Developing a Semantic Framework for Smart Grid

Jay Britton
jay.britton@areva-td.com
Interoperability Categories

Organizational

8: Economic/Regulatory Policy
7: Business Objectives
6: Business Procedures

Informational

5: Business Context
4: Semantic Understanding
3: Syntactic Interoperability
2: Network Interoperability
1: Basic Connectivity

Technical

- Political and Economic Objectives as Embodied in Policy and Regulation
- Strategic and Tactical Objectives Shared between Businesses
- Alignment between Operational Business Processes and Procedures
- Awareness of the Business Knowledge Related to a Specific Interaction
- Understanding of the Concepts Contained in the Message Data Structures
- Understanding of Data Structure in Messages Exchanged between Systems
- Mechanism to Exchange Messages between Multiple Systems across a Variety of Networks
- Mechanism to Establish Physical and Logical Connections between Systems
Some definitions...

- **Semantics** refers to the meaning of a set of information.
- A **semantic model** is a structured description of the semantics of a set of information, using some information modeling language (e.g. UML).
  - A semantic model contains ‘metadata’.
  - Many different semantic models are possible for the same semantics, even within one modeling language.
  - Semantic modeling only represents information content – it does not include formatting/encoding (syntactical) specifications.
- A **semantic transformation** is a procedure for converting a given semantic from one semantic model representation to another.
  - This is to be distinguished from a syntactic transformation that would convert a set of information governed by one semantic model from one format to another.
A **canonical data model** (CDM) is a semantic model chosen as a **unifying** model that will govern a collection of data specifications.
Example usage of CDM to define standard interfaces.
Considering the possibility of a single unified model.

• Definition: a unified model:
  – Is ‘normalized’ (no duplicate modeling of the same semantic).
  – Covers the entire problem scope of Smart Grid.

• Challenges:
  – A scope as large as Smart Grid has to be partitioned somehow into domains so that different focus groups can operate in parallel.
  – The difficulty of coordinating normalized modeling goes up exponentially with the number of different domains.
  – There is already significant investment in separate domain models which would have to be changed to achieve a global normalization.
Standard semantic integration within a unified domain – one CDM.
But the real world inevitably has multiple efforts to defined semantic standards.

- Key questions:
  - What happens when CDMs collide?
  - How can we achieve maximum consistency, without killing business domain independence and initiative?
  - This is what the Semantic Framework is trying to answer.
Harmonization: the next best thing for coordinating CDMs.

• Definition: two CDMs are harmonized if:
  – There is a lossless transformation defined between all duplicated semantics.
  – Both sides undertake to maintain the harmony, once established.
Standard semantic integration between harmonized domains – two CDMS.
The Semantic Framework needs to define where we unify and where we harmonize.

- Pragmatic objectives:
  - Minimize the number of CDM domains.
  - Minimize complexity of inter-domain exchanges.
  - Clarify scope and eliminate overlaps between domains.
  - Create contracts between adjacent CDMs that define how to move information between domains.

- The Semantic Framework technical strategy includes:
  - Unify some domains (as CIM has done).
  - Harmonize others in a peer-to-peer contract for transformation -- this is the strategy that preserves existing investment.
  - Create a shared abstract model for common modeling fragments (calendar?, price?, address?, ...).
The Conceptual Model provides a reasonable starting point for dividing Smart Grid by functions.

- **Markets**
  - Market Mgmt
  - Market Ops
  - DER Aggregation
  - Retailer
  - Wholesaler
  - Trading
  - Ancillary Ops

- **Network Operations**
  - Scada
  - EMS
  - DMS
  - Demand Response
  - Network Planning
  - GIS
  - Trans Planning
  - General Ops
  - Asset Mgmt
  - Work Mgmt
  - Meter Data Mgmt

- **Service Providers**
  - Customer Mgmt
  - Billing
  - Account Mgmt
  - Home Mgmt
  - Bldg Mgmt

- **Networks**
  - Nuclear Plants
  - Coal Plants
  - Gas Plants
  - Hydro Plants
  - Pumped Storage
  - Biomass Plants
  - Geothermal Plants
  - Wind Farms
  - Solar Farms

- **Substations**
  - Monitoring
  - Control
  - Relaying
  - WAMS
  - Lines
  - Special Protection
  - Schemes

- **Feeders**
  - Monitoring
  - Control
  - Relaying
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- **Meters**
  - Home
  - Buildings
  - Commercial/Industrial
  - Electric Vehicle

Source: NIST Smart Grid Framework 1.0 Sept 2008
Recasting the Conceptual Model for Semantic Mapping