SMART GRID SEMANTIC MODEL

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Acknowledgements

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1 Introduction

Some of the most challenging Use Cases of the Smart Grid involve the exchange of information across multiple Domains, and among devices and subsystems of diverse complexity. Not only do the Use Cases rely on interoperable communications between such devices, they rely on the availability and proper configuration and access through several ownership and management boundaries. For example, consider that real-time pricing involves, ultimately, the collaboration between Operations (Energy Management System), Markets (Pricing), Distribution (including distributed resources), Customer (Meter, Appliances).

This white paper describes the use of the concepts of Semantic Modeling and Canonical Data Models as a means of facilitating interoperability across such Smart Grid collaborations. Additionally, the subject is related to the GWAC Stack [1] as a means of localizing where specifically this level of interoperability provides benefit.

2 Multiple Perspectives

The shape and nature of the applications which must collaborate reveal multiple perspectives (which are classes of device/subsystem complexity and communications quality). For example:

Enterprise Perspective -- this perspective of information allows the Smart Grid to be viewed functionally and operationally almost as a single "machine".

Device Perspective -- this perspective allows information that must originate or be distributed to devices to be properly configured and maintained.

Digest Perspective -- although all customer devices are indeed devices, the constraints of cost and bandwidth available for small, potentially shrink-wrapped, and often battery operated devices requires especially compressed and shortened messages.

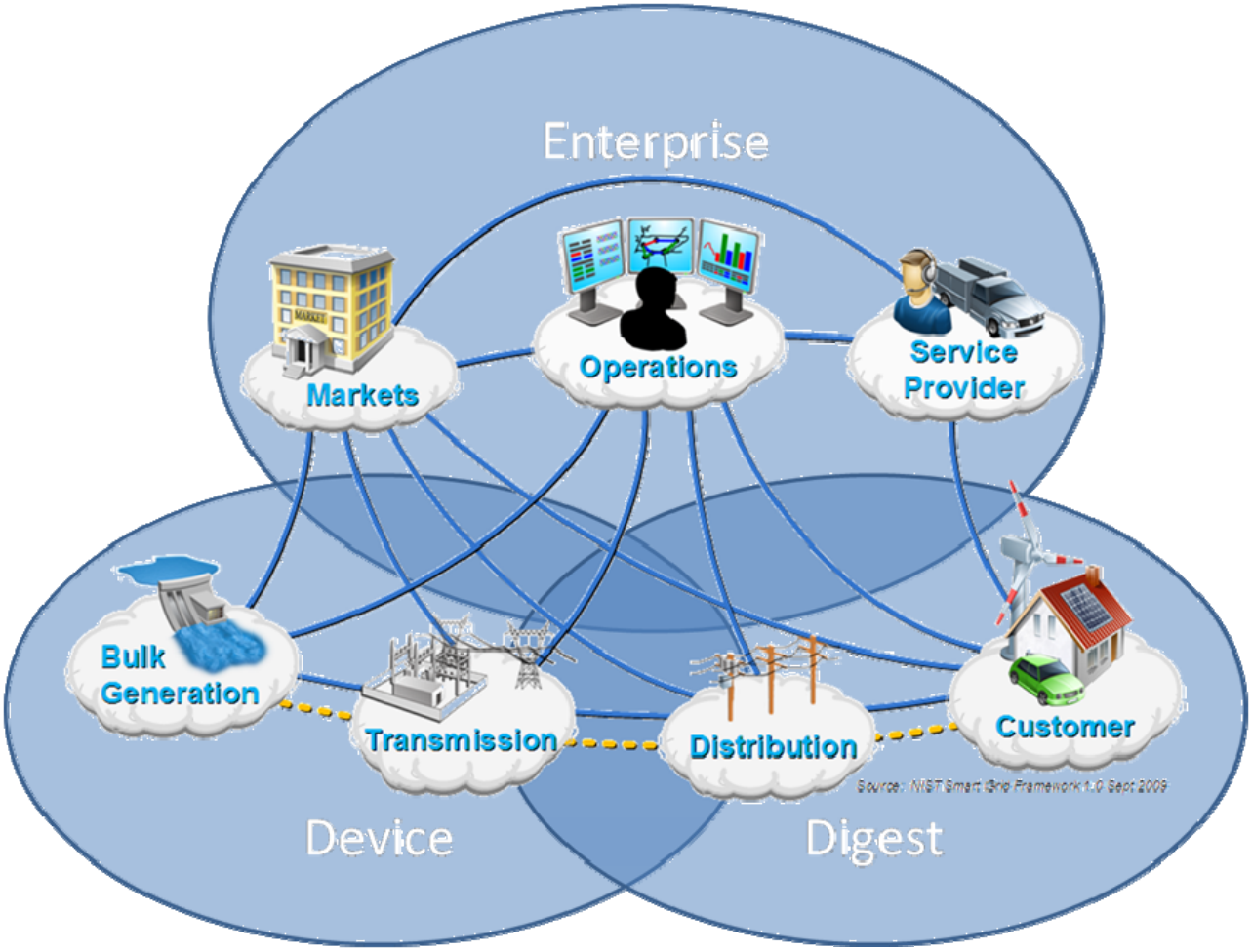

Figure 1: Common Semantic Model Perspectives

It is important to recognize the usefulness of having multiple perspectives. It may not be appropriate to make all practitioners operate under a single, context-free perspective. Each perspective brings with it a terminology and a world view. The important thing is to make sure that the unstated assumptions within each world view are made explicit when moving information from one perspective to another.

3 Problem Statement

For Smart Grid applications to be successful, it must be possible for information to be transferred between computers operating under these varied perspectives. This information can either be transferred algorithmically because of the definition of a common semantic model, or, must be hand tailored between varied and different

protocols and data representations. The latter approach is more brittle since the translation process must be performed, rather than one (the common semantic model) to many (the local model), between many to many. This is clearly more costly and therefore less optimal.

4 Semantic Models

Interoperability can perhaps best be defined as achieving the intended interpretation of a communication from one party to another. The notion of interpretation is key here because interoperability is more than the transmission of data or information – it must be correctly understood by the receiving party, who will usually be operating in a different context than the sending party. Because of this change in context, the chance of interpreting information differently becomes greater. How can we minimize the chance of an unintended interpretation of a piece of information? That is the problem that is directly addressed by the use of semantic models.

Semantic models can be thought of as pedantic information models, where assumptions that are taken for granted in any one context are explicitly represented in the model. For example, the notion of something like “price” that might be thought of in one way by a grocer, is thought of differently by a futures trader. Concepts such as tiered prices, of prices that are valid during a defined period of time, etc. must be written down if we want to be sure that both parties to a communication have the same understanding of “price.”

In the context of the Smart Grid, one can imagine a set of definitions for concepts such as “price” above that could be rigorously defined and, just as importantly, modeled in a computer-interpretable formalism. Doing this allows these definitions to be directly incorporated into computerized applications that depend upon effective communication within the smart grid. It is important to note that there can be multiple definitions of concepts like “price” within the system – we do not need to make every player use the same definition – but we must ensure that in any given transaction, both parties understand which definition is being used.

Semantic models can capture definitions and relationships for:

Business actions (functions & behaviors)

Business entities (information objects)

Transactions (messages)

5 Canonical Data Models (CDMs)

One can call sets of definitions Semantic Models, or ontologies, and they can be used to construct context-specific information models that are customized for a particular application domain (such as the use cases being defined within the SGIP). These context-specific information models are sometimes called Canonical Data Models (and this term will be used going forward in this paper), and are specializations of the definitions found in the broader semantic models for the grid. By documenting the specialized definitions, it becomes possible to see precisely what assumptions are being made in a given use case.

In a given integration situation, one generally needs joint-perspective, scenario-specific agreements on usage of terms between partners, with different agreements for different combinations of partners. One need not force agreement on all terms in the two partner contexts – just the terms that are used in the specific interactions under development. This “intersection of terms” is called the Joint Action Model in [4], and would be built from the canonical data models of two or more domains sharing information.

6 Use of Semantic Models in the Smart Grid

Semantic modeling for the electric power industry is a “maturing” technology. The use of a CDM is a well accepted technique, and several power industry SDOs have been developing canonical data models as part of the process of standardizing interfaces in their particular parts of the overall power industry application space. There are gaps and overlaps in the coverage of these CDMs, however, as well as differences in modeling approaches, degree of maturity, and methods for deriving and implementing standards. Despite these challenges, there is a great deal of potential value that can be applied to development of the Smart Grid.

The Priority Action Plans (PAPs) [3] of the SGIP currently rely on common definitions of information models -- PAP03 (Pricing), PAP04 (Schedule), PAP08 (Distribution models), PAP 10 (Energy Usage Information) for example. What is missing is a clear abstract Common Semantic Model that allows these perspectives to be unified along with these common definitions of information.

Interoperability for the SGIP Architecture Committee is described in terms of the GWAC Stack [1] as presented in the NIST Framework [2]. The GWAC stack describes 8 levels of interoperability technology, each of which builds on the levels below it. Level 4 is called 'Semantic Understanding'. Its purpose is to provide common semantics, encoded as one or more *canonical data models* (cdm), in order to a) provide consistent views of data to implementers across the Smart Grid spectrum, and b) provide this data in forms that can be used to drive generic data services used in constructing interfaces. Level 4 is the lowest level of the GWAC stack where the standards require domain specific information that can only be defined by power industry experts.

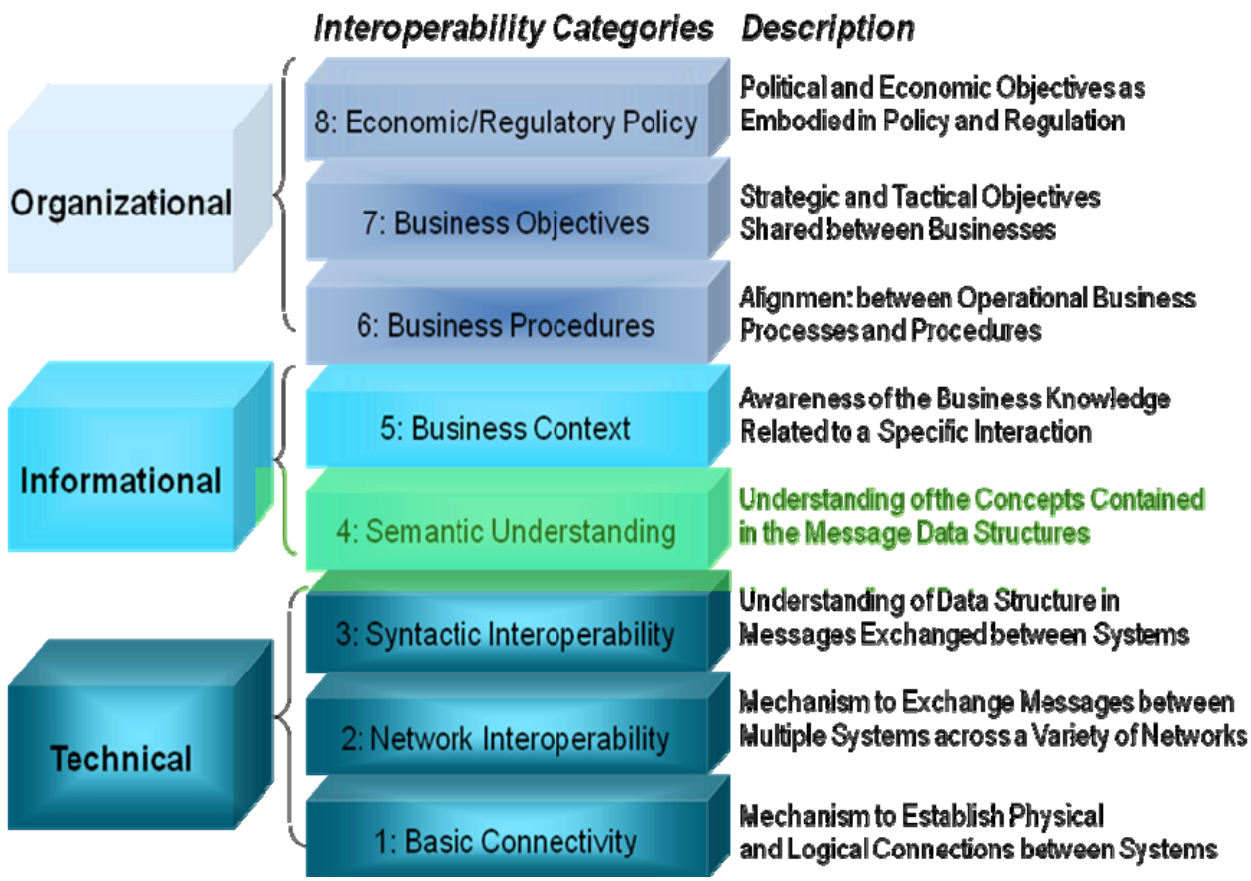

Figure 2: GWAC Stack

Additionally, there are and 10 cross cutting issues. There is the cross-cutting issue "Shared Meaning of Content" which describes semantic modeling at an abstract level, leaving level 4 to represent semantic modeling at the "specific" level. In other words, an abstract common semantic model is a cross-cutting issue. A robust set of

information models represented through inheritance from the common semantic model is at the Level 4 interoperability level.

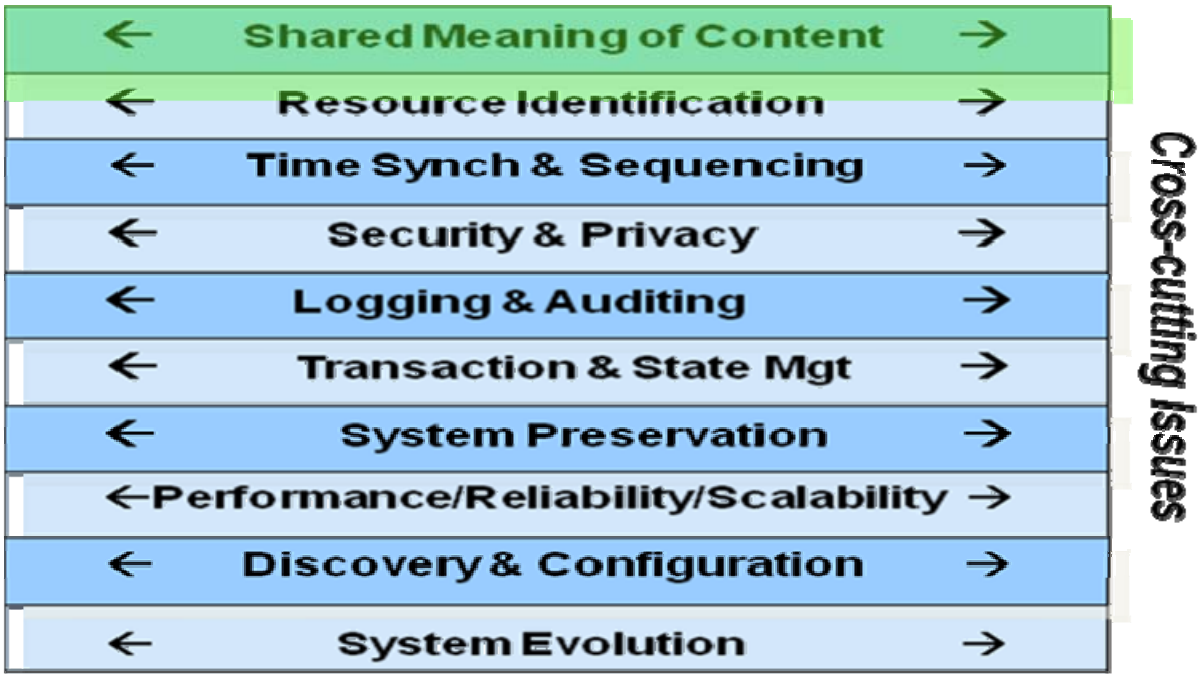

Figure 3: GWAC Stack Cross-Cutting Issues

7 Benefits of using Semantic Models

As mentioned above, while it makes sense to use common terms of practice when defining data models and interfaces within the Smart Grid architecture, the challenge of data integration between parties operating in different contexts will be made much easier if the domain-specific models can be mapped back to common, more abstract definitions of terms in a semantic model. It is through this mapping (which will often take the form of a specialization of a general concept with added constraints) that otherwise implicit assumptions will be exposed. By making these assumptions explicit, one can more easily spot situations where interoperability could become more difficult – before errors are built into applications.

Building integration solutions in such a model-based manner also ensures easier extensibility as the Smart Grid system grows in capability and complexity.

8 Vision

The vision for the Smart Grid Semantic Layer includes:

Standard semantics govern the data payloads communicated via the standard business interfaces identified in the Smart Grid Conceptual Model.

The standard interface semantics are consistent because they are derived from one or more shared *canonical data model* (s).

A common semantic model defines the abstractions from which these canonical data models are derived.

Key data sets are identified.

An understanding is created based on the Conceptual Model as to where key data sets originate and how they are communicated to the applications that need them.

Generic services are defined within Smart Grid architecture for creating and serving historical records of interface activity.

Generic services are defined for events and notifications representing incremental updates of interface data.

9 Existing and Emergent CDMs

Summary of existing and emergent CDMs in Smart Grid standards:

- CIM, MultiSpeak
- 61850
- BACnet
- Smart Energy Profile (ZigBee)
- ANSI C12
- OASIS

Whatever can be accomplished to align and focus these SDO efforts will create significant additional value to the Smart Grid – semantic consistency reduces complexity, lowers life cycle cost and reduces the time required to implement new functions. However, a final, crucial characteristic of semantic modeling is that it is far

easier to establish if it is introduced at the beginning of the design of any particular interface, so it is appropriate to identify priority needs and initiate needed work with all deliberate speed.

10 References

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