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TECHNICAL REPORT

colour inside

Information technology – Home electronic system application model – Part 3-2: GridWise – Interoperability context-setting framework



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Information technology – Home electronic system application model – Part 3-2: GridWise – Interoperability context-setting framework

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Part 3-2: GridWise – Interoperability context-setting framework

FOREWORD

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ISO/IEC TR 15067-3-2, which is a Technical Report, has been adopted and adapted by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This Technical Report is closely based on the document GridWise®[1] Interoperability Context-Setting Framework (March 2008), prepared by The GridWise Architecture. Also, the original structure of the technical part of this document has been maintained.

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1 GridWise® is a registered tradename by The GridWise Architecture Council.

This Technical Report has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

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INFORMATION TECHNOLOGY – HOME ELECTRONIC SYSTEM APPLICATION MODEL –

Part 3-2: GridWise – Interoperability context-setting framework

1 Executive Summary

As the deployment of automation technology advances, it touches upon many areas of our corporate and personal lives. A trend is emerging where automation systems are growing to the extent that integration is taking place with other systems to provide even greater capabilities more efficiently and effectively. GridWise provides a vision for this type of integration as it applies to the electric system.

Imagine a time in the not too distant future when homeowners can offer the management of their electricity demand to participate in a more efficient and environmentally friendly operation of the electric power grid. They will do this using automation technology that acts on their behalf in response to information from other automation components of the electric system. This technology will recognize their preferences to parameters such as comfort and the price of energy to form responses that optimize the local need to a signal that satisfies a higher-level need in the grid.

For example, consider a particularly hot day with air stagnation in an area with a significant dependence on wind generation. To manage the forecasted peak electricity demand, the bulk system operator issues a critical peak price warning. Their automation systems alert electric service providers who distribute electricity from the wholesale electricity system to consumers. In response, the electric service providers use their automation systems to inform consumers of impending price increases for electricity. This information is passed to an energy management system at the premises, which acts on the consumer's behalf, to adjust the electricity usage of the onsite equipment (which might include generation from such sources as a fuel cell). The objective of such a building automation system is to honor the agreement with the electricity service provider and reduce the consumer's bill while keeping the occupants as comfortable as possible. This will include actions such as moving the thermostat on the heating, ventilation, and air-conditioning (HVAC) unit up several degrees. The resulting load reduction becomes part of an aggregated response from the electricity service provider to the bulk power system operator who is now in a better position to manage total system load with available generation.

Looking across the electric system, from generating plants, to transmission substations, to the distribution system, to factories, office parks, and buildings, automation is growing, and the opportunities for unleashing new value propositions are exciting. How can we facilitate this change and do so in a way that ensures the reliability of electric resources for the wellbeing of our economy and security? The GridWise Architecture Council (GWAC) mission is to enable interoperability among the many entities that interact with the electric power system. A good definition of interoperability is, "The capability of two or more networks, systems, devices, applications, or components to exchange information between them and to use the information so exchanged."[2] As a step in the direction of enabling interoperability, the GWAC proposes a context-setting framework to organize concepts and terminology so that interoperability issues can be identified and debated, improvements to address issues articulated, and actions prioritized and coordinated across the electric power community.

By a context-setting framework, we mean something at a high, organizational level (see Figure S.1), some neutral ground upon which a community of stakeholders can talk about

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2 "EICTA Interoperability White Paper," European Industry Association, Information Systems Communication Technologies Consumer Electronics, 21 June 2004.

issues and concerns related to integrating parts of a large, complex system. Borrowing concepts from the Australian National E-Health Transition Authority, a *framework* sits at a broad, conceptual level and provides context for more detailed technical aspects of interoperability. In contrast, "A *model* (or architecture) identifies a particular problem space and defines a technology-independent analysis of requirements. The *design* maps model requirements into a particular family of solutions based upon standards and technical approaches. Finally a *solution* manifests a design into a particular vendor software technology, ensuring adherence to designs, models, and frameworks." [3]

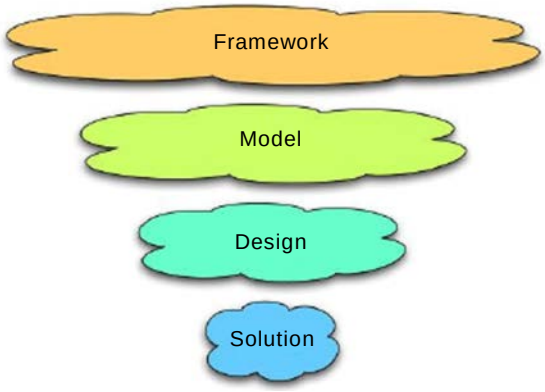


Figure S.1 – A Framework Provides High-Level Perspective

The intent of the interoperability framework is to provide the context for identifying and debating interoperability issues to advance actions that make integration within this complex system easier. The framework recognizes that interoperability is only achieved when agreement is reached across many layers of concern. These layers span the details of the technology involved to link systems together, to the understanding of the information exchanged, to the business processes and organizational objectives that are represented in business, economic, and regulatory policy.

Besides introducing new opportunities and benefits, the application of information technology (IT) also introduces a new set of challenges. As they contribute to all economic sectors, traditionally separate applications and infrastructures get more and more interconnected. Effects and decisions within each critical infrastructure influence the other infrastructures much more than before. The framework identifies the key interoperability issue areas and can help resolve interdependencies within the electric system and with other infrastructures. It reflects the increasingly important role of IT in the electric system, resulting in an electricity plus information (E+I) infrastructure. The framework also enables the representation and exchange of ideas with other critical infrastructure domains. It supports comparing, aligning, and harmonizing technical approaches with accompanying management procedures and business processes.

Figure S.2 summarizes the layered interoperability categories according to technical, informational, and organizational groups. In addition to these categories of interoperability, the framework proposes a classification of interoperability issues that cut across the layers. This document introduces these issue areas with the intent to explore and articulate the detailed nature of each issue area in separate documents engaging interested experts in their creation. The cross-cutting issues represent the areas we believe should be focused on to start improving interoperability across the web of electricity concerns.

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3 National E-Health Transition Authority (NEHTA), "Towards an Interoperability Framework, v 1.8," August 2005. (www.nehta.gov.au)

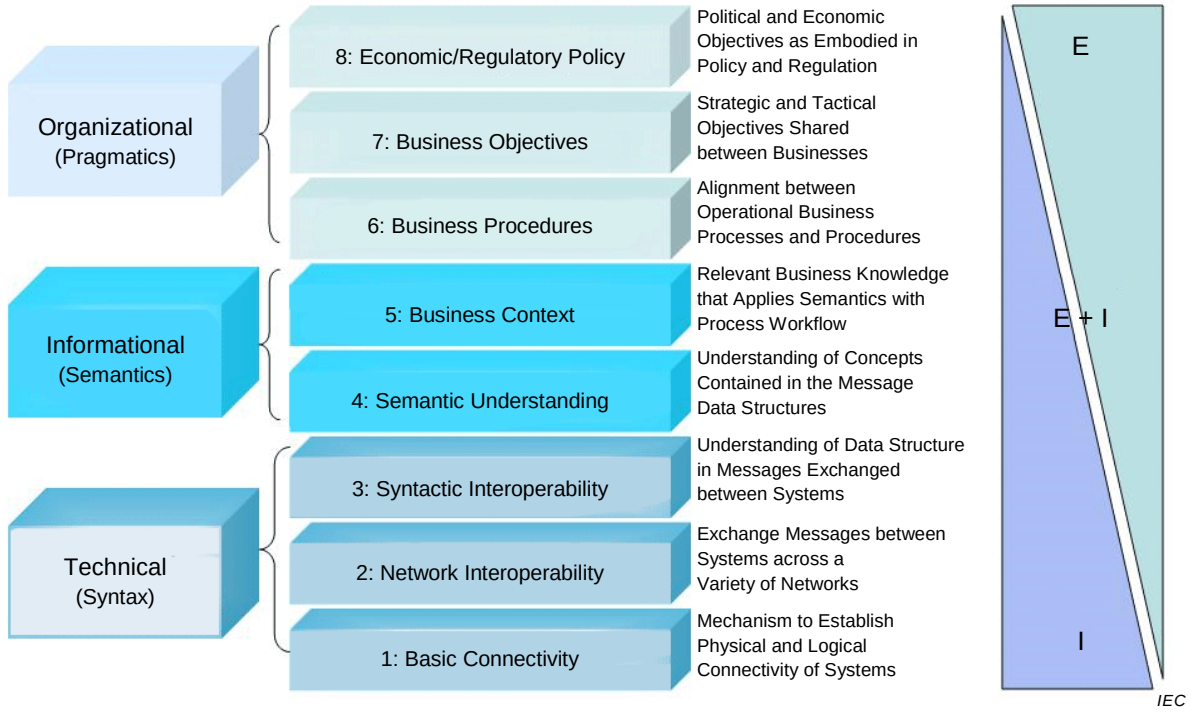


Figure S.2 – Interoperability Framework Categories

The audience for this document are system architects and integrators with the ability to participate in establishing a technical foundation to discuss interoperability, articulate issues to achieving interoperability, and develop proposals to improve the situation. It presumes the reader is knowledgeable of complex system integration and the technical, informational, and organizational issues that surround this area. This technical document lays the foundation for future, companion material to targeted purposes and audiences. Ideally, the reader will consider the application of the concepts presented in this material to their field of interest to help address interoperability challenges as well as to provide suggestions on improvements to this material.

The GWAC realizes that other versions of the framework should be tailored to speak to the interests of other audiences, such as regulators, business decision-makers, system operators, and system suppliers. This material may consist of white papers, checklists, or other forms of presentation.

To introduce this framework, we provide some background for this work in the context of past GWAC activity and establish some basic concepts and terminology. We then state some important points about the system-integration philosophy that influences the way automation components are expected to interface and operate in a collaborative manner in something as complex as the electric power system. These philosophical tenets are important because they emphasize the needs of the system integrator and underlie many of the statements made about the interoperability categories and the cross-cutting issues that are described in subsequent sections. The set of layered interoperability categories and the cross-cutting issues is followed by some clarifying examples.

The document closes with an acknowledgement that such a framework is a living concept, and therefore, a process needs to be put in place to govern its evolution over time both in terms of concepts and the material used to convey these concepts. If such a framework is to be helpful to interoperability improvements, the diverse stakeholders in the electric system should take ownership and have access to participate in its development. This then is the first of an evolutionary series of documents to describe an interoperability framework and articulate interoperability issues that assists discussions with participants at all levels. Providing venues for participation in this work is an important aspect of engaging the electricity community.

The process to specify and develop future material requires the participation of the electricity community. Figure S.3 provides a conceptual view of companion material envisaged to follow from the framework. These works include executive summaries for targeted audiences, technical papers that articulate interoperability issues and proposed approaches to address them, checklists, tools, use case scenarios that provide examples of applying the framework, and other similar documents.

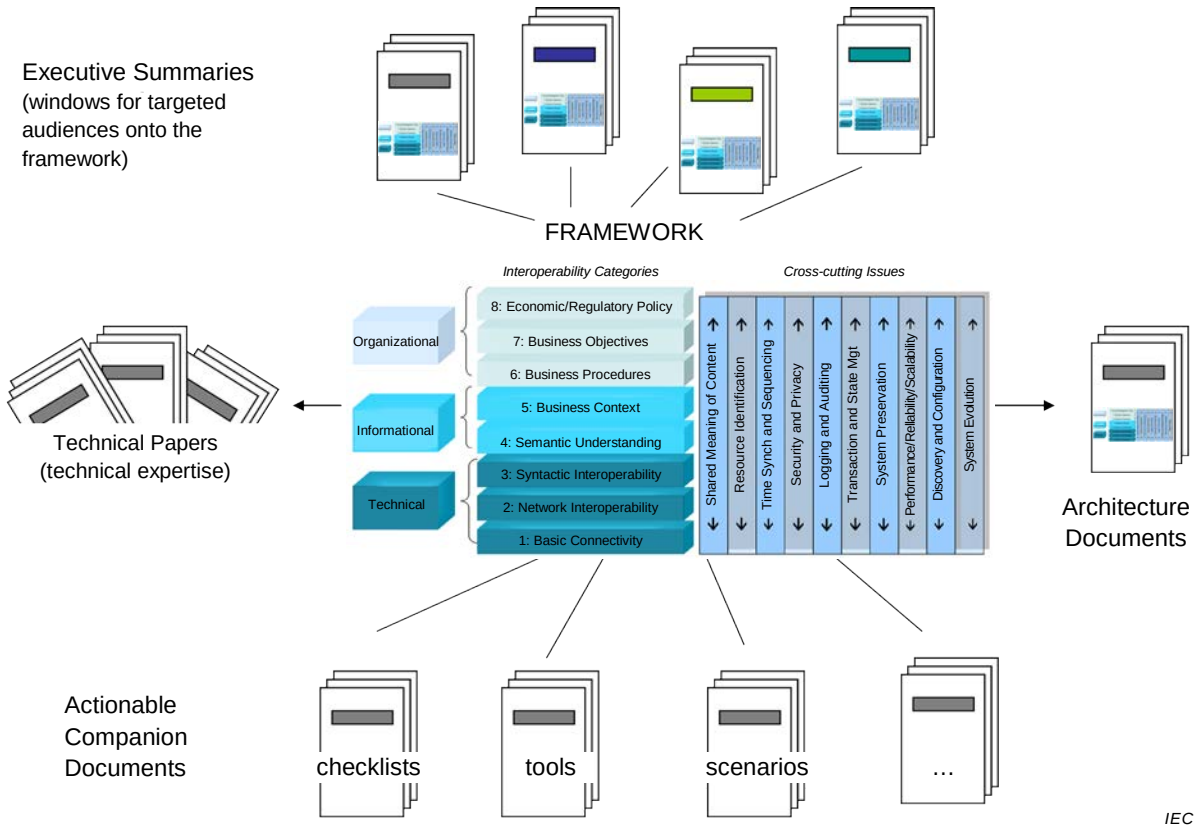


Figure S.3 – Interoperability Framework Companion Material

2 Introduction

The Gridwise Architecture Council (GWAC) exists to enable automation among the many entities that interact with the electric power infrastructure. Though we do not prejudge what this automation will be used for, once it is enabled, we presume that, given opportunity, many possibilities will be explored, and much economic and social good will result. The GWAC mission is merely to enable. The goal is a concept called *interoperability*, which incorporates the following characteristics:

- exchange of meaningful, actionable information between two or more systems across organizational boundaries
- a shared understanding of the exchanged information
- an agreed expectation for the response to the information exchange
- a requisite quality of service: reliability, fidelity, and security.

The result of such interaction enables a larger interconnected system capability that transcends the local perspective of each participating subsystem.

A commonly understood objective for interoperability is the concept of “plug-and-play”. With plug-and-play, the system integrator is able to configure an automation component into the system simply by “plugging” it in. Behind the scenes, automated processes determine the

nature of the newly connected automation component and the component determines the nature of the system so that it is properly configured and can begin to operation properly. If we consider the level of integration involved as a length or distance, then the “distance to integrate” for plug-and-play is small [1][4].

As attractive as this concept is, achieving plug-and-play is not easy and in many, complex situations it is not practical to specify standard interfaces to this level of detail. For example, consider specifying an interface to an electricity market. Market participants may use software tools to manage the resources that they trade. Integrating these tools with the market interface usually requires some manual changes so the interface agreements are satisfied. The greater the customization and effort to make and test these changes, the greater is the distance to integrate. However, standards or best practices can be used to shorten this distance. For example, a commonly used information model can provide semantics that a community of integrators readily understands. Standard syntax, such as XML, provides a familiar format and structure for use without significant training. With time, things can more closely approach plug-and-play. At least by reaching agreements in specific areas of interoperation, a community can improve system integration and the effort to achieve interoperation. Figure 1 visualizes this concept.

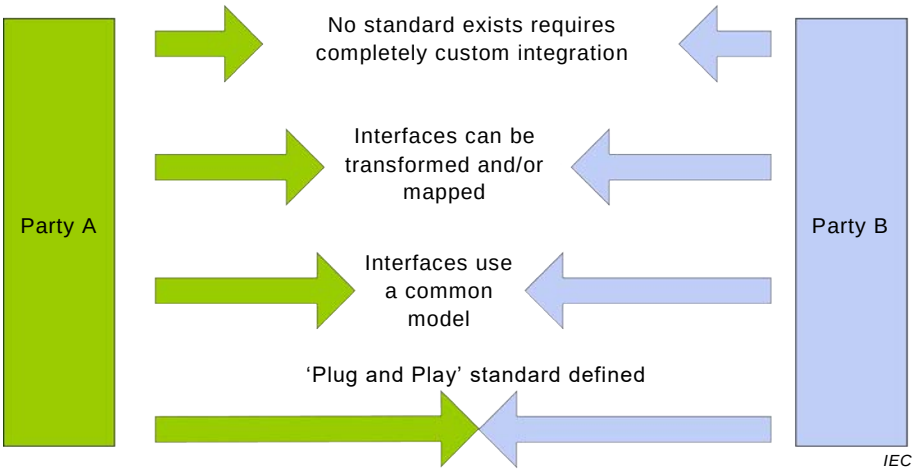


Figure 1 – Distance to Integrate

Why do we want to improve interoperability? Reducing the distance to integrate has a direct impact on installation and integration costs; however, it also creates well-defined points in a system of automation components and business enterprises that allow for new automation components and businesses to connect. This can enable one automation component to be substituted for another with a reasonable amount of effort; it can also provide a path to upgrade automation components in a localized fashion that preserves overall integrated system operation. The power system should accommodate such upgrades so that it can evolve to satisfy changing resources, demands, and more efficient technologies. Substitutability can create an environment where multiple vendors can compete to provide the same automation component capability, where things such as price and reliability become distinguishing characteristics. The same well-defined point of connection can also allow for new capabilities or features to be integrated into the system.

While we emphasize the local point of interaction aspect of interoperation, attention should also be given to broader system issues. Not only should the local dynamics of an interaction be resolved, but also the implications of behavior between automation components and

4 Numbers in square brackets refer to Clause 9, References.

business enterprises should be understood in the context of larger system dynamics. Seemingly, unrelated processes may interact in unforeseen ways to affect system stability in positive or negative ways. The way individual automation components and businesses interact may need to reflect constraints imposed because of larger systemic dynamic conditions.

A path toward enabling interoperability was outlined in GWAC's "Interoperability Path Forward Whitepaper" [2]. An important early step in the path forward is to develop a common understanding of interoperability, the various levels of interoperability, and a categorization of issue areas where a consensus on improvements can better enable interoperability. This document presents a context-setting framework to organize concepts and terminology so that interoperability issues can be identified and debated, improvements articulated, and actions prioritized and coordinated across the electric power community.

2.1 Why Develop a Framework?

The context-setting framework was developed as a tool in support of making the GridWise vision reality. To understand the value of the framework it is necessary to remember that GridWise is not an engineering product to deliver power, but that it is an entirely new way to think about how we generate, distribute and use energy. The framework strives to communicate and organize ideas about distributed system integration that can be used by decision makers, architects, designers, and solution providers within the electric system community. This document supports the discussion of ideas and steps to improve the present system integration situation by providing a structure to identify domains of concern and their interdependencies that need to be addressed through follow-on activities.

Our society is in a paradigm shift regarding the management and evolution of our electric infrastructure as well as other critical infrastructures and the resulting system engineering processes. The traditional approaches helped us to set up successful infrastructures for energy, water, transportation, communication, and many more. System engineering focused on all aspects of the lifecycle of a system, being able to draw clear lines between the system and its environment. This paradigm started to shift with the development of information technology (IT) in the recent decades. IT in the form of communication and computing power is ubiquitous. It allows a new way of information generation and transformation that influences the rules that govern all infrastructures.

While this introduces a new set of opportunities and potential benefits, IT also introduces a new set of challenges. As they contribute to all economic sectors, traditionally separate applications and infrastructures get more and more interconnected. Effects and decisions within each supply chain or critical infrastructure influence the others much more than before. The framework identifies the key interoperability issue areas and can help resolve interdependencies within the electric system and with other infrastructures. It reflects the increasingly important role of IT in the electric system, resulting in an electricity plus information (E+I) infrastructure. The framework also enables the representation and exchange of ideas with other supply chain and critical infrastructure domains. It supports comparing, aligning, and harmonizing technical approaches with accompanying management procedures and business processes.

Within the electricity community, the framework represents a context-setting level in a serious of specification and actions necessary to support the engineering and management processes required to make the GridWise vision a reality. The framework concept was inspired by a similar coordinating effort by the National Electronic Health Trust of Australia [3]. The framework sits at the top level of a hierarchy of well-known system engineering categories:

- A *framework* captures the key domains and their interdependencies in a way that partners can address how their contributions are placed within the overall context. As such, a framework makes no architectural or technical recommendations but establishes a context to discuss alternatives and complementary approaches. The framework is a high-level, operational view common to the electricity community used to communicate within the electricity system to compare, align, and harmonize solutions and processes as well as with the management other critical infrastructure.

- The next category comprises *architectures*. Architectures are the blueprints for solutions addressing the issues identified in the framework. Architectures are derived from the framework by modeling (which means creating meaningful abstractions from reality to identify a bounded and solvable problem space). Many architectures can be derived from the framework and alternative architecting principles and techniques can be applied. The framework is the means to compare alternatives on the operational level and supports managers and decision makers in the process of selection, migration, and development.
- Based on architectures, system engineers create *designs*. In this category, technology and standards become important. While the architecture is the blueprint for the system, the design category comprises the blueprints for the implementing automation components that have to deliver the required functionality.
- Finally, *solutions* are implemented designs, which are real systems with real use in the real world. This includes not only the automation components, but also the meters and sensors necessary to collect the information.

The management procedures and business processes in each category above are as important as the technical specifications. To bring together different groups and support evolutionary trends, the framework is technology and standard agnostic, but processes following recommended practices support standards-based solutions more than proprietary solutions. In the framework, concrete standards are only used as examples to clarify principles. The identification of applicable standards takes place in the modeling process and is captured as part of the resulting architecture.

To ease communication between the varied participants involved with the electric system, such a framework attempts to simplify an extremely complex topic. All the while, we should remember that the topic remains complex and crosses many disciplines. This document endeavors to use terms that align with the mainstream nomenclature used in information science, but while communication hopefully is improved, we acknowledge that semantic misunderstanding will remain a stumbling block and an area for continual improvement.

The interoperability concepts of this framework come from work relevant to distributed process integration and interoperation across the economic spectrum that includes many industries. By framing the debate, we endeavor to align thought and vision around the best ideas that exist in this field today, watching for the emergence of new concepts that may better address interoperation issues and expand the community of adopters in the future. With a shared meaning of interoperability and an appreciation of the related complex issues, we look to a path that prioritizes areas where policy agreements and/or standardization can ease integration and interoperability for all participants in the electric system.

2.2 Multiple Viewpoints

Multiple facets contribute to the complexity of interoperability concerns. The framework presumes some important points about the system-integration philosophy that influences the way automation components are expected to interface and operate in a collaborative manner in something as complex as the electric power system. These philosophical tenets are important because they emphasize the needs of the system integrator and underlie many of the statements made in the subsequent sections.

Beyond the philosophical tenets, the framework proposes two main dimensions to provide context to interoperability discussions. The first presents a categorization of interoperability into levels much like layers in the Open Systems Interconnection (OSI) 7-layer communication model [4]. The major categories cover technical, informational, and organizational levels. The second dimension presents issue areas for interoperability. Each issue area can cut across the multiple category levels. For example, an issue topic such as security and privacy may have concerns that involve aspects at technical levels, informational levels, as well as organizational levels in the interoperability categorization dimension.

The reader should keep in mind that to achieve interoperation between automation components, all relevant cross-cutting issues should be resolved across all of the categorical levels. The intent of the framework is to help bring focus to specific aspects of interoperation in a discussion while keeping that aspect in perspective of the many other items requiring agreement or resolution.

2.3 Background

The GWAC first engaged the electric system community to develop shared thinking around a set of interoperability principles [5]. Through a series of interviews, these high-level statements were debated and revised until they reflected broad agreement on their validity and their wording. The interoperability context-setting framework provides a perspective consistent with these principles. The topics addressed in the framework were selected to cover these principles. Throughout the description of the framework in this document, you will see references to related principles.

Large-scale system integration is not unique to the electric system. Interoperability issues are being tackled in all economic sectors, including banking, telecom, transportation, and healthcare. We are not alone or isolated in confronting these issues, though the scope of the electric system and the number of collaborating participants makes it particularly complex. The advancements to resolving interoperability problems will ultimately be shared by all sectors of the economy. By being aware of, learning, and borrowing from related efforts, we can influence synergistic directions that increase the chances of success. With this background, the framework borrows heavily from concepts put forth by others [3], [6], [7], [8], [9], [10] and [11].

On April 11 and 12, 2007, the GWAC held a workshop with 45 experts in complex software system integration and interoperability representing various aspects of the electric system including reliability coordinators, electric power company automation, building automation, and industrial systems automation, as well as the information technology and communications that enable this automation. The participants found that, overall, a draft version of the context –setting framework appeared sound. They also provided excellent recommendations on clarifications, modifications, and future extensions to that draft framework document. This version incorporates the valuable near-term recommendations from the workshop [12].

2.4 Scope

Consistent with the first business-related principle of interoperability, B01 [5], the context-setting framework focuses on the interface between two or more interacting parties. This may be associated with inter- or intra-organizational software; however, we emphasize the independence of information technology choices and solution approaches to the business that occurs on either side of the interface.

Our scope concentrates on the situation and needs of the system integrator. Improvements in interoperability facilitate the integrator’s job to hook-up and configure the interacting automation components so that they perform properly. Whereas other aspects of software engineering focus on the developer or end user, the framework focuses on concepts and a structure for discussing issues related to developing independent automation components and collaborative processes so that they can be integrated more easily.

With the support of the context-setting framework, opportunities and hindrances to interoperability can be debated and prioritized for resolution. For example, suggestions can be made to revise an existing standard so that it conforms to the current best practices in information science. In another example, an application segment may ease integration where ambiguous identification is an issue by considering a distributed identification authority that issues identifiers according to an agreed-upon process. The framework does not prescribe solutions, but it enables communities to identify issues, debate them, and take steps toward resolution in a manner that maintains alignment with other facets of interoperation.

2.5 Prerequisites

To achieve complete interoperability, common understanding and agreements should be reached on many levels, from the lowest layers of technology to the policies of government and industry. Relevant aspects of the framework should be articulated to the various audiences associated with these different levels. This is too much for one document to accomplish. Instead, we will develop specialized versions for targeted audiences sensitive to their language and perspective. This document is technical in orientation as it lays the foundation for future, targeted versions. The audience for this document is expected to be familiar with the issues surrounding the integration of large, networked software systems. This includes concepts associated with enterprise integration and recent trends in e-business collaboration.

2.6 Framework Progression

This version of the context-setting framework document represents a transition point from an introductory phase of development that reflects participation from system integration experts at the Interoperability Workshop to a foundation phase that solicits material from a wider community on the nature of interoperability, interoperability issues, and action steps to improve system integration in ways that enable the GridWise vision. As a result, a set of companion material is envisaged to follow this to this document.

The process to specify and develop future material requires the participation of the electricity community. Figure 2 provides a conceptual view of companion material envisaged to follow from the framework. These works include executive summaries for targeted audiences, technical papers that articulate interoperability issues and proposed approaches to address them, checklists, tools, use case scenarios that provide examples of applying the framework, and other similar documents.

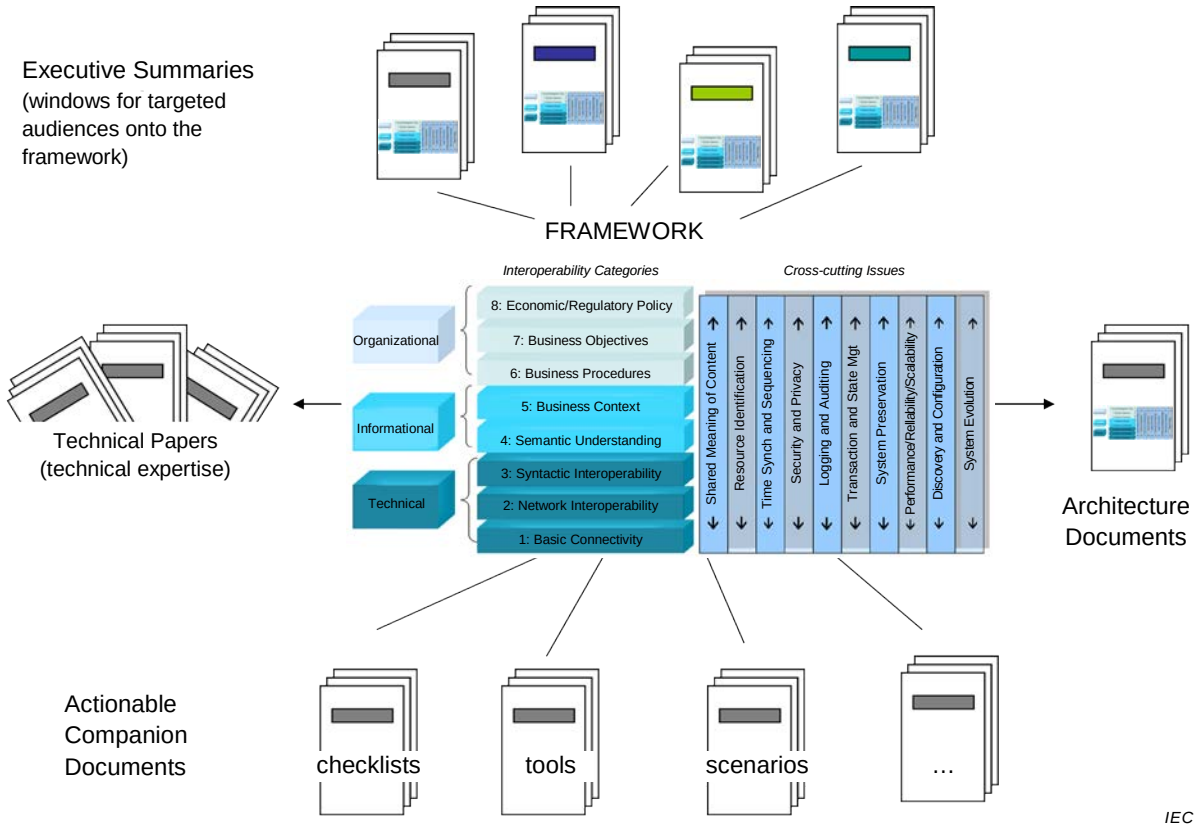


Figure 2 – Interoperability Framework Companion Material

This material will begin to appear at the first Grid Interop forum to be held in the last quarter of 2007. This meeting will engage a larger cross-section of the electricity community including technical, business, and policy decision-makers, As a result of that meeting, new material will be developed and existing material will be refined or converted into new products that reflect the needs of setting a foundation for advancing interoperability. Future forums will build on this foundation as we move to a phase that expands community awareness about interoperability concerns and directions. This will involve working with standards and trade organizations in all the relevant sectors, developing supporting materials, and initiating actions that address interoperability. Lastly, as community awareness expands, the emphasis of the next phase will be to nurture an interoperability culture. In this phase, methods, tools, and processes become mature resources for architects, business managers, and policymakers to continuously improve interoperability as a normal course of their work.

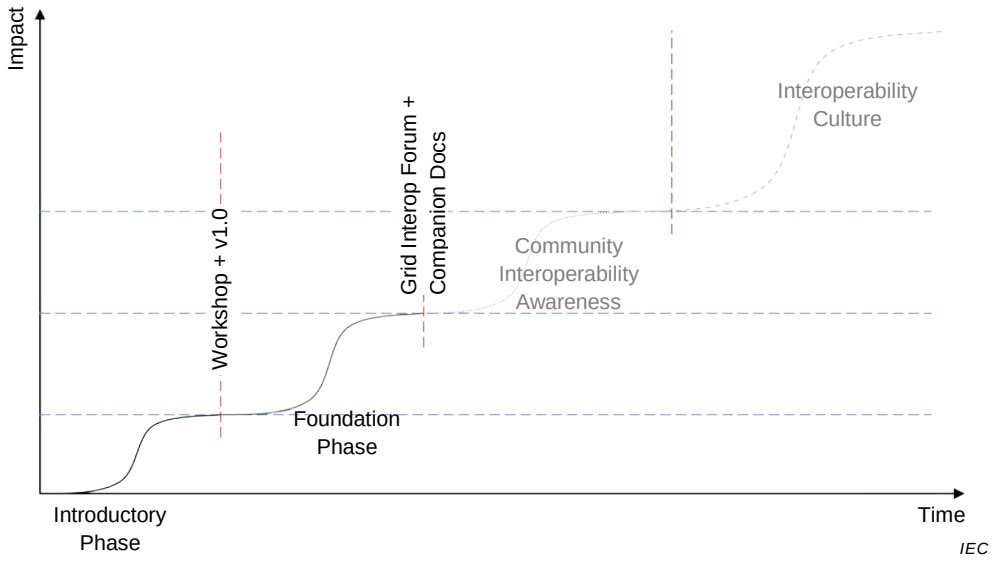


Figure 3 – Phases for Progressing Interoperability

2.7 Collaboration Terminology

This document discusses the information exchange between computer-based technology using electronic communications media to coordinate operation and achieve goals related to the electric power system. The computer-based technology may exist in devices, software applications, or systems that control or coordinate devices, applications, or other systems. Throughout the document, the term "automation component" is used to express an intelligent piece of the electricity system. This piece can be an intelligent device (e.g., breaker, water heater, distributed generator, transformer) or a system (e.g., transmission control center, building energy management system, substation automation system) or a software application (e.g., SCADA, billing system, feeder load balancing program). The common denominators between all automation components are 1) they can execute software programs and 2) they can communicate with other automation components in the application of their programs.

Suppose two parties, Party A and Party B, decide to collaborate on an activity. To do this, they need to agree on the interaction process between them to support their activity, the information required at each step of the process, and the mechanism they will use to make this information flow between them. We refer to the concepts involved in this electronic interaction as a collaboration model.

As shown in Figure 4 (adapted from [13]), for any interaction to succeed, the parties involved should agree on several elements of communication. The elements of a collaboration model are described in a collaboration agreement. This agreement specifies the interface that each party exposes to the outside world. The interfaces send or receive messages containing information in a certain format (syntax) and with mutually understandable content. The data

exchanged can be specified in an agreed-upon structured vocabulary that is common or shared between the two parties.

The collaboration agreement describes the roles and capabilities of the parties to achieve a shared outcome. It specifies the interface, message definition, message content supported between two transacting parties, and the expected response. The collaboration agreement explains what actions (services) its interface can perform, what format it expects in the message being communicated, what approach to secure that the interaction is used, and what things mean that are contained in the message.

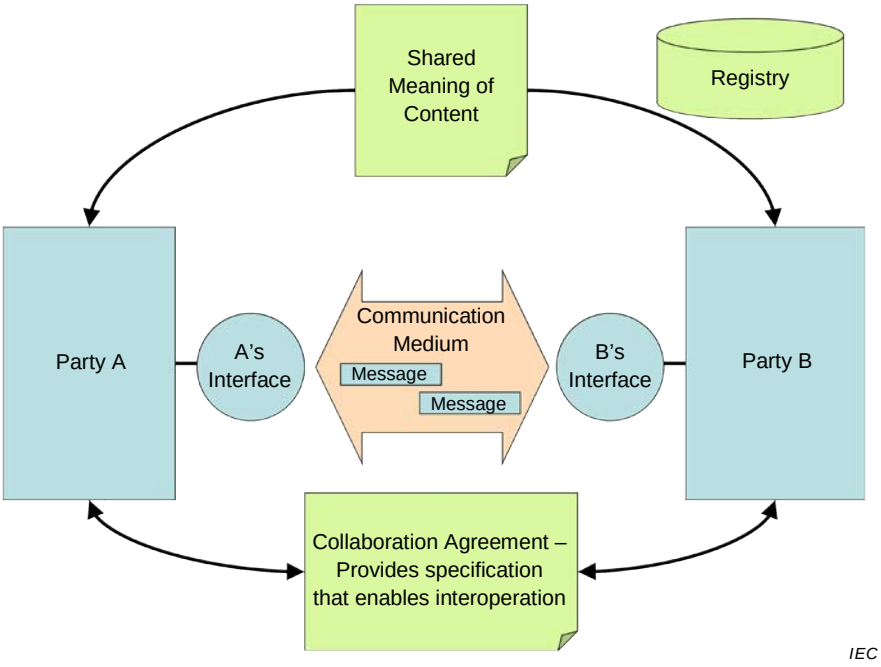


Figure 4 – Collaboration Model Elements

An interface is the point of contact that an automation component has with its interacting partners, and in particular, between communicating automation components. The interface describes the services that a party agrees to support including error handling. Interfaces also specify the proper sequencing of information needed to affect an outcome. For example, before a switch can be opened, it should be selected for operation in a previous message exchange.

The message is the packet of information that is communicated between parties. Protocols specify the format of the message packet and can have several layers of communication-related information in the message header. For our purposes, we focus on the action or service requested and the message content (payload) related to the business at hand.

A shared vocabulary unambiguously defines the real-world concepts that are referenced in an information exchange. It provides a common language (shared meaning) about these things and their relationship to one another. Interacting parties commit to the shared meaning so that they can communicate about message content without necessarily committing to a globally shared theory of operation. These things may be called by different names because of various information-exchange implementations involving different approaches and protocols, but the shared meaning of content serves as a common point for interpretation.

A registry is a separate set of software that stores information about the automation components involved in an information exchange as well as aspects of the collaboration agreement itself. A registry is a separate repository that is shared by a community of interested parties. It is much like a telephone book, though the community can decide to strictly control access to the registry. Registries need not be centrally managed repositories,

but can be distributed and divided into topics serving different needs. Parties can register their devices and interfaces with the registry. One can query the registry's repository to find information about registered subjects such as transacting parties and the communication mechanisms they support.

3 System Integration Philosophy

As mentioned in the introduction, our emphasis is easing the task (reducing the distance to integrate) of those who integrate and configure automation components into the system. We can arguably best frame the situation when considering interacting automation components that are managed by different organizations. In such situations, the transacting parties clearly and formally establish the lines of authority and rules of engagement. They maintain their autonomy while collaborating to share their resources in a federated manner [14], [15].

3.1 Agreement at the Interface – A Contract

In any business engagement, the associated parties establish the ground rules and capture them in a contract or an agreement. Sometimes these rules are assumed (such as, we will communicate using the English language), sometimes they are referenced (e.g., consistent with the commercial code of the State of Louisiana), and most of the time, the particulars are documented in a signed contract. Each party exchanges goods and services as an independent entity. The terms and conditions describe how goods and services flow between parties, the price, the scope, the schedule, and the quality of the deliverable. They also describe the consequences for failure to perform. They rarely state how the good or service is created or obtained.

Similarly, we presume that agreements between automation components concentrate at the place where the boundaries of each component meet – their interface. By establishing an interface agreement, each automation component preserves its integrity. It can change internally and react to various pressures independent of other automation components as long as it meets its interface agreements.

Interface agreements are important to maintain even within the same organization. The integrity of automation components established by the same authority can be compromised when designers discover that they can more easily realize new functionality by making coordinated changes in the software of both automation components and not reflecting the change in the interface agreement. This leads to undocumented assumptions that are lost when implementers change the software of an automation component or individual automation components are replaced. The situation is exacerbated in complex systems with thousands or millions of automation components where central planning and coordination is not humanly possible.

Designers specify intelligent devices and automated systems to provide desired capabilities or services. Even though the design requirements of a complex device or software system may need to accommodate a certain amount customization in each installation, reuse is an important goal. Similarly, common concepts may be sharable in a consistent fashion across a set of automation component interface agreements. For example, the same concepts of payment terms or scheduled delivery in a contract or interface agreement for energy from an automated building system could be used for a fuel cell or a micro-grid. The concept of polymorphism in computer science provides for a single definition to be used in multiple business contexts. This encourages consistency and eases system integration because common concepts become well-known and readily recognized. System integration situations can also become more scalable as integration tools can assist in connecting a heterogeneous mix of automation components with similar interface agreement concepts.

3.2 Boundary of Authority

Though agreements can specify the way in which automation goods and services are developed, competition and innovation is enhanced when the transacting parties concentrate