DEVELOPMENT OF A STANDARD GAS MEASUREMENT DATA MODEL IN SCADA SYSTEMS

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ABSTRACT

In large-scale gas SCADA systems, the variety and extent of field equipment requires a new look at the development of data concentrators, common data models, and broker based messaging for connection to the enterprise. Scanned devices have a limited range of data structures which must be aggregated and normalized to an 'open' vendor independent model at the front end of SCADA and MEASUREMENT systems before being applied to general applications and decision support in the enterprise. The development of object technology and brokered messaging systems is now allowing SCADA vendors to flatten architectures and improve interconnection between applications. The adoption of a Common Information Model (CIM) in gas measurement will allow SCADA and MEASUREMENT systems to operate as open peer data sources to the enterprise, yet still retain independence of purpose and ability to grow and evolve separately.

INTRODUCTION

In the 1990's, SCADA vendors have touted "open" systems as a path for vendor independence. Open systems of this era generally meant usage of common 3rd party hardware (*e.g.,* common workstation technology) and usage of a common operating system (*e.g.,* Posix complaint). Open systems were further extended to incorporate 3rd party database management systems, such as Sybase or Oracle, encouraging usage of such standard tools as Structured Query Language (SQL). However, the underlying database formats and application program interfaces (APIs) were still proprietary for each vendor, so it is not possible to take an application from vendor system "A" and plug it directly into vendor system "B."

An aspect of openness that has gained ground in the electrical industry is the use of a CIM or common information model, agreed on by standards committees and institutions. In the case of electric power the EPRI CIM model became a standard for definition of standard data models in the electric power industry. With the de-regulation of an industry, coupled with daily acquisitions and mergers, standard data models aid in the coupling of systems and transfer of common data. In addition, specialized applications for handling data should be vendor and acquisition independent. The use of a common model aids in developing vendor independence and adds real meaning to being able to provide a higher value of service application in gas measurement technology. Before looking at development of a standard, one should look at the differences between the Electric and Gas Industries.

A key difference for consideration in the gas industry is the incorporation of fluid flow and properties of gas, which couple the interchange of energy with the physical transport mechanisms. Electric power transmission models were primarily developed to aid in the management and accounting of energy. In gas transport the energy transported is related to the standard volume of gas and its heating value, rather than its actual potential and flow as in electric power systems. This is a key element for consideration in the augmentation of a common electric power model with the appropriate model for gas. In Gas Transmission systems, what then is energy is the actual energy related to the pressure and flow of gas. Applications are associated with the optimization of compression, however the real energy of concern to the market is the 'energy' and 'mass flow' associated with heating. Thus already in consideration of gas transfer models we need to consider mass, energy, and momentum in terms of flow and optimization models, and heating energy and mass flow in terms of the market and financial models.

WHAT IS AN OBJECT MODEL?

Development of an object model picks up all the standard components of the industry and attempts to define standard attributes or features of that component which could be applied. It contains elements which describe the object in terms of either other well defined objects as in aggregation, or as a minimum contains all the essential independent attributes of that component. Object models provide for concepts such as encapsulation, inheritance and association of data, which are concepts not found in traditional relational designs. These object models find rapid acceptance in the programmer community as they match the object oriented nature of common program languages today, including C++, C#, and Java.

The Object Model* in the Electric Power Industry

An important aspect of the new application architecture is the development of common object models that service an industry. These standards are displacing vendor specific models of today, and will require that

*The Modern Distributed Control System Application vendors invest in changing their systems to meet the new standards in order to survive. Several of these new object models have been designed in conjunction with protocols to field devices. Some of the new object model standards include:

- IEC TASE.2 for Inter Control Centre Protocol (ICCP) for Control Centre Information Exchange
- EPRI Common Information Model (CIM) for Power System Resource Information
- IEC 61850 Communication Network and Systems in Substations standard

The Electric Power Research Institute (EPRI) initiated the CCAPI Research Project[5] to lead the way to open Energy Management System (EMS) applications. The result of this effort has been the creation of the EPRI CIM, which models the various aspects of a transmission and generating utility. The common information model pulls together common aspects of the TASE.2, the IEC61850 and the CIM into a single model, hence the "common" designation.

The CIM model is viewable in web form on the Internet at http://www.cim-logic.com/cimu09a/index.html. The CIM model breaks the definition of the Electric Utility into the following broad categories:

- Core Objects
- Domain
- Energy Scheduling
- Financial
- Generation
- Load Model
- Measurements
- Outage
- Protection
- Reservation
- SCADA
- Topology
- Wires

Each major category can subdivide into further sub-categories. For example, the "Generation" topic subdivides into the following sub-categories:

- Generation Dynamics
- Production

Whereas the subcategory "Generation Dynamics" further subdivides into various object definitions, including objects such as Steam Turbine, Hydro Turbine, Drum Boiler, and others.

Although the CIM model has been initially implemented for electric power transmission utilities, there is interest in the CIM community in further development of the model as a general-purpose utility model.

AN OBJECT MODEL IN GAS MEASUREMENT

The object model in the electric power industry is well developed under the banner of CIM. We would now look at the development of similar object categories in the gas industry to help achieve the same interchangeability of data and vendor independency as achieved in the electric power industry. Some of the objects categories in electric power would have similar categories in the gas industry as per the following table. The object categories proposed for the gas industry are by no means standard at this point in time, and should be read as a potential categorization.

Electric Power Industry	***Gas Industry Model***
Core objects	Core Objects
Domain	Domain
Energy Scheduling	Energy Scheduling
Financial	Financial
Generation	Gas Transport
Load Model	Customer Load Model
Measurements	Gas Measurement
Outage	Outage
Protection	Emergency Shutdown
Reservation	Nominations
SCADA	SCADA
Topology	Topology Pipelines
Wires	Pipelines
	Properties
	Compression

TABLE 1. Correspondence of Gas Industry to EPRI CIM categories

The list in Table 1 is a guide to the way in which corresponding categories could be visualized in the gas industry. Looking at the key differentiators between the industries will help on the general development of an object model, which could be used.

GAS PHYSICAL CONTAINMENT MODEL

Its constraining physical model characterizes the general gas pipeline network. It consists of at least the following general elements:

- Pipeline segments
- Compressors
- Storage spaces

GAS MEASUREMENT MODEL

- Gas Chromatographs
- Gas Flow Meters

GAS TRANSPORT MODEL

- Pressure, Mass Flow, Transport Energy, Momentum
- Gas Properties — density, specific heat etc.

MARKET ENERGY (ME) MODEL

- Heating Value
- Standard Volume
- Energy

ADOPTION OF XML

A further development in the usefulness of the common information model comes through the adoption of XML, or eXtensible Markup Language (http://www.w3.org/XML), as a tool for exchanging and maintaining object models.[1] XML has its derivation from the standard HTML (Hyper-Text Markup Language) and SGML (Standard Generalized Markup Language, the language from which HTML is derived). SGML has been extended further into a completely extensible markup language (XML) which is suitable for describing both database schemas and also data content in a single text file. This XML format is being adopted quickly as a standard method of data exchange in applications, and is a key component of the future direction from Microsoft™ Corporation in the introduction of it's next generation microsoft.net platform. XML is also the basis of SOAP, Simple Object Access Protocol, which encapsulates the data in a transport mechanism to provide for a common information data exchange format.

Development of the Common Information Model has been in progress since 1995. The model has passed interchangeability tests among various vendors in December 2000 using XML,[6] where various vendors exchanged and read each other's data model in XML format. It has reached a level of maturity allowing vendors to successfully implement projects and deliver them with CIM compatibility.

While CIM can describe a data model for the industry, industry itself has to adopt the techniques and tools of the enterprise in order to collaborate with it. IT departments are placing demands on the SCADA system for information required to adapt and optimize the supply chain, this requires information regarding measurements and SCADA systems. Points of integration with the enterprise have traditionally been difficult in SCADA owing to the requirement to transform point and record based field data to the required rollups and forms needed for the enterprise, while maintaining high performance for operations on the pipeline and custody transfer management.

ENTERPRISE INFORMATION DEMAND

This increasing demand for information relating to the operational and maintenance aspects of pipelines has outpaced the ability to upgrade field device installations and communications networks to supply the data. De-regulation, business mergers and acquisitions, and supply chain optimization require a point of flexibility to be created for supply of operational and field data. This point becomes a provider of a variety of data relating to the plant and equipment in the field, and therefore the controlled process. Whilst the revamp and extension of plant equipment may evolve slowly, the pace of business and business model change is extreme and its demands for data are only growing, not diminishing.

Whereas at some point in the near past, the demand for SCADA data was seen as only few clients, adoption of the internet has given new meaning to client server, leaving the server or data source, with now middle tier architectures, middleware, and web integration technologies to deal with before actually reaching possible the 'ultimate thin client' a voice activated control session on a normal telephone. There is however a clear point of demarcation which we can describe in terms of industrial electronic measurement technology and the realm of the Internet. For this purpose the Blue Water Blue Sky Line in introduced as in Figure 1.

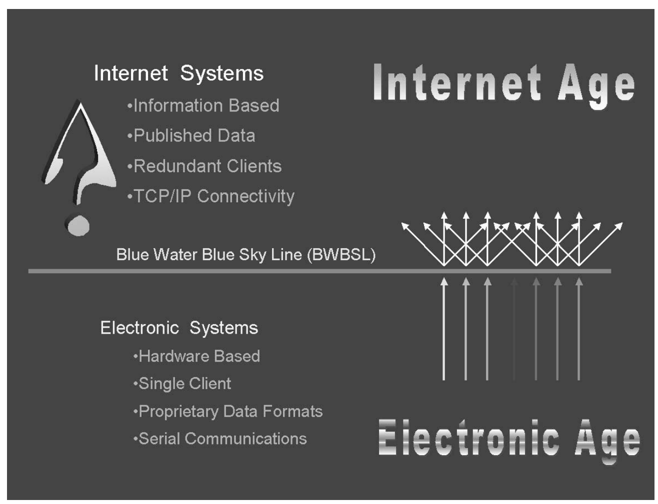

FIGURE 1. The Internet vs. Electronic Age

TECHNOLOGY LIFETIMES

In conjunction with the demand for data, there is another factor relating to the relative lifetime of the technologies involved. The following figure illustrates the problem showing a clear distinction between lifetimes for plant based electronic age technologies and those of the data servers and enterprise applications.

Somewhere between the Database server and the field equipment is the point at which internet access and communications flexibility is required, which would help to match the lifetimes of measurement equipment and field installations and the SCADA data servers and enterprise demands.

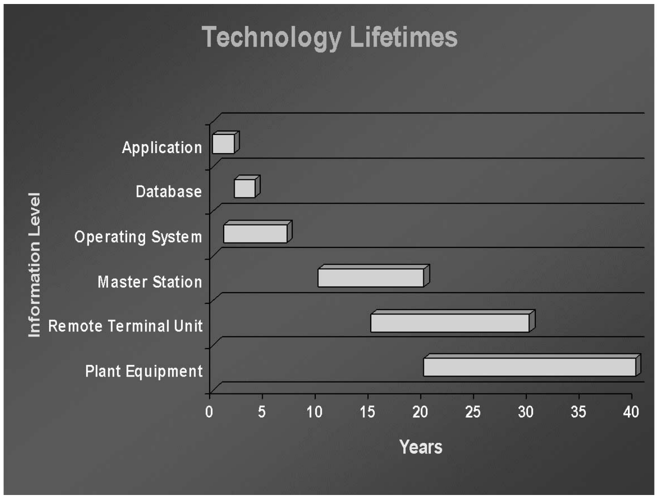

FIGURE 2. Technology Lifetimes in SCADA

BROKER TECHNOLOGY

Traditionally SCADA is based on dedicated serial point to multipoint communications and address schemes, where the complete communications access, addressing, and data structures and configuration of the physical device is known to the engineer of the SCADA system. This grand hierarchical plan provides a robust, self contained system which is developed from a single client type viewpoint, *i.e.,* the gas controller where a flat single or two level namespace was maintained virtually permanently to access and describe device borne data in the field. Typically "modbus" registers were used with known ranges assigned to specific data meanings. Message based brokers give a number of key advantages over the older rigid architectures. These are:

- NAMING A universal hierarchical naming convention, which can be applied to all data from all devices regardless of device type.

- AGGREGATION An ability to aggregate data into useful model forms from simpler data types

- PUBLISH/ SUBSCRIBE ability to accept messages or records of data from a data souce and decouple the source from any client demands.

- ACCESS AND DELIVERY of published messages is independent. A broker client can be contained in a field device and having access to a broker, can be assured that regardless of the location of connected or potential clients, the data is available.

Broker technology places demanding requirements for memory and processing power in addition to the requirement to access TCP stacks than does traditional proprietary API technologies. However, the incorporation of broker clients in high performance data concentration devices provides flexibility and scalability. Adoption of broker technology in the field provides ready access to record based named data immediately to the operational and enterprise level.

A broker therefore provides a reliable data messaging scheme, where data is accessible to the enterprise and operators. Brokered data sources have clear functionality through the use of the Interface Definition Language (IDL) and can describe the data in terms of its position in the hierarchical namespace and a standard agreed object form. Brokers' traditionally transmit 'blobs' of data associated with the leaf of the namespace tree. We really would like to be able to describe the blob as well as the tree. The XML will allow us to describe the data for use by clients, but understanding the data in terms of application function requires a better agreed standard data model in the industry.

STATION COMPUTING DEVICES

High power low cost computing technologies make it feasible to configure data concentrators for deployment to the field. A number of key features and benefits of these are described here.

Features

- Dual TCP/IP connections
- High performance processors
- Memory > 16MB
- Flash permanent memory- no moving parts
- Non Volatile Memory
- Environmental durability
- I/O Capability
- Central database
- Broker Technology
- Variety of legacy communications media and serial connectivity
- Configurable protocol stack selection and assignment
- Low cost

Benefits

- Enterprise access direct from the concentrator position
- Measurement system access direct to the concentrator
- Maintenance system access direct to the concentrator
- Better security of open access
- Alternate control room access to data
- Ability to service rapidly changing data needs and quantities
- Ability to incorporate standard or common information models close to the legacy source of data thus improving data consistency between clients

SUMMARY

This paper recommends that field device manufacturers and SCADA vendors work on the adoption of common information models for the gas industry and apply these either at source or as close to source as possible by the use of intelligent source devices or data concentration devices. This approach coupled with the adoption of broker based messaging would provide standardized enterprise and web based access to data, and also would enable application providers to focus on applications rather than vendor specific API's and data mappings for each peer server.

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