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Scalable, Integrated, Real-time Energy Management

Requirements and System Architecture

White Paper

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Abstract

The changes sweeping the utility industry both in home and commercial sectors due to deregulation, new technologies, and increased global competition are well known. To effectively deal with these changes, energy providers and consumers alike require new levels of capability for management and control of their energy systems. Providers require detailed information about usage patterns to enable efficient management and pricing of energy production - the move from 'peak' to 'average'-based production planning. And consumers, in this increasingly competitive and changing market, require the ability to understand their own energy usage needs to be able to control consumption and negotiate and verify rates.

LonWorks is a powerful technology for automating the local control and data acquisition associated with all energy-related subsystems in a building or home. From the control of the energy-consuming processes like heating and cooling to the monitoring and verification associated with performance-based upgrades in commercial buildings, LonWorks is being used to reduce costs and greatly increase system functionalities. LonWorks provides the detailed information from, and control over, system devices at the home or building level. But what about aggregating energy usage at the enterprise level, for example a multi-building campus of a large organization? And what about integrated access to data across an entire customer base of a utility?

To achieve this LonWorks must be augmented with appropriate information technology to deliver data to a wide range of different applications across the enterprise where it is actually utilized. For energy consumers with distributed facilities, and for the energy providers, information and control from the local LonWorks networks must be tied into enterprise applications via a WAN to provide the centralized management required. But WAN technology alone is far from sufficient. The energy information and control must be delivered over the WAN and into business applications and databases in a disciplined way that meets requirements for:

- operation over wide range of WAN networking technologies (wireless, POTS, ISDN, frame relay, xDSL, fiber/coax)
- security
- reliability
- scalability to tens of thousands of sites
- guaranteed information delivery
- simplified integration with legacy applications and databases
- ease of deployment and management
- incremental upgrade and additions
- low per-site and life-cycle costs

This paper will detail these requirements for integrated energy information systems for both home and commercial applications. Coactive's IOConnect architecture, presented here, provides the seamless enterprise connectivity solution needed to implement large-scale, manageable systems at reasonable cost and is available today.

- Energy Management Information System (EMIS) Requirements
- The intended audience for this paper is all stakeholders in energy usage information including:
- Energy users and end customers
- Facility owners and managers including purchasing, operations, financing
- Measurement and verification firms
- Utilities
- Energy services companies (ESCOs)

While all of these parties represent differing viewpoints and business models within the energy area, it is the premise of this paper that they share a core set of technical and business requirements that can be addressed with a single standards-based architecture for collecting and providing access to energy data.

We define an Energy Management Information System (EMIS) as:

> A communications and control infrastructure that ties together energy-related subsystems at distributed energy user end-points with multiple information consumers and applications.

Figure 1 shows a high-level view of the EMIS. The following subsections will refine this definition and discuss the requirements for the EMIS.

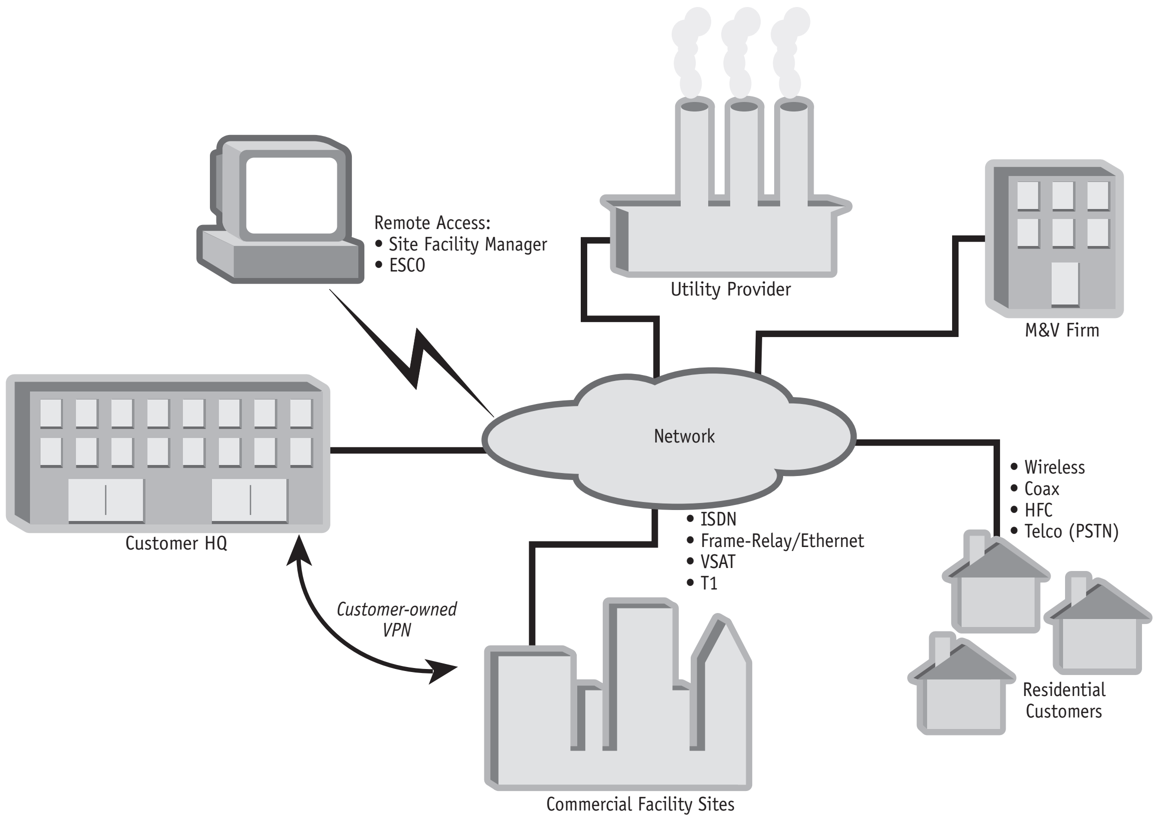

Figure 1 – High-level View of Energy Management Information Systems (EMIS)

The Many Uses of Energy Data

Most energy information systems today center around a single use or application of the information, such as demand-side management, or automatic meter reading. In fact there are many uses or applications for energy information including:

- guarding against billing errors
- allocation of costs to department/product/tenant
- scheduling of preventative and predictive maintenance
- supporting energy purchasing negotiations
- early identification of equipment or system operating problems
- informing changes in facility/building processes and schedules

- assisting in compliance with environmental requirements such as Indoor Air Quality (IAQ)
- remote upgrade and maintenance of local energy control equipment
- demand-side management via real-time and time-of-use pricing
- business operations planning

The basic information requirements for all these applications overlap greatly and are derived from a few key data elements:

- energy usage profiles (per submetered system)
- equipment-related events (on/off, failure events)
- rate information (including time-varying rates for tiered pricing)
- current programmed operational schedules and other control settings (e.g., setpoints)
- estimated bill summaries
- live measured values (e.g., temperature)
- equipment/device status information
- live and historical weather information

With the deployment of digital network-based systems for energy and facility measurement and control it is possible to view the control network as a single 'source' for all this required data. This enables a single coherent architecture which can satisfy needs of all the energy related applications across both commercial and residential sectors.

The Many Users of Energy Data

As a direct result of the many application requirements for energy information, there are multiple users of the information. This is an important aspect of the problem since the users of energy data typically belong to different companies and have different business motivations and constraints on their use of the data. Since users are geographically dispersed, there is a fundamental technical requirement for distributed access to the information. Distributed access should not be an 'optional' feature or an afterthought.

The requirement for multiple users of the data also imposes security requirements for controllable access to various subsets of the information. This is necessary to ensure privacy and to enable a variety of business models.

Bridge to Related Systems

Although markets and technologies for the various subsystems of a building or facility have evolved separately, the end customer or user of these systems views them as related pieces of a single facility management system. To deliver many of the required advanced energy management functions, it is necessary that there be sharing of information between the energy management system and related facility subsystems. These related subsystems include:

- Fire and life-safety
- HVAC
- Refrigeration control
- Home automation
- Security system

A link between the EMIS and these subsystems also can add value for the customer by providing remote access and wide-area communications capabilities.

Flexible and Future Proof

It is critical that the architecture for the EMIS be flexible and able to evolve with changing technologies for communications and control. Given the diverse set of stakeholders in the system, and the rapid change in underlying technologies for application integration and communication, expandability and support for smooth evolution of the system is key.

The wide range of applications that the EMIS must support also requires that things like computer platform independence be strongly considered. As the general computing infrastructure moves to thin clients and microservers, the architecture which implements the EMICS must be capable of supporting these new paradigms to protect the investments of all the stakeholders.

Part of being future proof means scalability to address applications ranging in size from a few sites to tens or hundreds of thousands. As energy information is used for an increasing number of applications it is also important that security features be built into the architecture. This includes both privacy functions to prevent unwanted snooping of the data, as well as authentication and access control to manage which parties have access to what types of information in the system.

Finally, one of the most important requirements for the EMIS architecture is that it be independent of communications technology. Even within a single application area of the EMIS, the connection to the home, it is not at all clear what communications technology will be the most widely available. Looking beyond the current race between Cable, Telco, and Utility efforts to provide the communications channel to the home, it is clear that technology in this area will continue to evolve rapidly. It is most likely that there will be multiple technologies and services available to reach the energy information end-points. To create a future-proof EMICS solution it is necessary to utilize a communications infrastructure which is independent of, or which supports the widest possible range of, communications technologies.

Standards-Based Solutions are the Way

The general computing industry has shown how open, standards-based technologies can be critical in meeting future-proof and expandability requirements. Given the number of stakeholders in energy information, and their diverse business viewpoints and constraints, it is clear that only an open standards-based solution for the EMIS will meet their requirements.

The architecture for implementing the EMIS must adopt existing standards where applicable and develop new ones only where needed. These standards should have the consensus of all the stakeholders involved to ensure that everyone's investments are preserved. Only a standards-based approach will allow multi-vendor solutions for implementing the EMIS. It will also ensure the ability to exploit existing standards-based subsystems and infrastructure such as the commercial customer's WAN/VPN, or the facility's HVAC system.

A standards-based solution is also the best insurance against a system which is tied to a single communications infrastructure. This is critical for future proofing and enabling the EMIS to adapt to new technologies which will lower customer costs and improve functionality.

Internet Protocol (IP) Provides Powerful Core Technology

Over the last few years, the Internet Protocol (IP) family has emerged as the clear standard for digital computer communications. The growth of the Internet and the adoption of IP for internal corporate Intranets has cemented IP as the core of the global enterprise network at all levels.

This adoption of IP is based on sound technical criteria. The number of physical networking media supported by IP is impressive and continues to grow. Some of the currently supported media include:

- Ethernet, Fast Ethernet, Gigabit Ethernet
- ATM
- Cable/Coax/HFC
- Fiber Optic
- PSTN
- ISDN
- Wireless (various, including cellular)

This media-independence is key to meeting the range of requirements for EMIS spanning both the commercial and residential applications. It is also key to a future-proof architecture. IP technology and the market forces behind it have shown tremendous ability to adapt to and exploit new networking and communications technologies as they emerge.

IP also offers several specific technical features that are required for the EMIS including scalability and security. The Internet is firm proof of the scalability of IP-based networks. And security solutions are now appearing for IP which address the full spectrum of needs including encryption, authentication, and digital signatures. These solutions are being driven ahead rapidly by very large business forces such as e-commerce. The EMIS architecture can piggy-back on the enormous technology and product base that exists for IP.

The requirements for platform independence, and the ability to easily integrate with many different types of applications on the enterprise side, are both clearly met by the use of IP. All operating systems and computing platforms support IP.

Is a Control Network Required?

With the obvious ubiquity and relatively low cost of IP networking, one might wonder if perhaps IP-based networks are all that is required to fully implement the EMIS. The answer to this is 'no.' Standard control networks, such as LonWorks, have emerged because they offer a low-cost networking technology specifically designed for monitoring and control applications such as energy management. While it seems clear that IP will continue to push 'downward' toward control systems, it will not fully displace them due both to cost considerations and technical requirements such as wiring flexibility offered by control networks.

In commercial building automation LonWorks has become the dominant standard for networking world-wide. The requirement of the EMIS to interface to the facility subsystems such as HVAC and security dictates that there be a bridge to the control network. For the Home applications, power-line carrier networks such as LonWorks, CEBus, and X-10 are critical to meeting ease-of-use requirements for retrofit applications.

Energy systems that focus on a single application segment, such as automatic meter reading, have often been implemented as a single-point device that provides some aspect of energy information (metering data). These solutions typically use a direct polling-based communications structure based on a proprietary wireless or modem-based protocol. Such single-point devices serve only the needs of one or a few of the functions required by an EMIS. There is typically little or no expandability and the communications technology is fixed and often proprietary. An architecture that includes a control network instead of single point devices allows the expandability and interface to other subsystems that is required for the EMIS.

IOConnect™ Architecture - A Comprehensive Solution

While IP provides a powerful communications infrastructure, it alone is not sufficient to meet all the requirements of the EMIS. A messaging and/or object structure is needed which provides seamless connectivity between enterprise energy applications and the remote I/O points. Benefits that this object layer provides include:

- Protects application investment by separating application from connectivity details.
- Allows more dynamic adding or changing of applications without reconfiguring entire network.
- Provides integrated security and message reliability features.

The IOConnect™ Architecture was developed as a result of years of experience with control systems and developing connectivity solutions. IOConnect fits particularly well with the requirements of the EMIS. It utilizes an object/messaging layer to deliver robust, secure communications across a range of platforms and network media.

A diagram of the IOConnect Architecture is shown in Figure 2. IOConnect is a unique approach that supports multiple types of interfaces to the same data on the network. This ensures that both custom and off-the-shelf applications can be deployed with the greatest flexibility and lowest costs. IOConnect supports the latest computing architectures including thin-clients (e.g., Network Computer, PDA, Web-TV).

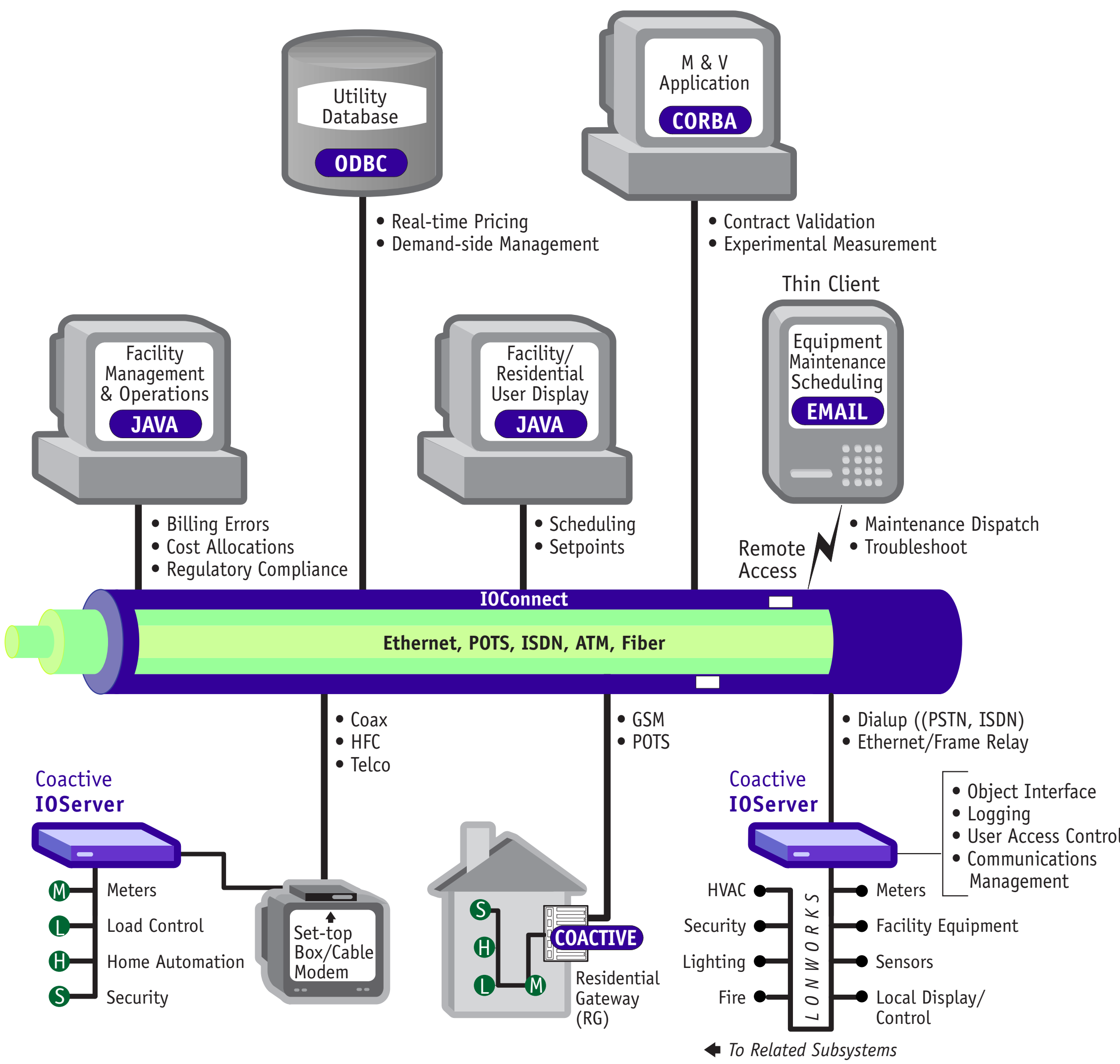

Figure 2 – The IOConnect Architecture for Energy Management

The IOServer is the family of connectivity appliances which provide both the physical and logical connectivity between control networks and IP. The IOServer provides access to the LonWorks network as a set of object or message interfaces. In addition these devices control access to the information to help support the security policy being used. The IOServer also provides data storage functions (data logging) as part of the object interface.

The following subsections describe how the IOConnect architecture meets the specific requirements of the EMIS.

Multiple Industry-standard Interfaces

There is not a single 'energy application' which must have access to energy information. It is unrealistic to assume that all energy applications now and in the future will be built to a single interface. Technical requirements of the application and other business realities dictate that multiple interfaces be supported.

IOConnect provides multiple interfaces to energy data thereby allowing all energy applications to be tied into a seamless system. Industry standard interfaces supported include:

- CORBA - IDL-based interface for developing powerful custom applications.
- LonWorks, LonTalk/IP - for interfacing to 3rd-party user interface and network management tools.
- Java - for creating thin-client applications for display and control.
- OPC - allows use of Windows-based SCADA tools.
- ODBC - to route data directly to standard databases without little or no custom code.
- Messaging (Publish/Subscribe) - flexible architecture for creating dynamic, distributed applications.

By supporting a wide range of industry-standard interfaces, the IOConnect Architecture ensures that the requirement for multi-vendor implementations remains a reality.

Scalability and Security

IOConnect is based on IP as the underlying network transport mechanism. By conforming fully to IP a variety of security technologies and products can be utilized to deliver the right cost/benefit tradeoff. Application-specific security policies can be implemented using the CORBA interface and its associated security services.

There are several aspects to scalability that must be met for the EMIS. The first is performance in the face of a large number of sites and/or applications in the system. IOConnect addresses this with its fully distributed architecture. By taking a distributed object approach, there is not a single server or database which can create a bottleneck or single point of failure in the system.

A second important scalability factor is management and maintainability. By conforming to standard network management protocols such as SNMP and HTTP, IOConnect devices can be efficiently managed using existing enterprise tools such as HP's OpenView or Sun's Solstice. This is crucial in keeping operational costs for the system low.

Integration of All Energy Information

The key requirement of the EMIS, if it is to truly meet the needs of a broad set of users and applications of energy information, is that it provide integrated access to all energy information. IOConnect meets this need with its embedded appliance approach which offers access to all required energy information through a range of standard interfaces.

Related energy subsystems such as HVAC, fire and life-safety, and security can all be linked seamlessly into IOConnect via LonWorks. Since IOConnect provides access to all LonWorks devices, not just energy measurement devices, top-to-bottom integration is achieved.

True Distributed Solution

IOConnect is a truly distributed architecture implemented with low-cost embedded appliances. This offers several advantages over traditional client/server or centralized database approaches. These advantages are key to creating a robust EMIS and include:

- Low cost per site due to appliance design.
- No single point of failure.
- Direct scalability for both performance and manageability.
- Supports multiple models of information dissemination (no single stakeholder need have control over all information).
- Can use different communications media for different sites/parts of the system.
- Supports many geographically dispersed applications/users of information.

Low Deployment and Life-cycle Costs

While not explicitly a requirement for the EMIS, any technology system must answer to initial cost of deployment, and more importantly to overall life-cycle cost of ownership. IOConnect meets the goal of low initial cost with a unique embedded, distributed appliance design that allows use of existing communications infrastructure whether it be an Ethernet VPN, shared dial-up, or IP over Cable to the home.

By supporting standard network management and application interfaces, IOConnect minimizes both initial development and ongoing maintenance costs.

Conclusions

There is a great deal of overlap in requirements for energy management information across traditional and emerging applications. These requirements can be met by a single standards-based architecture which provides flexibility and ability to adapt to new technologies and requirements. Stakeholders in energy management information including Utilities, ESCOs, M&V firms, and energy users can benefit greatly by requiring that solutions purchased or developed conform to such an architecture.

Coactive's IOConnect Architecture has features necessary to begin meeting this challenge today. Based on open standards, customers can be assured that their investment will be protected and that the full power of multi-vendor, open systems can be brought to bear on their businesses.