A Case Study in Integrating Multiple E-Commerce Standards via Semantic Web Technology

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Cataloging at Source - the last piece of the puzzle

Contract Information

TAXONOMY MAPPING USING ONTOLOGY STRUCTURES

Contract Number:	**SP4701-07-C-0006**
Sponsor:	**Defense Logistics Information Service**
Contractor:	**Lehigh University**
Subcontractors:	**Electronic Commerce Code Management Association (ECCMA)** **Concurrent Technologies Corporation**
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Outline

- Introduction
- Background
- Ontology Construction
- Approach
- Ontology Mapping
- Implementation

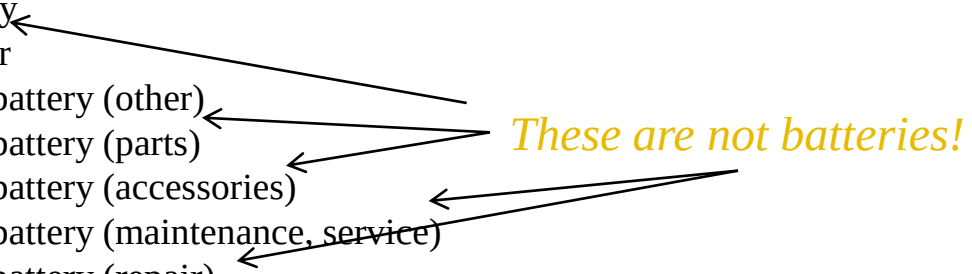
Introduction

- Motivation
  - Heterogeneity underlying B2B customers' product, catalog, and document descriptions
- Taxonomies and classification schemes
  - More than 40 have been publicly identified
    - eCl@ss, UNSPSC, CPV, NAICS, RTD, etc.
- Federal Cataloging System
  - Naming, classifying and describing items of supply for DoD – created & maintained by DLIS
  - Various codes: FSG, FSC, INC, NSN, MRC

Background

- Taxonomies have varied purposes
- eCl@ss example:

27 Electric engineering, automation, process control engineering
- 27-05 Accumulator, battery
- 27-05-01 Station. batt., accum.
- 27-05-02 Traction battery, starter battery
- 27-05-04 Portable battery
- 27-05-06 Battery charger
- 27-05-90 Accumulator, battery (other)
- 27-05-91 Accumulator, battery (parts)
- 27-05-92 Accumulator, battery (accessories)
- 27-05-98 Accumulator, battery (maintenance, service)
- 27-05-99 Accumulator, battery (repair)



- Ontology and Semantic Web

The Semantic Web

- Definition
  - The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation. (Berners-Lee et al., Scientific American, May 2001)
- Key International Standards
  - World Wide Web Consortium (W3C) recommendations
    - » Resource Description Framework (RDF)
    - » Web Ontology Language (OWL)
  - on par with HTML / XML

Ontology

- Definition
  - a logical theory that accounts for the intended meaning of a formal vocabulary (Guarino 98)
  - has a formal syntax and unambiguous semantics
  - usually more than just a hierarchy / taxonomy
  - inference algorithms can compute what logically follows
- Relevance to Web:
  - identify context
  - provide shared definitions
  - eases the integration of distinct resources

OWL Class Constructors

Constructor	DL Syntax	Example
intersectionOf	C1 ∩ C2	GasTurbine ∩ AircraftPart
unionOf	C1 ∪ C2	Door ∪ Airframe ∪ TailSection
complementOf	¬C	¬Aircraft
oneOf	{x1,…,x2}	{F15, F16}
allValuesFrom	∀P.C	∀partOf.Airframe
someValuesFrom	∃P.C	∃hasPart.Door
maxCardinality	≤ *n*P	≤10hasPart
minCardinality	≥ *n*P	≥2hasPart

Background

- Create ontologies from industrial standards
  - Taxonomies differ in scope and purpose
  - Naming conventions differ across classifications
    - e.g. “bearing, roller” versus “roller bearing”
  - Target taxonomies have one or more deficiencies:
    - lack of definitions or inaccurate definitions
    - lack of freely available electronic version
    - lack of sample data
    - poor superclass/subclass structures
    - inconsistent modeling
    - failure to state/observe modeling conventions

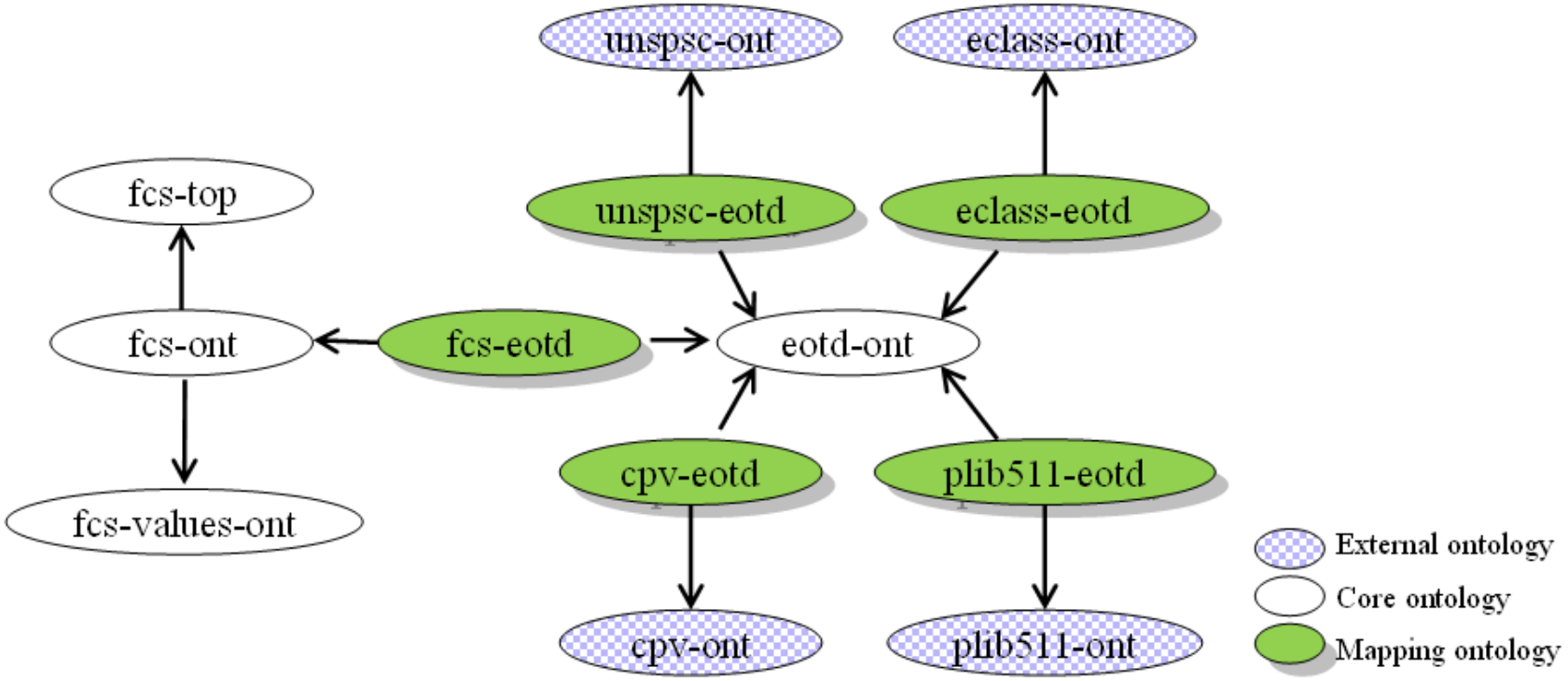
Ontology Construction

- External Ontologies
  - eCl@ss
  - UNSPSC
  - CPV
  - PLIB
- Scope
  - Bearings, Batteries, Microcircuit, Bushings, Fasteners and Gaskets

Ontology	Original		Scope	
	Classes	Properties	Classes	Properties
FCS			128	2
eOTD	60000	555	194	180
eCl@ss	25000	5500	313	18
UNSPSC	21000	0	228	0
CPV	8000	0	208	0
PLIB-511	186	204	186	204

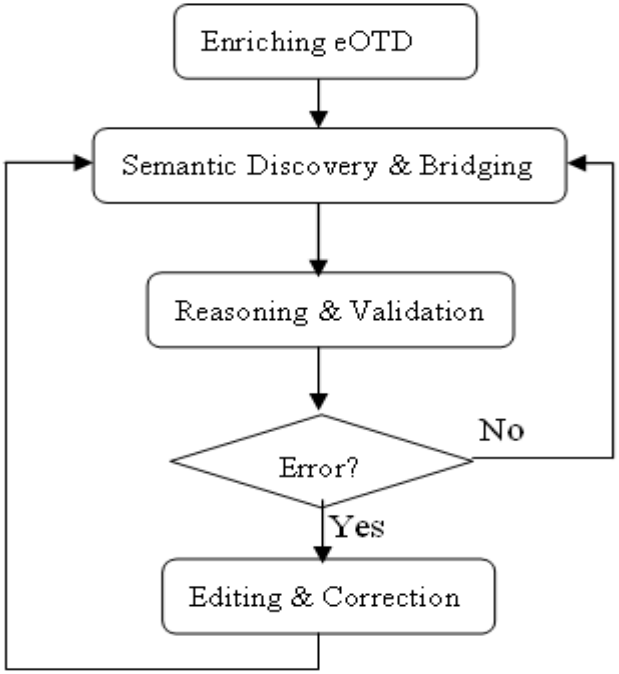
Approach

- eOTD is a *lingua franca*
- Mappings constitute “mediator” ontologies



Ontology Mapping

- Mapping process



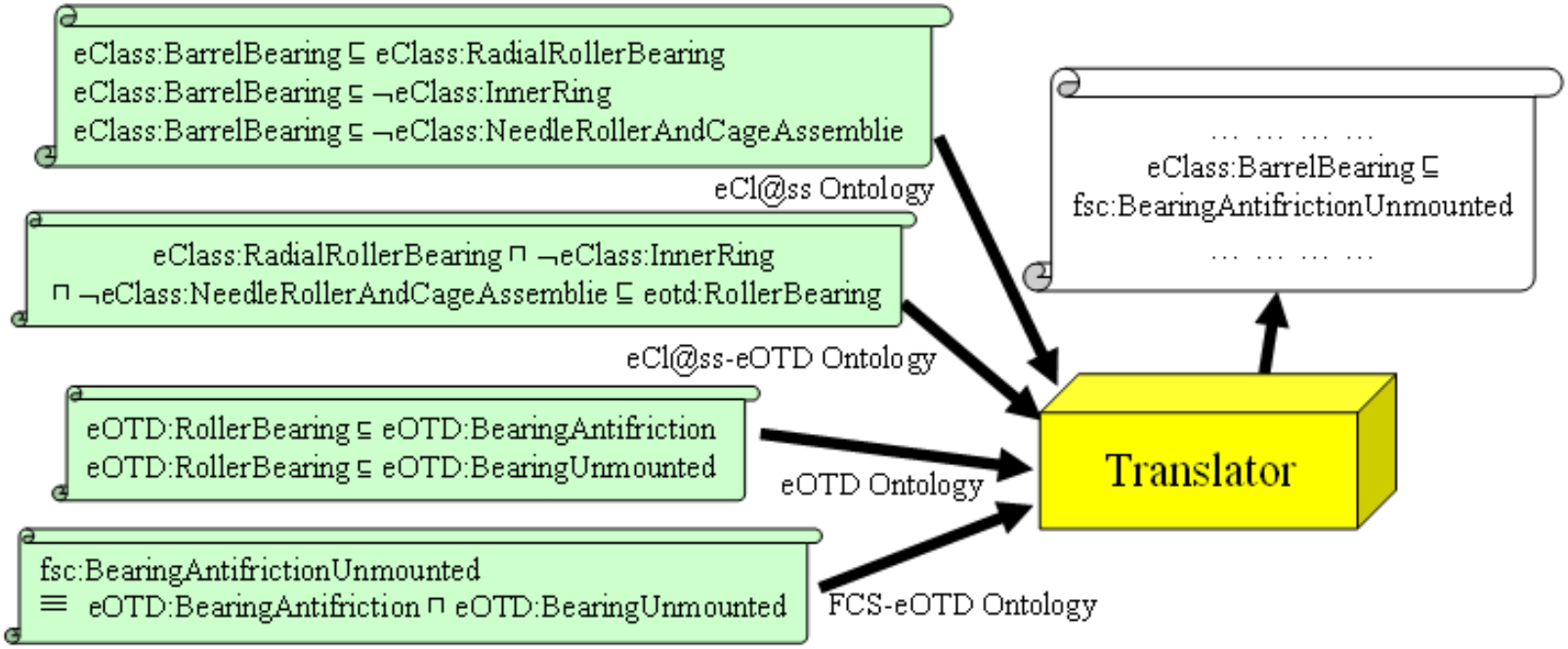
- Enriching the eOTD
  - Hierarchy
  - Abstract classes
    - Remove one or more modifiers
    - identify “foundational” classes from FSGs and FSCs
- Reasoning and Validation
  - FaCT++

Ontology Mapping

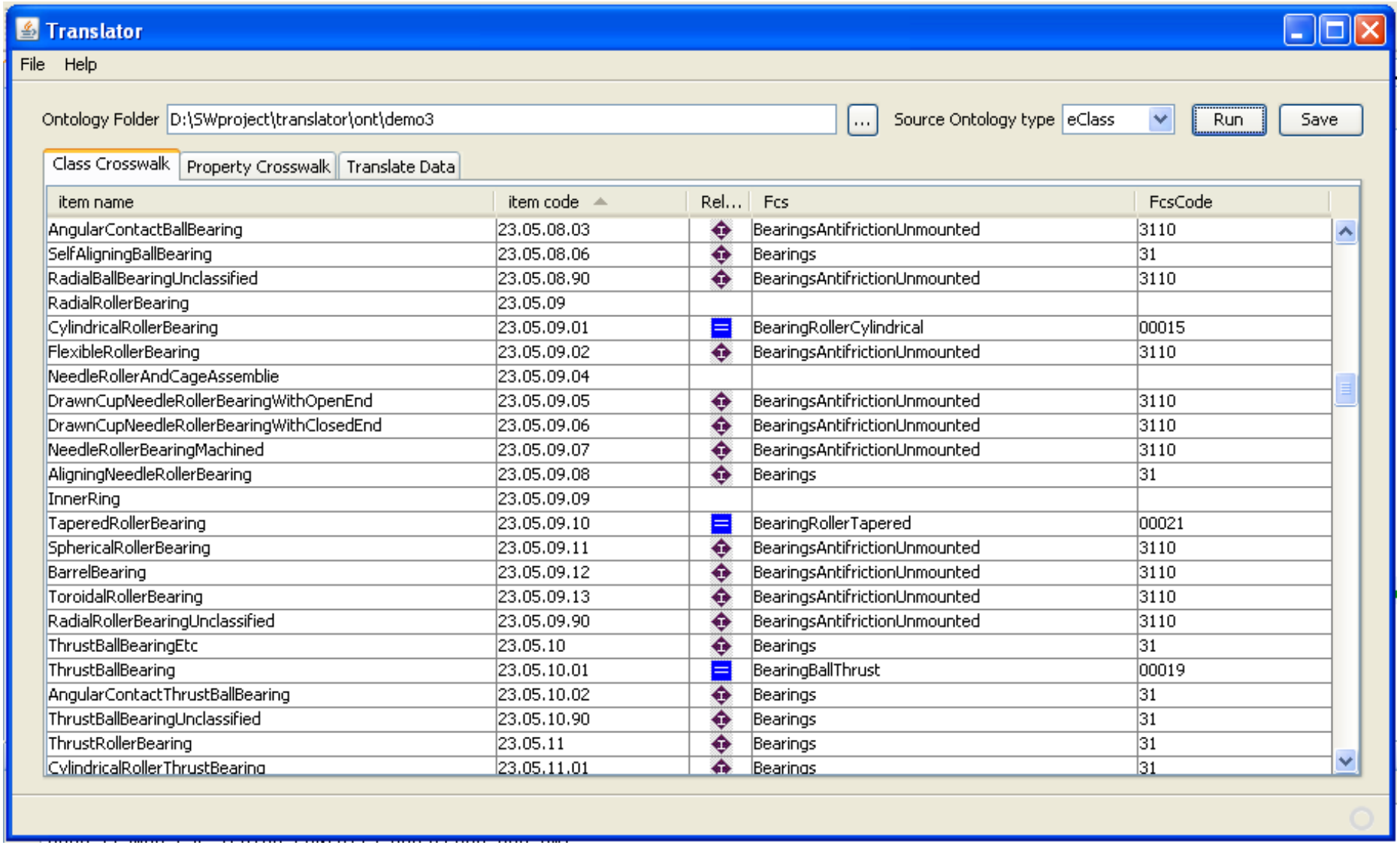
- Semantic Discovery and Bridging
  - Most specific subsumer and subsumee
    - “cpv:PrimaryBatteries ⊑ eOTD:BatteryAssemblyAll”
    - “eOTD:BatteryThermal ⊑ cpv:PrimaryBatteries”
  - Union (A ≡ B ⊔ C)
    - “fsc:KnobsAndPointers ≡ eOTD:Knob ⊔ eOTD:Pointer”
  - Intersection (A ≡ B ⊓ C)
    - “fsc:BearingAntifrictionUnmounted ≡ eOTD:Bearing-Antifriction ⊓ eOTD:Bearing-Unmounted”
  - Exclusion (A ≡ B ⊓ ¬ C)
    - “eOTD:BearingPlain ≡ eCl@ss:PlainBearing ⊓ ¬ eCl@ss:PlainBearingParts”
  - Class vs. property distinction (A ⊑ ∃P.{a, b, c})
    - “PLIB:HexagonHeadTappingScrewWithAFlatEnd ⊑ ∃eOTD:head-Style.{eOTD:Hexagon}”
    - “PLIB:HexagonHeadTappingScrewWithAFlatEnd ⊑ ∃eOTD:pointStyle.{eOTD:Flat, eOTD:Flat2, eOTD:Flat3}”

Implementation

- An example of translation



Translator Interface



item name	item code	Rel...	Fcs	FcsCode
AngularContactBallBearing	23.05.08.03		BearingsAntifrictionUnmounted	3110
SelfAligningBallBearing	23.05.08.06		Bearings	31
RadialBallBearingUnclassified	23.05.08.90		BearingsAntifrictionUnmounted	3110
RadialRollerBearing	23.05.09			
CylindricalRollerBearing	23.05.09.01	=	BearingRollerCylindrical	00015
FlexibleRollerBearing	23.05.09.02		BearingsAntifrictionUnmounted	3110
NeedleRollerAndCageAssemblie	23.05.09.04			
DrawnCupNeedleRollerBearingWithOpenEnd	23.05.09.05		BearingsAntifrictionUnmounted	3110
DrawnCupNeedleRollerBearingWithClosedEnd	23.05.09.06		BearingsAntifrictionUnmounted	3110
NeedleRollerBearingMachined	23.05.09.07		BearingsAntifrictionUnmounted	3110
AligningNeedleRollerBearing	23.05.09.08		Bearings	31
InnerRing	23.05.09.09			
TaperedRollerBearing	23.05.09.10	=	BearingRollerTapered	00021
SphericalRollerBearing	23.05.09.11		BearingsAntifrictionUnmounted	3110
BarrelBearing	23.05.09.12		BearingsAntifrictionUnmounted	3110
ToroidalRollerBearing	23.05.09.13		BearingsAntifrictionUnmounted	3110
RadialRollerBearingUnclassified	23.05.09.90		BearingsAntifrictionUnmounted	3110
ThrustBallBearingEtc	23.05.10		Bearings	31
ThrustBallBearing	23.05.10.01	=	BearingBallThrust	00019
AngularContactThrustBallBearing	23.05.10.02		Bearings	31
ThrustBallBearingUnclassified	23.05.10.90		Bearings	31
ThrustRollerBearing	23.05.11		Bearings	31
CylindricalRollerThrustBearing	23.05.11.01		Bearings	31

Implementation

- Summary of mapping results

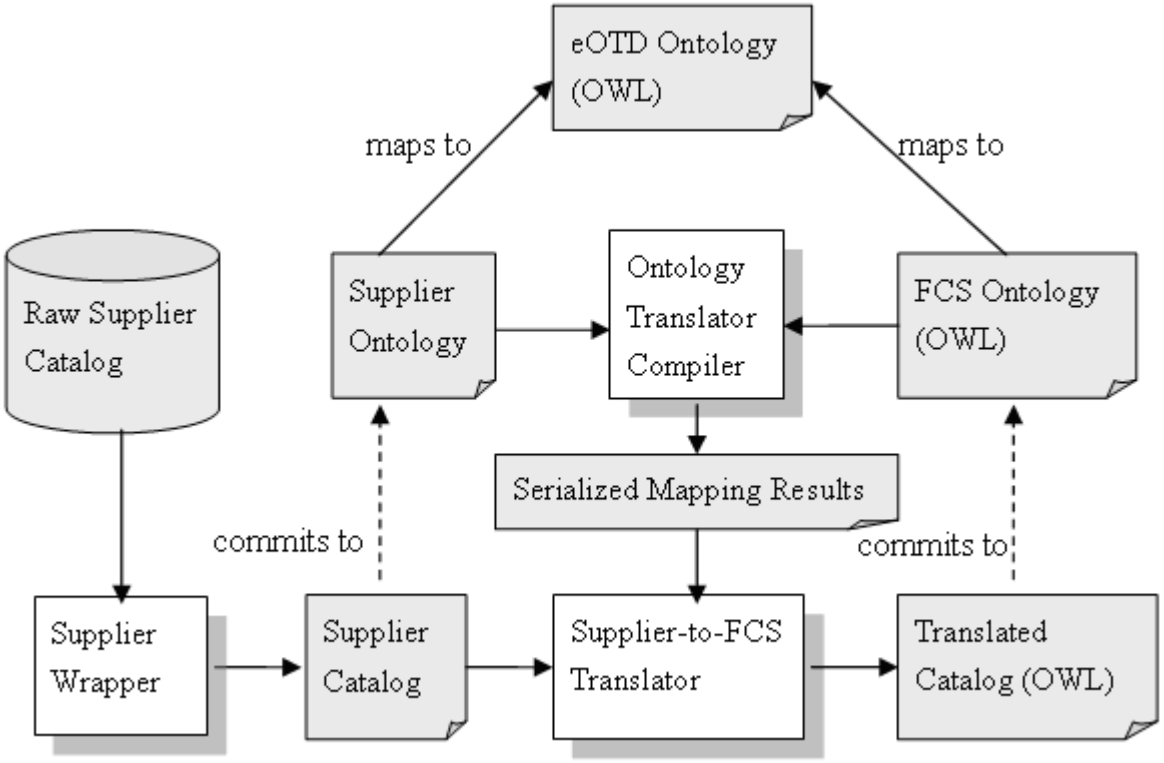
Ontology	Classes covered by mapping axioms	Matchings			Matching Percentage
		Equivalence	Direct Subsumption	Indirect Subsumption	
eCl@ss	191	13	21	78	58.64
UNSPSC	103	7	55	18	77.67
CPV	117	1	8	23	27.35
PLIB-511	86	0	13	72	98.83

Compiler and Translator

- Compiler constructed by mappings among ontologies
- Relationships built up as more taxonomies and terms added
- Translator uses compiler to provide online translations of target terms into FCS vocabulary

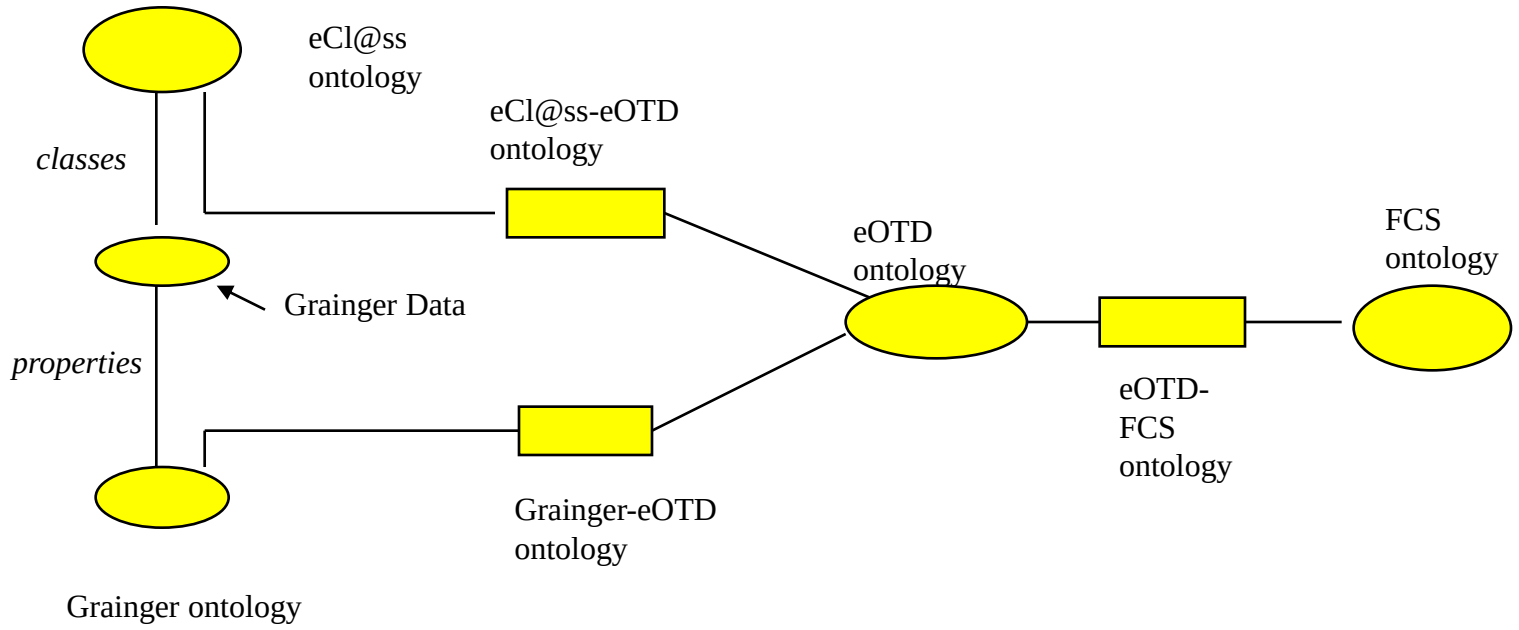
Implementation (continued)

- The complete process of compilation



Commercial Data Sheet (Grainger)

- We assume the Grainger data items are classified using the eCl@ss taxonomy
  - However, these items have their own set of properties



Conclusion

- Ontologies provide the means for representing the information in catalogs in a clear and unambiguous manner
- Ontologies have widespread applicability
- OWL has a large and growing user community
- There are potential benefits to be gained from using an ontology-based approach in NSN screening
- Ontologies can provide the means for improving the quality of catalog data and metadata