FEATURES OF SOFTWARE FOR A HIGH-POWER INFRARED FREE ELECTRON LASER

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The control system of the high power infrared FEL is the classical two-level distributed control system built on a basis of EPICS. This paper describes the software features of a control system and discuss the architecture ported variant of EPICS which is used for automation of the FEL complex.
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1 INTRODUCTION

The control system of FEL (Free Electron Laser) complex is used in EPICS (Experimental Physics and Industrial Control System) [1]. EPICS is a software tool that was developed for controlling Particle Accelerators and Large Experiments by Argonne National Laboratory and Los Alamos National Laboratory at the initial stage. At present time, the EPICS collaboration includes more than hundred laboratories and universities in the USA, Europe and Asia. Members of collaboration develop EPICS on a basis of new computer technologies.

A classical two-level distributed control system was created on a basis of EPICS. Each level executes special tasks, which put specified requirements on hardware and software. Such an approach allows optimal and economical utilization of computer resources. The upper level EPICS is **Operator Interface** (OPI) that is based on workstations with a good graphical system, all UNIX workstations uses X11-Window system as Graphical User Interface (GUI), Motif and Tcl/Tk tools as advanced graphical packages. FEL control system uses the free software such as OpenMotif and a lot of applications for data visualization and data processing written on a base of Motif. XFree86 (X11-Window for Intel x86 clone) and OpenMotif were ported to LynxOS to support new video cards and extent capabilities of GUI.

The lower level is **Input/Output Controllers** (IOC), which provide direct control for each accelerator subsystem in hard real time mode. IOC is computer under supervision hard real time operating system. FEL control system uses personal computers with Intel x86 processors under government of LynxOS. These computers contain interfaces for connection of CAMAC and CANbus hardware. Channel access (CA) instruments network-transparent communication between OPI and IOC software.

2 OPI SOFTWARE

EPICS provides a number of OPI tools [2]. We use only some applications such as **Database Configuration Tool** (DCT) editor written on Tcl/Tk tool. DCT is designed to create and maintain records in database that is loaded to IOC. Record has unique name, which is used by user's applications for control of physical parameter. It is named **Process Variable** (PV) which corresponds to a record or a chain of linked records. Control programs operates PVs with the instrumentality of CA library. Record has several fields. The "device type" field means the device that is manipulated by this record. DCT module was written for support of CAMAC equipment. It prepares CAMAC records, these records is serviced by the set of 20 device support routines. These routines were written for optimization of exchange with equipment. DCT editor allows preparation of a block of NAFs, as many as 5 NAFs for record initiation and as many as 10 NAFs for record processing. The chain of NAFs consists of the following information: N – the crate number, A – subaddress, F – function, data, cycle counter for waiting Q signal and time interval in ticks (1 tick = 0.01 sec) for delay in this cycle.

All control programs are used Motif features, user has set of windows made as set of manipulation panels with mnemonic diagrams. Color palette is utilized for indicating the alarm state. If the device fails, then corresponding element in the mnemonic diagram is painted by red. If device works without errors, then its color is green. Now voice warning on errors is discussed as a duplicate option of color flags.

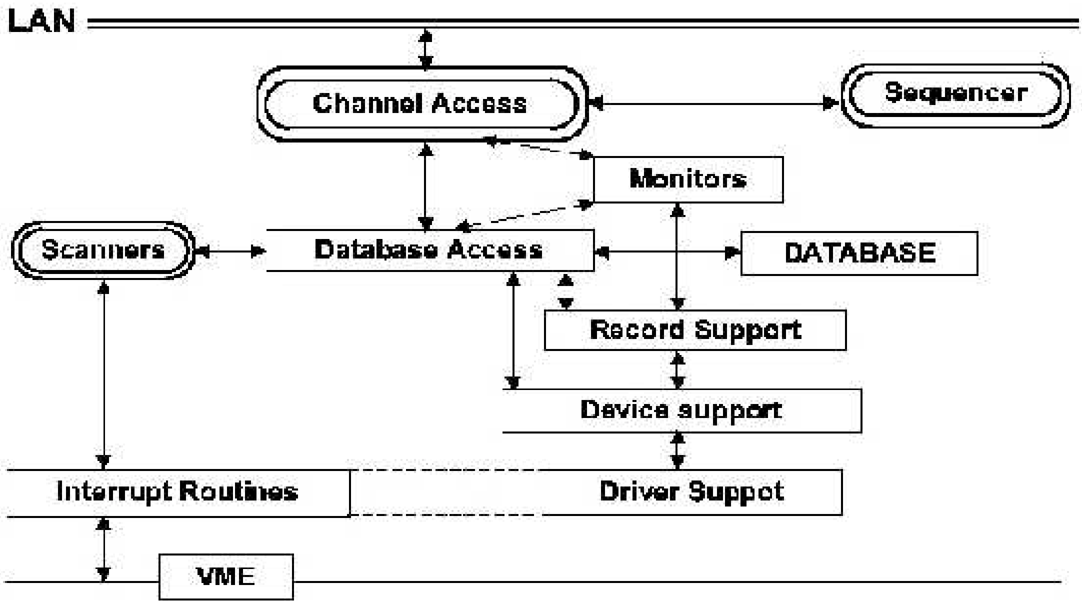
Any OPI workstation is chosen as console of FEL operator. **Channel access** is the mechanism that provides network-transparent access to PVs. CA is based on a client-server model and uses TCP/IP protocols.

3 IOC SOFTWARE

The FEL control system applies ported variant EPICS, were IOC computers are governed by real time operating system LynxOS. Architecture of a standard IOC is shown in Fig. 1. Ported variant IOC jumps functions of drivers support routines, interrupt routines to standard UNIX mechanism – drivers, which works with peripheral hardware. LynxOS kernel provides the possibility of synchronous and asynchronous exchange with hardware. This exchange serves 20 device support routines for CAMAC and CANbus equipment. If device fails, then device routines send a message to the error log, which is designed as an individual trace facility of hardware work. The core of IOC is **database,** it is the memory resident database plus associated data structures [3]. **Database access routines** executes all access to the database via the database access routines. **Scan-**

ners are the mechanism to determine when records should be processed. Ported variant EPICS supports periodical scanning (record is executed with following time intervals: 10, 5, 2, 1, 0.5, 0.2, 0.1 sec). Event scanning is cause by a user-define event, passive scanning is a result of CA operations. **Record Support** - each record type has an associated set of record support routines. These routines execute digital to engineering units conversions (and back conversions) and service the alarm mechanism [4]. Some alarm conditions are configured by user and some are automatic. Alarm types: scan alarm is generated if the record is not successfully placed/fetched in/from the scan queue, read/write alarm message is sent for fail exchange with hardware, limit alarms checks the minimal and maximal values of PV. **Device Support** - each record type has one or more sets of device support routines. **Channel Access** is the interface between the external world and the IOC. **Database monitors** are invoked when database field values change without constantly polling the database. **Sequencer** defines a finite state machine, based on the familiar state-transition diagram concepts.

Ported variant EPICS allows extended facilities such as OPI and IOC joined at one computer, which is necessary for debugging. IOC computer can execute non-EPICS processes that works directly with hardware through driver.



4 CONCLUSIONS

FEL control system uses modern GUI tools, low-cost hardware made in our institute for specific tasks of control system of particle accelerator. EPICS guarantee scalable system which is important for development of FEL control system. Performance EPICS tools fulfils the requirements for hard real time control: the average rate of the exchange between OPI programs and IOC data base is 1 msec, the rate of processing records in IOC is equal to 4000 records per second, the average time of selected device routine for service hardware interrupt is 80 msec (LynxOS interrupt latency - 10 msec).

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