




## ELEC-C8203 Automaatiojärjestelmät 2

AutomationML

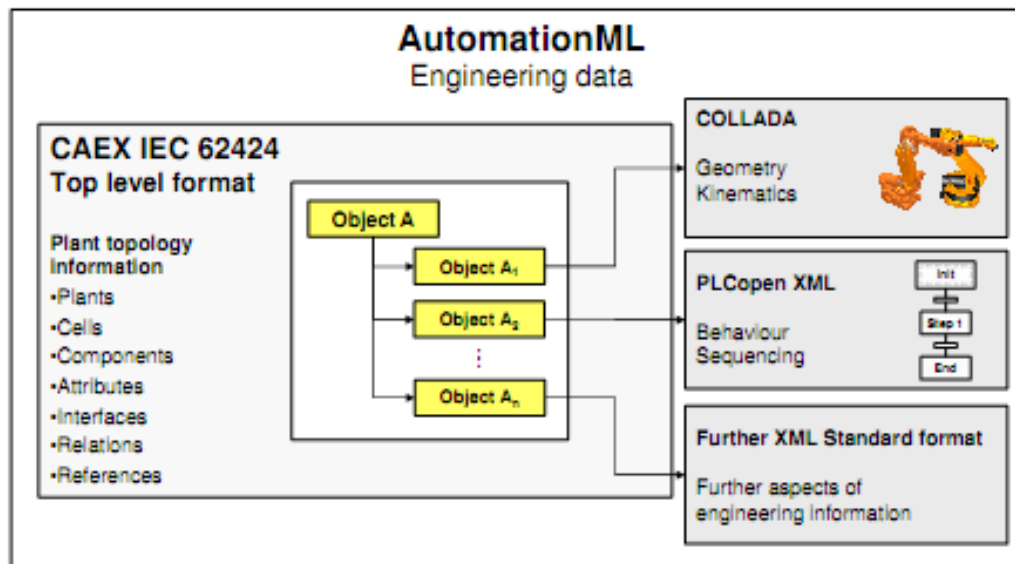
Pekka Aarnio

# sisältö

- 
- AutomationML (AML) lyhyt kuvaus
  - Kalvot 1-12 liittyvät harjoitustehtävään 2
    - (Huom: XML-dokumentin esimerkkinä käytetään kuvitteellista production\_line.xml dokumenttia)

# AutomationML Architecture

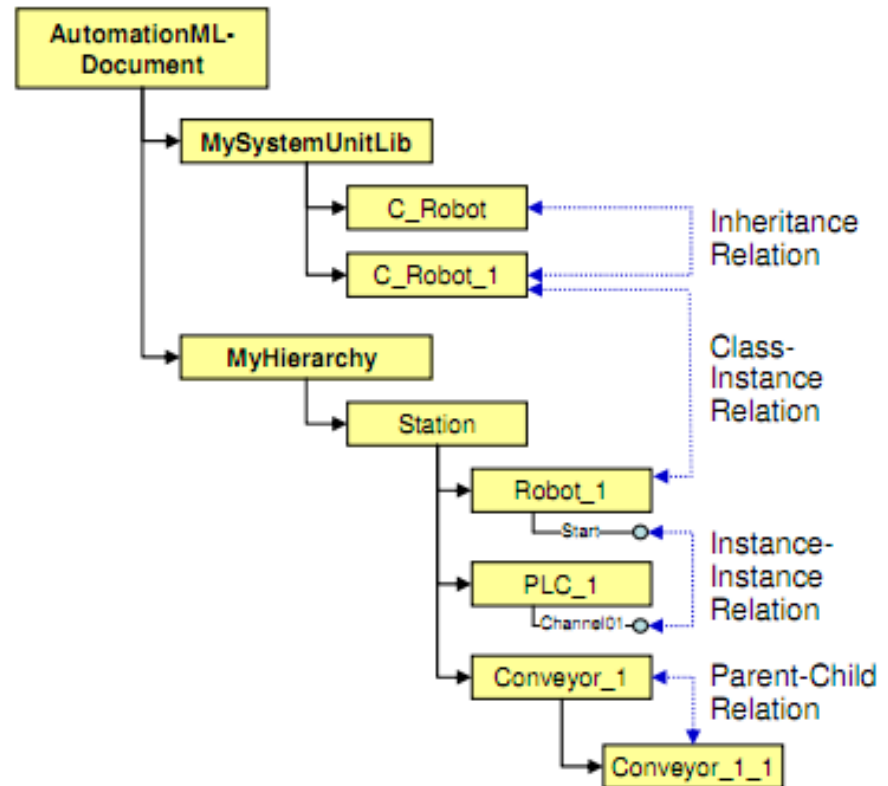
- **Automation Markup Language** is an XML schema-based data format designed for the vendor independent exchange of plant engineering information.
- The goal is to interconnect engineering tools from the existing heterogeneous tool landscape in their different disciplines, e.g.
  - mechanical plant engineering, electrical design, process engineering, process control engineering, HMI development, PLC programming, robot programming etc.



[AutomationML]

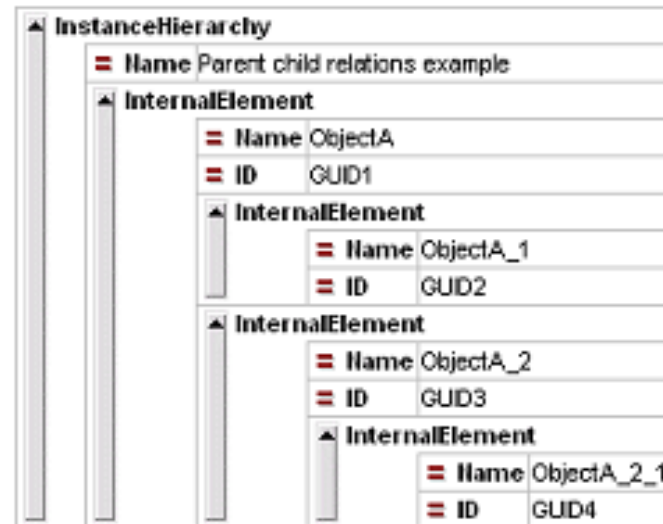
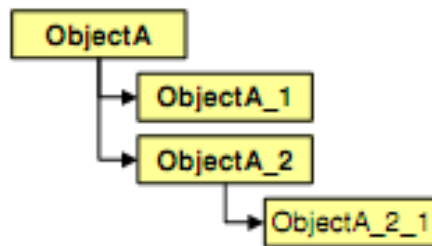
# Relations in AutomationML

- Parent-Child Relation
- Class-Instance Relation
- Inheritance Relation
- Instance-Instance Relation



# Parent-child-relation

- Parent-child-relations between object instances are used to represent hierarchical object structures and
- describe a “consist-of-relation”.



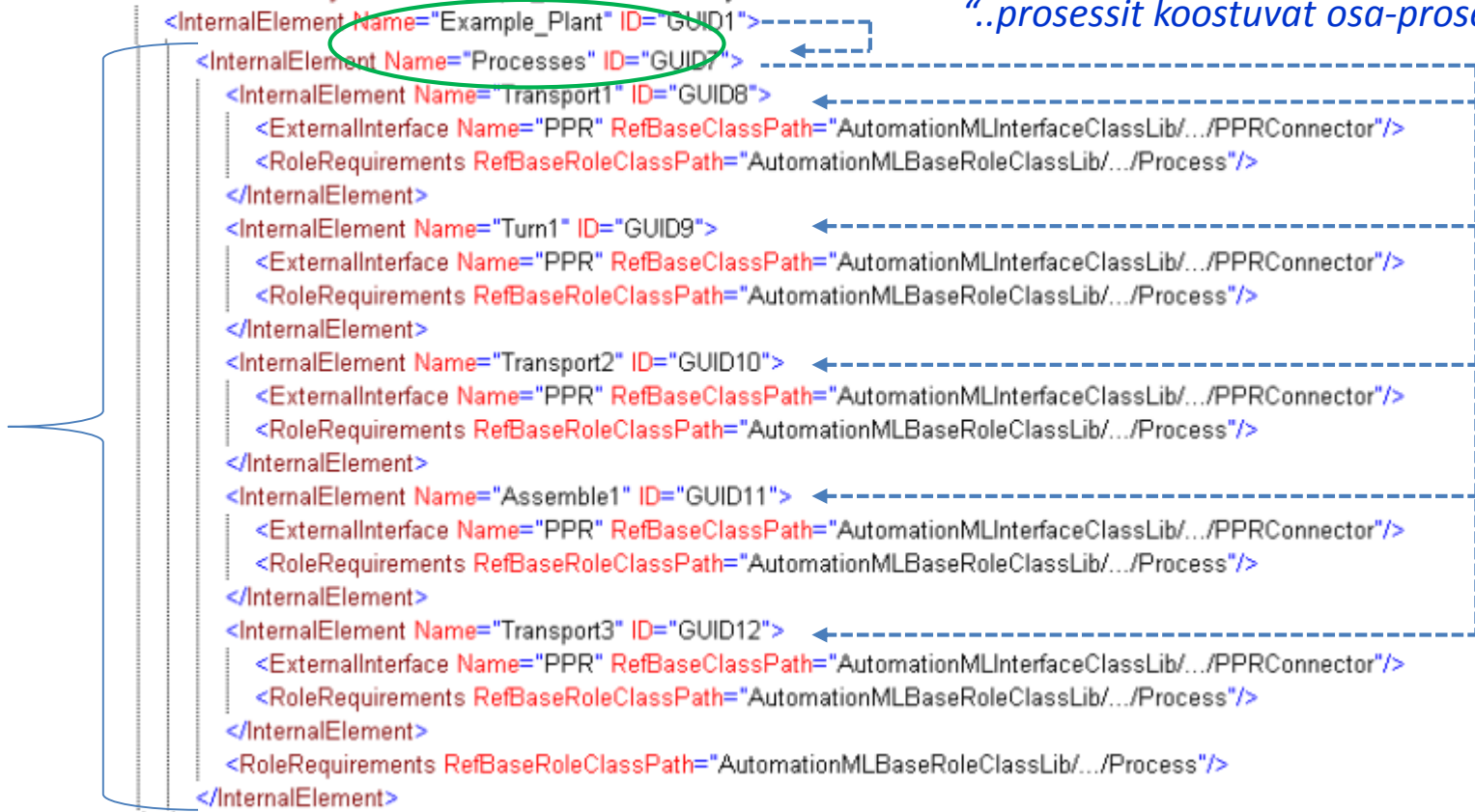
```
<InstanceHierarchy Name="Parent child relations example">
  <InternalElement Name="ObjectA" ID="GUID1">
    <InternalElement Name="ObjectA_1" ID="GUID2"/>
    <InternalElement Name="ObjectA_2" ID="GUID3">
      <InternalElement Name="ObjectA_2_1" ID="GUID4"/>
    </InternalElement>
  </InternalElement>
</InstanceHierarchy>
```

## (XML – Esimerkki)

- AutomationML InstanceHierarchy (parent-child/consists-of-relation)

```
<InstanceHierarchy Name="Example InstanceHierarchy">
  <InternalElement Name="Example_Plant" ID="GUID1">
    <InternalElement Name="Processes" ID="GUID7">
      <InternalElement Name="Transport1" ID="GUID8">
        <ExternalInterface Name="PPR" RefBaseClassPath="AutomationMLInterfaceClassLib/.../PPRConnector"/>
        <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
      </InternalElement>
      <InternalElement Name="Turn1" ID="GUID9">
        <ExternalInterface Name="PPR" RefBaseClassPath="AutomationMLInterfaceClassLib/.../PPRConnector"/>
        <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
      </InternalElement>
      <InternalElement Name="Transport2" ID="GUID10">
        <ExternalInterface Name="PPR" RefBaseClassPath="AutomationMLInterfaceClassLib/.../PPRConnector"/>
        <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
      </InternalElement>
      <InternalElement Name="Assemble1" ID="GUID11">
        <ExternalInterface Name="PPR" RefBaseClassPath="AutomationMLInterfaceClassLib/.../PPRConnector"/>
        <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
      </InternalElement>
      <InternalElement Name="Transport3" ID="GUID12">
        <ExternalInterface Name="PPR" RefBaseClassPath="AutomationMLInterfaceClassLib/.../PPRConnector"/>
        <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
      </InternalElement>
      <RoleRequirements RefBaseRoleClassPath="AutomationMLBaseRoleClassLib/.../Process"/>
    </InternalElement>
  </InternalElement>
</InstanceHierarchy>
```

*"..prosessit koostuvat osa-prosesseista..."*





# Rakennehierarkia XSL-muunnos: PL.xml -> AML.xml

- kohdedokumentin (AML.xml) `InternalElement`:n `Name`-attribuutti saa arvokseen ko. rakenneosan nimen lähdedokumentissa (PL.xml), jos se on siinä esitetty.
- Muussa tapauksessa `Name`-attribuutin arvo muodostetaan PL.xml:n ko. rakenneosan elementtimestä täydennettynä elementin paikkanumerolla (`position()`).

```
<production_line>
  <unit>
    <lift_module modID="LM001">
      <name>Päätynostin PN1</name>
      <description lang="fi">Nostaa paletin alakuljettimelta ylös Starter-moduulille</description>
      <conveyor type="BELT" level="down" feed="in">
        <description lang="fi">Palettikuljetin (ala)</description>
        <stopper/>
      </conveyor>
      <conveyor type="BELT" level="up" feed="out">
        <description lang="fi">Palettikuljetin (ylä)</description>
        <stopper/>
      </conveyor>
    </lift_module>
  </unit>
</production_line>
```

```
<InstanceHierarchy Name="production_line">
  <InternalElement Name="unit_1" ID="d0e9">
    <InternalElement Name="Päätynostin PN1" ID="LM001" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/lift_modu
    <InternalElement Name="conveyor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor
    <InternalElement Name="conveyor_2" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor
    <InternalElement Name="lifter_shelf_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/lifter_s
      <InternalElement Name="conveyor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BANDconve
    </InternalElement>
  </InternalElement>
</InstanceHierarchy>
```



# XSL-muunnos: PL.xml -> AML.xml

- Esimerkki: *Production\_line.xml*:n elementtien muunnos *InstanceHierarchy*:n ja *InternalElement*:tien attribuuttien arvoiksi

```
<production_line>
  <unit>
    <lift_module modID="LM001">
      <name>Päätynostin PN1</name>
      <conveyor type="BELT" level="down" feed="in">
```

```
<InstanceHierarchy Name="production_line">
  <InternalElement Name="unit_1" ID="101">
    <InternalElement Name="Päätynostin PN1" ID="LM001"
      RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/lift_module">
    <InternalElement Name="conveyor_1" ID="101"
      RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
```

# Harjoitustehtävä Vinkkejä

- Suositus: käytä *template*-tekniikkaa mahdollisimman paljon mieluummin kuin *for-each*-luuppeja, koska se on XSLT:n keskeinen tekniikka
- Ensimmäinen juuri-template kutsuu (`xsl:apply-templates`) ali-templatea, joka 'match:ää' *production\_line* elementtiin.
- Tämä ali-template kutsuu edelleen ali-templateja, jotka sisältävät säännöt *production\_line*-elementin lapsielementtien käsittelyyn ja niin edespäin...

```
<?xml version="1.0" encoding="utf-8"?>
<!-- U2E2_1: Students' version of aml_transform.xml. Extend this stub file -->
<!-- U2E2_1: Transforming source file production_line.xml to AML format. -->
<xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
  <xsl:output method="xml" indent="yes" encoding="utf-8" media-type="text/xml"/>
  <xsl:variable name="classlibpath">ProdLineSystemUnitClassLib</xsl:variable>

  <!-- Main entry point -->
  <xsl:template match="/">
    <xsl:element name="AutomationMLLibrary">
      <xsl:apply-templates select="production_line"/>
    </xsl:element>
  </xsl:template>

  <!-- TOTEUTA TÄHÄN MUUNNOKSEN TEMPLATET OHJEIDEN MUKAAN -->

</xsl:stylesheet>
```



HUOM: Tehtävässä 2 *assembly\_line* vastaa tämän esimerkin *production\_line* elemettiä.

# Parent-Child Relation & Class-Instance Relation

## Production\_line\_AML.aml - InstanceHierarchy

*Instance of*

```
<InstanceHierarchy Name="production_line">
  <InternalElement Name="unit_1" ID="d0e9">
    <InternalElement Name="Päätynostin PN1" ID="LM001" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/lift_module">
      <InternalElement Name="conveyor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
      <InternalElement Name="conveyor_2" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
      <InternalElement Name="lifter_shelf_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/lifter_shelf">
        <InternalElement Name="conveyor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BANDconveyor"/>
      </InternalElement>
      <InternalElement Name="sensor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/INDUCTIVEsensor"/>
      <InternalElement Name="chassis_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/SAFETYchassis"/>
    </InternalElement>
  </InternalElement>
  <InternalElement Name="unit_2" ID="d0e9">
    <InternalElement Name="Starter-moduuli ST1" ID="SM001" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/starter_module">
      <InternalElement Name="conveyor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
      <InternalElement Name="conveyor_2" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
      <InternalElement Name="conveyor_3" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/BELTconveyor"/>
      <InternalElement Name="sensor_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/INDUCTIVEsensor"/>
      <InternalElement Name="sensor_2" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/OPTICsensor"/>
      <InternalElement Name="crossing_1" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/GenericCrossing"/>
      <InternalElement Name="crossing_2" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/GenericCrossing"/>
      <InternalElement Name="crossing_3" ID="d0e9" RefBaseSystemUnitPath="ProdLineSystemUnitClassLib/GenericCrossing"/>
    </InternalElement>
  </InternalElement>
</InstanceHierarchy>
```

# AutomationML - Luokkahierarkia

- Laiteluokkakirjasto *SystemUnitClassLib* listaa laiteluokat, joihin rakennehierarkiassa *InternalElement* –elementteinä esitetyt laiteinstanssit viittaavat.
- Jokainen laiteluokka esitetään yhtenä *SystemUnitClass*-elementtinä ja luokkien nimet esitetään sen *Name*-attribuutin arvona.
- Luokkien perintähierarkia esitetään viittauksena attribuutin *RefBaseClassPath* arvolla

```
<SystemUnitClassLib Name="ProdLineSystemUnitClassLib">  
  <SystemUnitClass Name="GenericModule"/>  
  <SystemUnitClass Name="GenericConveyor"/>  
  <SystemUnitClass Name="BANDconveyor" RefBaseClassPath=  
    "ProdLineSystemUnitClassLib/GenericConveyor"/>
```

*Instance of*

Class-Instance-Relations

Inheritance-Relations

Instance-Instance-Relations

**MUUT RELAATIOIT**

# Class-Instance-Relations

- Class-Instance-Relations
- Instances represent individual objects and are characterized by a unique identifier and parameter set.
- An AutomationML object shall be modelled as CAEX *InternalElement* as part of the CAEX *InstanceHierarchy* tree.
- The source class shall be indicated in the CAEX tag *"RefBaseSystemUnitPath"* of the instance.
  - This tag shall comprise the full path and name of the source class.

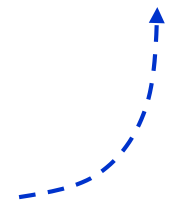
|                         |                                    |
|-------------------------|------------------------------------|
| ▲ InstanceHierarchy     |                                    |
| = Name                  | ClassInstanceRelation Example      |
| ▲ InternalElement       |                                    |
| = Name                  | ObjectA                            |
| = ID                    | GUID1                              |
| = RefBaseSystemUnitPath | mySystemUnitClassLib/generic_Valve |

```
<InstanceHierarchy Name="ClassInstanceRelation Example">
```

```
  <InternalElement Name="ObjectA" ID="GUID1" RefBaseSystemUnitPath="mySystemUnitClassLib/generic_Valve"/>
```

```
</InstanceHierarchy>
```

*Instance of*



# Inheritance-Relations

- Inheritance-Relations
- **Inheritance between classes** shall be defined according to the IEC 62424.
- If inheritance is required, the parent class shall be specified using the CAEX tag *“RefBaseClassPath”* comprising the full path of the class according to IEC 62424.

|                      |                                 |
|----------------------|---------------------------------|
| ▲ SystemUnitClassLib |                                 |
| = Name               | InheritanceExampleLib           |
| ▲ SystemUnitClass    |                                 |
| = Name               | Robot1234                       |
| ▲ SystemUnitClass    |                                 |
| = Name               | SpecialRobot1234                |
| = RefBaseClassPath   | InheritanceExampleLib/Robot1234 |

```
<SystemUnitClassLib Name="InheritanceExampleLib">  
  <SystemUnitClass Name="Robot1234"/>  
  <SystemUnitClass Name="SpecialRobot1234" RefBaseClassPath="InheritanceExampleLib/Robot1234"/>  
</SystemUnitClassLib>
```

*Sub-class of*



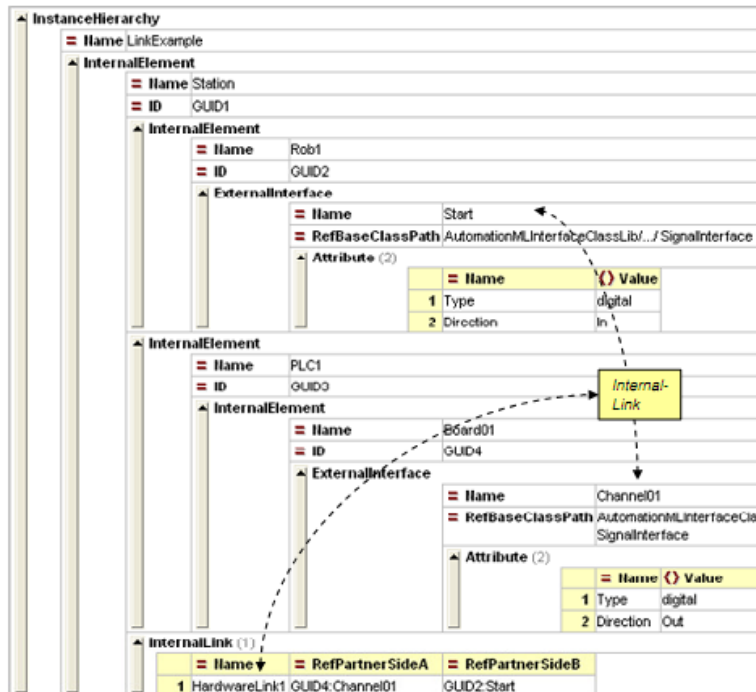
# Instance-Instance-Relations

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- Instance-Instance-Relations are relations between two interfaces of arbitrary AutomationML objects.
- Instance-Instance-Relations shall be stored by means of the CAEX *InternalLink* functionality.
- *InternalLinks* should be stored at the *InternalElement* which is the lowest common parent of the corresponding connected CAEX objects.
- Instance-Instance-Relations shall be defined only between corresponding CAEX *ExternalInterfaces*
  - The ExternalInterfaces should be derived directly or indirectly from one of the AutomationML standard interface classes.



# Instance-Instance-Relations



```

<InstanceHierarchy Name="LinkExample">
  <InternalElement Name="Station" ID="GUID1">
    <InternalElement Name="Rob1" ID="GUID2">
      <ExternalInterface Name="Start" RefBaseClassPath="AutomationMLInterfaceClassLib/.../SignalInterface">
        <Attribute Name="Type">
          <Value>digital</Value>
        </Attribute>
        <Attribute Name="Direction">
          <Value>In</Value>
        </Attribute>
      </ExternalInterface>
    </InternalElement>
    <InternalElement Name="PLC1" ID="GUID3">
      <InternalElement Name="Board01" ID="GUID4">
        <ExternalInterface Name="Channel01" RefBaseClassPath="AutomationMLInterfaceClassLib/.../SignalInterface">
          <Attribute Name="Type">
            <Value>digital</Value>
          </Attribute>
          <Attribute Name="Direction">
            <Value>Out</Value>
          </Attribute>
        </ExternalInterface>
      </InternalElement>
    </InternalElement>
    <InternalLink Name="HardwareLink1" RefPartnerSideA="GUID4:Channel01" RefPartnerSideB="GUID2:Start"/>
  </InternalElement>
</InstanceHierarchy>
  
```

*Link between*

# Inheritance Relation

## Production\_line\_AML.aml - SystemUnitClassLib

```
<?xml version="1.0" encoding="utf-8"?>
<AutomationMLLibrary>
  <SystemUnitClassLib Name="ProdLineSystemUnitClassLib">
    <SystemUnitClass Name="GenericModule"/>
    <SystemUnitClass Name="GenericConveyor"/>
    <SystemUnitClass Name="GenericSensor"/>
    <SystemUnitClass Name="GenericCrossing"/>
    <SystemUnitClass Name="GenericChassis"/>
    <SystemUnitClass Name="lift_module" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericModule"/>
    <SystemUnitClass Name="starter_module" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericModule"/>
    <SystemUnitClass Name="workstation" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericModule"/>
    <SystemUnitClass Name="BANDconveyor" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericConveyor"/>
    <SystemUnitClass Name="BELTconveyor" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericConveyor"/>
    <SystemUnitClass Name="INDUCTIVEsensor" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericSensor"/>
    <SystemUnitClass Name="OPTICsensor" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericSensor"/>
    <SystemUnitClass Name="SAFETYchassis" RefBaseClassPath="ProdLineSystemUnitClassLib/GenericChassis"/>
  </SystemUnitClassLib>
  <InstanceHierarchy Name="production_line">
```

*Sub-class of*

*Sub-class of*