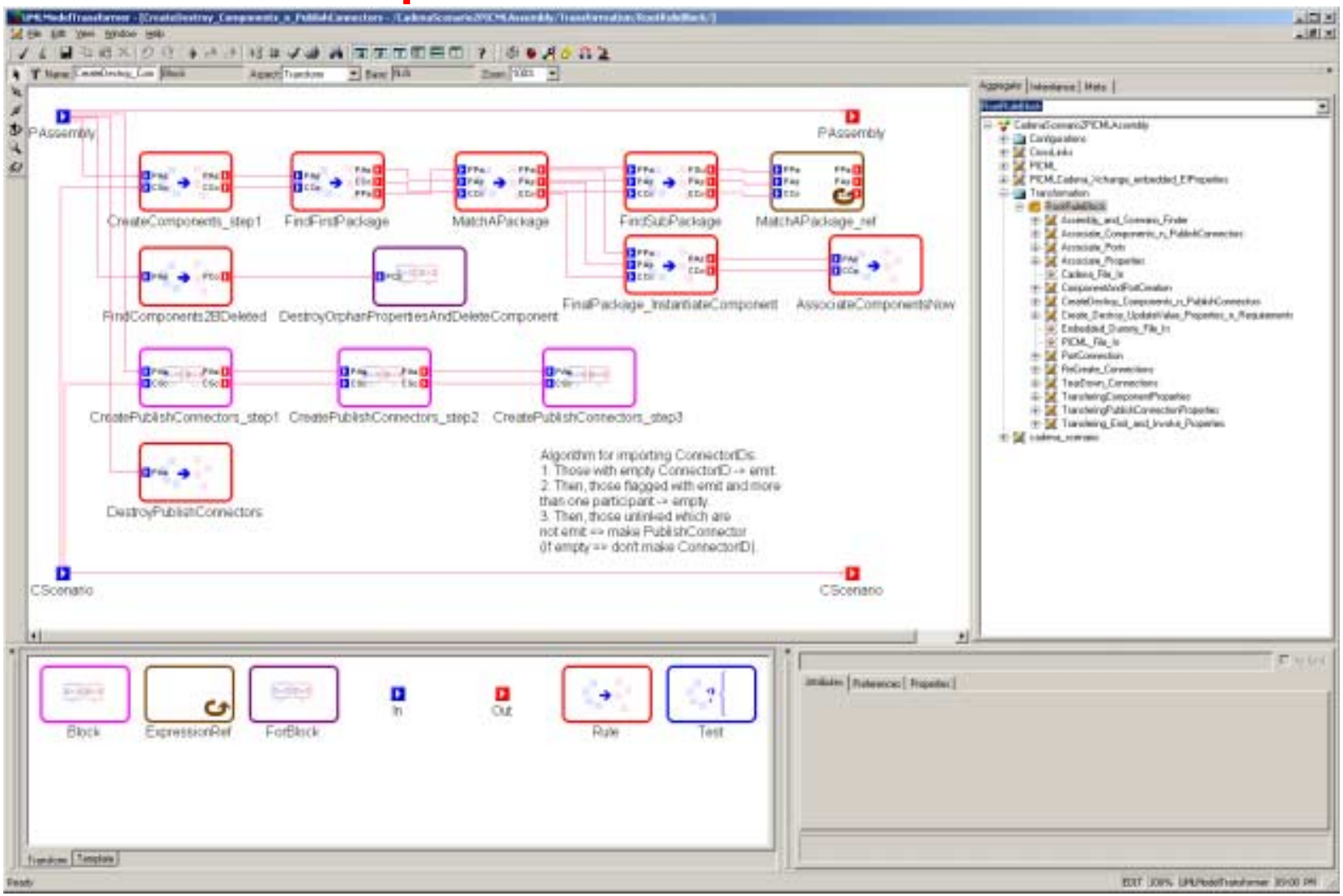
Graph Transformation



Graph Transformation

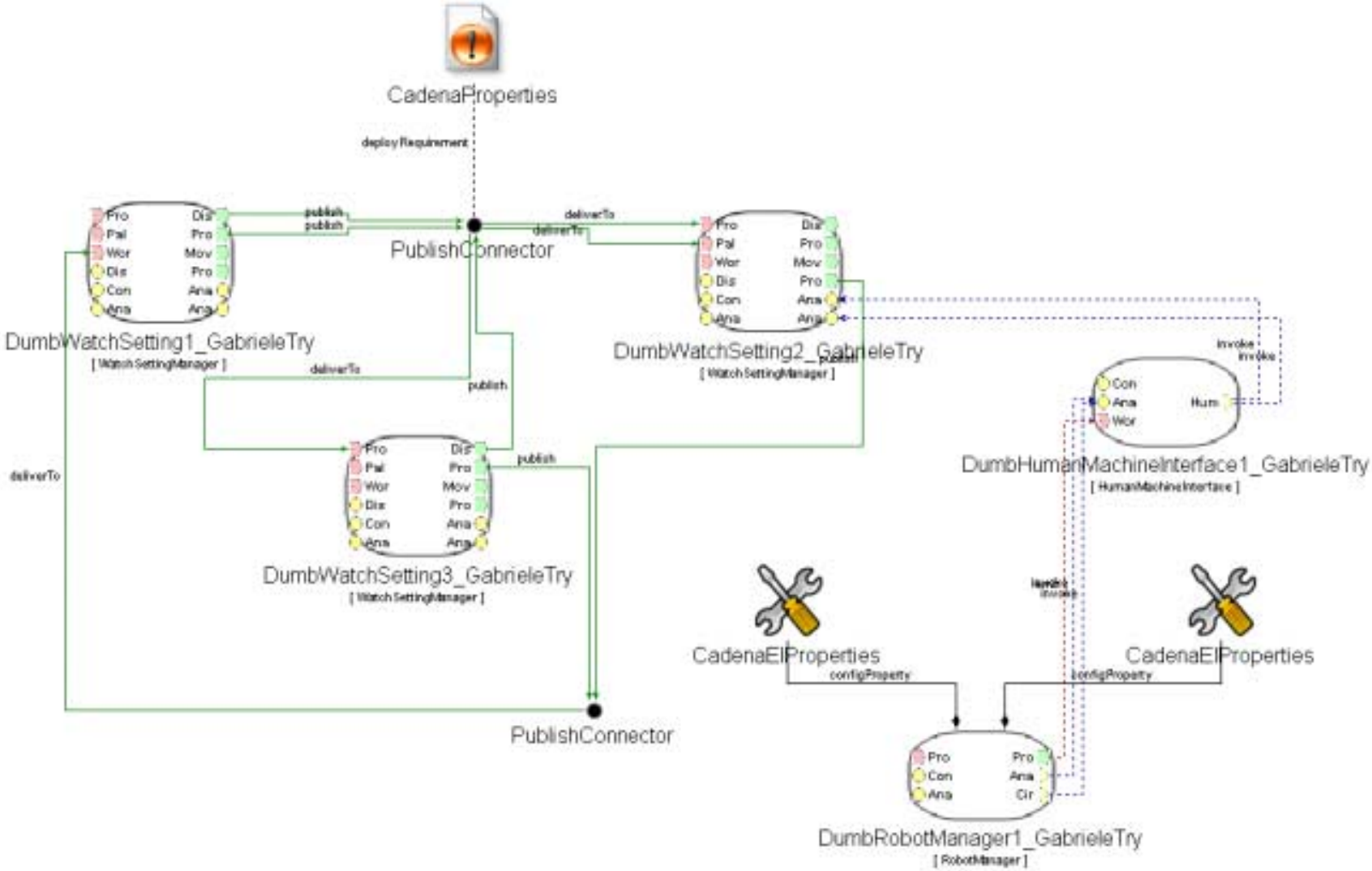


Graph Transformation

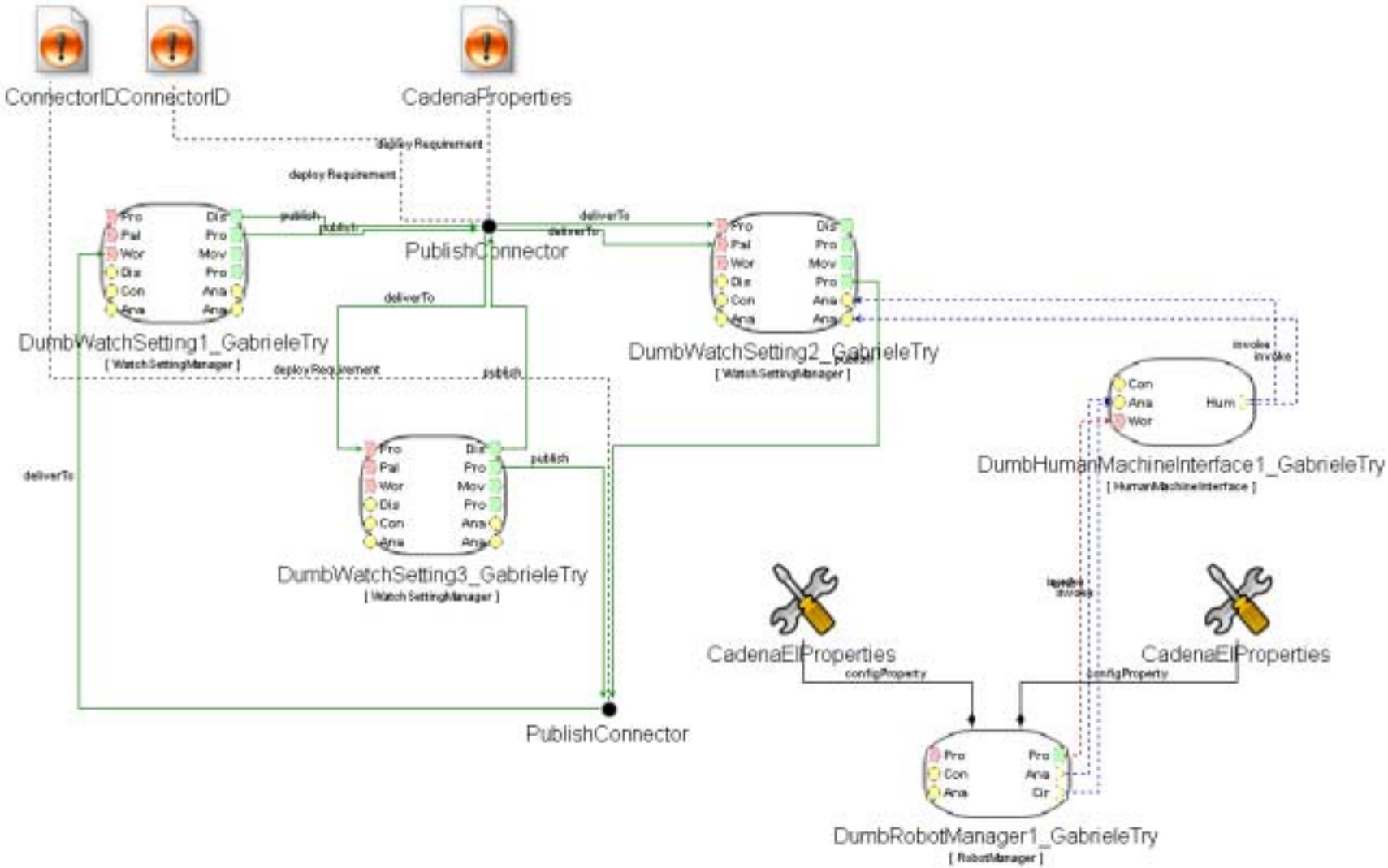


Test Drive

Tweaked-RobotAssembly: before export



TweakedRobotAssembly: after export



TweakedRobotAssembly: exported

```
- <Scenarios xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="..\Udm\cadena_scenario.xs">
- <Scenario>
- <ComponentInstance name="HumanMachineInterface" type="RobotAssembly/HumanMachineInterface">
  <EventSink _id="id18a4" name="WorkDisplayUpdate" sourcesConnections="id18a5" />
  <Facet name="AnalysisController" />
  <Facet name="Controller" />
  <Property name="Prop_Longint_999thousand" type="INT" value="999000" />
  <Receptacle _id="id18a6" name="HumanResponse" facets="id18a7" />
  </ComponentInstance>
- <ComponentInstance name="ManagementWorkInstructions" type="RobotAssembly/ManagementWorkInstructions">
  <EventSink _id="id18aa" name="ProductionReport" sourcesConnections="id18ab" />
  <EventSource _id="id18a8" name="WorkOrder" sinksConnections="id18a9" />
  <Facet name="Controller" />
  <Property name="Prop_Longint_999thousand" type="INT" value="999000" />
  <Property name="Prop_str_hi_foo" type="STRING" value="Hi foo!!" />
  </ComponentInstance>
- <ComponentInstance name="WatchSettingManager" type="RobotAssembly/WatchSettingManager">
  <EventSink _id="id18b2" name="ProcessingStatus" sourcesConnections="id18b3" />
  <EventSink _id="id18b4" name="PalletStatus" sourcesConnections="id18b5" />
  <EventSink _id="id18b6" name="WorkOrder" sourcesConnections="id18a9" />
  <EventSource _id="id18ac" name="Display" sinksConnections="id18a5" />
  <EventSource _id="id18ad" name="ProductionControl" sinksConnections="id18ae" />
  <EventSource _id="id18af" name="MovePallet" sinksConnections="id18b0" />
  <EventSource _id="id18b1" name="ProductionReport" sinksConnections="id18ab" />
  <Facet name="AnalysisCalls" />
  <Facet _id="id18b7" name="DisplayResponse" receptacles="id18a7" />
  <Facet name="Controller" />
  <Facet _id="id18b8" name="AnalysisOne" receptacles="id18b9" />
  <Facet _id="id18ba" name="AnalysisTwo" receptacles="id18bb" />
  <Property name="Prop_bool_true" type="BOOLEAN" value="TRUE" />
  </ComponentInstance>
- <ComponentInstance name="PalletConveyorManager" type="RobotAssembly/PalletConveyorManager">
  <EventSink _id="id18bd" name="PalletRequests" sourcesConnections="id18b0" />
  <EventSource _id="id18bc" name="PalletStatus" sinksConnections="id18b5" />
  <Facet name="Controller" />
  <Facet _id="id18bf" name="CircleAnalysis" receptacles="id18c0" />
  <Receptacle _id="id18be" name="AnalysisTwo" facets="id18bb" />
  </ComponentInstance>
  [..................]
```

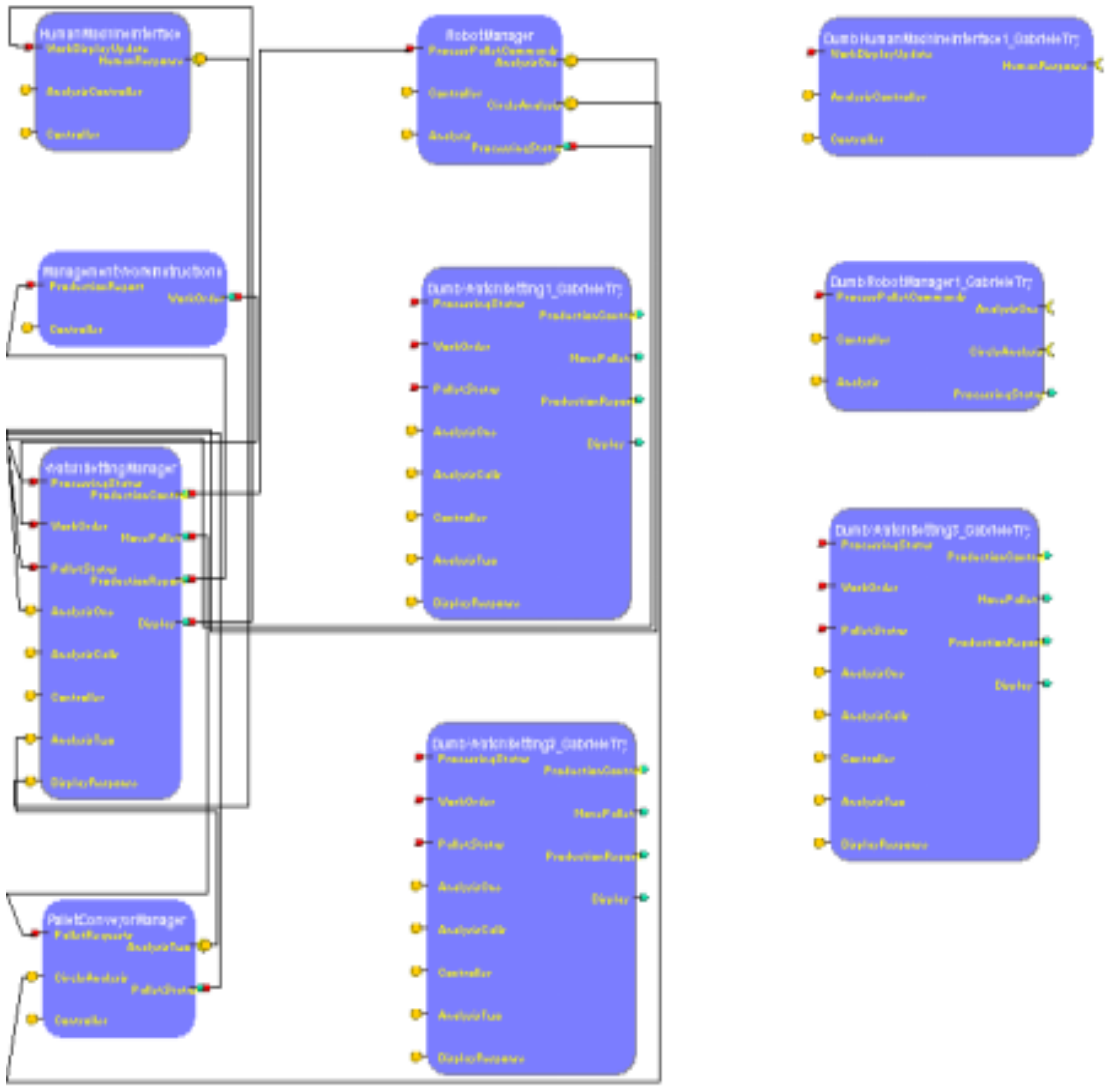
Importing scenario in Cadena

Tasks (14 items)

✓	!	Description	Resource	In Folder	Location
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 42
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 48
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 54
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 60
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 66
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 72
		Expecting instance_name.port for Display or DumbWatchSetting3_GabrieleTry.ProcessingStatus	RobotAss...	Integration_TestDrive/sys...	line 78
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 84
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 88
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 120
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 139
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 142
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 145
		Expecting same types for source and destination of connection	RobotAss...	Integration_TestDrive/sys...	line 149

Cadena detects type inconsistencies for connections

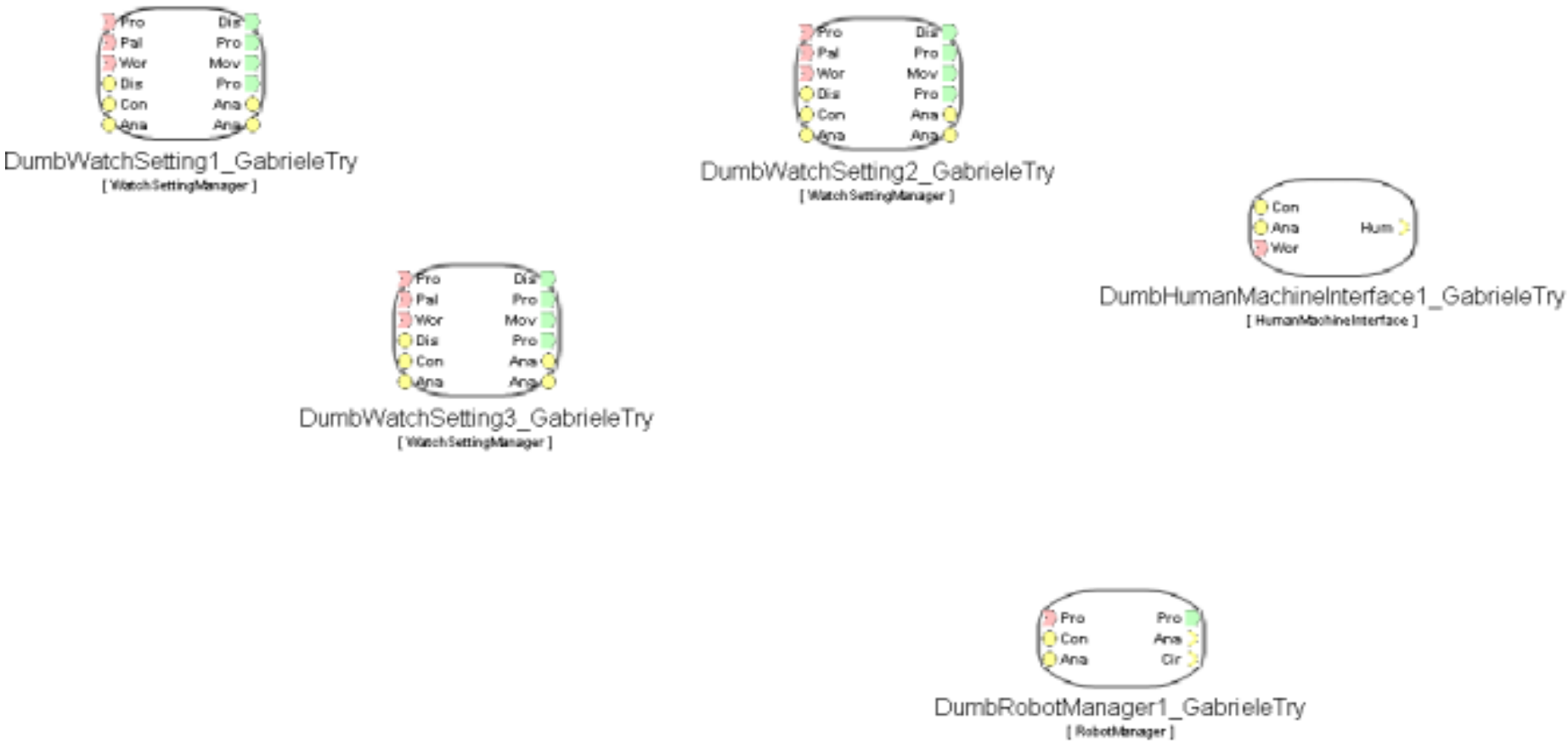
Imported in Cadena



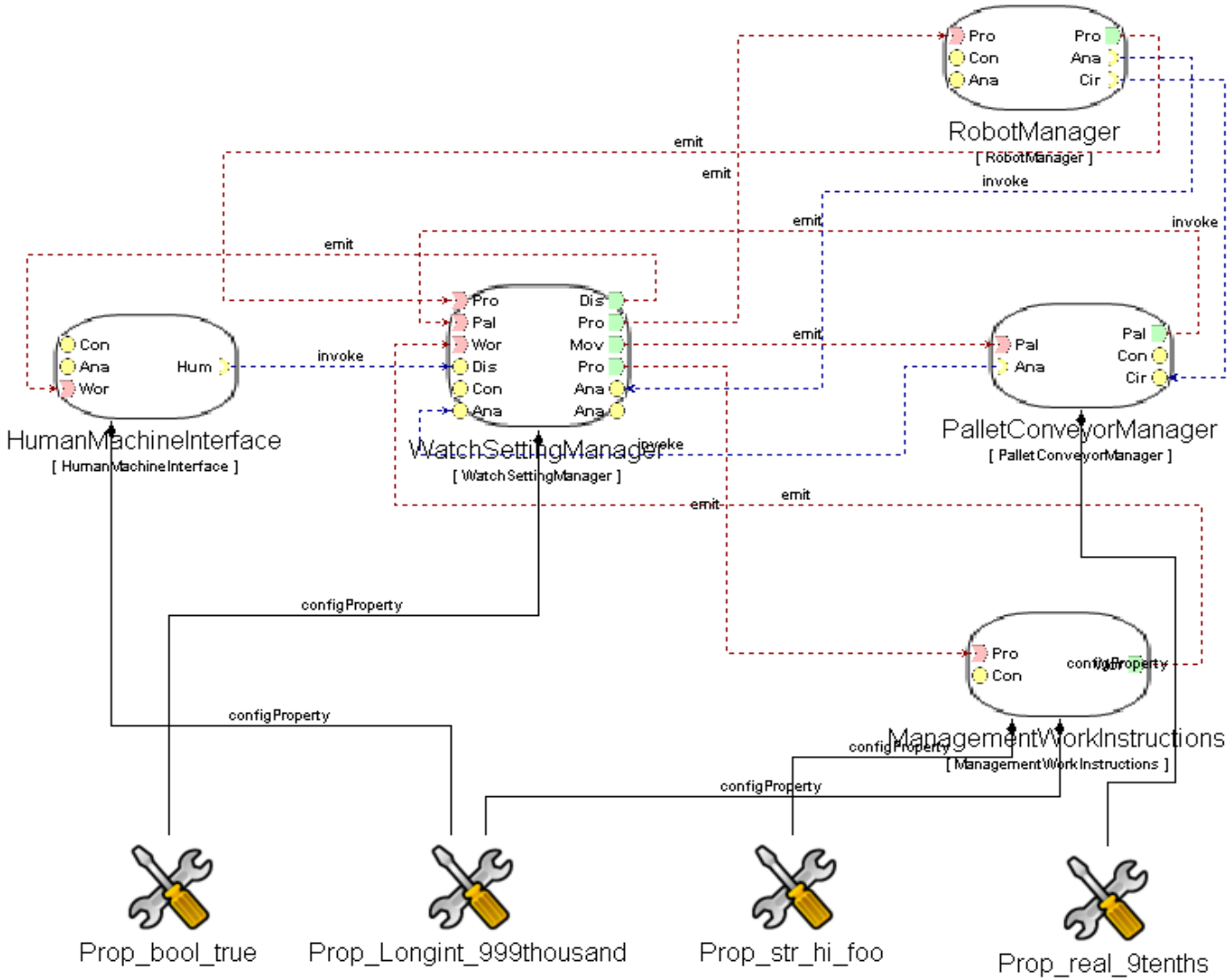
Reimporting scenario in PICML

```
GR Engine v1.3.1.
Copyright (c) 2000-2004 ISIS, Vanderbilt University

Engine Started. Loading relevent files...
Running...

Executing Block RootRuleBlock
   Executing Rule Assembly_and_Scenario_Finder
      -- InputPackets:1 Matches:1 OutputPackets:1
   Executing Block Associate_Components_n_PublishConnectors
      Executing Rule AssociatePublishConnectors
         -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Rule AssociateComponents
         -- InputPackets:1 Matches:10 OutputPackets:10
   Executing Block CreateDestroy_Components_n_PublishConnectors
      Executing Block CreatePublishConnectors_step1
         Executing Rule CreatePublishConnectors_step1_rule
            -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Block CreatePublishConnectors_step2
         Executing Rule CreatePublishConnectors_step2_rule
            -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Block CreatePublishConnectors_step3
         Executing Rule CreatePublishConnectors_step3_rule
            -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Rule DestroyPublishConnectors
         -- InputPackets:1 Matches:2 OutputPackets:2
      Executing Rule FindComponents2BDeleted
         -- InputPackets:1 Matches:0 OutputPackets:0
      Executing Rule CreateComponents_step1
         -- InputPackets:1 Matches:0 OutputPackets:0
   Executing Block TearDown_Connections
      Executing Rule Optimization_FindComponents
         -- InputPackets:1 Matches:10 OutputPackets:10
      Executing Rule TD_Emits
         -- InputPackets:10 Matches:8 OutputPackets:13
      Executing Rule TD_Invokes
         -- InputPackets:10 Matches:8 OutputPackets:13
      Executing Rule TD_DeliverTo
         -- InputPackets:10 Matches:0 OutputPackets:10
      Executing Rule TD_SrcPublish
         -- InputPackets:10 Matches:0 OutputPackets:10
   Executing Block Associate_Ports
      Executing Rule Match_Components
         -- InputPackets:1 Matches:10 OutputPackets:10
      Executing Rule Associate_Ports_rule
         -- InputPackets:10 Matches:76 OutputPackets:76
   Executing Block ReCreate_Connections
      Executing Rule Create_DeliverTo
         -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Rule Create_SrcPublish
         -- InputPackets:1 Matches:0 OutputPackets:1
      Executing Rule Create_Invokes
         -- InputPackets:1 Matches:4 OutputPackets:4
      Executing Rule Create_Emits
         -- InputPackets:1 Matches:7 OutputPackets:7
   Executing Block Associate_Properties
      Executing Rule Associate_CadenaProperties_on_PublishConnectors
         -- InputPackets:1 Matches:0 OutputPackets:1
   [........]

 The Transformation took 45.347seconds
Done!
```

Reimporting scenario in PICML



Reimporting scenario in PICML (valid part)



Special Thanks

Special Thanks to:

Institute for Software Integrated Systems - Vanderbilt University
Computer and Information Systems Department - Kansas State University
Object Management Group
Developers of: Cadena, GME, GReAT, OTIF, UDM, Python.org

More information about this opensource integration projec
and the latest version of the slides at:

WEBPAGE: http://www.dre.vanderbilt.edu/~gtrombetti/

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QUESTIONS

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