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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 It will also present a means of unifying them into a 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 LAN s) and those designed for Plantwide Distributed Processing and Control Systems (DPCS) The fundamental differences between these communication network 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

It is 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 ing forecast or product scheduling software report is desirable In fact, 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 is 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 completes their incremental step by step refinement of the physical means of production they all draw closer and closer together in production cost It is at this point that the benefits of plantwide integration along 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) and then to take the resultant decision to the point of implementation quickly will be the new competitive edge

In order to achieve this goal of integrated process and management information and therefore achieve the resultant strategic competitive advantage, a hardware and software environment is required that will provide not only primary and supervisory control but additionally the integration of relevant information that ranges from the most elementary sensing device in the plant to the most sophisticated business analysis, planning and decision support tools in the corporation Such a tool can be called a Strategic Process Management System or SPMS

This SPMS environment is required because of the time critical nature of data and its effect on productivity throughout the organization As data from the unit/plant ages it becomes less and less able to effect the operating conditions of that unit/plant and the quality or quantity of the product being manufactured now The use of yesterdays data to make decisions about how to operate today will over time have a statistical benefit for increasing the long term productivity of the operation But this statistical gain will be innately limited in its ability to control variation by the window of time defined by the statistical sample period and the time required for the results of that sample period to be usable for control correction

The contro of on ne var ab ty n real t me s n tse f one of the most h gh y everaged areas for product v ty ga ns n any of the mass product on operat on Th s s because the ab ıty to see and prevent the cont nued product on of the wrong or off spec f cat on product creates the opportun ty to correct t n t me, and the'efore save the run batch or ot Add t ona y ıt also prevents the added t me/resource oss ncurred by hav ng to store the wrong product and make the r ght one or to do t aga n Therefore the ab ty to get the data or nformat on to the peop e who need t and to get t there when they need t s a strategıc compet t ve advantage To state th s n another manner *every m nute ost mak ng e ther* bad or the ncorrect product s actua y two m nutes lost because of the attendant need to make the rıght one or to redo the bad prɔduct correct y *Converse y every m nute gaıned by the t me y ava ab ıty* of nformatıon and dec sıons has the potent a to doub e the advantage over the (non ntegrated) competıt on

INFORMATION SOURCES

There are many types and sources of nformat on ava ab e ın the d str buted process ng and controls systems Data about the actua process as we as nformat on about the control system tse f ıs deve oped at thıs eve Product mode ng opt m zat on energy management and performance ana ys s as we as real t me stat st ca (SPC/SQC) ınformat on may also be deve oped at thıs level, depend ng on the power and the eve of soph st cat on of the DPCS

n contrast, bus ness data and nformat on s usua y deve oped n the h gher eve s of the operat on us ng custom or commerc a software packages execut ng on genera purpose computer systems and networks Data from ab ana ys s operat ons opt m zat on ma ntenance management nventory contro p ann ng, custom procurement systems as we as other product schedu ng order entry and purchasıng nformat on systems are accompl shed n th s separate bus ness env ronment As stated ear er the means of ntegrat on of these var ous types and sources of nformat on s referred to as a strateg c process management system (SPMS) It s the ntegratıon of these that forms the bas s of Strateg c nformatıon Ine s ngle most dom nant factor current y ıso at ng these forms and types of nformat on from each other s that each data *type or data set ıs on a commun cat on system* that s ncompat b e w th the other

The og cal quest on m ght be asked as to why not use ȷust one commun cat on system? n fact many attempts have been made to create a s ng e commun cat on system to do both funct ons *Unfortunate y* the desıgn cr ter a and n fact the desıgn goa s of the two network types are not on y vast y d fferent but ın some attr butes they are mutua y exclus ve

The follow ng chart l ustrates ȷust some of the maȷor d fferences that make these two commun cat on systems ncompatıb e

Process Communication Systems vs.	**Business Communication Systems**
T me Crıt cal Response	Non Determ n st c Response T me
Fast,Short messages	Frequent Large Fıle Transfers
Redundancy Mandatory	No Redundancy
R sk of Bad Data	R sk of Bad Data (Safety & Equ p) (nconven ence)
Data Secur ty Imperat ve	S mple Fı e ntegr ty tests
Predetermıned # of user's	Random # & Pattern of user s
Rapıd Request/Response V ta	Cost/Drop Key dec s on po nt
Multıp e dest nat ons/message	Multıp e Vendor Env ronment

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 vital to an efficient Distributed Control System. Coupling the latest in available technology with innovation has effectively solved the primary requirements such as data security, redundancy, reliability, speed, deterministic response and others. Maximizing "real" data throughput by minimizing overhead and unnecessary data transfers yields the most effective process communication network possible. This is accomplished by employing exception reporting techniques (only transfer values which have changed by a definable amount), multiple destination techniques (forward the same physical message to all users needing it), multiple values per message (combine all exporting values leaving at a particular drop into a single message) and a Buffer Insertion Communication Network Protocol (a.k.a. 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 potentially 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. IEEE 802.3 Ethernet) bandwidth of a 10 MB would seem at first glance fast enough to handle most DPCS data transfer needs, the time deterministic data and data security required for safe process control alone would warrant isolating process data transfers from information data transfers. (Consider the cost of just one shutdown due to a piece of data not getting where its needed in time.)

Some of the many items that demonstrate the opposing design requirements 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 resolves itself to 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 in a specific time. In fact 802.3 does not guarantee that any specific user will ever get access, it presumes that he will based on a statistical average over time.

If we define deterministic as having a predictable guaranteed time response, it implies that a message gets to its destination in a predictable consistent time frame. A non–deterministic business network can be likened to the mail system where your message is sent and will probably get there sometime. A deterministic DPCS communication system must be like the telephone system where your message is sent, received and confirmed now.

For a very similar reason simple point to point message transfer while obviously not the most efficient or timely means of keeping multiple destinations updated is much easier to support in a business communication 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 (i.e. any value that is used in multiple consoles or multiple control loops within the system.)

THE INTEGRATION DILEMMA

These items are illustrated not to indicate 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 incurred by any attempt to design a single all encompassing communication system is 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 widely accepted windowing technology standard (like X windows) to support access to both the business/management data and normal process console functions from the process. Also needed is a gateway to provide data access bi-directionally between the business network and the process network. This seemingly simple approach is the best solution currently available with existing technology. Lets 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 controlled windows of information to flow easily between the business and process areas of the company but maintains each departments needs and operational methods of work. Additionally the dual network approach also supports the maintenance of information security where necessary. Few companies want their accountants changing a setpoint or conversely, their operators changing payrolls.

Real time process data can be communicated to the business or other higher level packages as well as information from the business or higher level packages communicated directly to the process or process operations. In many plants elements of each or both types of communication networks already exist and under the dual network architecture they can be expanded.

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

The four key elements of this SPMS architecture are:

1) A secure, deterministic high speed process control communication network
2) A range of high speed secure network gateways
3) Dual network operators consoles using a widely accepted windowing' technology
4) A low cost per drop large transfer file capacity multiple computer vendor supported LAN

The Distributed processing and control network and the business/management LAN have been discussed, the remaining item are 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, reconciliation, or historian packages, 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 links becomes apparent. Industry standard alternatives to the serial RS232 19.2 Kbaud link or a parallel IEEE 488 250 KByte/sec link will be required in some cases. The ACIU should provide high speed access to process data through a Small Computer System Interface (SCSI). The SCSI bus is an industry standard high speed parallel bus that can can operate 4 Mbytes per second. This type of interface is available on most general purpose computer architecture. The ACIU in this manner provides a deterministic bus structure providing the ability to support a wide range of time critical interfaces to computer or computational devices.

THE NETWORK GATEWAY INTERFACE

Providing process data to information networks or information from business networks to the process control system in a cost effective method has suggested the Network Gateway Interface (NGI). The NGI provides direct support to an Ethernet (IEEE 802.3) communication network which is the most widely installed hardware protocol standard for Local Area Networks worldwide. The NGI should provide embedded Transmission Control Protocol/Internet Protocol (TCP/IP) or Local Area Transport (L.A.T.) protocol format. It should also have a modular design so it can be expanded to support other formats, protocols and functions as they are defined or required.

Besides speed or possibly virtual tags (call for a value 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 requesting computer. Functionally the NGI holds or maintains a miniature data base of all requested values. These values are sent to the NGI by the process control system based on multi value multi–cast messages as explained earlier. The update of the miniature data base 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 I/O channels capacity and the ability of the user device to accept and process the received data. This approach of decoupling of the DPCS communication network from the external data users communication channe a ows each network to operate in ts norma 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 ast major p ece of the p antw de commun cation needed to comp ete the SPMS architecture s an operator s conso e support ng both w ndow ng' techno ogy and a dua network nterface Along w th prov d ng a comp ete set of standard conso e contro and mon tor ng funct ons such as process graphic displays alarm management report generat on summaries ogs, arch val storage and retrieval trending, etc this console effectively links the nformation requ rements of the operator for both process control and the bus ness env ronments together

The dua network console connects d rectly to the Process control commun cat on network on the one side and to the Loca Area Network on the other Here rea –t me data for control and mon toring s processed on one network asychronous to nformation exchange w th the bus ness or h gher eve app cat on packages on the other network

A so requ red s a wide y accepted, non–propr etary windowing technology (like X Windows) to provide the mechanism to support the process operators abi ty to nteract as needed w th h gher level appl cation packages or with bus ness nformat on systems Us ng h gh resolut on screens and a fu X W ndow graphic display system mp ementat on process d sp ays are ava lable from the conso e tself, from other conso es on the network or from any computer app cat on on the LAN that conform to the X standard These d sp ays can be v ewed as a w ndow by not on y the process operator, but by other X termina dev ces on the LAN

APPLICATION PACKAGES

A s gn f cant feature not deta ed n this paper but none the less noted for its mportance is the application env ronment that th s overa arch tecture prov des Having a conso e that can access software runn ng on mu t ple commerc a y ava ab e operat ng systems prov des an ab ity to eas 'y ntegrate soph st cated app cat on packages nto the conso e funct ons Connect on to other plant computers by way of widely accepted network and software protoco s results in a ncrementally expandab e virtually limitless plantwide application execution env ronment It is these h gher eve app cat on packages that coupled with the DCS completes the Strateg c Process Management arch tecture

SUMMARY

Moving towards a comp ete enterpr se–w de contro and nformat on system w l be the compet t ve edge for the 90's Max miz ng what runs we today (not throw ng the baby out with the bathwater!) along w th deve op ng tools to match the corporate structure (not change the structure to match the tools) are not on y reasonable techn ca so utions but also economic imperatives Taking advantage of current techno og es (applied where they can prov de the best return on investment) and respecting the techn cal d fferences and requ rements between the process contro network and the nformat on network render the follow ng sa ient po nts

- Separate Process and Business Commun cation Networks

  Use a commercia ly ava lable standard zed Local Area Network for high level strategic communica t ons

  Use the Process Control Commun cat ons Network for high speed rap d response h gh secure, rel able, control commun cat ons

- Network to Network Gateways

  Use a high speed gateway to nk the two networks for non–determin st c data access

  Use a h gh speed interface to d rectly connect t me critical data to commercially available computational resources

- Dua Network Consoles w th W ndow ng Techno ogy

  Imp ement conso es w th access to both the bus ness nformat on and process contro nformation and allow the needed secur ty between both

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