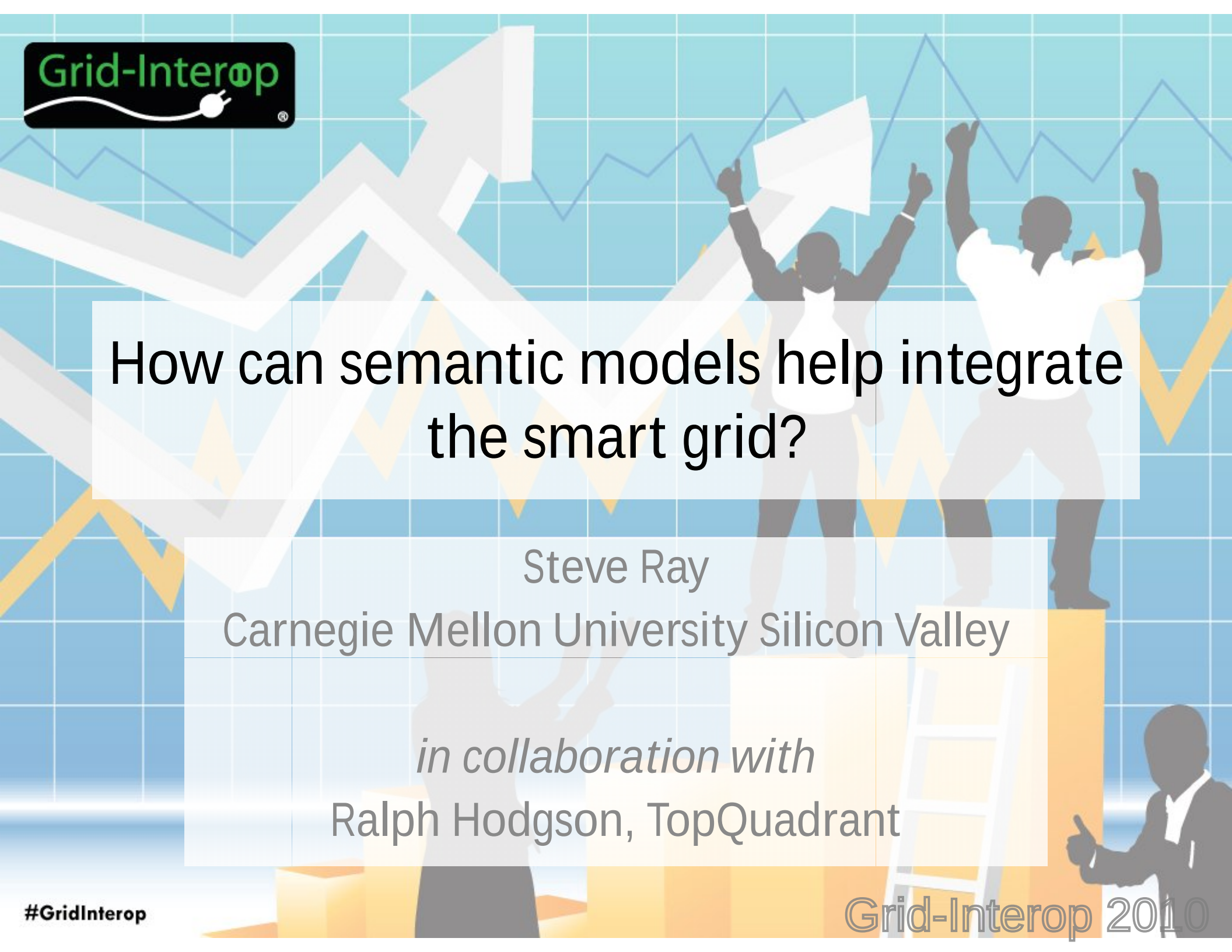


How can semantic models help integrate the smart grid?

Steve Ray
Carnegie Mellon University Silicon Valley

in collaboration with
Ralph Hodgson, TopQuadrant

Goal

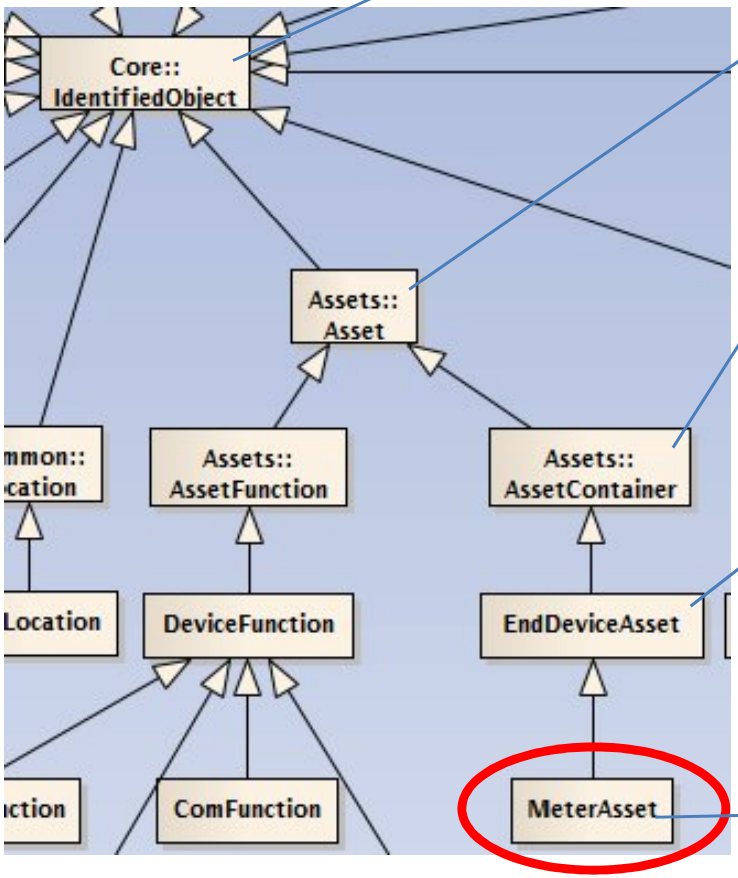
- To enable effective, error-free information exchange among all the players in the smart grid
  - The messages used to carry the information are based upon underlying information models

Problem

- Many existing, and more emerging, information models reflect distinct industry sector perspectives on the electrical grid
- Legacy systems are already using these models
- The models:
  - Are at varying levels of abstraction
  - Partition concepts in different ways

Example: Meter

IEC 61968



This is a root class to provide common naming attributes for all classes needing naming attributes

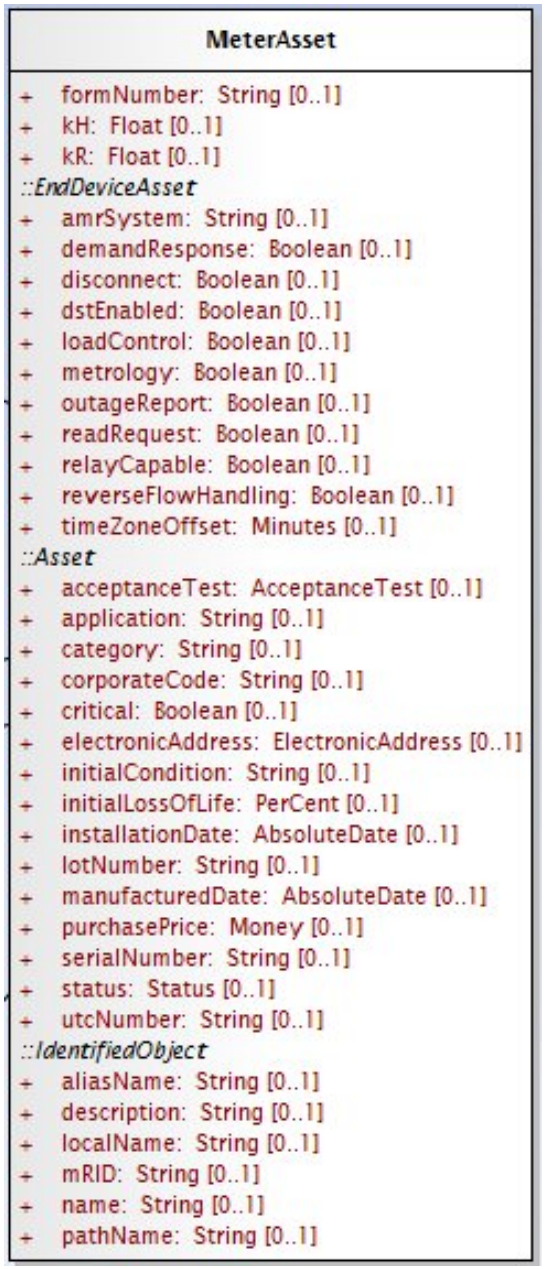
Tangible resource of the utility, including power system equipment, cabinets, buildings, etc. For electrical network equipment, the role of the asset is defined through PowerSystemResource and its subclasses, defined mainly in the Wires model (refer to IEC61970-301 and model package IEC61970::Wires). Asset description places emphasis on the physical characteristics of the equipment fulfilling that role.

Asset that is aggregation of other assets such as conductors, transformers, switchgear, land, fences, buildings, equipment, vehicles, etc.

AssetContainer that performs one or more end device functions. One type of EndDeviceAsset is a MeterAsset which can perform metering, load management, connect/disconnect, accounting functions, etc. Some EndDeviceAssets, such as ones monitoring and controlling air conditioner, refrigerator, pool pumps may be connected to a MeterAsset. All EndDeviceAssets may have communication capability defined by the associated ComFunction(s). An EndDeviceAsset may be owned by a consumer, a service provider, utility or otherwise.
There may be a related end device function that identifies a sensor or control point within a metering application or communications systems (e.g., water, gas, electricity). Some devices may use an optical port that conforms to the ANSI C12.18 standard for communications.

Physical asset that performs the metering role of the ServiceDeliveryPoint. Used for measuring consumption and detection of events.

IEC 61968
Meter Attributes



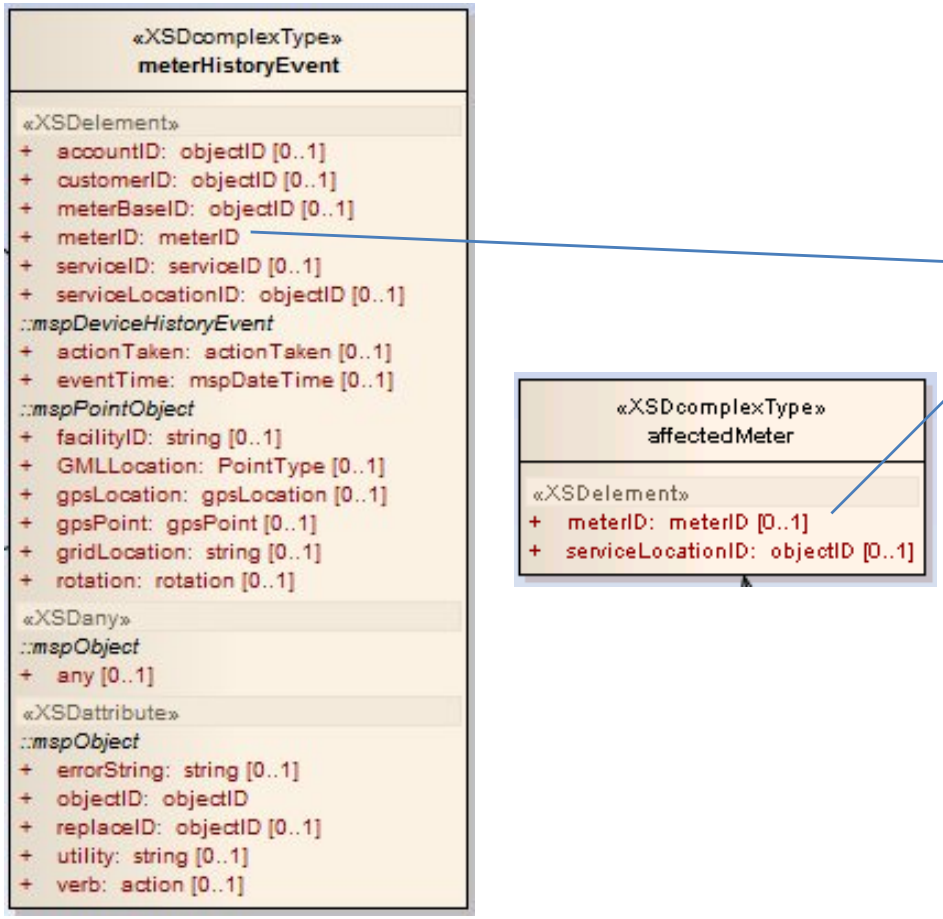
Generally speaking…

These are about what a device can do
(from a control perspective)

These support the tracking and inventory of assets
(from an owner's perspective)

These just help identify any object

Multispeak V4.1
Meter Attributes

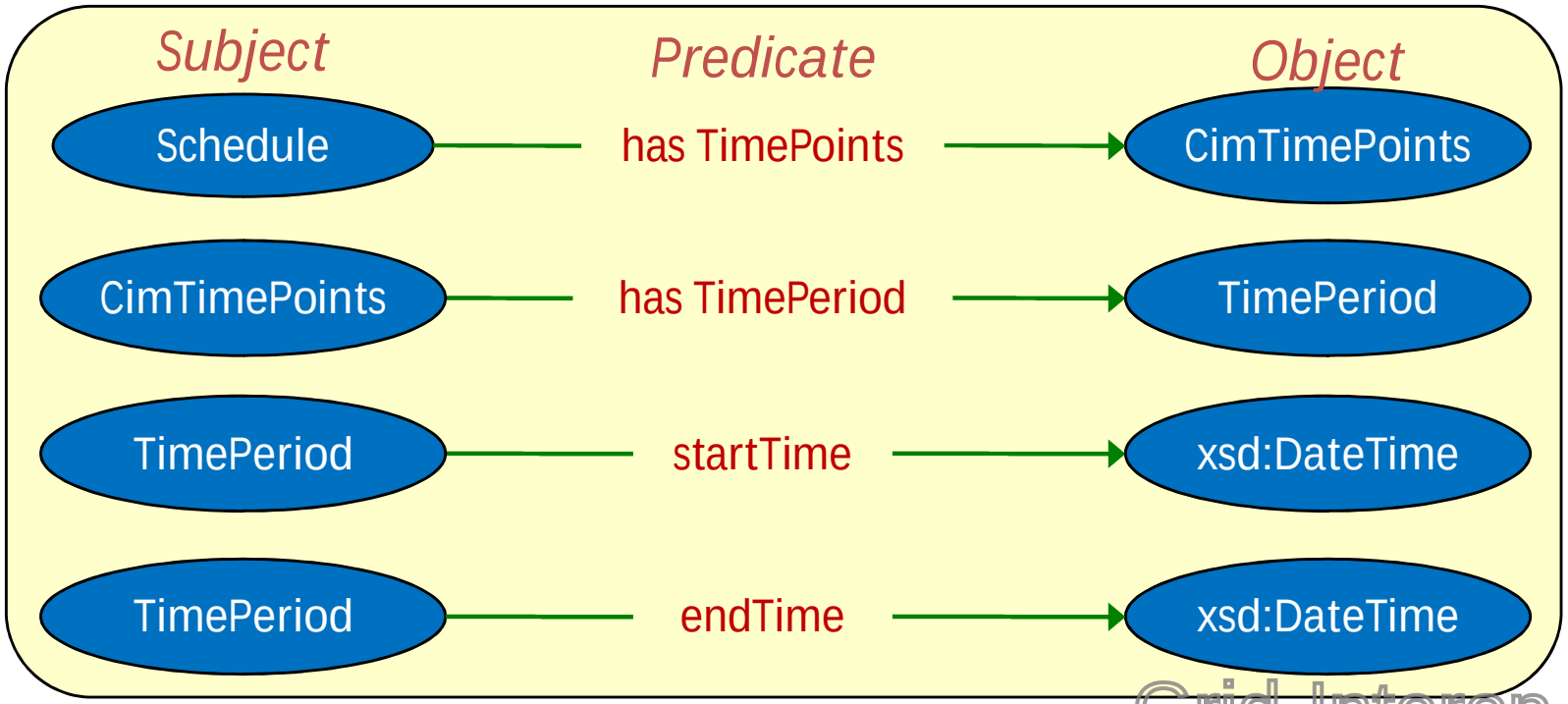


Emphasis here is on the actions taken on a meter.
Meter is not modeled explicitly, and is simply identified via a meterID string
(user's perspective)

What is Semantic Technology?

"Semantic Technology allows the meaning of and associations between information to be represented precisely and, optionally, consulted and processed at execution time. "

Semantic Technology represents information in a neutral form called Triples that consist of a Subject, a Predicate and an Object. Each of these can have properties that infer new information. Each has a unique identity, enabling merging of different datasets.



Semantic Web Technologies provide increased expressiveness for Information Models

Query Language

SPARQL

OWL

RDFS

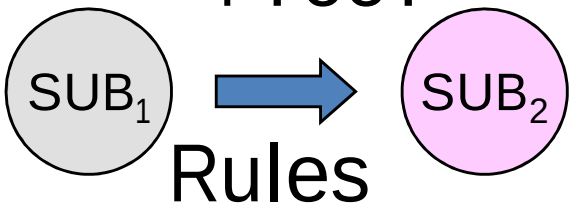
RDF

XML

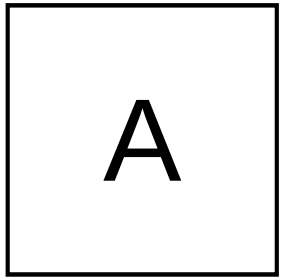
More Model Formalism + Reasoning

+ Trust

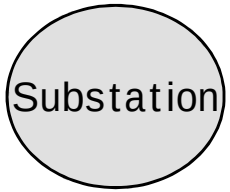
+ Proof



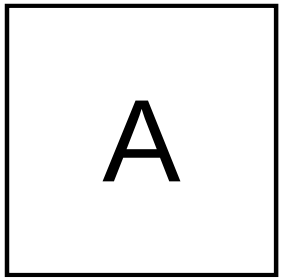
Classes



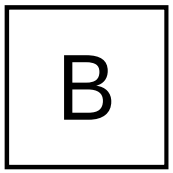
is a



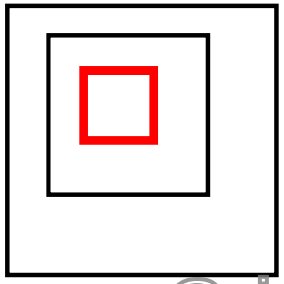
Relationships



has Substation

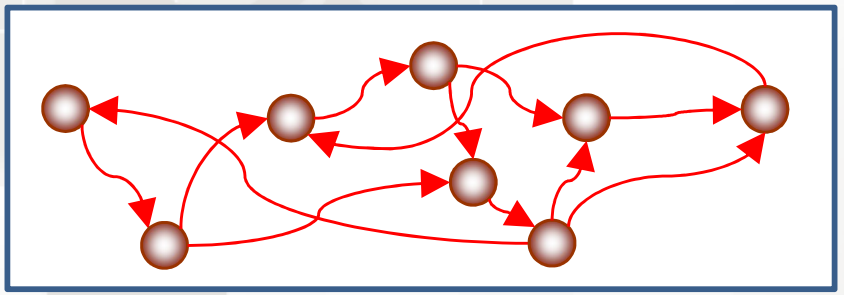


Structures



What Problems can be Solved by Semantic Technology

- Alignment of Terms and relationships
- Generation of consistent XML Schemas
  - Component-Based
- Generation of controlled vocabularies
- Aggregation of data from disparate sources
- “Smart Data” - Inference of new information from data



Recommended Steps

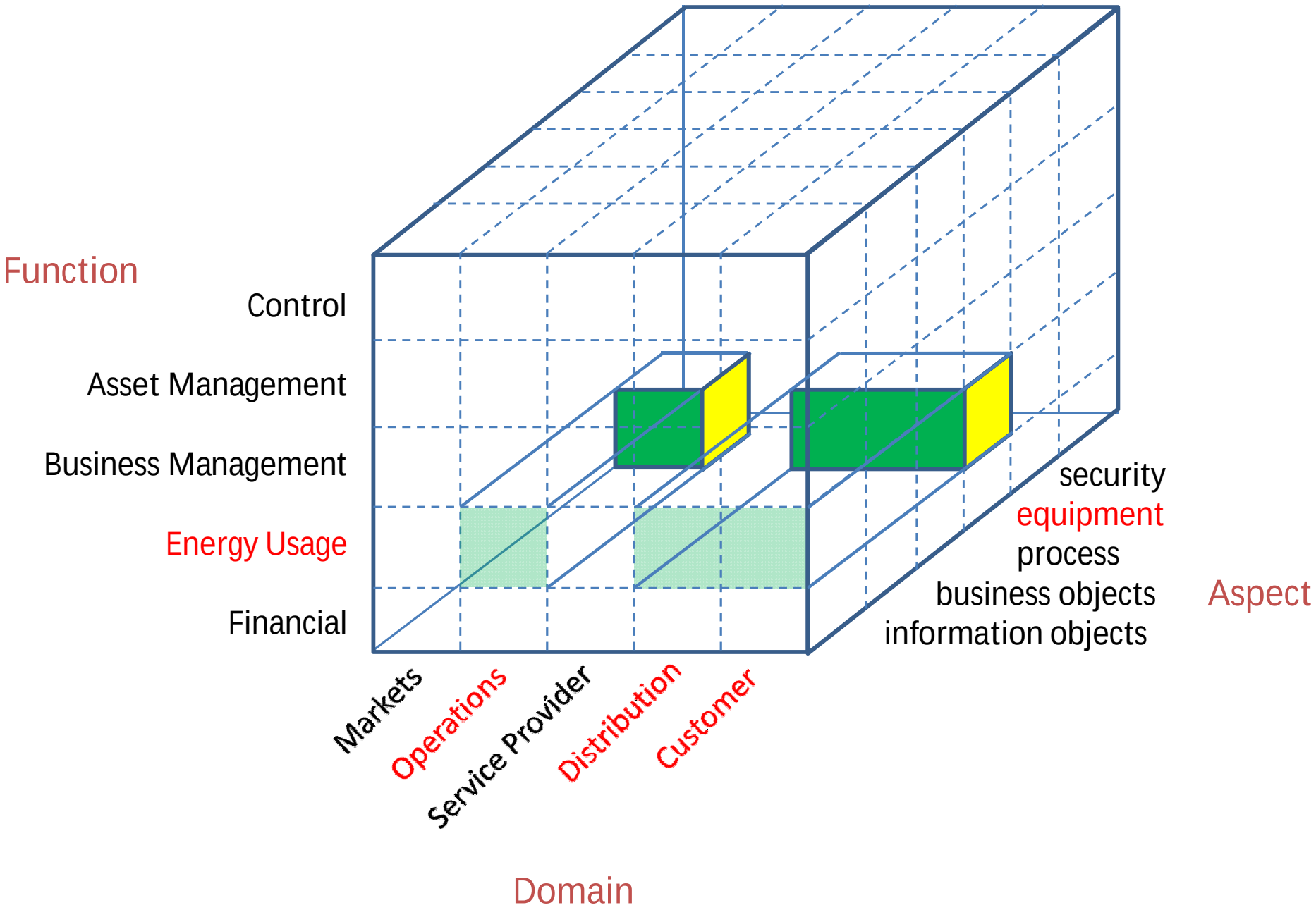
- Define a semantic framework in which we can position an abstract semantic model, and the component standards
- Migrate selected UML models to OWL Specifications
- Determine opportunities and approach for standardizing vocabularies
- Verify and Validate the OWL Models
- Coordinate Revisions with other CIM efforts
- Demonstrate creation of UN/CEFACT CCTS Schemas
- Define pilot assessment strategy

The Semantic Framework (i.e. Context)

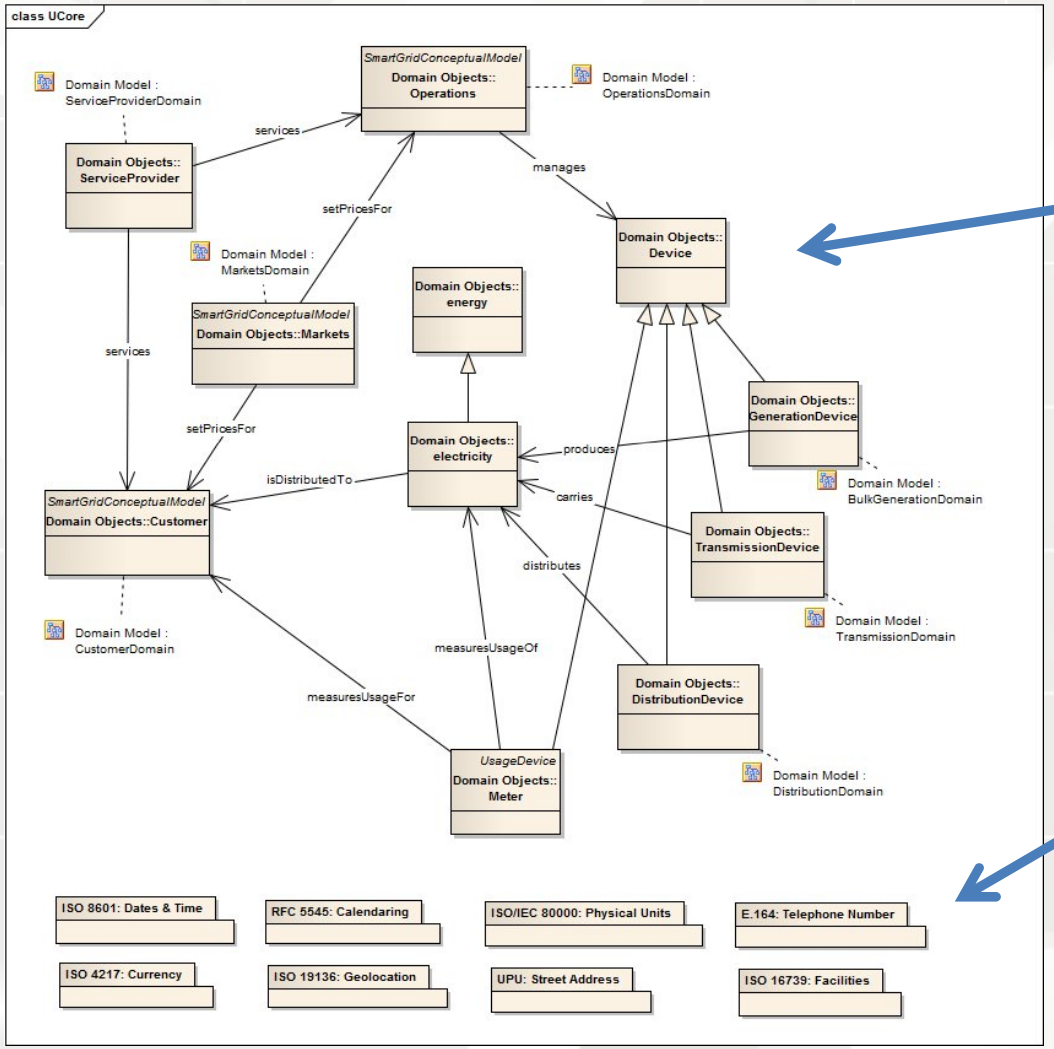
Semantic models (or model fragments) need to be positioned in terms of:

- What Function is it fulfilling (grid control, inventory & maintenance, business management, billing?)
- What Aspect is it modeling (security, equipment, process, business objects, information objects?)
- What Domain perspective within the smart grid community does it reflect (operations, customer, transmission?)
- What Specificity does it capture (individual appliance consumption, regional demand?)
- Is it Time Invariant information (snapshot) or Time Variant (recording history)?

e.g. IEC 61968, Part 9



Abstract Information Model



- The abstract layer relates the concepts found in all the smart grid standards
- It also contains links to standards outside the smart grid that can be incorporated

Using RDF/OWL for Specifications

- An OWL Class specifies the data type properties (attributes) and object properties (associations) of an Information Object
- Multiple inheritance allows common properties to be factored out into reusable classes
- OWL models can be transformed to other representations using mappings
- Examples of transformations are:
  - OWL to XML Schema and XML Vocabularies at NASA
  - OWL to UN/CEFACT CCTS (Core Component Technical Specifications) at the Netherlands Ministry of Justice

Work To-date on SmartGrid OWL Models

- Conversions of CIM and IEC Models to OWL
  - IEC61968
  - IEC61970
  - EUI Core
  - Multispeak V41
- UN/CEFACT approach to generating Schemas

XML Schema (XSD) Constructs are converted to OWL Constructs

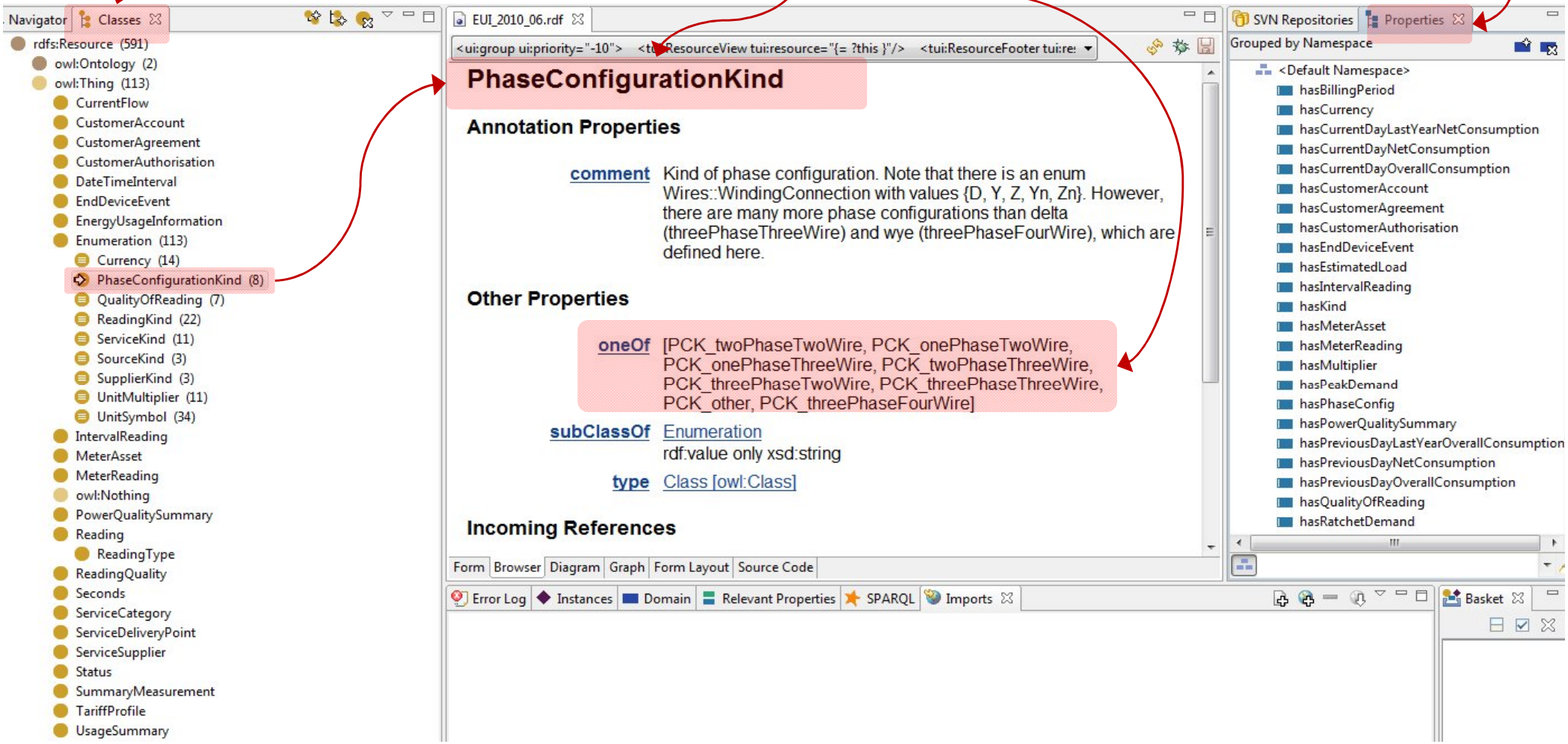
XSD	OWL	Notes
Complex Type	Class	
Scalar Attribute	Datatype Property	Values are xsd datatypes
Reference to Complex Type	Object Property	Expressed as a restriction on the OWL Class
Simple Type	Two Classes	One class is for the Simple Type and another subclasses an xsd data type. An rdf:value property is used to connect the first class to the xsd datatype subclass.
Complex Type extending Simple Type	Two Classes	One class is for the Simple Type and another subclasses an xsd data type. An rdf:value property is used to connect the first class to the xsd data type subclass.
Enumeration	Class with an additional class for members	OWL oneOf is used for enumerations with less than 100 members. This could be configured.
Substitution Group	Class	The Substitution Group Class is inherited at each occurrence of use
(Element) Group	Class	The Element Group Class is inherited at each occurrence of use
Attribute Group	Class	The Attribute Group Class is inherited at each occurrence of use

Example of EUI OWL Model

Classes

Phase Configuration Kind is an Enumeration

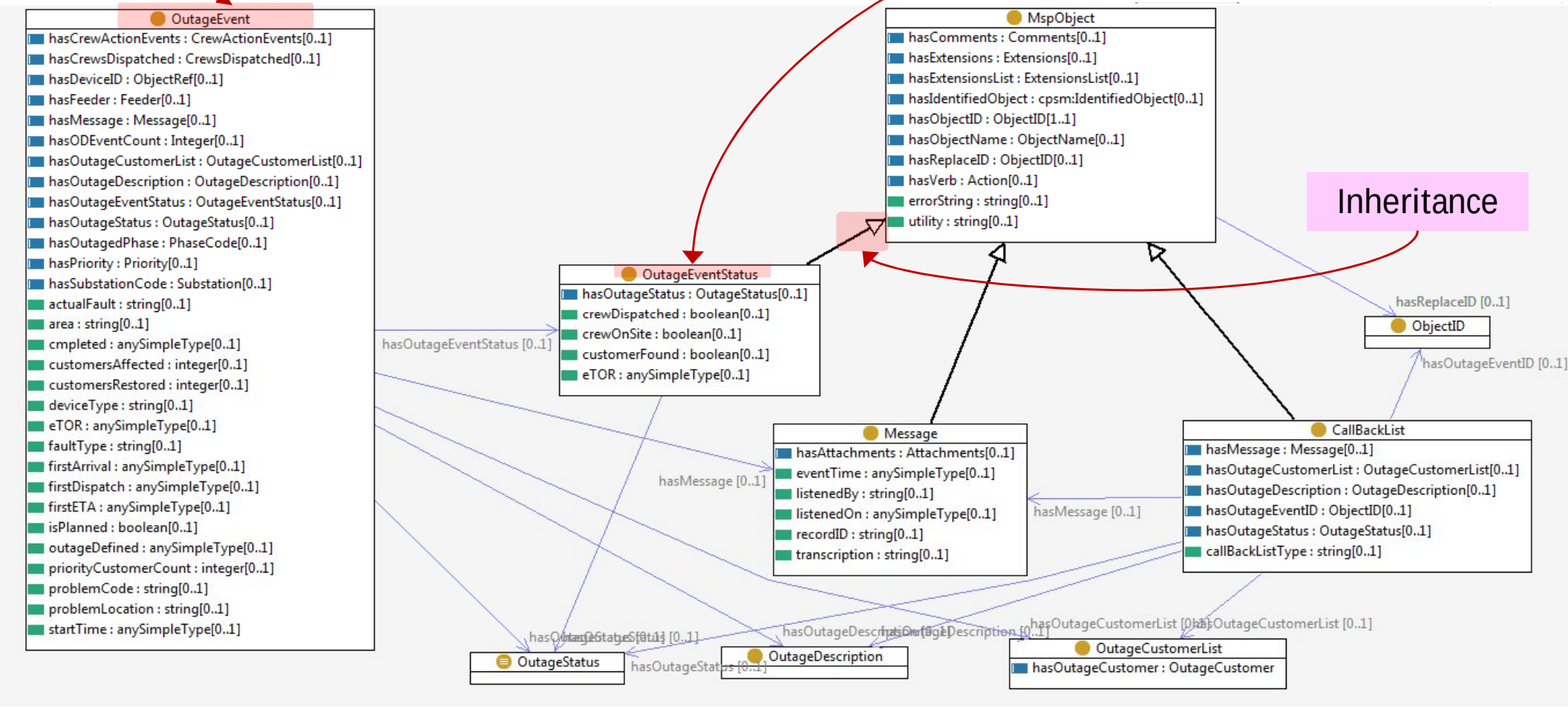
Properties



Example 1: Outage Event

Outage Event Class – showing object properties (associations) with blue icons and datatype properties (attributes) with green icons

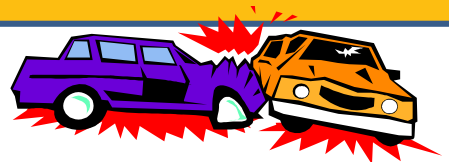
Outage Event Status – an example of an object association

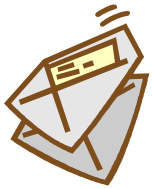


The Netherlands Ministry of Justice Message Builder

Justice Data Exchange covers many Domains of Law

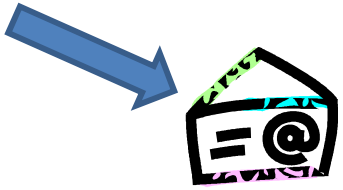
Traffic Violations





Drug Abuse

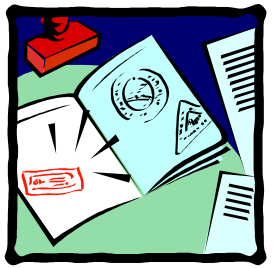
Criminal Justice



Child Care Protection

Litigation

Immigration

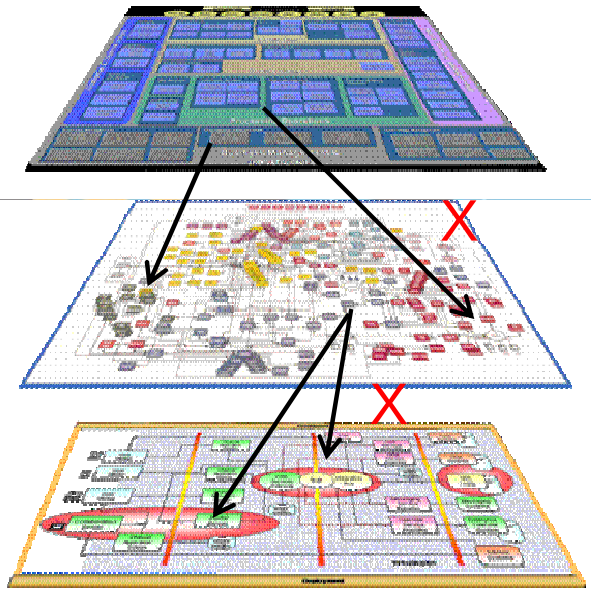


Seamless data exchanges are challenging:

Unique data requirements exist at courts, police, hospitals, border control, motor vehicle, local and federal offices.

“Living in the XML Ecology”: Challenges

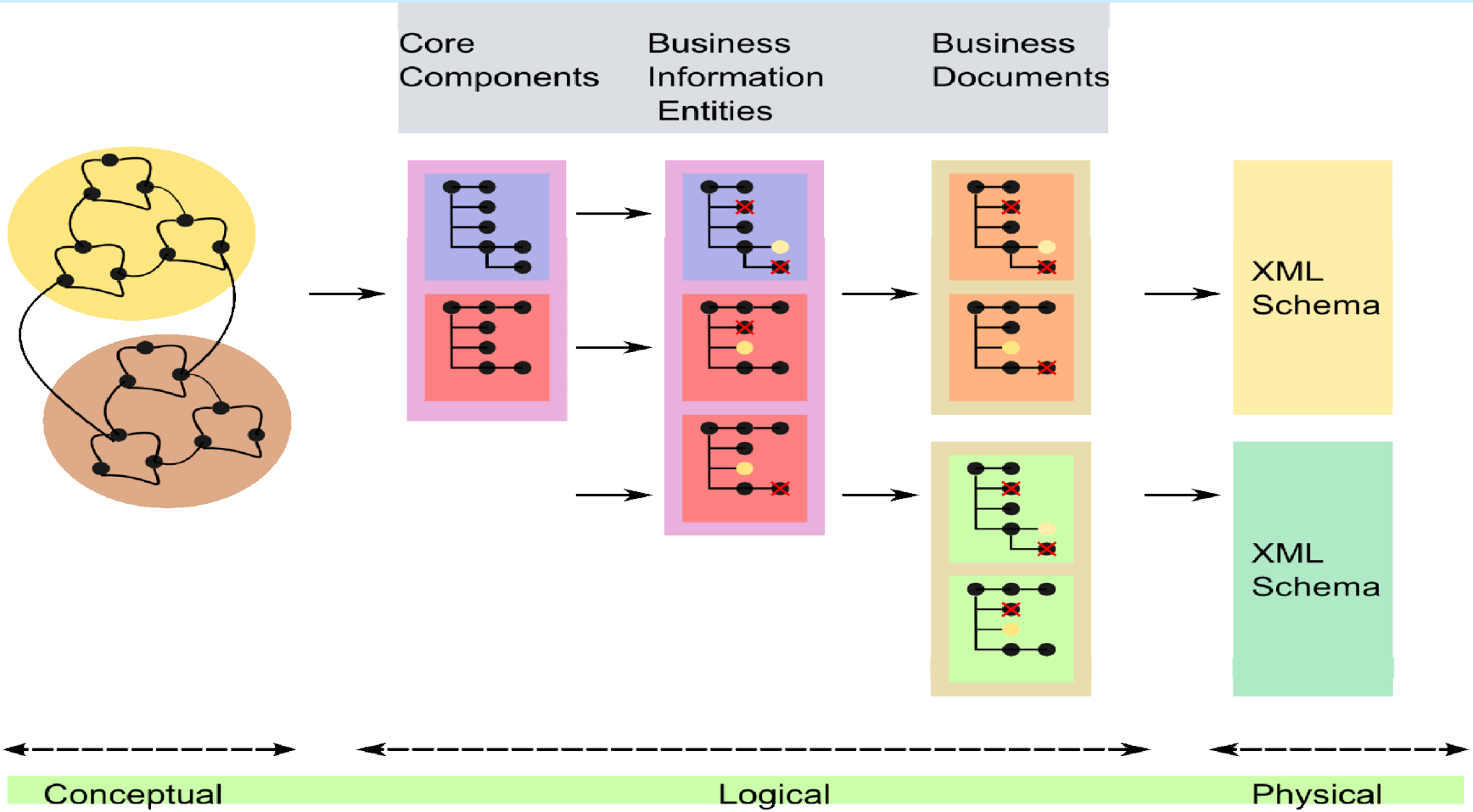
- Addressing the "standards dilemma“
  - Too many exchange mechanisms and standards
  - Lack of conformance to XML (and OWL) Naming and Design Rules
- Brittleness in data models:
  - Often very complex,
  - Often incomprehensible
  - Sometimes non-implementable.



Ontology-Driven Approach to Message Design for Interoperability

Solution: Ontology-Based Metadata Workbench:

Transform Domain Models into UN/CEFACT CCTS compliant representation and allow Business Analysts to assemble business documents for electronic messages from Component Parts.



Creation of XML Message Schemas

Rich Ontologies
- Projects
- Contexts
- Domains

CCTS Ontologies
- Business Document Ontologies
- Business Component Overlay
- Core Component Overlay

CCTS Document

CCTS XML SchemaPlus

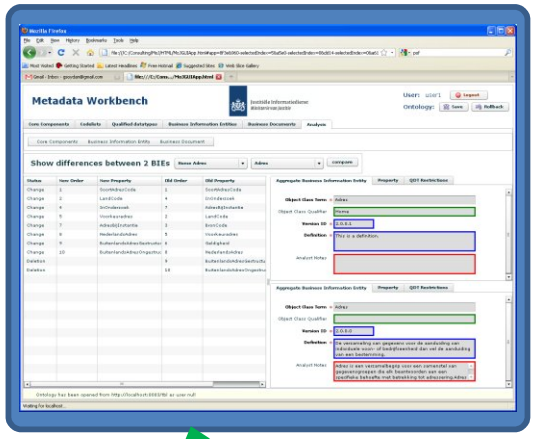
CCTS XML Schema

CCTS-Compliant XML Schemas are generated from the XSP Document

SPIN Transformation rules

CCTS MetaModel

CCTS Document Editor



XSP Generation

XSP MetaModel

XSD Generation

XSLT Script

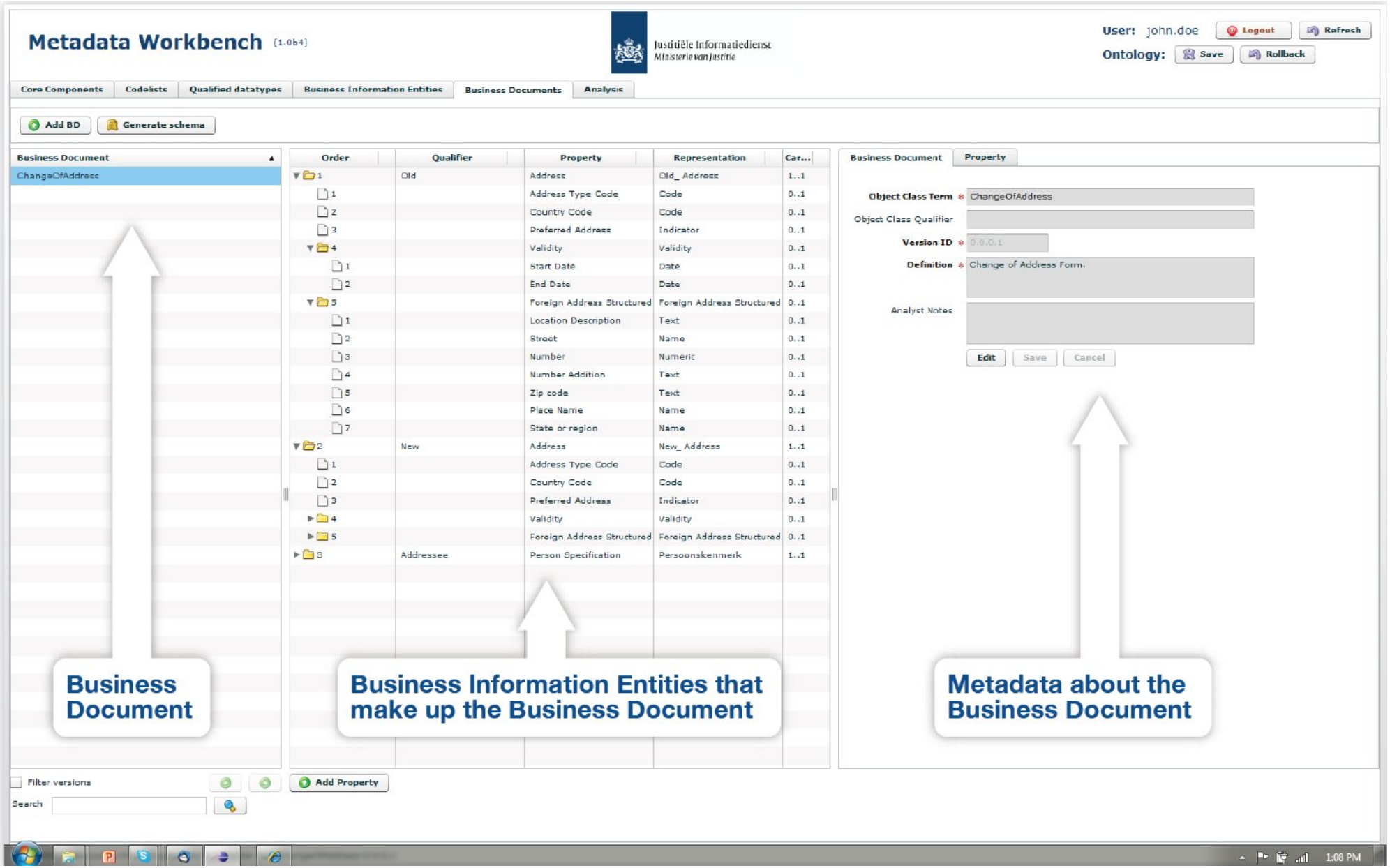
"Rich" Ontologies are expressive models of domains. These include LKIF and detailed situations of law and legal document and procedures.

Users create CCTS documents from BIEs and Core Components

Acronyms

BIE	Business Information Entity
CCTS	UN/CEFACT Core Component Technical Specifications
LKIF	Legal Knowledge Interchange Format
SPIN	SPARQL Inferencing Notation
XSLT	XSL Transformations (XSLT) Version 2.0
XSP	XML SchemaPlus

The Netherlands Ministry of Justice Metadata Workbench



Example of a User Composing a Business Document from the CCTS Core Vocabulary.

Benefits of the MoJ Solution

- Business Benefits
  - Accurate and rapid Information Sharing between Organizations
  - Agility in response to Legislation Changes
  - Data Quality is guaranteed
  - Reduced Costs of Message Schema Development
- Technical Benefits
  - Direct and flexible Reuse of Data Components
  - Full Automation of XML Schema creation
  - Semantic Consistency is preserved and confirmed
  - Linked Data / traceability
  - Version Management


EnterpriseData Journal
DATA SOLUTIONS FOR BUSINESS LEADERS
HOME | ARTICLES | NEWS | BLOGS | RESOURCES | EVENTS | LOGIN
Home
SHARE Print
The Netherlands Ministry of Justice Metadata Workbench: Composing XML Message Schemas from OWL Models
Article | 03.05.10 | By EDJ Staff
Authored by: Harry Biersteker and Ralph Hodgson
Exchanging information between government parties requires a consistent, reusable and repeatable approach to specifying data exchanges as structured electronic business documents built from components. At the Ministry of Justice in The Netherlands, hereafter referred to as "The MoJ," a new approach is underway to construct XML Schemas from OWL Ontology Models.
The MoJ is challenged to handle the complexity of electronic message exchange. With ten central information systems on a government level, specialized information systems for the criminal chain, juvenile chain, immigration services and over twenty organizations communication is a big undertaking. As a principal

See Enterprise Data Journal Article for more details on this solution:

- http://www.enterprisedatajournal.com/article/netherlands-ministry-justice-metadata-workbench-composing-xml-message-schemas-owl-models.htm