Service Oriented Buildings, Net Zero Energy, and Autonomous Systems Architecting for Service not Process, Policy not Control

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Abstract

For building occupants and building owners, energy is a means to an end, not an end in itself. Any disconnect between energy management, and managing the services provided by energy introduces risk and thereby reduces participation mediated by the business interests in the end nodes of the smart grid.

A variety of initiatives in buildings, campuses, and military bases are defining abstractions of building services. This paper describes a model for abstraction of building services to more fully engage building occupants and building owners in interactions with the smart grid as well as to reduce integration barriers to smart and net zero buildings.

1. INTRODUCTION

Building occupants understand their buildings through the lens of space. Building systems use energy to provide services to building spaces. Space defines tenants and quality of service agreements. Building systems have value because of the services they provide to space. Even plug loads can be understood through knowing the space the plugs are located in. Building Information Models (BIM) are the standards that define space and how it is used. Systems that integrate BIM and energy information will incorporate the work of Smart Grid Priority Action Plans (PAP) 03, 04, 09, and 10

The business services required by a dynamic organization can continuously change the service levels demanded to support business services. These interactions will rarely be defined in terms of the low-level building systems. Policy-based assertions can define the high level service requirements of a changing business. Policy applied to space defines the changing service levels that building systems must provide space. Policy-based energy management applies the needs of changing business requirements to the services provided by building systems.

Autonomous load management is a critical enabler of policy based energy management. Interactions designed to assume peer-to-peer interactions between building-based systems increase competition while reducing integration requirements. Reduced integration costs are essential to meet the needs for accelerated innovation in building systems technology required to meet smart grid goals.

Process oriented integration uses deep knowledge of sub-systems to wring out every drop of performance from well-understood systems. Such integrations are expensive in time and in people; the expense of integration grows much faster than the diversity of technologies supported using such integration. This growing expense increases the cost of introducing new technologies into any system, and becomes a barrier to innovation.

A variety of initiatives in buildings, campuses, and military bases are defining the abstractions of building services. This paper describes a model for abstraction of building services to more fully engage building occupants and building owners in interactions with the smart grid as well as to reduce integration barriers to smart and net zero buildings.

2. BETWEEN DATA AND ACTIONABLE INFORMATION

The acquisition of operational data from building systems presents three challenges. (1) Building systems use a plethora of standards, specifications, and proprietary mechanisms for their internal communications. Even when the communication specification is known, there is often only facial compliance, especially as to informational payload. (2) Data from building systems Building system integrations are too concrete while lacking metadata on control points. (3) Systems lack sub-metering to identify actual loci of energy use. Building system energy use is not traceable back to the space it supports.

2.1. The Building Services Interface

Even the newest buildings that adhere most closely to published specifications present challenges to data mining for energy performance. If all data mining were limited to a single protocol, say BACnet, the protocol would still present the knowledge problem of what those points represent. Tagging schemes are not standardized and are poorly enforced. Without knowledge that is only imperfectly available by discovery, it is difficult to distinguish between, say, temperature readings for return vents, coils, outside air, and more.

Most buildings are, and always will be legacy buildings. They were not built in the last couple years. They are not up to modern codes. The variants of the standards-based communications are not up to modern specifications. Even if an owner rigorously enforced tagging standards during commissioning, these would not apply to buildings acquired rather than built.

Low level control protocols are API oriented rather than message oriented. They are fast and efficient for local systems. They have not been designed to support any modern federated security. Direct access to the building system will always present security issues. Building systems will require some sort of security gateway. The additional architectural costs of protocol translation are minimal.

Energy usage metering, where it exists, communicates using the native building system protocols only rarely. It may be available with low granularity much later, through protocols such as OpenADE. If sub-metering is installed, its native communication is likely to be ModBus based. Energy metering needs to be translated to line up with the building systems event data.

All communication between cloud services and the building should be through a building services interface (BSI). The standards for a BSI are not yet defined.

2.2. Standards for Building System Interfaces

In an idealized world, all communications to a BSI would be messaging based through a fully securable protocol supporting composition. There would be well defined abstractions overlaying the low level communications. Communications would be batched of efficiency and reliability. We are not in that world.

The BSI would apply consistent building system metadata to the underlying tags and events. Analog sensors would become fully qualified temperature sensors, with calibration information applied, perhaps using SensorML. Temoperature sensors would be accurately classified as to where in the building, or where in the building system, they are measuring.

Common schematics for the building systems would generalize how those building systems are laid out. Control functions would be generalized through generic notion, perhaps using Open Automation Object Model. (OAOM). Simpler systems could be fully described using the Specifier's Property Information Exchange (SPie).

One can't analyze energy use by system without understanding the space that is involved, and how that space is being used. This requires a taggable building model that can link systems to the space they support. One would be able to generate light, loose building models using retro-BIM, or generate models directly from construction BIM. This suggests that the spatial metadata would be delivered via GBXML.

Energy usage information would be reported as per the NIST Smart Grid PAP10 Energy Usage Information Model. EMIX, the first specification to use that model is just now going out for public review. In time, that work may align with the work now going on in ASHRAE SPC201.

All of the right standards to develop a BSI around are not quite ready. If they were ready, a project such as this could scale rapidly, putting a large proportion of existing buildings into the realm of cloud-based live energy modeling and reporting.

For this project to produce a proof of concept rapidly, it cannot wait for the standards. If this concept demonstrates successfully, it will speed the arrival of these standards.

2.3. Standards for Weather Observational Data

A good energy use analysis must be based on full accurate energy observations. Unfortunately, today, there is no clear standard. Actually, there are too many of them.

1) Weather Information Exchange Model/Schema (WXXM): http://www2.icao.int/en/ais-aimsg/AISAIM%20Meeting%20MetaData/EUROCONTROL%20Meteorological%20Information%20Management%20Activities.doc
2) OGC Candidate standards for Weather and Climate forecast model communication and sharing. Developed by the weather community and already widely used on an international basis: http://www.opengeospatial.org/pressroom/pressreleases/1279
3) Climate Science Modeling Language: http://csml.badc.rl.ac.uk/

For predictions, there is the un-standardized, hard-to-use DWML from NOAA.

We will have to take what we can get for weather.

3. APPROACHES FOR TODAY

The target buildings we are looking at will have some sort of BAS in place, and that BAS will have some sort of control system and data logger. It may have a middleware layer in place. Those fall into three categories:

3.1. SQL Server Access

Systems that maintain a building state engine and event historian in a database. This database has normalized the data within the standards of the brand. The database is usually a variant of SQL Server. Many buildings have firewalls that prevent SQL Server based traffic from passing through. Many corporate IT security groups are adamant that this wall stay in place, remembering the SQL Slammer worm that overwhelmed much of the internet in minutes a decade ago.

When available, we can access SQL Server directly. Sensus has experience is accessing the most popular variants of these systems. Some of these systems are not licensed for direct remote access. A local application, offering up a web service would not violate the licensing agreement. It may be easier to negotiate corporate access to such a web service. Such a service would also enable some first steps toward the standards we will one day expect from a BSI.

3.2. Middleware Access

Some building systems already have middleware installed, especially if they support integration on a larger level across multiple buildings. The predominant middleware today is based on the NIAGARA framework running on a JACE from Tridium. The current version of NIAGARA uses RESTful web services for internal communications. These services, built around the OBIX specification, define methods to query, explore, and read all system points.

Because NIAGARA was built as an integration layer, off the shelf software exists for most add-in devices, including many meters. Where needed, JACEs support Java-based applets, expanding our future options. The critical limiting factor for the long term is that Tridium-based oBIX is RESTful rather than message oriented. This will limit scale in the mid-term, but presents no barriers to early demonstrations.

3.3. LON-based Access

The iLON and similar systems offer direct access to LON-based systems. The iLON offers up much of the metadata that we would need to construct from scratch in other systems. The iLON may be the only message-based web service in building systems today, offering up full WSDL and enabling message-bases security firewalls to in front.

A potential problem arises in that many building integrators install their own “custom” extensions to LON, creating metadata that is not easily understood by others. A LON-based building should be examined for the use of custom extensions before being included in the pilot stage of this project.

4. LOOKING FORWARD: ENTERPRISE INTERACTIONS

Each of the approaches above leaves out an important determinant of building energy posture: the business activities of the occupants. For tenant-occupied commercial buildings, occupancy and use heuristics may be as close as we can get. For owner-occupied and institutional buildings, better information may soon be available.

Last summer, I worked with makers of enterprise schedule software, including Microsoft, IBM, Oracle, and Apple, on message exchanges between corporate calendars and building systems. The long term vision for this project should include WS-Calendar based exchange of schedule information with the energy modeling service. For now, though, the answer is “not yet.”

5. ENERGY AVAILABILITY AND VOLATILITY

In the long term, building systems that accept volatility of energy supplies will be less efficient; energy storage will never be lossless. In the long term, building systems that accept volatility of energy supplies will be better customers for grid-based renewable energy resources. In the long term, the building that is both efficient and able to accept volatility of energy supply is best able to live within its site-based renewable energy resources.

In the short term, we must always keep energy volatility, and the messages needed to exchange information about that volatility, in mind when examining building energy performance. We do not have to worry about this during the proof of concept.

5.1. Barriers to Innovation

6. THE INTERNET AS AN INNOVATION ENGINE

There are two narrative of the rise of the Internet. In one, a few key legal decisions opened up markets to enable innovation. In another, the internet achieved abundance by planning to manage scarcity. Both narratives are informative.

7. INTRODUCTION

Scarcity of time on the part of the consumer is the ultimate limiting factor even if we remove physical constraints of shelf space and supply chains."

8. INTRODUCTION

9. NEW SERVICES

Unbundling of the key services:

Price Risk Arbitrage

Avalaibility Risk Arbitrage

Privacy (including mis-direction)

Energy

10. COLLABORATIVE ENERGY

Collaboration has been defined as "a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals[1]." It is also defined as a process that "...occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain[2]." The International Telecommunications Union further specifies that a "formal agreement, such as a Service Level Agreement (SLA), puts contract type language around the collaboration[3]".

We define Collaborative energy[45] as two or more organizations working together to balance energy supply and demand. Either side may have energy to buy or sell. Either side may be able to mediate energy consumption. Either or both sides may have resources for energy generation or storage. Even storage itself is energy consumption or supply depending upon collaboration signals and direction of energy flow.

Unbundling of the key services:

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Energy

Limiting interactions to economic transactions minimally constrains solutions on either side of the interface. We need the fewest constraints consistent with grid coordination to enable rapid innovation on either side of each interface. Economic interfaces allow the introduction of new intermediation services that may add new value or better engage consumers. Economic interfaces are also likely to offer the least personally identifiable information and thereby improve privacy on smart grids.

10.1. Benefits of Smart Grids

The biggest benefits from smart grids will come from engaging the end nodes to assist in balancing energy supply and demand. This requires clear communications of energy scarcity and abundance, of the value each assigns to that energy, and of responsibility for outcomes. These signals are all in the realms traditionally assigned to economics and markets. The significant interfaces of smart grids are economic and market interfaces.

Current best practices in large system architecture define services, and assign responsibility for providing those services to systems n either side of an interface. To allow innovation and competition, services are agnostic of process, and focus exclusively on quality and timeliness of performance. Any system, including ones provided through innovative new technologies, can compete on quality and timeliness of service delivery without re-development of systems architectures or of interfaces. We require approaches that present minimal barriers to innovation to achieve smart grid goals.

The architecturally significant interfaces of smart grids are economic communications using service oriented architectures. These architecturally significant interfaces of smart grids are at boundaries between the collaborating entities. These interfaces minimally constrain the parties on either side while providing effective conduits for actionable information between the entities. These interfaces honor the principles of symmetry and minimal knowledge, and interact with each other through carefully defined general services.

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Biography

Toby Considine is a recognized thought leader in applying IT to energy, physical security, and emergency response. He is a frequent conference speaker and provides advice to companies and consortia on new business models and integration strategies.

Toby has been integrating building systems and business processes for longer than he cares to confess. He has supported and managed interfaces to and between buildings, cogeneration plants, substations, chilled water plants, and steam and electrical distribution. This work led to Toby's focus on standards-based enterprise interaction with the engineered systems in buildings.

Toby has been chair of the OASIS oBIX Technical Committee. oBIX is an unencumbered web services standard designed to interface between building systems and e-business. He is an elected member of the OASIS Technical Advisory Board. He is active on the NIST Smart Grid Domain Experts Groups and works to promote applying information technology to buildings with groups such as buildingSmart and FIATECH.

Before coming to the university, Mr. Considine developed enterprise systems for technology companies, apparel companies, manufacturing plants, architectural firms, and media companies old and new. Before that, Toby worked in pharmaceutical research following undergraduate work in developmental neuropharmacology at UNC.

William Cox is a leader in commercial and open source software definition, specification, design, and development.

He is active in the NIST Smart Grid interoperability efforts, including the Domain Expert Working Groups. He contributed to the NIST conceptual model, architectural guidelines, and the interim roadmap and framework documents.

Bill is co-chair of the OASIS Energy Interoperation and Energy Market Information Exchange Technical Committees, and an elected member of the OASIS Technical Advisory Board, where he advises the Board and membership of the leading XML and Web services standards organization in the world.

Bill has developed enterprise product architectures for Bell Labs, Unix System Labs, Novell, and BEA, and has done related standards work in OASIS, ebXML, the Java Community Process, Object Management Group, and the IEEE, typically working the boundaries between technology and business requirements.

He earned a Ph.D. and M.S. in Computer Sciences from the University of Wisconsin-Madison.