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EMERIS

AN ADVANCED INFORMATION SYSTEM FOR A MATERIALS TESTING REACTOR

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E M E R I S

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ABSTRACT

The basic features of the MR Information System (EMERIS) are outlined in this document. The purpose of the system is to support reactor and experimental test loop operators by a flexible, fully computerized and user-friendly tool for the acquisition, analysis, archivation and presentation of data obtained during the operation of the experimental facility. High availability of EMERIS services is ensured by redundant hardware and software components, and by an automatic reconfiguration procedure. A novel software feature of the system is the automatic Disturbance Analysis package, which is aimed to discover primary causes of irregularities occurred in the technology.

Ф. Адорьян, Л. Бюргер, В.В. Иванов, И. Лукс, Л. Мешко, А.А. Можаев, К. Сабо, Я. Вег, В.В. Яковлев: EMERIS: Новая информационная система для материаловедческого реактора. KFKI-1990-24/G

АННОТАЦИЯ

В статье описаны основные характеристики информационной системы EMERIS для реактора МР. Система поддерживает операторов реактора и экспериментальных петель гибкими, эффективными и легко используемыми средствами сбора, анализа, архивации и отображения данных, собранных с помощью средств вычислительной техники. Высокая надежность системы EMERIS обеспечена дублированием вычислительных средств и специальным матобеспечением автоматического распределения задач. Новейшей службой системы является подсистема автоматического анализа причин возмущений, появляющихся в технологии.

Adorján F., Bürger L., Ivanov V.V., Lux I., Meskó L., Mozhaev A.A., Szabó K., Végh J., Yakovlev V.V.: EMERIS: Egy modern információs rendszer anyagvizsgáló reaktor számára. KFKI-1990-24/G

KIVONAT

A riportban az MR Információs Rendszer (EMERIS) alapvető jellemzőit tárgyaljuk. A rendszer célja, hogy a reaktor és a kísérleti hurkok operátorait egy rugalmas, teljesen számítógépesített és felhasználóbarát eszközzel támogassa a kísérleti berendezés üzemeltetése során nyert adatok gyűjtésében, analizálásában, archiválásában és megjelenítésében. Az EMERIS szolgáltatásainak magasfokú rendelkezésreállását redundáns hardver és szoftver elemek, és egy automatikus rekonfigurációs program biztosítják. A rendszer egyik alapvető újdonsága az automatikus Hibaanalízis alrendszer, melynek célja, hogy a technológiában észlelt zavarok elsődleges okait kiderítse.

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1. INTRODUCTION

The MR Information System (EMERIS) will be installed at the MR reactor of IAE Moscow in early 1991. The basic aim of the system is to support reactor and test loop operators by an up-to-date information system, thus ensuring more reliable operation of the the facility. The following main functions are incorporated:

- collection of measured data from the technology,
- periodic calculations reflecting actual operation conditions,
- archivation of measured and calculated parameters and events,
- automatic identification and analysis of system disturbances,
- displaying the information in a comprehensive manner.

High reliability of the EMERIS is ensured by introducing redundancy in HW and SW components, on-line HW/SW self-tests and an automatic HW reconfiguration program.

The highly modular SW can be divided into hierarchical Functional Subsystems as follows:

- Intelligent Data Acquisition and Control Subsystem, which performs signal scanning and primary processing.
- Technological Subsystem, managing all data manipulations and calculations related to the technology, including long-term archive handling.
- Disturbance Analysis Subsystem, which is dedicated to find the primary cause of a critical event happened in the technology.
- Graphic Workstations, which serve as primary user interface.

The EMERIS system is not aimed to perform any action directly related to reactor safety and control functions, it merely serves as an effective, user-friendly information source and advisory system for the operators.

2. PRIMARY GOAL OF INSTALLING THE EMERIS

The EMERIS has been designed to provide the Materials Testing Reactor and Experimental Loops of the Kurchatov Institute of Atomic Energy (IAE Moscow) with a flexible,fully computerized and user-friendly tool for the acquisition, analysis and archivation of data obtained during the operation of the experimental facility.

The MR reactor is a pool-type, light-water/beryllium moderated MTR of 30 MW(th) power. The basic application of the reactor is testing fuel elements and structural materials for commercial nuclear facilities (e.g. VVER or RBMK type reactors). Power ramp tests and irradiation sessions are performed in 10 experimental loops, each loop may consist of several fuel channels. Different types of loops are applied regularly: pressurized loops may be operated up to 20 MPa, boiling loops use coolant in bulk boiling state, some channels can be operated with high temperature gas cooling (see Ref. [1] for details).

The reason of installing a computerized information system for the MR has been manifold. First of all, the basic requirement for such a reactor is the uninterrupted and stable operation during the predetermined irradiation sessions, since the experiments are expensive and occasionally a full test must be repeated in case the prescribed irradiation history could not be kept for operational reasons. Such regulations are e.g. the allowed number of reactor scrams during the test period, allowed number of power ramps, etc. EMERIS has been designed to support as smooth reactor operation as possible, by improving the operator's comprehension about the actual status of the experimental facility.

The operation of an MTR type reactor and its connected loops represents a task different from the operation of an NPP. The application of automatic control mechanisms is rather limited here (mainly reactor protection functions are automatized, due to inherent safety reasons), and manoeuvreing the reactor with its loops into the desired status requires more interventions from the operator, than in the case of a conventional NPP. Therefore, EMERIS has been designed to be strictly an information supply system, with no automatic action directly influencing the control of the reactor or its safety system.

However, one of the most important services of the EMERIS, the Disturbance Analysis (DA) is being performed in a fully automatized manner. The basic aim of the DA is to discover the primary cause of a disturbance occured in the technology. The analysis starts automatically, if the abnormality (e.g. a limit violation of an important parameter) has been detected by the system. DA gives early warnings about evolving irregularities in the technology, and corrective actions can be taken by the operators in time.

If for any reason a major transient does happen in the reactor, it is essential to have the possibility of performing a post mortem analysis of the events, in order to establish the primary cause for the occurrence of the transient. This feature is efficiently supported by the EMERIS, basically most of the on-line functions are also available at archive-replay, including full DA service.

As mentioned above, the system is not aimed to perform any reactor safety related function. However, uninterrupted operation has been one of the basic requirements to be fulfilled by the HW and SW design, in order to have continuous information supply. The prescribed high availability has been achieved by redundant HW and SW components and by the introduction of an on-line reconfiguration manager program.

3. DATA PROCESSING AND INFORMATION FLOW

Approximately 1000 analog and 1000 discrete measured signals are available for further processing from the MR instrumentation. The scanning frequency for the analog parameters is 10 Hz, while for the discrete signals is 50 Hz. The complete HW configuration of the EMERIS is shown on Fig. 1.

The following four functional subsystems can be distinguished in the data processing procedure:

3.1. Analog Interface System (AIS)

This level performs analog signal conditioning: each signal is led through a special low-pass filter, which serves as isolation amplifier, as well. These modules produce two identical output signals, which can be handled independently, thus giving the possibility of creating two fully parallel signal processing routes, which are essential if redundancy and high reliability is needed. No such conditioning is required for discrete signals.

3.2. Intelligent Data Acquisition and Control Subsystems (IDACS)

Five TPA-11/170 processors (category of LSI-11) and the connected CAMAC crates constitute the next level of signal processing. The CAMAC crates contain analog multiplexer, ADC and change-sensitive discrete multiplexer modules. One TPA-11/170 processor and the coupled CAMAC modules form a single IDACS unit.

Four analog units (handling analog signals) and one discrete unit (processing discrete measurements) cover all measured signals with the required redundancy. Duplication is realized in the following way: first, so called 'function groups' are formed from the analog parameters (there are 256 signals in each group). In normal (fully distributed) operation mode each analog IDACS measures only one group (see A, B, C and D on Figure 1.), while another group is assigned to the unit as standby. If one of the analog IDACS fails,then the IDACS where the failed function group was in standby, takes over and no data is lost. There is no such duplication for the discrete IDACS.

The minimal configuration to cover all signals without duplication is two analog and one discrete IDACS.

In the IDACS-level primarily preprocessing is performed, namely:

- linearization and conversion to engineering units,
- limit violation checking,
- simple logical status derivation.

After forming standard data packets from the preprocessed signals, these packets are sent to the central computers via the network in each second.

3.3. Technological Subsystem (TS)

The highest level incorporates three TPA-11/580 processors (category of VAX-780), dedicated to more complex tasks.

In normal (distributed) situation the 'labour division' between the three computers is as follows. One processor (called TSA) plays the central role in the sense, that only TSA keeps active links with the Graphic Workstations (see later), initiates DA and controls the reconfiguration of the IDACS units, if required.

The second processor (TSS) works as a hot-reserve for TSA, which means, that TSS also receives all data packets from the IDACS, performs cyclic technological calculations and archivation. In this manner TSS is ready to take over the TSA function at any moment, without data loss or operator's action.

The third processor is dedicated to the DA function, but it is able to substitute any of the TSA/TSS computers automatically. Normally the DA system waits for a start message from the TSA, which is issued when a DA initiative event has been detected in the technology.

In order to ensure the highest possible availability of the EMERIS, on-line HW/SW self-test programs are running continuously in the IDACS and TS computers. In case a severe degradation of a particular HW component has been detected by the on-line test system (OTS) a prompt decision is made about the reconfiguration of the EMERIS HW. The purpose of the reconfiguration is to substitute (if possible) the degrading/lost function, or in case of a severe degradation to cover the vital system functions with the available resources. It must be emphasized, that no human action is required in the reconfiguration procedure (except, of course, forced changes), the whole series of actions is carried out in an automatic manner. The changing functions of the TS processors during reconfigurations can be illustrated as follows:

Processor.	1.	2.	3.	
Function:	TSA	TSS	DA	fully distributed case
	TSA	TSS/DA	X	one processor failed
	TSA/DA	X	X	two processors failed

Thus, even in a highly unprobable severely degraded case (i.e. only one processor is working) the vital measuring/analysis functions are covered by the system, although with reduced speed and without a standby TS computer. The on-line reconfiguration system and the OTS have been developed by the LIAS Ltd. software group, Budapest.

The most important services of the TS are as follows:

- Technological calculations to obtain parameters characterizing the actual neutronic and thermal status of the reactor and the experimental channels (e.g. channel powers, axial temperature distributions for coolant and cladding, outlet steam contents, DNBR, burnup, Xe-poisoning, reactivity conditions, etc.).

- Accumulation and archivation of characteristic experimental conditions (such as integrated working times in special power ranges, total number of reactor scrams during the test period, max. delivered surface heat flux values, etc.) for all tested fuel assemblies.

- Archivation of measured and calculated data into 3 different archives: PAR, TAR and HAR. Periodic archivation (PAR) is carried out in every 15 minutes, when those variables assigned to PAR are written to a disk file. A change in a measured signal is registered in the Transient Archive (TAR), if the deviation of the actual signal value from the last archived one exceeds a given limit (e.g. 1% of the measuring range). TAR and PAR works from a memory resident circular buffer, which contains all EMERIS variables for the last 10 minutes with 1 sec resolution. The historical archive (HAR) contains records referring to events happened in the technology or events related to the operation of the EMERIS (e.g. refueling, inhibition of a measurement, insertion of a new fault-tree to the FT-library, DB modifications, etc.).

- Dynamic reparametrization of the IDACS units when the reactor operation regime changes (e.g. at a scram or at startup). In this procedure individual signal warning/safety limit values are recalculated in the TSA and sent to the IDACS via the network.

3.4. Graphic Workstations (GWs)

This level represents the primary man-machine interface between the EMERIS and its users. Reactor and loop operators communicate with the system through 12 IBM PC/AT based Graphic Workstations (GWs), using simple parametrized commands and menus. The GWs can display the following types of information:

- Technological scheme pictures supplying detailed information about the reactor and experimental loop measurements, core parameters, technological elements, etc. The mnemoschemes can

be constructed and modified with the help of a flexible picture editor program.
- Parameter trend-curves and chronograms.
- Evaluated fault trees, i.e. the results of a completed DA.
- Event lists.

Functional keyboards are applied at each GW for the quick issuing of precomposed command strings, which are most frequently used by the operators. Dynamic updating of GW-pictures, event dispatching to dedicated users, on-line trend support, handling of other GW requests is controlled in the TSA computer. The shell program for GW-services is the product of MTA SZTAKI, Budapest.

4. ADAPTIVITY TO CHANGES IN TECHNOLOGY

The experimental setup of the MR changes regularly, according to the requirements of the tests to be performed (e.g. new channels are introduced, others are removed, a new core configuration is used, new measurements are installed, etc.). Thus the majority of the programs runs on a database, which changes its structure and contents rather frequently. In the framework of a conventional approach, these changes should imply partial recoding of the programs, when modifications in the technology take place, in order to comply with the new conditions. In order to avoid this nuisance the following method has been elaborated. During reactor shutdown period computer operators modify the database according to the new setup. The DB maintenance program performs extensive checks on the consistency of the new DB, before it is actually created and loaded (e.g. it checks the cross-references, the correctness of the new symbols, etc.).

When the system is started for the next time, database-dependent programs perform the so called 'configuration', when programs search the actual DB for all variables and constants, which are required for their normal functioning. If the configuration is successful, periodic calculations can be started, otherwise error messages or warnings are issued forcing the operator to take corrective actions. With this method even the recompilation and relink of programs became unnecessary.

The situation is similar for the graphic mnemoschemes and fault trees, where only the 'recompilation' of the corresponding database is required for those objects, which contain new or modified DB-elements.

The basic idea behind the above outlined method is that control and modifications of SW functions are performed on DB level, rather than on source code level, which makes the system more flexible, adaptive and controllable by the experts of technology.

Two key ideas were implemented to fulfil these requirements:
- the separation of the specification and real-time databases,
- the application of structured symbolic DB-item identifiers.

The first feature means, that an extensive description of all database items is maintained in the system by using conventional DB management tools. This is the so-called Specification Database. The semantic coherence (i.e. obeying several cross correlation rules) for all DB-items is being checked when this DB is created. After proving their correctness, data are 'compiled' into a special memory resident database, which is based on the CRDB (Core Resident Database Management System, product of MTA SZTAKI, Budapest). Real time programs access this DB during their cyclic operation without further consistency checks.

The application of structured symbolic identifiers (SIDs) was designed to support the programs in the task of finding those sets of variables, which are required for their operation. The SIDs consist of four fields (four characters each), and the fields are assigned to have specific meanings: the first field refers to the technological subsystem (e.g. primary circuit of the reactor), the second to the technological element (e.g. main circulating pump), the third refers to physical meaning or parameter type of the variable (e.g. flow rate). The last field can be used as a special identifier, if the uniqueness of the SID requires (e.g. sequence number of a pump). The 'name elements' can be selected from a predefined dictionary. By the application of WILDCARDs in SID references, arbitrary sets of variables can be selected in a convenient way, which makes it possible for the programs to determine all variable sets of their interest. Since the addresses of the DB-items are fixed after a DB-compilation, programs have to locate their input and output parameters only once, in their initialization ('configuration') phase, therefore during real-time operations no DB search is required. Some valid SIDs corresponding to experimental loop PWC1 are given in Fig. 2. (e.g. PWC1.1.TY refers to the coolant outlet temperature in channel 1.).

5. DISTURBANCE ANALYSIS (DA) SYSTEM

5.1. Knowledge acquisition and representation

The expert's knowledge about possible malfunctions occurring in the MR technology is decomposed into separate fault trees. Each tree contains a piece of information about states (symbolically denoted by nodes of the tree), which show the local symptoms of a possible malfunction, depending on the values of the corresponding variables. These variables are directly connected with or derived from the measurements and transformed into logical variables using a predefined set of operators.

Each node receives a logical value during evaluation and, in case of a correctly defined tree structure, the failure nodes determine a coherent subtree as a result of the analysis. The logical expressions are assigned to the nodes in the tree definition phase and may have a rather complex syntax. These expressions may contain logical operators, WILDCARD expressions and exceptions (to choose a subset of variables), special serial logical operators which act upon these variable sets. During the fault tree definition procedure, the knowledge of the expert manifests itself in the topological structure of the trees and in the logical expressions assigned to the nodes. The EMERIS offers a highly interactive and intelligent tool called Fault Tree Editor to transform the expert's knowledge into a form which is suitable for further computer processing.

This method of knowledge description requires an expert system type organization of the DA module (see Ref. [2] for details). The main features can be summarized as follows:

- The process of knowledge acquisition is fully separated from other parts of the real-time SW. Fault trees can be inserted or deleted from the data base individually, using a special SW tool called Fault Tree Compiler.
- The separate memory-resident knowledge base is not simply the sum of the individual trees but it reflects a higher level of

organization, as well. The trees may contain information about 'initiatives' to start the evaluation process and 'connected tree' nodes to force the evaluation of other trees. The Fault Tree Linker takes care of these references. These features also provide a 'learning' mode in the first phase of program operation, in order to resolve possible logical inconsistencies in the tree logic.
- The inference engine works very quickly on the data base records without any search process or backtracking.
- An explanatory facility follows the chains of failure symptoms and gives the relevant explanations of the system's diagnosis.

5.2. User interface for knowledge editing

The Fault Tree editor is a stand-alone program written in PROLOG. It was designed for the creation and modification of the individual trees. The graphical representation of the fault trees can be designed on the screen from node to node. Figure 2. shows a simple tree as it appears on the editor's screen. The nodes are denoted by numbers and 'n' means a 'default' node. For each node the corresponding logical expression is listed, in the example these expressions are quite simple ones (e.g. LU means an upper limit violation). Each node has an explanation record giving the description of the failure type, other records describe further important information about the start node name, symbolic identifier of the tree, priority, connected tree nodes, initiatives, etc.

5.3. The DA evaluation procedure

The automatic evaluation procedure starts if an initiative event has occurred. Analog limit violations or discrete signal status changes can be defined as DA initiatives. In case of such an event the TSA computer initiates the DA processor to evaluate the corresponding fault tree. The evaluation procedure is divided into two stages:
- data preprocessing phase,
- fault tree evaluating phase.

The values and states of the variables, necessary for the evaluation of the relevant fault tree are read from the central data base in the preprocessing phase. These are actual values at the moment of the initiative, or values corresponding to an earlier time interval (time differences relative to the initiative may be defined during the creation of the knowledge base. The preprocessor converts the analog values into logical ones either by considering their limit violation status, or by performing comparisons with given constants.

The inference engine evaluating the fault trees is a fast and simple algorithm, scanning the trees by a depth-first technique. It traverses the whole tree to find every possible solution. The route of traversing is directed by pointers on the rules. As the paths on the tree are arranged in the order of significance, the first solution will be the most important one. Every evaluation has - at least a 'default' - result.

A fault tree can be initiated as a 'connected' tree. In this case its evaluation starts if a path leading to a specific node, where another tree is connected becomes 'TRUE'. The evaluation of the connected trees is based on the data set corresponding to the coherent time slice.

5.4. Man-machine interface

The first result found by traversing the fault tree is presented promtly on the display of the operator's workstation, accompanied by a blinking signal to call the operator's attention. As another output of the fault tree evaluation, explanatory texts assigned to the rules along the 'TRUE' paths are inserted into an archive consisting of max. 50 trees. The blinking signal remains on the screen until all archived trees are called for presentation at least once.

The DA evaluation can also be initiated from a GW by issuing a simple command. In this case the analysis of the specified fault tree is performed on the data set corresponding to the selected time point. The time selection is limited by the time span of the data archives (i.e. TAR and PAR).

5.5. Automation versus human action in the DA

The results of the DA are only diagnostic statements pointing to one or more possible causes of a failure. If the limit values used for the calculation of DA initiative signals are chosen properly, an early failure detection can be achieved. However, the DA system provides only information about the failure, the decision and the corrective actions are the responsibility of the operator. Although automatic learning mechanism is not included, the SW tools for knowledge base generation facilitate on-line fault tree modifications. This gives a fast and convenient way to feed back the experiences gained during the application of DA.

6. SUMMARY

The features of the MR Information System have been described in this paper. In software design flexibility and adaptivity to regular technological changes are the basic achivements. High availability of the EMERIS services is ensured by an automatic system response ('reconfiguration') to possible HW failures.

Reactor and experimental loop operators are supported by an automatic Disturbance Analysis program in the complicated task of finding a primary cause of an abnormal event happened in the technology. For the realization of the DA an 'expert system' approach has been chosen.

Convenient software tools have been applied for GW-picture and fault tree construction/modification purposes and the man-machine interface programs use extensively the latest, user-friendly SW tools applied for PC-based workstations.

7. REFERENCES

[1] Petrosiantz, A.M., Atomnaia nauka i tehnika USSR, Moscow, Energoatomizdat, 1987.

[2] Meskó, L., A Prototype Expert System to Support the Development of a Fault-Tree Analysis Software for Nuclear Reactor Safety, IAEA Specialist's Meeting on Artificial Intelligence in Nuclear Power Plants, 10-12 October 1989, Helsinki, Finland.

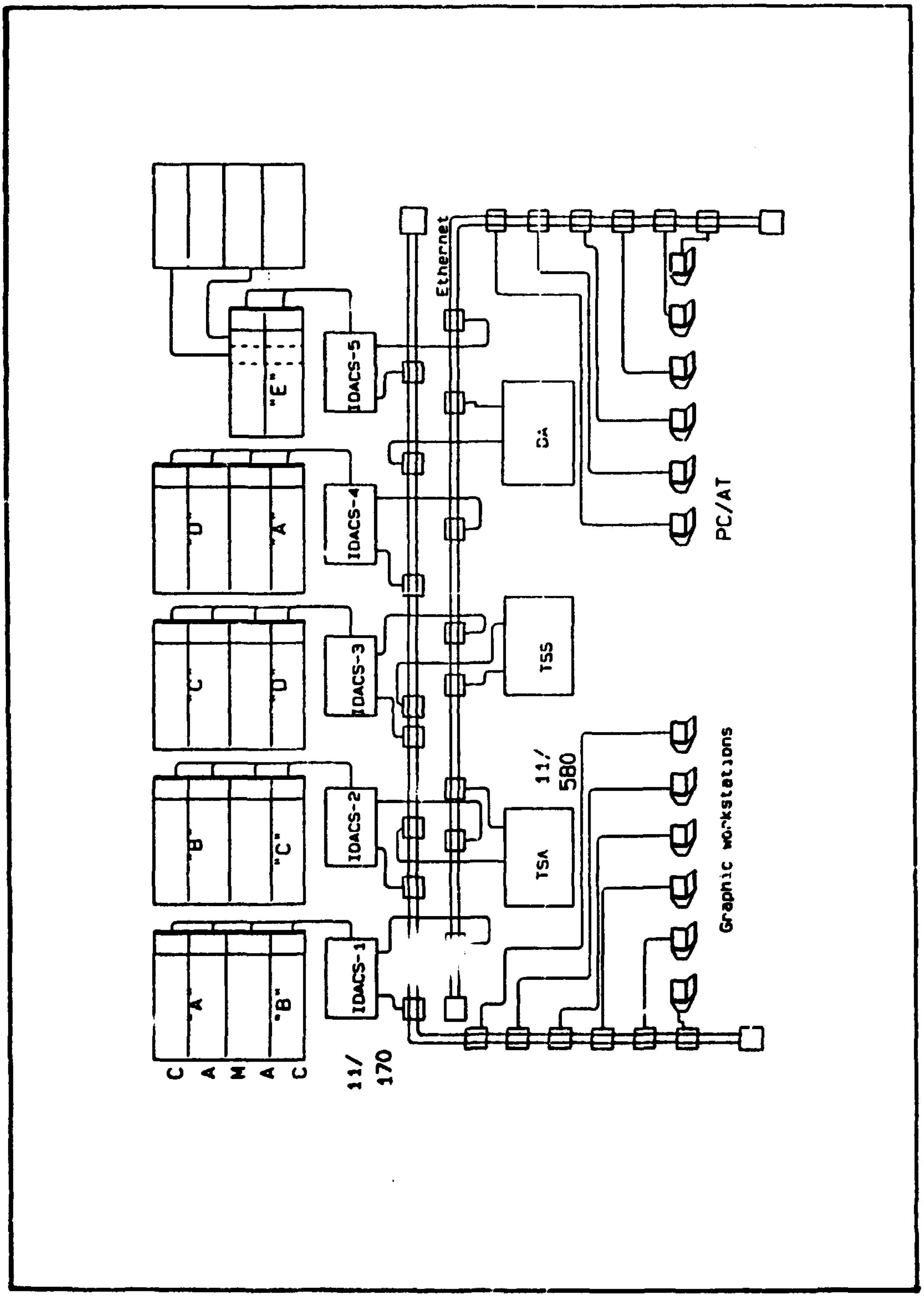
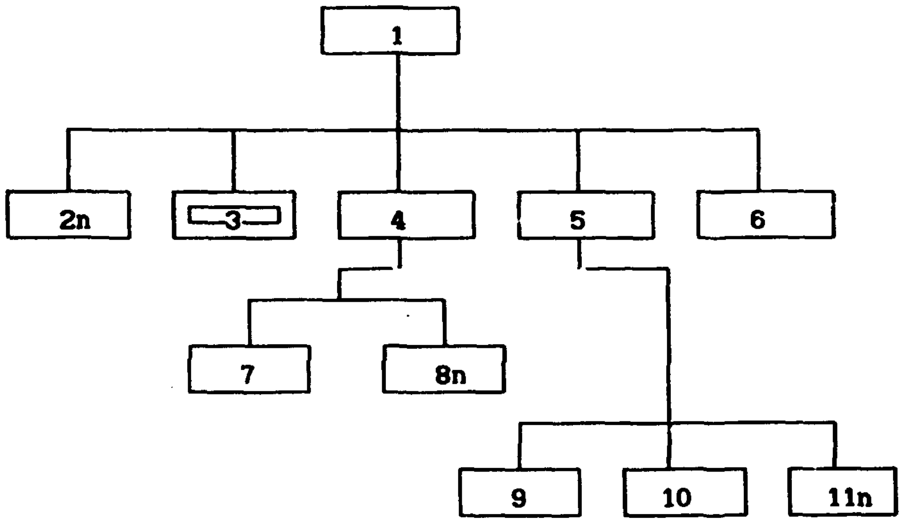


Figure 1. The HW configuration of EMERIS.



NODE NAME	LOGICAL EXPRESSION , EXPLANATION
2n	DEFAULT
	Invalid measurement
3	S_AND(LL[PWC1.#.DP].AND.LL[PWC1.#.Q])
	Decrease of pumps' capacity in the loop
4	S_OR(LU[PWC1.#.DP].AND.LU[PWC1.#.Q])
	Redistribution of channel flows
5	LL[PWC1.1.DP].AND.LU[PWC1.1.TY]
	Change of channel's working mode
6	(LU[PWC1.1.DP].OR.LL[PWC1.DP]).AND.LU[PWC1.1.Y]
	Fuel assembly damage
7	D01[PWC1.1.VVVS]
	Decrease of inlet valve's flow resistance
8n	DEFAULT
	Decrease of channel's flow resistance
9	D10[PWC1.1.VVVS]
	Increase of inlet valve's flow resistance
10	LU[PWC1.KE.H]
	Flow to pressurizer
11n	DEFAULT
	Increase of channel's flow resistance

Fault tree SID : PWC1.1.Q.FL
Fault tree text: Decrease of coolant flow in channel 1. in PWC1
Connected trees: PWC1.1_4.FLnp (connected to node 3)
Start node : 1
Initiative : LL[PWC1.1.Q] (lower limit violation)

<u>Notations</u>:

LU, LL	-	upper, lower limit violation
S_OR	-	serial OR operator
S_AND	-	serial AND operator
D10, D01	-	test of 2. or 1. bit in an integer
PWC1	-	experimental loop ID
#	-	substitutes any numeric field

Figure 2. Example of a fault-tree.

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KFKI-1990-23/C M.I. Verigin et al.: Ions of planetary origin in the martian magnetosphere (PHOBOS-2/TAUS experiment)

KFKI-1990-24/G F. Adorján et al.: EMERIS: An advanced information system for a materials testing reactor

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