# MAN-MACHINE INTERFACE SYSTEMS FOR LHD EXPERIMENTAL OPERATION

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*Abstract*

A man-machine-interface system, we call LMS (LHD Man-machine-interface System), is a primary component of the central control system for LHD (Large Helical Device). LMS involves a variety of intelligent functions. LMS consists of 3 Layer model, Presentation, Transmission and data house, and Device Control Layers, which correspond to LMS clients, LMS servers and Sub-systems. At the end of 1998, 8 LMS clients, 2 LMS servers and 6 Sub-systems are running.

## 1 INTRODUCTION

The large helical device (LHD) [1] is a super-conducting toroidal facility with a mission to steady-state operation of high temperature plasmas to magnetic fusion research. The major radius, the minor radius of plasmas, and the designed toroidal field are 3.9m, 0.65m, and 4T, respectively. While LHD is a plasma physics experimental device, it has a specific feature of a large-scale plant due to a steady-state capability and cryogenic systems. The facilities composing LHD are arranged into 30 sub-systems, e.g., a vacuum pumping unit, a power supply for super-conducting coils and ECRF heating units, etc. Major sub-systems have their own control computers, and can be operated independently and protect themselves.

The control system of LHD [2,3] is required to co-operate a number of plant component devices/facilities (sub-systems) as well as manage flexible plasma experiments. Also safety protection against all expected occasion and easy extension for up-grade are key issues. The control system of LHD should be, therefore, reliable, flexible and extensible. Composition of conservative hard-wired logic control with a programmable logic controller and the man-machine interface (MMIF) system with a client/server system fulfils these requirements complementarily (see Fig.1). The central control system has been designed to operate LHD reliably without help of the MMIF system and hard-wired logic has priority over information transmitter through LAN, however, the MMIF system has various intelligent functions, which leads to flexible and extensible system, and contributes to prevent operational human errors and

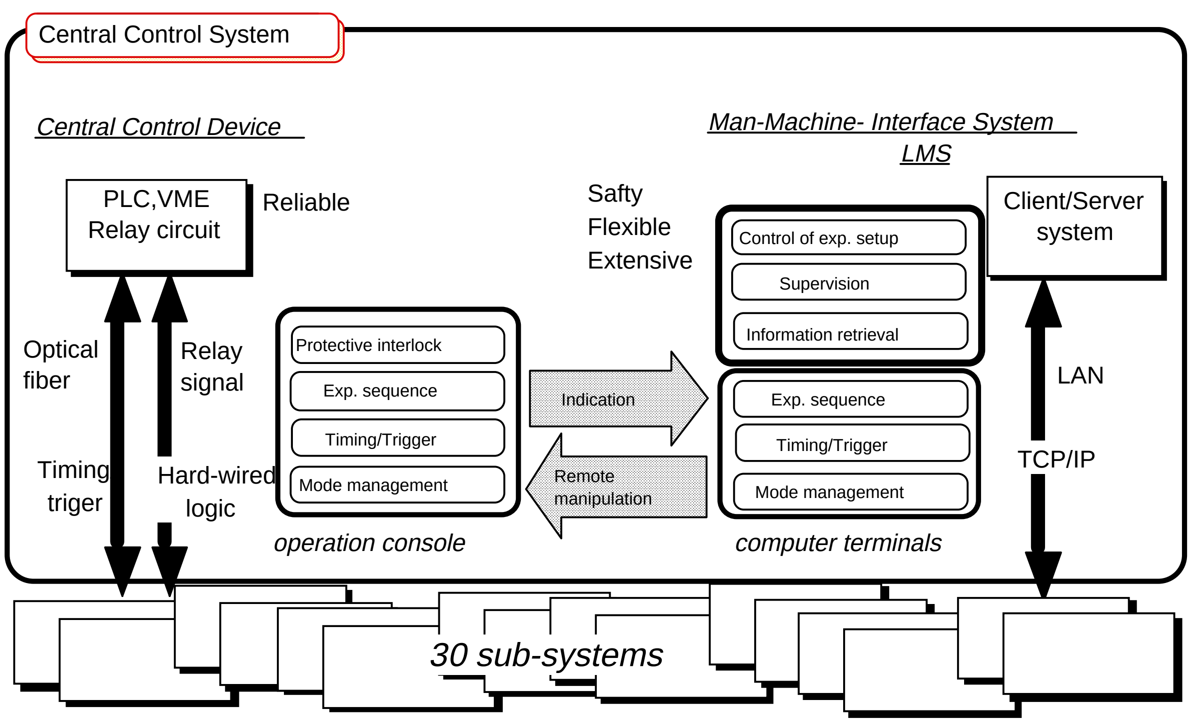


Figure 1 Position and role of LMS in central control system

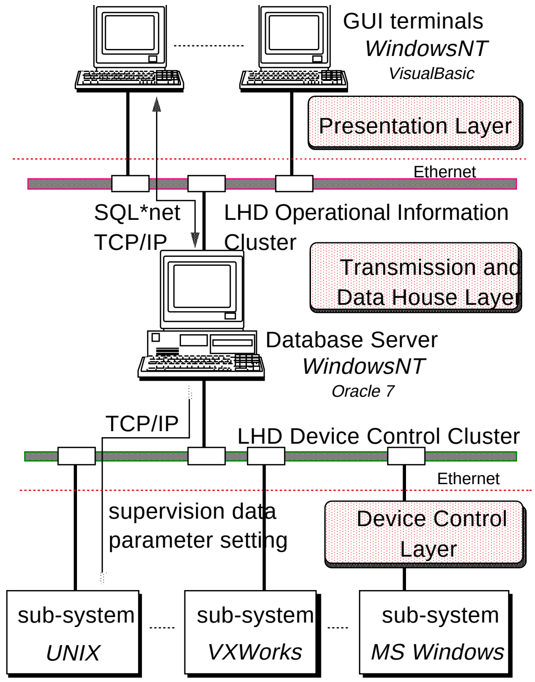


Figure 2 Architecture of LMS.

consequent accidents by human friendly graphical user interface (GUI).

## 2 MAN-MACHINE-INTERFACE SYSTEM

A man-machine-interface (MMIF) system which is a primary component of the central control system for LHD has been specified. The MMIF system, here involves a variety of intelligent functions needed in the LHD experiments as well as a scheme of GUI in a narrow sense. The MMIF system provides a variety of information transmissions through LAN.

Major functions of the MMIF system are the following three:

(1) Manipulation of experimental sequence and operational mode management.

The duration of discharge, the interval of each pulsed discharge and operational mode transition are set from the graphical terminal by a permitted operator. Sequential procedure of experimental set-up is also managed. Usual users can check the status of LHD experiment on client computers. In LHD, Physical acquisition data is managed with an experimental index, so-called Shot Number. It is also managed.

(2) Management of experimental set-up on component devices/facilities,

The numbers of subsystem and parameters to be controlled are 30 and more than 300, respectively. Here major parameters have physical meanings and substantial set-up of each device conducted by an individual control computer based on transmitted condition. Set-up procedure should be done within 90 sec. While users can write out candidates of experimental condition sets and store them. The set-up data sets are managed with database systems. Scheduling candidates of experimental condition sets is also done.

(3) Supervision of status of component devices/facilities.

This system does not have own data acquisition system but integrate monitoring data from a number of sub-systems through data transmission. Although the data are primarily representing ones to watch status of whole LHD system, the number reaches 3000 in total. When an accident is detected by the central PLC, information related to the cause of the accident is accumulated in detail with this function.

The architecture of platform of the MMIF system is shown in Fig.2. In LMS, 3 layers model is applied. All manipulation and indication are conducted in human friendly graphical environment on client terminals (a presentation layer). A server manages information between client terminals and control computers for component devices/facilities with a relational database (a transmission and data house layer). It should be here noted that LMS does not directly control component devices/facilities, but conduct them through each control system for component (a device control layer).

We have organised LMS on so-called de facto standard so that it can develop along with rapid progress in computer application fields. The network OS, relational database managing system (RDBMS) and GUI development environment in LMS are WindowsNT, ORACLE 7, and VisualBasic.

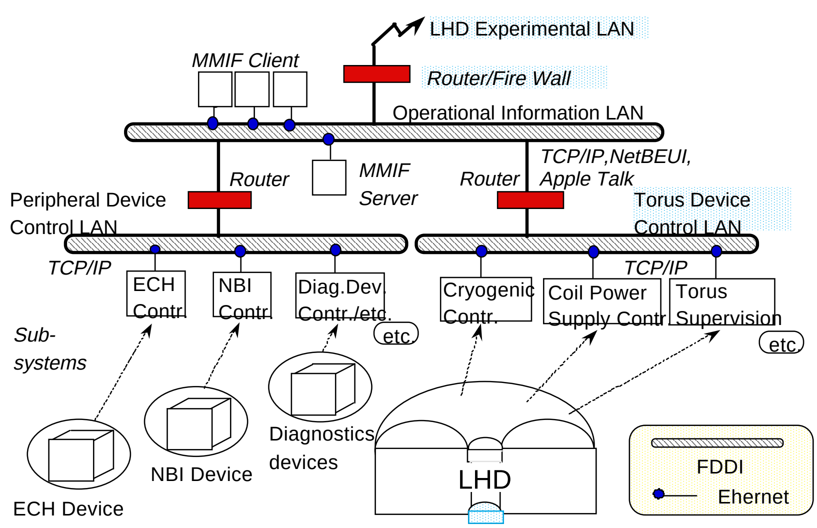


Figure 3 Schematic draw of LHD operation LAN

Transmission between GUI terminal and a server is done by a database access protocol (SQL*net) to promote efficiency in database access. A socket transmission on TCP/IP is also used for event-driven action and synchronisation of sequential procedures. The transmission protocol between the server machine and the sub-system is limited to TCP/IP, since a variety of computers are utilised for the sub-systems.

The information data in LMS is transmitted through LHD operation LAN. The LHD operation LAN is one component of the LHD experimental LAN, on which the information of LHD experiment is transmitted. The LHD experimental LAN consists of three sub-networks (clusters), i.e., operation, analysis and plasma data acquisition clusters. The LHD experimental LAN is designed based on a concept that the data with different purposes are transmitted on a independent cluster in order to transmit the network data reliably and safely, and to control network traffic. The LHD operation cluster composes an operational information LAN. Torus device and peripheral devices control LAN's. Information exchanges for operation and discharge condition, management of the sequence of experiments and plasma discharges are conducted on these LAN. In order to keep security of the whole LHD operation LAN clusters, the firewall system which controls security in the level of network application software carefully is employed on the upper network streamside.

## 3 SUMMARY

Reliable protection of super-conducting coils and flexibility for plasma physics experiments are simultaneously prerequisite to the central control system for LHD. In order to fulfil the requisite, we have applied the composition of conservative hard-wired logic and information transmission by client/server system with LAN, so-called LMS to the central control system.

The planning of LMS started at F.Y.1995. It took about 3 years to fix the specification, to examine the performance of basic architecture by prototype systems and make an application code. LHD experiment started at March of 1998. LMS have been applied since the beginning of LHD experiment.

In 1st experimental period (1998/3-5), 2 clients, 1 server and 3 controllers of sub-system were running. The following functions were running; (1) presentation of status of experimental condition, sequence and events, (2) writing-up and setting-up of experimental condition, (3) supervision of plant data from sub-systems. 2 clients, 1 server and 3 controllers of sub-system were running. The following functions were running; (1) presentation of status of experimental condition, sequence and events, (2) writing-up and setting-up of experimental condition, (3) supervision of plant data from sub-systems.

In 2nd experimental period (1998/9-12), 8 clients, 2 servers and 6 controllers of sub-system were running. The following functions were running additionally; (1) management and presentation of experimental condition, (2) management of shot number (experimental index).

The development is in progress. There are the following future subjects; (1) addition of connection with more sub-systems, (2) manipulation function of experimental mode transition and experimental sequence, (3) retrieval function of experimental condition, (4) improvement of presentation of status of experiment, (5) improvement of experimental condition management function.

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