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The Role of Alarm Management Functions in the Ergonomic Design of Control Consoles

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Introduction

The role of alarm detection, presentation and management is essential to the proper use of the video based operator consoles in Distributed Processing and Control (DPC) systems. The widespread use of Cathode Ray Tube (CRT) based Computer / Human Interfaces (CHI) as the primary means of monitoring and/or control access to both "Batch" and "Continuous" processes, has encouraged system designs in which larger and larger quantities of data become the responsibility of a fewer and fewer number of operators. Not only has the quantity of real time facts about the process increased, but the types and formats of this raw data have also greatly expanded. Many new system designs represent a huge increase in the level of sophistication not only in terms of raw data to be processed into information but also in the complexity of the relationships between various data items presented to the user. This dramatic expansion in quantity, type and interrelationship of information, with the attendant increase in the complexity, has elevated the data acquisition and alarm management functions of the operator's graphic display console to a critical ergonomic design parameter for the safe operation of any large scale process.

Other factors which may add to the complexity of the interface between the human operator and the DPC system of a large plant is that the operator sometimes must interpret and take appropriate time critical action based on data and information which may be coming from dissimilar types of systems, formatted differently and presented in diverse graphic styles on separate display systems.

Ideally, all of this information that is presented to the console user should be acquired, processed for alarm status and otherwise managed in a uniform manner. Alarm information must be closely integrated with the console's ability to represent that data to the operator in clear and meaningful ways that are consistent regardless of the source of the input data. The system must, in a manner, become an assistant that acquires, analyzes, prioritizes, and if need be, guides the user (the operator) to the information necessary for him to make the proper operational decisions.

Historical Perspective

To understand the mixture of functional demands that is now expected from CRT based control consoles in modern DPC system control rooms, it is helpful to understand that in the beginning, these CRT based interfaces were sold as "A means to reduce the 12 m (40 ft.) of panel board into a 48 cm (19 in.) screen." Unfortunately, in many of the early CRT based control rooms designs, that initial description was painfully accurate in terms of the amount of thought and design effort that was expended in the operator interface requirements of this emerging media for man / machine interaction.

Some of the early CRT systems simply presented a continually scrolling list of the current plant data with no attempt to assist the user in interpreting the meaning of this data. These data loggers were intended mainly to provide simple data scanning and recording functions. The primary goal of such devices was to eliminate the need for humans with clipboards and pencils to physically walk around the plant and capture operating data.

Early attempts to improve this data logger functionality included text displays which closely mimicked the existing panelboard control stations and switches. Early systems used many "pages" of these stations and switches displays to duplicate the panelboard function. Later, the concept of using simplified pictures or schematics of the process as control displays soon gained acceptance and brought the graphic CRT to the focal point of the control room. The advent of powerful microprocessors and their attendant decrease in price / performance ratio, led to the stand alone CRT based integrated control system console.

At the same time that graphic CRT display systems were being used to reduce the panelboard area of control room in terms of gages, meters and switches, there was a steady increase in both the type of useful information available for operations, and the methods used to transform data into useful operating information.

On Line analytical, spectrographic, as well as inferential types of instrumentation became available for use in the refinement of the control application and the extension of equipment life. Real time performance analysis, process modeling and statistical process and quality control (SPC/SQC) calculations also became possible. Greater understanding of the applications and the nature of their control, mandated the installation of additional primary instrumentation in some cases. Proper use of all this information could allow a skilled operator to monitor and control the process to tighter parameters and to achieve higher and higher goals of productivity. Once achieved, these new levels of productivity became the baselines for future expectations and enhancements.

The Operator's "Assistant"

At the focus of this array of data and potential productivity gain flowing into the control room, the operator becomes the single, most critical variable in the safe control of the productivity, availability and profitability of any process control operation. The human capacity for processing information is at best magnitudes lower then what is required to monitor and correlate this huge data stream as it funnels into the control room. In order for the operator to be able to succeed in this information packed environment the operator's video display console must be fully integrated with the data acquisition and control system to the point of becoming the operator's trusted Assistant.

An analysis of operator functions for any large control application quickly establishes that CRT based Computer Human Interface (CHI) systems must be capable of reducing the complexity of the data presented to the user. Advanced techniques in data grouping, information sorting and status prioritizing of this data into terms that are relevant to the current situation and status of the process are required. The use of the latest developments in ergonomics and human biotechnology to convey this information to the operator are only part of the answer. The ability of the operators assistant to reliably monitor those thousands of data points that the human operator is not observing at any given moment, and to bring the relevant changes in the condition of the process to the operator's attention quickly and unerringly is the hidden factor in the ergonomics of console designs.

Implementation of consoles designs utilizing criteria developed through the study of human physical parameters and cognitive perception as a means to reduce operator stress will be nullified if the resultant device is not perceived and trusted by its user to bring relevant information to his attention quickly and predictably. Additionally his assistant should lead or prompt him to the proper displays or functions necessary to resolve the alarmed condition in the least traumatic manner.

Architectural Considerations of Alarm Management

The architecture of the DPC system will to some degree determine the ability of the man/machine interface to provide these Operators Assistant' functions. Some DPC system architectures attempt to accomplish alarm processing in an old fashion centralized alarm detection facility (sometimes integrated with the system historian functions). This approach can result in the same set of engineering compromises that restricted the centralized DDC & DAS (Direct Digital Control & Data Acquisition Systems) of the 70's and early 80's. These restrictions which included data throughput and processing as well as resulted in the modern Distributed Processing and Control (DPC) concepts and caused DPC systems to become the dominant process controls offerings of the later half of the 80's and 90's. Many centralized alarm processing systems are limited in the rate at which they can acquire (point scan) process and test the points in the system. Sometimes only a subset of system points can be alarm monitored. Some architectures can only provide limited alarm types or restrict the ability to prioritize or group alarms into meaningful classes or cognitive groups at different consoles around the system. All of these restrictions require ergonomic compromises to the CHI of the control console.

All of the design criteria which led to the development and domination of multi processing architectures for Distributed Control Systems are also valid for Data Acquisition Systems and are imperative for integrated DCS / DAS systems. Alarm testing and detection must be done at the distributed processor level in order to achieve a useful rate of testing (alarm detection resolution) and the quantity (all points in the system) of alarm monitoring required to support the operator in monitoring the process.

Alarm Detection Methods

Alarm management begins with alarm detection at the lowest level possible in the DPC system. Some of the common forms of alarm detection are level and multi level. Level alarming simply compares a monitored value with pre configured limits and generates an alarm status when a High or Low level is exceeded. Multi level is an enhanced form of level alarm processing that quantifies the degree of monitored variable variation by means of incremental values above the primary High alarm level and below the primary Low' alarm level.

A useful variation of simple alarm level processing is variable alarm levels in which the value used as the primary alarm level is itself a dynamic value derived from other elements in the system. This technique allows the alarm levels for a measured variable to track the operating level, *feed rate or load rate of that area of the process. This is one* way of preventing 'nuisance alarms' during start-up or low levels of operation. As in fixed multi-level alarming, variable multi-level alarming tests for the additional levels of alarm at specified incremental levels above and below the values currently being used for variable 'High' and 'Low' alarms. Level alarm detection is one of the most widely used methods of determining a process excursion, and drawing the operator focus to it.

Deviation alarm detection is in essence a variation of variable level alarming. The current value of some other variable in the system (real input or calculated) is specified as the 'reference' to determine this points alarm status. A percentage bandwidth above and below this 'reference' value is calculated in real time and used as the monitored variables high and low deviation alarm levels. As long as *the monitored variable* follows the value of the deviation target within specified percentage limits, no alarms are *generated. But if the equivalency between these two* values (monitored and reference) fails to remain within the *specified percentage, a deviation alarm condition will exist.*

Rate alarming is *a means of having the system* determine if the manner that a variable is changing is within predicted rate of change (engineering units / time unit) boundaries. This allows the 'operators assistant' to not only monitor the relatively quiescent operation of the process at an established operating levels but also to monitor the process while it is changing levels of operation or modes.

Another method of calling the operators attention to an ongoing variation of a monitored variable is to re-assert the alarm after a configured amount of time. This function is invoked only if the monitored variable has remained in alarm past a pre-configured amount of time. This method insures that lower priority alarms do not become effectively buried by being pressed lower in a chronologic alarm by equal or higher priority items that have since been *resolved.*

Nuisance Alarm Prevention Methods

Because operator confidence in the credibility of his alarm system is critical to the computer / human interface concept, nuisance or inappropriate alarms must be minimized. An alarm system which crys wolf very often will increase the operators stress by reducing his confidence that the system will assist him properly in this *complex occupation. Alarm cutouts which disable the* alarm processing when pre-configured conditions in the *process are tested and found 'true' can significantly* reduce the false alarms. (If the pump is not running, don't alarm the low pressure in the output line.)

Another way of preventing alarms is to invoke a 'chatter *filter' on a variable which continually cycles into and out of* an alarm condition. This time based function is invoked when *a monitored variable repeatedly crosses into and out of* designated alarm level. A less sophisticated alarm system *can attempt to prevent these types of false alarms by* increasing the deadband of alarm level.

Note: Deadband may be defined as a value by which the monitored variable must be lower than a high alarm limit, or higher than a low alarm limit, before that monitored variable is recognized as having returned to the next lower alarm state or nominal (non alarm) state.

A chatter filter function is usually defined in terms of event crossings per unit of time and maintains the active alarm as long as the number of alarm state crossings per time unit is exceeded. This means that the system is not desensitized to detect the level alarm condition should one occur. But this filter does prevent false multiple alarm status *changes when a contact bounces or a control loop is* %seeking& near an alarm level.

Console Alarm Grouping Methods

Once the alarm condition has been determined, the relationship of this information to other plant data must be determined. Normally this is accomplished by grouping all the information coming from a common area of the process together at the users CRT console. Since individual data and alarm condition may be the critical responsibility of one operator (console) but only information to another. The *association of any particular datum to other data must also* be allowed to be different at one console to another in that *system. This will require that each console be able to* assign local groupings and have a totally independent means of *prioritizing and responding to both individual* control points and sets of data. Each console must also be capable of notifying the other consoles in the system of it's actions with reference to data points that are common.

Alarm Routing and Console Prompting Methods

Because these console groupings and data association *techniques are valid for both normal information "browsing"* by the operator as well as alarm annunciations and *response prompting by the system their establishment* provides a useful ergonomic means of reducing the operators time to access information. *These groups or* areas can be related to logical functions within the process or even geographical process boundaries. As members of pre-defined groups or areas the alarm status of a number of individual points within the group can be condensed and used to summarize the alarm status of the group as a geographic or logical entity that the group represents.

These summary po nts, n turn can be used as e ements n plant or fac *ity overv ews or as ndicators or annunc ators* of cr t cal alarm conditions n the summary area By ntegrat ng these annunc ators w th d sp ay select on buttons one method of automatica y routing the operator to the proper d splay can be ach eved

A method of operator prompting and d sp ay se ection can be imp emented by the use of a arm summaries w th n the conso e areas or groups These summar es are normal y presented to the user sorted nto chrono og cal order *Another option is to sort them by pre established* pr or ty w th n the group For each entry nc uded n an a arm summary an nd v dua ized comment can be nc uded to prompt the operators act ons n response to that specif c cond tion Prompt ng the reference to other nformation *in the system (e "Check drum eve) as we* as adv s ng d rect act on (e Disengage pump actuator) s also supported n th s manner Se ect on of the pr mary graphic d splay offering access to the contro of the alarmed control point *is achieved directly from the alarm summary* by cursor entry or *nd cated button se ect on These* methods can be used to reduce the tota ty of the p antw de or process w de data spectrum rto s mp ified dec s on trees for the conso e user

An a arm cond t on s re evance to an nd v dual operator (conso e device) can then be determ ned and d sp ayed by referenc ng t aga nst other cond t ons n that operators *responsib lity The assignment of priority within the groups* of an nd v dua operators respons b ty can a so be accomp ished (at that console) and that operators nd v dua response prompted by pre conf gured a arm comment or hopeful y in the not so distant future an expert system response

Summary

This paper has attempted to show that the functiona ty of the a arm detect on process ng analyzing and presentat on of a D str buted Process ng & Contro system data s a key parameter n the ergonom c design cons derations for contro consoles Th s a arm management functiona ty s a pr mary e ement in maxim z ng the Computer to Human nterface (CHI) for these systems The concept of the ntegrated console a arm system as trusted Operator s Ass stant n the *monitoring and safe prof.tab e operat on of a process has* been ntroduced a ong w th a group ng' methodo ogy for reduc ng p antw de data to manageab e terms As a result t is hoped that the ro e of a arm detect on presentation and management and t s essent a nature to the proper use of *the v deo based operator conso es* n D str buted Process ng and Contro (DPC) systems s better understood

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