12th ICCRTS

On the Automated Generation of an OWL Ontology based on the Joint C3 Information Exchange Data Model (JC3IEDM)

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Talk Outline

- What is JC3IEDM?
- What is OWL?
- Translation Method:
  - Erwin XML Definition
  - Entity translation
  - Attribute translation
  - Relationship translation
  - Codes translation
- Comments and Issues
What is JC3IEDM?

- Joint Consultation, Command & Control Information Exchange Data Model (JC3IEDM)
  - Generic Hub -> Land C2IEDM -> C2IEDM -> JC3IEDM
- Developed by the Multinational Interoperability Programme (MIP)
  - NATO organization
  - Goal: international interoperability of C2IS to support multinational (NATO) combined and joint operations
- Relational Data Model for Information Exchange
  - 289 entities
  - 396 relationships between entities
  - 1729 entity attributes
  - nearly 7000 value codes
JC3IEDM High-level Entities

- RULE-OF-ENGAGEMENT
- CANDIDATE-TARGET-LIST
- REPORTING-DATA
- REFERENCE
- CONTEXT
- VERTICAL-DISTANCE
- LOCATION
- COORDINATE-SYSTEM
- AFFILIATION
- GROUP-CHARACTERISTIC
- ADDRESS
- OBJECT-TYPE
- OBJECT-ITEM
Objects Hierarchies in JC3IEDM

```
+----------------+------------------+
  | OBJECT-TYPE    | OBJECT-ITEM      |
  +----------------+------------------+
  |   FACILITY-TYPE    |   FACILITY       |
  |            FEATURE-TYPE  | FEATURE     |
  |            MATERIEL-TYPE | MATERIEL   |
  | ORGANISATION-TYPE     | ORGANISATION   |
  +----------------+------------------+
  | PERSON-TYPE      | PERSON          |
```
What is OWL?

- W3C’s Web Ontology Language
  - A formal language for defining and using ontologies
- What is an ontology?
  - An exact description of things and their relationships in the context of a specific domain
- What is a formal ontology?
  - One logically (mathematically) defined (formal semantics)
- Based on RDF triples: subject-predicate-object
- Has an XML syntax
- Intended for processing by computers
- Part of the vision of the Semantic Web
- Three versions: OWL Full, OWL DL, OWL Lite

- Why use OWL?
  - Formal automated reasoning with generic reasoning engines, e.g. BaseVISor, Fact++, Pellet
Fundamental OWL/RDF Elements

- **owl:Class**
  - *set of individuals with common properties*
- **rdfs:subClassOf**
  - *defines isA relationship*
- **owl:DatatypeProperty**
  - *relation from a class to a data value type*
- **owl:ObjectProperty**
  - *relation from a class to a class*
- **rdf:ID**
  - *unique identifier*
- **rdf:type**
  - *defines instanceOf relationship*
Translation Method

- Automated translation of the JC3IEDM ERWin XML definition into OWL Lite
- Motivation:
  - Very large data model
  - Regular changes to JC3IEDM
- The Method:
  - Series of XSLT translation scripts
ERWin XML Definition

- Complete definition of JC3IEDM as an XML document
- Key definitional elements:
  - **Entity Groups**
  - **Domain Groups**
  - **Relationship Groups**
  - **Validation Rule Groups**
- Mapping to OWL elements:
  - **Entity** -> **Class**
  - **Domain** -> **DatatypeProperty**
  - **Relationship** -> **ObjectProperty**
  - **Codes** -> **Enumeration Class**
Entity to Class Translation

- Every **Entity** element is translated into an owl:Class
  - *entity’s xml attribute* Name *used as rdf:ID*
  - EntityProps/Name *value used as label*
  - EntityProps/Definition *used as text comment*

```xml
<owl:Class rdf:ID="{@Name}">
  <rdfs:label>{EntityProps/Name}</rdfs:label>
  <rdfs:comment>{EntityProps/Definition}</rdfs:comment>
</owl:Class>
```

- Entity category-codes also translated into owl:Classes
- Subclass relationship detected by presence of entity name in a validation rule for another entity’s category-code
- Disambiguation of rdf:IDs achieved by prepending parent’s rdf:ID
Virtually every Attribute element is translated into either a owl:DatatypeProperty or an owl:ObjectProperty (when range is over a category-code)

Key issues: obtaining rdf:ID, rdfs:domain, rdfs:range

Property’s domain is the parent of the Attribute

DatatypeProperty range determined by Datatype value:

<table>
<thead>
<tr>
<th>ERWin Datatype value</th>
<th>XSD Datatype</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER(<em>,</em>)</td>
<td>xsd:decimal</td>
</tr>
<tr>
<td>NUMBER(*)</td>
<td>xsd:integer</td>
</tr>
<tr>
<td>CHAR(*)</td>
<td>VARCHAR(*)</td>
</tr>
<tr>
<td>DATE</td>
<td>xsd:dateTime</td>
</tr>
</tbody>
</table>
<owl:DatatypeProperty
    rdf:ID="action-aircraft-employment-ingress-direction-angle">

    <rdfs:comment>The numeric quotient value that represents the portion of a whole OBJECT-ITEM that is estimated in a specific ACTION-EFFECT-ITEM to have the result specified in ACTION-EFFECT.
    </rdfs:comment>

    <rdfs:domain rdf:resource="#ACTION-AIRCRAFT-EMPLOYMENT"/>
    <rdfs:range rdf:resource="xsd:decimal"/>

</owl:DatatypeProperty>
Relationship to ObjectProperty Translation

- Every Relationship element is translated to an owl:ObjectProperty
- rdf:ID obtained from attribute’s Name, disambiguated with class name acronyms, e.g. OIGOA-has-OIGOAS
- owl:inverseOf relationship identified from RelationshipProps/Child_To_Parent_Phrase
- Cardinality constraints obtained from optional Child-cardinality-code element

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>OWL implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>one or more</td>
<td>minCardinality=&quot;1&quot;</td>
</tr>
<tr>
<td>ZO</td>
<td>zero or one</td>
<td>FunctionalProperty</td>
</tr>
<tr>
<td>ZM</td>
<td>zero, one or more</td>
<td>nothing</td>
</tr>
</tbody>
</table>
ObjectProperty Example

```xml
<owl:ObjectProperty
  rdf:ID="AT-is-used-in-the-definition-of-FC">
  <rdfs:domain
    rdf:resource="#AMMUNITION-TYPE"/>
  <rdfs:range
    rdf:resource="#FIRE-CAPABILITY"/>
  <rdf:type
    rdf:resource="owl:FunctionalProperty"/>
</owl:ObjectProperty>
```
Codes to Enumeration Classes Translation

- Codes translated from XSD file with every element becoming an owl:Class defined as an enumeration of the permitted values
- Enumeration Class: use of owl:oneOf to enumerate the set of all instances defining a class
- rdf:IDs disambiguated by adding numeric suffix
<owl:Class rdf:ID="ActionTaskOvertCovertCode">
   <rdfs:comment> The specific value that represents the property of an ACTION-TASK to be overt or covert. </rdfs:comment>
   <owl:oneOf rdf:parseType="Collection">
      <ActionTaskOvertCovertCode rdf:ID="COVERT">
         <rdfs:label>COVERT</rdfs:label>
         <rdfs:comment>
            The ACTION-TASK is to be conducted secretly.
         </rdfs:comment>
      </ActionTaskOvertCovertCode>
      <ActionTaskOvertCovertCode rdf:ID="OVERT">
         <rdfs:label>OVERT</rdfs:label>
         <rdfs:comment>
            The ACTION-TASK is to be conducted openly.
         </rdfs:comment>
      </ActionTaskOvertCovertCode>
   </owl:oneOf>
</owl:Class>
Comments and Issues

- **Quantitative Information:**
  - JC3IEDM3-1.owl available at [http://www.vistology.com/onts](http://www.vistology.com/onts)
  - Consistency checked using ConsVISor [http://www.vistology.com/consvisor](http://www.vistology.com/consvisor)
  - Can be loaded into Protégé

- **Issues:**
  - Great deal of “semantics” trapped in text descriptions
  - JC3IEDM business rules for valid value combinations not included – would necessitate going beyond OWL with a language like SWRL
  - Parallel OBJECT-ITEM and OBJECT-TYPE hierarchies
    - prevent natural owl/rdf inheritance of OBJECT-TYPE properties
    - but permit conflicting data to refer to same object

---

<table>
<thead>
<tr>
<th>Element/Attribute</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines of XSLT code</td>
<td>470</td>
</tr>
<tr>
<td>Lines of OWL code</td>
<td>&gt;64,000</td>
</tr>
<tr>
<td>rdf:Ids</td>
<td>12,527</td>
</tr>
<tr>
<td>All Classes</td>
<td>1561</td>
</tr>
<tr>
<td>Enumeration Classes</td>
<td>323</td>
</tr>
<tr>
<td>All Properties</td>
<td>2480</td>
</tr>
<tr>
<td>ObjectProperties</td>
<td>1101</td>
</tr>
<tr>
<td>DatatypeProperties</td>
<td>379</td>
</tr>
<tr>
<td>InverseProperties</td>
<td>139</td>
</tr>
<tr>
<td>minCardinality=1</td>
<td>13</td>
</tr>
<tr>
<td>FunctionalProperties</td>
<td>1111</td>
</tr>
</tbody>
</table>
Acknowledgements

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  - *U.S. ONR STTR Contract Number N00014-05-C-0367*
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