University of Bonn Report

Automation ML Integration:

AutomationML (Automation Markup Language) is a data format based on XML for data exchange focusing on the domain of automation engineering [1]. The objective of AML is to integrate engineering tools information's in different disciplines, e.g. mechanical plant building, electrical configuration, process designing, process control building, HMI improvement, PLC programming, robot programming, and so forth [1]. Data integration of heterogeneous sources is a well-known problem nowadays [2] [3] [4] and holds utmost importance in modern engineering industry.

This research is proposed to characterize best quality level of AutomationML Files integration that can be utilized as a preparation set for our Automation ML integration tool to accomplish precision and recall for the outcomes. Integration performed in this research relies on upon GOLD standard, which infers simply that expert human input is used to perform the integration.

Automation ML architecture:

The Automation ML data format has been developed by AutomationML e.V.[5] as answer for the information exchange concentrating on robotization framework designing. It is XML-based which allows the organization to exchange data in heterogeneous environment. Figure 1 shows in nutshell the Automation ML Meta data model. Automation ML stores information based on object oriented data model [6]. Parts of Automation ML are [7]:

- CAEX as top-level format used for expressing component topology and networking information including object properties expressed as a hierarchy of Automation ML objects [8].
- COLLADA 1.5 (Khronos Group) for geometry, kinematics, and motion planning [9].
- PLCopen XML SFCs for behavior and sequence descriptions [10].
- MathML 2.0 for formulas.

Figure 1: Automation ML Meta data model

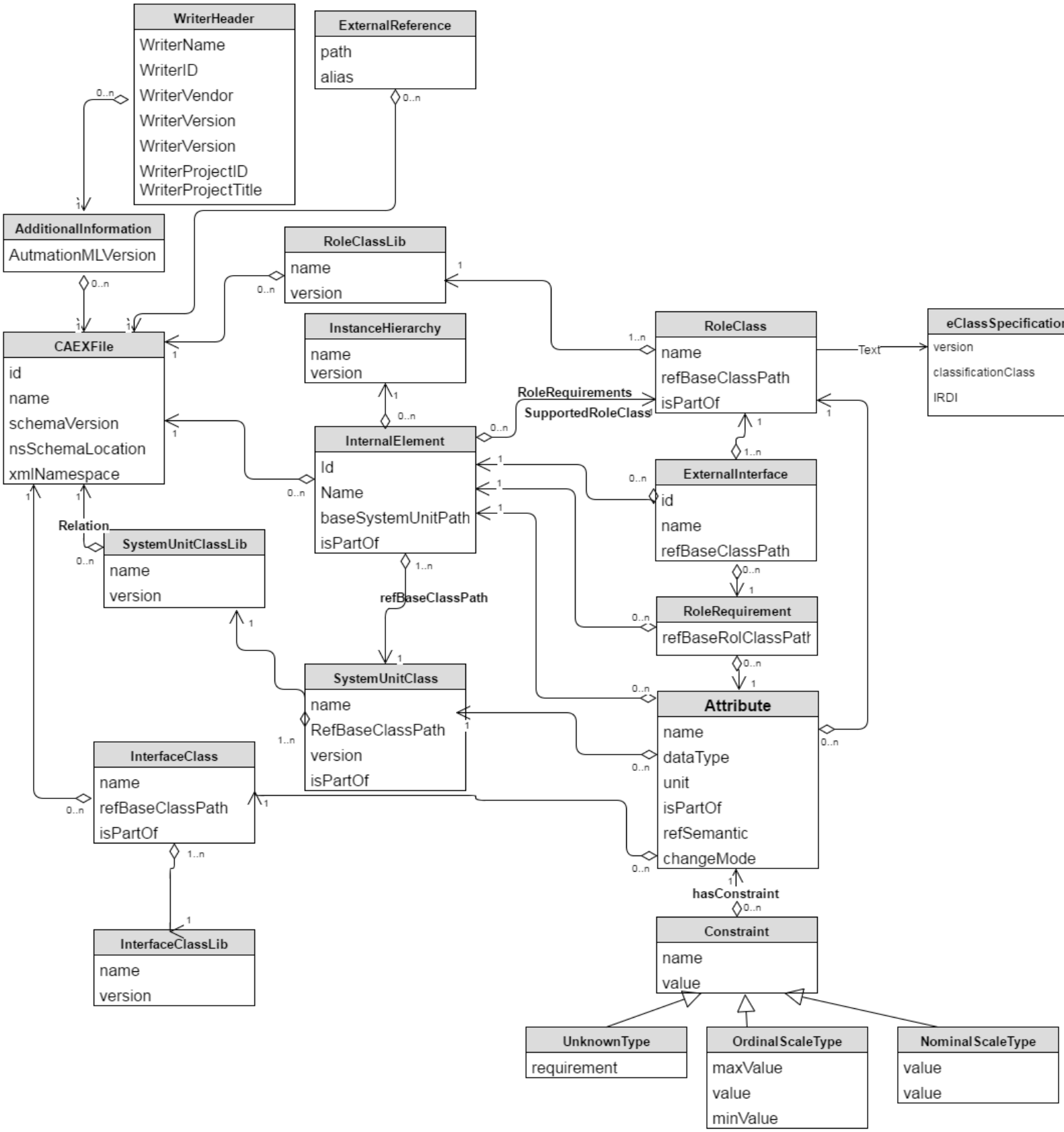


Figure 1 depicts the base of AutomationML is the application of CAEX. CAEX enables an object-oriented approach where semantics of system objects can be specified using roles defined and collected in role class libraries. Ecl@ss specifications are used to describe the underlying semantics. Ecl@ss is catalogue for engineering tool to describe their semantics.[11].
In general, Automation ML provides four main modeling means:

1- Modeling of Role class as an indicator for semantics of the object. Role class can have attribute or External reference as seen in diagram.

2- Modeling of the interface classes. CAEX based model may not cover all the information therefore an interface class is used to describe an abstract relation not covered in CAEX based model also it describes abstract relation between different elements.

3- The third modelling means are system unit classes. System unit classes are templates for system modelling. They normally are used to describe vendor dependent library of components or system devices that are used in engineering tool. They are also used as a template to structure discipline dependent information within an engineering tool.

4- The last modelling means is the Instance Hierarchy, which defines hierarchy of Internal Elements. It allows object oriented and hierarchical structure representation of engineering data to be modelled using CAEX.

In summary Automation ML, modeling follows a hierarchical structure to define data and use of XML makes thing very easy. Automation Ml uses Ecl@ss to identify the semantics of Internal Elements.

Automation ML provides two main mechanisms for semantic identification:

Referencing of roles:

- For referencing of roles the subobjects RoleRequirements and SupportedRoleClass are provided. They can contain the complete role name including the role path.

Referencing of SystemUnitClasses :

- For referencing a SystemUnitClass the attribute RefBaseSystemUnitPath can be used. This contains the complete name and path of the SystemUnitClass in an arbitrary SystemUnitClassLib.
- For the representation of attribute semantics, the RefSemantik sub-attribute of an attribute object can be used. It is given for each Automation ML attribute.

Modeling of Examples:

Utilizing the above Meta model of Automation ML, we made the accompanying information schema for the example of data integration. In figure 2, we have created Role class schema utilizing the eCl@ss catalogue basic Version 9.0 for the case DC Engine (IEC). Utilizing the "aml:classification" esteem we can seek the ecl@ss catalogue[11] and locate the applicable semantics. Aml:IRDI likewise reference to ecl@ss catalogue for referencing of DC motor (IEC) and "aml:refSemantic" tag refers to attributes in the ecl@ass catalogue. Notwithstanding this, applicable qualities for various classes are likewise characterized. In this example there are two properties characterized for our Role Class illustration "Development type of DC engine" and "Cooling Type". These two attributes characterize our granularity for this illustration. Granularity here alludes to the most reduced level of subtle elements.

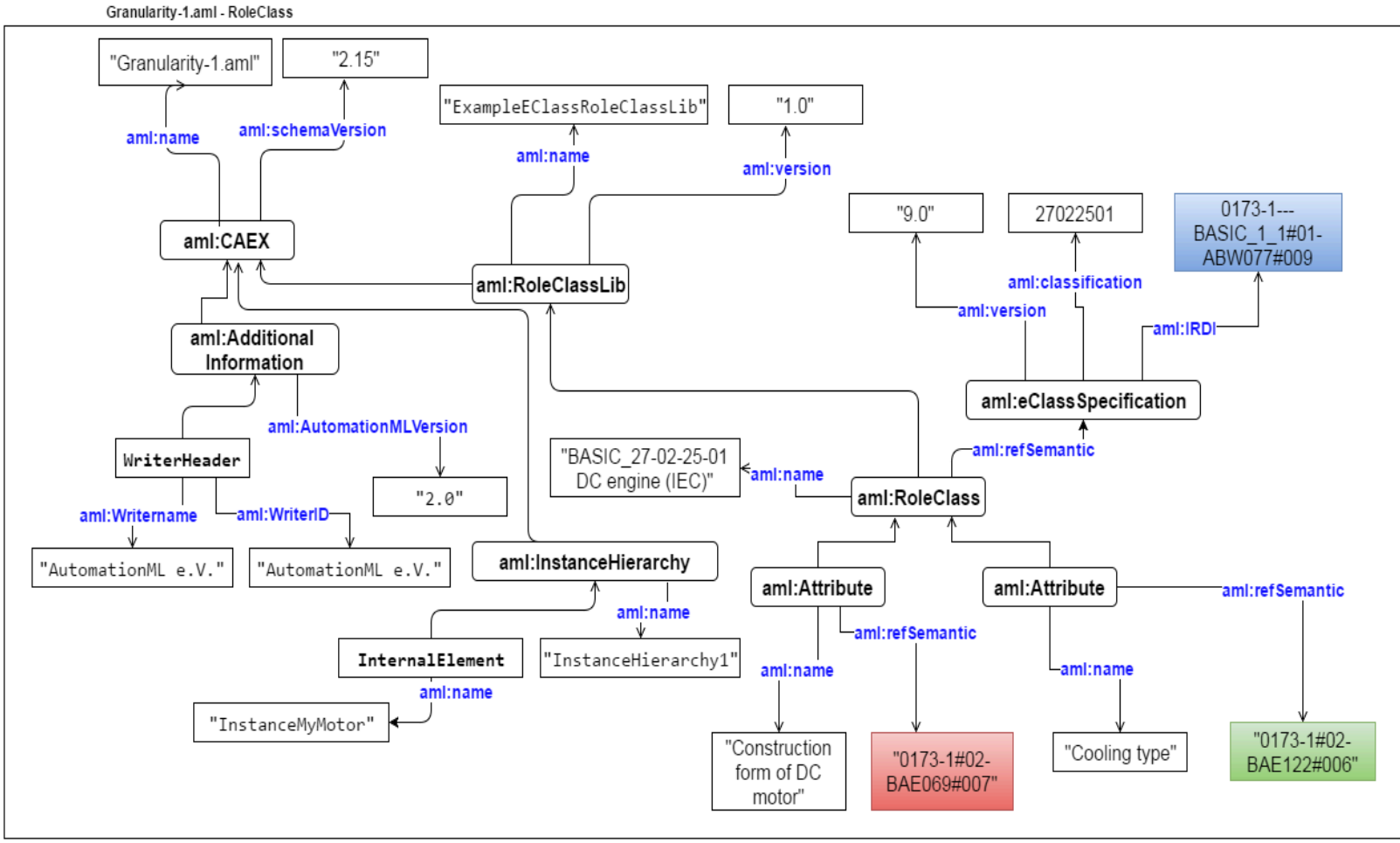
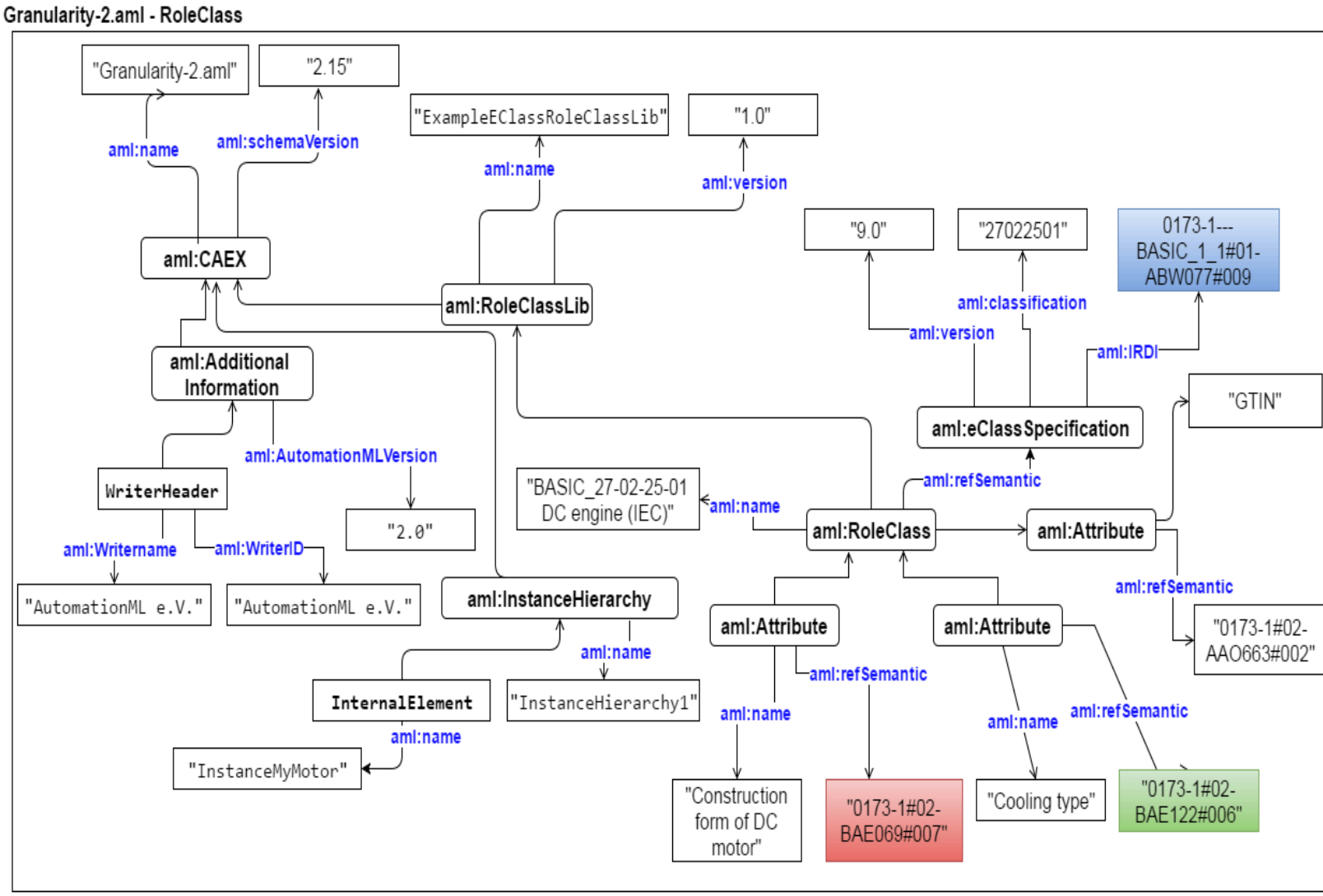


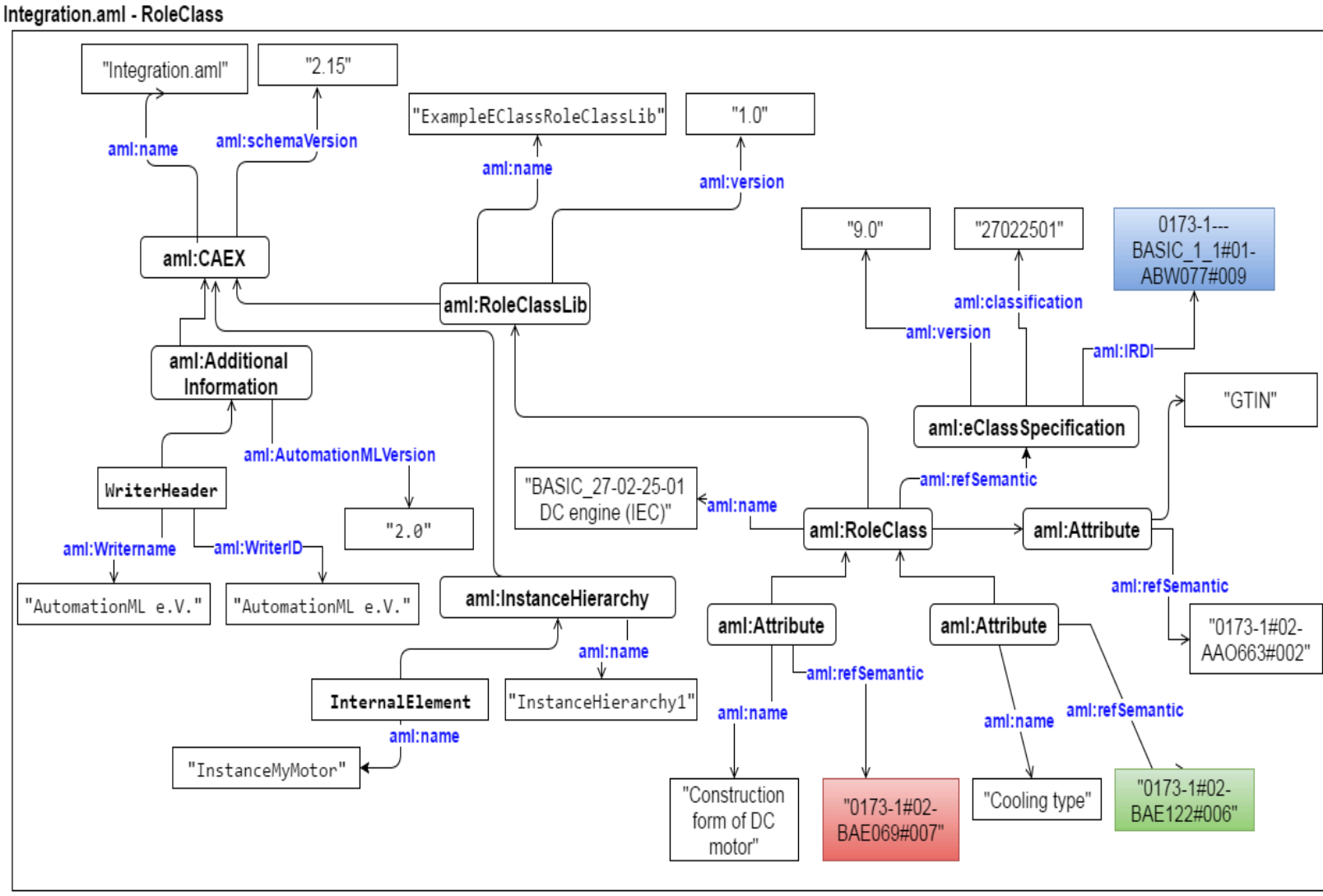
Figure 2- Granularity File-1.aml:

Figure 3- Granularity File-2.aml:



In our second example shown in figure 3. We have increased the granularity of our schema so that we can have relevant examples for data integration in terms different data granularity. In figure 3 we can see that everything is same except for our Role Class we have defined one more attributes “GTIN” along with its ecl@ss semantic reference to increase the granularity . Our goal is to integrate different level of granularity of information which we have achieved in Figure 4.

Figure 4- Integration –File .aml



In figure 4, this is our final result for the information integration. We have combined the relevant schema from figure 2 and figure 3 to perform the integration process.

AML Files Integration:

After defining our schema model our next step is to create the Automation ML files based on the above schema and perform the integration. We used the AutomationML editor [12] to create the corresponding XML files for our schema.

Granularity – File 1.aml

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Mit XMLSpy v2011 rel. 3 (http://www.altova.com) von Josef Prinz (INPRO)
bearbeitet -->

<CAEXFile xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
FileName="Granularity-1.aml" SchemaVersion="2.15"
xsi:noNamespaceSchemaLocation="Source/CAEX_ClassModel_V2.15.xsd">

   <AdditionalInformation AutomationMLVersion="2.0" />

   <AdditionalInformation>

      <WriterHeader>

         <WriterName>AutomationML e.V.</WriterName>

         <WriterID>AutomationML e.V.</WriterID>

         <WriterVendor>AutomationML e.V.</WriterVendor>

         <WriterVendorURL>www.AutomationML.org</WriterVendorURL>

         <WriterVersion>1.0</WriterVersion>

         <WriterRelease>1.0</WriterRelease>

         <LastWritingDateTime>2012-02-20</LastWritingDateTime>

         <WriterProjectTitle>AutomationML Tutorial Examples</WriterProjectTitle>

         <WriterProjectID>AutomationML Tutorial Examples</WriterProjectID>

      </WriterHeader>

   </AdditionalInformation>
```

```
   <ExternalReference Path="Libs/RoleClass
Libraries/AutomationMLBaseRoleClassLib.aml" Alias="BaseRoleClassLib" />

   <ExternalReference Path="Libs/InterfaceClass
Libraries/AutomationMLInterfaceClassLib.aml" Alias="BaseInterfaceClassLib" />

   <InstanceHierarchy Name="InstanceHierarchy1">

      <Version>1.0.0</Version>

      <InternalElement Name="InstanceMyMotor"
ID="3fc3ade7-aa58-44a4-ab37-fa7e7665a74e" />

   </InstanceHierarchy>

   <RoleClassLib Name="ExampleEClassRoleClassLib">

      <Version>1.0.0</Version>

      <RoleClass Name="BASIC_27-02-25-01 DC engine (IEC)">

         <Attribute Name="eClassVersion" AttributeDataType="xs:string">

            <Value>9.0</Value>

         </Attribute>

         <Attribute Name="eClassClassificationClass" AttributeDataType="xs:string">

            <Value>27022501</Value>

         </Attribute>

         <Attribute Name="eClassIRDI" AttributeDataType="xs:string">

            <Value>0173-1---BASIC_1_1#01-ABW077#009</Value>

         </Attribute>

         <Attribute Name="Construction form of DC motor"
AttributeDataType="xs:string">

            <Description>Arrangement of machine parts in reference to anchorage,
arrangement of bearings and shafts</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE069#007" />

         </Attribute>
```

```
        <Attribute Name="Cooling type" AttributeDataType="xs:string">

            <Description>Summary of various types of cooling, for use as search
criteria that limit a selection</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE122#006" />

        </Attribute>

    </RoleClass>

  </RoleClassLib>

</CAEXFile>
```

Granularity – File 2.aml

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Mit XMLSpy v2011 rel. 3 (http://www.altova.com) von Josef Prinz (INPRO)
bearbeitet -->

<CAEXFile xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
FileName="Granularity-2.aml" SchemaVersion="2.15"
xsi:noNamespaceSchemaLocation="Source/CAEX_ClassModel_V2.15.xsd">

  <AdditionalInformation AutomationMLVersion="2.0" />

  <AdditionalInformation>

    <WriterHeader>

        <WriterName>AutomationML e.V.</WriterName>

        <WriterID>AutomationML e.V.</WriterID>

        <WriterVendor>AutomationML e.V.</WriterVendor>

        <WriterVendorURL>www.AutomationML.org</WriterVendorURL>

        <WriterVersion>1.0</WriterVersion>
```

```
         <WriterRelease>1.0</WriterRelease>

         <LastWritingDateTime>2012-02-20</LastWritingDateTime>

         <WriterProjectTitle>AutomationML Tutorial Examples</WriterProjectTitle>

         <WriterProjectID>AutomationML Tutorial Examples</WriterProjectID>

      </WriterHeader>

   </AdditionalInformation>

   <ExternalReference Path="Libs/RoleClass
Libraries/AutomationMLBaseRoleClassLib.aml" Alias="BaseRoleClassLib" />

   <ExternalReference Path="Libs/InterfaceClass
Libraries/AutomationMLInterfaceClassLib.aml" Alias="BaseInterfaceClassLib" />

   <InstanceHierarchy Name="InstanceHierarchy1">

      <Version>1.0.0</Version>

      <InternalElement Name="InstanceMyMotor"
ID="3fc3ade7-aa58-44a4-ab37-fa7e7665a74e" />

   </InstanceHierarchy>

   <RoleClassLib Name="ExampleEClassRoleClassLib">

      <Version>1.0.0</Version>

      <RoleClass Name="BASIC_27-02-25-01 DC engine (IEC)">

         <Attribute Name="eClassVersion" AttributeDataType="xs:string">

            <Value>9.0</Value>

         </Attribute>

         <Attribute Name="eClassClassificationClass" AttributeDataType="xs:string">

            <Value>27022501</Value>

         </Attribute>

         <Attribute Name="eClassIRDI" AttributeDataType="xs:string">

            <Value>0173-1---BASIC_1_1#01-ABW077#009</Value>

         </Attribute>
```

```
        <Attribute Name="Construction form of DC motor"
AttributeDataType="xs:string">

            <Description>Arrangement of machine parts in reference to anchorage,
arrangement of bearings and shafts</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE069#007" />

        </Attribute>

        <Attribute Name="Cooling type" AttributeDataType="xs:string">

            <Description>Summary of various types of cooling, for use as search
criteria that limit a selection</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE122#006" />

        </Attribute>

        <Attribute Name="GTIN" AttributeDataType="xs:string">

            <Description>internationally unique and unambiguous article number for
products and services (Global Trade Item Number, formerly

EAN)</Description>

            <RefSemantic CorrespondingAttributePath="0173-1#02-AAO663#002" />

        </Attribute>

      </RoleClass>

   </RoleClassLib>

</CAEXFile>
```

Integration-File.aml

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Mit XMLSpy v2011 rel. 3 (http://www.altova.com) von Josef Prinz (INPRO)
bearbeitet -->
```

```
<CAEXFile xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
FileName="Integration.aml" SchemaVersion="2.15"
xsi:noNamespaceSchemaLocation="Source/CAEX_ClassModel_V2.15.xsd">

   <AdditionalInformation AutomationMLVersion="2.0" />

   <AdditionalInformation>

      <WriterHeader>

         <WriterName>AutomationML e.V.</WriterName>

         <WriterID>AutomationML e.V.</WriterID>

         <WriterVendor>AutomationML e.V.</WriterVendor>

         <WriterVendorURL>www.AutomationML.org</WriterVendorURL>

         <WriterVersion>1.0</WriterVersion>

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         <LastWritingDateTime>2012-02-20</LastWritingDateTime>

         <WriterProjectTitle>AutomationML Tutorial Examples</WriterProjectTitle>

         <WriterProjectID>AutomationML Tutorial Examples</WriterProjectID>

      </WriterHeader>

   </AdditionalInformation>

   <ExternalReference Path="Libs/RoleClass
Libraries/AutomationMLBaseRoleClassLib.aml" Alias="BaseRoleClassLib" />

   <ExternalReference Path="Libs/InterfaceClass
Libraries/AutomationMLInterfaceClassLib.aml" Alias="BaseInterfaceClassLib" />

   <InstanceHierarchy Name="InstanceHierarchy1">

      <Version>1.0.0</Version>

      <InternalElement Name="InstanceMyMotor"
ID="3fc3ade7-aa58-44a4-ab37-fa7e7665a74e" />

   </InstanceHierarchy>

   <RoleClassLib Name="ExampleEClassRoleClassLib">

      <Version>1.0.0</Version>

      <RoleClass Name="BASIC_27-02-25-01 DC engine (IEC)">
```

```
        <Attribute Name="eClassVersion" AttributeDataType="xs:string">

            <Value>9.0</Value>

        </Attribute>

        <Attribute Name="eClassClassificationClass" AttributeDataType="xs:string">

            <Value>27022501</Value>

        </Attribute>

        <Attribute Name="eClassIRDI" AttributeDataType="xs:string">

            <Value>0173-1---BASIC_1_1#01-ABW077#009</Value>

        </Attribute>

        <Attribute Name="Construction form of DC motor"
AttributeDataType="xs:string">

            <Description>Arrangement of machine parts in reference to anchorage,
arrangement of bearings and shafts</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE069#007" />

        </Attribute>

        <Attribute Name="Cooling type" AttributeDataType="xs:string">

            <Description>Summary of various types of cooling, for use as search
criteria that limit a selection</Description>

            <RefSemantic CorrespondingAttributePath="ECLASS:0173-1#02-BAE122#006" />

        </Attribute>

        <Attribute Name="GTIN" AttributeDataType="xs:string">

            <Description>internationally unique and unambiguous article number for
products and services (Global Trade Item Number, formerly

EAN)</Description>

            <RefSemantic CorrespondingAttributePath="0173-1#02-AAO663#002" />

        </Attribute>

      </RoleClass>

   </RoleClassLib>
```

```
</CAEXFile>
```

Conclusion:

We successfully created our Automation ML files using Automation Ml editor and performed the integration using Gold standard. Our result is verified by human experts in this domain, which will be used as a training set for our Automation ML tool for data integration to achieve precision and recall for the outcomes.

References:

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