# GridWise™ Architecture Tenets & Illustrations

**The Architecture Board gathers great minds in related fields of interest to capture and describe the abstract underpinnings for information exchange and control of a society of devices, subsystems, and businesses that by the nature of their transactions and local decisions will improve the performance of the electric power system as a whole. This board must do this with full knowledge of the existing and emerging mechanisms for information exchange that serve collaboration between organizations in the economy in general.**

GridWise™ is a concept of how advanced communications, information and controls technology can transform the nation's energy system—across the spectrum of large scale, central generation to common consumer appliances and equipment—into a collaborative network, rich in the exchange of decision making information and an abundance of market-based opportunities.

The tenets and illustrations discussed here suggest a foundation for a GridWise architecture, demonstrating possible directions which this architecture may take, and stimulating reflection and debate about such an architecture.

## Architecture Tenets & the GridWise Vision

At the foundation of the GridWise initiative is a commonly held understanding that the information age will significantly impact the traditional ways in which energy is managed in our society today. The change is inevitable; however, the speed and effectiveness of change can be enhanced with coordinated forethought to the way it becomes realized over time. The architectural aspects of GridWise provide a reference vision and guidelines for stakeholder communication and decision making.

The GridWise vision covers a wide spectrum of interactions related to the electric power industry. It focuses beyond individual organizations' areas of responsibility to promote cross-party transactions that benefit the system as a whole. It sees continued evolution of today's control structures, processes, and organizational boundaries and imagines an electric infrastructure that more fully integrates with the operation of the economy in general. The actual nature of the future operational structure of electric energy in our economy is the product of a series of choices to which we each contribute, but cannot fully control.

In an open economic environment, businesses strive for efficiency and quick response to changing conditions as driven by their clients' freedom of choice. Good economic policy encourages competition and protects social choice; it does not prescribe what we choose or how we choose. This right is articulated, agreed upon, and maintained in laws and rules of engagement. At its most effective, these rules identify abstract concepts through which the spirit of the law can be applied to the widest number of actual circumstances.

As with good social law and rules of engagement, so should the GridWise architecture identify abstract concepts and describe a philosophy of inter-system operation that preserves the freedom to innovate, design, implement, and maintain each organization's portion of the system for which they are responsible. Critical to the success and longevity of this philosophy is that it reflects the shared beliefs and values of the constituency to which it applies.

Pacific Northwest National Laboratory
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To stimulate interest and initiate engagement with those who believe they have the background, architectural skills, and conviction to contribute to this undertaking, this document provides a provocative set of philosophical tenets and illustrative examples related to the nature of the GridWise architecture under consideration. As such, the following material should be taken as suggestive, not prescriptive.

## Architecture v. Design v. Standards

The architecture describes the philosophy and structural patterns which frame the technical and economic designs, demonstrations, implementations, and standards related to the GridWise vision. The architecture is abstract. It does not prescribe specific designs or methods for implementation; however, it expresses a common language for conceptual understanding and a set of high level tenets and requirements within which designs and implementations must conform. It organizes concepts for ease of communication and clarity; however, this organization does not necessarily transfer directly to specific designs.

Take the reference model for OPC (OLE for Process Control) industrial SCADA consortium. The OPC group created a framework from which industry standards for systems integration could be derived. The high level architecture specifies a component reference model and certain requirements (such as the use of Microsoft DCOM specification for component connectivity). **Figure 1: OPC Reference Architecture**, shows overly simplified aspects of the framework. Industrial systems consist of servos with local controllers that are integrated into plant controllers that coordinate activity throughout a shop floor. The servo controllers reveal OPC interfaces that allow a plant controller to query information about the status

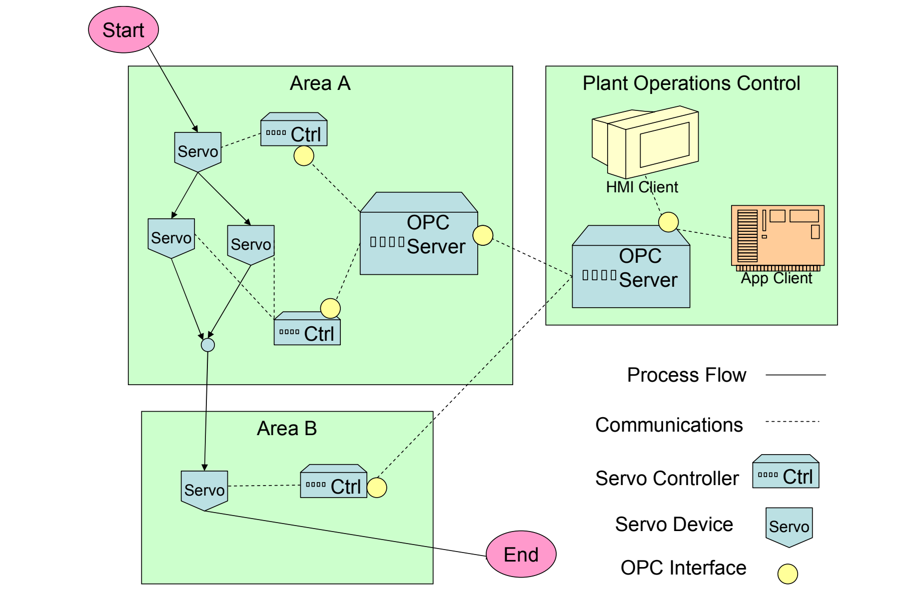


**Figure 1: OPC Reference Architecture**

of the device (points with attributes of value, quality, and timestamp) and issue commands. Servo components register in standard OLE mechanisms to aid in integration. They support an introspective interface that allows the plant controller to understand what information the servo component has to offer. OPC can integrate several servos and also work in a hierarchical control arrangement with other OPC servers. Underlying this framework is a master/slave relationship where the servo component "serves" the plant controllers OPC Server, and the server provides information to the OPC clients. Such an operational philosophy is an important part of the OPC architecture and permeates the interface standards.

In contrast to this industrial process control architecture, collaborative approaches are emerging for electronic business integration. ebXML is an example of such a framework, see **Figure 2: E-business ebXML Reference**

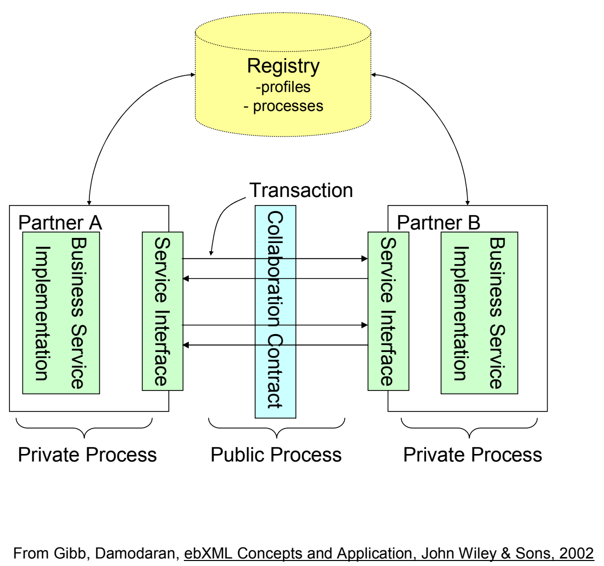


**Figure 2: E-business ebXML Reference Architecture**

**Architecture**. In a B2B (business to business) or B2C (business to customer) situation, the interaction is more peer to peer than master to slave. A requirement of the architecture is that transacting parties have the ability to hide their internal business processes. Also, since each organization has its own procedures for doing business, the architecture allows external business processes to be defined and stored in a registry available to potential partners. If you are Partner B and you want to do business with Partner A, then you can obtain Partner A's business service specification, negotiate a collaboration contract with the company, and set up business integration using the business service specification.

Both OPC and ebXML go further in their specifications to facilitate interoperation for their development communities, but the level of concern for the GridWise Architecture Board is the reference model and framework that point out the places where specification and standardization can be most beneficial.

The GridWise vision does not stipulate a shared design specification to which all functioning components of our complex energy system must adhere. From a requirements point of view, the specification of each component must be flexible and changeable, because the components may be owned and managed by independent entities. Given the autonomous nature of these independent entities, this system of systems is less specifiable than a federated enterprise system of subsystems. It is more like a society of components, reflecting an economic paradigm based on contracts and transactions. It must have the flexibility that businesses have to interact with each other; but to effectively approach the GridWise vision it must exhibit smoother mechanisms for configuration (collaboration, discovery, and initialization) and interoperation.

Though more abstract than a design, the GridWise architecture must layout some fundamental rules to which specific designs and resulting implementations must conform. Creating a commonly held architecture for our scope of applications will reveal prime areas for standardization, while avoiding duplicative and inconsistent nomenclature and philosophical approaches that are not sufficiently flexible or scalable to meet the general system requirements.

As the Architecture Board is not a design team, it is also not a standards making body. An objective of the architecture reference material is to identify areas for standardization that facilitate significant levels of interoperation between system components; but it does not specify standards. Rather, an architecture reference helps the work of existing or emerging standards organizations to create standards that promote interoperation. The Architecture Board supports these standards making groups through interpretation and guidance so that attention is placed on the areas where the least amount of agreement provides the greatest leverage to interoperability.

**Figure 3: Moving from architecture toward implementation**, depicts the position of the GridWise Architecture Board and associated standards work in relation to designs and implementation. To be complete, one must consider that the experience gained from existing designs, implementations, and standards greatly influences the architecture. Above all, this percolating process is about developing mindshare to make significant change achievable.

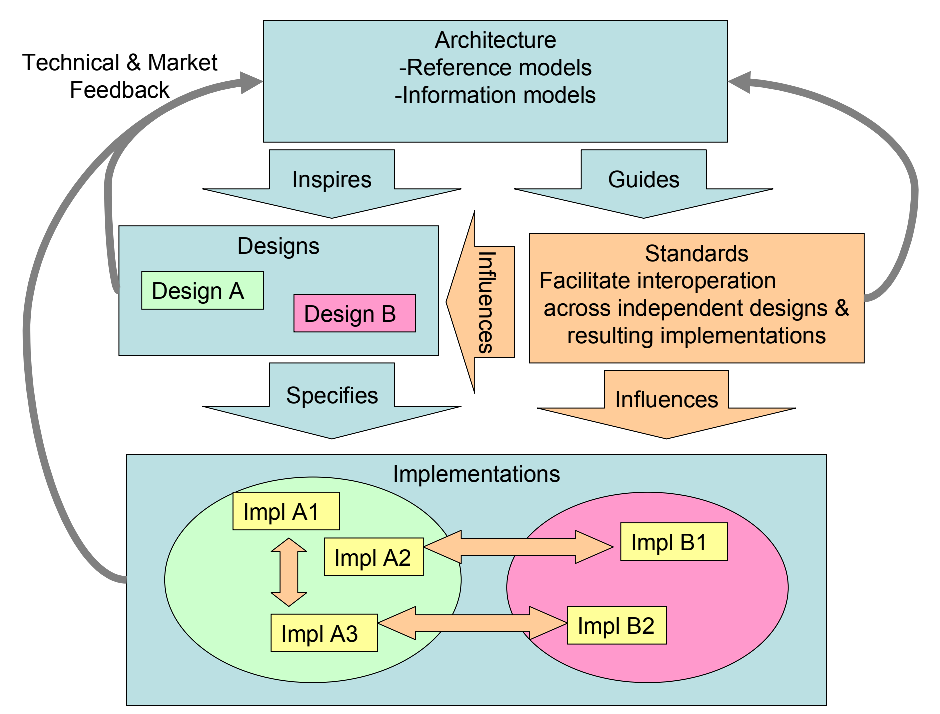


**Figure 3: Moving from architecture toward implementation.** The GridWise Architecture Board guides and inspires associated standards work and designs.

## Principles for a GridWise Architecture

Architecture is anchored in beliefs and principles so that it may guide a large number of specific designs and implementations. The more relevant and fundamental the principles are to the architecture's constituency, the more enduring and successful the approaches they inspire. The following sections describe the basic tenets behind GridWise and attributes that the GridWise Architecture should possess.

### *Tenets*

The architecture describes the commonly held beliefs that invigorate change to the status quo. Examples follow:

- The information age will revolutionize the way in which energy systems work today.
- Intelligence (better information supports better decision making) will invade all levels of the energy systems from generation, to bulk transmission, local distribution, and residential, commercial, and industrial consumption.
- Value is best judged in a fair market environment open to participation and review by regulatory authority. This should be exposed at all levels of the system.
- Transparency of value allows market participants to develop and deploy economical solutions that cross traditional enterprise and regulatory boundaries.
- The system will evolve from its present form of operation, through a series of tractable changes over time. Changes include organizational boundaries (ownership and operational responsibility), technology deployment, and forms of collaboration between system components.
- Collaboration based upon autonomous decision making enhances the resilience of complex systems to system-wide failure and accommodates evolutionary changes.
- Timely information exchange enhances the quality of autonomous decisions to the betterment of the security and reliability of the system.

With its long-term sights on these beliefs, the GridWise Architecture aims to provide high-level, abstract views of systems, software, information, and communication to help orient energy systems and technologies as they evolve.

### *Architecture Attributes*

A well-heeled GridWise Architecture possesses the following attributes:

- Succinctness: effective communication is elegant in its simplicity.
- Mindshare: the stakeholders must embrace it.
- Common Language: concepts must be clearly described. Where domain (technical or business) information must be exchanged, the type of information must be clearly defined (e.g., name, topological location, units).
- Innovation and Choice: the architecture allows flexibility for innovation of design and implementation. Creative solutions that can intermingle with other implementations (be they services, infrastructures, or applications) are encouraged.
- Performance: though abstract, the architecture must be sensitive to and appropriate for the problem domain.
- Resilience: The system must be resilient in that the system should be able to isolate itself from local problems and local regions should be able to isolate themselves from higher level system problems. This breeds self-organization and distributed, autonomous control principles. It is also sensitive to the tension between privacy and national security requirements.
- Evolvement/Renewal: a good architecture requires little change over time. A wise architecture recognizes that change is necessary and has a process to accommodate it.
- Adoption of Appropriate Material from All Sources: avoid inventing principles or approaches where leadership is exhibited elsewhere (e.g., communications protocols, information technology paradigms, and infrastructure are being driven by the information technology industry). Keep creative focus on concerns unique to the energy system communication and control problem domain while adopting appropriate solutions that have more general applicability.
- Consistency: the architecture does not allow compromise to affect integrity.

## Illustrations

The GridWise architecture pertains to the technology and business processes as applicable to the operations of the electric energy systems industry. This industry includes the electric production commodity (gas, oil, coal, etc.), its conversion to intermediary and end uses, its distribution from source to consumer, the economic and business frameworks (markets, contracts, payment reconciliation, etc.), its regulatory systems (technical and social), and their interrelationships. The following scenarios illustrate the nature of the types of interactions to be addressed by the Architecture Board.

To emphasize bringing new capabilities to the operation of the system, the following scenario focuses on the integration of distributed energy resources (DER, including generation, storage, and controllable load) into the electricity network.

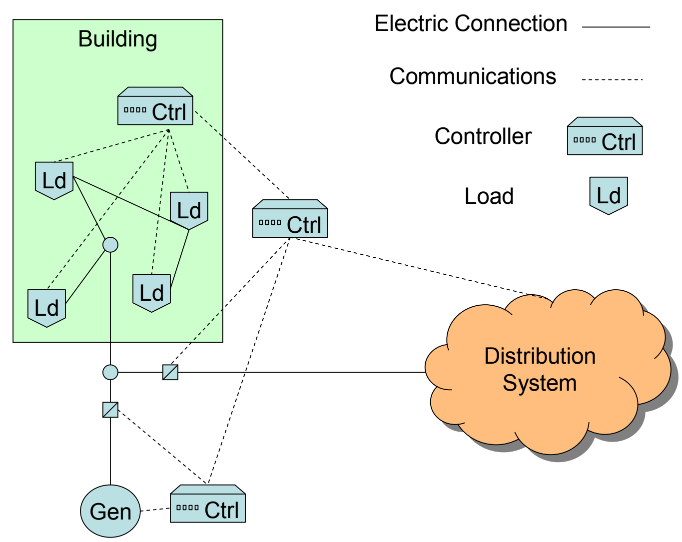


**Figure 4: Facility controlled DER.** An integrated subsystem that includes a building energy management system (EMS) and on-site generation. The Architecture Board must grapple with the great variation in configurations and the need to develop principles that allow for flexibility and evolvement as islands of automation shrink and grow within greater systems of interoperating entities.

**Figure 4: Facility controlled DER**, shows an integrated subsystem that includes a building energy management system (EMS) and on-site generation. The subsystem interconnects with the local distribution system and may be operated synchronously or independently as an island. Communication paths between intelligent controls indicate the coordinated interaction between demand, local generation, and the distribution system. The contract between the site and the distribution system operator may stipulate that synchronous operation is allowed, but the distribution operator must be assured that any active power is removed from the distribution system upon their signal. To enforce these rules, isolation breakers are installed to trip on events detected by protective relaying or from a decision by the subsystem controllers. In addition, the distribution operator or a separate load serving entity contracted to provide electricity to the site may also have a demand response agreement to reduce or curtail power from the distribution system under stressed conditions. Such a signal may come in the form of a pre-arranged "call" to reduce usage or via an energy price increase.

The requirements of this scenario range from fast acting relaying for system protection to considerably slower exchanges concerning economic operating decision making. The players involved have different responsibilities and missions. The Architecture Board needs to consider such situations and their permutations in defining an architectural framework that facilitates the integration of the components for such a system.

From this basic scenario, one can imagine other scenarios including the operation of DER strategically arranged by the distribution system operator to support feeder level contingencies, the aggregation of such resources by load serving entities for participation in the bulk wholesale energy markets, the coordination with substation controls that provide energy from the transmission system to the distribution system, to higher level interactions with transmission level operations and bulk generation. The interfaces between parties that have different areas of responsibility are of particular interest for developing architectural frameworks that facilitate multi-party interoperation. Scenarios that generally interact within a party's area of responsibility have greater freedom to decide architecture, design, and implementation directions, though concepts from a more generally accepted framework may be beneficial to consider as well.

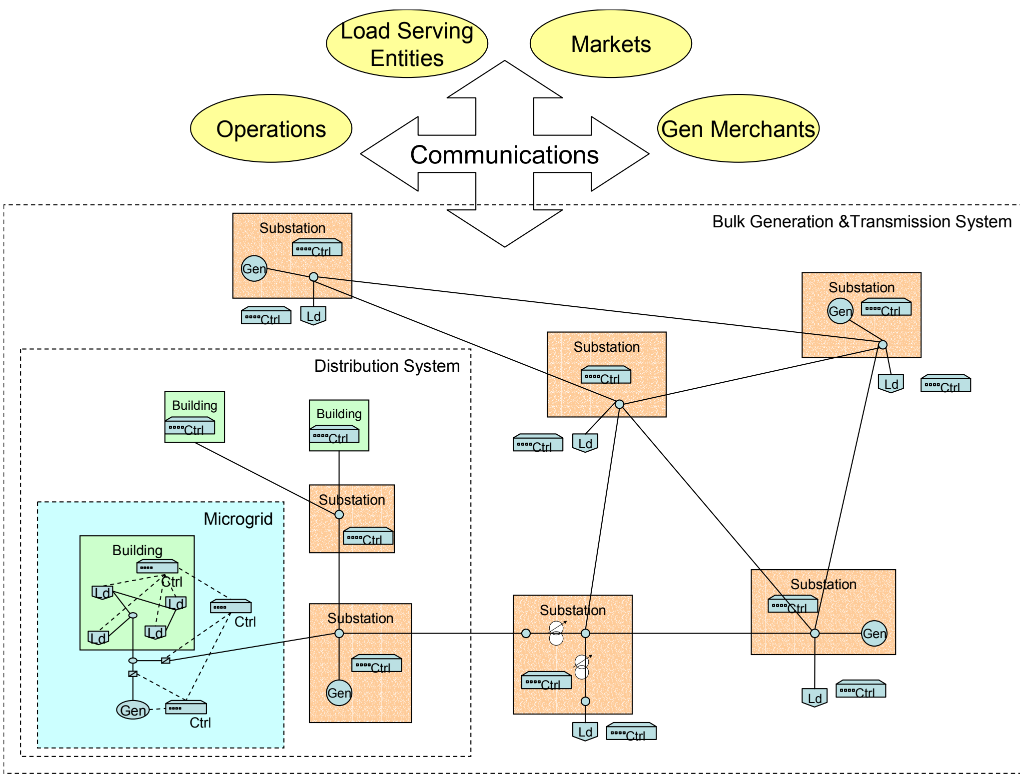


**Figure 5: Levels of system interaction**
Businesses and operating entities have economic and physical responsibilities for different aspects of this system. Thanks to the pervasiveness of communications and distributed intelligence (as represented by the controllers) these organizations can reach into all levels of the system looking for opportunities to reduce operating expenses and increase profits.

The Architecture Board must grapple with the great variation in configurations and the need to develop principles that allow for flexibility and evolvement as islands of automation shrink and grow within greater systems of inter-operating entities. Though electric energy is emphasized here, the same integration and control issues arise if one were to overlay a foil representing the gas, oil, and other energy infrastructures. Indeed, adding these other layers further enriches the picture with the inherent interactions between these infrastructures (e.g., the trade-off between burning gas to generate electricity to heat homes versus burning gas directly in the homes) and the combinatorial variety of business organizations and scenarios that arise.

**Figure 5: Levels of system interaction**, gives a flavor for the different organizing concepts that emerge at different levels of the electric energy system. Businesses and operating entities have economic and physical responsibilities for different aspects of this system. Thanks to the pervasiveness of communications and distributed intelligence (as represented by the controllers) these organizations can reach into all levels of the system looking for opportunities to reduce operating expenses and increase profits. They can merge and divide depending upon insights into changing market conditions.

The challenge to the Architecture Board is to communicate the possibilities for interaction and provide a guiding framework to engage constituents as they progress in the realization of their business or regulatory missions.

**For more information, contact:**

Steve Widergren
Pacific Northwest National Laboratory
P.O. Box 999, K5-20
Richland, WA 99352
509-372-6410

GridWiseAB.Coordinator@pnl.gov

http://www.pnl.gov/gridwise

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