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RiseClipse: why Working at the Model Level is Better for Validating Data Conforming to IEC Standards

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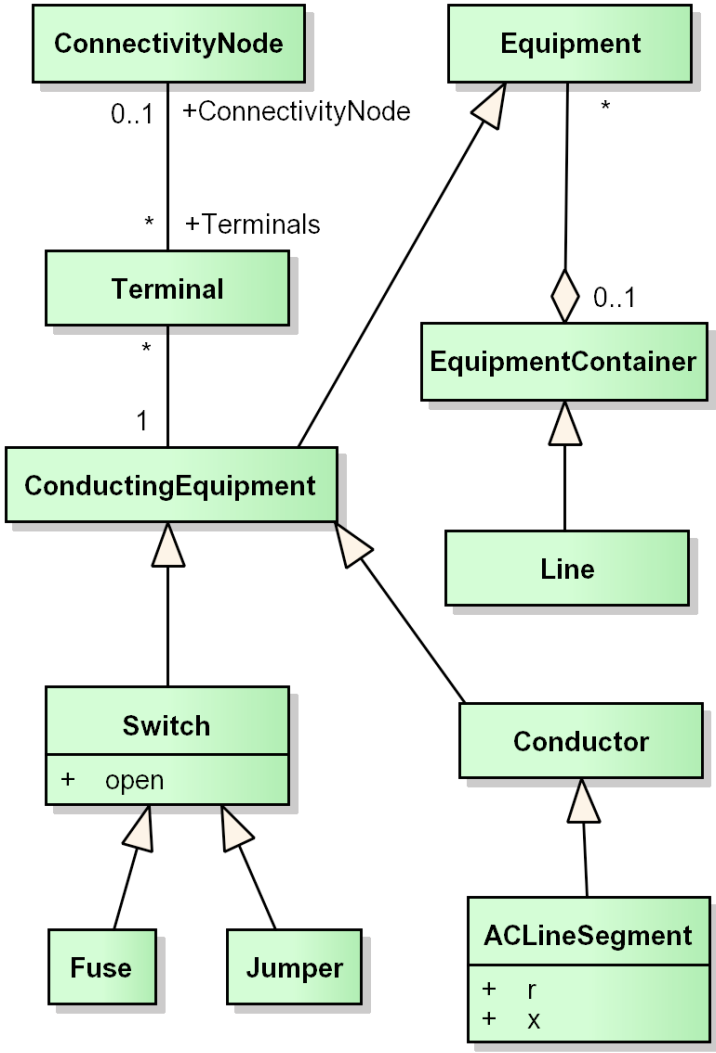
Context

- In the context of smart grids, more and more data is produced and exchanged
- Standards are needed to allow for this exchange of data
- These standards must specify the syntax **and** the semantic of data
- XML is often used for the syntactic level, the use of UML for the semantic level is more and more common
- Interoperability tests are conducted

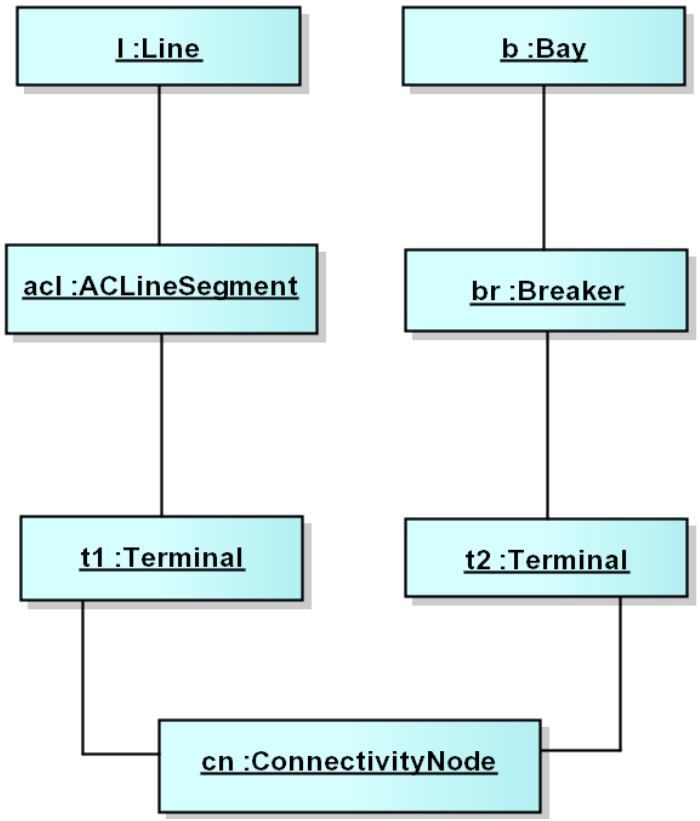
Common Information Model

- Initially developed by EPRI, now a series of standards under the IEC
- Common definition for power system components for use in the EMS API
  - Extended to assets, customer billing, electricity markets…
- Theses standards use (a small part of) UML as an ontology language: the CIM is an UML model



Exchange of CIM data

- A CIM model (e.g. the description of an electric network) is a graph which must be serialized in order to be exchanged
- IEC 61970-501 defines a mapping from the CIM UML model to an RDF Schema
- IEC 61970-552 defines an XML serialization of CIM data based on RDF (the CIM RDF XML format)



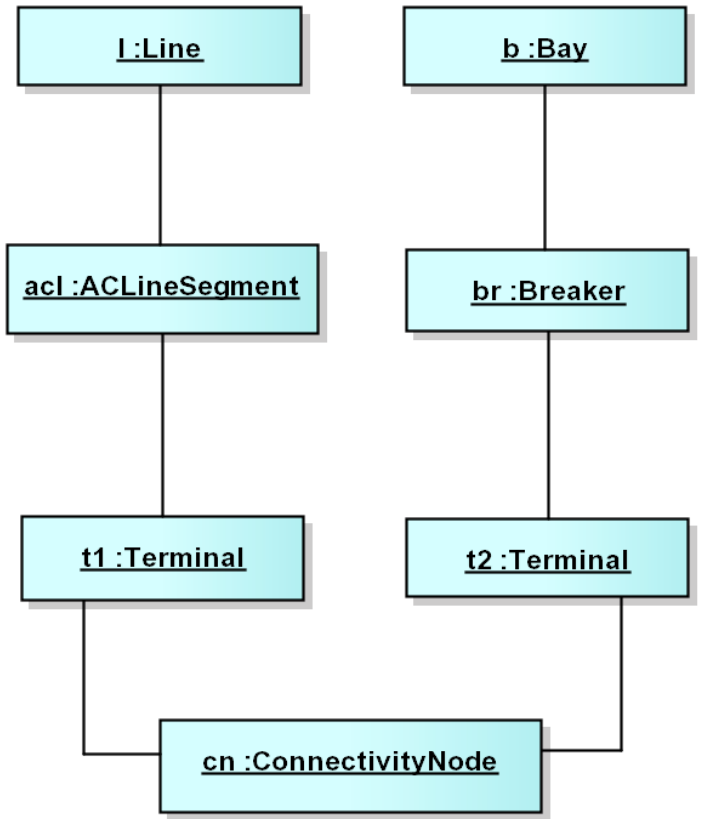
Serialization of CIM data

```
<cim:Line rdf:ID="l"/>

<cim:ACLineSegment rdf:ID="acl">
  <cim:Equipment.EquipmentContainer
                    rdf:resource="l"/>
<cim:ACLineSegment/>

<cim:Terminal rdf:ID="t1">
  <cim:Terminal.ConductingEquipment
                   rdf:resource="acl"/>
  <cim:Terminal.ConnectivityNode
                    rdf:resource="cn"/>
<cim:Terminal/>

<cim:ConnectivityNode rdf:ID="cn"/>
```



Validation of CIM data

- At the syntactic level using XML tools
  - Well-formed
  - Valid (conformed to the schema)
- At the semantic level using XML tools
  - Cardinalities and type of object for the association end present in the serialized data
- Not possible with standards XML tools
  - Cardinalities and type of object for the other association end
  - Constraints on values
  - Constraints depending on values

From software engineering to IEC standards

- Model Driven Engineering is the (not so) new approach for building (software) systems
  - Models help to manage complexity
  - Modeling languages can be defined for a specific domain
- This approach used dedicated tools (validation of models, transformation of models…) based on standards (OMG is the main actor)
- These tools can be used outside software engineering if the needed pieces are presents

OMG modeling layers

M3	MOF	Meta-language	Meta-class
M2	MOF models (e.g. UML)	Languages	Class
M1	UML models (e.g. CIM)	Models	Line
M0	Real things (e.g. power system)	Systems	The real line

- Object Constraint Language is used for specifying constraints (invariants) on models
- It can be used on models (M1) defined using a known (i.e. defined with MOF) language (M2)
- It can be used on systems (M0) modeled with UML

Eclipse Modeling Framework

- Ecore is an implementation of MOF inside Eclipse
- From an Ecore model, EMF generate Java code for manipulating data conforming to the model and for (de-)serializing these data in XML
- There is an operational implementation of OCL on top of EMF
- CimClipse was built using these technologies
  - We adapted the (de-)serialization to be compatible with CIM RDF XML
  - We added later CIM difference files, profiles…

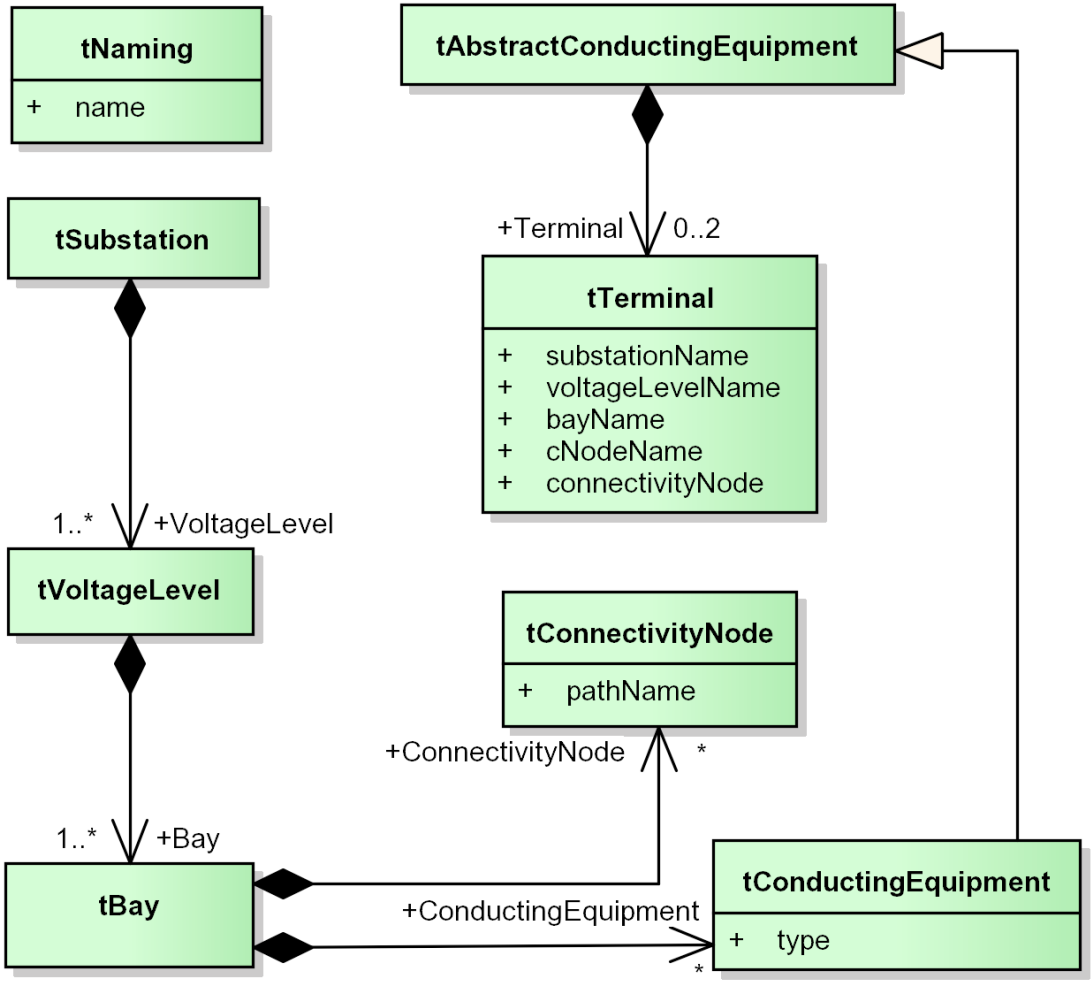
CimClipse layers

M3	Ecore	Meta-Language	Class
M2	CIM	Languages	Line
M1	CIM models	Models	<cim:Line rdf:id="l"/>
M0	Power systems	Data	The real line

- OCL is used to check CIM models (M1) defined using the CIM language (M2) which is itself defined using the Ecore meta-language (M3)
- CIM has been promoted to a Domain Specific Modeling Language (DSML)

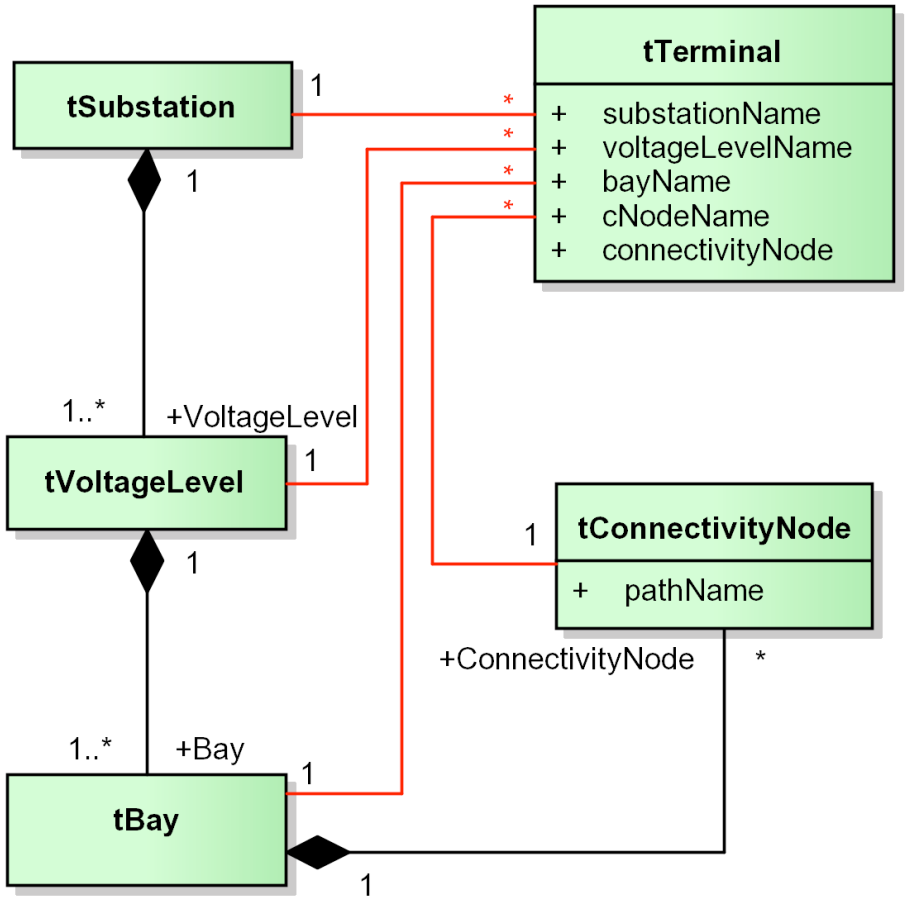
Substation Configuration Language

- SCL is one of the IEC 61850 series of standards
- XML Schema is used to define the language, UML is used to illustrate the definitions



RiseClipse

- We added explicit links in the model for navigation purpose
- We also made all links bidirectional
- Our tool became agnostic with respect to (meta-)models
- And rename it RiseClipse



Future work

- Some features of CimClipse have still to be ported to RiseClipse
- Other standards (COSEC)
- We are investigating model transformations
  - Evolutions of CIM
  - CIM-IEC 61850 harmonization effort
- We have to finalize an agreement between CentraleSupélec and EDF to be able to release RiseClipse as open source
- http://riseclipse.foundry.supelec.fr

Thanks !

Questions ?

Backup

OWL vs OCL

- OWL:

```
<rdf:Description rdf:nodeID= "…" >
  <owl:minCardinality rdf:datatype="int">
    1
  </owl:minCardinality>
  <owl:onProperty
      rdf:resource=”Terminal.ConnectivityNode"/>
  <rdf:type rdf:resource="Restriction"/>
</rdf:Description>
```

- OCL:

```
context Terminal inv:
   self.ConnectivityNode <> null
```

CimTool vs OCL

- CimTool:

```
problem("Isolated node")
  <-(?n rdf:type ConnectivityNode)
       countLessThan(2 * Terminal.ConnectivityNode ?n)
```

- OCL:

```
context ConnectivityNode inv "Isolated node":
   self.Terminals->size() >= 2
```

Inheritance

- OCL:

```
context ACLineSegment inv:
    self.EquipmentContainer.oclIsTypeOf(Line)

context Equipment inv:
   not self.oclIsTypeOf(ACLineSegment) implies
   self.EquipmentContainer.oclIsTypeOf(Bay)
   xor
   self.EquipmentContainer.oclIsTypeOf(VoltageLevel)
```

Smart grids domains