Using New Standards to Develop IC Ontologies

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Abstract: In this paper we describe recent work in adapting various new OWL and ontology standards to ontology development for the IC and DoD. We present work done to adapt the Universal Core Semantic Layer (UCore SL) standard ontology to support intelligence analysts. We show how new features in the OWL 2 standard can be used to make such ontologies simpler and more readable, and how they facilitate modeling the relationships of concepts across models. We present a proposed standard security model using OWL 2. We conclude with planned future ontology development using these standards.

Key words: Ontologies, OWL 2, Universal Core Semantic Layer, Standards

1. Introduction

Over the last several years, we have created OWL ontologies for use with the METS (Metadata Extraction and Tagging Service) system [1, 2], to represent the document metadata and semantic extraction results it produces. In the most recent iteration, these ontologies included and extended OWL versions of (parts of) SUMO, TWPDES, DDMS, ISM, code lists from ISO et al, and the "standard" Time and GML ontologies.

When the Universal Core (UCore) 2 standard [3] was released, it included a simple OWL taxonomy, so we added declarations to the master METS ontology to relate its concepts to those in the UCore taxonomy.

Barry Smith et al at NCOR started from the UCore model to develop a full foundational OWL ontology called the Universal Core Semantic Layer (UCore SL) [4]. In our recent (non-METS) work, we have developed an ontology based on it, to support a cell of IC/DoD analysts. We have also begun incorporating new OWL 2 [5] features.

2. Universal Core Semantic Layer Adaptation

In our most recent work, we were tasked with supporting a group of analysts by devising a consistent and inter-related set of models for their wide range of data sources and analytical processes, covering the usual assortment of people, organizations, and places, as well as numerous kinds of materials, equipment, and processes. We elected to create a set of ontologies, mapping to OWL each of:

- the schema for the desired subset of each data source (MIDB, TIDE, Artemis, …)
- the Palantir ontology we developed with the analysts
- the common organizational models called PMESII and CTAF

We also created a "master" OWL ontology, based on UCore SL, which covered all the concepts of interest to the analysts, and provided the OWL declarations needed to relate the concepts across all the other ontologies, for data mapping and correlation purposes.

In order to do this, we of course needed to extend UCore SL, adding whole sublattices of concepts under various of its concepts. For example, we have a handful of new classes refining UCore SL's *ActOfCommunication*. Similarly, we have new classes under its *Vehicle* and *Sensor*. In doing this, we borrowed heavily from SUMO [6]. For example, the whole area of *Equipment* / *Sensor* / *Vehicle* / *Weapon* is one where we found it expedient to insert a few higher-level concepts from SUMO. Since the various data sources, and UCore SL, differed on the question of which, if any, of the latter 3 concepts belonged under the former, SUMO's *Device* and some of its subclasses were the perfect root under which to organize and relate all those concepts from all the other models. Thus, for a representative sample of that part of the ontology, we have:

```
<owl:Class rdf:ID="Equipment">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#ExplosiveDevice"/>
  <owl:disjointWith rdf:resource="#Sensor"/>
  <owl:disjointWith rdf:resource="#Vehicle"/>
  <owl:disjointWith rdf:resource="#Weapon"/>
  <rdfs:subClassOf rdf:resource="&art;Equipment"/>
</owl:Class>

<owl:Class rdf:ID="MeasuringDevice">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#CommunicationDevice"/>
  <owl:disjointWith rdf:resource="#ExplosiveDevice"/>
  <owl:disjointWith rdf:resource="#Vehicle"/>
  <owl:disjointWith rdf:resource="#Weapon"/>
</owl:Class>

<owl:Class rdf:ID="Sensor">
  <rdfs:subClassOf rdf:resource="#MeasuringDevice"/>
  <owl:disjointWith rdf:resource="#Equipment"/>
  <owl:equivalentClass rdf:resource="&ucsl;Sensor"/>
  <owl:equivalentClass rdf:resource="&pal;Sensor"/>
</owl:Class>
```

```
<owl:Class rdf:ID="Vehicle">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#CommunicationDevice"/>
  <owl:disjointWith rdf:resource="#Equipment"/>
  <owl:disjointWith rdf:resource="#ExplosiveDevice"/>
  <owl:disjointWith rdf:resource="#MeasuringDevice"/>
  <owl:equivalentClass rdf:resource="&ucsl;Vehicle"/>
  <owl:equivalentClass rdf:resource="&sumo;Vehicle"/>
  <owl:equivalentClass rdf:resource="&pal;Vehicle"/>
  <owl:equivalentClass rdf:resource="&avrs;Conveyance"/>
  <owl:equivalentClass rdf:resource="&tide;Vehicle"/>
  <rdfs:subClassOf rdf:resource="&meped;Equipment"/>
</owl:Class>

<owl:Class rdf:ID="Bomb">
  <rdfs:subClassOf rdf:resource="#Weapon"/>
  <rdfs:subClassOf rdf:resource="#ExplosiveDevice"/>
  <owl:equivalentClass rdf:resource="&sumo;Bomb"/>
  <owl:equivalentClass rdf:resource="&pal;Bomb"/>
</owl:Class>

<owl:Class rdf:about="&ucsl;Equipment">
  <rdfs:subClassOf rdf:resource="#Device"/>
</owl:Class>

<owl:Class rdf:about="&meped;Equipment">
  <rdfs:subClassOf rdf:resource="#Device"/>
</owl:Class>

… etc …
```

We also found it useful to borrow from SUMO to impose a bit more structure and detail in other areas, such as Geophysical and Geopolitical concepts.

3. OWL 2 Use for Simplifying Ontologies

The above examples follow the UCore SL practice of carefully declaring all the *disjointWith* relationships, including declaring each pair (redundantly) in both directions. One of the new features in OWL 2 is a pair of constructs for declaring this information in a cleaner, more compact fashion. Since some of the classes above are allowed to overlap (for example, *Weapon* can overlap both *ExplosiveDevice* and *Vehicle*), we don't have a nice clean partition which would enable removing all the *disjointWith*'s, but using the new *AllDisjointClasses* still helps somewhat:

```
<owl:AllDisjointClasses>
  <owl:members rdf:parseType="Collection">
    <owl:Class rdf:about="#Equipment"/>
    <owl:Class rdf:about="#ExplosiveDevice"/>
    <owl:Class rdf:about="#Sensor"/>
    <owl:Class rdf:about="#Vehicle"/>
  </owl:members>
</owl:AllDisjointClasses>
```

```
<owl:Class rdf:ID="Equipment">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#Weapon"/>
  <rdfs:subClassOf rdf:resource="&art;Equipment"/>
</owl:Class>

<owl:Class rdf:ID="MeasuringDevice">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#CommunicationDevice"/>
  <owl:disjointWith rdf:resource="#ExplosiveDevice"/>
  <owl:disjointWith rdf:resource="#Vehicle"/>
  <owl:disjointWith rdf:resource="#Weapon"/>
</owl:Class>

<owl:Class rdf:ID="Sensor">
  <rdfs:subClassOf rdf:resource="#MeasuringDevice"/>
  <owl:equivalentClass rdf:resource="&ucsl;Sensor"/>
  <owl:equivalentClass rdf:resource="&pal;Sensor"/>
</owl:Class>

<owl:Class rdf:ID="Vehicle">
  <rdfs:subClassOf rdf:resource="#Device"/>
  <owl:disjointWith rdf:resource="#CommunicationDevice"/>
  <owl:disjointWith rdf:resource="#MeasuringDevice"/>
  <owl:equivalentClass rdf:resource="&ucsl;Vehicle"/>
  <owl:equivalentClass rdf:resource="&sumo;Vehicle"/>
  <owl:equivalentClass rdf:resource="&pal;Vehicle"/>
  <owl:equivalentClass rdf:resource="&avrs;Conveyance"/>
  <owl:equivalentClass rdf:resource="&tide;Vehicle"/>
  <rdfs:subClassOf rdf:resource="&meped;Equipment"/>
</owl:Class>

… etc …
```

4. OWL 2 Use for Relating Ontologies

One of the principles in our modeling work was to represent all multi-faceted things as first-class objects, with classes in the ontology. In particular, it was clear that *Location*s should be represented in that way. By attaching properties to a *Location*, such as location containment (address contained in city contained in etc), location adjacency, location position (coordinates), even the Political, Military, Economic, etc circumstances of a location, the door is opened to reasoning about locations and the things at those locations.

Some of the RDB models we worked with made the same decisions on first-class objects, but many did not. For example, to relate a *Location* to some *Person*, *Organization*, *Event*, et al, the value of the relationship (*birthplace*, *residence*, *affiliation*, *destination*, et al) would often be, not a pointer to a *Location* record, but simply a string naming the location (often, just a country name).

Since one of our goals was to relate concepts across models, these string-vs-object differences were a problem. Again, OWL 2 introduces a handy construct which makes it possible to relate the two approaches. If, say, model **a** represents *birthCountry* as simply the name of a country, whereas model **b** represents *birthCountry* as a link to a country which has a name, we can indicate the equivalence via:

```
<rdf:Description rdf:about="&a;birthCountry">
  <owl:propertyChainAxiom rdf:parseType="Collection">
    <owl:ObjectProperty rdf:about="&b;birthCountry"/>
    <owl:DatatypeProperty rdf:about="&b;name"/>
  </owl:propertyChainAxiom>
</rdf:Description>
```

5. OWL 2 Use for a Standard Security Model

When the new OWL 2 model was discussed at the 2008 Semantic Technology Conference, it was noted that the new annotation property capabilities were suited for capturing information such as security, provenance, and confidence, all uses of great interest to this community. We have accordingly mapped the IC's recently-released XML security model, IC-ISM v3, into an OWL ontology called ISM3 using the new constructs.

We have defined a property for each of the ISM v3 XML attributes, a *Security* class as their domain, and a *security* annotation property to relate a *Security* class instance to anything. We have mapped each of the "CVEs" (Controlled Vocabulary Enumerations) defined by the IC-ISM v3 XML specification into the OWL equivalent. For example:

```
<owl:Class rdf:ID="CVE_Classification_US">
  <rdfs:label>CVE: Classification (US)</rdfs:label>
  <rdfs:comment>allowed values for a classification, US-
only</rdfs:comment>
  <owl:oneOf rdf:parseType="Collection">
    <owl:Thing rdf:about="#U">
      <rdfs:comment>UNCLASSIFIED</rdfs:comment>
      <ism:security rdf:resource="#U-USA"/>
    </owl:Thing>
    <owl:Thing rdf:about="#C">
      <rdfs:comment>CONFIDENTIAL</rdfs:comment>
      <ism:security rdf:resource="#U-USA"/>
    </owl:Thing>
    <owl:Thing rdf:about="#S">
      <rdfs:comment>SECRET</rdfs:comment>
      <ism:security rdf:resource="#U-USA"/>
    </owl:Thing>
    <owl:Thing rdf:about="#TS">
      <rdfs:comment>TOP SECRET</rdfs:comment>
      <ism:security rdf:resource="#U-USA"/>
    </owl:Thing>
  </owl:oneOf>
</owl:Class>

<ism:Security rdf:ID="U-USA">
  <ism:classification rdf:resource="#U"/>
```

```
    <ism:ownerProducer rdf:resource="#USA"/>
  </ism:Security>
```

In contrast to the usage of *Security* above, which annotates each entry in the enumeration with its security markings, we note that usual practice would be the use of annotated axioms, each of which simultaneously asserts and annotates a triple:

```
  <owl:Axiom>
    <owl:annotatedSource rdf:resource="#ID1"/>
    <owl:annotatedProperty
rdf:resource="http://example.com/example.owl#memberOf"/>
    <owl:annotatedTarget rdf:resource="#ID2"/>
    <ism:security rdf:resource="#Sec1"/>
  </owl:Axiom>
```

We should note that ICS500-21 "Tagging of Intelligence and Intelligence-Related Information" directs that all XML documents shall use the ISM XML standard for security markings. This is of course impossible for XML languages such as RDF/XML. But the rationale for that directive is obvious, and applies to OWL data as well. We urge the community to agree on a standard OWL ontology for security, so that it can be approved as an alternative, and provide the same benefits for OWL use that agreeing on ISM XML does for XML use. We offer this as a possible approach for that standard. We suggest that a similar standard for provenance (sourcing) would be beneficial as well.

6. Future Work

We plan to:

- incorporate mappings to UCore SL into the METS ontology
- return to the other project to model and map additional data sources and concepts
- continue retrofitting OWL 2 constructs in both
- continue devising ontologies such as IC-ISM v3, ideally in coordination with others across the community

7. References

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