Petroleum Refinery and Petrochemical Plant Data Integration

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The success of Enterprise Resource Planning, ERP, systems and the structural changes in the business climate are dictating a change in the view and role of refining and petrochemical plants. When one looks at the dramatic changes in the U.S. electrical power industry, one can make an inference as to the changes in store for refining and petrochemical plants. While these changes are facilitated by the capabilities of information technology and the intranet/internet, but the IT technologies are only as successful as the people who are using, assimilating, and applying those technologies.

This article presents a different way to view refineries and petrochemical plants as part of the supply chain and a way to design for data integration of any application to any other application via COTS software products---configurable/adaptable/integratable-off-the-shelf software products. The resulting nimble refiner or petrochemical plant is likely to be the lowest-cost and highest-quality leader in the market. Being nimble is a result of users adapting the system to their current needs upon demand. Toyota implements 19 suggestions per employee per year---they believe that this yields significant competitive advantage. COTS systems will do the same for refiners and petrochemical plants.

Integration with ERP Systems

ISA's SP95 Control to Enterprise Integration Standards Committee is developing data models and terminology for the data that needs to be interchanged between the ERP systems and the "Control Domain[1]." The high-level view of this integration is shown in Figure 1[2]. Since SP95 addresses all industries, (discrete manufacturing, batch, continuous batch, and continuous plant operations), the single data model requires some interpretation for refineries and petrochemical plants. Since these data models are meant to be "object data models," the unique features of each facility can be easily accommodated.

Product Definition Information contains key elements of the production rules and sequencing with the bill of resources and bill of materials that both the enterprise and the control domain need to effectively schedule. (Please note this means the control domain will know more details than the ERP environment, but those details are not critical to ERP level scheduling.) For refineries and petrochemical plants, this includes

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1 ISA's SP 95 *Enterprise-Control System Integration Part 1: Models and Terminology* Draft 12 has been released for Committee Vote. For information, please contact Mr. Charley Robinson, SP95 Coordinator, The Int'l Society for Measurement and Control, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709-2277; Phone: 919-990-9213; Fax: 919-549-8288; E-Mail: CRobinson@ISA.org

2 ibid., Figure 7

all operating, regulatory and safety procedures, as well as, materials and skilled personnel required to produce a given product or series of products.

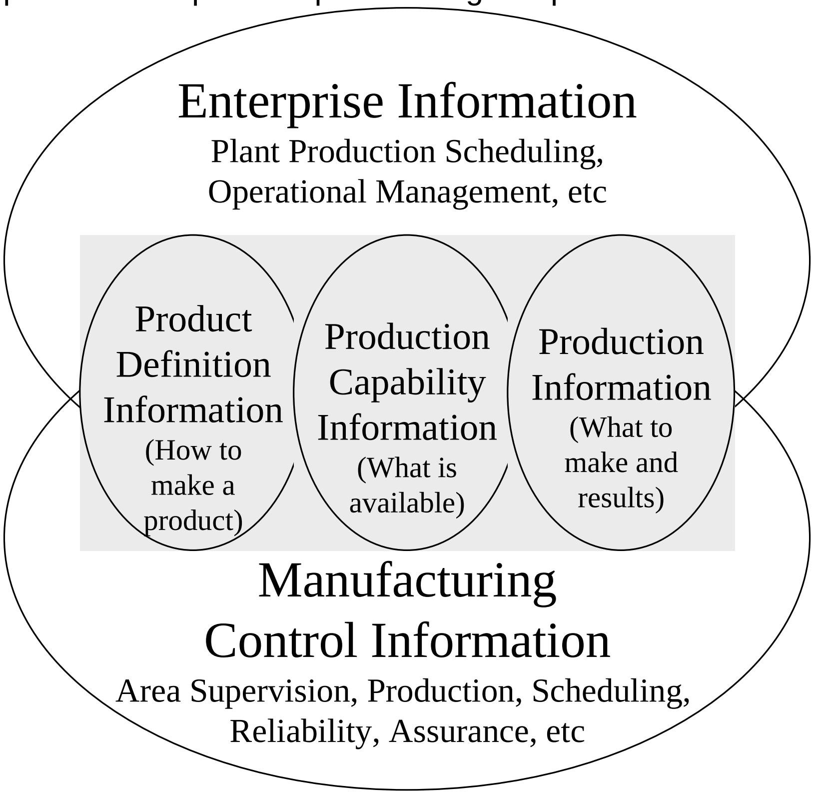

Figure 1 SP95 Control to Enterprise Integration

Production Capability Information contains all the information about the current and planned status of equipment, materials, and people. Planned equipment status includes all known maintenance scheduling information. For refineries and petrochemical plants, this includes all equipment and operating options for that equipment, as well as the planned maintenance and engineering changes to that equipment over time. The availability (or not) of combinations of the equipment and units to perform specific tasks would also be documented.

Production Information contains all the history and production schedule of products, raw materials and intermediates. For refineries and petrochemical plants, this information includes the genealogy of the products, and unit operations, as well as all future schedules.

> Genealogy is becoming a much more important element of refinery and petrochemical plant product reporting. One refiner is reported to be setting up with the capability to specify the wells from which to draw his crude and then monitor the unique segregation of that crude to (and through) the refinery to produce a specific product for a specific petrochemical company. Of course, the entire genealogy of operations and records are to be retrievable by product batch to the petrochemical plant. Coupled with the genealogy through the petrochemical plant reactors, silos and mixers, one will be able to know the total genealogy of each lot of polyolefin pellets.

A key part of this information is the production capability, as shown in Figure 2[3].

[3] ibid., Figure 15

This figure shows the committed, available and unattainable capability over current and future time. As such, this considers all maintenance and new construction activities. The concept is to constantly publish all the information for any product scheduling application to be able to determine the available to promise, ATP, data for specific products to specific customers and to be able to commit the facility to so doing---without any other communication to the refinery or petrochemical plant.

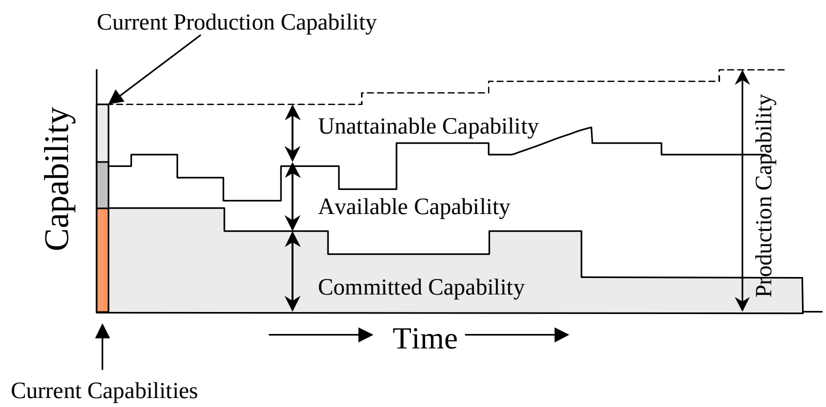

Figure 2 SP95 Production Capability

It is this ATP requirement that will require dramatic changes in the speed with which information is handled within refineries and petrochemical plants. This is done today by e-mail, faxes, etc., between individuals. In this model, the person using the scheduling program makes the commitment. Those responsible for performing the activities will have the challenge of making sure that they can deliver without retaining too much “reserve” in their published capability.

Traditional Functional View

This rapid informational need makes the implementation of the traditional “level model” of refinery information needs obsolete. That model treated information as being aggregated at each level before being “passed up” to the higher level. The implication was that data at higher levels did not need to be “refreshed” very often. So while the level concept is still valid, the method of implementation is not. The levels are shown in Figure 3.

There are several key concepts presented in Figure 3[4] that are even more valid today then when they were first developed.

- The plant network is split into two logical pieces with a high-fidelity security device in between. Since every process instrument will soon have its own IP address, the need for ensuring control of access to those IP addresses becomes even more important. Also, a global two-phase commit management of change business

4 Figure 1, page 2, American Institute Recommended Practice 554, Process Instrumentation and Control, First Edition, September 1995.

process will be required to keep all instrument, DCS, APC, MVC and application configurations synchronized.

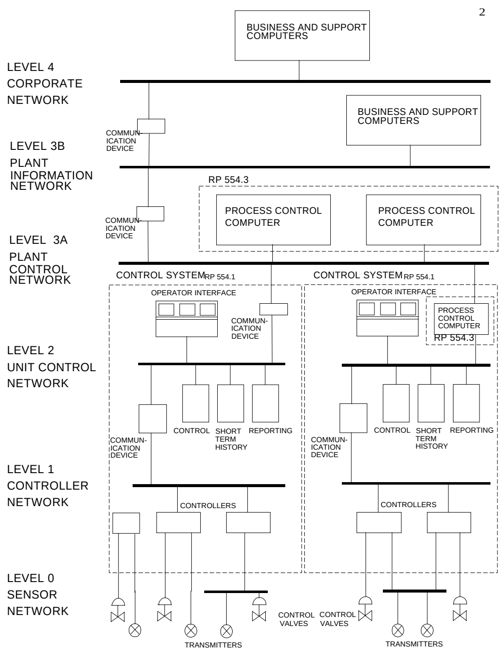

FIGURE 1 -- FUNCTIONAL PROCESS INSTRUMENTATION, CONTROL, AND INFORMATION NETWORK ARCHITECTURE

Figure 3 API RP554 Functional Information Network

- Since this drawing was completed well before the breadth of the Internet integration was known, it does not explicitly represent the Internet. However, access today across the Intranet and the Internet would connect to the Level 3B portion of the plant network. While process operators will---by definition---be simultaneously connected to both Level 3A and 3B portions of the plant network (probably within the same Windows/NT PC), the functional capability of each connection will need to be properly controlled to guard against unauthorized access to Level 3A.

Now that OPC has the potential to evolve into a very powerful portal to the real-time world[5], the same security and control issues need to be properly handled.

- Additional figures and text in RP 554 clearly state that if one wants to write an application to interact with the DCS either mono- or bi-directionally, then they should not talk directly to the DCS or other real-time devices. Instead, they should talk to the real-time data historian. This was because oil companies found that the very expensive advanced process control person was spending over half of his/her time on issues related to the DCS, but not their current project; the resultant code was dedicated to that DCS, so it was not reusable; and it was difficult to change the DCS, since all the applications would have to be rewritten. During this time frame, the DCS vendors have either developed or partnered with a company to provide a real-time data historian (Figure 4).

- To satisfy the new requirements, that information will need to move up the information chain on demand, schedule or exception, an embedded business rule agent will need to be continuously executing in the background. Since this information moves directly into the ERP systems, the fidelity of the data will need to

[5] W.H. Bosler's Guest Editorial in the March, 1999 issue of Hydrocarbon Processing.

be improved. One way to improve the fidelity of the data would be to apply the knowledge learned from offline daily data reconciliation to online calculations to estimate the reconciled values. Hedging and other delivery requirements will dictate a business process to reliably predict these values and then to precisely deliver the predicted values. Ideally, the combined efforts of the OPC foundation and the fieldbus foundation (FF) will lead to 1) OPC servers totally exposing their configurations and accepting a download of a new configuration through a two-phase commit process; and 2) FF configurators to being able to manage those OPC configurations through a PSM hazop-style graphic to ensure full PSM and regulatory compliance.

Revised Functional View

Given this environment, the level or pyramid representation of information within each facility needs to change to an integrated view focused upon delivery against the mission statement. Such a view might look like that in Figure 5.

This view focuses on the operations purpose of the facility showing direct support requirements and all the services needed to support the primary activities. By focusing

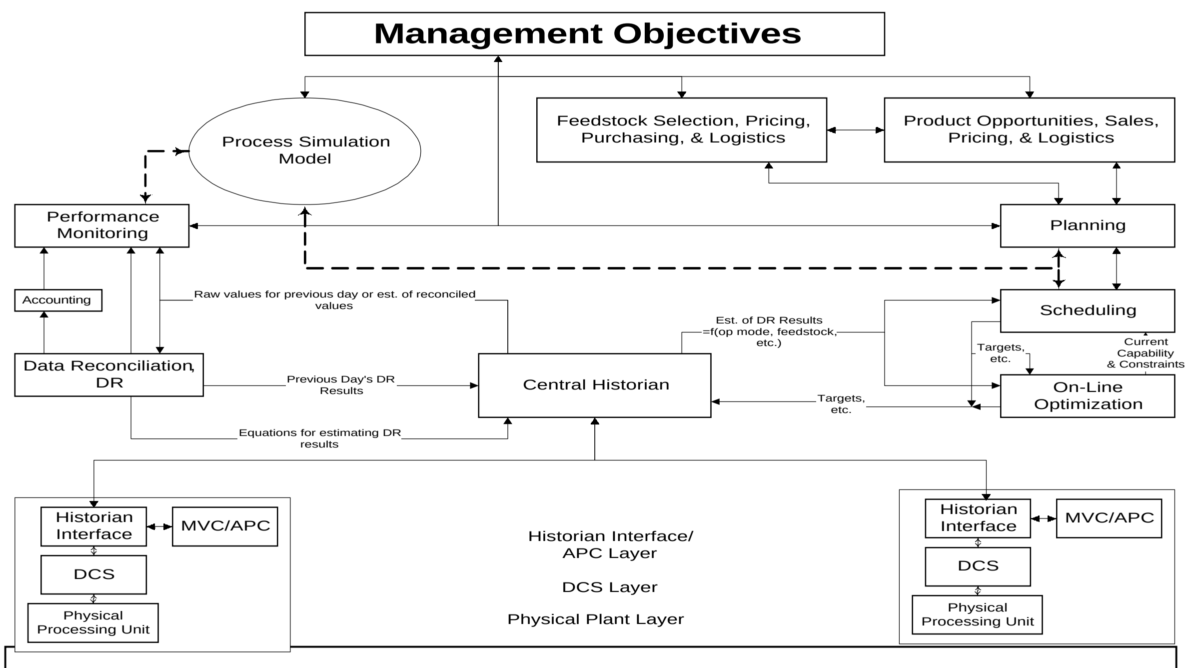

Figure 4 Management Objectives

through the depth of the model, one "sees" all the services required for all the activities. This model also shows that all the activities and data are intertwined. Therefore, one needs to integrate the data into one data model that knows where all the data reside to minimize duplication, ensure consistency, and to free the user from needing to know where the data resides and how to get it. To add new functionality, one would access the existing repository configuration data to auto configure the new application and then sign-up for notification of changes to its configuration and sign-up for receipt of changes to data elements.

This model focuses on the direct activities to accomplish the mission statement. Other functions are referred to as services. Once viewed as services, one can then streamline them to be as efficient as possible by leveraging the data integration. This requires that the business rules for the services are embedded within the "objects" so that no matter

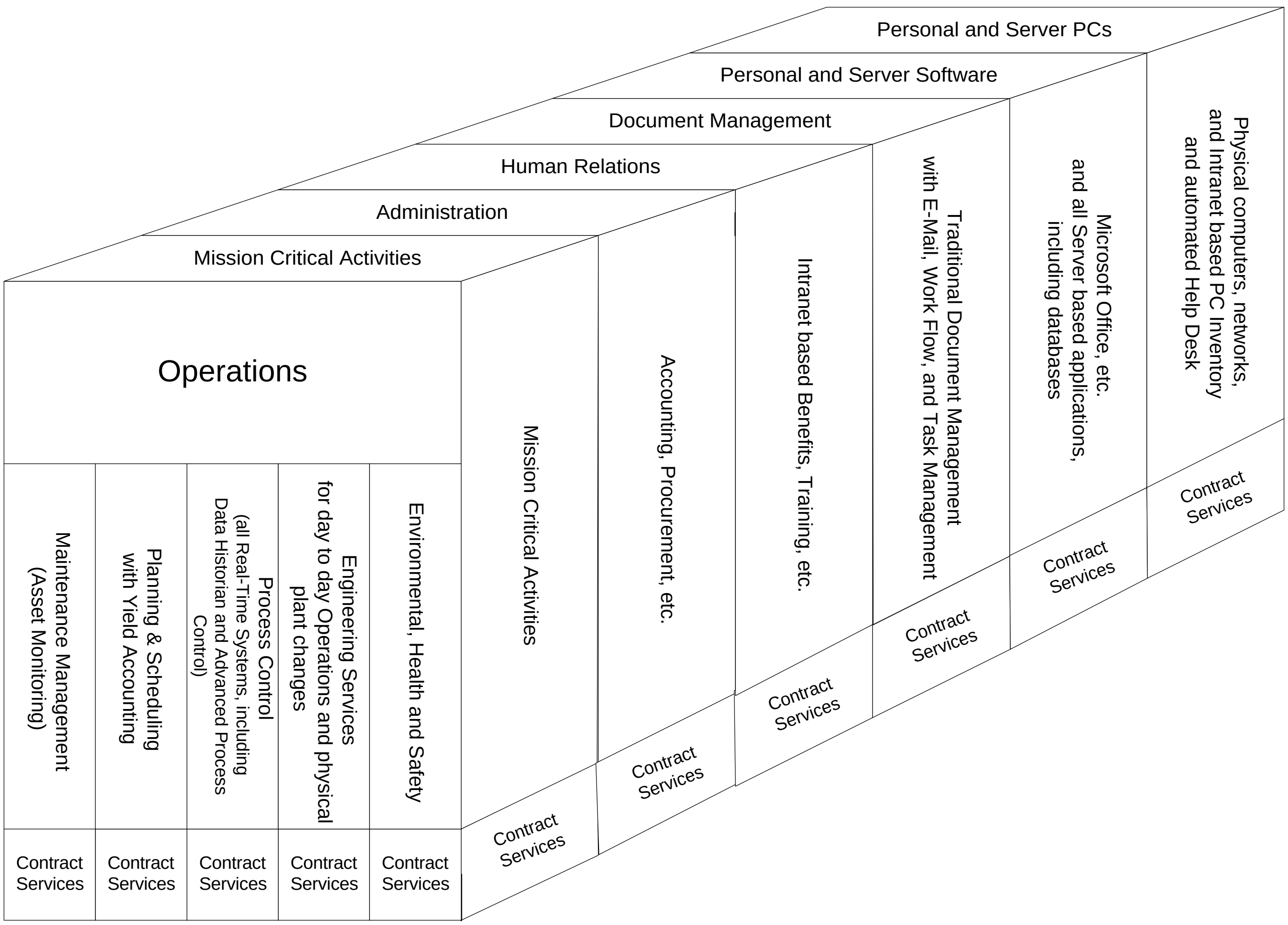

Figure 5 Revised Functional Data Model

who does the updating the rules are followed. Several changes are happening as a result of this focus:

- Outsourcing of services is being broadened considerably. (This is shown in Figure 5 as "contract services.")
  - At least one company will purchase your water treatment, steam generation, power generation or other commodity and then sell you the commodity on a

usage basis. Any improvements that they produce over the time of the arrangements are usually shared.

- PG&E Energy Services will work with customers as a long-term partner, developing a comprehensive energy strategy to drive down energy costs by sharing in the risks and rewards of the strategy. This includes conducting an energy audit of the customer's facilities (at PG&E Energy Services' cost) and providing the financing and project management necessary to realize the benefits of the opportunities identified.

  PG&E Energy Services is not the same company as Pacific Gas and Electric Co., the utility. PG&E Energy Services is not regulated by the California Public Utilities Commission; and you do not have to buy PG&E Energy Services' products in order to continue to receive quality regulated services from Pacific Gas and Electric Co., the utility.

The common theme here is to free the refiner from worrying about non-core performance issues, but to have those facilities well managed. In some cases, the relationship also frees up capital in exchange for expenses over time.

- Some companies are forming low cost buying consortiums for non-competitive items such as cars and maintenance materials. These consortiums use existing personnel in member companies to do the buying for all the companies via the Internet. The increased buying power provides significant discounts.
- There is at least one excellent web site for buying, selling or trading petrochemical products. How soon before there will be one for crude oil and refinery products? What restructuring will that cause?

The IT structure for this model is shown in Figure 6.

There are a few key concepts within this approach:

- Both the real-time data and the application data information buses are publish subscribe buses. That is, a real-time system or an application signs-up for changes to data (configuration data or values of configured items). Both buses are designed to not lose any transactions.
- The real-time database stores the signature of each point and is the source for all raw data about each point.
- The data repository contains the data model for the site, knows how to communicate with every application, and contains all data that does not have an application to properly archive its data. The repository application interface for each application knows the mnemonic and engineering unit translations necessary to integrate with the overall data model.
- Functionality can easily be added to the overall system by creating ActiveX components that use the data from the data model or by integrating third-party applications to the information bus. Ideally, the data model is the same for all sites and the vendor can also provide mini-ActiveX components that efficiently model your business processes.

- All of the data is mapped to the data model, but not all of the data is moved from its originating point to the data model. From a user's perspective, all they have to do is learn how to navigate the data model to access all of the information---regardless of where it is stored or who updates it.
- Functionality can drive directly off of changes noted by the repository. For instance, a change to the DCS configuration can cause a notification to all applications that use that particular data item, the addition of a piece of equipment to the maintenance management system can cause a request for a change to a CAD drawing referenced in a process operations manual, etc.
- The upload of a new process schedule would cause the electronic white boards for each control room to reflect the new schedule with hot links back to the originating document.
- Key performance indicator calculations would be embedded into the data repository and displayed wherever appropriate.
- Business process applets would be created to notify appropriate personnel in a timely manner of priority deviations.
- Global task management and work flow services are evolving that will enable resource leveling across the entire entity and ensure that all tasks are completed in a timely manner within all the business rules. Ashland first demonstrated this concept with their operations task manager in the mid-1980s. Now, with all the "right sizing," etc., global, site-wide task management is necessary to ensure that everybody can view their tasks and know when others will complete the necessary supporting tasks.
- Another key element to the success of such an undertaking is an intranet-based help desk with an extensive on-demand 7x24 training library. This help desk will have to have a complete hardware and software inventory of the entire computing network and all associated PCs and other devices. This inventory will need to be maintained by agents checking the systems constantly. These IT systems are very complex; and precise inventory is required to quickly identify and fix incompatibilities. An expert system can guide the user to the problem and its correction over the Intranet.

Mechanics. For the application information Bus to function efficiently, it needs a standard method of data interchange. As mentioned previously, the repository needs to know about all the data to be interchanged, including the appropriate mnemonic names for everything to be exchanged. Fortunately, the World Wide Web consortium's eXtensible mark-up language, XML, is evolving and will provide structured messages for data exchange. In addition, the XML document type definition, DTD, is the means of validating the completeness of a message, if desired. Consortiums are developing DTDs for purchase orders, invoices, etc. These DTDs could actually be stored on the web so that a purchase order could be validated before it ever left the sender's PC and then processed by any vender's system, including this information bus.

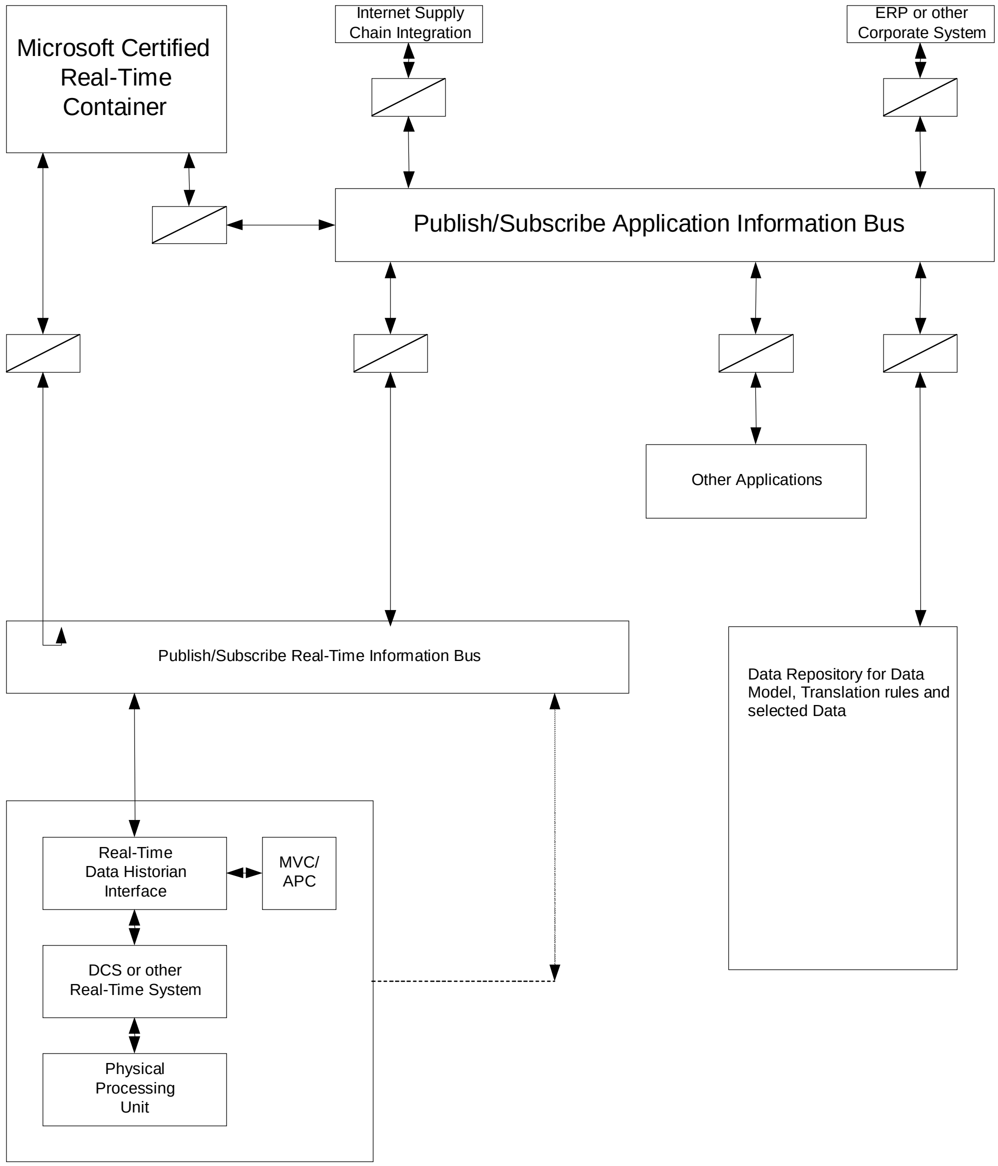

Figure 6 Integrated Real-Time and Application Information Buses

- A key feature of XML is that one can add to the content of the message incrementally and the message flows through the system to the application that needs the new data content.
- XML is expected to become the medium of choice for e-commerce solutions. If it does, then the refinery or petrochemical plant with such and internal application information bus is well positioned to capitalize on e-commerce.

One of the changes occurring is that vendors such as Fluor Daniel's Enterprise Integration & Communication Systems, EICS, Group will review all your telephone, radio, computer network, physical and logical systems to ensure that they are designed for maximum value.

They call this offering the 4Rs of system architecture design (or a pile of bricks is not a building). The 4Rs: response, resolution, reliability and reparability provide a mechanism for placing applications and hardware at the correct level in the information architecture. They use the Purdue Enterprise Reference Architecture[6], PERA, as the foundation of this work. PERA recognizes that there are three major components of a cradle to grave enterprise: facilities, people and control systems. For new facilities, Fluor has broken the 28 PERA steps into disciplines so that the customer understands the effort involved and the rework necessary to ensure consistency of any change. In other words, they show the customer up front why they want to minimize changes.

- **Response** deals with the time delay that can be tolerated in receiving data changes. For instance, a compressor surge protection system requires a very fast response; whereas, an engineer can analyze catalyst behavior in the quiet of his office by reviewing data from the real-time data historian.
- **Resolution** deals with the frequency of the data values, e.g., accounting is usually happy with a single validated number for the prior days activities; whereas, an engineer looking at the events around a furnace tube failure might want to see second or sub-second data.
- **Reliability** deals with the consequences of the system not being available on demand. For instance, a control engineer should not base his advanced process control optimizer on accessing economic values in the ERP system, because most ERP systems are designed to be taken offline two hours every day and at least an additional four hours once a week. Therefore, there would need to be a business process to ensure the consistency between the ERP system values and the repository values. Since the repository is designed for 7x24 operation, referring the values in the repository eliminates the step to ensure consistency with the values in the APC application.
- **Reparability** deals with the way in which the device is repaired; i.e., does it have to be taken offline to be repaired or can it be repaired online. Since the continuous processes in refineries and petrochemical plants are only shutdown every few years, the computer equipment and associated applications need to be repairable online (i.e., “hot”). Reparability applies to reloading, reconfiguring and updating software, as well as firmware and hardware. Conversely, office computers and their associated LANs can usually be shut down for maintenance on demand with little adverse effect on operations.

Challenge. This degree of availability of data and information about a plant will result in a significant change in the political power structure within the organization. Any organization that undertakes a move in this direction needs to address the reward system for each employee so that appropriate behavior within the new information structure leads to increased rewards for the participants.

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[6] More information on the PERA Model can be found on the web site maintained by Fluor Daniel’s EICS Group, http://www.pera.net/Pera/PeraReferenceModel/ReferenceModel.html PERA is also the foundation for ISA’s evolving SP95 Control to Enterprise Integration Standard.

In summary, configurable/adaptable/integratable-off-the-shelf software products can provide a way for refinery and petrochemical plant personnel to adapt to an ever-changing environment. The challenge is to do it in such a way that the personnel using the systems do the changing, adapting and integrating on a daily basis and are rewarded for so doing. That way, the business entity is substantially increasing the probability that they will survive and prosper. The old model of one vendor supplying all your applications limits you to the products and functionality that they choose to provide and when they provide it. A COTS implementation as described herein would be several generations down the road before the monolithic vendor processes your formal request for change.

Request. If you have comments or observations about this concept, we encourage you to contact us. Hopefully, this article will encourage more of us to become involved in determining our future as refinery and petrochemical plant operators and service providers. It is only through your comments that mutually beneficial change will occur.

Acknowledgement

This article is based on work and discussions that we have had with clients and colleagues over the last decade or so. We thank each of them for their time and effort.

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