



# <AutomationML/>

**The Glue for Seamless  
Automation Engineering**

**Best Practice Recommendations:  
DataVariable**

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## Preface

AutomationML provides the basis for an efficient data exchange within the engineering process of production systems. The AutomationML standard series IEC 62714 “Engineering data exchange format for use in industrial automation systems engineering” already contains many use cases and guidelines of how system engineering information is modelled.

In order to specify these definitions with examples, to apply them to specific use cases, and to facilitate the first steps with AutomationML, specific issues for the modelling of data in AutomationML are illustrated in Best Practice Recommendations (BPR).

In addition, the BPR shall provide a consistent realisation for specific use cases and shall thus, complement the AutomationML standard documents.

## 1 Motivation for data variables

AutomationML models can e.g. describe communication networks in manufacturing systems. This includes the description of logical devices responsible for the communication, e.g. OPC UA server.

One object/element in AutomationML can be found in another world (communicating elements), too. Examples of another world can be the OPC UA address space/information model with OPC UA Nodes which can be addressed.

The DataVariable concept helps to describe how to “find” the element in the other world.

This gives the possibility to create links from AutomationML to “online” data/communication, e.g. OPC UA or CANopen.

The DataVariable concept serves for describing information respectively configuration data to set up communication.

The DataVariable concept can be combined with other existing modelling concepts of AutomationML. As within the AML Communication Whitepaper, DataSources (e.g. an OPC UA Server) are modelled as logical devices (derived from the RoleClass of the AML Communication Whitepaper) using logical connections and communication packages. For a general description of a DataSource as device within the plant network, the Communication Whitepaper explains how to model this. For the description of concrete elements inside the DataSource – the DataVariables – including all information necessary to setup a communication connection and request their values, the DataVariable concept can be combined with the Communication Whitepaper approach.

## 2 Implementation

The DataVariable concept includes two main conceptual elements: the DataSource and the DataVariables which are shown in relation in *Figure 1*.

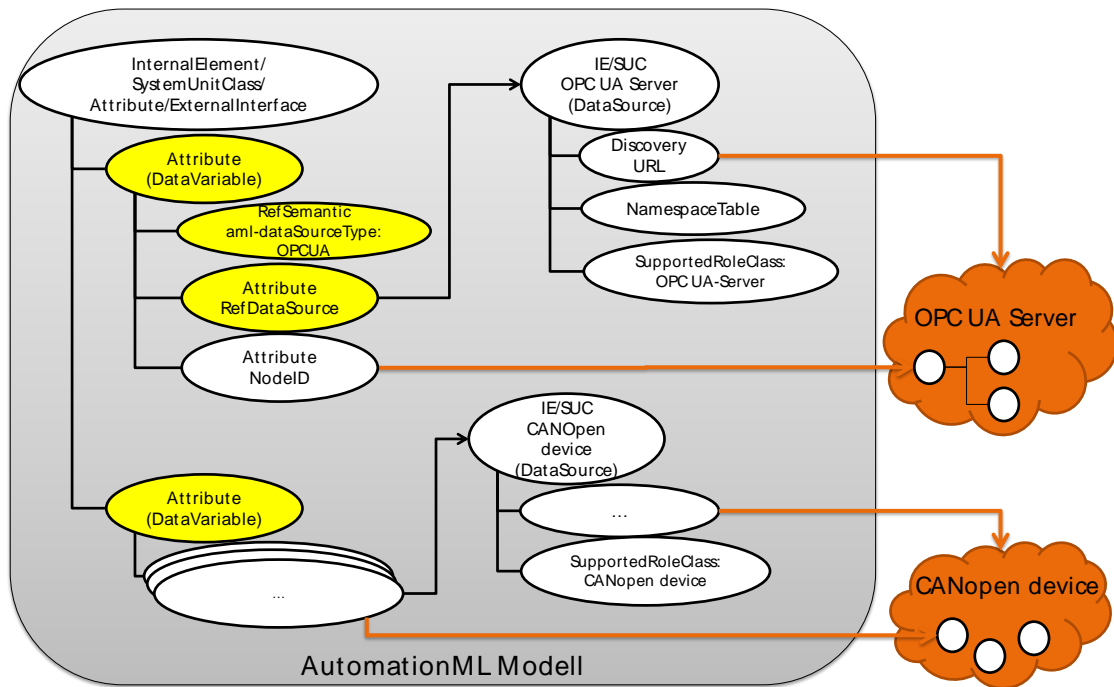


Figure 1 – Structure of DataVariables including their DataSource

- The DataSource element exists as InternalElement or SystemUnitClass containing attributes describing the communication host, e.g. OPC UA Server.
  - The DataSource type is indicated by the association of a specific RoleClass (see clause 3.1.1) derived from the RoleClass AutomationMLDataVariableRoleClassLib/DataSource. (all communication host specific attributes are defined in this role). An example is the assignment of the RoleClass AutomationMLDataVariableRoleClassLib/DataSource/OPCUA-Server (see Figure 2).
  - Attributes needed for storing the appropriate information to describe the element in the other domain/world (e.g. DiscoveryURL of OPC UA Server). These attributes are listed for specific examples in clause 3.1.1.
- Any AML element (e.g. SystemUnitClass, InternalElement, ExternalInterface, but especially Attributes within InstanceHierarchies) can contain a DataVariable by adding a sub-attribute to this element (see example in Figure 3).
  - This sub-attribute is the DataVariable and indicates its specific type itself (by specific RefSemantic). The name of the DataVariable Attribute can be chosen arbitrarily.
  - Multiple DataVariables in parallel are possible. An example is a Profinet PLC with additional OPC UA Server. The DataVariable content is available via Profinet and OPC UA, this means two DataVariables of Type Profinet and OPC UA exist.
  - The DataVariable attribute shall contain:
    - A RefSemantic element with the content ,aml-dataSourceType:', followed by the DataSourceType (e.g. ,aml-dataSourceType:OPCUA'; see Table 1).
    - A Sub-attribute named ,RefDataSource' containing the GUID of the DataSource element. (see Table 2). Note: This attribute is necessary, because InternalLinks from/to AML Attributes are not possible.
    - Sub-attributes needed for storing the appropriate information to address the element in the other domain/world (e.g. NodeID of OPC UA Node). These sub-attributes for specific examples are listed in clause 3.2.

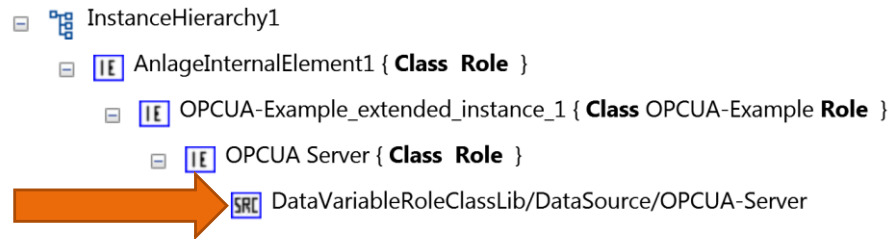


Figure 2 – DataSource element with assigned RoleClass

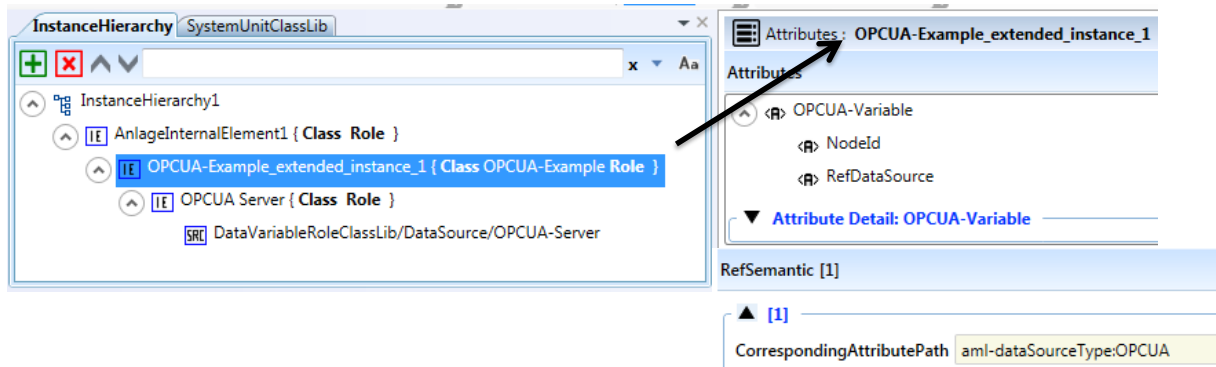


Figure 3 – DataVariable attribute (OPCUA-Variable) indicated by RefSemantic

The types depicted in *Table 1* are currently available and can be used within the RefSemantic of the AML attributes representing a DataVariable:

Table 1 – RefSemantic for DataVariables

Type	RefSemantic	Example in clause
OPC UA	aml-dataSourceType:OPCUA	4.1, 8
Iso-on-TCP (S7)	aml-dataSourceType: ITOT	Tbd
CANopen	aml-dataSourceType: CANOpen	Tbd
Profinet	aml-dataSourceType: Profinet	Tbd
ModbusTCP	aml-dataSourceType: ModbusTCP	Tbd
IOLink	aml-dataSourceType: IOLink	Tbd
EthernetIP	aml-dataSourceType: EthernetIP	Tbd
MTConnect	aml-dataSourceType: MTConnect	Tbd
CCLink	aml-dataSourceType: CCLink	Tbd

The description of the general sub-attribute of each DataVariable RefDataSource is given in *Table 2*. Specific attributes for each type of DataVariable are described in clause 3.2.

*Table 2 – Attribute RefDataSource*

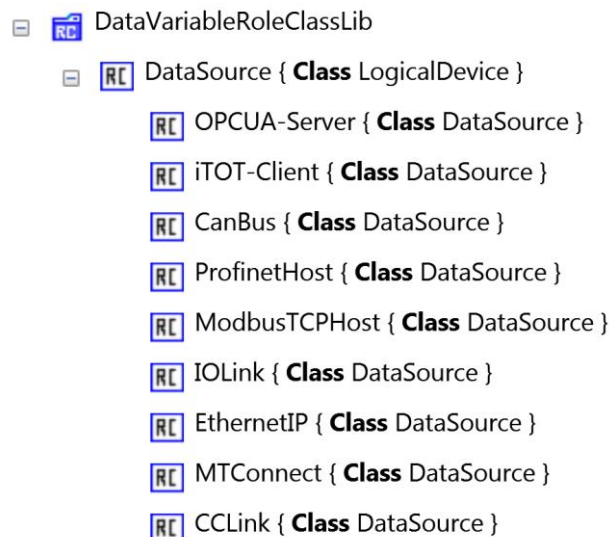
<b>Attribute name</b>	RefDataSource
<b>Description</b>	The attribute “RefDataSource” of a DataVariable shall be used in order to reference the DataSource element within the AutomationML model by its ID, e.g. GUID of AML element.

### 3 Extensions of AutomationML libraries for DataVariable concept

For the implementation of the DataVariable concept the following extensions of AutomationML libraries are defined.

#### 3.1 RoleClassLibrary DataVariableRoleClassLib

*Figure 4* presents the DataVariableRoleClassLib (Version 0.2.4) as object tree. Clause 6 depicts the XML representation of the DataVariableRoleClassLib. Details to each role class are given below. The list of possible DataSource types is not complete and can be extended in the future (further version of this BPR). The current selection and order do not indicate any importance.



*Figure 4 – DataVariableRoleClassLib as object tree in AutomationML editor*

##### 3.1.1 RoleClasses

*Table 3 – RoleClass DataSource*

<b>Class name</b>	DataSource
<b>Description</b>	The role class “DataSource” is an abstract role for a DataSource of the DataVariable concept and the base class for all DataSource roles. AutomationML DataSource objects shall directly or indirectly reference this role.
<b>Parent class</b>	CommunicationRoleClassLib/LogicalDevice



<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource
<b>Attributes</b>	None

Table 4 – RoleClass OPCUA-Server

<b>Class name</b>	OPCUA-Server	
<b>Description</b>	The role class “OPCUA-Server” is used to describe OPC UA server elements in AutomationML.	
<b>Parent class</b>	DataVariableRoleClassLib/DataSource	
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/OPCUA-Server	
<b>Attributes</b>	DiscoveryURL (type: xs:anyURI)	The DiscoveryURL contains the complete information which is necessary to connect to a specific endpoint of an OPC UA server with a defined selection of e.g. available security policies. If this attribute is given all others except of the namespace table are obsolete.
	EndpointURL (type: xs:anyURI)	The EndpointURL contains the protocol and network address.
	TransportProfileURI (type: xs:anyURI)	The TransportProfileURI contains the URI of the Transport Profile supported by the Endpoint.
	SecurityPolicy	The SecurityPolicy describes the set of algorithms and key length used for the SecureChannel between the client and server application.
	MessageSecurityMode	The MessageSecurityMode defines if the messages exchanged between the client and server is secured by signing the message or by signing and encrypting the message. There is also a mode without signing and encrypting.
	UserToken	OPC UA supports different user identity token types like Anonymous, User Password and Certificates. This attribute describes types of user authentication supported by the server
	NamespaceTable	All namespaces are represented as sub-attributes of this attribute indicating the NamespaceIndex by the name of the sub-attribute. At least one sub-attribute with name „0“ is necessary which is of AttributeDataType xs:anyURI and contains the value „http://opcfoundation.org/UA/“.



Table 5 – RoleClass iTOT-Client

<b>Class name</b>	iTOT-Client
<b>Description</b>	The role class “iTOT-Client” is used to describe ISO-on-TCP client (Siemens S7 communication) elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/iTOT-Client
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 6 – RoleClass CanBus

<b>Class name</b>	CanBus
<b>Description</b>	The role class “CanBus” is used to describe Can bus elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/CanBus
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 7 – RoleClass ProfinetHost

<b>Class name</b>	ProfinetHost
<b>Description</b>	The role class “ProfinetHost” is used to describe Profinet host elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/ProfinetHost
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 8 – RoleClass ModbusTCPHost

<b>Class name</b>	ModbusTCPHost
<b>Description</b>	The role class “ModbusTCPHost” is used to describe ModbusTCP host elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/ModbusTCPHost
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 9 – RoleClass IOLink

<b>Class name</b>	IOLink
<b>Description</b>	The role class “IOLink” is used to describe IOLink elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/IOLink
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 10 – RoleClass EthernetIP

<b>Class name</b>	EthernetIP
<b>Description</b>	The role class “EthernetIP” is used to describe EthernetIP elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/EthernetIP
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 11 – RoleClass MTConnect

<b>Class name</b>	MTConnect
<b>Description</b>	The role class “MTConnect” is used to describe MTConnect elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/MTConnect
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 12 – RoleClass CCLink

<b>Class name</b>	CCLink
<b>Description</b>	The role class “CCLink” is used to describe CCLink elements in AutomationML.
<b>Parent class</b>	DataVariableRoleClassLib/DataSource
<b>Path for element reference</b>	DataVariableRoleClassLib/DataSource/CCLink
<b>Attributes</b>	To be defined and to follow in later version of this BPR

### 3.2 Specific AutomationML attributes of the DataVariable

For the implementation of the DataVariable concept the following specific Attributes are defined.

Table 13 – Attributes of DataVariable of Type OPCUA

<b>Data-Variable Type</b>	OPCUA	
<b>Attributes</b>	NodeID	The NodeID contains the specific ID of the Node referenced within the DataVariable. Example: ns=1;i=123

*Table 14 – Attributes of DataVariable of Type Iso-on-TCP (S7)*

<b>Data-Variable Type</b>	ITOT
<b>Attributes</b>	To be defined and to follow in later version of this BPR

*Table 15 – Attributes of DataVariable of Type CANopen*

<b>Data-Variable Type</b>	CANopen
<b>Attributes</b>	To be defined and to follow in later version of this BPR

*Table 16 – Attributes of DataVariable of Type Profinet*

<b>Data-Variable Type</b>	Profinet
<b>Attributes</b>	To be defined and to follow in later version of this BPR

*Table 17 – Attributes of DataVariable of Type ModbusTCP*

<b>Data-Variable Type</b>	ModbusTCP
<b>Attributes</b>	To be defined and to follow in later version of this BPR

*Table 18 – Attributes of DataVariable of Type IOLink*

<b>Data-Variable Type</b>	IOLink
<b>Attributes</b>	To be defined and to follow in later version of this BPR

*Table 19 – Attributes of DataVariable of Type EthernetIP*

<b>Data-Variable Type</b>	EthernetIP
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 20 – Attributes of DataVariable of Type MTConnect

<b>Data-Variable Type</b>	MTConnect
<b>Attributes</b>	To be defined and to follow in later version of this BPR

Table 21 – Attributes of DataVariable of Type CCLink

<b>Data-Variable Type</b>	CCLink
<b>Attributes</b>	To be defined and to follow in later version of this BPR

## 4 Examples

The following example show different possibilities to use the different types of DataVariables. More examples shall follow when further types of DataVariables and their content are defined.

### 4.1 Example 1: DataVariable of type OPC UA

Within this example, the usage of DataVariables for describing OPC UA Server configuration is explained. One concrete example can be found in Annex B – XML representation of OPC UA example.

- The DataSource element OPC UA Server is modeled as InternalElement referencing the RoleClass OPCUA-Server. It contains one or more of the following attributes (at least NamespaceTable and DiscoveryURL):
  - DiscoveryURL
  - EndpointURL
  - TransportProfileURI
  - SecurityPolicy
  - MessageSecurityMode
  - UserToken
  - NamespaceTable with two entries
- The variables (Nodes) of the OPC Unified Architecture server shall be modelled related to the properties of the manufacturing system elements they belong to.
- The DataVariable attribute ,OPCUA-Variable' contains
  - Element ,RefSemantic' with content ,aml-accessPath:OPCUA'
  - Sub-attribute ,RefDataSource' with the GUID of the DataSource InternalElement
  - Sub-attribute ,NodeId' to store the NodeId of the referenced OPC UA Node

Figure 5 depicts the example within the AutomationML editor.

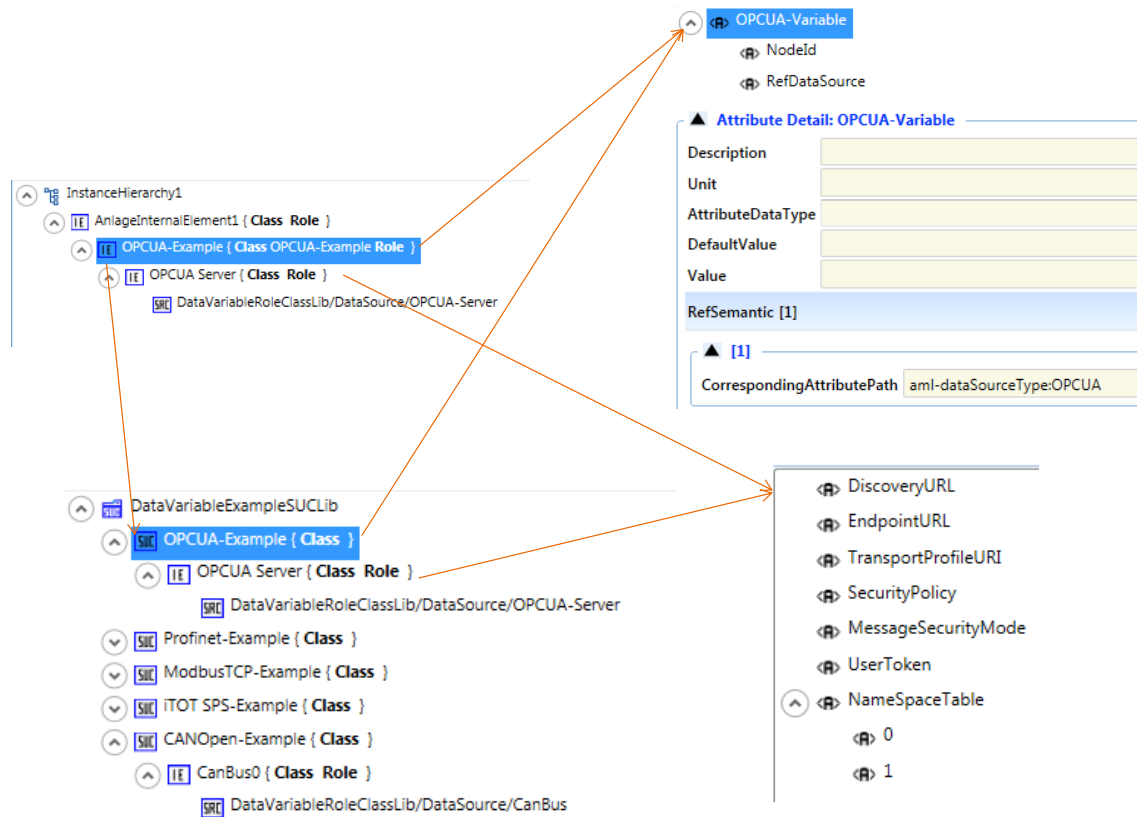


Figure 5 – OPC UA example

Clause 7 (Annex C – OPC UA Example in AutomationML and OPC UA XML) shows the XML representation of the complete AutomationML example.

Clause 8 (Annex C – OPC UA Example in AutomationML and OPC UA XML) gives a concrete example of an existing sample OPC UA Server and its DataVariables.

## 5 References

- [1] DIN SPEC 16592 “Combining OPC Unified Architecture and Automation Markup Language”, <https://www.beuth.de/de/technische-regel/din-spec-16592/265597431>, 12-2016.



## 6 Annex A - XML representation of extension of AutomationML libraries

```

<RoleClassLib Name="DataVariableRoleClassLib">
  <Version>0.2.4</Version>
  <RoleClass Name="DataSource" RefBaseClassPath="CommunicationRoleClassLib/LogicalDevice">
    <Version>0.1</Version>
    <RoleClass Name="OPCUA-Server" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
        <Description>If this attribute is given all others except of the namespace table are
obsolet.</Description>
      </Attribute>
      <Attribute Name="EndpointURL" AttributeDataType="xs:anyURI" />
      <Attribute Name="TransportProfileURI" AttributeDataType="xs:anyURI" />
      <Attribute Name="SecurityPolicy" />
      <Attribute Name="MessageSecurityMode" />
      <Attribute Name="UserToken" />
      <Attribute Name="NameSpaceTable">
        <Attribute Name="0" AttributeDataType="xs:anyURI">
          <Value>http://opcfoundation.org/UA/</Value>
        </Attribute>
      </Attribute>
    </RoleClass>
    <RoleClass Name="iTOT-Client" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="Host" />
      <Attribute Name="Port" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="ReconnectTimeout" AttributeDataType="xs:double" Unit="sec" />
      <Attribute Name="KeepAlive" AttributeDataType="xs:boolean">
        <DefaultValue>FALSE</DefaultValue>
      </Attribute>
      <Attribute Name="NoDelay" AttributeDataType="xs:boolean">
        <DefaultValue>FALSE</DefaultValue>
      </Attribute>
      <Attribute Name="PLCType">
        <Description>(S7-1200)</Description>
      </Attribute>
      <Attribute Name="Priority" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="QueueSize" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="WriteQueueSize" AttributeDataType="xs:unsignedInt" Unit="Bytes" />
      <RoleClass Name="iTOT-DataBlock" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
        <Version>0.1</Version>
        <Attribute Name="DBName" />
        <Attribute Name="Type">
          <Constraint Name="InputOrOutput">
            <NominalScaledType>
              <RequiredValue>Input</RequiredValue>
              <RequiredValue>Output</RequiredValue>
            </NominalScaledType>
          </Constraint>
        </Attribute>
        <Attribute Name="RegisterNumber" AttributeDataType="xs:unsignedInt">
          <Description>Optional</Description>
        </Attribute>
        <Attribute Name="LocalEventList">
          <Description>optional</Description>
        </Attribute>
        <Attribute Name="DBBaustein" AttributeDataType="xs:unsignedInt">
          <Description>Optional</Description>
        </Attribute>
        <Attribute Name="RefDataSource" />
      </RoleClass>
    </RoleClass>
    <RoleClass Name="CanBus" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DeviceName" />
      <Attribute Name="Baudrate" />
    </RoleClass>
    <RoleClass Name="ProfinetHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
    </RoleClass>
    <RoleClass Name="ModbusTCPHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
    </RoleClass>
    <RoleClass Name="IOLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
    </RoleClass>
    <RoleClass Name="EthernetIP" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
    </RoleClass>
  </RoleClass>

```

```
</RoleClass>  
<RoleClass Name="MTConnect" RefBaseClassPath="DataVariableRoleClassLib/DataSource">  
  <Version>0.1</Version>  
</RoleClass>  
<RoleClass Name="CCLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">  
  <Version>0.1</Version>  
</RoleClass>  
</RoleClass>  
</RoleClassLib>
```

*Figure 6 – XML representation of DataVariableRoleClassLib*

## 7 Annex B – XML representation of OPC UA example

```
<?xml version="1.0" encoding="utf-8"?>
<CAEXFile xsi:noNamespaceSchemaLocation="CAEX_ClassModel_V2.15.xsd" SchemaVersion="2.15" FileName="2017-02-
20_DataVariable.aml" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <AdditionalInformation AutomationMLVersion="2.0" />
  <AdditionalInformation>
    <WriterHeader>
      <WriterName>CAEXEditor</WriterName>
      <WriterID>CAEXEditor20130613</WriterID>
      <WriterVendor>Fraunhofer IOSB</WriterVendor>
      <WriterVendorURL>www.mes.fraunhofer.de</WriterVendorURL>
      <WriterVersion>2.2.15</WriterVersion>
      <WriterRelease />
      <LastWritingDateTime>2017-02-20T15:02:20.0500013+01:00</LastWritingDateTime>
      <WriterProjectTitle />
      <WriterProjectID />
    </WriterHeader>
  </AdditionalInformation>
  <InstanceHierarchy Name="InstanceHierarchy1">
    <Version>1.0.0</Version>
    <InternalElement Name="AnlageInternalElement1" ID="f96af602-9efe-4a34-b86d-e3add58dffbba">
      <InternalElement Name="OPCUA-Example_extended_instance_1" ID="82f8e2cb-5cec-4bb9-b937-75dd78e04899"
RefBaseSystemUnitPath="DataVariableExampleSUClib/OPCUA-Example">
        <Attribute Name="OPCUA-Variable">
          <RefSemantic CorrespondingAttributePath="aml-dataSourceType:OPCUA" />
          <Attribute Name="NodeId">
            <Value>ns=1;i=123</Value>
          </Attribute>
          <Attribute Name="RefDataSource">
            <Value>6b9a13e6-974b-4a94-b19a-cd70bf472d46</Value>
          </Attribute>
        </Attribute>
        <InternalElement Name="OPCUA Server" ID="6b9a13e6-974b-4a94-b19a-cd70bf472d46">
          <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
            <Description>If this attribute is given all others except of the namespace table are
obsolete.</Description>
            <Value>opc.tcp://opcua.iosb.fraunhofer.de:4840</Value>
          </Attribute>
          <Attribute Name="EndpointURL" AttributeDataType="xs:anyURI" />
          <Attribute Name="TransportProfileURI" AttributeDataType="xs:anyURI" />
          <Attribute Name="SecurityPolicy" />
          <Attribute Name="MessageSecurityMode" />
          <Attribute Name="UserToken" />
          <Attribute Name="NamespaceTable">
            <Attribute Name="0" AttributeDataType="xs:anyURI">
              <Value>http://opcfoundation.org/UA/</Value>
            </Attribute>
            <Attribute Name="1" AttributeDataType="xs:anyURI">
              <Value>http://iosb.fraunhofer.de/Example/</Value>
            </Attribute>
          </Attribute>
          <SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/OPCUA-Server" />
        </InternalElement>
      </InternalElement>
    </InternalElement>
  </InstanceHierarchy>
  <InterfaceClassLib Name="AutomationMLInterfaceClassLib">
    <Description>Standard Automation Markup Language Interface Class Library - Part 1 Content extended with Part
3 and Part 4 Content</Description>
    <Version>2.2.2</Version>
    <InterfaceClass Name="AutomationMLBaseInterface">
      <InterfaceClass Name="Order" RefBaseClassPath="AutomationMLBaseInterface">
        <Attribute Name="Direction" AttributeDataType="xs:string" />
      </InterfaceClass>
      <InterfaceClass Name="PortConnector" RefBaseClassPath="AutomationMLBaseInterface" />
      <InterfaceClass Name="InterlockingConnector" RefBaseClassPath="AutomationMLBaseInterface" />
      <InterfaceClass Name="PPRConnector" RefBaseClassPath="AutomationMLBaseInterface" />
      <InterfaceClass Name="ExternalDataConnector" RefBaseClassPath="AutomationMLBaseInterface">
        <Attribute Name="refURI" AttributeDataType="xs:anyURI" />
      </InterfaceClass>
      <InterfaceClass Name="COLLADAInterface" RefBaseClassPath="ExternalDataConnector" />
      <InterfaceClass Name="PLCopenXMLInterface" RefBaseClassPath="ExternalDataConnector">
        <InterfaceClass Name="LogicInterface" RefBaseClassPath="PLCopenXMLInterface" />
        <InterfaceClass Name="VariableInterface" RefBaseClassPath="PLCopenXMLInterface">
          <InterfaceClass Name="InterlockingVariableInterface" RefBaseClassPath="VariableInterface">
            <Attribute Name="SafeConditionEquals" AttributeDataType="xs:boolean">
              <DefaultValue>true</DefaultValue>
            </Attribute>
          </InterfaceClass>
        </InterfaceClass>
      </InterfaceClass>
    </InterfaceClass>
  </InterfaceClassLib>
</CAEXFile>
```

```

    </InterfaceClass>
  </InterfaceClass>
</InterfaceClass>
<InterfaceClass Name="Communication" RefBaseClassPath="AutomationMLBaseInterface">
  <InterfaceClass Name="SignalInterface" RefBaseClassPath="Communication" />
</InterfaceClass>
<InterfaceClass Name="AttachmentInterface" RefBaseClassPath="AutomationMLBaseInterface" />
</InterfaceClass>
</InterfaceClassLib>
<RoleClassLib Name="CommunicationRoleClassLib">
  <Description>AutomationML Communication Role Class Library</Description>
  <Version>0.9</Version>
  <RoleClass Name="PhysicalDevice" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole">
    <RoleClass Name="PhysicalEndpointlist" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  />
  </RoleClass>
  <RoleClass Name="PhysicalConnection" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="PhysicalNetwork" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="LogicalDevice" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole">
    <RoleClass Name="LogicalEndpointlist" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  />
  </RoleClass>
  <RoleClass Name="LogicalConnection" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="LogicalNetwork" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="CommunicationPackage" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  />
</RoleClassLib>
<RoleClassLib Name="DataVariableRoleClassLib">
  <Version>0.2.4</Version>
  <RoleClass Name="DataSource" RefBaseClassPath="CommunicationRoleClassLib/LogicalDevice">
    <Version>0.1</Version>
    <RoleClass Name="OPCUA-Server" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
        <Description>If this attribute is given all others except of the namespace table are
        obsolete.</Description>
      </Attribute>
      <Attribute Name="EndpointURL" AttributeDataType="xs:anyURI" />
      <Attribute Name="TransportProfileURI" AttributeDataType="xs:anyURI" />
      <Attribute Name="SecurityPolicy" />
      <Attribute Name="MessageSecurityMode" />
      <Attribute Name="UserToken" />
      <Attribute Name="NamespaceTable">
        <Attribute Name="0" AttributeDataType="xs:anyURI">
          <Value>http://opcfoundation.org/UA/</Value>
        </Attribute>
      </Attribute>
    </RoleClass>
  </RoleClass>
  <RoleClass Name="iTOT-Client" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
    <Attribute Name="Host" />
    <Attribute Name="Port" AttributeDataType="xs:unsignedInt" />
    <Attribute Name="ReconnectTimeout" AttributeDataType="xs:double" Unit="sec" />
    <Attribute Name="KeepAlive" AttributeDataType="xs:boolean">
      <DefaultValue>FALSE</DefaultValue>
    </Attribute>
    <Attribute Name="NoDelay" AttributeDataType="xs:boolean">
      <DefaultValue>FALSE</DefaultValue>
    </Attribute>
    <Attribute Name="PLCType">
      <Description>(S7-1200)</Description>
    </Attribute>
    <Attribute Name="Priority" AttributeDataType="xs:unsignedInt" />
    <Attribute Name="QueueSize" AttributeDataType="xs:unsignedInt" />
    <Attribute Name="WriteQueueSize" AttributeDataType="xs:unsignedInt" Unit="Bytes" />
    <RoleClass Name="iTOT-DataBlock" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DBName" />
      <Attribute Name="Type">
        <Constraint Name="InputOrOutput">
          <NominalScaledType>
            <RequiredValue>Input</RequiredValue>
            <RequiredValue>Output</RequiredValue>
          </NominalScaledType>
        </Constraint>
      </Attribute>
      <Attribute Name="RegisterNumber" AttributeDataType="xs:unsignedInt">
        <Description>Optional</Description>
      </Attribute>
      <Attribute Name="LocalEventList">
        <Description>optional</Description>
      </Attribute>
    </RoleClass>
  </RoleClass>
</RoleClassLib>

```

```

    <Attribute Name="DBBaustein" AttributeDataType="xs:unsignedInt">
      <Description>Optional</Description>
    </Attribute>
    <Attribute Name="RefDataSource" />
  </RoleClass>
</RoleClass>
<RoleClass Name="CanBus" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
  <Attribute Name="DeviceName" />
  <Attribute Name="Baudrate" />
</RoleClass>
<RoleClass Name="ProfinetHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
<RoleClass Name="ModbusTCPHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
<RoleClass Name="IOLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
<RoleClass Name="EthernetIP" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
<RoleClass Name="MTConnect" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
<RoleClass Name="CCLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
  <Version>0.1</Version>
</RoleClass>
</RoleClass>
</RoleClassLib>
<RoleClassLib Name="AutomationMLBaseRoleClassLib">
  <Description>Automation Markup Language Base Role Class Library - Part 1 Content extended with Part 3 and
Part 4 Content</Description>
  <Version>2.2.2</Version>
  <RoleClass Name="AutomationMLBaseRole">
    <RoleClass Name="Group" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="AssociatedFacet" AttributeDataType="xs:string" />
      <RoleClass Name="SignalGroup" RefBaseClassPath="Group" />
      <RoleClass Name="ComponentGroup" RefBaseClassPath="Group" />
    </RoleClass>
    <RoleClass Name="Facet" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Port" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="Direction" AttributeDataType="xs:string" />
      <Attribute Name="Cardinality">
        <Attribute Name="MinOccur" AttributeDataType="xs:unsignedInt" />
        <Attribute Name="MaxOccur" AttributeDataType="xs:unsignedInt" />
      </Attribute>
      <Attribute Name="Category" AttributeDataType="xs:string" />
      <ExternalInterface Name="ConnectionPoint" ID="9942bd9c-c19d-44e4-a197-11b9edf264e7"
RefBaseClassPath="AutomationMLInterfaceClassLib/AutomationMLBaseInterface/PortConnector" />
    </RoleClass>
    <RoleClass Name="Resource" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Product" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Process" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Structure" RefBaseClassPath="AutomationMLBaseRole">
      <RoleClass Name="ProductStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ProcessStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ResourceStructure" RefBaseClassPath="Structure" />
    </RoleClass>
    <RoleClass Name="PropertySet" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Frame" RefBaseClassPath="AutomationMLBaseRole" />
  </RoleClass>
</RoleClassLib>
<SystemUnitClassLib Name="DataVariableExampleSUCLib">
  <Version>1.0.0</Version>
  <SystemUnitClass Name="OPCUA-Example">
    <Attribute Name="OPCUA-Variable">
      <RefSemantic CorrespondingAttributePath="aml-dataSourceType:OPCUA" />
      <Attribute Name="NodeId">
        <Value>ns=1;i=123</Value>
      </Attribute>
      <Attribute Name="RefDataSource">
        <Value>bd82110e-9a49-41ef-93a8-0a1b932a488f</Value>
      </Attribute>
    </Attribute>
    <InternalElement Name="OPCUA Server" ID="bd82110e-9a49-41ef-93a8-0a1b932a488f">
      <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
        <Description>If this attribute is given all others except of the namespace table are
obsolet.</Description>
        <Value>opc.tcp://opcua.iosb.fraunhofer.de:4840</Value>
      </Attribute>

```

```

<Attribute Name="EndpointURL" AttributeDataType="xs:anyURI" />
<Attribute Name="TransportProfileURI" AttributeDataType="xs:anyURI" />
<Attribute Name="SecurityPolicy" />
<Attribute Name="MessageSecurityMode" />
<Attribute Name="UserToken" />
<Attribute Name="NamespaceTable">
  <Attribute Name="0" AttributeDataType="xs:anyURI">
    <Value>http://opcfoundation.org/UA/</Value>
  </Attribute>
  <Attribute Name="1" AttributeDataType="xs:anyURI">
    <Value>http://iosb.fraunhofer.de/Example/</Value>
  </Attribute>
</Attribute>
<SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/OPCUA-Server" />
</InternalElement>
</SystemUnitClass>
<SystemUnitClass Name="Profinet-Example">
  <Attribute Name="Profinet-Variable">
    <RefSemantic CorrespondingAttributePath="aml-dataSourceType:Profinet" />
    <Attribute Name="VariableName">
      <Value>Variable1</Value>
    </Attribute>
    <Attribute Name="refDataSource">
      <Value>b83ceb57-b59b-4c0c-86a8-9974a2fdf01c</Value>
    </Attribute>
  </Attribute>
  <InternalElement Name="ProfinetHost" ID="b83ceb57-b59b-4c0c-86a8-9974a2fdf01c">
    <SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/ProfinetHost" />
  </InternalElement>
</SystemUnitClass>
<SystemUnitClass Name="ModbusTCP-Example">
  <Attribute Name="ModbusTCP-Variable">
    <RefSemantic CorrespondingAttributePath="aml-dataSourceType:ModbusTCP" />
    <Attribute Name="VariableName">
      <Value>Variable1</Value>
    </Attribute>
    <Attribute Name="refDataSource">
      <Value>ddcc0174-96f3-4e9f-ad6f-f01060bd6d81</Value>
    </Attribute>
  </Attribute>
  <InternalElement Name="ModbusTCPHost" ID="ddcc0174-96f3-4e9f-ad6f-f01060bd6d81">
    <SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/ModbusTCPHost" />
  </InternalElement>
</SystemUnitClass>
<SystemUnitClass Name="iTOT SPS-Example">
  <Attribute Name="Var1" ID="f132239a-ef63-42b0-9fc0-22a0780ce668">
    <RefSemantic CorrespondingAttributePath="aml-dataSourceType:iTOT" />
    <Attribute Name="DataBlockName">
      <Value>Data</Value>
    </Attribute>
    <Attribute Name="Type">
      <Value>Input</Value>
      <Constraint Name="InputOrOutput">
        <NominalScaledType>
          <RequiredValue>Input</RequiredValue>
          <RequiredValue>Output</RequiredValue>
        </NominalScaledType>
      </Constraint>
    </Attribute>
    <Attribute Name="RegisterNumber" AttributeDataType="xs:unsignedInt">
      <Description>Optional</Description>
    </Attribute>
    <Attribute Name="Timer" AttributeDataType="xs:unsignedInt" Unit="ms">
      <Value>10</Value>
    </Attribute>
    <Attribute Name="DBBaustein" AttributeDataType="xs:unsignedInt">
      <Description>Optional</Description>
      <Value>60</Value>
    </Attribute>
    <Attribute Name="SPSAddress">
      <Description>Byte offset and optional bit offset</Description>
      <Value>10.0</Value>
    </Attribute>
    <Attribute Name="SPSVariableName">
      <Value>Var1</Value>
    </Attribute>
    <Attribute Name="SPSRegisterNumber" AttributeDataType="xs:unsignedInt">
      <Description>Optional</Description>
    </Attribute>
    <Attribute Name="SPSDataType">
      <Value>INT</Value>
    </Attribute>
  </SystemUnitClass>

```

```

    <Attribute Name="refDataSource">
      <Value>705cd901-3adb-4333-9e01-7ec2bebd2e20</Value>
    </Attribute>
  </Attribute>
</InternalElement Name="iTOT Client" ID="705cd901-3adb-4333-9e01-7ec2bebd2e20">
  <Attribute Name="Host">
    <Value>127.0.0.1</Value>
  </Attribute>
  <Attribute Name="Port" AttributeDataType="xs:unsignedInt">
    <Value>550</Value>
  </Attribute>
  <Attribute Name="ReconnectTimeout" AttributeDataType="xs:double" Unit="sec">
    <Value>10</Value>
  </Attribute>
  <Attribute Name="KeepAlive" AttributeDataType="xs:boolean">
    <Value>TRUE</Value>
  </Attribute>
  <Attribute Name="PLCType">
    <Value>S7-400</Value>
  </Attribute>
  <Attribute Name="Priority" AttributeDataType="xs:unsignedInt" />
  <Attribute Name="WriteQueueSize" AttributeDataType="xs:unsignedInt" Unit="Bytes" />
  <Attribute Name="QueueSize" AttributeDataType="xs:unsignedInt" />
  <Attribute Name="NoDelay" AttributeDataType="xs:boolean">
    <DefaultValue>FALSE</DefaultValue>
  </Attribute>
  <SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/iTOT-Client" />
</InternalElement>
</SystemUnitClass>
<SystemUnitClass Name="CANOpen-Example">
  <Attribute Name="CANOpen-Variable">
    <RefSemantic CorrespondingAttributePath="aml-dataSourceType:CANOpen" />
    <Attribute Name="CANDatentyp">
      <Value>Integer32</Value>
    </Attribute>
    <Attribute Name="VariableName">
      <Value>Position_Actual_Value</Value>
    </Attribute>
    <Attribute Name="Index" AttributeDataType="xs:unsignedInt">
      <Value>6064</Value>
    </Attribute>
    <Attribute Name="Subindex" AttributeDataType="xs:unsignedInt">
      <Value>0</Value>
    </Attribute>
    <Attribute Name="Zugriffstyp">
      <Value>ReadOnly</Value>
    </Attribute>
    <Attribute Name="NodeID" AttributeDataType="xs:unsignedInt">
      <Value>3</Value>
    </Attribute>
    <Attribute Name="refDataSource">
      <Value>21d32a07-490a-4986-917b-d5a8d418b209</Value>
    </Attribute>
  </Attribute>
</InternalElement Name="CanBus0" ID="21d32a07-490a-4986-917b-d5a8d418b209">
  <Attribute Name="DeviceName">
    <Value>can0</Value>
  </Attribute>
  <Attribute Name="Baudrate">
    <Value>5K</Value>
  </Attribute>
  <SupportedRoleClass RefRoleClassPath="DataVariableRoleClassLib/DataSource/CanBus" />
</InternalElement>
</SystemUnitClass>
</SystemUnitClassLib>
</CAEXFile>

```

Figure 7 – XML representation of OPC UA example including libraries



## 8 Annex C – OPC UA Example in AutomationML and OPC UA XML

This Annex describes a concrete example of an existing OPC UA server and its DataVariables. *Figure 8* depicts the InstanceHierarchy of the example. There are some InternalElements organized within a hierarchy which consist of a Start button including a LED and a Stop button. The values of the buttons and LED are accessible via an OPC UA server of the corresponding PLC and shall be described inside the model.

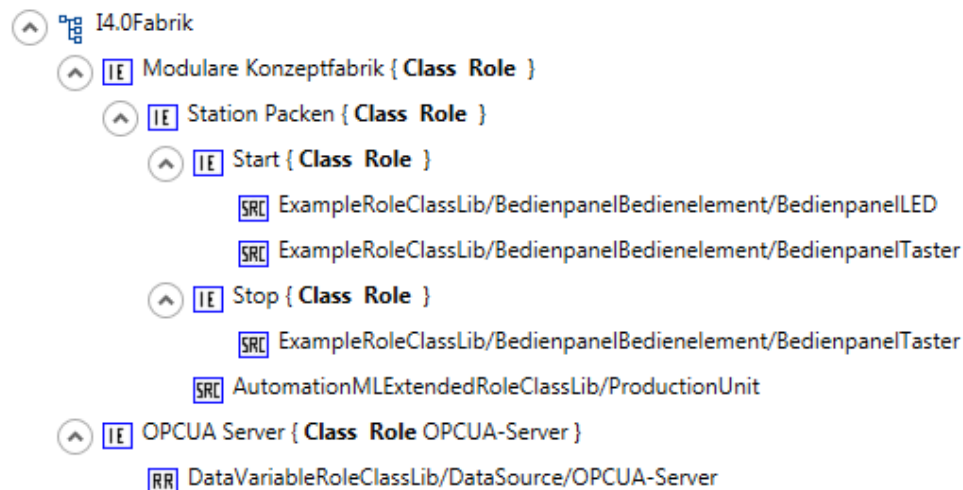


Figure 8 – InstanceHierarchy of AutomationML model

*Figure 9* depicts the OPC UA server attributes. The DiscoveryURL of the server is: “opc.tcp://i40-demoanlage:4845”. The OPC UA server includes one namespace: Namespace 0 - http://opcfoundation.org/UA/.

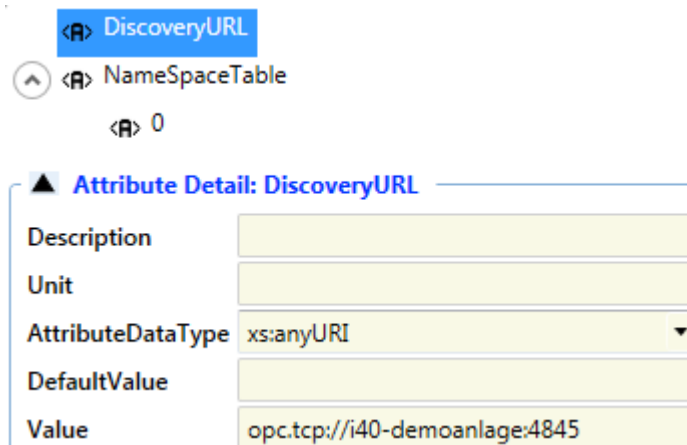


Figure 9 – OPC UA Server attributes of AutomationML model

The Start button inside the example consists of the LED and button. Attributes which are accessible as OPC UA Nodes possess a sub-attribute with the RefSemantic indicating that it is a DataVariable of type OPC UA (see *Figure 10*). This sub-attribute consists of further sub-attributes (relevant to OPC UA communication – NodeId and general ones – RefDataSource). The LEDValue of the Start button is part of the OPC UA server. This is indicated by the GUID of the InternalElement OPC UA Server inside the RefDataSource sub-attribute: 1ea9c9d1-6ed3-431f-9935-db2b8c8f2bb5. The NodeId sub-

attribute of the LEDValue is: ns=7;s=AFB\_Packaging.CPU 314C-2 PNDP.H1. The namespace (ns=7) is part of the OPC UA server address space. NodeIds inside this server are given as String ID (indicated by "s="). Other possible NodeId formats are given within the OPC UA specification. The Id of the specific LED H1 is: AFB\_Packaging.CPU 314C-2 PNDP.H1.

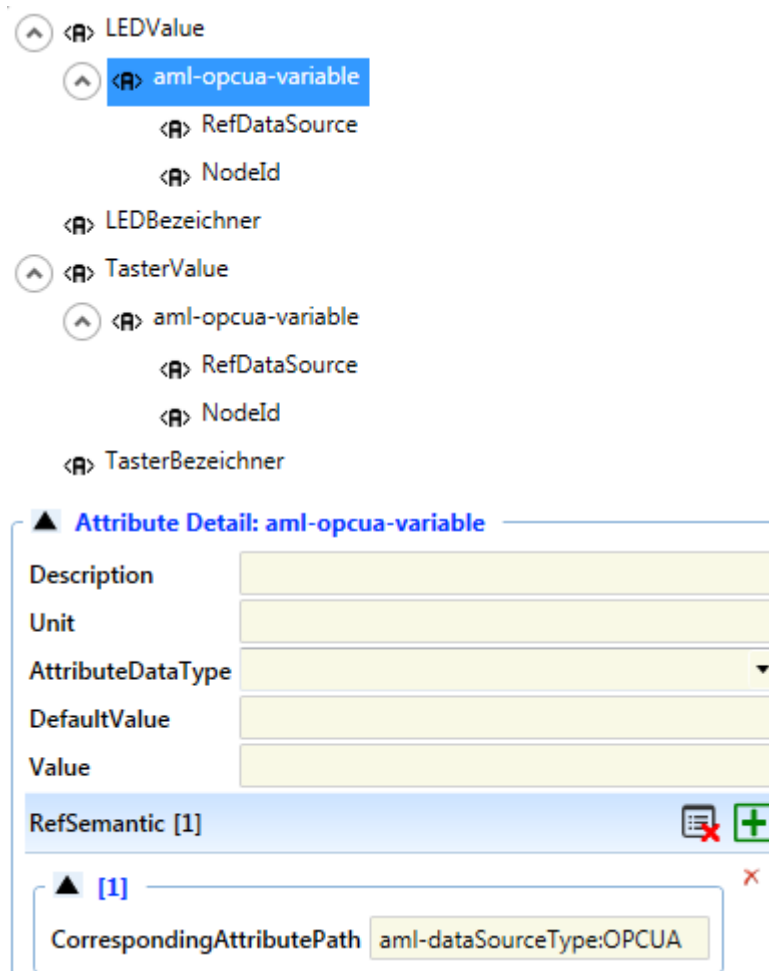


Figure 10 – DataVariable attributes of Start button in AutomationML

Figure 11 depicts the XML representation of the complete example in AutomationML.

```
<?xml version="1.0" encoding="utf-8"?>
<CAEXFile xsi:noNamespaceSchemaLocation="CAEX_ClassModel_V2.15.xsd" FileName="I40_UA-AML-Example.aml"
SchemaVersion="2.15" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <AdditionalInformation AutomationMLVersion="2.0" />
  <AdditionalInformation>
    <WriterHeader>
      <WriterName>CAEXEditor</WriterName>
      <WriterID>CAEXEditor20130613</WriterID>
      <WriterVendor>Fraunhofer IOSB</WriterVendor>
      <WriterVendorURL>www.mes.fraunhofer.de</WriterVendorURL>
      <WriterVersion>2.2.15</WriterVersion>
      <WriterRelease />
      <LastWritingDateTime>2017-02-20T15:02:20.0500020+01:00</LastWritingDateTime>
      <WriterProjectTitle />
      <WriterProjectID />
    </WriterHeader>
  </AdditionalInformation>
  <InstanceHierarchy Name="I4.0Fabrik">
    <Version>0.3.5</Version>
    <InternalElement Name="Modulare Konzeptfabrik" ID="282c58aa-1c61-40c0-adbe-c6006c8aee6b">
      <Attribute Name="Breite" AttributeDataType="xs:unsignedInt" Unit="mm">
```

```

    <Value>2336</Value>
  </Attribute>
  <Attribute Name="Länge" AttributeDataType="xs:unsignedInt" Unit="mm">
    <Value>3915</Value>
  </Attribute>
  <Attribute Name="Höhe" AttributeDataType="xs:unsignedInt" Unit="mm">
    <Value>1797</Value>
  </Attribute>
  <InternalElement Name="Station Packen" ID="8f11d523-8848-4964-8c18-b26b5ab2fcc0">
    <Description>
      Die Station Kommissionieren ist für die Befüllung der Trays mit Flaschen zuständig. Die Trays werden
      auf jeder Seite mit je 3 Flaschen bestückt.
      Die Flaschen werden auf dem Transportband der Station gestoppt. Die Kamera überprüft ob der Tray auf
      dem Transportsystem leer ist. Sind sechs Flaschen am Ende des Bandes angelangt, nimmt der Greifer die ersten drei
      Flaschen und lagert diese auf den Tray auf dem Werkstückträger wartenden Tray aus. Anschließend werden die
      nächsten 3 Flaschen auf den Tray ausgelagert. Sind beide Seiten des Trays befüllt, wird der Werkstückträger
      entlassen und an die Station Hochregallager transportiert.
    </Description>
    <Version>0.1</Version>
    <Attribute Name="Position" AttributeDataType="xs:unsignedInt">
      <Value>10</Value>
    </Attribute>
    <Attribute Name="Breite" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>700</Value>
    </Attribute>
    <Attribute Name="Maximale Breite mit Kamera" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>750</Value>
    </Attribute>
    <Attribute Name="Länge" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>700</Value>
    </Attribute>
    <Attribute Name="Maximale Länge mit Kamera und Handling" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>980</Value>
    </Attribute>
    <Attribute Name="Höhe" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>1524</Value>
    </Attribute>
    <Attribute Name="Maximale Höhe" AttributeDataType="xs:unsignedInt" Unit="mm">
      <Value>1524</Value>
    </Attribute>
    <Attribute Name="Gewicht" AttributeDataType="xs:unsignedInt" Unit="kg">
      <Value>200</Value>
    </Attribute>
    <Attribute Name="Maximale Anzahl von Flaschen im Greifer" AttributeDataType="xs:unsignedInt" Unit="Stk">
      <Value>3</Value>
    </Attribute>
    <Attribute Name="Maximale Anzahl von Flaschen auf dem Band" AttributeDataType="xs:unsignedInt"
Unit="Stk">
      <Value>8</Value>
    </Attribute>
    <InternalElement Name="Start" ID="bd800d94-1c48-46d3-9cc5-e1c238fa3af0">
      <Attribute Name="LEDValue" AttributeDataType="xs:boolean">
        <Description>Blinkt = Aufforderung/Freigabe Start; leuchtet = Automatikbetrieb aktiv</Description>
        <Attribute Name="aml-opcua-variable">
          <RefSemantic CorrespondingAttributePath="aml-dataSourceType:OPCUA" />
          <Attribute Name="RefDataSource">
            <Value>1ea9c9d1-6ed3-431f-9935-db2b8c8f2bb5</Value>
          </Attribute>
          <Attribute Name="NodeId">
            <Value>ns=7;s=AFB_Packaging.CPU 314C-2 PNPD.H1</Value>
          </Attribute>
        </Attribute>
      </Attribute>
      <Attribute Name="LEDBezeichner">
        <Value>H1</Value>
      </Attribute>
      <Attribute Name="TasterValue" AttributeDataType="xs:boolean">
        <Description>Starte Automatikbetrieb</Description>
        <Attribute Name="aml-opcua-variable">
          <RefSemantic CorrespondingAttributePath="aml-dataSourceType:OPCUA" />
          <Attribute Name="RefDataSource">
            <Value>1ea9c9d1-6ed3-431f-9935-db2b8c8f2bb5</Value>
          </Attribute>
          <Attribute Name="NodeId">
            <Value>ns=7;s=AFB_Packaging.CPU 314C-2 PNPD.S1</Value>
          </Attribute>
        </Attribute>
      </Attribute>
      <Attribute Name="TasterBezeichner">
        <Value>S1</Value>
      </Attribute>
      <SupportedRoleClass RefRoleClassPath="ExampleRoleClassLib/BedienpanelBedienelement/BedienpanelLED" />
    </InternalElement>
  </InternalElement>

```

```

    <SupportedRoleClass RefRoleClassPath="ExampleRoleClassLib/BedienpanelBedienelement/BedienpanelTaster"
  />
</InternalElement>
<InternalElement Name="Stop" ID="8e04da19-af16-4b97-a165-50be34bf87e2">
  <Attribute Name="TasterValue" AttributeDataType="xs:boolean">
    <Description>Stoppt den Automatikbetrieb sofort</Description>
    <Attribute Name="aml-opcua-variable">
      <RefSemantic CorrespondingAttributePath="aml-dataSourceType:OPCUA" />
      <Attribute Name="RefDataSource">
        <Value>1ea9c9d1-6ed3-431f-9935-db2b8c8f2bb5</Value>
      </Attribute>
      <Attribute Name="NodeId">
        <Value>ns=7;s=AFB_Packaging.CPU 314C-2 PNDP.S2</Value>
      </Attribute>
    </Attribute>
  </Attribute>
  <Attribute Name="TasterBezeichner">
    <Value>S2</Value>
  </Attribute>
  <SupportedRoleClass RefRoleClassPath="ExampleRoleClassLib/BedienpanelBedienelement/BedienpanelTaster"
  />
</InternalElement>
<SupportedRoleClass RefRoleClassPath="AutomationMLExtendedRoleClassLib/ProductionUnit" />
</InternalElement>
</InternalElement>
<InternalElement Name="OPCUA Server" ID="1ea9c9d1-6ed3-431f-9935-db2b8c8f2bb5">
  <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
    <Value>opc.tcp://i40-demoanlage:4845</Value>
  </Attribute>
  <Attribute Name="NameSpaceTable">
    <Attribute Name="0" AttributeDataType="xs:anyURI">
      <Value>http://opcfoundation.org/UA</Value>
    </Attribute>
  </Attribute>
  <RoleRequirements RefBaseRoleClassPath="DataVariableRoleClassLib/DataSource/OPCUA-Server" />
</InternalElement>
</InstanceHierarchy>
<InterfaceClassLib Name="AutomationMLInterfaceClassLib">
  <Description>Standard Automation Markup Language Interface Class Library</Description>
  <Version>2.2.0</Version>
  <InterfaceClass Name="AutomationMLBaseInterface">
    <InterfaceClass Name="Order" RefBaseClassPath="AutomationMLBaseInterface">
      <Attribute Name="Direction" AttributeDataType="xs:string" />
    </InterfaceClass>
    <InterfaceClass Name="PortConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="InterlockingConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="PPRConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="ExternalDataConnector" RefBaseClassPath="AutomationMLBaseInterface">
      <Attribute Name="refURI" AttributeDataType="xs:anyURI" />
    </InterfaceClass>
    <InterfaceClass Name="COLLADAInterface" RefBaseClassPath="ExternalDataConnector" />
    <InterfaceClass Name="PLCopenXMLInterface" RefBaseClassPath="ExternalDataConnector" />
  </InterfaceClass>
  <InterfaceClass Name="Communication" RefBaseClassPath="AutomationMLBaseInterface">
    <InterfaceClass Name="SignalInterface" RefBaseClassPath="Communication" />
  </InterfaceClass>
</InterfaceClass>
</InterfaceClassLib>
<RoleClassLib Name="ExampleRoleClassLib">
  <Version>0.1</Version>
  <RoleClass Name="BedienpanelBedienelement" RefBaseClassPath="AutomationMLExtendedRoleClassLib/HMI">
    <RoleClass Name="BedienpanelLED" RefBaseClassPath="ExampleRoleClassLib/BedienpanelBedienelement">
      <Attribute Name="LEDValue" AttributeDataType="xs:boolean">
        <Attribute Name="aml-opcua-variable">
          <Attribute Name="VariableNodeId">
            <Value>ns=7;s=</Value>
          </Attribute>
          <Attribute Name="VariableName">
            <Value>H1</Value>
          </Attribute>
          <Attribute Name="ServerAddress">
            <Value>opc.tcp://I40-DEMOANLAGE:4845</Value>
          </Attribute>
          <Attribute Name="ServerAlias">
            <Value>I4.0 Siemens S7</Value>
          </Attribute>
        </Attribute>
      </Attribute>
      <Attribute Name="LEDBezeichner" />
    </RoleClass>
    <RoleClass Name="BedienpanelTaster" RefBaseClassPath="ExampleRoleClassLib/BedienpanelBedienelement">
      <Attribute Name="TasterValue" AttributeDataType="xs:boolean">
        <Attribute Name="aml-opcua-variable">

```

```

    <Attribute Name="VariableNodeId">
      <Value>ns=7;s=</Value>
    </Attribute>
    <Attribute Name="VariableName">
      <Value>S1</Value>
    </Attribute>
    <Attribute Name="ServerAddress">
      <Value>opc.tcp://I40-DEMOANLAGE:4845</Value>
    </Attribute>
    <Attribute Name="ServerAlias">
      <Value>I4.0 Siemens S7</Value>
    </Attribute>
  </Attribute>
</RoleClass>
</RoleClassLib>
</RoleClassLib>
<RoleClassLib Name="DataVariableRoleClassLib">
  <Version>0.2.4</Version>
  <RoleClass Name="DataSource" RefBaseClassPath="CommunicationRoleClassLib/LogicalDevice">
    <Version>0.1</Version>
    <RoleClass Name="OPCUA-Server" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DiscoveryURL" AttributeDataType="xs:anyURI">
        <Description>If this attribute is given all others except of the namespace table are
obsolete.</Description>
      </Attribute>
      <Attribute Name="EndpointURL" AttributeDataType="xs:anyURI" />
      <Attribute Name="TransportProfileURI" AttributeDataType="xs:anyURI" />
      <Attribute Name="SecurityPolicy" />
      <Attribute Name="MessageSecurityMode" />
      <Attribute Name="UserToken" />
      <Attribute Name="NameSpaceTable">
        <Attribute Name="0" AttributeDataType="xs:anyURI">
          <Value>http://opcfoundation.org/UA/</Value>
        </Attribute>
      </Attribute>
    </RoleClass>
    <RoleClass Name="iTOT-Client" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="Host" />
      <Attribute Name="Port" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="ReconnectTimeout" AttributeDataType="xs:double" Unit="sec" />
      <Attribute Name="KeepAlive" AttributeDataType="xs:boolean">
        <DefaultValue>FALSE</DefaultValue>
      </Attribute>
      <Attribute Name="NoDelay" AttributeDataType="xs:boolean">
        <DefaultValue>FALSE</DefaultValue>
      </Attribute>
      <Attribute Name="PLCType">
        <Description>(S7-1200)</Description>
      </Attribute>
      <Attribute Name="Priority" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="QueueSize" AttributeDataType="xs:unsignedInt" />
      <Attribute Name="WriteQueueSize" AttributeDataType="xs:unsignedInt" Unit="Bytes" />
      <RoleClass Name="iTOT-DataBlock" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
        <Version>0.1</Version>
        <Attribute Name="DBName" />
        <Attribute Name="Type">
          <Constraint Name="InputOrOutput">
            <NominalScaledType>
              <RequiredValue>Input</RequiredValue>
              <RequiredValue>Output</RequiredValue>
            </NominalScaledType>
          </Constraint>
        </Attribute>
        <Attribute Name="RegisterNumber" AttributeDataType="xs:unsignedInt">
          <Description>Optional</Description>
        </Attribute>
        <Attribute Name="LocalEventList">
          <Description>optional</Description>
        </Attribute>
        <Attribute Name="DBBaustein" AttributeDataType="xs:unsignedInt">
          <Description>Optional</Description>
        </Attribute>
        <Attribute Name="RefDataSource" />
      </RoleClass>
    </RoleClass>
    <RoleClass Name="CanBus" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
      <Version>0.1</Version>
      <Attribute Name="DeviceName" />

```

```

    <Attribute Name="Baudrate" />
  </RoleClass>
  <RoleClass Name="ProfinetHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
  <RoleClass Name="ModbusTCPHost" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
  <RoleClass Name="IOLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
  <RoleClass Name="EthernetIP" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
  <RoleClass Name="MTConnect" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
  <RoleClass Name="CCLink" RefBaseClassPath="DataVariableRoleClassLib/DataSource">
    <Version>0.1</Version>
  </RoleClass>
</RoleClassLib>
<RoleClassLib Name="CommunicationRoleClassLib">
  <Description>AutomationML Communication Role Class Library</Description>
  <Version>0.9</Version>
  <RoleClass Name="PhysicalDevice" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole">
    <RoleClass Name="PhysicalEndpointlist" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  </RoleClass>
  <RoleClass Name="PhysicalConnection" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="PhysicalNetwork" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="LogicalDevice" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole">
    <RoleClass Name="LogicalEndpointlist" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  </RoleClass>
  <RoleClass Name="LogicalConnection" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="LogicalNetwork" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
  <RoleClass Name="CommunicationPackage" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole"
  </RoleClassLib>
<RoleClassLib Name="AutomationMLBaseRoleClassLib">
  <Description>Automation Markup Language base role class library</Description>
  <Version>2.2.0</Version>
  <RoleClass Name="AutomationMLBaseRole">
    <RoleClass Name="Group" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="AssociatedFacet" AttributeDataType="xs:string" />
    </RoleClass>
    <RoleClass Name="Facet" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Port" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="Direction" AttributeDataType="xs:string" />
      <Attribute Name="Cardinality">
        <Attribute Name="MinOccur" AttributeDataType="xs:unsignedInt" />
        <Attribute Name="MaxOccur" AttributeDataType="xs:unsignedInt" />
      </Attribute>
      <Attribute Name="Category" AttributeDataType="xs:string" />
      <ExternalInterface Name="ConnectionPoint" ID="9942bd9c-c19d-44e4-a197-11b9edf264e7"
RefBaseClassPath="AutomationMLInterfaceClassLib/AutomationMLBaseInterface/PortConnector" />
    </RoleClass>
    <RoleClass Name="Resource" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Product" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Process" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Structure" RefBaseClassPath="AutomationMLBaseRole">
      <RoleClass Name="ProductStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ProcessStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ResourceStructure" RefBaseClassPath="Structure" />
    </RoleClass>
    <RoleClass Name="PropertySet" RefBaseClassPath="AutomationMLBaseRole" />
  </RoleClass>
</RoleClassLib>
<RoleClassLib Name="AutomationMLBMITRoleClassLib">
  <Description>Automation Markup Language Batch Manufacturing Industry Role Class Library</Description>
  <Version>1.1.0</Version>
  <RoleClass Name="BatchManufacturingEquipment"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource" />
  </RoleClassLib>
<RoleClassLib Name="AutomationMLCMIRoleClassLib">
  <Description>Automation Markup Language Continuous Manufacturing Industry Role Class Library</Description>
  <Version>1.1.0</Version>
  <RoleClass Name="ContManufacturingEquipment"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource" />
  </RoleClassLib>
<RoleClassLib Name="AutomationMLCSRoleClassLib">

```



```

<Description>Automation Markup Language Control Industry Role Class Library</Description>
<Version>2.3.0</Version>
<RoleClass Name="ControlEquipment"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource">
  <RoleClass Name="Communication" RefBaseClassPath="ControlEquipment" />
  <RoleClass Name="ControlHardware" RefBaseClassPath="ControlEquipment">
    <RoleClass Name="PC" RefBaseClassPath="ControlHardware" />
    <RoleClass Name="IPC" RefBaseClassPath="ControlHardware" />
    <RoleClass Name="EmbeddedDevice" RefBaseClassPath="ControlHardware" />
    <RoleClass Name="Handheld" RefBaseClassPath="ControlHardware" />
  </RoleClass>
  <RoleClass Name="Sensor" RefBaseClassPath="ControlEquipment" />
  <RoleClass Name="Actuator" RefBaseClassPath="ControlEquipment" />
  <RoleClass Name="Controller" RefBaseClassPath="ControlEquipment">
    <RoleClass Name="PLC" RefBaseClassPath="Controller" />
    <RoleClass Name="NC" RefBaseClassPath="Controller" />
    <RoleClass Name="RC" RefBaseClassPath="Controller" />
    <RoleClass Name="PAC" RefBaseClassPath="Controller" />
  </RoleClass>
</RoleClass>
</RoleClassLib>
<RoleClassLib Name="AutomationMLDMIRoleClassLib">
  <Description>Automation Markup Language Discrete Manufacturing Industry Role Class Library</Description>
  <Version>2.4.0</Version>
  <RoleClass Name="DiscManufacturingEquipment"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource">
    <RoleClass Name="Transport" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Storage" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Fixture" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Gate" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Robot" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Tool" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Carrier" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="Machine" RefBaseClassPath="DiscManufacturingEquipment" />
    <RoleClass Name="StaticObject" RefBaseClassPath="DiscManufacturingEquipment" />
  </RoleClass>
</RoleClassLib>
<RoleClassLib Name="AutomationMLExtendedRoleClassLib">
  <Version>2.7.0</Version>
  <RoleClass Name="PLCFacet" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Facet" />
  <RoleClass Name="HMIFacet" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Facet" />
  <RoleClass Name="Enterprise"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
    <RoleClass Name="Site"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
        <RoleClass Name="Area"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
            <RoleClass Name="ProductionLine"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                <RoleClass Name="WorkCell"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                    <RoleClass Name="ProcessCell"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                        <RoleClass Name="Unit"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                            <RoleClass Name="ProductionUnit"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                                <RoleClass Name="StorageZone"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                                    <RoleClass Name="StorageUnit"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Structure/ResourceStructure" />
                                        <RoleClass Name="Turntable"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                            <RoleClass Name="Conveyor"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport">
                                                <RoleClass Name="BeltConveyor" RefBaseClassPath="Conveyor" />
                                                <RoleClass Name="RollConveyor" RefBaseClassPath="Conveyor" />
                                                <RoleClass Name="ChainConveyor" RefBaseClassPath="Conveyor" />
                                                <RoleClass Name="PalletConveyor" RefBaseClassPath="Conveyor" />
                                                <RoleClass Name="OverheadConveyor" RefBaseClassPath="Conveyor" />
                                            </RoleClass>
                                            <RoleClass Name="LiftingTable"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                                <RoleClass Name="AGV" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                                <RoleClass Name="Transposer"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                                    <RoleClass Name="CarrierHandlingSystem"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                                        <RoleClass Name="BodyStore" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Storage"
/>
                                                        <RoleClass Name="Lift" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
                                                        <RoleClass Name="Rollerbed"

```



```

RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Transport" />
<RoleClass Name="StationaryTool"
RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool" />
<RoleClass Name="MovableTool" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool"
/>
<RoleClass Name="ControlCabinet" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment" />
<RoleClass Name="IODevice" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment" />
<RoleClass Name="HMI" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment">
<RoleClass Name="WarningEquipment" RefBaseClassPath="AutomationMLExtendedRoleClassLib/HMI" />
</RoleClass>
<RoleClass Name="ActuatingDrive" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment/Actuator" />
<RoleClass Name="MotionController" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment" />
<RoleClass Name="Panel" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment/ControlHardware" />
<RoleClass Name="MeasuringEquipment"
RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole/Resource" />
<RoleClass Name="Clamp" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Fixture" />
<RoleClass Name="ProcessController" RefBaseClassPath="AutomationMLCSRoleClassLib/ControlEquipment/Controller"
/>
<RoleClass Name="Loader" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Storage" />
<RoleClass Name="Unloader" RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Storage"
/>
</RoleClassLib>
</CAEXFile>

```

Figure 11 – XML representation of example in AutomationML

It is possible to derive from such an AutomationML model e.g. aggregating OPC UA servers which do not mirror the complete underlying OPC UA servers, but subscribe only the Nodes of interest. To this end, the complete AutomationML model is transformed into OPC UA XML following the transformation rules of DIN SPEC 16592. The result is depicted in Figure 12.

Furthermore the connection of e.g. SCADA systems to the production process can be automatically realized by using such an AutomationML model as data source specifying not only the elements to visualize, but also their accessible/available process values.

Examples of use cases for the DataVariable are given in DIN SPEC 16592.

```

<?xml version="1.0" encoding="utf-8"?>
<UANodeSet xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns="http://opcfoundation.org/UA/2011/03/UANodeSet.xsd">
  <NamespaceUris>
    <Uri>http://opcfoundation.org/UA/AML/</Uri>
    <Uri>http://www.iosb.fraunhofer.de/I40_UA-AML-Example.aml</Uri>
  </NamespaceUris>
  <Aliases>
    <Alias Alias="Boolean">i=1</Alias>
    <Alias Alias="SByte">i=2</Alias>
    <Alias Alias="Byte">i=3</Alias>
    <Alias Alias="Int16">i=4</Alias>
    <Alias Alias="UInt16">i=5</Alias>
    <Alias Alias="Int32">i=6</Alias>
    <Alias Alias="UInt32">i=7</Alias>
    <Alias Alias="Int64">i=8</Alias>
    <Alias Alias="UInt64">i=9</Alias>
    <Alias Alias="Float">i=10</Alias>
    <Alias Alias="Double">i=11</Alias>
    <Alias Alias="DateTime">i=13</Alias>
    <Alias Alias="String">i=12</Alias>
    <Alias Alias="ByteString">i=15</Alias>
    <Alias Alias="Guid">i=14</Alias>
    <Alias Alias="XmlElement">i=16</Alias>
    <Alias Alias="NodeId">i=17</Alias>
    <Alias Alias="ExpandedNodeId">i=18</Alias>
    <Alias Alias="StatusCode">i=19</Alias>
    <Alias Alias="QualifiedName">i=20</Alias>
    <Alias Alias="LocalizedText">i=21</Alias>
    <Alias Alias="Structure">i=22</Alias>
    <Alias Alias="Number">i=26</Alias>
    <Alias Alias="Integer">i=27</Alias>
    <Alias Alias="UInteger">i=28</Alias>
    <Alias Alias="Organizes">i=35</Alias>
    <Alias Alias="HasEventSource">i=36</Alias>
    <Alias Alias="HasModellingRule">i=37</Alias>
    <Alias Alias="HasEncoding">i=38</Alias>

```

```

<Alias Alias="HasDescription">i=39</Alias>
<Alias Alias="HasTypeDefinition">i=40</Alias>
<Alias Alias="HasSubtype">i=45</Alias>
<Alias Alias="HasProperty">i=46</Alias>
<Alias Alias="HasComponent">i=47</Alias>
<Alias Alias="HasNotifier">i=48</Alias>
<Alias Alias="FolderType">i=61</Alias>
<Alias Alias="PropertyType">i=68</Alias>
<Alias Alias="Mandatory">i=78</Alias>
<Alias Alias="Optional">i=80</Alias>
<Alias Alias="Objects">i=85</Alias>
<Alias Alias="Duration">i=290</Alias>
</Aliases>
<UAObject NodeId="ns=2;i=1" BrowseName="I4.0Fabrik">
  <DisplayName>I4.0Fabrik</DisplayName>
  <Description></Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=2</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5002</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=259</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=23</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=25</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=3" BrowseName="AutomationMLInterfaceClassLib">
  <DisplayName>AutomationMLInterfaceClassLib</DisplayName>
  <Description>Standard Automation Markup Language Interface Class Library</Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=4</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5004</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=262</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=80</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=5" BrowseName="ExampleRoleClassLib">
  <DisplayName>ExampleRoleClassLib</DisplayName>
  <Description></Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=6</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5005</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=261</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=92</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=7" BrowseName="DataVariableRoleClassLib">
  <DisplayName>DataVariableRoleClassLib</DisplayName>
  <Description></Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=8</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5005</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=261</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=109</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=9" BrowseName="CommunicationRoleClassLib">
  <DisplayName>CommunicationRoleClassLib</DisplayName>
  <Description>AutomationML Communication Role Class Library</Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=10</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5005</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=261</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=161</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=162</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=163</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=164</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=165</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=166</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=167</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=11" BrowseName="AutomationMLBaseRoleClassLib">
  <DisplayName>AutomationMLBaseRoleClassLib</DisplayName>
  <Description>Automation Markup Language base role class library</Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=12</Reference>
    <Reference ReferenceType="HasTypeDefinition">FolderType</Reference>
    <Reference ReferenceType="Organizes" IsForward="false">ns=1;i=5005</Reference>

```

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```

<Reference ReferenceType="HasComponent">ns=2;i=242</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=243</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=244</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=245</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=246</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=247</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=248</Reference>
<Reference ReferenceType="HasComponent">ns=2;i=249</Reference>
</References>
</UAObject>
<UAObject NodeId="ns=2;i=23" BrowseName="Modulare Konzeptfabrik">
  <DisplayName>Modulare Konzeptfabrik</DisplayName>
  <Description></Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=24</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=1</Reference>
    <Reference ReferenceType="HasTypeDefinition">ns=1;i=1003</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=27</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=29</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=31</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=33</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=25" BrowseName="OPCUA Server">
  <DisplayName>OPCUA Server</DisplayName>
  <Description></Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=26</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=1</Reference>
    <Reference ReferenceType="HasTypeDefinition">ns=1;i=1003</Reference>
    <Reference ReferenceType="ns=1;i=4002">ns=2;i=111</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=77</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=78</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=33" BrowseName="Station Packen">
  <DisplayName>Station Packen</DisplayName>
  <Description>Die Station Kommissionieren ist für die Befüllung der Trays mit Flaschen zuständig. Die Trays werden
auf jeder Seite mit je 3 Flaschen bestückt.
Die Flaschen werden auf dem Transportband der Station gestoppt. Die Kamera überprüft ob der Tray auf dem
Transportsystem leer ist. Sind sechs Flaschen am Ende des Bandes angelangt, nimmt der Greifer die ersten drei
Flaschen und lagert diese auf den Tray auf dem Werkstückträger wartenden Tray aus. Anschließend werden die nächsten 3
Flaschen auf den Tray ausgelagert. Sind beide Seiten des Trays befüllt, wird der Werkstückträger entlassen und an die
Station Hochregallager transportiert.</Description>
  <References>
    <Reference ReferenceType="HasProperty">ns=2;i=34</Reference>
    <Reference ReferenceType="HasProperty">ns=2;i=35</Reference>
    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=23</Reference>
    <Reference ReferenceType="HasTypeDefinition">ns=1;i=1003</Reference>
    <Reference ReferenceType="ns=1;i=4001">ns=2;i=225</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=36</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=37</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=39</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=41</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=43</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=45</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=47</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=49</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=51</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=53</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=55</Reference>
    <Reference ReferenceType="HasComponent">ns=2;i=57</Reference>
  </References>
</UAObject>
<UAObject NodeId="ns=2;i=55" BrowseName="Start">
  <DisplayName>Start</DisplayName>
  <Description></Description>
  <References>
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    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=33</Reference>
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      <Reference ReferenceType="HasComponent">ns=2;i=63</Reference>
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      <Reference ReferenceType="HasComponent">ns=2;i=67</Reference>
    </References>
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    </References>
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    <Reference ReferenceType="HasComponent" IsForward="false">ns=2;i=63</Reference>
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    <Reference ReferenceType="HasProperty">ns=2;i=68</Reference>
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  </References>
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Figure 12 – XML representation of example in OPC UA XML