

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

Christopher J. Matheus and Brian Ulicny
VIStology, Inc.

Framingham, MA, U.S.A.

{cmatheus,bulicny}@vistology.com



Talk Outline

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

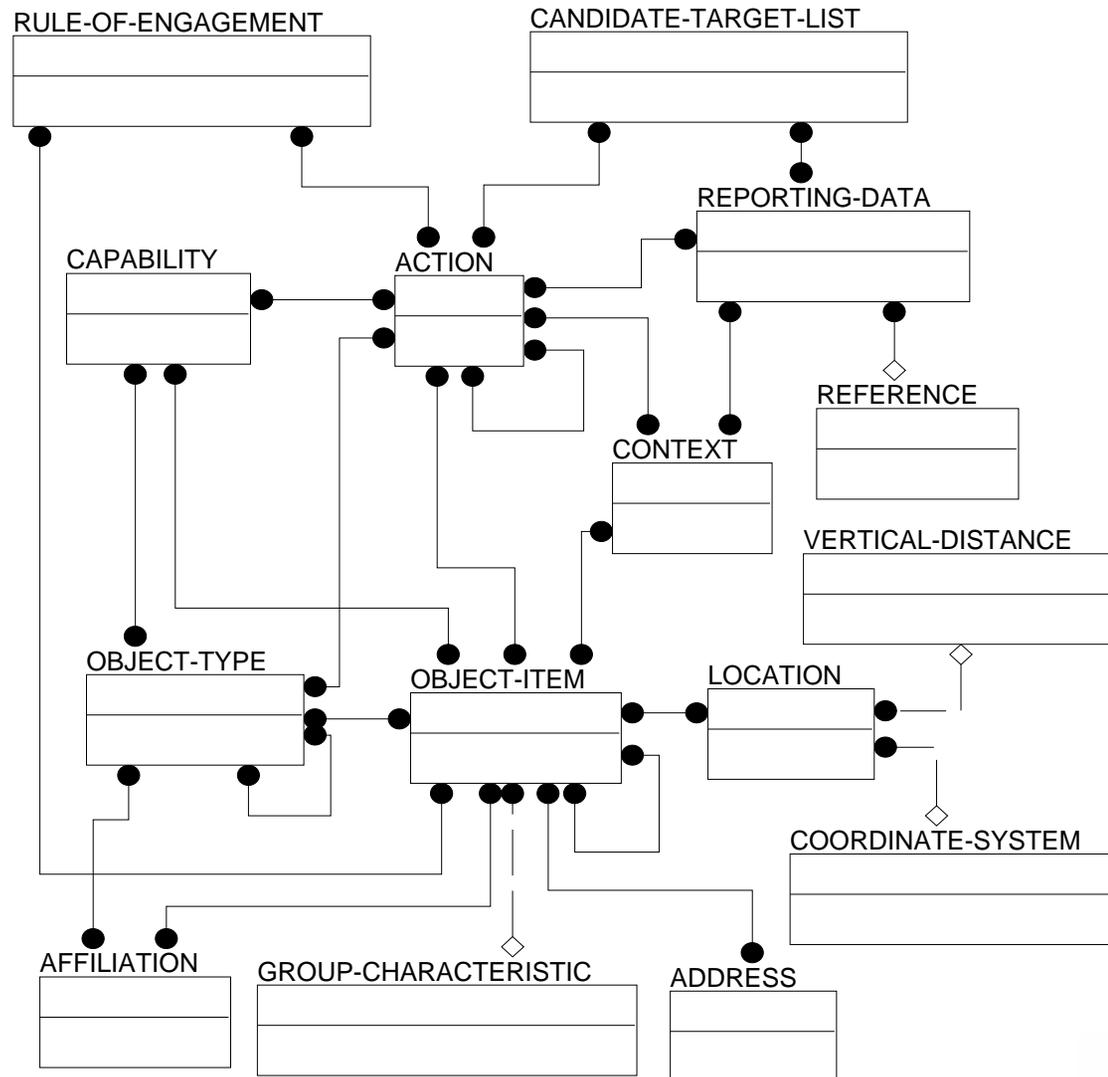


What is JC3IEDM?

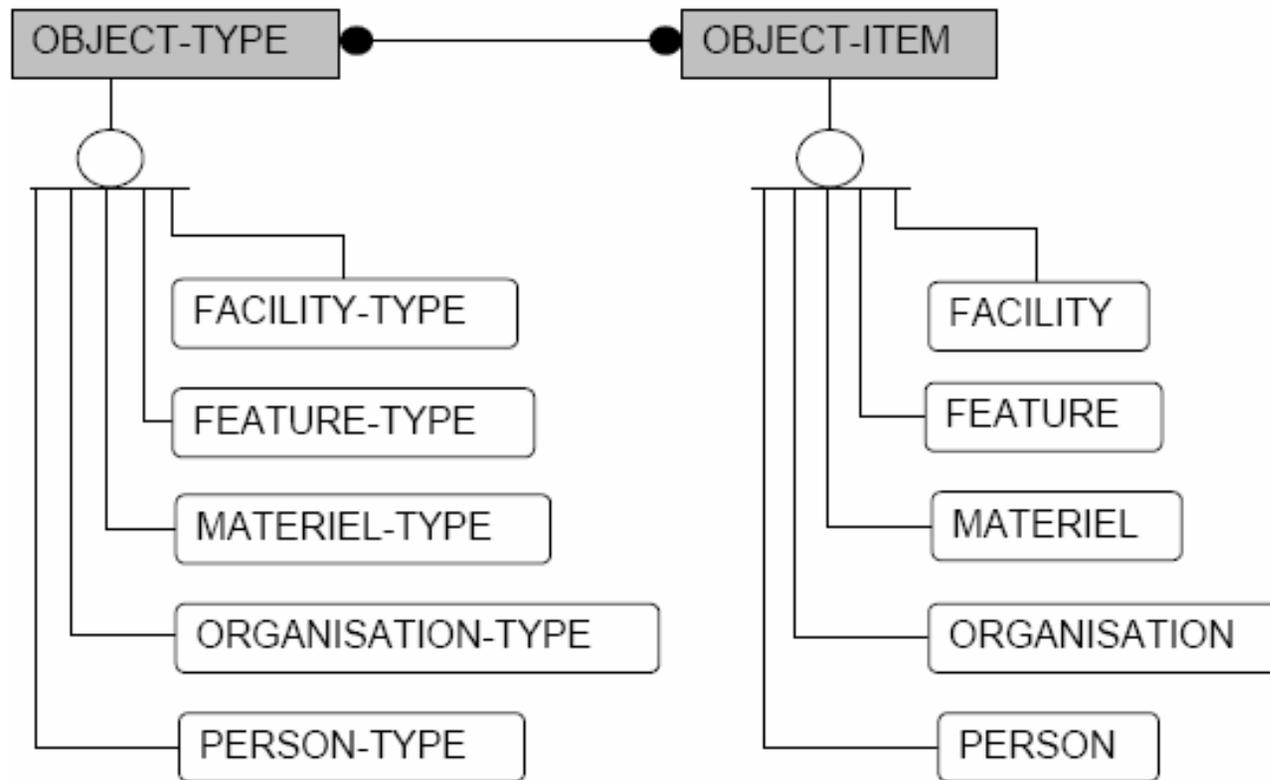
- **Joint Consultation, Command & Control Information Exchange Data Model (JC3IEDM)**
 - *Generic Hub -> Land C2IEDM -> C2IEDM -> JC3IEDM*
- **Developed by the Multinational Interoperability Programme (MIP)**
 - *NATO organization*
 - *Goal: international interoperability of C2IS to support multinational (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



Objects Hierarchies in JC3IEDM



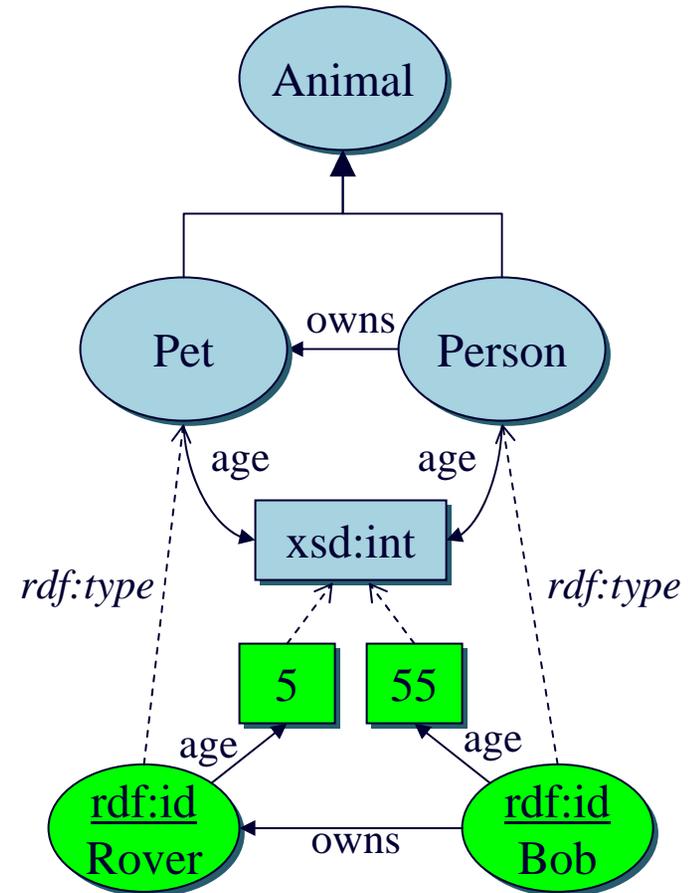
What is OWL?

- 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*

```
<ERwin4>
  <Entity_Groups>
    <Entity>
      <EntityProps/>
      <Attribute_Groups>
        <Attribute/>
        ...
      </Attribute_Groups>
    </Entity>
  </Entity_Groups>
  <Domain_Groups>
    <Domain/>
    ...
  <Domain_Groups>
  <Relationship_Groups>
    <Relationship/>
    ...
  </Relationship_Groups>
  <Validation_Rule_Groups>
    <Validation_Rule/>
    ...
  </Validation_Rule_Groups>
</ERwin4>
```



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*

```
<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`



Attribute to DatatypeProperty

- 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:

ERWin Datatype value	XSD Datatype
-----	-----
<code>NUMBER(*,*)</code>	<code>xsd:decimal</code>
<code>NUMBER(*)</code>	<code>xsd:integer</code>
<code>CHAR(*)</code> <code>VARCHAR(*)</code> <code>BLOB</code>	<code>xsd:string</code>
<code>DATE</code>	<code>xsd:dateTime</code>



DatatypeProperty Example

```
<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

Code	Meaning	OWL implications
PM	one or more	<code>minCardinality="1"</code>
ZO	zero or one	<code>FunctionalProperty</code>
ZM	zero, one or more	nothing



ObjectProperty Example

```
<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



Code Enumeration Class Example

```
<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>
- Consistency checked using ConsVISor <http://www.vistology.com/consvisor>
- Can be loaded into Protégé
- Issues:

Element/Attribute	Quantity
Lines of XSLT code	470
Lines of OWL code	>64,000
rdf:IDs	12,527
All Classes	1561
Enumeration Classes	323
All Properties	2480
ObjectProperties	1101
DatatypeProperties	379
InverseProperties	139
minCardinality=1	13
FunctionalProperties	1111

- *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



Acknowledgements

- **Work support in part by:**
 - *U.S. ONR STTR Contract Number N00014-05-C-0367*
 - *U.S. Army SBIR Contract Number W15P7T-05-C-T204*



Questions?

