A Semantic Testbed for Smart Grid Information Standards

Steve Ray

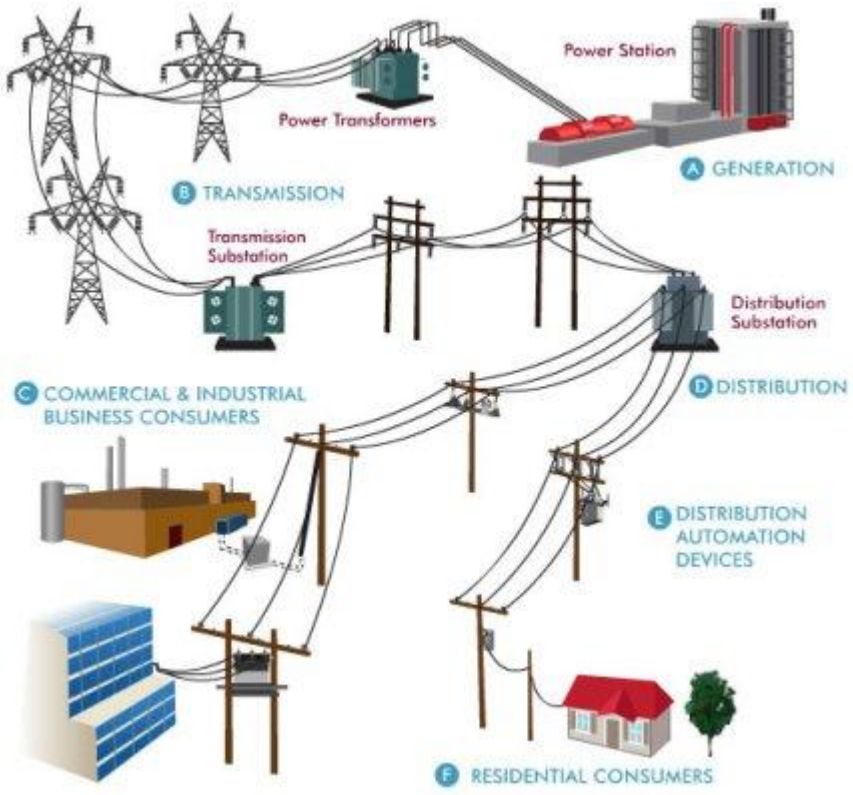
Testbeds for Smart Grids and Smart Cities

April 1, 2015

Carnegie Mellon University
Silicon Valley

Electrical Grid

Models of electricity

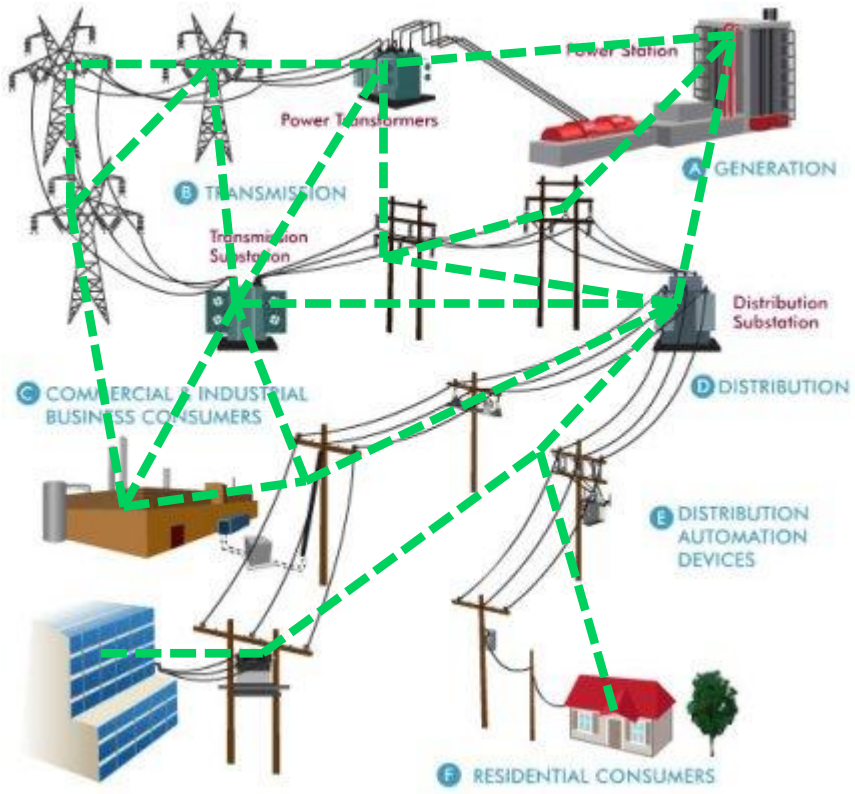


Electricity

Smart Electrical Grid

Models of electricity

Models of information

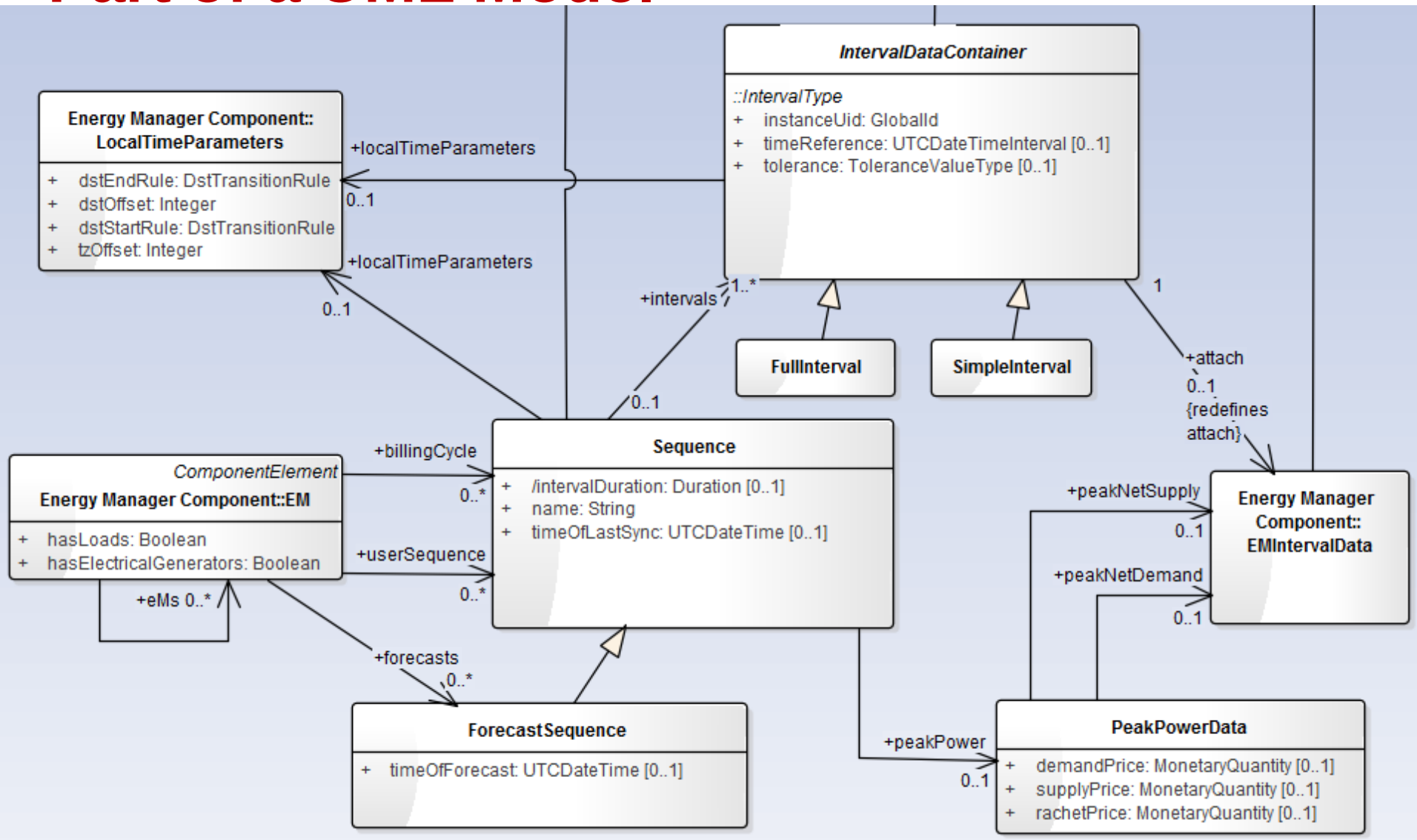


Electricity

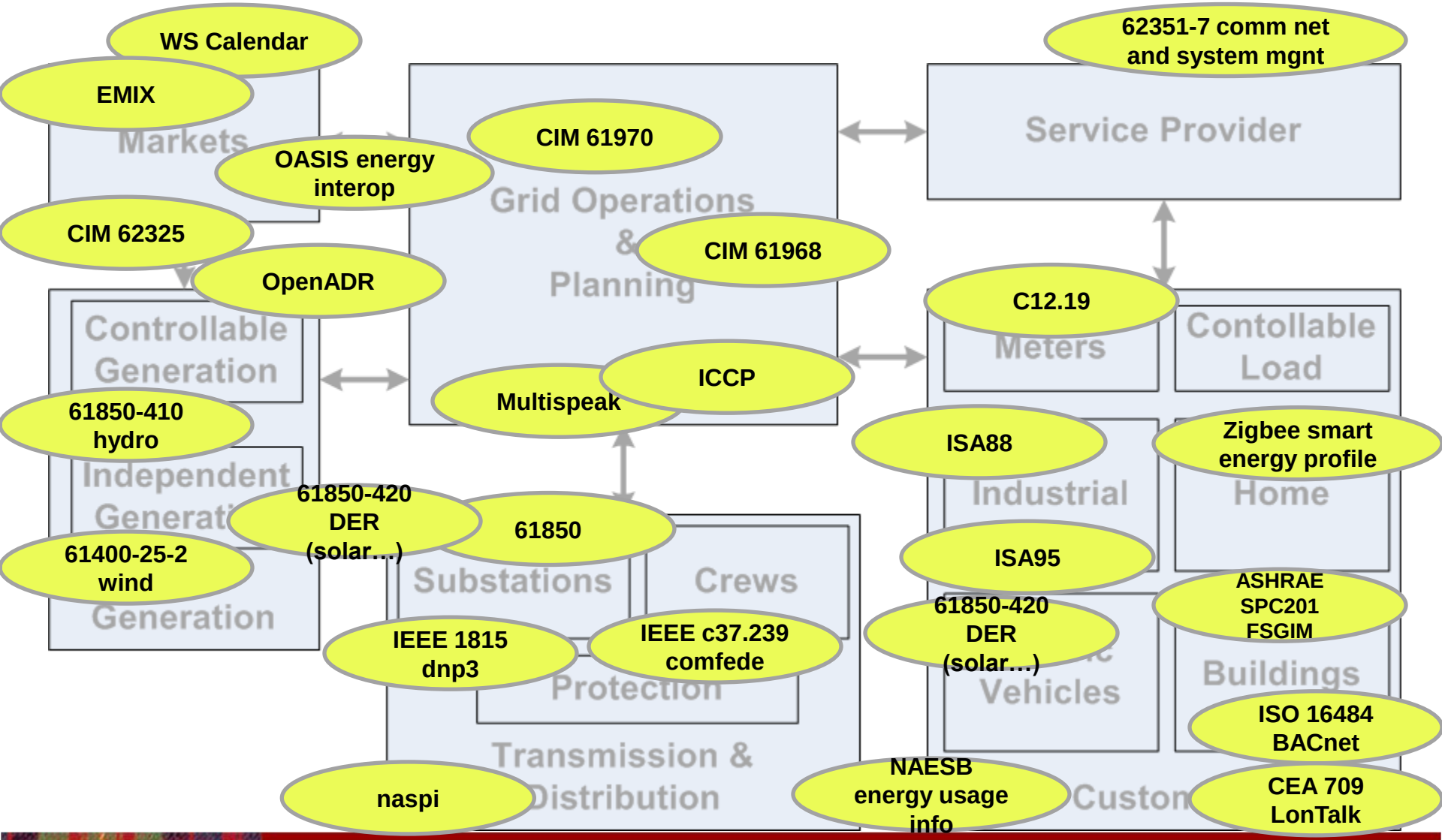
Information

How is Smart Grid Information Modeled?

Part of a UML Model



Some Smart Grid Information Standards

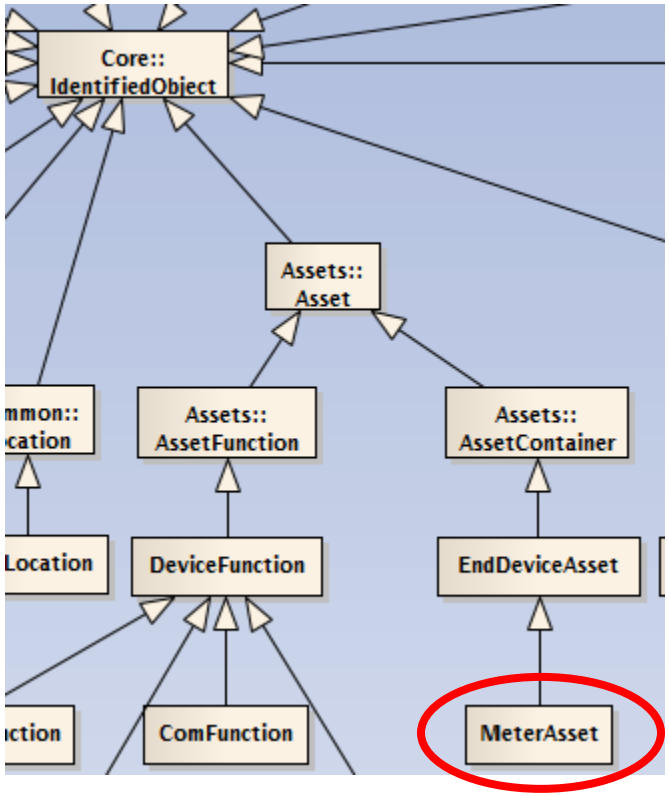


Challenge

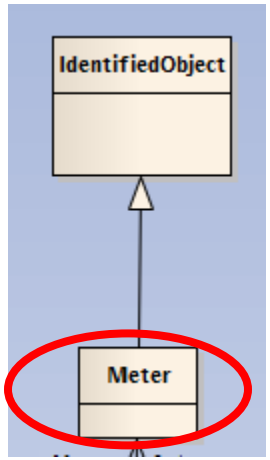
- How to test whether an information standard (i.e. information model)
  1. is self consistent? (verification testing)
  2. is compatible with other standards? (to support interoperability)
     - How to reconcile vocabularies, concepts and relations among all the smart grid information standards?
- Information models are engineered artifacts designed within a stated or unstated context

“Meter”
Do they all really mean the same thing?

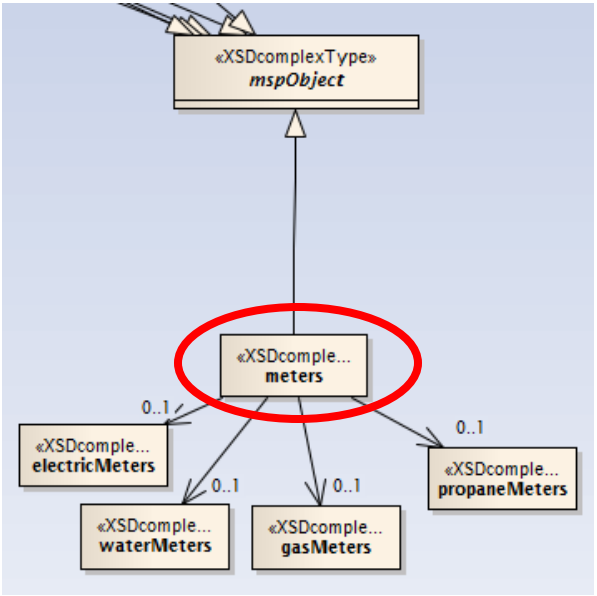
IEC 61968



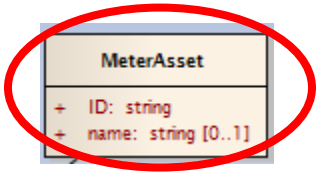
IEC 61970



Multispeak V4.1



NAESB PAP10



What's the risk?

- You might have **connectivity** but not **interoperability**
- Misunderstanding of information flowing between systems

By Robin Lloyd
CNN Interactive Senior Writer

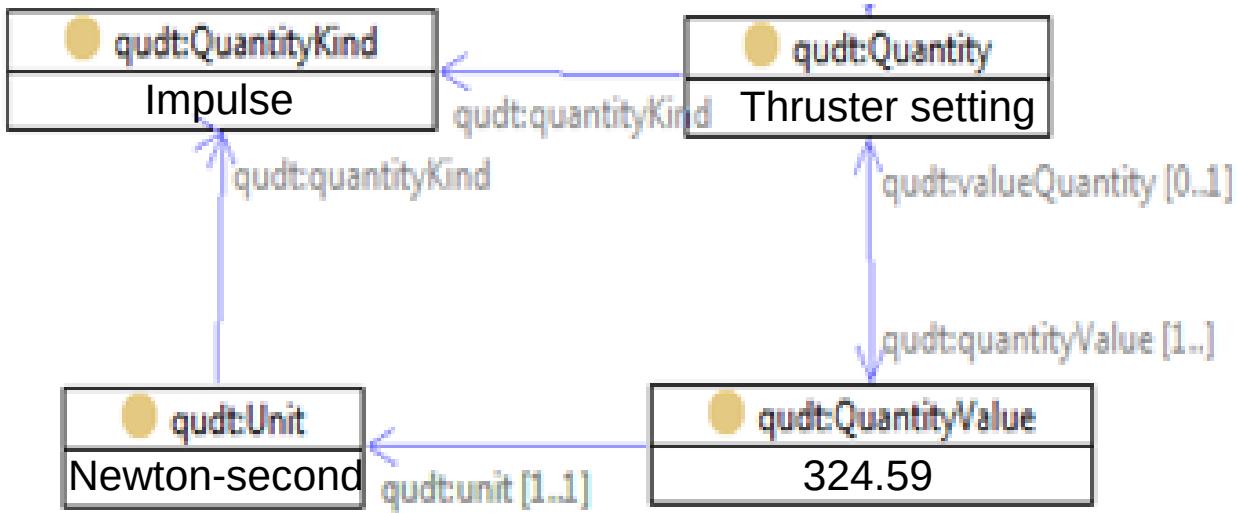
Sep. 30, 1999

(CNN) -- NASA lost a $125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the agency's team used the more conventional metric system for a key spacecraft operation, according to a review finding released Thursday.

- "Set Thruster to 324.59"

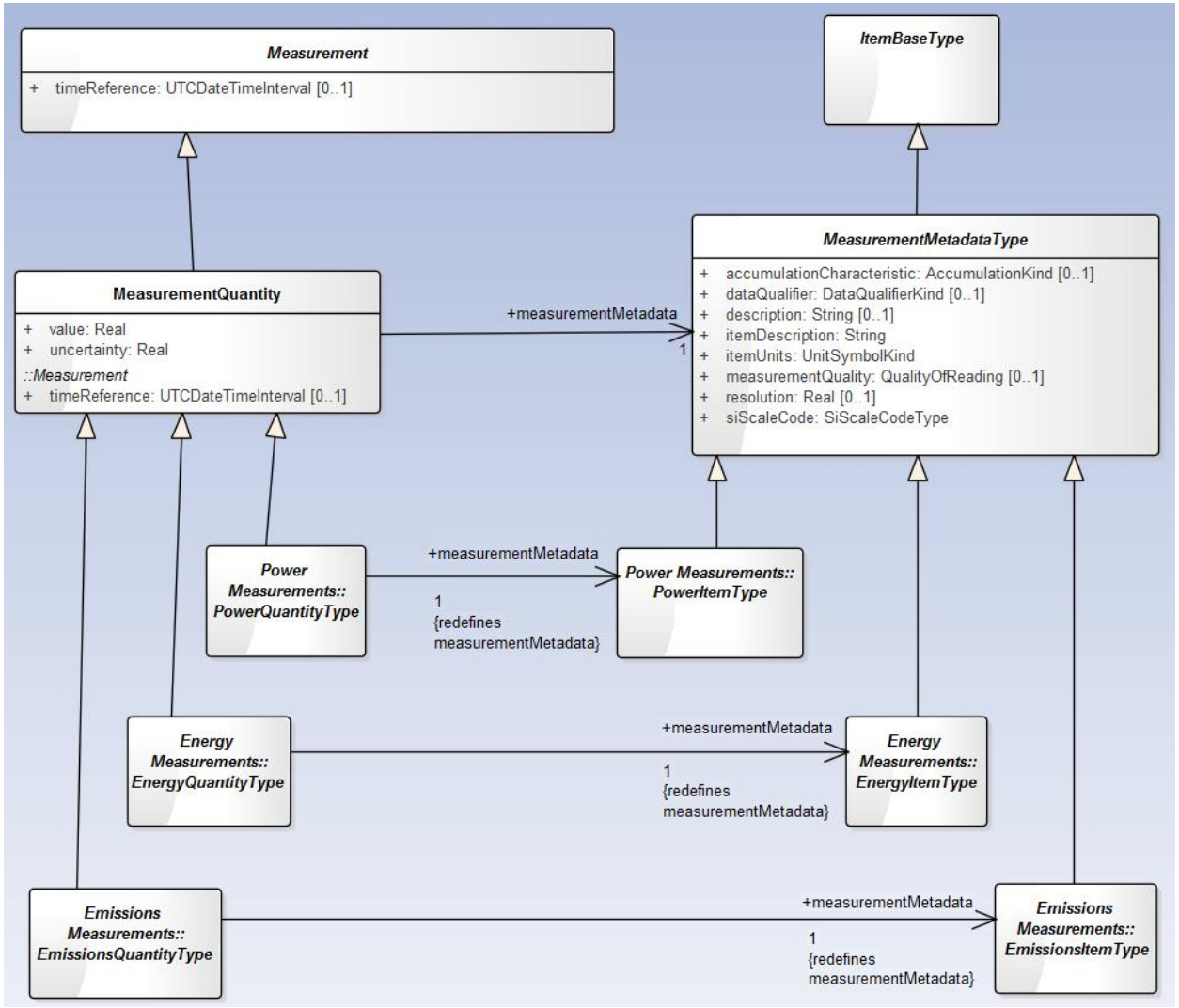
Need context (a.k.a. metadata)

"Set Thruster to 324.59"



(…without even getting into uncertainty)

ASHRAE SPC201 Standard (excerpt)

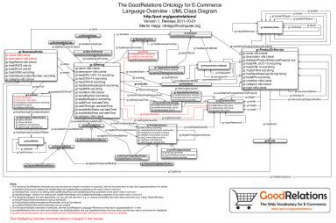


Semantic Testbed

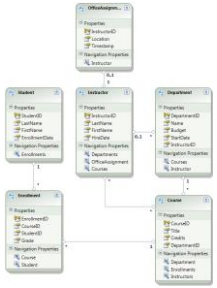
Testing the integrity of a standard

Standards

Text



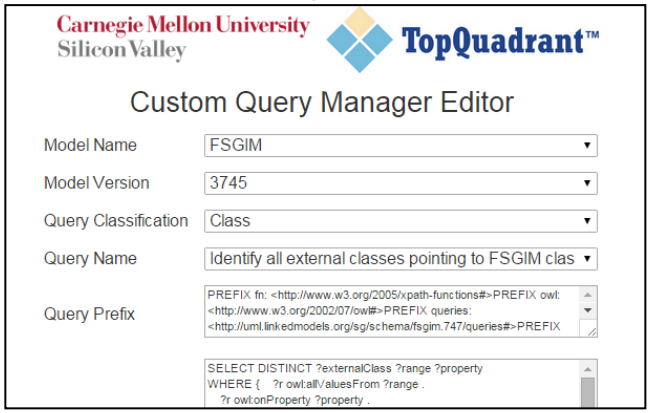
UML



XSD

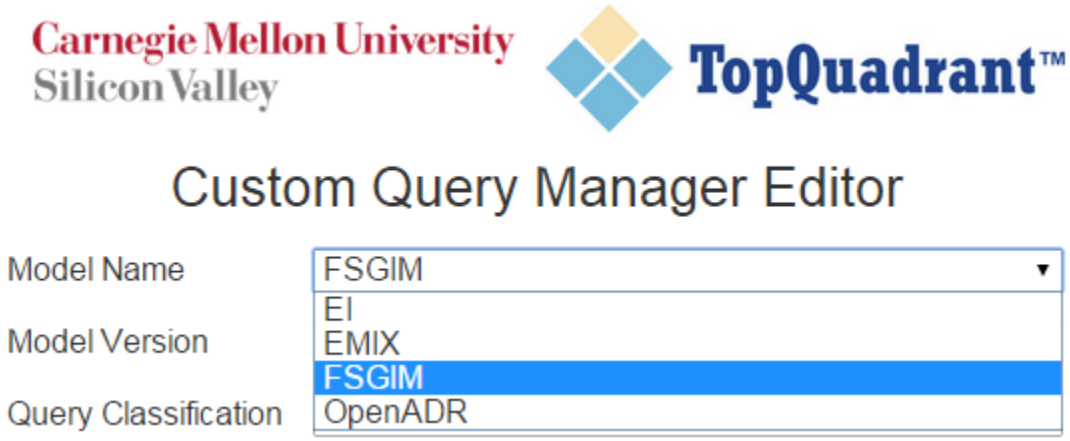
Model Transformation

Semantic representation
Web Ontology Language
(OWL)

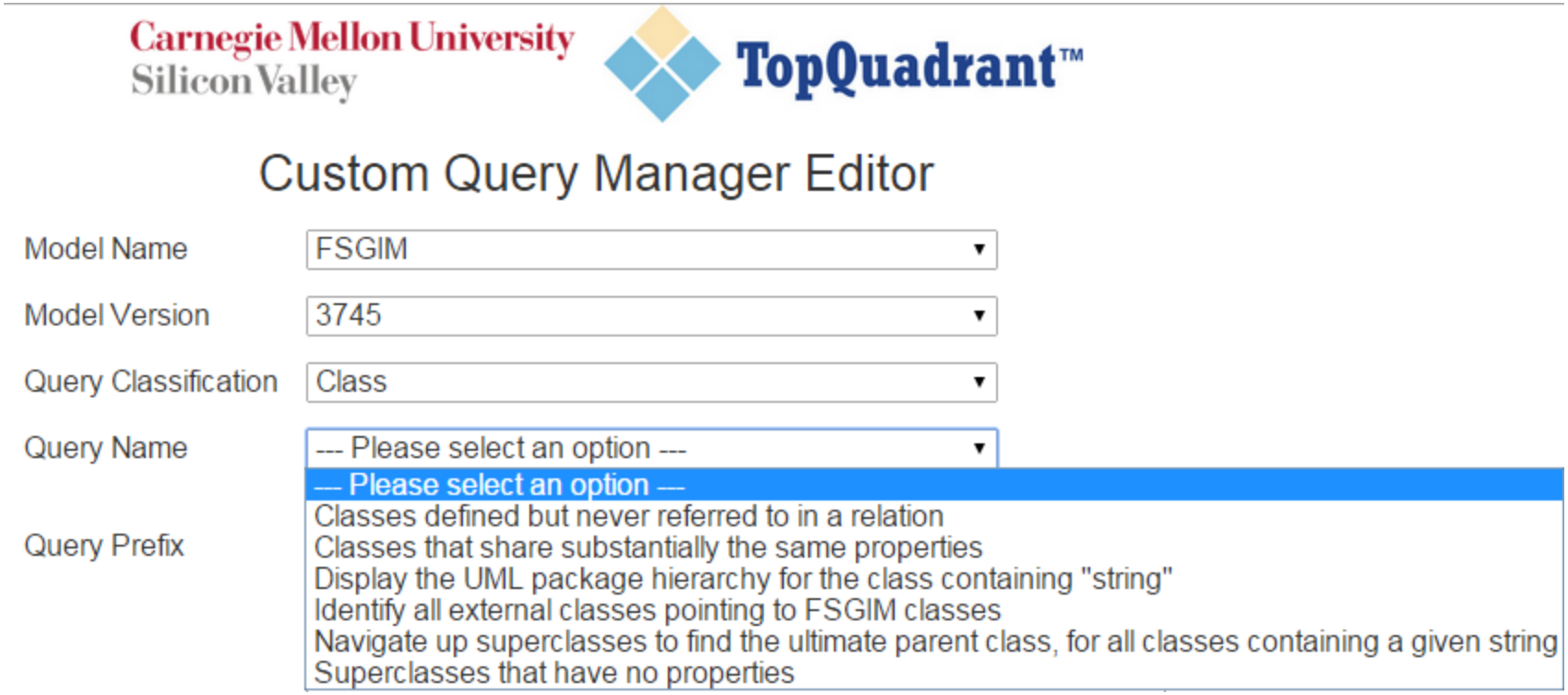


Model Verification Testing

Multiple Smart Grid Standards



Pick-lists of queries



Sample Query

Model Name: OpenADR

Model Version: 201307

Query Classification: xsd

Query Name: Finding in-line complex type definitions

Query Prefix:

```
PREFIX composite:
<http://www.topbraid.org/2007/05/composite.owl#>PREFIX smf:
<http://topbraid.org/sparqlmotionfunctions#>PREFIX sxsd:
```

Query:

```
SELECT ?subject ?parentName
WHERE {    ?subject a sxsd:ComplexType .
   OPTIONAL {       ?subject sxsd:name ?name .
   } .
   FILTER (!smf:isBound(?name)) .
   OPTIONAL {       ?parent composite:child ?subject .
      ?parent sxsd:name ?parentName .
   } .
```

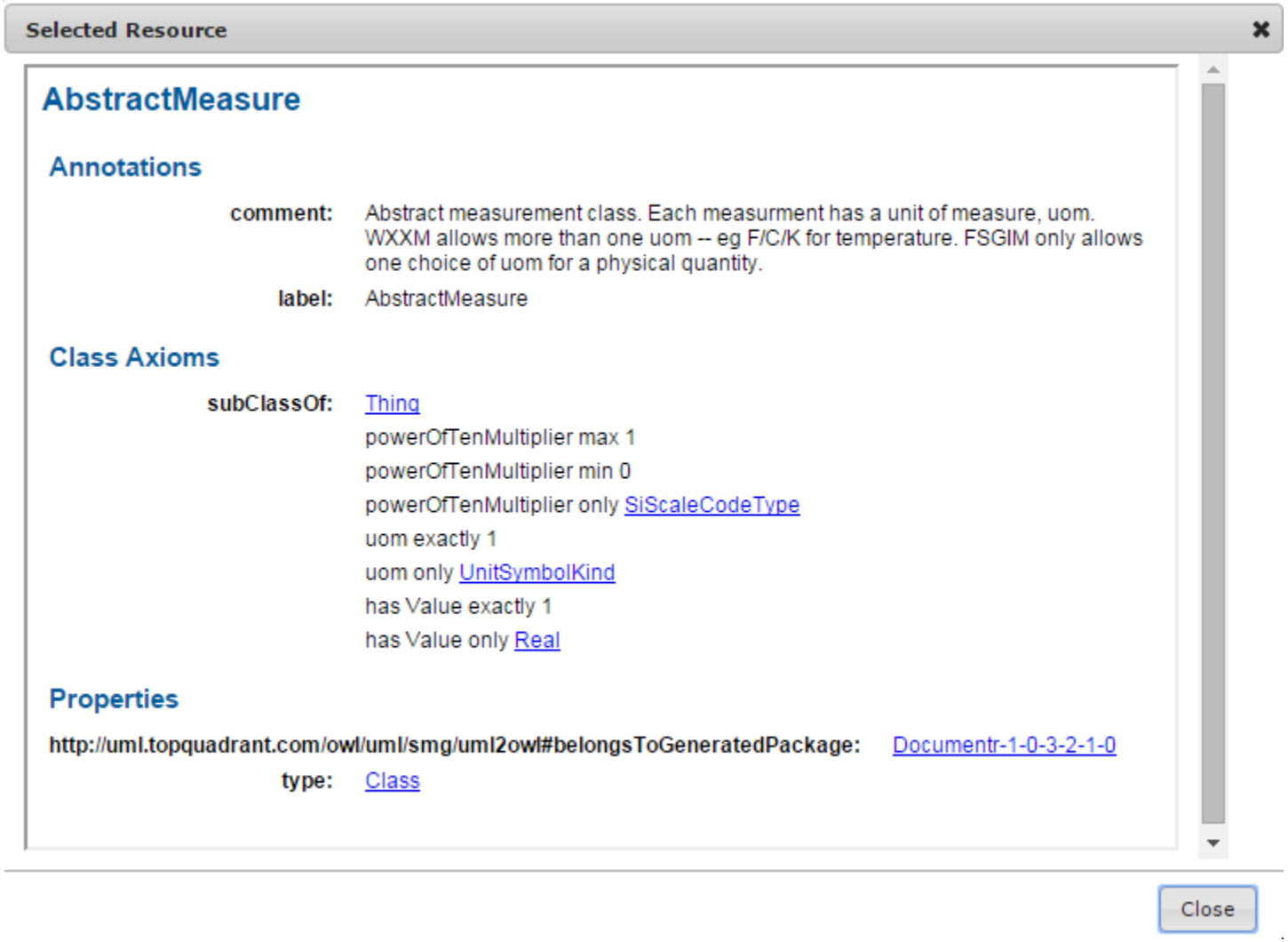
Result Display: (•) Truncated ( ) Complete

Execute Query | Save Query | Clear Results

Query Result

subject	parentName
file:///OpenADR/input/oadr_ei_20b.xsd#r-61-1	eventResponses
file:///OpenADR/input/oadr_20b.xsd#r-100-1	oadrTransports
file:///OpenADR/input/oadr_20b.xsd#r-110-1	oadrInfo

Viewing and Navigation between classes



Benefits

- Exhaustively searches a standard to find errors that might escape human detection
  - Orphan definitions (defined but never used)
  - Opportunities for model refactoring (similar classes)
  - Disallowed changes to imported standards
  - Redundant classes and properties
  - Non-standard data type definitions

After Verification Testing

- Model Healing
  - Recommendations to correct errors
  - Automatic error correction for native OWL specifications
- Conformance Testing
  - Does a particular implementation properly represent the information according to the standard?
  - Generation of reference data sets
- Standards Harmonization
  - Checking for missing information
    - Information present in one standard but not in another
  - Mapping among different ways of modeling the same information

Thank you

More information: steve.ray@sv.cmu.edu