Grid-Interop

Overcoming Challenges Using the CIM as a Semantic Model for Energy Applications

Andrew Crapo[1], Katrina Griffith[2], Ankesh Khandelwal[3], John Lizzi[1], Abha Moitra[1], and Xiaofeng Wang[2]

[1]GE Global Research, [2]GE Energy, [3]RPI

For details please see full paper at
http://www.pointview.com/data/files/3/2433/1730.pdf

Sem Tech Alignment with Smart Grid

The "GWAC Stack"

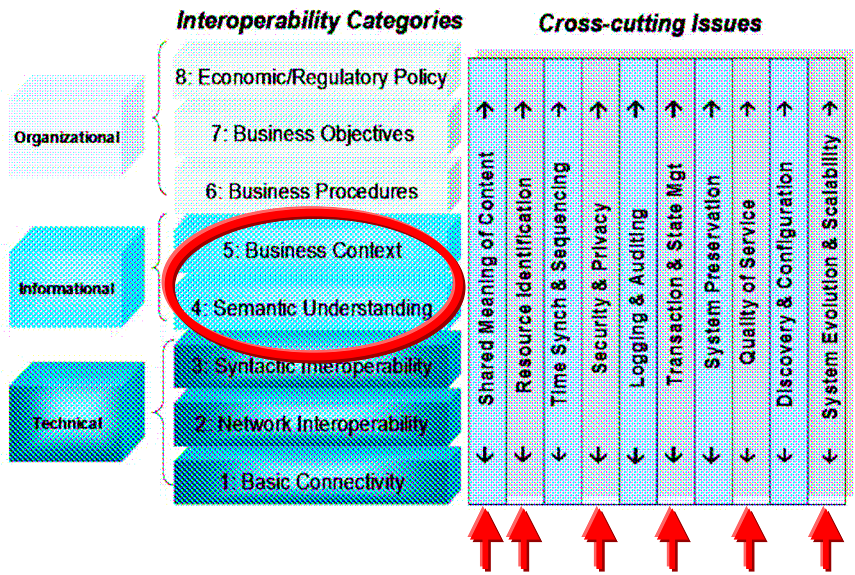


Figure from http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf

- Semantics enable modeling of business context and organization categories
- Semantics addresses many cross-cutting issues

The Semantic Web Stack

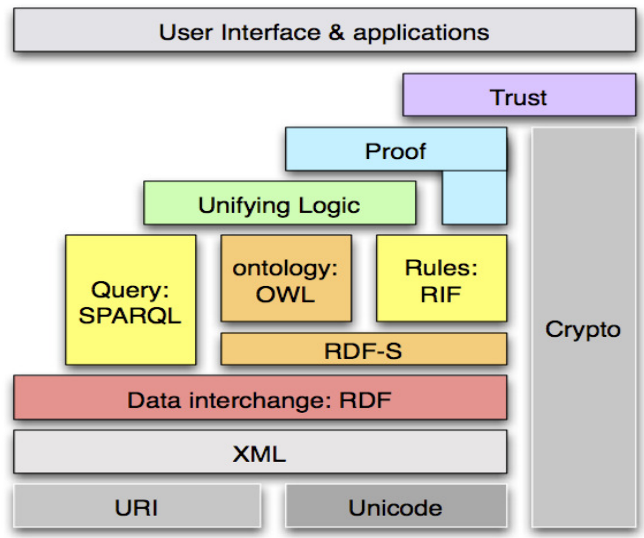
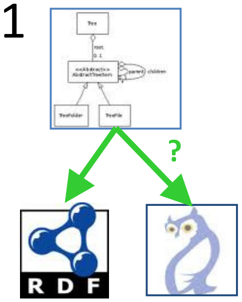


Figure from http://www.w3.org/2006/Talks/1023-sb-W3CTechSemWeb/SemWebStack-tbl-2006a.png

- Semantic Web is a large, distributed knowledge base providing world-web interoperability
- The Semantic Web encounters many of the same challenges faced by Smart Grid

CIM Is Natively in UML; What about OWL?

- Generation of CIM-RDF from CIM-UML is addressed by IEC 61970-501
- OWL is much more expressive than RDF
- An OWL model can be checked for consistency, reasoned over, etc.
- Semantic Rules can be overlaid on top of the OWL model



Category	Functionality	Example in Semantic Application Design Language (SADL) Syntax SADL
Class Relationships	equivalentClass disjointWith complementOf	**President** is the same as **ResidentOfWhiteHouse**. **Man** and **Woman** are disjoint. **Vegetable** is the same as not **Meat**.
Property Types	functional inverseFunctional symmetric transitive inverseOf equivalentProperty	**spouse** has a single value. **biologicalMotherOf** has a single subject. **spouse** is symmetrical. **descendant** is transitive. **wife** is the inverse of **husband**. **hammer** is the same as **pound**.
Class Restrictions	allValuesFrom someValuesFrom cardinality	**cim:ConductingEquipment.Terminals** of **cim:Conductor** only has values of type **cim:Terminal**. **cim:ConductingEquipment.Terminals** of **cim:Conductor** has at least one value of type **cim:Terminal**. **cim:ConductingEquipment.Terminals** of **cim:Switch** has exactly 2 values.
Necessary & Sufficient Conditions	equivalentClass + Class Restrictions	A **Woman** is a **Mother** only if **child** has at least 1 value.
Additional Layers in Semantic Web Stack	Domain Rules	Rule BreakerIsolationViolation: if **b** is a **cim:Breaker** and **ecd** is **cim:Terminal.ConductingEquipment** of **cim:ConnectivityNode.Terminals** of **cim:Terminal.ConnectivityNode** of **cim:ConductingEquipment.Terminals** of **b** and **ecd** is not a **cim:Disconnector** then **isolationCompliance** of **b** is false.

Challenges Using OWL Versions of CIM

- Modularity and Namespaces
  - Our CIM-OWL versions had all namespaces combined into a single OWL file with an unused base URI
  - In one case the UML package hierarchy was preserved in a sequence of rdfs:isDefinedBy annotation properties
- Inconsistent handling of Data Types
  - rdfs:Datatype named String but with no mapping to xsd:string
  - An owl:DatatypeProperty with range an owl:Class

Translation from UML to OWL should preserve modularity and should map data types to XML Schema

Challenges Using Semantic Models

- Reasoner and Query Engine performance is highly dependent upon the exact formulation of rules and queries
  - Clauses should be ordered to reduce matching data as early as possible
  - Avoid unnecessary type checking
  - Factor out common rule clauses so they will evaluate fewer times
  - Use backward chaining rules when/if possible
  - And so forth... (see paper)
- Sometimes optimal formulation is reasoner/query engine specific
- Beware the Open World Assumption (OWA)
- Understand negation and what the target reasoner supports

Technology Evaluation

- Network tracing use case: “directly connected to” and “topologically connected to” a specific cim:ConductingEquipment, 10,000 - 240,000 RDF triples
- Evaluated several reasoners/rule engines in three categories

Java-Based Generic Rule Engines	Drools JRules	Out-of-memory for > 25,000 triples (64-bit Linux, 3 GB)
General-Purpose Logic Programming Systems	XSB……………….. YAP………………..	Unable to run in Windows > 30 min, then ~10 sec (adapts)
“Semantic” Reasoners	AllegroGraph®.. OntoBroker®….. Jena………………..	~20 sec on 130,000 triples ~2 sec (left-bound), ~78 sec (right-bound) ~5 sec on 180,000 triples (with optimization)

Conclusions

- OWL models are an effective mechanism for capturing and using Smart Grid domain knowledge
- Translations from UML to OWL should
  - Tie to standard data types
  - Preserve modularity and enable extensibility
  - Support versioning and feedback mechanisms
- Optimization of rules/queries should be automatic or collaboratively achieved
- No single technology/tool currently provides the best solution across Smart Grid use cases

Version 2 of the Semantic Application Design Language (SADL):

- Improved support of building/managing models by domain experts
- Support of full OWL DL expressivity
- Support of plug-in reasoner/translator pairs with optimization