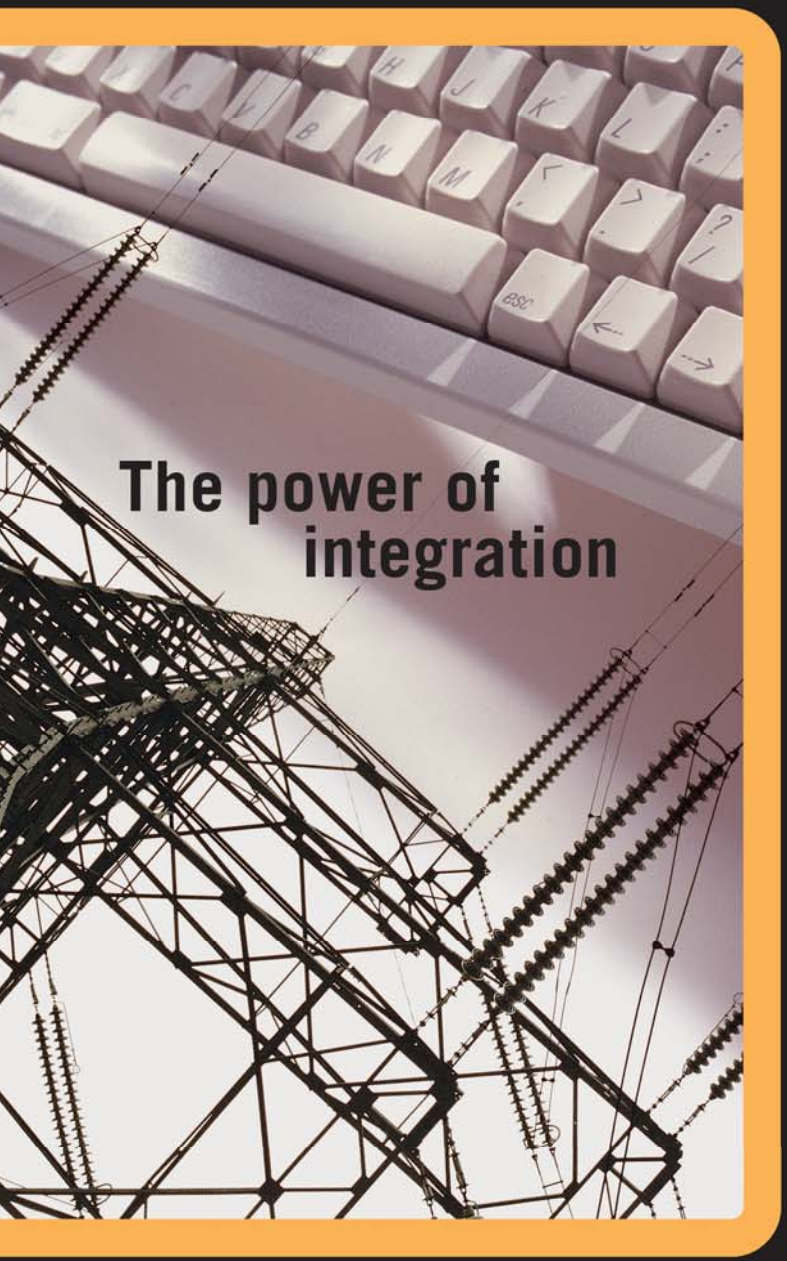


UISOL

Utility Integration Solutions, Inc.

Use of the CIM Ontology

Scott Neumann, UISOL
Arnold DeVos, Langdale
Steve Widergren, PNNL
Jay Britton, Areva

LANGDALE

AREVA

Pacific Northwest National Laboratory

Operated by Battelle for the U.S. Department of Energy

Common Information Model (CIM)

- IEC Common Information Model (CIM) models objects and information exchanges for transmission, distribution, generation and markets for electric utilities
- The CIM is currently defined using Unified Modeling Language (UML)
- CIM is the foundation for several industry standards and related efforts (e.g. IEC 61970, IEC 61968)
- CIM used for system and business process integration by utilities worldwide

Common Uses of the CIM

The CIM provides a common vocabulary that is used to define:

- interfaces for the integration of services and applications
- data structures internal to applications
- database schemas
- messages structures for the exchange of information (typically using RDF or XML Schema)

CIM Facts …

- The CIM is the most developed and widely accepted model for describing an electrical network
- The CIM is but one of a number of models that will typically be leveraged for enterprise integration with electric utilities
- Local extensions will typically be required for any enterprise integration effort
- Relations between the CIM and other models (as well as future CIM versions) will need to be maintained and managed
- The needs of electric utilities will continue to evolve
- The CIM and related industry standards will continue to evolve
- There are a diverse and evolving set of tools that users will want to leverage

CIM Usage Experience

- CIM was originally defined with a transmission focus
- As you start moving from the CIM center of mass (i.e. the CIM Wires model), the more likely that gaps will be found
- This can be said from the perspectives of models, business processes, system integration, etc.
- There are often legacy application models, enterprise models and other domain models that need to be recognized for any integration effort that may supplement or overlap the CIM
- Many applications and integration efforts require only a subset of the CIM
- Where the CIM was designed to meet the needs of existing applications, issues are often identified in the development of next generation applications

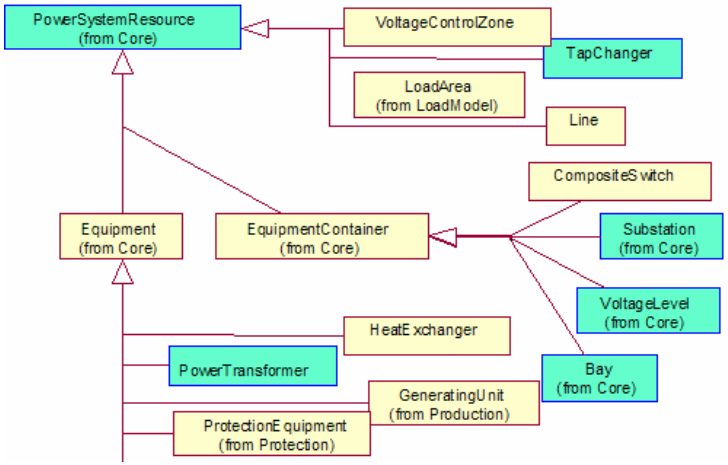
What is an Ontology?

- An ontology is an explicit formal specification of how to represent the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them
- A language of ‘sets’
- There are typically three different levels to the content of an ontology:
  - An ‘is-a’ taxonomy of concepts
  - An internal concept structure and the relationship between concepts
  - Explicit axioms that define restrictions for relationships and properties

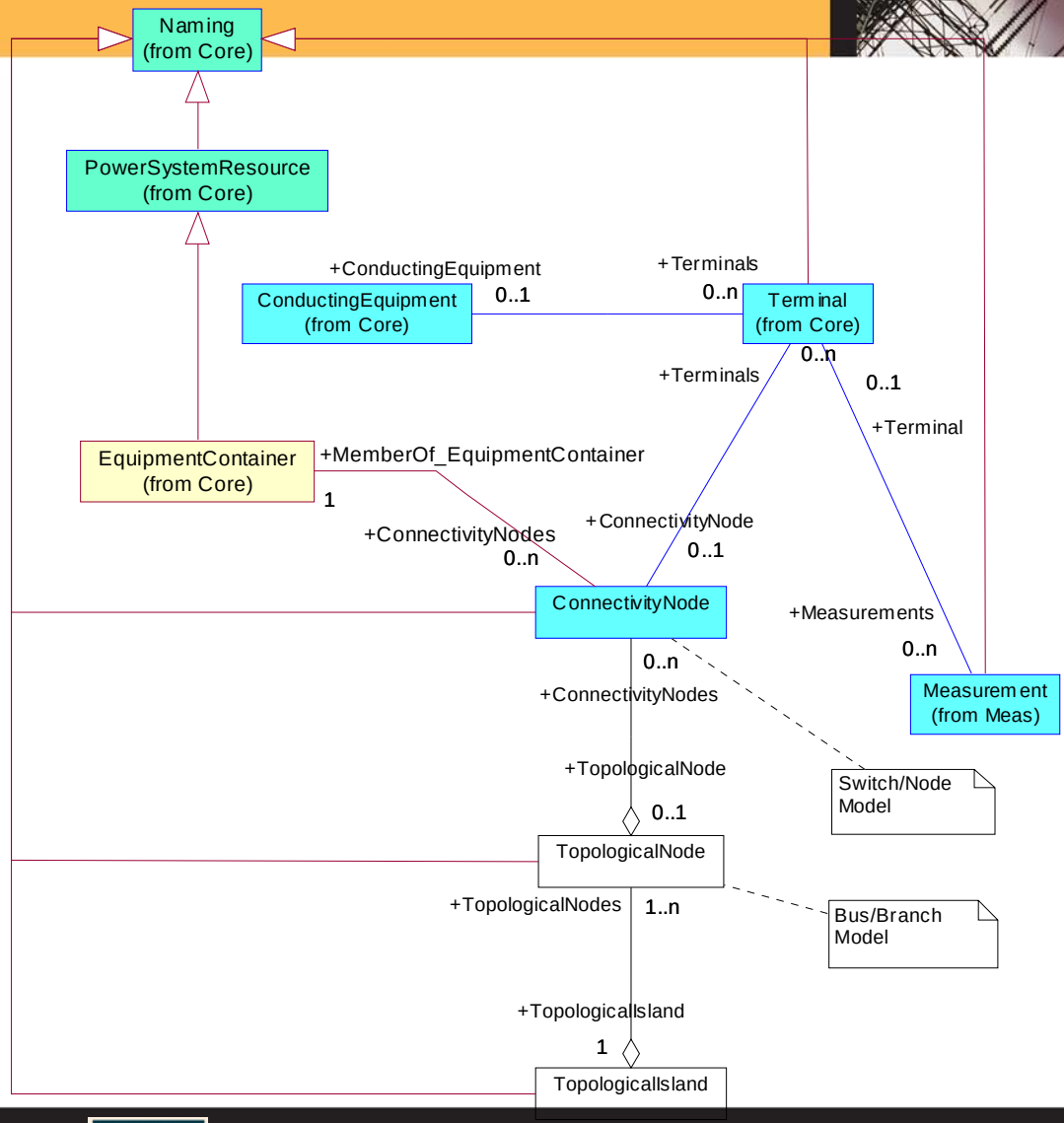
Data Modeling vs. Ontological Engineering

- The CIM is currently expressed as a Unified Modeling Language (UML) data model
- UML models usually define the classes, properties and relationships that might potentially be used to describe an object
- Within a UML model relationships between classes are limited to is-a (subclasses) and associations, where there is a richer vocabulary available for ontologies (e.g. using OWL)
- Within ontological engineering, explicit axioms define the conditions where specific property values and relationships are valid for specific instances of a class
- Ontologies provide the ability to deduce what is implied by the model

CIM UML Example



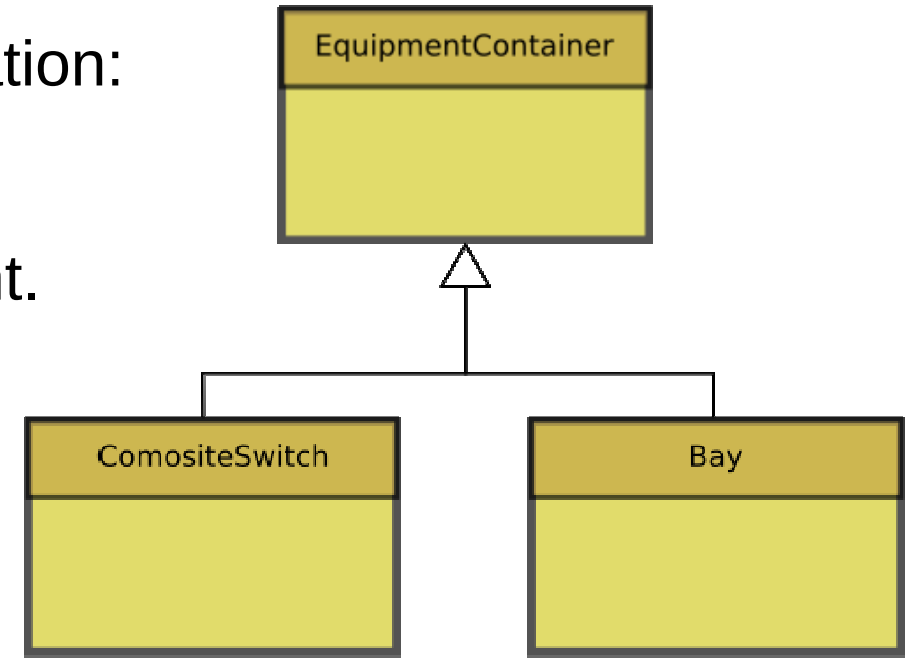
- CIM Network Topology modeling fragment
- Classes, relationships and properties defined using UML
- Nothing says that a line at 345kV bus in one substation must terminate at 345kV bus in another



UML Expresses OO Concepts

Object-Oriented Generalization:

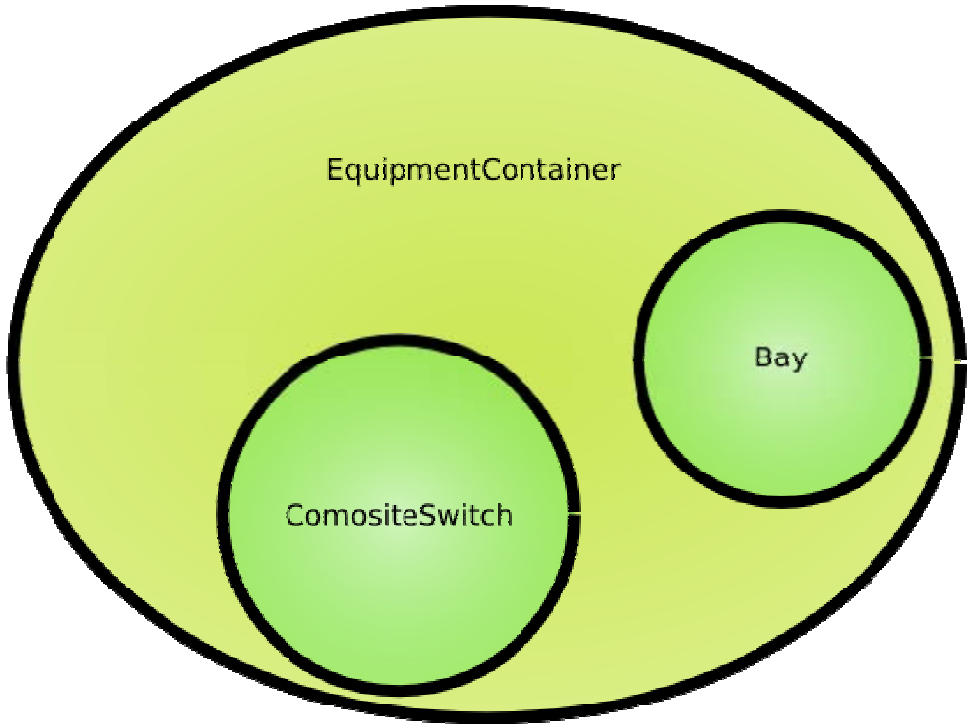
The child class inherits
the *features* of the parent.



Ontology: A Language of Sets

Subclass Axiom:

The extent of the child class is a subset of the parent.

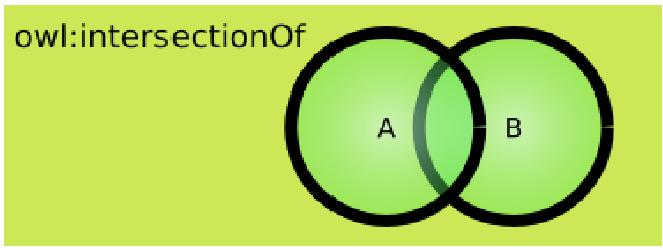


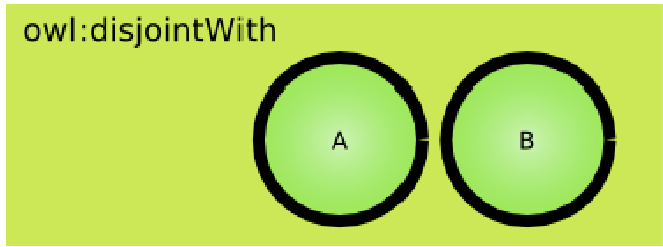
OWL

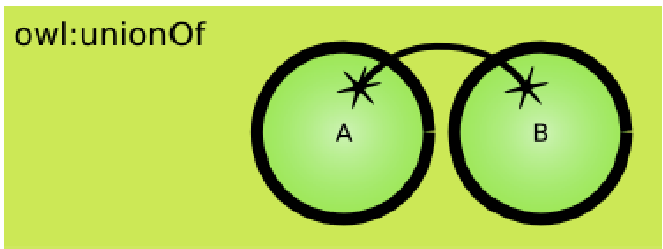
- Ontological Web Language
- Based on RDF
- Uses data types defined by XML Schema (e.g. xsd:float, xsd:string, …)
- Three dialects: Lite, DL and Full
- Supported by a growing set of tools:
  - Protégé
  - Altova SemanticWorks
  - SWOOP
  - Unicorn
  - SWeDE
  - CIMTool

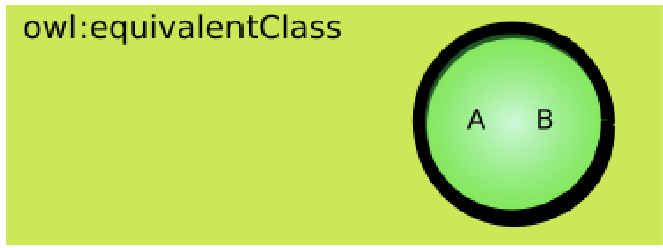
Beyond sub-Classes

OWL Class Axioms



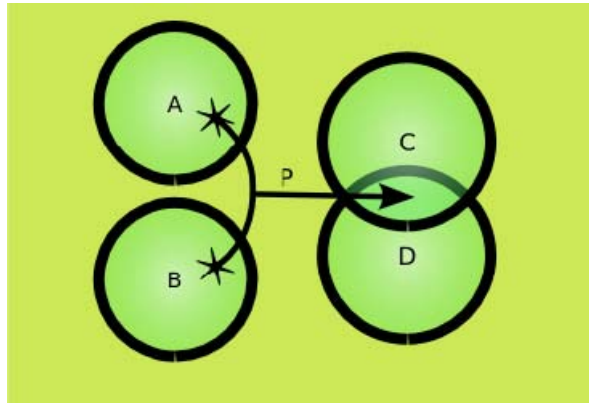


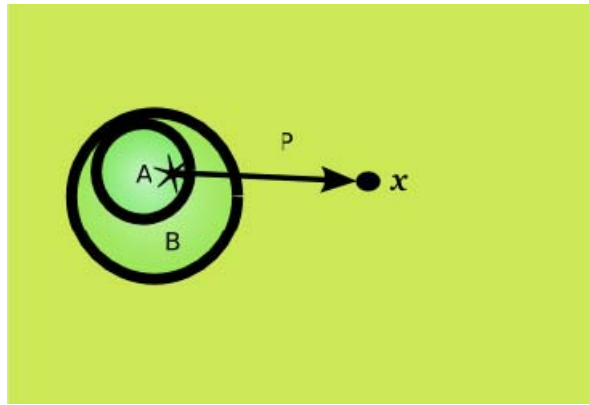




Properties

- Define sets linked by property:
  - For any A or B, the value of P is both a C and a D
- Define individual cases:
  - For any A, the value of P is x.
- Also:
  - Cardinality
  - Quantifiers: all or some

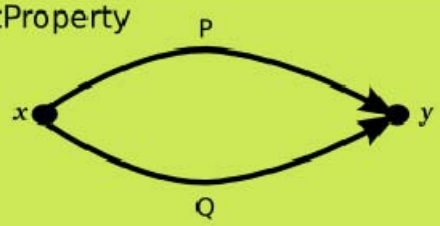




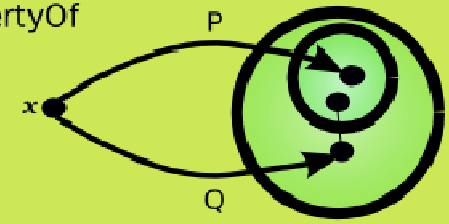
More on Properties

OWL Property Axioms

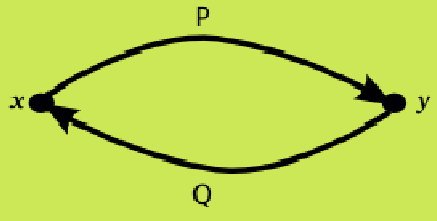
owl:equivalentProperty



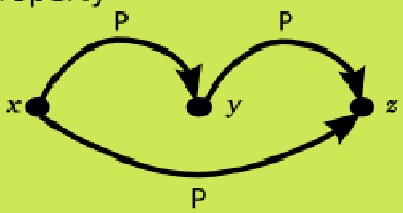
rdfs:subPropertyOf



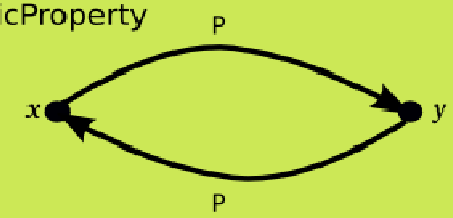
owl:inverseOf



owl:TransitiveProperty



owl:SymmetricProperty



What are the Benefits of Ontologies?

- Ontologies allow for more complete and accurate modeling of domain knowledge than a UML data model, where assumptions can be explicitly defined
- Ontologies be readily reused through equivalences and mappings (e.g. CIM MeasurementValue is equivalent to an OPC ItemValue)
- Ontologies provide the means to describe knowledge in a form that can be leveraged by both humans and intelligent agents
- Ontologies can be leveraged by rule-driven applications to make inferences from models
- Implementation artifacts (e.g. XML Schemas) can be generated from an ontology as necessary for application development or systems integration
- Natural language and query capabilities of Ontology tools make models useful to wider audiences

Is the CIM an Ontology?

- Some might not currently view the CIM in its current UML form as an ontology
- Work has been done to provide the means to convert the CIM UML model to OWL
- At some point in the future the CIM will likely be maintained and evolved using OWL
- Yes … the CIM is an ontology

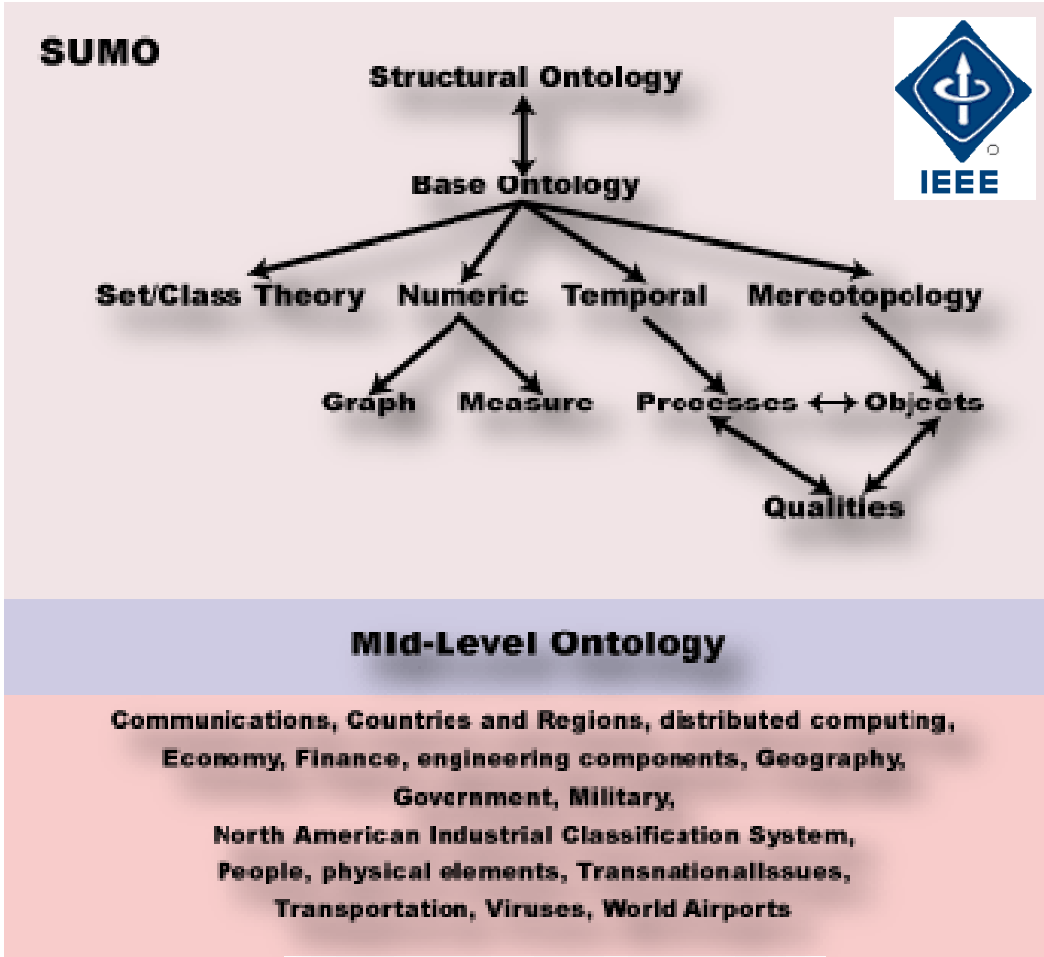
CIM OWL Example

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xml:base="http://iec.ch/TC57/2001/CIM-schema-cim10#"
      xmlns:owl="&owl;“
      xmlns:rdf="&rdf;"
      xmlns:rdfs="&rdfs;">
      <owl:Class rdf:about="#ACLineSegment">
            <rdfs:comment>A wire or combination of wires, with consistent electrical characteristics,
             building a single electrical system, used to carry alternating current between points in
            the power system.</rdfs:comment>
            <rdfs:isDefinedBy rdf:resource="#Package_Wires"/>
            <rdfs:label xml:lang="en">ACLineSegment</rdfs:label>
            <rdfs:subClassOf>
                  <owl:Class rdf:about="#Conductor"/>
            </rdfs:subClassOf>
      </owl:Class>

      <owl:AnnotationProperty rdf:about="&rdfs;comment"/>
      <owl:AnnotationProperty rdf:about="&rdfs;isDefinedBy"/>
      <owl:AnnotationProperty rdf:about="&rdfs;label"/>
</rdf:RDF>
```

Suggested Upper Merged Ontology

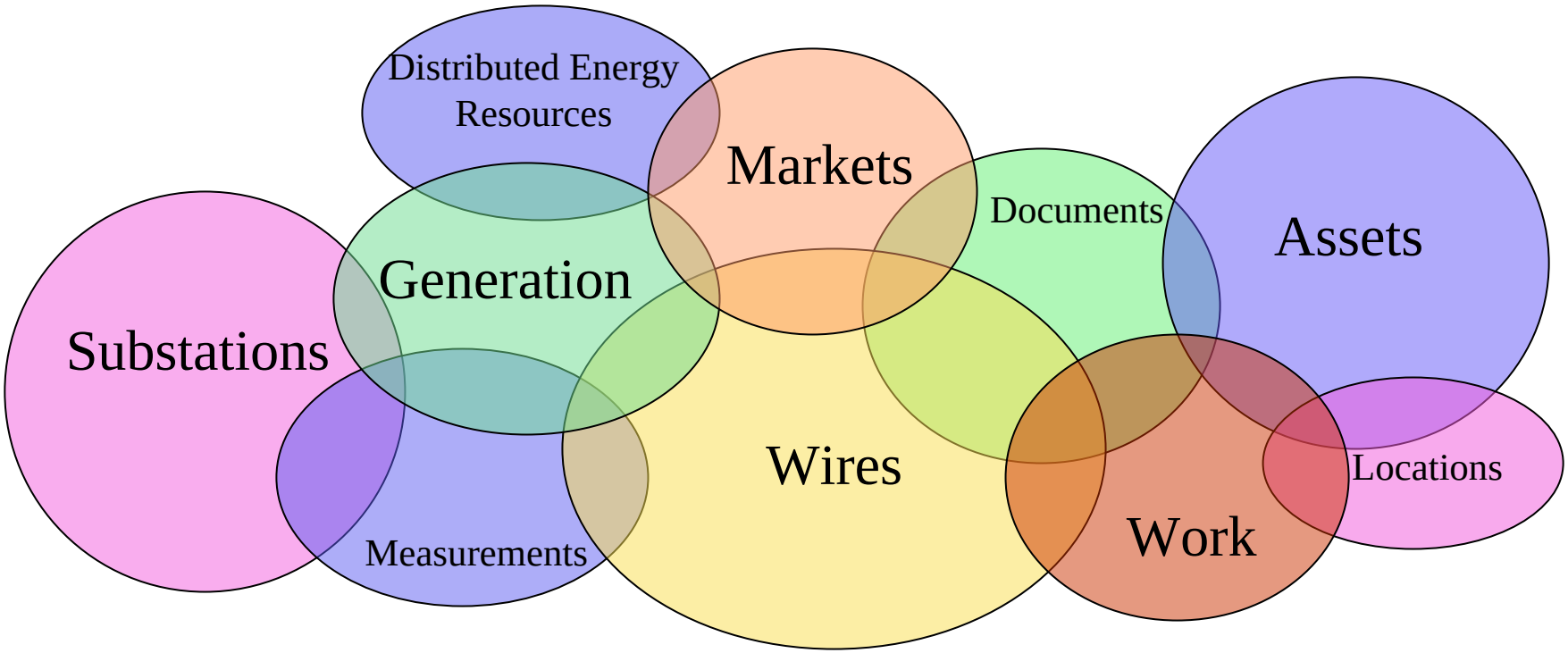
- A top-level ontology
- IEEE P1600.1
- Developed within the IEEE Standard Upper Ontology working group
- SUMO is freely available under an IEEE license
- SUMO is a modular ontology



Federation of Ontologies

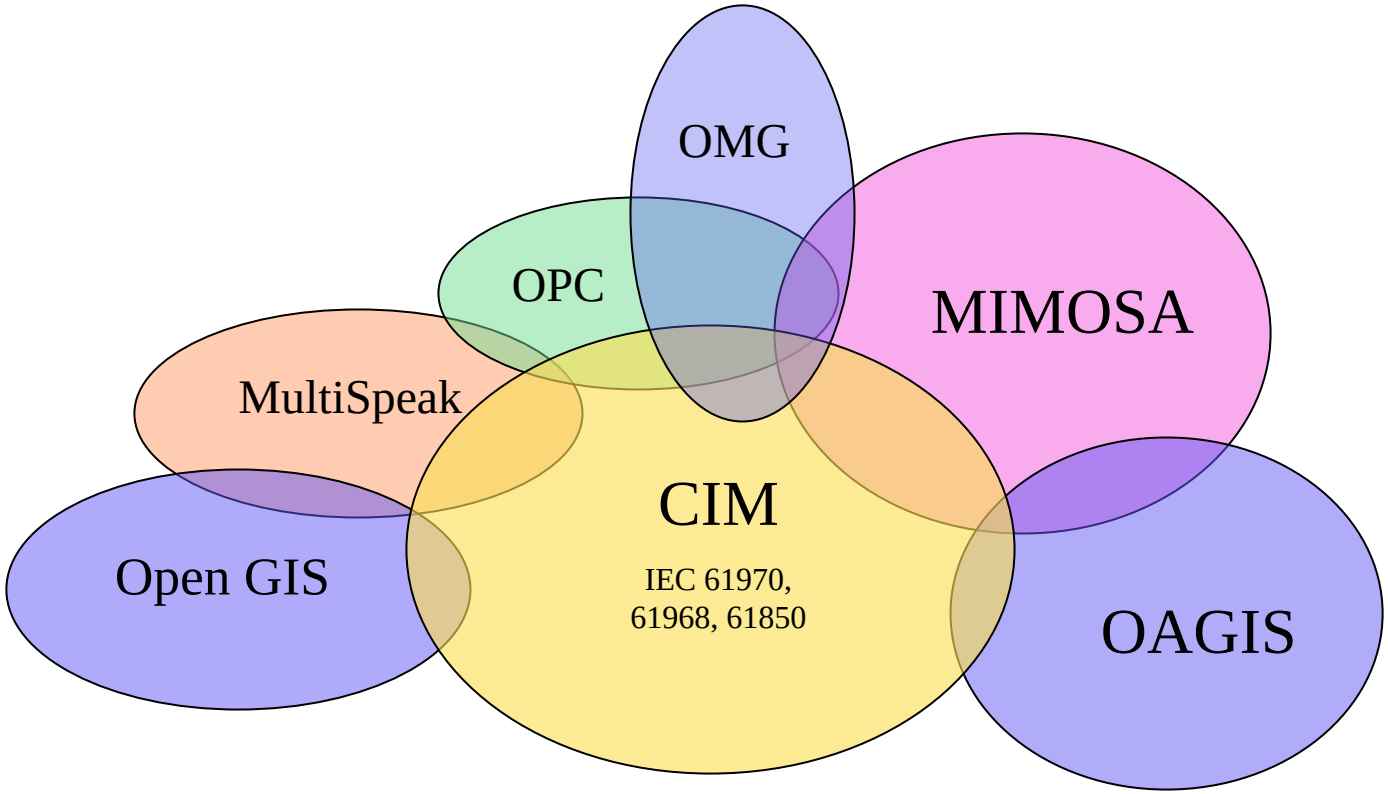
- The notion of a Global Federation of Ontologies is an emerging concept
- The CIM is only one of a number of ontologies that may need to be leveraged/recognized for integration efforts within a utility enterprise
- Other ontologies are defined by standards organizations and application vendors: Open Applications, MIMOSA, OPC, Open GIS, MultiSpeak, SAP, …
- The CIM itself could be viewed as a federation of domain ontologies (transmission, generation, distribution, markets, …)
- Many other domains seem to be advancing the use of ontologies ahead of the energy/utility domain

CIM as a Federated Ontology



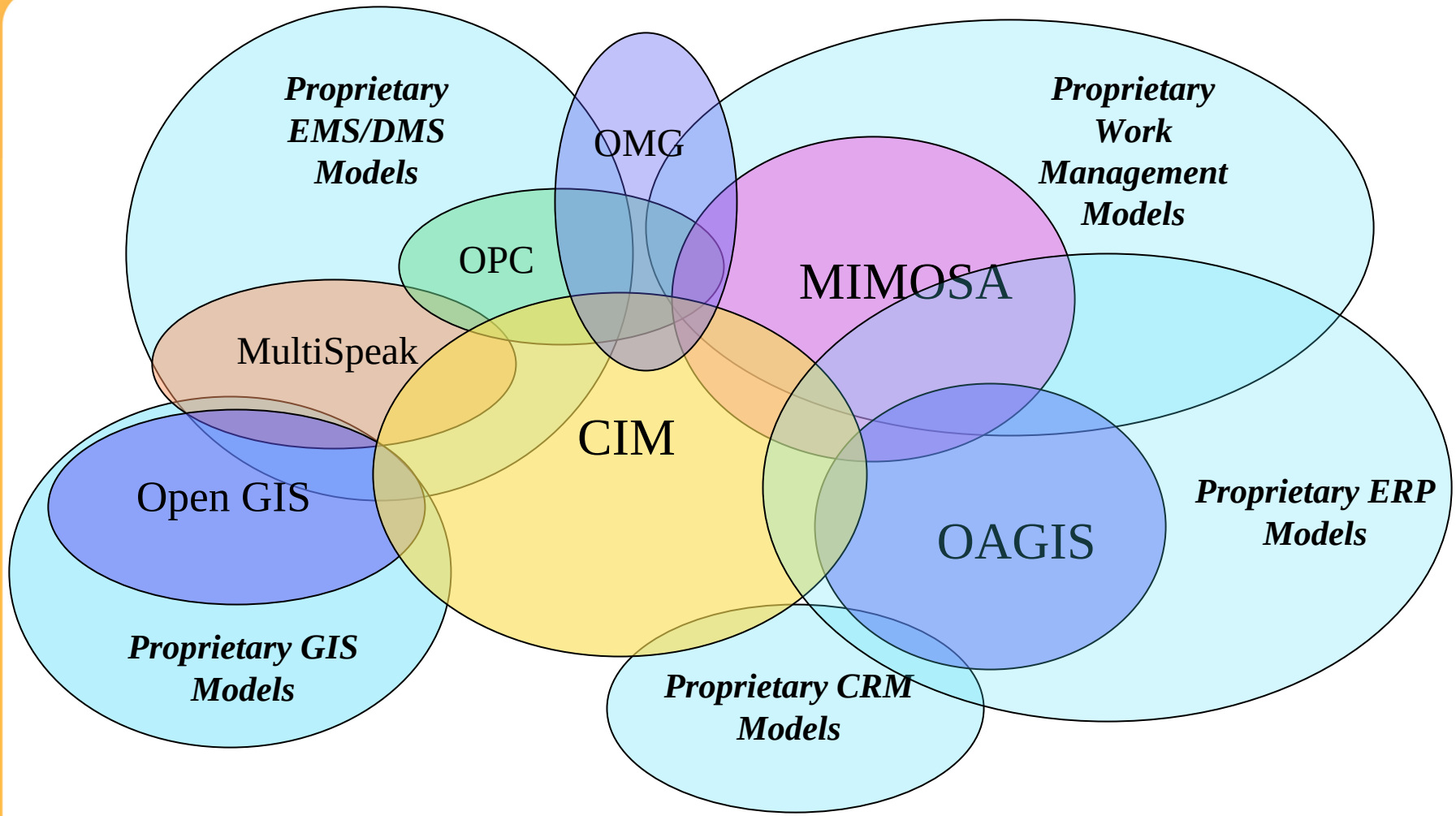
Each current UML package in the CIM could be viewed as an ontology

CIM in a Federation of Ontologies



Ontologies derived from standards commonly encountered for systems integration within electric utilities

CIM in a Federation of Ontologies

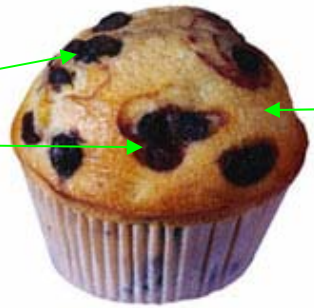


Using OWL with UML

Use Web Ontology Language (OWL) to federate different CIM domains.

'Muffin' structure: UML chocolate chips with OWL dough.

UML Domain Models



OWL Binding

Integration: XML Artifacts

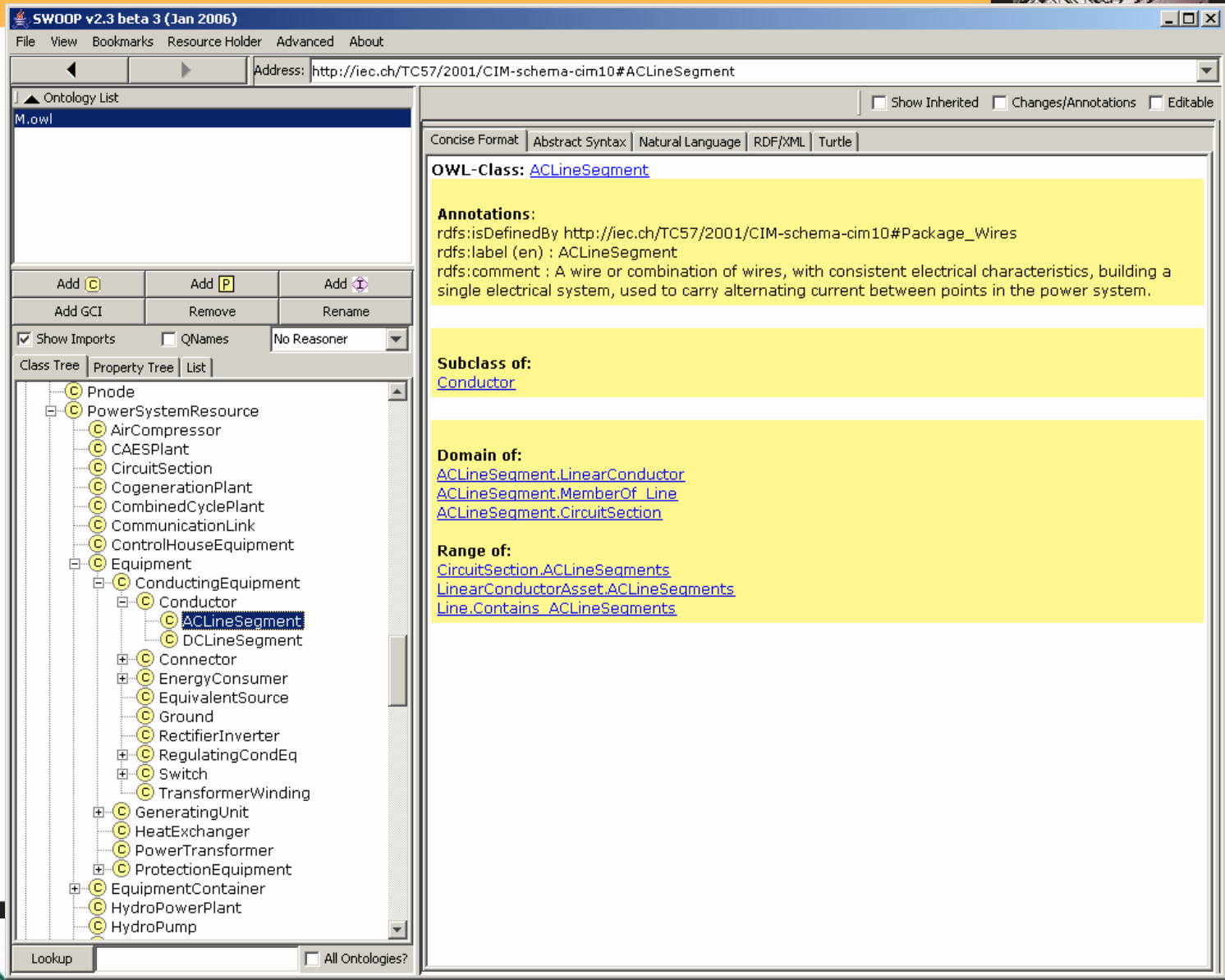
- From an ontology, it is important to be able to create and manage XML artifacts for design and integration purposes:
  - XMI files for model interchange
  - XML Schemas for complex type definitions derived from a model
  - XML Schemas for message definitions (usually referencing all or portions of complex type definitions)
- Fragile XML Syndrome
  - Need to recognize (and expect) that the CIM and local integration needs will evolve
  - XML definitions are often easily broken from the perspective of an application
  - Ontologies can be exploited to provide the necessary flexibility to provide the ability to adapt to changing models more easily

What Should We Expect from Tools?

- The ability to create, edit and manage an ontology and it's versions
- The ability to define relationships, mappings and synonyms between federated ontologies
- Browsing and searching of ontologies
- Generation, regeneration and management of schemas and XML artifacts
- Generation of diagrams and reports
- Support for XMI, RDF and OWL dialects
- Natural language support
- Must avoid vendor lock in to proprietary tools and formats

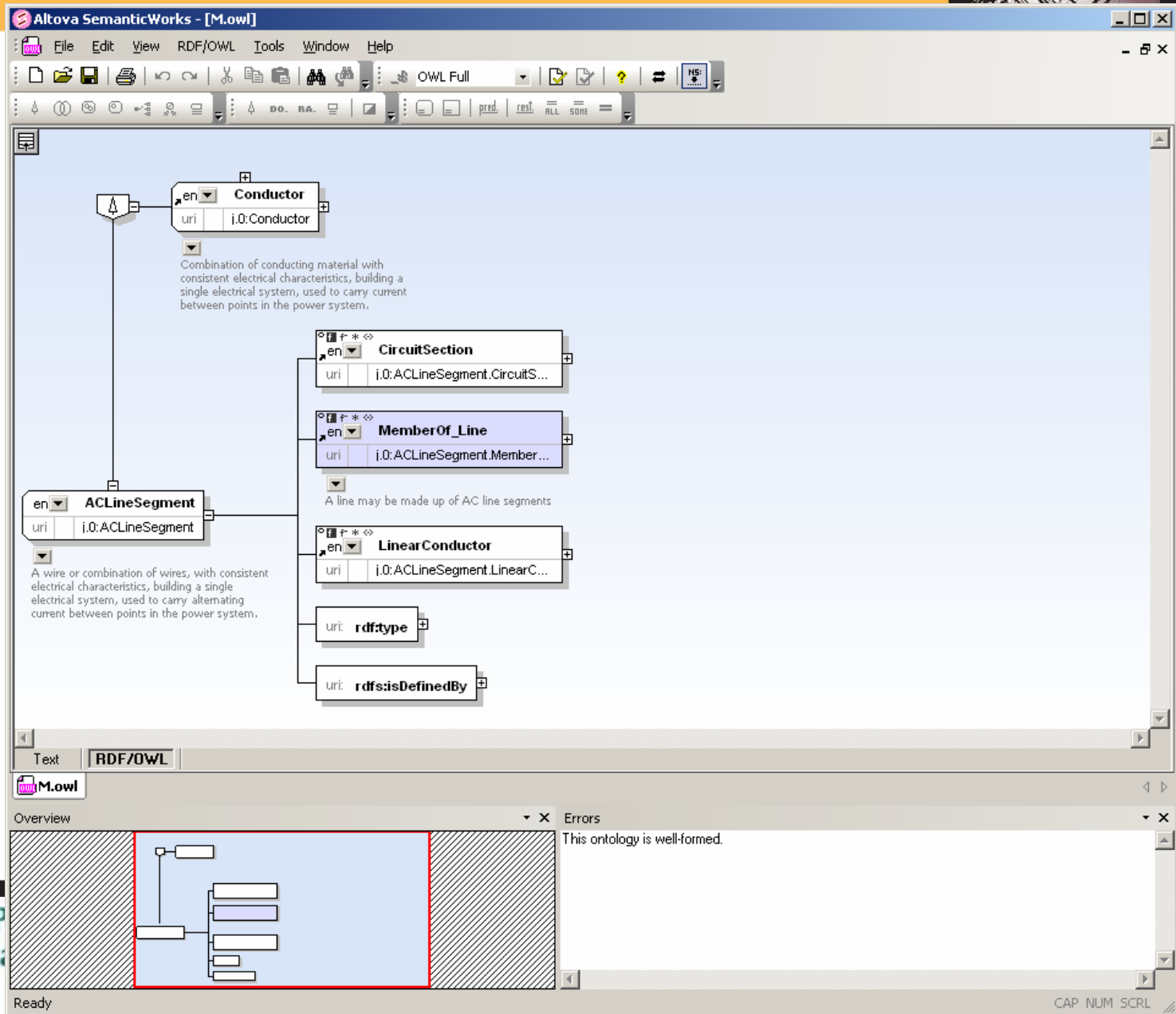
Tool Example: SWOOP

- Free tool from University of Maryland, mindswap.org
- Capabilities
  - Browser
  - Editor
  - Debugger
- CIM OWL example shown
- Integrates with Pellet query tool



Tool Example: SemanticWorks

- Commercial tool sold by Altova (makers of XML Spy)
- Sophisticated graphical browser and editor
- CIM ontology example shown

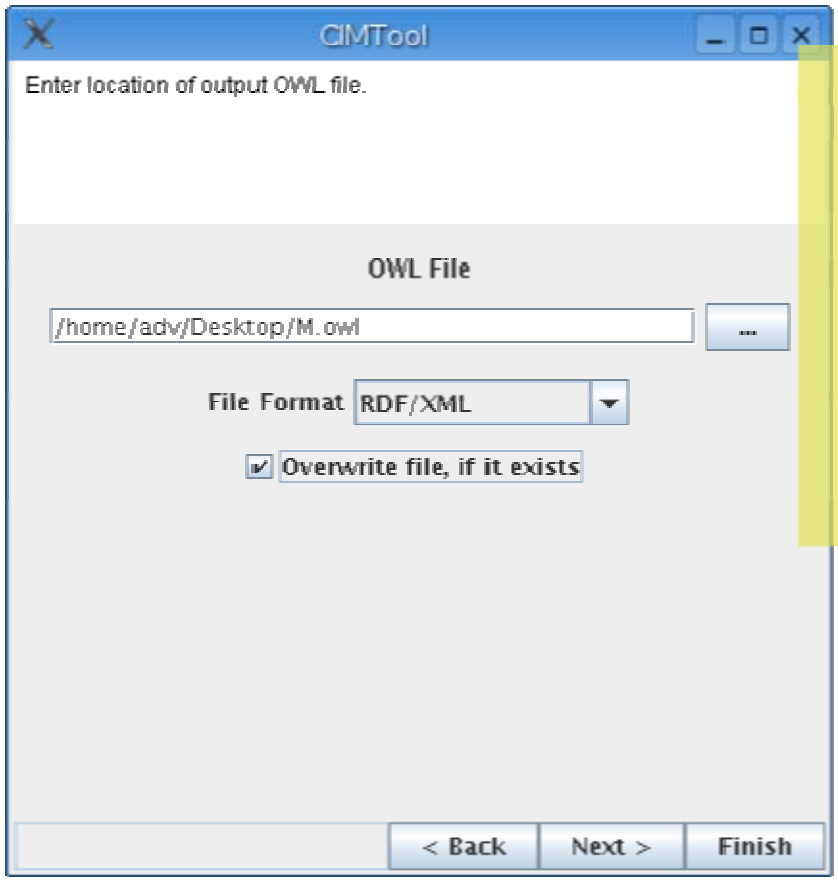


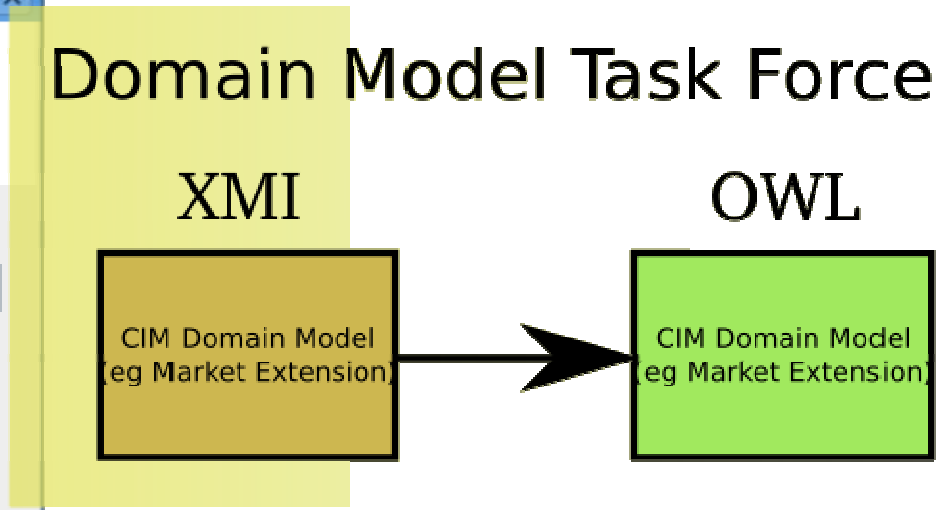
CIMTool

- New tool being developed by Langdale (developer of Xpetal), Areva and Siemens
- To be offered as a ***free, open source tool***
- Can convert a UML model in XMI format to OWL format
- Using XMI or OWL files as input it can generate XML Schemas
- Can be used to create profiles that identify specific CIM classes, properties and relationships to be included within message definitions, resulting in generation/regeneration of appropriate XSD
- Current GUI is in the form of a wizard, but it might be potentially offered as an Eclipse plug-in in the future
- ***Where this clearly provides benefits to CIM users, it is in no way domain specific!***

SIEMENS

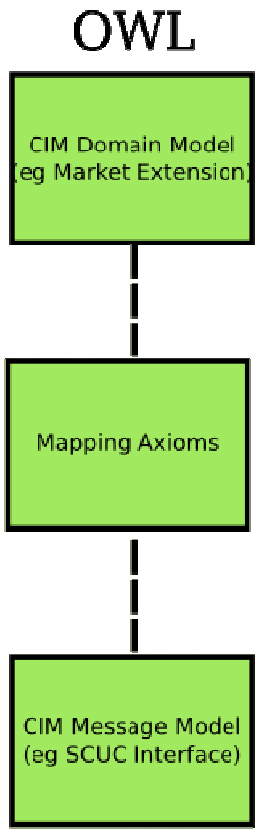
Generating OWL with CIMTool



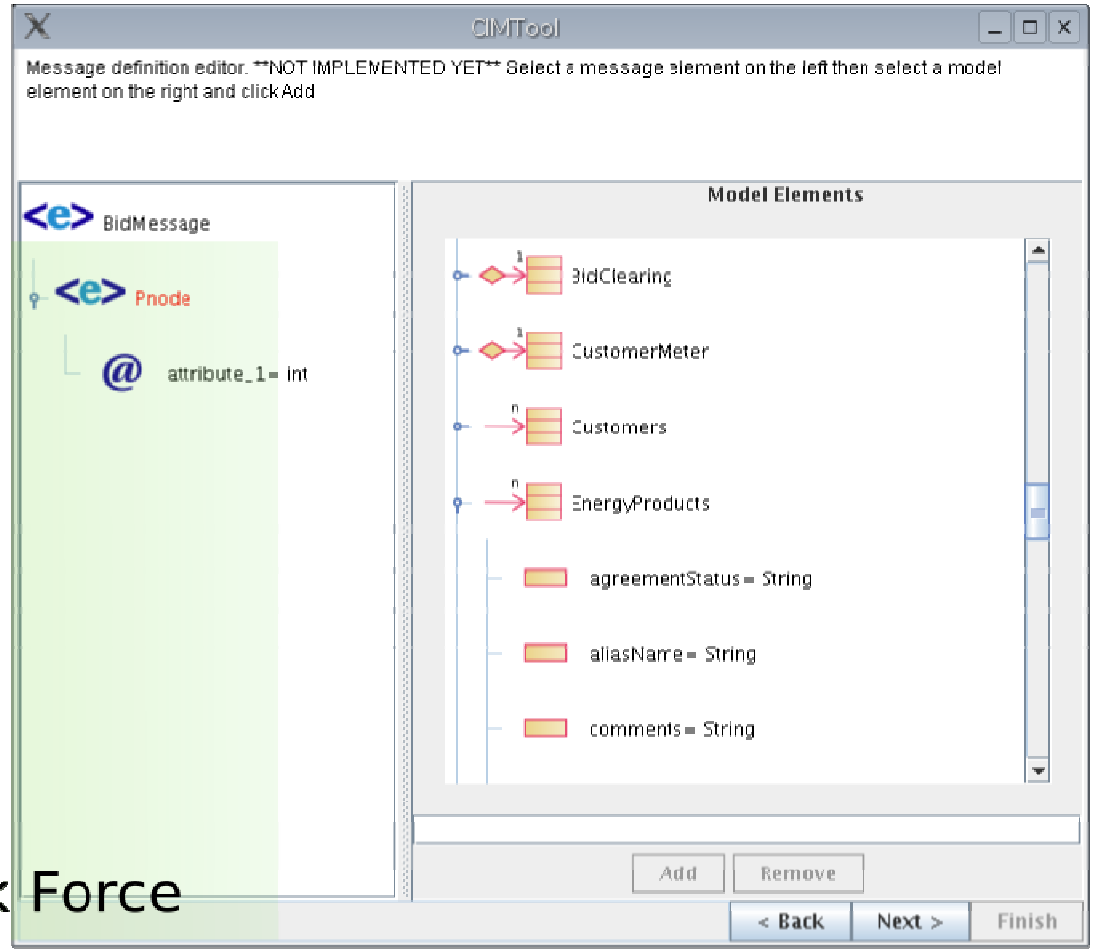


SIEMENS

Defining a Message with CIMTool



Interface Task Force



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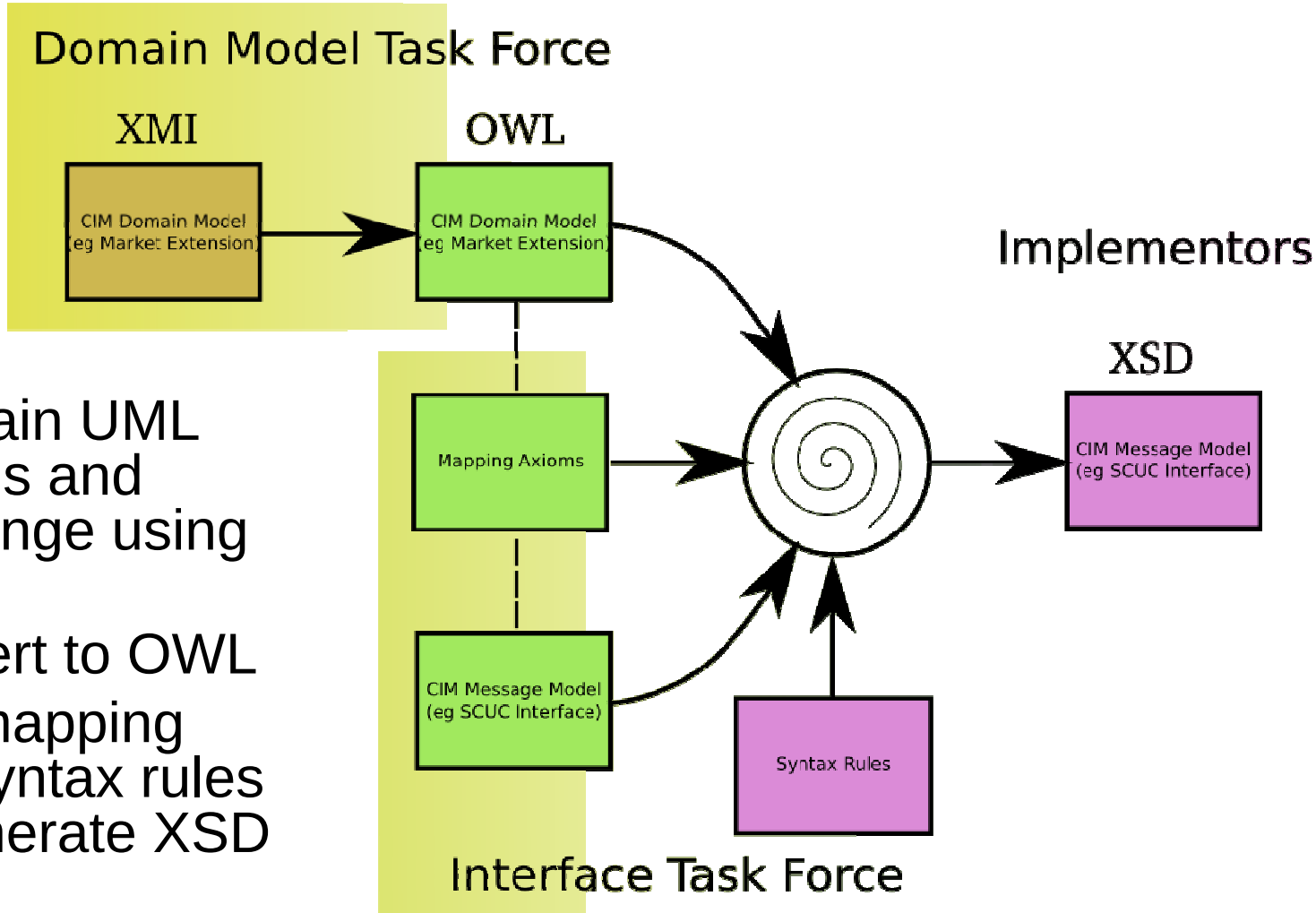
CIM Roadmap

- CIM evolves to a federated set of ontologies and related XML schemas
- CIM ontologies are intended to change continuously as new work is done or better ideas emerge in the community at large
- CIM schemas are intended to remain stable and, after development, will pass to the IEC TC57 working groups for standardization
- CIM technical architecture would be:
  - A core ontology defining the most widely used concepts surrounded by interlinked domain ontologies.
  - XML schemas and other implementation-level specifications in a third, outer tier.
  - Linkages between ontologies consist of equivalences, sub-classes, sub-properties, and property and class restrictions. Linkages between the XML schemas and the ontologies consist of rules, definitions and/or profiles which are updated as the ontologies change.

New Modeling Process

- Maintain UML models and exchange using XMI
- Convert to OWL
- Use mapping and syntax rules to generate XSD



Summary

- Ontologies provide the means to describe models in more detail than UML
- The CIM needs to be viewed within the context of a global federation of ontologies
- There is a new generation of modeling tools that will permit CIM users to leverage the CIM in conjunction with other ontologies

References

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- CIM User Group web site – coming soon! http://ucausersgroup.org
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