OPC Unified Architecture for Industrial Demand Response

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Abstract

Web Services require reliable communication over a wide area. While Internet can be used for this communications, for customers these Web Services must satisfy requirements for security, availability, reliability, and performance/scalability. Additionally, these web services must be readily integrated into existing communication networks at the communication end points. This paper considers the use of Web Services based OPC Unified Architecture.

Keywords: *Demand Response, Web Services, OPC UA, Communication Network.*

1. Introduction

In order for utilities to more effectively control equipment, we must be able to communicate reliably with load control systems and devices. Frequently, communication system designers will start by developing a set of XML documents that get exchanged between parties.

For customers, the architecture must support two-way PUSH and the PULL communications between a centralized utility server and distributed client load control systems and devices. When using PUSH, the server sends client load control systems XML documents asynchronously. When using PULL, the load control clients request XML documents from the server.

While it is easier and frequently necessary to employ a PULL model for communication, clients typically don't know when events occur in the server. Clients can continuously poll the server, but as the number of clients increases, the latency of message delivery increases. A reliable standardized mechanism for clients to asynchronously receive an XML document is needed.

This paper describes how Web Services can be use to perform reliable asynchronous communication through which a client can receive demand response related XML documents. The proposed solution employs OPC UA Web Services. OPC UA does not define the content of the XML document, but only the means by which clients set up a reliable and secure two-way communication channel with servers.

1.1 Communication Technology

Communication Technology Requirements Demand Response communication requirements include:

- Object Technology Neutrality – It shall be possible to implement the Web Service Profile using a variety of Object Technologies including Java, Microsoft's .Net, 'C' Language, and others.

- Middleware Neutrality − Given that technology and platforms vary widely, it is required that service definitions be as decoupled from middleware specifics as possible. The Web Services defined in this profile must be able to provide access to messaging middleware, databases, content repositories, and a wide variety of applications including ERP systems.
- Performance/scalability − The capabilities of Demand Response communication end points and communication channels vary widely. The varying availability of resources rules out a single way of exchanging data. Consequently Demand Response communications standards seek to maximize interoperability while at the same time enabling choice of transport and encoding technologies.
- Reliability − Reliability related to demand response data exchange needs to be insured. Lost or corrupted messages can severely impact the profitability of operations. Service definitions are required to insure reliable data exchange.
- Availability − Some systems need to run year round with minimal disruptions. Service definitions must provide robust interoperable mechanisms for failing over clients and servers.
- Security − Traditional web service deployments secure the transport layer only using Transport Layer Security (TSL) or Secure Sockets Layer (SSL).

However, these technologies alone do not ensure a secure exchange of messages. While more complete security can be added to TSL or SSL, the large number of options available makes interoperability difficult to achieve. The specification for demand response Web Services must provide enough detail to achieve interoperability without the need for superfluous bilateral agreements.

2. Possible Solutions

The development of Web Services for Demand Response can be seen as consisting of two tasks. The first is the specification of message payloads and the second is the specification of how Web Service technology is used to transmit payloads. The specification of payloads is particular to Demand Response since the content of message payloads reflects the content of the communication. However, the specification of the way in which Web Service technology is used to reliably communicate information need not be specific to Demand Response. Instead, the reuse of generic technology may be employed as long as that technology meets the requirements of Demand Response Communication.

For example, the PSMSC1 addresses both aspects of Web Service communication by specifying the content of the messages exchanged (payloads) as well as a set of technical profiles by which the payloads are transmitted. PSMSCM specifies a set of XML documents to be exchanged between a Demand Response Automation Server (DRAS) and load control systems and devices. The PSMSCM technical profiles for communication with building automation systems as well as several custom profiles for communication with systems other than building automation systems. However, it is not clear that the specification of custom technical profiles related communication is preferred over an approach that reuses existing technical profiles. When communicating with systems, the reuse of Web Services designed for communication may be preferred. By using existing standards for communication, existing system are more readily integrated into a Demand Response System. For example, the OPC Unified Architecture (OPC UA) standard could be considered. OPC UA is based on work originally done by the OPC Foundation2.

OPC UA is attractive for communication for several reasons:

- Older OPC technology based on Microsoft COM technology is widely used by control systems. It is straight forward task to wrap existing OPC COM based interfaces
- OPC UA is under consideration for communication within the operations and maintenance areas within electric utilities.

It is believed that OPC UA meets all requirements for Demand Response communication and will enable more rapid uptake. In particular, since OPC UA has been developed in cooperation with many of the large management/process automation/utility SCADA companies, OPC UA provides the most expedient way to reach consensus with regard to communication.

2.1 OPC UA Object Technology Neutrality

OPC UA provides cross platform Web Services that have been implemented using:

- .Net
- Java
- ANSI C

2.2 OPC UA Middleware Neutrality

OPC UA can be implemented over a variety of middleware and applications. The figure below illustrates OPC UA applications.

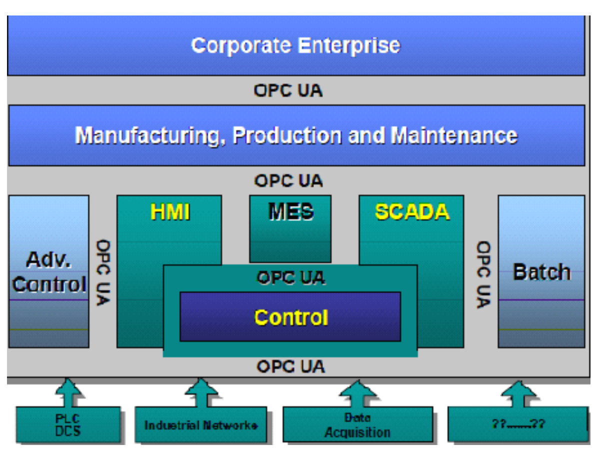

Figure 1. OPC UA Applications

2.3 OPC UA Performance/Scalability

OPC UA services can be implemented over a variety of communication transport profiles. This means a single application wrapper can be used regardless of the technology used to transport data. Consequently, the technology used for a communications link can be optimized based on end point and communication channel sizing. For example, requirements for a high throughput link may not allow the use of XML data encoding, but instead may employ binary encoding of data on the network. However, switching binary encoding on the network does not mean the adapter needs to be rewritten.

OPC UA provides three transport profiles to meet the varied performance/scalability requirements of the utility metering and operations environment:

- XML Web Services (HTTP, XML, SOA)

1) Excellent tool support
2) Firewall friendly
3) CPU and Bandwidth intensive
4) Recommended applications: Enterprise integration and general business/information applications

- SOAP/HTTP with binary attachments

1) Mid-range performance
2) Firewall friendly
3) Requires secure conversation implementation
4) Recommended applications: Integration across the Internet in the case where data payloads are large

- Pure Binary (TCP Secure Conversation and Binary attachments)

1) Best performance
2) Limited Tool Support
3) Requires firewall configuration
4) Single TCP port per server
5) Recommended Applications: Specialized high speed applications or when running on a platform with limited resources.

It should be noted that which profile is used can be configured at run-time. The OPC UA API supplied by the OPC Foundation provides portability between profiles.

2.4 OPC UA Reliability

The WS specifications by themselves do not provide reliable messaging. OPC UA provides additional reliability via:

- Timely detection of communication failure

1) Keep-alive interval negotiated by client and server
2) Both client and server monitor activity

- Rapid recovery from communication failure

1) Resynchronization with existing channel

- With no loss of Data

1) Data loss unlikely for intermittent failures

2) Servers cache delivered notifications allowing retransmission

It should be noted that the requirement for reliable communication for communications suggests that the Web Services should not follow the Representational State Transfer (REST) paradigm. Typically REST based services have the following the characteristics:

- A pull-based interaction style: consuming components pull representations. However, for demand response, push is also needed.
- Stateless: each request from client to server must contain all the information necessary to understand the request, and cannot take advantage of any stored context on the server. Therefore, neither the client nor the server can positively know if all messages sent by the server have been received.

It should be noted that a REST based protocol may be suitable with residential customers for whom a lost message does not have as great a potential economic impact.

2.5 OPC UA Availability

The WS specifications by themselves do not enable the construction of interoperable highly available components. OPC UA high-availability is provided by:

- Keep Alive messages provide timely detection of communication failures
- Client/Server Sessions allow OPC UA components to maintain state context
- Notification Sequence Numbers allow clients to keep track what messages have been received
- Subscription republishing allows seamless transfer

2.6 OPC UA Securities

In the absence of OPC UA, WS Security provides a very large number of options. It is difficult to achieve interoperability without limiting the choices to those that are applicable to the utility metering and operations environment. OPC UA includes a set of mandatory encryption and authentication profiles based on WS standards. The OPC UA authorization is illustrated in Figure 2.

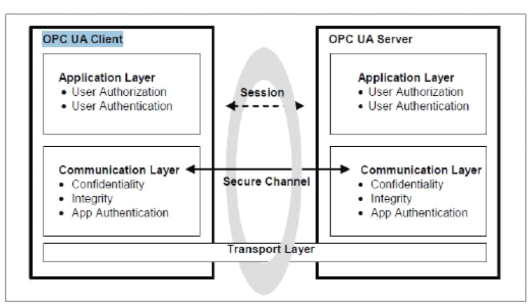

Figure 2. OPC UA Authorization

The OPC UA WS security stack includes many of the WS Security specifications. A closer look of the OPC UA Security stack is shown in the figure below:

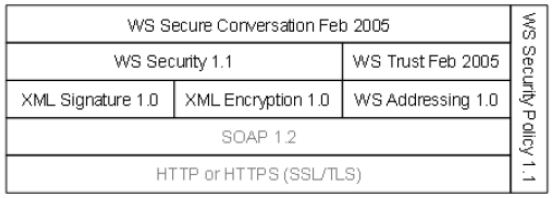

Figure 3. OPC UA Implements the WS Security Specifications

3. Conclusions

Web Services could defined that implement the WS specifications to meet specific needs, however UA provides a pre engineered solution with support by major vendors. By reusing the generic OPC UA services, building/industrial/utility automation systems can limit the number of supported interfaces.

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References

[1] Productive Safety Monitoring System in Coal Mine (PSMSCM), Taiyuan University of Science and Technology **(2011)**.

[2] The Object Linking and Embedding for Process Control (OPC) Foundation is an industry consortium that creates and maintains standards for open connectivity of industrial automation devices and systems, such as industrial control systems and process control generally. The OPC standards specify the communication of industrial process data, alarms and events, historical data and batch process data between sensors, instruments, controllers, software systems, and notification devices.

[3] Qiu Jianping and Chen lichao, "Demand Forecasting Based on Internet of Things", CASoN **(2010)**, pp. 45-48.