VIRTUAL INSTRUMENTATION, CONTROL AND DATA ACQUISITION FOR INTENSIVE CARES UNITS

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Abstract: The tools disposition of the industrial Automation, like SCADA in hospital services is a tendency, that optimizes the processes and health services; these tools, provide resources with support, validating, facilitating and make faster the processes, as much of diagnosis (monitoring), as of specialized intervention (control) and legal responsibilities (reports). This document presents/displays advances in the technological development of an application, where techniques oriented to the control, the communications, the virtual and conventional instrumentation take advantage of, the management and information processing, among others; proposing a system of monitoring, registry and control, reliable and flexible, improving the UCIN (Units of Intensive Cares Neonatal), as well as other processes in the clinical atmosphere.

Keywords: Automation, Virtual Instrumentation, Bioengineering, CIM, Fuzzy logic, Incubator, SCADA, LabVIEW, Microcontrollers, Neonatology.

1. INTRODUCTION

The strategies for the monitoring of signals, facilitate and make agile the processes of diagnosis and medical intervention, when identifying, to analyze, to characterize and to evaluate these signals, can be related more and more to pathological, by means of tools of processing of information, allowing the unquestionable diagnoses with a high degree of certainty.

The SCADA, are the best and economic alternative to generate centers robust of supervision, control and data acquisition; offering all the advantages of an automated system. The human body, Integra diverse types of process, where, a symptom that makes reference to special causes represents infinity of complementary variables, which often are not analyzed. Not to identify its logical relation, cause-effect, it does not mean that it must be not known, all the opposite, it is needed to provide tools with engineering that demonstrate them by means of signals, and from them, to find new forms of diagnosis and medical intervention.

2. REFERRING HOSPITABLE

In the regions separated from the technological centers, the problem of the health, must to economic factors, as much technological, among others. In order to surpass these disadvantages, the academy and other sectors in the investigation tie, contributing new developments and applications; generating new materials, techniques of diagnosis, techniques of supervision and intervention, as much

invasive (surgical), like external (treatments and therapies), such as the therapies of ultrasound, the transplant of vital organs or the simulators of surgery.

3. SCADA WITHIN THE IPS

SCADA is based on two fundamental applications of computer science and the telecommunications: Communications networks of data and data bases; systems that have been applied for more than two decades in sectors of manufacture of oil automobiles and, today they position as a control form of distributed processes, when integrating itself with the traditional and virtual instrumentation, the screens of operator, the programmable security systems, controllers, robots and communications equipment. Allowing by means of the work with bioelectric signals or of images; to visualize the state of organs of the body, determining factor in the diagnosis or divides doctor, and in the formulation of treatments, which must be watched to verify the evolution of the patients in their process of recovery? In addition, thanks to the monitoring of these processes, the investigation and development in the medicine have generated of optimization of the procedures and specialized intervention technical. Consequently, the application of opportune medicine and the handling adapted in the treatment of diseases and anomalies of the human health, have meant, the continuous improvement of the quality of the services in health.

A typical system SCADA is synthesized in Fig. 1, showing the acquisition, analysis and supervision stages for any process. And it at least must fulfill the following characteristics:

- Panels of visualization of alarms, allowing the opportune intervention of personnel who evaluates the system state, and takes corrective actions, with faults registry.
- The generation of historical, to be analyzed statistically, determining tendencies and other indicators, in case of responsibilities to third and/or management of the processes.
- Execution of programs in line, that allow to modify the control variables, activates or deactivates processes, according to restrictions and levels of security.

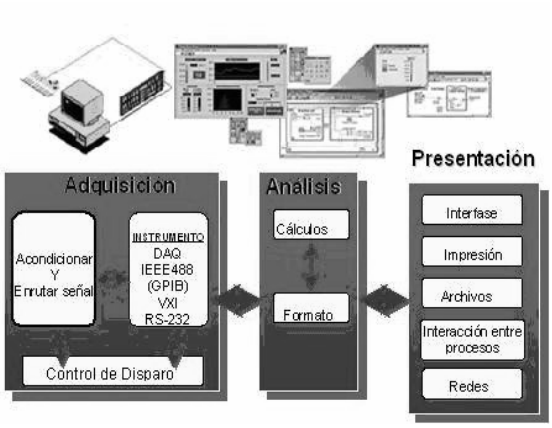

Fig. 1: Image taken from applications SCADA [1]

- Flexibility in presentation of signals and/or data in screen, by means of interface with worker, graph and friendly, that as much facilitates manipulation and identification of the elements that integrate the system, in the panel of monitoring like in the programming screen.
- To have opened architecture and communications, making possible integration with other systems and levels of automatism. Thus as the possibility of connection with other networks like Internet.
- Modular structure, with the purpose of obtaining flexibility and adaptability, guarantee of robustness and redundancy.
- Possibility of programming, which it allows to make complex calculations on the CPU of the computer.
- Import and export of historical of data, to be process in other programs.

The Virtual instrumentation fortifies the SCADA; since I SAW or virtual, accompanied instrument of a minimum hardware (Sensorial, cards of acquisition, networks and controller) and with the software of platform, we can turn a PC of moderate exigencies a powerful measuring instrument, precise and trustworthy, reducing costs of the specialized instrumentation.

3.1. Industrial analogy SCADA, SCADA in medicine

The decisions of control and supervision, are subordinated in dependency of the pyramid of Automation CIM (Manufacture Integrated by Computer), which, settles down as much from the importance of the handling of the information as of the level networks in sequence ascending Machine

(Field) to Company. As it is observed in Figure 2, analogy with the levels of hierarchy of the institutions of health becomes. When applying this pyramid within the IPS, these levels would be satisfied as it is described to continuation:

Level Health for all: It has greater contact with the end users (patient); conformed by all the elements and/or equipment of: diagnosis, treatment, therapy, surgery, rehabilitation etc. In model CIM, this level corresponds to the manufacture or manufacture of pieces (manipulation), and in the medicine, this production imagines by the quality in the service.

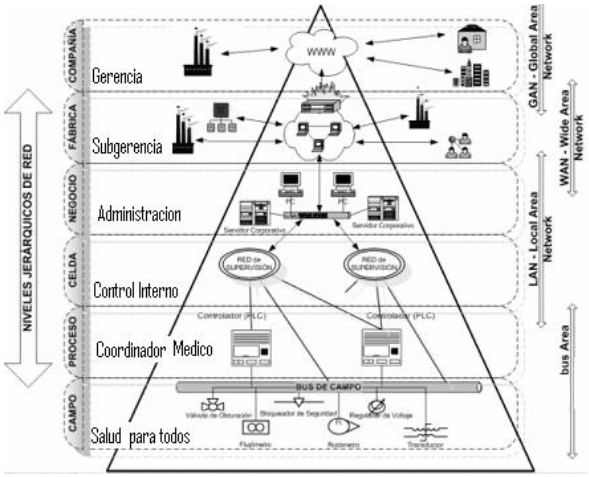

Fig. 2: Hierarchy of networks versus 2 organization IPS [2]

The level of medical coordinator, this compound of one more a more specific pyramid, dedicated to the processes, that will be explained with more detail in section 4 (practical Application in Neonatology). The level of internal control is related analogically to the cell level, since the coordination of all the inferior elements is necessary; and in this case it is the bridge between the processes and the administrative section and of management. In the level administration, the control elements are coordinated and synchronization of the inferior elements, in addition, is the one in charge to handle the information of the processes, as well as the communications and the quality of the services in health. The level sub management handles the productivity indices (cost-Benefit), statistics, management of resources, and on this the operational control of the institution depends. Finally the management fulfills the approach of integration of surroundings CIM developing the processes of: human productivity, planning, calculations, trade, resources, I+D, among others.

4. PRACTICAL APPLICATION IN NEONATOLOGY

The Neonatal Incubators requires specialized supervision and control, where variable like temperature, humidity, level of oxygen etc, they are due to regulate, guaranteeing the security of the newborn one. When integrating SCADA to the process, their advantages are applied all and other benefits like: smaller exhibition of the newborn one with disturbing and polluting agents.

According to the level of hierarchy in pyramid CIM, the different users accede to panels who allow them to interact with the process. The Figure 3a, shows the Panel of alarms of the field level. In this screen reports of operation and maintenance can be observed the states of operation of actuators and sensors, and be entered other menus to modify the processes and be seen.

The reports are created automatically in agreement to the programmed time and the tasks in supervision. Reports that according to the security level, will contain information of the superior levels of pyramid CIM or the local processes. The Figure 3b shows the summary of the report of faults of sensors and actuators of an incubation unit, where by means of a codification one settles down the device of reference, the type of fault and the made procedure to correct it.

a) b)

Fig. 3: a) Panel of Alarms in Instrumentation, created with LabVIEW6i.
b) Screen of report in a local station (process)

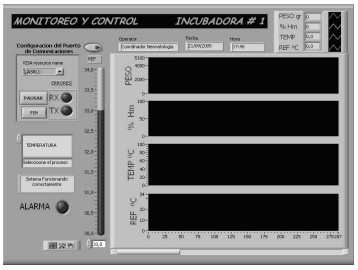

Fig. 4: Screen of pursuit and control of the neonatal unit

The panels, present/display the information of graphical and friendly form, in Figure 4 is the panel of user for a maintenance session, where communication parameters can be modified, operation, presentation of information, etc.

As far as the exchange of information, the system allows the communication from the level of neonatal infirmary with multiple neonatal Units (up to 255 Incubators), using identification directions (YOU GO c/u), and origin directions, distributed in the levels superior to the process level. Each unit has manifold modules (Processes), with specific tasks of control: temperature, humidity, monitoring of weight, etc. They are administered by a management system (Controller unit), that get supply the information path, and one communicates with the operator of the process (personal specialized) and the neonatal infirmary (Central of monitoring), storing to the behavior of the module during a time, determined by the capacity of storage and the time of sampling. In Figure 5 the general diagram of the modular configuration can be observed of system.

The designed communication protocol is conformed by two plots, (to see Figure 6) one for the supervision and another one for the control of the process; (control: 10 data y supervising: 6 data, of eight bits each one). Another difference between the plots is the state of the most significant bit of the block control; if the state of this bit is a 1 logical one, the plot is of control, otherwise, it is of supervision.

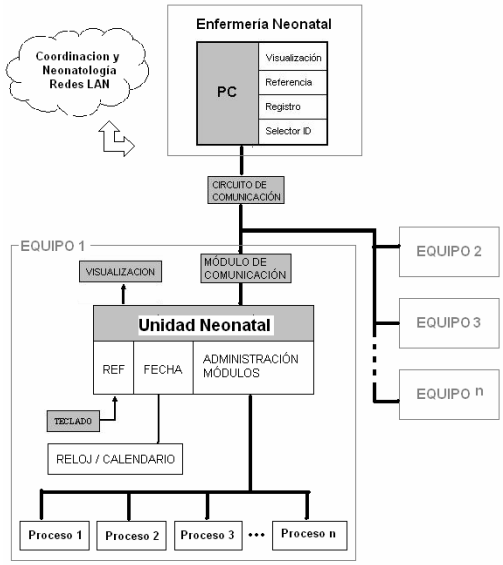

Fig. 5: General diagram of the modular configuration of the system

FORMATO DE LA TRAMA DE CONTROL									
DELIMITADOR DE INICIO	DIRECCION		CONTROL		INFORMACION				DETECCION DE ERRORES	DELIMITADOR FINAL
	MAESTRO	ESCLAVO	CS'	INSTRUCCION	DATO 3	DATO 2	DATO 1	DATO 0		
7E	XX	XX	1	Siete bits	XX	XX	XX	XX	XX	7E

FORMATO DE LA TRAMA DE SUPERVISION						
DELIMITADOR DE INICIO	DIRECCION		CONTROL		DETECCION DE ERRORES	DELIMITADOR FINAL
	MAESTRO	ESCLAVO	CS'	INSTRUCCION		
7E	XX	XX	0	Siete bits	XX	7E

Fig. 6: Plots of communication of Control and Supervision

The control field of the plot, has, a space of 7 Bits, that determines the type of information a to interchange. Existing 128 plots for control and 128 for supervision. The medical implementation of SCADA in machines of newnative incubation. One acquires knowledge in Figure 7. and it is described thus by levels:

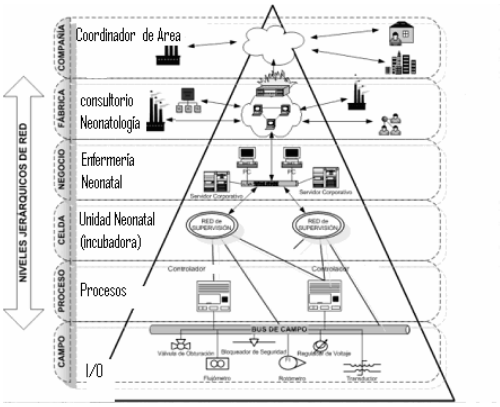

Fig. 7: SCADA applied in Neonatology an incubation processes

4.1. Level of Coordinator of Area

It corresponds to the director of Neonatology that has responsibilities and functions similar to the institutional management, for this process. (Developing Level).

4.2. Level of Doctor's office of Neonatology

It corresponds to the management processes, where the Newnatologist doctor accedes to the information, makes changes in the system according to the level of security, asks for reports and/or administers the resources of the neonatal unit. (Developing Level).

4.3. Level of Neonatal Unit (Incubator)

1. Communications: It conducts operations of management of the information between processes and neonatal infirmary, as well as verification of information, delimiters and other blocks of the plot, makes detection of errors applying Checksum.

2. *Instrumentation:* Module interface between the level of infirmary and the neonatal unit, conformed by transceivers RS485 and RS232.
3. *Control:* Routing of the signals of process and instructions of superior levels, variation of parameters in the sublevels, by means of the use of keyboard, generation of date, hour and synchronization of the system.
4. *Monitoring:* Luminance and sonorous visualization of the processes of the equipment through LCD and indicators.

The system contains the following elements:

- Housing of Incubator of medical use.
- Resistance of heating of 250 W.
- Ventilator of low noise.
- Conditioning of signals.
- Sensors of temperature, humidity, weight.
- Sensors of instrumentation state.
- Microcontrollers of the Motorola family (CPU08)
- Serial memories EEPROM.
- Clock calendar (years 2000-2100).
- Screen LCD.
- Matrix keyboard.
- Application in LabVIEW 6i.
- Interface RS232-RS485.
- Computer of moderate exigencies.
- Simulation and modules of test ECG, Oximetry, etc.

4.4. Level of Processes (controller)

1. *Communications:* It takes the parameters of the plant (sensorial, actuators and process) to the control unit of process and codifies the information to be sent to the superior levels.
2. *Instrumentation:* It makes the preparation of signal for the necessary instrumentation of plant (sensorial and actuators), as well as isolations that they guarantee the security of equipment, patients and workers in plant.
3. *Control:* It executes the algorithms of control in agreement to the references and estimations of means (disturbances), for it is fundamental the mathematical model of the plant, characterizing its behavior.
4. *Monitoring:* By means of luminance indicators sonorous type LED and that relate the state of the instrumentation and the value of the variables with respect to established pattern.

4.5. Level of Sensors and Actuators

1. *Instrumentation:* The variables room temperature of incubation, and relative humidity, is controlled and variable as temperature and weight of the newborn one, are monitoring. The room temperature of incubation has a window of operation of 0ºC to 50ºC, this signal is taken by means of 3 sensors AD22100. A ventilator of low noise homogenizes the atmosphere of the incubation camera. The temperature actuator consists of a heating resistance, the tension fall in the resistance it controls by angle of phase by means of PWM, according to the temperature wished in the medical considerations. The control signal varies of 0 to 5 volts, the tension of feeding of the resistance is of 120 VAC RMS, and the reference signal has a window of 5 operations from 0 to standardize V. The temperature of the newborn one has window of operation of 0ºC to 50ºC, the signal is sensed with the thermistor of precision 44031, which is placed according to medical considerations in the body of the newborn one. The signal preparation is made by means of the use of a bridge of Wheatstone and amplifiers of instrumentation. The relative humidity of the atmosphere, has a window of operation from 0% to 100%, this signal is taken by means of sensor HIH3610. The state of operation of the sensors is made with individual reading, averaging and comparison of the readings; the state of the ventilator is verified by means of the verification of moving by the interruption of a luminance beam, and the normal operation of the resistance, by means of current readings.

2. *Control:* The function of transference of the plant was by curve of reaction, determined from a value of the manipulated, equal or greater variable to 63% of its final value, to find the constant of time of the process, the response time and the dynamics of the system. Considering the rank of operation wished with initial conditions t=0 and a T=26º C, until a maximum of T=50º C, was observed that it is a system of first order as 8a acquires knowledge in the Figure) and 8b)

a) b)

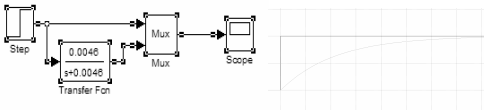

Fig. 8: a) Diagram of simulation of function b) Result of the simulation

The system requires a stable value of temperature, given by the reference, which is modified in a rank between 0 and 50 degrees Celsius. The controller operates on the actuators, modifying the temperature and regulating it according to the indicated reference; generating a suitable answer forehead to the disturbances (in normal conditions of work) that they are possible to be presented/displayed. The fuzzy logic controllers (to see Figure 9), inherit of the theory of conventional control, the idea to include proportional, integral and derivative elements, that optimize the performance of the system to control. The first block is the fuzzing, that transforms the entrance variables into fuzzy values. The following block, is the rules bases, where the influence of each one of them in the final decisions calculates.

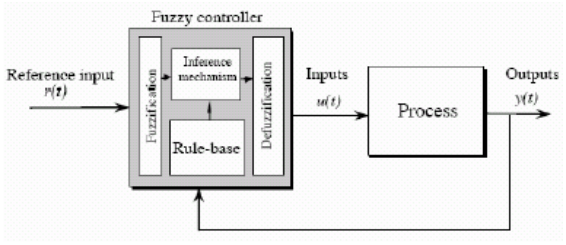

Fig. 9. Structure of a fuzzy controller with its four main components

Finally, the defuzzying block, finds an exit of unique or numerical type, in relation to an originating entrance of the inference mechanism, which is indeterminate or vague. The control of temperature and humidity of the incubation camera, applies a fuzzy controller, for who they consider elements: proportional and derivative; where the antecedents of the rules, respectively combine the values of the error and the variation of the error. For the fuzzy controller software Matlab® 6 has been used and the Fuzzy Logic Toolbox. Using like linguistic variables of entrance: errort, derrort, erroh, derrorh and linguistic variables of exit: Temperature (T), Relative Humidity (H). 10 figures a) and 10 b) show the allocation of linguistic variables of input-output, and the selection of the property function of the process respectively.

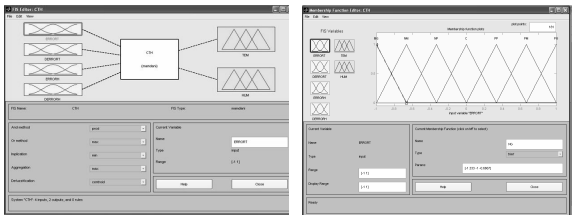

Fig. 10: a) Allocation of linguistic input and output variables b) Election of the membership function

5. SIGNIFICANT RESULTS

- Control and monitoring of room temperature, relative humidity, applying Servo Fuzzy Control.
- Monitoring of temperature and neonatal weight, state of the devices actuators and sensors of the system.
- Distribution of tasks, flexibility, adaptability and modular security, by means of the design and elaboration of protocols of administrative management, Control, Supervision and Communications, allowing the inclusion of new modules (Electrocardiography, Oximetry, Heart rate, etc.).
- Human interface machine that it establishes I engage in a dialog of easy understanding, with a graphical and numerical language sure, by means of keyboards, screens LCD and PC.
- Data bases of users, generation of reports of faults and maintenance, creating the leaf of life of the equipment, event after event.
- Creation of applications and sessions that guarantee the levels of access security, in dependency to the pyramid of Automation CIM using LabView.

6. CONCLUSIONS

Systems SCADA, offer the best and economic alternative to generate centers robust of supervision, control and data acquisition; which substantially improves the processes of production of any type of organization, the indices of quality, supervision, maintenance, speed etc.

The Virtual instrumentation (VI) accompanied by a minimum hardware (Sensorial, cards of acquisition, networks and controller) and with the software of platform, can turn a PC of moderate exigencies a powerful measuring instrument of much precision and reliability. Due to the security exigencies that require an equipment of medical use, the optimal operation of the system is due to guarantee, indicating permanently the state of its operation.

In a measurement system, when it is going away to choose the sensor, factors are due to consider like: the magnitude to measure, the characteristics of exit, and feeding, and the characteristics environmental, among other factors.

A linguistic variable is a variable whose values, can be expressed by means of terms of the natural language and they imagine by means of fuzzy sets, characterized by membership functions within the speech universe.

A fuzzy system is based on the knowledge. That structure in a set of symbolic rules of the type "*if-then*", which use terms of the natural language to represent vague or vague information.

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