SUMMARY OF ACTIVITIES ON CSS RELATED ISSUES

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Abstract

In the Netherlands there are two nuclear power plants. One 60Mw BWR for research purposes in Dodewaard, and one PWR 450 Mw IN Borssele. Both of these NPPs are undergoing an extensive upgrading. These plants use several CSS-like systems. These systems are primarily aimed to support and monitor safe and correct operation of the process or to detect specific (e.g. mechanical) problems in an early stage. The NPP in Dodewaard is upgrading its training simulator and process presentation system ("Datalogger"). The activities related to the CRP are mainly within the framework of the Dodewaard plant. This final national report will give an overview of these activities with particular emphasis on the replacement of the Datalogger system. Some additional information is given on trends in CSSs as used in fossil power plants.

1. Introduction, GKN-systems

The GKN joint Dutch Nuclear Power Plant in Dodewaard is a 60 MWe BWR, with a natural circulation GE-design, which was taken in operation in 1968. In the early nineties, it became clear that both the training simulator and the process presentation system ('datalogger') needed to be renovated or replaced. KEMA developed a concept to meet the general requirements on flexibility, extendibility, and maintainability with competitive pricing.

The concept uses open-systems standards and practices, a modular system architecture, the re-use of software where possible, and readily available workstation technology. Both systems have the same type of MMI; mimics can be easily translated from one system to the other.

Both projects were awarded to KEMA. In order to ensure both the necessary quality of the systems and the efficient use of bounded budgetary resources, much attention was paid to proper project control - and systems engineering procedures. These procedures are prescribed by the IS09000-based certified quality system of KEMA.

1.1. Training simulator

The first training simulator was developed in the early eighties. It was based on NorskData (ND) computers. It is a compact simulator, with full-scope modeling and MMI emulation, based on CRTs. The development was done by KEMA and IFE/HRP.

After some ten years of use, maintenance became problematic. Also the capacity of the system was not sufficient to support the extensions of the models. This is why it was decided to renovate the simulator.

The general requirements are already stated in the introduction. In addition, it was decided to leave the actual models unchanged. Therefore the modeling tool was ported by IFE-Norway from the Sintran-ND platform to the UNIX platform. This tool is able to interpret the original model codes.

The renovated simulator is based on HP-700 series workstations. The user-interface was developed using PICASSO-3, a product by HRP. The simulator has four operator work-places, an instructor station, and a workplace simulating the datalogger. The four operator-workplaces are equipped with large 29" high resolution screens by Barco.

Approximately 50 mimics are available for process presentation and control. The simulator contains some 30 process models, ranging from typical nuclear systems, safety systems, auxiliary systems, to the conventional elements such as electrical systems and the steam water cycle with the turbine, condenser etc.

1.2 Procedure support

GKN uses a paper-based procedure for supporting emergency operations. A project which was reported earlier within the CRP was aimed at the evaluation of a computer-based operating procedures support system. The system evaluated was COPMA, developed by HRP.

The concept of COPMA was found to be interesting. However the status of the actual product was considered to be not ready for operational use. The lack of overview, and the lack of support of team-operations were the main issues to be improved.

1.3 Datalogger

One of the systems used for operating the power plant is the Datalogger system. This is a data acquisition and management information system acquiring process data: flow, level, pressure, temperature and control bar position as well as alarms, on/off signals and switches. Some 1200 input data are available, half of them analog, the other half binary.

Why a new Datalogger system ?

The system that was in use up to January 1995 was technically outdated and maintenance of hardware as well as of software became difficult. For this reason GKN decided to replace the Datalogger system. KEMA's Business Unit Process Control & Information Technology acquired the order to replace the Datalogger system and GKN stated a number of strict conditions in terms of planning, budget and connection to other systems.

Conditions

The three major conditions are planning, budget and connection to other systems. Planning is a strict condition because of the necessary synchronization of completion of the project with other activities in the yearly maintenance period of Dodewaard in January 1995.

A very strict budget was used, into which specification, design, realization, testing and training of operators had to be incorporated.
Connection to other systems was important because a number of other systems of various suppliers had to be connected to the Datalogger system. It was also important because of a parallel project of the development of a new Simulator for operator training. This implied the necessity of using identical user interfaces for both Simulator and Datalogger.

Realization in two phases

Because of the limited time available, 13 months from the initial specification until the Factory Acceptance Test, it was decided to realize the system in two phases. Phase 1 had to be realized during the maintenance stop of January 1995 and included the functionality of the replaced system, although a number of functions were realized in a more modern outline.

This was the case for e.g. the user interface. Phase 2, including new functions as well extensions of already realized functions, has to be realized in the maintenance stop of January 1996.

This article deals with phase 1 up to and including the maintenance stop of January 1995.

Specification of functionality and reliability

Functional specification

Since the system to be replaced had been in use for a large number of years already, it was decided not to use the old specification. Instead, a new specification was developed in order to meet today's criteria. The functional specification is a description of the requirements.

Data acquisition

The functionality of data acquisition consists of acquiring measurement data, state transitions, alarms and control rod positions. Analog input data are provided with sample times of 7.5 s and 100 ms, binary input data are provided with sample times of 1s and 10 ms. Analog input data are voltages of 0-20 mV, 0-40 mV, 20-100 mV and 0-100 mV. Binaries are contact sense input.

Data processing

Data processing is used to convert data to information that is understandable to operators and management. In this case this means calculations, linking to alarm levels, aggregation of information and subsequently storing information. A specific item in this case is checking the order of movement of control rods. The Datalogger checks whether the control rod that is selected by the operator matches a prescribed pattern. When this is the case, moving of the control rods is released, when this is not the case, moving of the control rods remains blocked.

Presentation of information

Information is presented on graphic screens and printers in terms of alarm lists, process diagrams, trends and reports. In addition, information acquired by the Datalogger system is passed on to other systems. Presentation of the information is done on graphical screens by means of window-oriented user interfaces as well as on printers. Information on printers is only presented at the request of an operator. This is also the case with printing of alarm lists. The Datalogger system also provides a function of exporting measurement data to be analyzed on other computer systems.

Open systems and flexibility

The new Datalogger system is constructed with standard hardware and software components, already applied elsewhere. One of the requirements was that components of various manufacturers could be integrated.

Reliability

Reliability of the system is defined in terms of foreseen and unforeseen unavailability. Requirements are a maximum of four weeks of foreseen unavailability during the yearly maintenance stop combined with two days per annum of unforeseen unavailability.

Design and realization

In the design phase, requirements were translated into a system architecture that was able to meet these requirements.

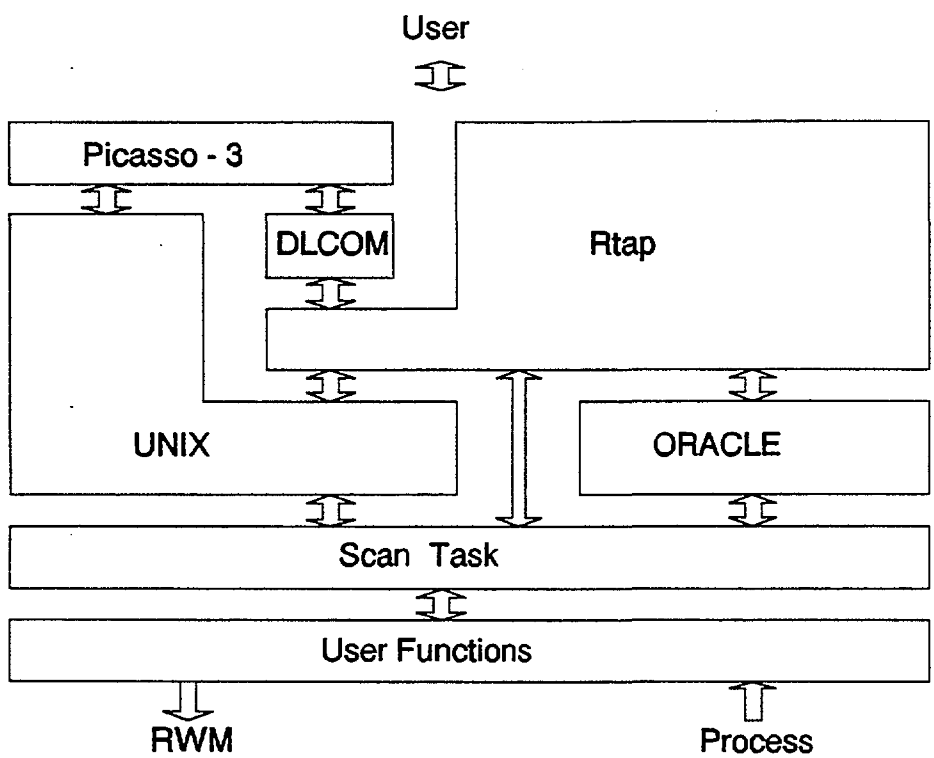

FIG. 1. Software architecture.

Software

Because of requirements of open systems and flexibility, UNIX was selected as the operating system, ORACLE as database management software, Rtap as SCADA software, X-Windows and Picasso-3 as Graphical User Interfaces and C as programming language. TCP/IP on Ethernet was selected as the communications protocol. To realize data exchange, two drivers were written in C. SCANTAAK is a driver between the I/O-system and Rtap, DLCOM is a driver between Rtap and Picasso-3. In the software architecture the applicable relations are shown.

Hardware

The hardware architecture consists of an input/output system (I/O-system) of Computer Products for data acquisition, a server for data processing, workstations, X-terminals and printers of Hewlett Packard for presentation and user interaction. Hardware items are connected by means of local area networks. In the figure below, the hardware architecture is shown. To avoid network data overload, two separate local area networks are used: one for data acquisition and one for presentation of information.

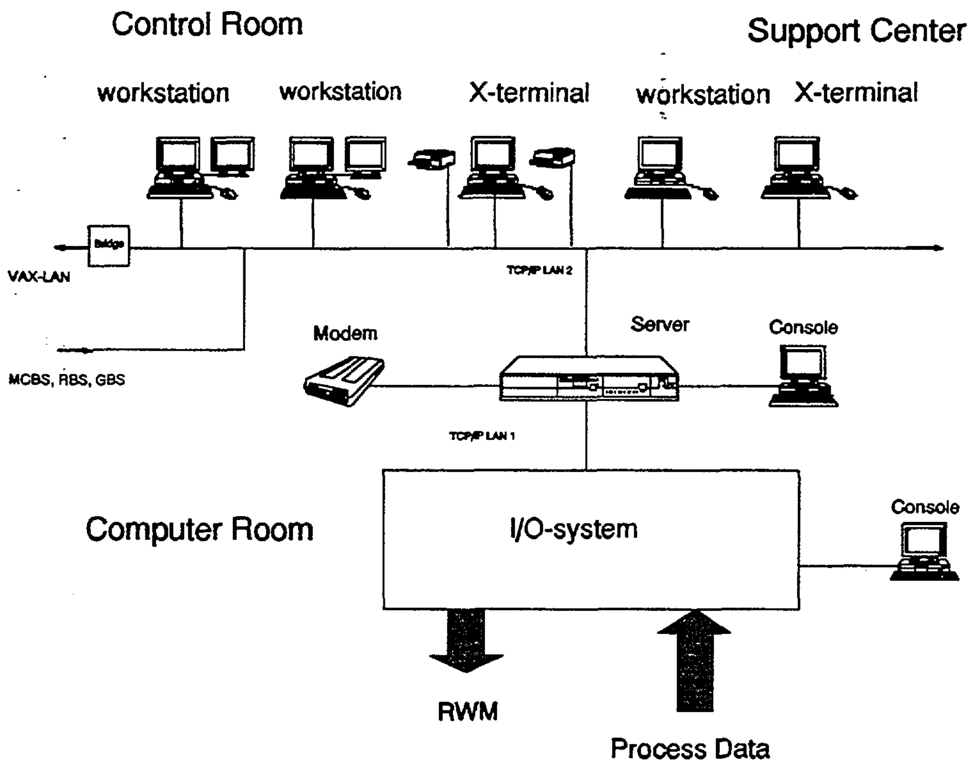

FIG. 2. Hardware architecture.

I/O-system

The I/O-system realizes the actual data acquisition and realizes preprocessing in terms of conversion to SI units, filtering, data reduction, time stamping, alarm limits and buffering of data. By means of this approach real-time aspects of the power generation process can be separated from other parts of the Datalogger system that are not necessarily real-time. This provides easier choices for software to meet requirements of open systems and flexibility. The I/O-system sends data by means of data packages via TCP/IP on Ethernet to the server.

Server

The server, that runs UNIX, ORACLE, Rtap and Picasso-3, realizes data processing. By means of this software, the major part of the required functionality can be realized. With a number of modules written in C, the remaining part of the required functionality is realized. The server is provided with mirror discs to avoid loss of measurement data in case of disc errors.

Workstations and X-terminals

By means of workstations and X-terminals information is presented to the operators and other users via CRT, keyboard and mouse. Presently the Datalogger system consists of three workstations and two X-terminals. CRT's are graphical monitors using X-windows as a user interface. Two dual headed workstations are used. The approach to the presentation development was characterized by two prototyping sessions with users. In these prototyping sessions design of usage of colors, lay-out of process diagrams and reports, size and type of symbols as well as number of symbols in a diagram were evaluated. In this way results and reactions of users could be incorporated before the test period.

Integration and testing

Maintenance stop and test period

The yearly maintenance stop of GKN Dodewaard takes about five weeks, of which only a part was available for integration and testing of the Datalogger system. Because the necessary period of time was much larger than the period of time available, it was decided to integrate the complete system at KEMA's premises and subsequently perform integration tests in order to make it possible to track and solve problems as early as possible. For the same reasons I/O-system and prototypes of DLCOM and Scantask drivers were tested at an early stage, i.e. before integration.

In the period of testing, process inputs were simulated and connected to the inputs of the I/O-system. Analog inputs were simulated by means of voltages and binary inputs by means of opening and closing switches. Using this method, the complete line from input up to and including presentation on workstations could be tested.

The period of integration and testing was completed by a Factory Acceptance Test (FAT). The procedure used in this FAT was agreed beforehand.

Introduction to users

Following FAT and before transportation to Dodewaard, the new Datalogger was introduced to its future users in a course. In a course of two days per shift, each shift received training on how to operate the new system. In these courses a number of interesting items for improvement were suggested by the participants. These suggestions will, where possible, be implemented in the next phase of development.

Installation and commissioning

In general the period of installation, assembly and commissioning is a really busy time and this was also the case in Dodewaard. Installation of the Datalogger system and assembly of process signal cables was completed according to planning. Commissioning the system following assembly was only a matter of hours. There were, as expected, some problems and in this case they were caused by unexpected last-minute changes which had to be implemented. The flexibility of the Datalogger system contributed to a large extent to solving these problems on time.

2 CSS in Fossil fired power plants

In general, the power industry faces an increasing competitive market with the advent of small Combined cycle plants. The attitude and behavior has to change from one belonging to a semi governmental organization to one that is fit for ' making business'. This forces companies to improve their efficiency and flexibility. New, more strict environmental regulations and labor-laws demand advanced process control.

The increasing level of automation changes the role of the operator. The modern operator is a Supervisor handling information, using support systems to act as an expert, managing, optimizing and planning the production process and taking the responsibility for certain maintenance tasks. His knowledge is volatile and he will need to keep it up to date by courses and training on a regularly basis. The modern operator is more career conscious and this requires more training of new operators.

The operator is advised more and more by expert-like systems such as Operator Support Systems. These systems are typically developed by experts resulting in proprietary mmi's and protocols. This is confusing to the operator and unsafe for the operation. CSS's should be able to connect to the plant-computer and to each-other, preferably with a uniform MMI. KEMA has conducted a survey on which standards can be used in order to migrate to a situation where systems from different vendors may be integrated. The models used were derived from EPRI's Utility Communications Architecture (UCA).

KEMA has been involved in development of Condition monitoring systems for the purpose of optimization of plant performance by integrating vibration monitoring, gasturbine condition monitoring and condenser condition monitoring.