S95 in Real Time

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ABSTRACT

The ISA S95 Standard is proving to be a viable model for integration of factory information systems with high level business systems such as ERP (Enterprise Resource Planning). (1) Current implementations exchange documents utilizing XML Schemas, such as those defined by the World Batch Forum's B2MML standard. (2) This paper describes the application of the newest technologies for integrating factory floor control systems in real time to such business systems. At the factory control level, messaging technologies include OPC-DA, real time messaging buses, and transactional message buses. (3) Messaging technologies used at the plant-wide level for integration of the factory floor with information systems include OPC-XML, IBM MQSeries and Microsoft BizTalk Orchestration. (4)(5) These are linked to ERP via standardized message exchange adapters. In the future, standardized Service Oriented Architectures (SOA) will help further enable multi-vendor interoperability. By applying these technologies, businesses can realize significant improvements in asset and resource management and agility in responding to markets. Additionally these technologies provide minute-to-minute visibility into key performance indicators (KPI) leading to greater profitability.

Business Context

Manufacturing businesses are under extreme competitive pressure to minimize surplus inventory and maximize profit margins while at the same time being able to satisfy customers demand for product. It's common knowledge that if a customer can not purchase needed products from one company, they quickly move on to another. One of the primary goals of effective business management is the ability to forecast or predict the market demand for any given product. Knowing future market demand allows predictable planning and scheduling to occur. Market predictability, however, is a function of many variables. Products in some markets are controlled by long term contract. These markets are relatively stable and the easiest to model and predict. In other markets, the demand for products can be very volatile and fluctuate based on perturbations to any number of market variables. As the inaccuracies of long term forecasting increase and the time to build product decreases, the value of "building to order" increases. This has often been described as "on demand" or "agile" production. (5) It is the ability to link the business process of order fulfillment to the manufacturing floor as efficiently as possible.

Consider a customer who desires a product such as "designer" paint and places an order with a vendor for the paint. Many questions quickly arise. Are the raw materials available? Are the people available? Is production equipment available? Which site is best suited to produce the product? How long will it take? What special processes are needed? Once we've selected the site location, equipment, raw material and personnel resources, how do we transmit the "build order" and related instructions to the plant? When the product has been manufactured, what did it cost? How long did it take? What quality control data is available to verify that the product meets specification? What other process information was associated with the batch and how can I archive it for later analysis and troubleshooting? How do we request and ultimately receive this information? And last, but far from least, did we make or lose money? "Real time" business information processing is about making these decisions within a window of time that meets customer expectations. The ability to manufacture products as needed, and when needed, allows a manufacturer to reduce unnecessary production and minimize dead inventory while simultaneously satisfying the consumer's needs. The bottom line is a strong value proposition with a high monetary return.

Let's evaluate the case in which the time to produce a product is long, economies of scale are significant and demand can be forecasted with reasonable accuracy. In this scenario, the production planning and scheduling process becomes very important. The planning process usually involves creating and solving a multivariable model which forecasts longer-term production. This is used as the basis for scheduling incremental production. The two are joined at the hip in the sense that if the incremental production occurs as scheduled, then the overall planned production targets will be achieved. In order to accomplish this however, each scheduled production unit needs to be monitored and compared with the planned or requested production unit. Any deviations are "fedback" into the plan so that future production runs can compensate as required.

As illustrated above, the need to integrate production requirements at the business level with plant-floor product manufacturing can be of value in many different product manufacturing scenarios. The traditional solution for integrating these two environments has been to pick up the phone or send an email. Time wasn't considered very critical. As a company's processes and systems are modernized, tangible economic benefits can be obtained through tighter integration of business and automation systems.

What technologies are required to achieve this level of integration? What are the integration options available to enterprises? Should manufacturers develop custom proprietary solutions or can open industry standards provide more flexibility at a lower cost? Given that technology is evolving, what technologies and standards will be important in the future?

S95, A Closer Look

Enter ISA and the S95 standard. (1) S95 is all about production management and the information that needs to flow between business and production systems. It consists of an abstract object model with associated attributes. The following statements are excerpted from **ANSI/ISA–95.00.01–2000** putting into perspective the goals of the standard with respect to real time production systems:

Annex C (informative) — Discussion on models

> *"...the trend in systems integration has been toward the use of automatic control in its broadest sense (including dynamic control, scheduling and the closure of information loops) to integrate all aspects of the plant's operations including closing the information loops within the plant.... It has long been known which tasks such a system had to be able to carry out to accomplish these goals. Only since the advent of advanced computer technology has it been possible to handle the enormous computational load involved in carrying out these functions in real time and thus hoping to compensate for all of the factors affecting plant productivity and economic return.*
>
> ***Table D-II — An overall plant automation system must provide***
> *4 - A method of assuring the overall reliability and availability of the total control system through fault detection, fault tolerance, redundancy, uninterruptible power supplies, maintenance planning, and other applicable techniques built into the system's specification and operation.*"

The reference in **Annex C** to "*real time"* does not restrict the concept to traditional data acquisition, control and actuation loops. Ideally the manufacturing component of an enterprise must have all of its information loops executing with minimum lag times and must have optimal information density with proper context in addition to a well-defined feedback mechanism.

The reference in Table D-II to "reliability and availability of the total control system" should not be interpreted narrowly, nor should it be considered to be the responsibility of an *external* system. The "total control system" must include the information loops. Reliability and availability are in fact system parameters measured in *real time*. Traditional off-line maintenance management systems (MMS) do not deal with information about plant resources in *real time*. The S95 Standard acknowledges that any existing *external* MMS needs to be integrated, and it includes model components accordingly. However there is a great business benefit to be gained by implementing features of the maintenance management model using *real time* messaging technologies and by integrating with the personnel and equipment models by direct relationship modeling.

The flexibility of the S95 models with respect to varying industry requirements can be illustrated by an example cited in **ANSI/ISA–95.00.02–2001:**

> ***B.3 Multiple products per process segment***
> *"... In petrochemical refining and chemical production it is even more complicated, since the ratio of produced material can vary based on production parameters (such as temperatures of trays in distillation columns) and on the specific properties of the consumed materials (such as the sulfur content of the oil). In those cases, if the information needed to be exchanged on a regular basis, the most common approach would be to extend the Process Segment - Material Segment Specifications to include the mathematical relationships, such as an equation, tables, or LP, or a reference to an LP, equation, or table."*

The information exchange regarding products produced in process segments must carry context so that segment response information may be interpreted immediately, either by operators, automated optimization technologies such as Advanced Process Control (APC) or workflow orchestration technologies such as BizTalk. The example cited in **S95 B.3** above could be implemented by encapsulating the referenced mathematical relationships as executable code and serializing them using XML-encoded SOAP (Standard Object Access Protocol) transmission protocol. A specific code module would be specified for a particular process segment and for a particular product. Upon initiating a production run, production management tools would 'inject' the code module into the APC controller. The tools handling the segment response would carry a reference to the code module (or even the serialized code module itself) as context for analysis of the production results.

KPI – Moving From Process State to Business State

The concept of "information loop", used above, is an important one. It is similar to the concept of closed-loop feedback control in process automation where process variables are monitored and process actuators are controlled in "real time" in such a way as to minimize the difference between the desired condition and the actual condition. In an information loop, the variables measured are often called "Key Performance Indicators" or "KPI". These variables usually measure industry-specific business level properties that can vary with time and that reflect business "state". In addition, the feedback control mechanisms and the actuated outputs of information loops are clearly quite different from their simple single control loop cousins. Information loops are generally complex with many interdependent variables. These variables must be monitored and visualized within the organization. To further quantify this, what's measured must be available and seen within a time frame that allows 1) actions to be taken that can affect the immediate outcome or 2) actions to be taken that effect subsequent manufacturing cycles. If these aren't met then the information is useful for historical analysis or accounting purposes only. Scenario one implies a fast response and is normally associated with closed loop control. Scenario two is a slower process but is still a closed loop process.

Another important concept that affects KPI variables is that the levels of abstraction change as information flows vertically up an organization. Let's take a look at a continuous petrochemical process. At the control level, the physical attributes of materials such as flows, pressures and temperatures, are of importance. These are the things that are directly measured and controlled. At the process and advanced control level, the flow of a liquid in a pipe becomes the number of moles of a specific chemical flowing in the pipe. The generic liquid becomes a specific chemical. At the yield accounting and ERP level, the unit of granularity is typically the total chemical flow into and out of a process unit or area during some time period. At the highest business level, the total quantity and quality of a valuable chemical product produced by a plant, within some time period, along with the total resources required to produce that amount of product, are of greatest importance. Key variables exist at each of these abstraction levels.

Information loops within manufacturing include both production operations and asset maintenance. Comprehensive resource management requires both. Often in the past, these two areas were treated as essentially orthogonal areas which were loosely coupled. This was reinforced by organizational structures that mated them together at the highest levels of authority. The indigenous relationship and interdependencies that exist between operations and maintenance are becoming more and more recognized as is the importance of preventative maintenance and model-predictive asset management. (9)

As the business drivers become more clearly defined, the question quickly turns from "What should I do?" to "How can I do it?" S95 is an abstract specification which must be implemented using concrete technologies.

Tactical Integration Technologies for S95

"Time is of the Essence"

An enterprise doesn't achieve these business benefits overnight, nor is it simply a matter of "throwing money" to an ERP vendor. There are countless examples of failed ERP integration projects. Many projects did not meet their goals because of a mismatch between the out-of-the-box features of the ERP system and the de facto implementation of the enterprise business rules. The fundamental error was the assumption that the people in the enterprise would (very quickly!) learn new behavior according to the business rules and the strict user interfaces encoded into the ERP system – as purchased.

Successful enterprise integration recognizes that there are business processes that are natural to each specific component of the business. Furthermore, there are fine-grained details of business processes within each component that do not have one-to-one correspondence with elements within the ERP system. In fact, there need not be such a one-to-one correspondence. What is needed is a way to consolidate and aggregate information from those fine-grained processes into the format required by the ERP system.

Another aspect not accommodated by a monolithic ERP system is the need to support the different business process time constants in the enterprise. An ERP system is designed from an informational 'batch' perspective. In many cases, the time constant of the ERP system doesn't accommodate events that happen faster than the daily reporting cycle. Tactical implementations using integration technologies need to perform their functions at the cyclical rates appropriate for the process that is being managed.

For example, although distillation in a refinery can't be redirected to make different cuts from one minute to the next, it is possible to plan for two or more changes in cuts over the course of a day, directing product streams to different post-distillation processing units at the scheduled hour, or simply directing the streams to different storage vessels.

In discrete manufacturing, a work cell assembling customized computers is an example of the rapid reallocation of resources. Each computer has a unique specification which includes both the hardware and software components that must be installed. The time cycle of the work cell can be defined in minutes and there could be dozens of different orders flowing through that work cell in a given day.

Physical processes comprise numerous measurable components which may or may not include sensors and transmitters and data acquisition. In the design of the process, whether continuous or discrete, an engineer makes decisions about what should be measured and what should be controlled. Computer technology in general has expanded the limits with regards to what measurements can be acquired and which actuation elements can be manipulated to control the process. The evolution of computer technologies for information sharing in real time has expanded the limits with regards to how much influence business processes can have on the control of physical processes.

Successful information integration requires three core components: structured data content, standard data delivery, and business process workflow.

Structuring Data Content

The nature of data in documents has changed dramatically with the introduction of XML as a standard. But XML alone is insufficient. It is simply a formatting specification which is "human readable" and can be verified as "well formed". The creation of XML Schemas has accelerated the adoption of XML into many document-centric information systems by providing rich metadata that can be used for document validation. Furthermore, computer database vendors have formally embraced XML documents as native data types that may be stored directly into a database. They also embrace Schemas as standard technology for defining database structure and provide powerful XML-based query protocols based upon XPath and XQuery specifications.

Enterprise system integration of data content has been significantly improved by removing the 'proprietary' nature of the document format. XML Schema specifies both format and allowable content as well as allowable names for tagged information. Vertical market industries have collaborated to specify Schemas that provide structure to the documents that are exchanged between entities of the enterprises serving those vertical markets. An example is the Rosetta Schema used for coordinating information in purchase orders for parts in the electronics industry.

Even with XML Schemas as the base technology, each industry has exhibited the tendency to create unique Schemas for such basics as purchase orders or bill-of-ladings for shipping, that fail to comply with generic industry-wide definitions. Realistically, it is an industry's "supply chain" that dictates the necessity for coordinated XML Schemas. A single technology vendor cannot dictate the XML Schema for all industries. ERP vendors must accommodate a variety of Schemas when their solution suites are sold into different industries and even different enterprise customers within a given industry.

The ISA S95 standard recommends a common model and data structure for information exchange between enterprise business systems and the process systems that make the products. This model is an abstract model which can be realized in many different forms. The World Batch Forum (WBF) has developed the B2MML (Business to Manufacturing Markup Language) standard for batch/discrete manufacturing processes which represents a concrete XML Schema implementation of a subset of S95. In addition, ISA has created the S88 abstract batch standard for modeling batch processes with the WBF providing the BatchML (Batch Markup Language) XML Schema.

Data content structured according to common industry and enterprise specifications is very important but still not sufficient for successful integration. These documents must be transported between systems, which means data delivery must be standardized.

Standardizing Data Delivery

The issue of standard data delivery has been around for quite a long time. Many control system engineers never experienced the paradigm shift that occurred moving from a large variety of different vendor-specific electrical and pneumatic signal transmission encoding schemes to the three primary standards defined by ISA – i.e. 4 to 20 mA, 1 to 5 volts, and 3 to 15 psig. The engineer's decision was greatly simplified to one of three choices: "current", "voltage" or "pneumatic pressure". Transmitters and receivers could be purchased accordingly. Transmitted signals could be easily decoded by standard receiving equipment (electronic or pneumatic indicators, loop controllers or chart recorders). The control engineer's work focused on the management of loop sheets and instrument lists. There is however a significant limitation imposed by traditional control systems – the information transferred has very simple content and is hardwired point-to-point. Clearly, we need different data transfer technology to encode and deliver S95/B2MML documents between enterprise and manufacturing systems.

Data delivery today is done almost universally using TCP/IP (or UDP/IP) transport over Ethernet. But TCP/IP by itself doesn't specify the encoded information. It is simply a standard transport protocol for an Ethernet network. In order to successfully transmit information content, an application-level protocol is required. This is where things get interesting. There are many high-level protocols in use today that provide a rich variety of features and capabilities. HTTP (Hyper Text Transfer Protocol) specifies a protocol that supports on-the-fly message encapsulation and translation and is widely used on the Internet. This is very important for messaging systems as it enables the ability to dynamically change message destinations.

In addition to translation and encapsulation, real time messaging software should possess the following basic characteristics:

- Low latency and high throughput
- Event-driven/report-by-exception semantics
- Fast failure detection
- Failover to a backup channel upon failure detection and
- Indigenous security

Given the volume of network traffic and the propensity for interruptions in network services, a transaction queuing system is vital. Several vendors provide technology that supports guaranteed, secure message delivery. These transaction-based messaging systems are typically referred to as "Messaging Buses". Examples are BEA (6), TIBCO (7), IBM's MQSeries and Microsoft's MSMQ. Transactions are critical for ensuring data integrity and correctness through adherence to the ACID principles: Atomic, Consistent, Isolated and Durable.

Message transactions come at a price: response time. Transferring S95/B2MML documents can take valuable application processing time. Sufficient system bandwidth is essential for the real time operation of business rules applied to feedback control mechanisms in manufacturing processes.

Message buses also provide asynchronous queuing for messages. This effectively decouples the processing of a series of interconnected applications and allows each to be optimized individually. Throughput and scalability is often increased at the expense of individual transaction response.

New technologies are also emerging. Enterprise Service Bus (ESB) vendors promise a robust architecture for integrating enterprise systems of all types. This technology implements a very good general concept, but lacks an industry-accepted definition.

Interoperability between vendors is a major concern for customers. The lack of interoperability significantly increases the cost of integration. The ability to utilize and leverage best-of-breed applications from several vendors allows customers to negotiate functionality in a competitive environment without sacrificing overall system functionality. Two industry standards currently exist for implementing information exchange within manufacturing systems: OPC-DA and OPC-XML.

OPC-DA is excellent for interoperable transport of simple data using Microsoft's COM. It provides a partial solution to the integration problem and it can be used to tunnel XML documents through its string data type.

OPC-XML is excellent for transporting simple data using Web Services. In addition, it has been utilized to tunnel S95/B2MML documents using the "string" datatype.

Both of these protocol standards are primarily focused on providing message delivery within S95 Level 3 production systems. In order to successfully bridge the functional gap between Level 3 systems and Level 4 Enterprise systems, as defined in S95, it is necessary to look at technologies for handling workflow and complex transactions.

Integrating Business Process Workflow

The concept of business process workflow has long been a particularly gray area for integration projects connecting real time manufacturing with ERP systems. Point-to-point technologies were essentially the only way to implement data exchange and the handling of workflow was dictated by the way that endpoints were attached and by how the messages were formatted for each individual point-to-point connection.

Microsoft launched a bundle of technologies called the "Value Chain Initiative" about six years ago that attempted to address the complexity of the problem. With the advent of Microsoft .NET Framework and the associated Visual Studio .NET development suite the "Value Chain Initiative" became Microsoft "BizTalk" which is now at version 2004. Although the following facts about BizTalk may appear a bit like marketing jargon, the technical descriptions illustrate functionality that is needed to map business processes to manufacturing processes.

The suite of technologies integrated into BizTalk results in applications that are resilient to communication interface changes. It supports multiple message transport standards including a SOAP-based (Standard Object Access Protocol) Web Services stack. BizTalk's architecture assumes that message content format mapping is resolved by the system using source/target parameters. The architecture accommodates the fact that messages may not be XML encoded at both ends. Also within the BizTalk architecture, there is an infrastructure for the management of security through the support of standards such as HTTPS and Kerberos.

BizTalk avoids point-to-point integration complexity by routing messages using standard integration services. Although custom interfaces may be required, numerous adapters are available that provide connection services for many applications, including the well-known ERP systems. Example adapters: are FTP, HTTP and HTTPS, MSMQ, SQL, EDI, SMTP, Files, MQSeries, Web Services with WS-Security and WS-Policy. Specific adapters for SAP are available for IDOC, BAPI, and now XI. (8)

The BizTalk architecture supports design and implementation of business processes, state management, and transaction management. Both short and long running transactions are accommodated via the asynchronous design and by publish-subscribe message buses. For ERP system integration, real time is relative. Short running transactions may be a matter of minutes. Long running transactions may transpire over hours. The architecture also supports the flexible implementation of business rules and policies.

The developer toolset for BizTalk is integrated with Visual Studio .NET including plug-in application designers for message schema, message maps, business processes (called Orchestrations), business rules and policies. Additionally, the system has a set of management tools and a simplified deployment methodology, implemented using .NET assemblies and manifests.

A structural analysis of the components of the BizTalk architecture reveals the following major components: Rules Engine, several modules addressing Orchestration, and Integration Services. Integration Services encompass: Topology, Publish-Subscribe, Management, Tracking, Security Adapters, Message Format, and Message Transformation.

Several key aspects of an integrated system that handles business process workflow are “asynchronicity”, “transport independence”, “security” and “business centricity”.

“Asynchronicity” guarantees that messages are dealt with upon receipt, and responses are dispatched as soon as the response information has been collected. Using encoded business rules and policies, the responses are automatically generated by the system. This includes the demand for, and receipt of, required information from the process control system, the laboratory information system, the maintenance management system, and other system sources.

Transport independence insures that alternate message channels may carry the data. It also insures that message sources and targets can be swapped out at any time to accommodate changes in the manufacturing business itself.

Security is critical and inversely proportional to the number of human hands that touch the data along the message chain. Automated message processing using public key encryption (PKI) technologies can have a very positive affect on transaction security.

Business-centricity implies the need to encode the business rules and policies that actually apply to any given step in a manufacturing process. Rules and policies encoded as XML rules and policy documents may be automatically interpreted by systems implementing the ‘Orchestration’.

In addition to BizTalk, other integration technologies are available for potentially filling the gap between S95 defined Level 3 and Level 4 Enterprise Systems.

For example, IBM offers integration technologies that leverage Java and Java Beans with J2EE. Given that Web Services are based upon the open standard of HTTP transport and XML-encoded messaging, any operating system may be used to implement the message handlers at either end.

Given an architecture that removes the bottlenecks inherent in human intervention, a manufacturing system based on S95 concepts could operate with real time response to business orders, delivering real time status reports, real time accounting and ultimately rapid delivery of the physical product.

Strategic Integration Considerations

Strategically, enterprise integration will be based on well-accepted, industry-wide technologies and standards. A core issue is multi-vendor interoperability. Interoperability between vendors is a major concern for customers because of its impact on the cost and functionality of integrated solutions. The ability to utilize and leverage best-of-breed applications from several vendors allows customers to negotiate functionality in a competitive environment without sacrificing overall system functionality. Options and quality can increase dramatically. The products get better and costs decrease. Vendors compete based on product features, performance and quality, not compliance with the standard interface.

The best example is the Internet. HTML, a simple file encoding, was mated with HTTP, a simple messaging protocol, to create the core standards that allowed the Internet to explode once vendor support grew to a critical mass. The vendor turf wars during this period were violent as they all tried to gain the high ground. After the dust settled and a level of stability and maturity was attained, the Internet went on to become an integral and very important element of everyday life.

This same basic process is currently at work in industry. The problems and issues are more complex, but the same dynamics and economics are in play. In the manufacturing industries, one of the best examples is OPC-DA. This is the core interface standard for accessing process data from manufacturing control systems. It's a simple interface that was developed ten years ago and is now widely accepted. It provides access to 80-90 percent of the world's manufacturing process data. Subsequent OPC specifications never reached the same high level of acceptance. As a further complication, the technology upon which OPC-DA was built is proprietary and dated.

So what's next? Can manufacturing enterprise integration reach a level akin to the Internet? Can the vendors in the industry ever agree on a standard equivalent to the Internet's HTML/HTTP? Hopefully so! The industry needs it!

One very important emerging concept is called Service Oriented Architecture (SOA). The industry definition of Service Oriented Architecture is still evolving, but can be described in general by the following:

> Service Oriented Architecture refers to a portfolio of loosely-coupled, network addressable business Services. These Services are programs that 1) communicate by exchanging well-understood messages and 2) are composed of a set of components which can be invoked and whose interface descriptions can be published and discovered.

Why is SOA important? Interoperability! If the S95 model is to become the standard for manufacturing integration, then a set of standardized, interoperable S95 Services need to be defined and implemented on an industry-wide basis.

To date, a critical mass of interoperability standards have been agreed to by the big players in the industry, namely, Microsoft and IBM. These standards provide secure, robust communications based on interoperable Web Services. It hasn't been easy going, but there is light at the end of the tunnel. Both companies have agreed on several very critical WS-* standards and are currently "baking" them into their developer's tools. Once this is done, companies will be able to easily build products that can interoperate at the lowest levels. Creating a .NET application that consumes a secure web service exposed by an IBM platform written in Java will not require a lot of work. Even though this level of standardization is very important, it still will not be sufficient for rich interoperability. Companies in any given domain will need to agree on the syntax and semantics of the services that will be exposed and consumed. This will take time, but is occurring now.

The Next Step in SOA

As an example, all major vendors in the manufacturing control and information domain are working together to define such a set of SOA services that would expose the rich, complex process information contained within manufacturing control and intelligent fieldbus systems. This effort is called OPC Unified Architecture (OPC-UA). If successful, it will become the industry standard SOA for manufacturing information and control systems integration of real time, historical and alarm/event data. The communication architecture at this level must be secure and highly robust. The OPC-UA Service definitions are being designed to provide for the following:

- Must build upon and improve the existing connectivity offered by the OPC Foundation's suite of specifications.
- Must leverage the installed base of OPC DA, HDA and A&E servers which provide access to 90% of the world's manufacturing systems process data.
- Must support the transport of process and manufacturing information from intelligent field devices up to ERP (Enterprise Resource Planning) systems including S95/B2MML.
- Must support security, robustness and fault tolerance.
- Should be based on SOA concepts and leverage Web Service technology and application development tools.
- Must be efficient in transferring large amounts of data but flexible enough to transfer standard XML payloads.
- Must inherently handle complex data.
- Should leverage as many existing industry standards as practical and viable.

At this level of information management within manufacturing, a large quantity of complex data must be transferred at high speed while maintaining high data quality, even under failure conditions. A strong argument can very quickly be made that these requirements are not limited to the control domain, but are becoming more important in the information and business domains as well. As manufacturing companies continue to strive for more automated and integrated manufacturing facilities, the reliance on plant information systems will increase. Failures that are tolerated today will not be tolerated tomorrow. The quantity and quality of data moving around a plant is increasing, as is its complexity.

One can quickly imagine a highly automated production environment where S95 Level 4 systems communicate directly with Level 3 and even Level 2, systems all the way down to modern intelligent field devices that contain highly structured data and are capable of very advanced behaviors. These production control systems should maintain the robustness and integrity that is indigenous to modern Distributed Control Systems (DCS). OPC-UA brings to the table the SOA technology that enables this scenario by providing the vehicle for rich, secure, efficient and interoperable S95/B2MML Services within a manufacturing plant.

Conclusion

Better decision making through the timely delivery of quality information between business and automation systems will lead to improved manufacturing production management. ISA S95 provides an excellent abstract model and basis for this integration, but does not specify specific implementation technology. B2MML provides S95 with a set of standard, concrete XML formats. By combining these with software tools and communication technology that currently exists, very flexible and robust S95-based solutions can be built.

As the industry matures, solutions based on industry-wide standards promise to provide even greater interoperability at lower cost. Service Oriented Architecture (SOA) is poised to play a major role in providing the architectural basis for future multi-vendor interoperability, while OPC Unified Architecture brings this technology into the manufacturing domain. OPC Unified Architecture has been designed with many of the characteristics needed to make it a viable contender as the standard for robust, secure S95/B2MML document messaging.

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