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Simulation Architecture Design of vLABHMI and VRCR for Nuclear Power Plant

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Abstract: Practical training of nuclear power plants operators are partially performed by means of simulators. Usually these simulators are physical copies of the original control room, needing a large space on a facility being also very expensive. In this way, the proposal of this paper is to implement the use of Virtual Reality techniques to design a full scope control room simulator, in a manner to reduce costs and physical space usage. Process Instrumentation & control is a vast area where 100% emulation of a component and its control in real time simulation environment is not achievable. Hence some of the instruments are conceptually emulated to represent the functionality of the main control room for simulator development phase. Models simulated in the development phase have been verified and validated by the emulated instruments in soft panels and tuned to meet the simulator requirement specification as per the Nuclear power plant operator training simulator.
Keywords: Nuclear Power Plant, Simulators, Virtual Instrumentation, Process Instrumentation and Control

I. INTRODUCTION

Nuclear Power Plant (NPP) is a facility for electrical energy generation, developed for operating on continuous regimen, stopping only for reloading its fuel. Because of its high degree of complexity and very rigid norms of security it is extremely necessary that operators are very well trained for the NPP operation. A mistaken operation by a human operator may cause a shutdown of the NPP, incurring in a huge economical damage for the owner and for the population in the case of a electric net black out. To reduce the possibility of a mistaken operation, the NPP usually have a full scope simulator of the plant´s control room, which is the physical copy of the original control room. The control of this simulator is a computer program that can generate the equal functioning of the normal one or some scenarios of accidents to train the operators in many abnormal conditions of the plant. A physical copy of the control room has a high cost for its construction, not only of its facilities but also for its physical components. Usually only one copy is constructed and the operators teams have to be trained one by one, implying in a longer in-between time for the training of each team as it has to wait for all the other teams to be trained to use again the simulator.

The nuclear industry in large parts of the world –exception is probably only Southeast Asia, primarily China, is struggling with more or less the same problems:

1) Falling prices for electricity
2) Rising costs for modernization and refurbishment and increasing production rates (in the United States, the production cost per MWh increased by 28% over the last 12 years)
3) Unwillingness from owners to make the large and long-term investments which are often needed
4) New regulatory requirements impose ever higher and higher requirements and often involve high costs
5) Other types of production (e.g. solar and wind) receive subsidies and does not have the same cost driving authority monitoring
6) Hard to gain trust in the public and difficult to highlight the environmentally beneficial parts of nuclear power to the common man

In short, it is currently very difficult to be profitable and competitive and to win the public support they need to provide the basis for continued operation and production. One notable fact of this is that in recent years a number of commercial NPP closed down, or took a decision on the close in advance (before end of license), and all of these early closings have been due to lack of profitability or other economic reasons. According to the IAEA, a decision to shut down early was taken for 12 reactors worldwide, all due to financial reasons in 2016. And in Sweden this is certainly very obvious where we are seeing the shutdown of the O1-O2 and R1-R2 because of these reasons. And from an capacity perspective, it is estimated that twice as much nuclear power can be shutdown compared with what is expected to be built and commissioned up to 2030.

In addition, the nuclear power plants are aging, and in order to continue operation, major investments are often required, and in the current situation these investments are very difficult to deem profitable. The nuclear industry -in the western world, are therefore facing a rather precarious situation, if it does not manage to reverse the trend, it will liquidate itself.

The proposal of this work is to present a project of a virtual simulator with the modeling in 3D stereo of a control room of a given nuclear plant with the same operation functions of the original simulator. This virtual simulator will have a lower cost and serves for pre-training of operators with the intention of making them familiar to the original control room.

II. LITERATURE

Successful operation of any nuclear power plant requires a carefully planned training program for the engineers, supervisors and operators. The operators are expected to have acquired the necessary theoretical knowledge as well as practical knowledge in operating the controls in the control room, before they can be authorized to operate the plant. The design proposed here is a full scope replica type operator training simulator is developed as per Atomic Energy Regulatory Board guidelines at Computer Division in collaboration with Reactor Design Group and Nuclear Safety & Engineering group of IGCAR [1].

Full scope simulator simulates various reactor states and systems starting from nuclear core to turbo generator and replica feature are brought into the simulator control room by providing 1:1 correspondence with main control room with respect to its panels, desks, chairs and lighting arrangement etc [2] and [3]. As an alternative way, some countries are developing simulators of nuclear plants with digital techniques. In this type of operation, the physical project of the control room is not necessarily a full scope one, with all the process being carried through synoptic screens. Among these simulators, the LABIHS [4] and HAMLAB [5] are the distinguished. Taking these as examples it is aimed to develop virtual instrumentation based control rooms for nuclear power plants.

III.METHODOLOGY

Control panels in any process control plants are flat, often vertical and area where high quality analog / digital instruments are placed for extensive range of process, electrical and electronic parameters for control or monitoring instruments are displayed. Control panels are most often equipped with push buttons, selector switches, digital indicators, pen recorders and analog instruments. Simulator has two main control centres for different purposes and geographically distributed also [4] [5]. vLABHMI and VRCR.

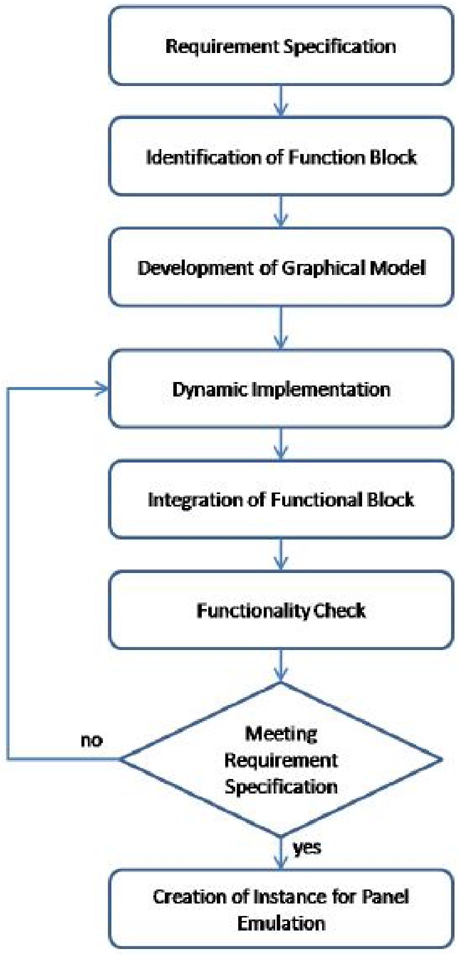

Fig.1 Step by Step Emulator Modelling Process

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A. Development Stages

This work was developed following these stages:

1) Definition of the implemented full scope simulator;
2) Definition of the simulation program for the physical variables of the nuclear plant;
3) Development of the of virtual control room (VCR) of the full scope simulator;
4) Development of the communication program between the simulation program and the virtual control room.
5) Validation of the virtual control room.

B. System Architecture

The computational architecture of the implemented system has three elements:

1) Nuclear reactor simulation program.
2) Synoptic screen generating program.
3) A memory buffer to be shared by the previous two programs.

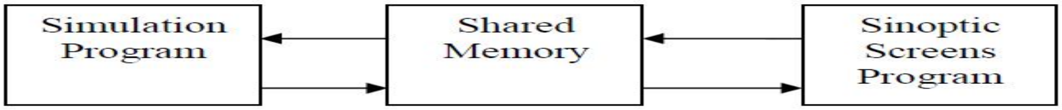


Fig.2 Virtual Laboratory Human Machine Interface (vLABHMI) Architecture

This memory buffer contains all the variables of the system (control bar position, reactor temperatures and outflows, pumps activation status, etc.). The simulator program calculates the reactor behavior through these variables. The synoptic screen generating program makes the interaction with the user using these variables. A program was developed to communicate the simulator of the vLABHMI with the VRCR. This program, resident on the HP server, has access to the shared memory and with a TCP/IP socket communicates itself with another program, resident in the Virtual Reality Laboratory (LABRV), where the VRCR is implemented.

In this way, the program that manages the VRCR has access to the shared memory data to feed its diverse graphical components, such as: (i) analogical displays; (ii) numerical displays; (iii) alarm displays; (iv) buttons, etc.. Figure 5 presents details of these graphical components. The 3D modeling of the VRCR and its graphical components were made using the OpenGL library compiled with Microsoft VC++.

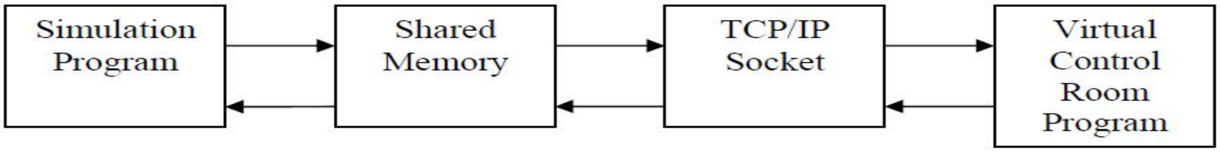


Fig.3 Virtual Reactor Control Room (VRCR) Architecture

The interactivity of the operator with the VCR is made through the computer´s mouse, selecting, in the exhibition screen, which control component is desired to act, sending its status by the TCP/IP socket to feed the simulation program. In the future this interaction could be made with tactile feedback gloves to enhance freedom and reality to the operator. Zoom and pan effects controlled by head tracking could also be achieved to a better visualization of, and interaction with, the VRCR. For the sake of greater realism, the LABRV, located in the installations of the DICH/IEN, uses a 3 by 2 meters polarized projection screen, with two projectors, to produce the 3D stereo projection.

IV. CONCLUSIONS

The control rod bars and neutron flux monitoring module is supposed to be fully operational and under intensive operation and reliability tests to compare it to the simulator of the vLABHMI. No major errors have been found. The reason to first implement this module is to make tests on the reliability of the system parallel to the construction of the rest of the VRCR. After the construction of the whole VRCR, validation tests will be made with the operators. Using a Pentium 4 3.2 GHz Core Duo, this module consumes 3% of the CPU processing time and 2% of the network traffic. As the whole of the VCR is about 6 modules, the projection of about 20% of the use of the CPU, seems to be reasonable. This system is expected to evaluate the use of the virtual reality techniques on a low cost virtual full scope simulator.

REFERENCES

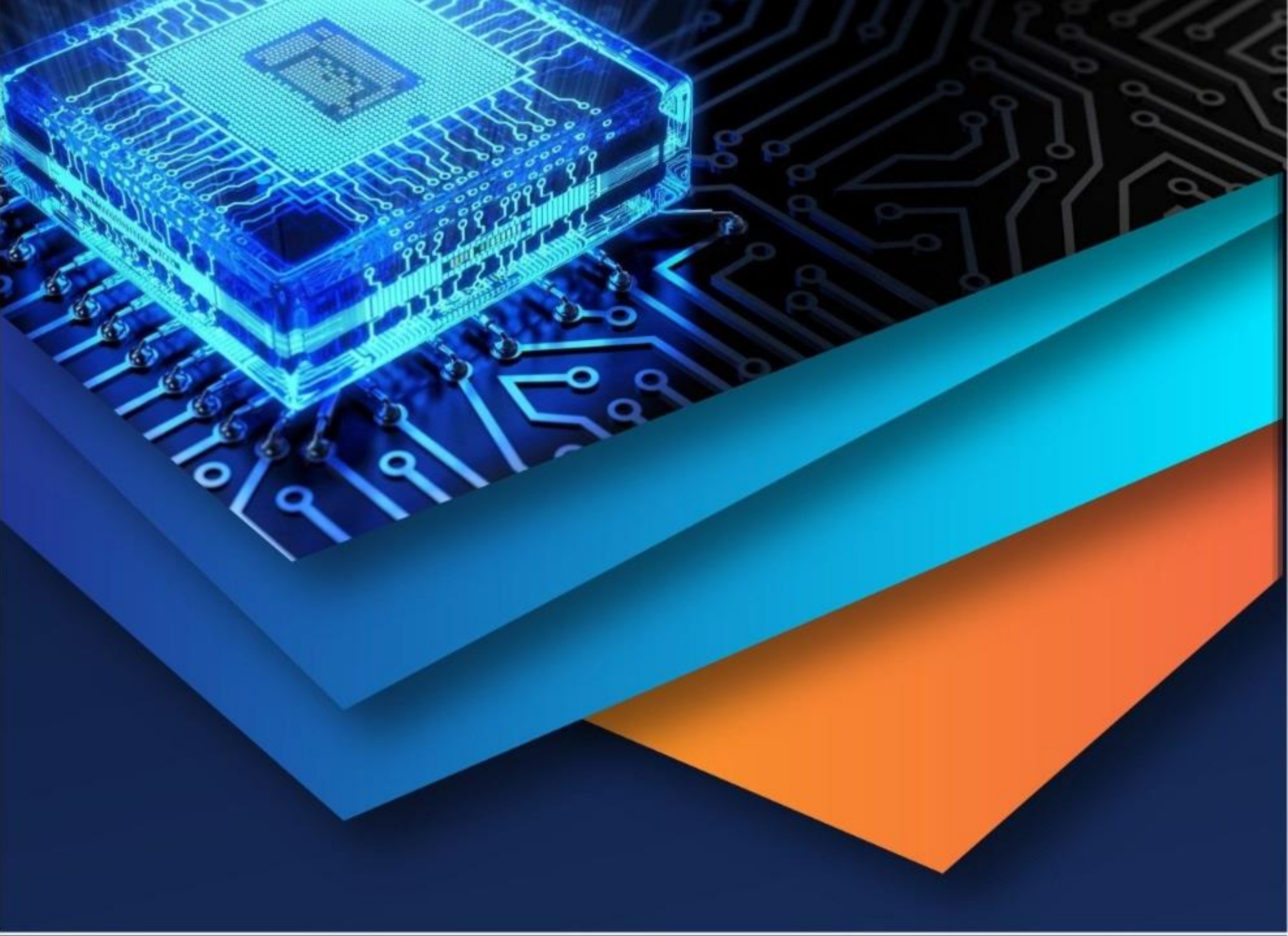
[1] Scope Document for PFBR Operator Training Simulator, T. Jayanthi, S.A.V. SatyaMurty, K.K. Kuriakose, S. Srinivasan, M.L. Jayalal, PFBR/08610/DN/1003/REV-A, IGCAR, 2007 .

[2] Operator Training Simulator, T.R. Ellappan, S. Athinarayanan, PFBR/08610/DN/1000/REV-A, IGCAR, 2003.

[3] Training Requirements of PFBR Simulator, T. Jayanthi, S. Rajeswari, PFBR/08610/DN/1008/REV-A, IGCAR,2008.

[4] Carvalho, P. V. R. ; Obadia, I. J. . Projeto e Implementação do Laboratório de Interfaces Homem Sistema do Instituto de Engenharia Nuclear. Revista Brasileira de Pesquisa e Desenvolvimento, rio de janeiro, v. 4, n. 2, p. 226-231, (2002).

[5] Kvalem J., Haugset K., Owre F., "THE SIMULATOR-BASED HALDEN MAN MACHINE LABORATORY (HAMMLAB) AND ITS APPLICATION IN HUMAN FACTOR STUDIES", OECD Halden Reactor Project, Institute for Energy Technology, Norway (2000).



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