Process Real Time Control Experience

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Abstract: During the last ten years, the Chemical Process Control staff of The "Oil-Gas" University Ploiesti has been researching into the chemical and petrochemical processes' modelling, simulation and control. Most of these researches resulted in industrial applications carried out in numerous refineries from Romania. This work focuses on the main achievements of the Chemical Process Control staff regarding the "real-time" automatic control of the petrochemical processes, keeping in the foreground the important role of the hardware and software resources in solving the process control problems. The display of the staff's experience is preceded by the analysis of the main aspects of the real time concept. These aspects make possible the inclusion of the staff's applications in the hierarchical system of Sheridan [12].

Keywords: real time, control system, petrochemical plant, hardware and software resources, process computer, process interface.

1. Some considerations about real time control

As shown in [6], a system has a real – time behaviour if it can control an environment by receiving and processing data, by performing actions or by giving results rapidly enough to influence its evolution.

Basically, this definition reveals the necessity of obtaining the *results in useful time*, so that they may exceed their purely informative meaning, influencing, thus, the evolution of the system. The definition has a general meaning, being valid for any RT application due to the following features [1]:

- the "environment" is a global notion;
- there is no necessity of a direct action upon the environment (it is enough to supply the results which will permit an external intervention);
- there is no restriction of the response time and thus, of the reaction time.

The last feature introduces the *real time* concept as an alternative to the concept of *useful* time. This alternative needs a direct connection between the response time and the dynamic behaviour of the environment. The useful time concept limits certain tendencies to apply it in commercial purposes. Such tendencies manifest themselves for the real time concept which from the commercial point of view means the digital equipment's capacity to answer *very rapidly* to different stimuli.

The process control plays an important part in the real time applications; in figure no. 1 are shown the typical entities for an application of this kind. Examining the informational circuit in figure no. 1, we can point out three elements of vital importance for any real-time control application:

- the time factor, which can appear in different hypostasis;
- the process events, considered as stimuli of the control system;
- the human intervention in the global feedback loop.

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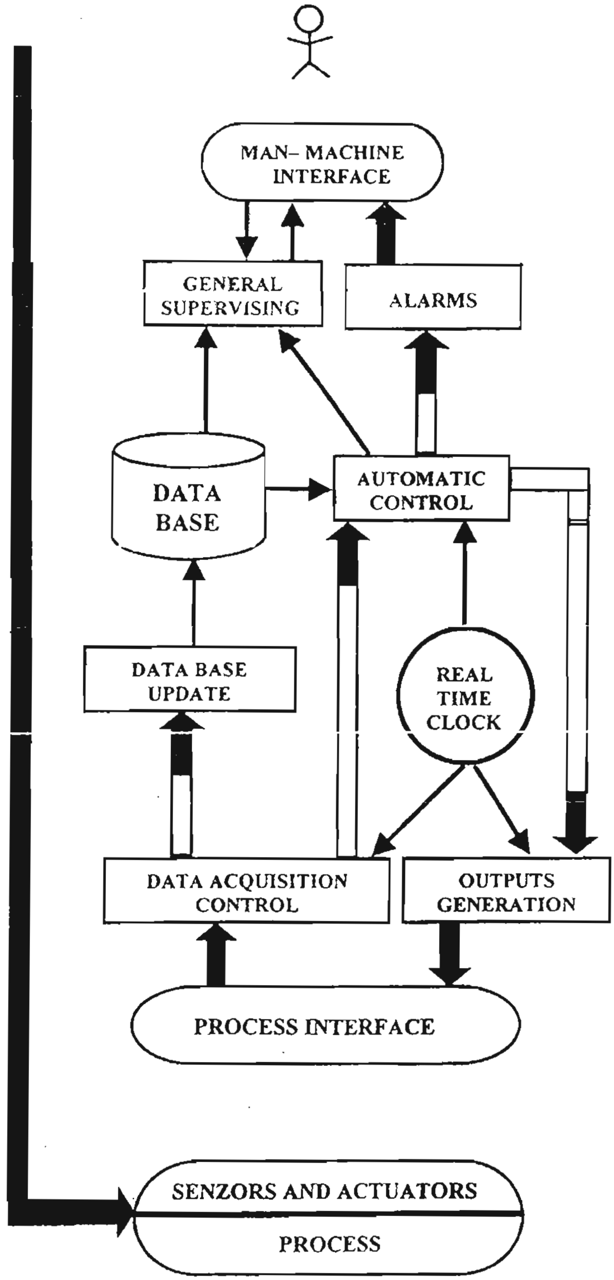
MAN– MACHINE INTERFACE
GENERAL SUPERVISING
ALARMS
DATA BASE
AUTOMATIC CONTROL
DATA BASE UPDATE
REAL TIME CLOCK
DATA ACQUISITION CONTROL
OUTPUTS GENERATION
PROCESS INTERFACE
SENZORS AND ACTUATORS
PROCESS

As to the *time*, it can occur in three hypostasis:

- ***the absolute time***, which is the time worked by the real time clock; for the example from figure no. 1, the **ACQUISITION, CONTROL & OUTPUT tasks,** and partially the **SUPERVISION** task must be periodically executed, with different frequencies depending on the hierarchical level of the application segment;
- ***the response time***, which is the time between the moment the data inputs come and the moment these data begin to generate automatic or manual outputs. This time has an upper limit, which is obviously given by the dynamic features of the process. As regards the lower limit, we must consider the fact that if it has a too small value, the resource cannot be justified by the global performances of the system..
- ***the relative time***, which is the time expressed in relation to other activities. This time becomes very important on condition that the tasks integrated in the application interact (precedence, antecedence, synchronization etc.).

As regards the stimuli,, they can appear at any moment and must release predictable reactions of the control system.

Taking into account the time factor and the stimuli, two processing levels adherent to the real time control system appear as possible:

- time - driven processing;
- event - driven processing.

As to the human involvement in the real time systems, it role seems to paradoxically become more and more complex.

The human activities can be *sinnoetics actions* (cooperation with the system by intellectual actions) or *sinnoenergetics actions* (physical actions to the process) [4].

By its actions, man can be placed on one of the automation levels of the Sheridan scale [12], as shown in table 1.

Table 1. **Automation levels [12]**

Level	Content
1	The control system assists the human operator who carries all the tasks.
2	The control system offers a complete set of alternatives *AND*
3	Reduces the searching space to some *OR*
4	Recommends one alternative action *AND*
5	Executes it with the approval of the human operator *OR*
6	Permits to human operator a short time to cancel the automatic command *OR* before executing it.
7	Executes and then informs the human operator *OR*
8	Informs the human operator only on demand *OR*
9	Informs the human operator only if this is the decision of the control system
10	All decisions and executions are automatically carried out, without human intervention.

The features of a system designed for real time applications must be regarded from both *hardware* and *software* points of view.

As regards the hardware section the main demands focus on the existence of the real time clock and the interrupting system. To these we must add the two interfaces for the connection with the process and human operator.

The software section needs the existence of a real time operating system which must dispose of all types of methods of solving the interactions between tasks.

2. Experience in real time control applications

During the last ten years the authors, members of the **Process Control Staff** (Automatics and Computers Control from "Oil – Gas" University of Ploiesti) have been carring out activities that aimed at developing the real time control applications. The outcome of these activities consisted in industrial implementations of real time control systems for petrochemical industry (Catalythical Cracking, Crude and Vacuum Oil, Gas Separations plants) – situated on the first six levels described in table 1.

- **The first application,** implemented in 1986 , was the real time control system for the propane – propylene column from a Catalytical Cracking Plant [9].

The control system had three hierarchical levels:

- *conventional feedback loops,*
- *feedforward control,*
- *optimal control.*

As equipment was used the **Felix M18** computer (based on 8080 processor) with **a** process interface designed and manufactured in Automatics and Computers Department laboratories.

The operating system was CP/M – sequential processing oriented – with a *real time kernel* added in order to give some real time features to the operating system, needed by the control system structure.

The real time kernel was intercepting the system clock, running the application modules at pre-setted times intervals [7].

The software control system was developed using both the assembly code for 8080 CPU and the BASIC language (its mathematical library). Because of the impossibility of providing the reentrance feature, the library was placed in two distinct memory areas, and the functions were called using the absolute addresses of these areas.

- **The second application** was implemented in 1988 to Catalytical Cracking unit too, controlling propylene – propane and butylenes – butane columns [8].

This time was used a TPD computer, manufacturing at Peripheral Equipments Factory from Bucharest. The TPD computer, which had a Z80 CPU, was equipped with a process interface designed and manufactured in our Department's laboratories, too. In comparison with FELIX M18, this TPD had some improvements like the capacity of using floppy disk drivers and the existence of a console with video display.

The software control system was written in FORTRAN IV language, except for the routines for the process interface, written in Z80 assembly code.

The program consisted of one infinite loop, the functions being activated as a result of time conditions achievement.

In comparison with the first application, the report functions of the operator were improved due to the video display presence.

- **The third application** group used SPOT equipments, especially the computers designed for industrial environments, their process interface system accepting different kinds of sensors and final controlling elements (actuators).

The man machine interface was implemented using the VDT52S video terminal, which had some graphical facilities.

At the software level, the *real time kernel S83* created important pseudo – parallel processing features for the CP/M operating system. This *real time kernel* [5,13] had a large class of primitives for multitasking operations implementations (such as *synchronization, mutual exclusion, inter – tasks communication)*. For the tasks codification it were used the Z80 assembly language and S83 primitives.

After the 8086 microprocessor was released, another version of the *real time kernel*, S86, was implemented, but it did not have a large field of application, because it was not enough tested.

Many industrial applications were based on SPOT 83 equipment beginning from 1989-1990, the first step being the replacement of old FELIX M18 and TPD computers on the Catalytical Cracking units.

In 1992 was implemented an advanced structure of automatic flows balance through heaters steps for a Crude Oil Atmospheric and Vacuum Distillation Plant [11]. The aim of the flows balance is to obtain the near temperatures for each heater's step. The heater's operation style with near temperatures on the steps determines a uniform coking for each step's pipes.

The next step with the SPOT 83 equipment was the implementation of the supervisory system for a Liquid Gas Separation Plant [2]. The system ran three years and had very important results concerning the early operation and safer work.

Although for all instrumentation with SPOT 83 equipment the assembly language was still used, the software application was more easily built because this time the kernel functions were easy to be called.

As a conclusion, the SPOT, family based on the real time kernel S83 had a good performance, giving complete satisfaction for its time.

Beginning from 1994-1995 the staff have oriented their applications on PC – compatible industrial computers using preferment operating systems, with powerful graphical features.

Remarkable from this point of view is the *real time advanced control system* for a Crude Oil Distillation Plant, implemented in 1997.

This systems has the following hierarchical structure:

- the first level is the conventional automation level, where there are digital feedback controllers connected through the serial lines with the second level equipment;
- the second level contains the Main Process Computer [3,10] and workstations for the human operators.

As operating system is used MSDOS, together with the **Real Time Kernel – RTK** 4.5 [14]. This kernel includes over 200 functions, which permit a parallel and pseudo – parallel process information processing.

The principals problems solved by the advanced control system are:

- facilities for an easy operation for digital controllers;
- complete information of human operator about the state of the process;
- determination of values for each lateral product and steam flows regarding at the principal disturbance: the crude oil flow. This feedforward control system assures an optimal recovering of lateral products from the feed.

3. Conclusions

After ten years, the experience of Process Control Staff proves the necessity of a team formed of experts from the following domains:

- *chemical process engineering;*
- *process control;*
- *computer science.*

All experts from the team will be implied in each phase of the project building.

All these applications tried to turn to good account the already existent automation infrastructure of the plants, with positive consequences regarding the gain of the operating personnel trust and lowering investment costs.

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