The Role of Communication Networks in Strategic Process Management

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OVERVIEW

This paper will discuss the difference between Plantwide Business Management Networks and Plantwide Process Control Networks. A so present means of unifying them into an integrated Plantwide Information Architecture.

OBJECTIVE

The purpose of this paper is to investigate the relationship between communication networks designed for Business Information and Management Systems (Local Area Networks or LANs) and those designed for Plantwide Distributed Process Control Systems (DPCS). The fundamental differences between these communication networks design requirements and the divergent goals of each will be discussed along with an architectural approach to solving the resultant enterprise wide integration challenge.

INTRODUCTION

The becoming a generally accepted fact that enterprise wide integration of every aspect of data from the position of an individual switch to the most sophisticated market forecast or product scheduling software report is significant. This enterprise wide integration is perceived by many as the minimum requirement for survival of commodity producers in the near future. The increasing reality of the global marketplace as driving managers at every level of an organization to find ways of making each phase of their operations capable of doing more, faster, better and at less cost. As each member of a group of competitors competes the increment in step-by-step refinement of the physical means of production they all draw closer together in product cost. So at this rate point that the benefits of plantwide integration on a one with information and decision management will become a major contributor to the cost differential between these competitors, and therefore the paramount determinant of winners and losers in these global markets.

The ability to support enterprise wide communication is a primary requirement of this age where information management becomes a means of cost containment and product differentiation. The ability to move precise information in a timely manner both from the point of origin to the decision maker (man or machine), then to take the resultant decisions to the point of implementation quickly will be the new competitive edge.

In order to achieve the goal of integrated process and management information and therefore achieve the resultant strategies competitive advantage, a hardware and software environment is required that will provide not only primary and supervisory control but add to the information that ranges from the most elementary sensing device to the most sophisticated business analysis, planning and decision support. This is the corporate on. Such a tool can be created as a Process Management System or SPMS.

The SPMS environment is required because of the true nature of data and its effect on product vity throughout the organization. As data from the unit/pant ages, it becomes less and less effective to effect the operation control of that unit/pant and the quality or quantity of the product being manufactured. The use of yesterday's data to make decisions about how to operate today will over time have a statistical benefit for increasing the overall product quality of the operation. But the statistical gap will be innately limited in its ability to control variation by the window of time of the real time data sample per period and the time required for the results of that sample period to be usable for control correction.
The control of non-value-added time is one of the most hidden leveraged areas for productivity gains. Any of the mass product on operation that is because the ability to see and prevent the continued product on of the wrong or off-specified product on product creates the opportunity to correct the time, and therefore save the run batch or out. Add on a year it also prevents the added time/resource cost incurred by having to store the wrong product and make the right one to do it again. Therefore the ability to get the data or information on the people who need it to get there when they need it is a strategic competitive advantage. To state this another manner every minute costs making the bad or the incorrect product of actual two minutes lost because of the attendant need to make the right one to redo the bad product correctly. Conversely, every minute gained by the time you can be of information and decisions has the potential to double the advantage over the (non-integrated) competition.

INFORMATION SOURCES

There are many types and sources of information available in the distributed process and control systems. Data about the actual process as we as information on about the control system makes development at this level difficult. Product modality on maintenance and performance analyses as well as real-time statistical (SPC/SQC) information may also be developed at this level, depending on the power and the desire of sophisticated control on the DPCS.

In contrast, business data and information is usually developed in the higher levels of the operating system. Custom or commercial software packages executing on general-purpose computer systems and networks. Data from all analysis operational opt on maintenance control planning, custom procurement systems as well as other product scheduling and purchasing information systems are accomplished in the separate business environment. As stated earlier, means of integration of these various types and sources of information referred to as a strategy in process management systems (SPMS).

The integration of these that forms the basis of strategic information in the single most dominant factor current tests at these forms and types of information from each other. That each data type or data set is on a common system, that is compatible with the other.

The logical question might be asked as to why not use just one common system? In fact, many attempts have been made to create a single common system on system to do both functions. Unfortunately, the design criteria and the design goals of the two network types are not on the vast different but in some attributes they are mutual exclusion.

The following chart illustrates just some of the major differences that make these two common systems incompatible.

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<tr>
<td>Time Critical Response</td>
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<tr>
<td>Fast, Short messages</td>
</tr>
<tr>
<td>Redundancy Mandatory</td>
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<tr>
<td>Risk of Bad Data</td>
</tr>
<tr>
<td>Data Security Imperative</td>
</tr>
<tr>
<td>Predetermined # of User's</td>
</tr>
<tr>
<td>Rapid Request/Response Time</td>
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<tr>
<td>Multiple Destinations/Message</td>
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**FIGURE 1**
DISTRIBUTED PROCESSING AND CONTROL COMMUNICATION NETWORKS

Maximizing process data responsiveness and throughput to ensure fast and complete real-time data where and when it is needed has been a design goal continuously evolved and enhanced over many years because these items are critical in the Distributed Control System. Coupling the latest available technology with innovation has effectively solved the primary requirements such as data security, redundancy, and high-speed deterministic response and others. Maximizing real data throughput by minimizing overhead and unnecessary data transfers yields the most effective process communication on network possible. This is accomplished by employing exception reporting techniques (only transfer values which have changed by a defensible amount) multiple destination techniques (forward the same physical message to all users needing it) multiple values per message (combination of multiple destinations leaving at a particular drop into a single message) and a Buffer Insert on Communication Network Protocol (and an All nodes are masters protocol, see Reference #5) for responsiveness. Each message contains a header defining the message contents, the node addresses, and actual user destinations for each of the potential multiple destinations for each value. The values along with their alarm, quality, and status as well as reporting time are included in each outbound message. Multiple checksums across subsections of the message as well as a total checksum for the entire message ensure data integrity.

BUSINESS COMMUNICATION SYSTEMS

Although a typical business communication system (i.e., EEE 802.3 Ethernet) bandwidth of a 10 MB would seem at first glance fast enough to handle most DPCS data transfer needs, the timing deterministic data and data security required for safe process control alone would warrant monitoring process data transfers from information data transfers (Consider the cost of just one shutdown due to a piece of data not getting where it is needed in time).

Some of the many items that demonstrate the opposing demands for a business network from a DPCS communication networks are the Business networks non-specific access time and typical single destination message routing. Business communication systems typically require a protocol that allows many users to connect and disconnect somewhat randomly. Because of this prerequisite, the protocols that are most successful are the ones which require little or no pre-structuring. This generally results in a scheme where possession of the communication channel is the only and therefore highest priority. These protocols offer no guarantees that any individual user will get access at a specific time. In fact 802.3 does not guarantee that any specific user will ever get access, it presumes that we will based on a statistical average over time.

If we define deterministic as having a predictable guaranteed message response time, protocols that a message gets to its destination at a predictable consistent time frame. A non-deterministic bus system can be likened to a master-slave system where messages are sent and will probably get there sometime. A deterministic DPCS communication system must be in the telephone system where your message is sent, received, and confirmed now.

For a very similar reason, it is possible to point to points of message transfer where obvious not the most efficient or timely means of keeping multiple destinations updated so much easier to support a business communication on network that has users randomly appearing and disappearing. Contrast that with the DPCS communication systems constant requirement to send almost every value to multiple destinations (e.g., any value that is used in multiple consoles or multiple control loops with the system).

THE INTEGRATION DILEMMA

These items are illustrated not to conclude that one type of communication system is better than the other, but rather to highlight the gross differences between them. Each need to be designed for a very different task.

The dilemma occurred by any attempt to design a single encompassing communication system of course where do you make the concessions? Continued attempts to reconcile these two diverse communication system's requirements have resulted in compromised networks that accomplish neither set of functions well or completely.
THE SPMS ARCHITECTURE

This is the point that the simplicity of the SPMS architecture addresses. Accept the necessity of a dual network and provide appropriate gateways between them. Use a well-accepted network technology standard (like X window) to support access to both the business/management data and normal process console functions from the process. A so needed is a gateway to provide data access directly to the business network and the process network. This seemingly simple approach is the best solution currently available with existing network technology. Let's not forget that the goal of an SPMS system is not to re-structure the company to the communication system but rather to structure the communication system to the company. This dual network architecture allows for centralized data storage and the easy transfer of data between the business and process areas of the company but maintains each department's needs and operational methods of work. Additional network support in the dual network approach also supports the maintenance of information security where necessary. A few companies want their accountants changing a set point or conversely, the operators changing a set point.

Real-time process data can be communicated to the business or other higher-level packages as well as information from the business network or higher-level packages communicated directly to the process or process operators in many plants. Elements of each or both types of communication networks are a ready existence under the dual network architecture, they can be expanded.

Use of the dual network architecture as an approach to achieving the SPMS goals protects the best features of both the process control communication and the business information network.

The four key elements of the SPMS architecture are:

1. A secure, determined high-speed process control communication network
2. A range of high-speed, secure network gateways
3. Dual network operator console usage and a well-designed windowing technology
4. A low-cost per drop large transfer file capacity multiplexed computer vendor supported LAN

The dynamically process network and control network, and the business/management LAN have been discussed. The remainder of the gateways and the dual network consoles

THE ADVANCED COMPUTER INTERFACE UNIT

In some applications, the reporting of process data to higher-level application programs such as data acquisition or record keeping, must be accomplished in a high-speed snapshot manner. As the ability to manage larger and larger sets of this data increases, the requirements for faster direct communication networks becomes apparent. Industry standards are necessary, as are standards for high-speed parallel buses that can operate at 4 Mbytes per second. The type of interface is available on most general-purpose computer architecture. The ACU's manner of providing the determined network structure provides the ability to support a wide range of the critical interfaces to computer or computer devices.

THE NETWORK GATEWAY INTERFACE

Provision of process data to information networks or information from the bus network to the process control system has been suggested in the Network Gateway Interface (NGI). The NGI provides direct support to an Ethernet (IEEE 802.3) communication network which is one of the most well-accepted standard for Local Area Networks (LAN) communication protocols. This protocol format should also have a modular design so it can be expanded to support other protocols and functions as they are defined or required.

Besides speed or pass-by-virtual tags (ca-a va ue by tag or point name not address) an important concept of both a Network Gateway Interface or a Computer Interface unit is the asynchronous operation of data transfers between the process control system and a request or computer. Functionality of the NGI holds or maintains a memory database of all requested values. These values are sent to the NGI by the process control system based on a particular set of messages as an independent ear. The update of the memory database is accomplished by exception reports when the data changes on the computer side and asynchronous to the DCS communication network. Actual transfers are determined by the physical device, the capacity of the user device to accept and process the received data. This approach of decoupling of the DPII communication network from the external data users communicates.
channel a few each network to operate in its normal manner. Output channel capacity to the non-deterministic device can range from 0 to 4 Mbytes per second with no adverse affects on either network due to the queuing nature of the NG.

"WINDOWING" AND THE DUAL NETWORK OPERATORS CONSOLE

The last major piece of the plant-wide communication needed to compete the SPMS architecture is an operator's console supporting both windowing technology and a dual network interface. Along with providing a complete set of standard console control and monitoring functions such as process graphic displays, alarm management report generation, summary logs, archival storage and retrieval, trending, etc., this console effectively links the information requirements of the operator for both process control and the business environment together.

The dual network console connects directly to the Process control communication network on the one side and to the Local Area Network on the other. Here real-time data for control and monitoring is processed on one network asynchronously to information exchanged with the business or higher level applications on packages into the console functions. Connect on to other plant computers by way of widely accepted network and software protocols results in an incrementally expandable, virtually limitless plantwide application execution environment. It is these higher level applications that coupled with the DCS completes the Strategc Process Management architecture.

SUMMARY

Moving towards a complete enterprise-wide control and communication system will be the competitive edge for the 90's. Maximizing what runs well today (not throw the baby out with the bathwater!) along with the development of tools to match the corporate structure (not change the structure to match the tools) are not on reasonable techniques but also economic imperatives. Taking advantage of current technologies (applied where they can provide the best return on investment) and respecting the technical differences and requirements between the process control network and the information network render the following points.

- Separate Process and Business Communication Networks

  Use a commercially available standardized Local Area Network for high-level strategic communications.

  Use the Process Control Communication Network for high-speed rapid response, high security, reliable control communication.

- Network to Network Gateways

  Use a high-speed gateway to link the two networks for non-deterministic data access.

  Use a high-speed interface to directly connect the two critical data to commercially available computational resources.

- Dual Network Consoles with Windowing Technology

  Implement consoles with high access to both the business information and process control information and allow the needed security between both...
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