A Smart Grid Reference Architecture Drives Information Management at SCE

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Abstract

The word "Smart" in "Smart Grid" implies a higher level of automation in how utilities operate their grid. With so many moving parts (i.e. evolving technologies, standards, regulations, organizations), operating the grid like the human brain operates its body is certainly a complex undertaking. The SCE Smart Grid Reference Architecture (SGRA) serves as a useful starting point for utilities, by addressing questions architects are expected to encounter, helps utilities to develop coherent investment roadmaps, and aides in planning the transition from today's project-oriented systems to a "system of systems" that spans business units.

An emphasis of the SGRA is information management because data sources cannot easily communicate if proprietary or differing data standards are used. To do this, SGRA builds on the NIST Framework and Roadmap for Smart Grid Interoperability Standards (SGIP). But while standards help, they are not sufficient for integrating so many systems and devices into a holistic smart grid.

This paper describes the SGRA and how it is being applied at SCE, highlighting the example of the Energy Services Provider Interface (ESPI) standard, based on the IEC CIM information model. The reuse of standard interfaces simplifies integration and lowers costs.

1. SMART GRID REFERENCE ARCHITECTURE

1.1. Using the Smart Grid Reference Architecture

SCE coauthored the Smart Grid Reference Architecture (SGRA) [1] to provide a guide for a Smart Grid architect to be able to develop specific smart grid architectural designs. This reference model serves as a template for smart grid system design, as a guide to best architectural practices for smart grids, and as a checklist for smart grid system elements. To begin, a process flow is leveraged covers steps not typically addressed in generic architectural frameworks. Referring to figure 1 below, these steps a rational order to execute the design steps to ensure each succeeding step is properly informed by those already completed.

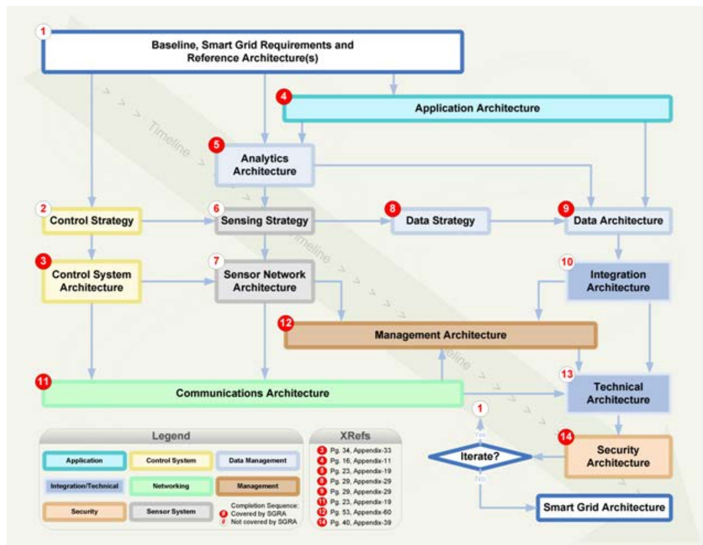

Figure 1 - Smart Grid Architecture Development Process

1.2. Focusing on the Data

Once the analytics and application architectures are specified, the data strategy can be specified, as depicted in step 8 of figure 1. The data strategy includes data governance definition and the data quality plan, as well as overall data representation schema selection/specification. Once the data strategy is defined, the data architecture can be specified (step 9 of Figure 1). The data architecture includes data types, principal databases and data structures, data dictionaries, message schema, master data models, and data flow models. The Reference Architecture provides a checklist of data elements to consider, as well as indications of how they should be integrated and how to use appropriate standards in their implementation, such as ones for ESPI [2] that are described in subsequent sections. Once key system interfaces and interactions are understood, the integration architecture can be defined. This includes system interfaces, middleware, adapters, data and message transformations, and business process choreography.

1.3. Systematic Information Management

An effective Enterprise Information Management (EIM) methodology allows a utility to embrace industry standards as well as create its own internal information model by organizing metadata and models from its existing applications. This is a critical component of an enterprise strategy for creating reusable data services that would otherwise not be achieved with Service-Oriented Architecture (SOA) investments. While many industry models may be helpful, at the core of the SCE Enterprise Semantic Model (ESM) is the utility industry standard Common Information Model (CIM), which was designed for the purpose of integrating disparate utility applications (IEC 61968 and IEC 61970 series of standards). However, as enterprise resource planning (ERP) and supply chain is largely outside of the scope of the CIM, additional industry and proprietary models are employed for these aspects. For communicating with intelligent electronic devices, IEC 61850 contains a rich model that can be incorporated into the ESM.

Each service resource specifies a Canonical Data Model (CDM) that uses a subset of the structures defined in the ESM. A CDM describes the structure or 'signature' of information using a data description language such as XML Schema Definition, or "XSD". The XSD facilitates syntactic integration, but has the benefit of the full semantic definition in the ESM and CIM.

New projects at SCE are generating their CDMs from SCE's ESM - the heart of SCE's model-driven integration concept. The ESM describes information in a way that is independent of its canonical form, using a full UML graph. For example, it is possible to order the elements of an XML document in any way desired without changing the meaning of the information contained in the elements. After all it is not the tag or its position in the document that defines that information. Because of this, compact CDM representations are also possible, since any token can be used to identify the field, while traceability is maintained to the semantics.

So in similar fashion as IEC 61968 message types are model-driven from the CIM, SCE's enterprise CDMs are model-driven from its ESM. This approach allows for internal flexibility, but adheres to the standard model whenever possible. If a given industry standard meets SCE's data requirements for a given interface, then CDM will be the same as the standard interface. So while SCE has the ability to systematically extend standard interfaces when necessary, it does not sacrifice the benefits of using industry standards when doing so.

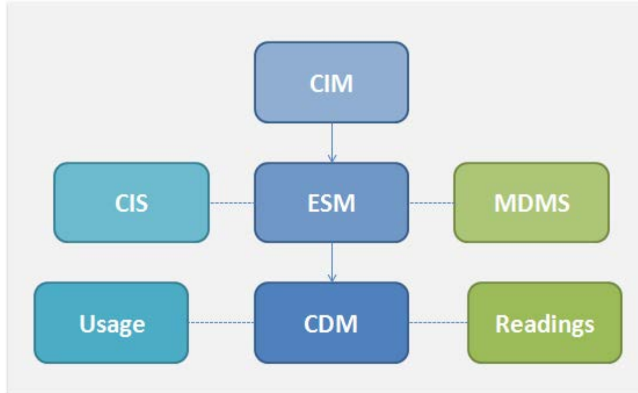

Figure 2 – CIM, ESM, and CDM Relationships

This process minimally ensures that systems are loosely coupled, since all adapters translate to and from the CDM formats, never directly to another proprietary interface or format. In the case where systems also use the same models, or implement the common services directly, the adapters are much simpler, and may not be needed at all. In addition, mappings can be stored with respect to the ESM or CIM, instead of the CDM, so that new translations can reuse existing logic.

2. ENERGY SERVICES PROVIDER INTERFACE

One of the primary drivers for Smart Grid technology is the ability to shift load away from peak consumption times, especially when generation is stretched to the limit. In order to do that, simple interfaces are needed to communicate data with customers and affect their energy usage.

The Smart Energy protocol allows home area network (HAN) devices to receive signals directly, usually through service endpoints in the electric meters. Another option is to use the Internet to exchange customer-specific data with their third-party agents, who can then provide management and scheduling services however they choose. The SGIP recognized this priority and has been nurturing the development of usage data exchange protocols. The initiative recently resulted in the ratification of a new North American Energy Standards Board (NAESB) model business practice, the implementable interface definition ESPI.

By implementing ESPI, third-party energy services providers can allow their customers to authorize the exchange of their energy usage information from utilities who have also implemented ESPI. To manage interoperability across numerous implementations, the OpenSG users group within UCAIug, where the requirements originated, is also where the community is building the capability to certify conformance to the interface.

2.1. Savings through Reuse

To conceptualize the cost savings of the standard interface architectural pattern, imagine that each utility and third party defined their own interface for this purpose. Even with a simple ecosystem, where there are six providers and six consumers, each implements their own interface plus six adapters, as well as identifier correlation storage for each. If each implementation costs one hundred dollars, and each adapter costs fifty (they actually cost more), then the multi-interface price would be 12 * $100 + (12 * 6) * $50 = $1,200 + $3,600 = $4,800. If everyone implements the same interface, even if that means each participant builds an adapter to the common one, the cost is only $1,200 + (12 * $50) = $1,800, a savings of over 60%!

2.2. Extensibility and Loose Coupling

A critical feature of reusable standard interfaces is the ability to support a variety of versions of the interface simultaneously. The first version of ESPI, for example, only defines models for usage readings, power quality summaries, and usage summary data. Additional information, such as demand response events, rate schedules, and informational messages, will be need to be added without breaking any existing implementations, but clients will adopt different features and versions at different times. By only adding new optional elements, it will be possible to support multiple versions of clients, using the interface for various reasons.

The initial version of the protocol includes the basic elements of any data interface, including initial configuration, user resource authorization, and delivery. Multiple delivery options are specified, including automated subscription and asynchronous delivery using polling, push or pull, as well as on-demand synchronous request. Because of this, future versions will only need to specify new object definitions, and the existing mechanisms can be used as-is. New encodings or capability negotiation could also be added. But implemented clients won't stop working when servers are upgraded. Nor will servers have problems if newer clients connect, since everything new will be optional.

2.3. Power of Ecosystem

Because ESPI was built on existing standards, including HTTP, XML, Atom Publishing Protocol, Open Authorization, and the IEC CIM object model, additional savings are realized due to the existence of communities around each technology, providing examples, discussions, experts, libraries, and products that implement much of the functionality.

2.4. Scalability

ESPI was also designed to be massively scalable, by adhering to best practices from the latest in web design. Namely, publication servers are not required to save client session information, and by using basic HTTP verbs appropriately, caching techniques can be used to the fullest benefit. This means that additional servers can be added as necessary to meet demand.

2.5. Uses

Because the interface was designed as a general-purpose data sharing capability, it meets the needs of a number of scenarios. The California Public Utility Commission (CPUC) has been advocating for and requesting this sort of capability from California IOUs, and ESPI seems to fit the bill. Since one service can support any number of Third Party Providers and Customers, ESPI is also being discussed for use in related initiatives, including Plug-In Electric Vehicle (PEV) submetering, as well as third party customer access for the "Green Button" initiative.

3. CONCLUSION

By adhering to industry best practices, including loose coupling, standardization and reuse, dependencies between systems can be minimized. This enables the move from siloed architectures into federated and distributed systems architectures. This progression allows for integration with the larger ecosystem of services, so that information can be available when and where it is needed, in order to support the demands of Smart Grid and beyond.

References

[1] SCE, Cisco, IBM, "Smart Grid Reference Architecture," 2011

[2] NAESB, "Energy Services Provider Interface Standard (R10008, REQ.21)," 2011

Biography

Jeff Gooding, IT General Manager of Smart Grid Engineering at Southern California Edison, is responsible for managing the architecture and engineering team that supports the Edison SmartConnect project, SCE's Advanced Metering Infrastructure (AMI) Program. Jeff holds M.B.A. and B.S. degrees from California State Polytechnic University, Pomona.

Greg Robinson is the general manager of Xtensible Solutions, an ESCO Technologies company. Xtensible provides enterprise information management and integration services to utilities. Greg is the international convener of IEC TC57 Working Group 14 (IEC 61968 series of standards), which is extending the Common Information Model (CIM) for utility enterprise-wide messaging. He is also a member of the NIST Smart Grid Interoperability Panel (SGIP), IEEE Power Engineering Society, the DistribuTECH Advisory Committee, and OpenSG, where he co-chairs of the Enterprise Information Management (EIM) Task Force. Participating in these organizations enables Greg to help companies leverage and drive industry standards to their benefit while simultaneously aiding the standards development process. He has a BSEE from Georgia Tech and a MBA from the Florida Institute of Technology.

Steve Van Ausdall is a Senior Solutions Architect with Xtensible Solutions, providing standards-based integration architecture and interface design services to the utility industry. Steve is vice-chair of the OpenSG OpenADE task force working on PAP10-related usage data sharing initiatives, is co-chair of the NAESB ESPI task force, and is also a technical editor providing modeling and service definition expertise for the Smart Energy Profile 2.0.