



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

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For details please see full paper at

<http://www.pointview.com/data/files/3/2433/1730.pdf>

The "GWAC Stack"

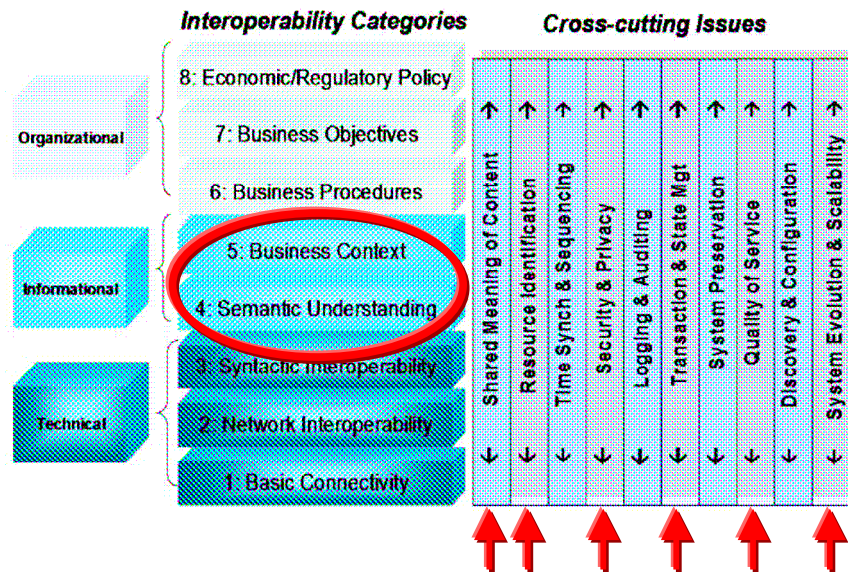


Figure from http://www.gridwiseac.org/pdfs/interopframework_v1_1.pdf

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

The Semantic Web Stack

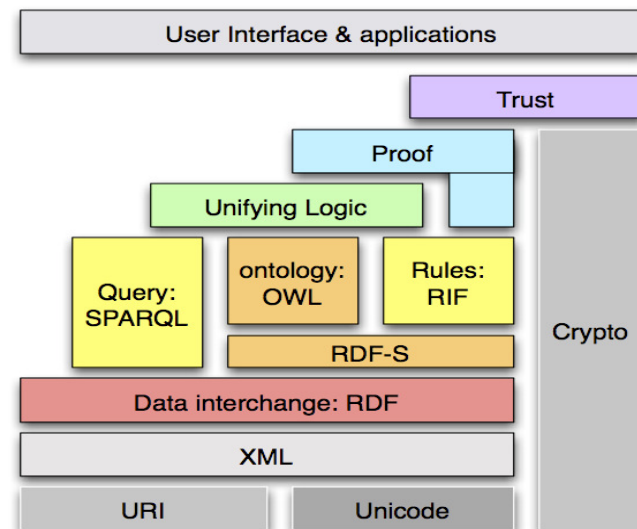
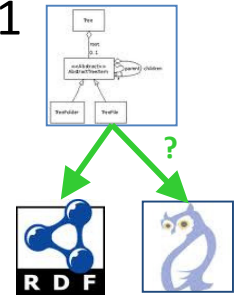


Figure from <http://www.w3.org/2006/Talks/1023-sb-W3CTechSemWeb/SemWebStack-tbl-2006a.png>

- 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:Disconnecter then isolationCompliance of b is false.	

- 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

- 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