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BUDKER INSTITUTE OF NUCLEAR PHYSICS

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PROJECT FOR DEVELOPING A LOW COST AND HIGH PERFORMANCE VERSION OF EPICS.

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Project for developing a low cost and high performance version of EPICS.

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Abstract

The development of integrated control systems for complex industrial and research facilities has proven to be a challenging problem, accounting the need to provide for flexibility in the architecture, rapid response for the real time control, and an easy-to-use GUI interface, capable of effectively conveying information to update the configuration, status, and data. At present time, the architecture of the Experimental Physics and Industrial Control System (EPICS) developed by a consortium of USA national and university laboratories, has addressed these needs in a rather satisfactory manner. As a result, EPICS has been widely and enthusiastically adopted as the basis for accelerator control in the United States and Europe. In the proposed research, we plan to modify EPICS to allow its use on PC (personal computers), thereby substantially reducing the cost of the hardware and software required to implement this system. This development is critical in the enhancement of the capabilities of research laboratories in Russia and elsewhere. With the advance of the computer technology, PCs have become highly powerful computers with comparable or higher computation power than workstations but with much lower prices thanks to the huge PC market and the fierce competition.The planned porting process will include the following steps:

1) Porting of EPICS Operator Interface (OPI) traditionally running on Unixworkstations to an Intel x86 based PC running LynxOS;
2) Porting of EPICS Input Output Controller (IOC) to the LynxOS/x86 platform to replace a VME/VXI based IO system with a PCI bus based system;
3) Testing and debugging of ported EPICS in a homogeneous environment with LynxOS/x86.

Motivation and Goal.

With the reduction of scientific funding to physics research during the recent years, researchers in the national laboratories, especially those in Russia, are becoming more cost conscious about their research development.The advance of the computer technologies in the past decade has opened up a new era for developing distributed, reliable, and user friendly computer systems for accelerator controls in a cost-effective manner. At Budker Institute of Nuclear Physics (INP), with an urgent need to upgrade our outdated accelerator control systems, we believe that a time has come for us to take advantage of new technological advances in both the computer hardware and the accelerator control software.

Our project of developing a cost-effective accelerator control system for INP is motivated by the fact that EPICS has gradually become a dominant system for the charged particle accelerator controls, adopted by a growing number of the accelerator laboratories, large and small, across the world, and by the fact that the powerful and reliable PC systems are becoming a common place with a much low cost, compared with the expensive workstations with similar performance. The goal of this project is to develop a low cost solution for accelerator controls by combining the strengths of both the PC hardware and the EPICS control software.

Proposed Project to Developing the PC based EPICS system

EPICS is a distributed control system designed for controlling a variety of accelerators and other industrial machineries. EPICS was initially co-developed in early 1990's by Argonne National Laboratory (ANL) and Los Alamos National Laboratory (LANL), later joined by a number of other national laboratories including Thomas Jefferson National Accelerator Facility (Jefferson Lab), Deutsches Elektronen-Synchrotron (DESY), as well as a large number of other laboratories, large or small, across the world including the Budker Institute of Nuclear Physics (INP) in Russia and the Duke FEL laboratory in the US. Through the multi-laboratory collaboration development of EPICS has managed to avoid many drawbacks suffered by the traditional approach of developing control systems by individual laboratories.The cooperative approach has greatly reduced the cost of developing a highly sophisticated and complex system, eliminated the development redundancy, and ensured the software compatibility. The development of EPICS has been one of great successful stories of international cooperation, involving laboratories of all sizes. Since its official release EPICS has been chosen by a large number of laboratories in the US and around the world as development environment for accelerator control systems.

Comparing to EPICS, the present control system at INP developed in 1970's is a centralized system based on ODRENOK microprocessors and IBM-compatible PCs. Because of its centralized architecture, the performance of this system suffers from the communication bottleneck problem. Due to the outdated hardware and operating system, this control system does not have the capability of handling a large number of control tasks simultaneously. The text-based unfriendly user interface has also prevented operators from performing accelerator control tasks in an efficient manner. To keep up with the accelerator technology advance, it is apparent that the present computer control systems for several INP accelerators need to be upgraded. Given the

successful adoptions of the EPICS based control systems in many accelerator laboratories, it is a relatively easy decision for us to adopt EPICS as our next generation control system at INP.
A minimum set of hardware and software is shown in figure 1. The standard implementation of EPICS requires OPI that contain the workstation UltraSPRC with operating system Solaris v2.5. IOC contain a VME crate and an embedded processor MVME167 based on Motorola 680x0 with the real time operating system VxWorks v5.3, and a communication module MVME712 with Ethernet port. In this figure, we use the VME to CAMAC interface module (branch driver) to communicate with CAMAC crate controllers.

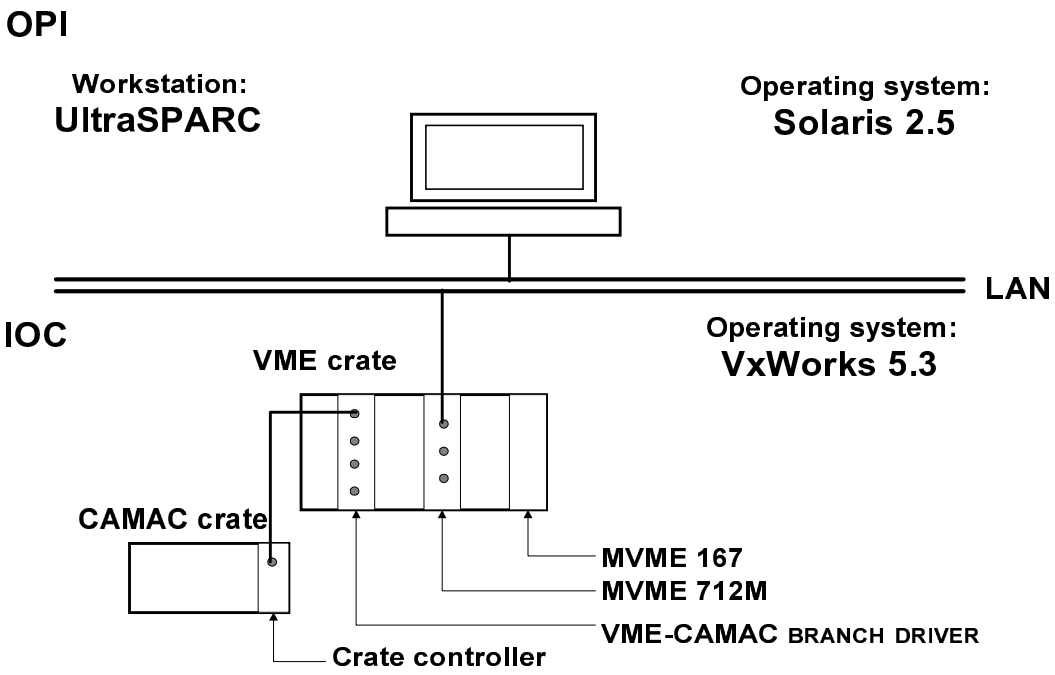

Figure. 1 Scheme of the minimum set of the hardware and software for standard EPICS implementation.

However, with the advance of the computer technology, PCs have become highly powerful computers with comparable or higher computation power than workstations, but with much lower prices thanks to the huge PC market and the fierce competition. Employing the low cost PC computer hardware, an entirely PC hardware based control system for the same accelerator would cost only a fraction of a VME/SUN based system. To further reduce the cost of such a system as well as to simplify the software development environment, a different realtime operating system, LynxOS, can be used to replace the much more expensive VxWorks, used by the standard EPICS systems.
Another justification for using LynxOs is that INP has already adopted LynxOS/x86 as real time control development environment. The expertise gained with this system

can be fully utilized during the process of developing LynxOS/x86 based systems. As result, homogeneous control development and real time operation environment can be constructed with single LynxOS/x86 platform.
Additional saving can also be made possible by using the existing hardware for control systems. For example, by utilizing PC-CAMAC interface to be manufactured at INP, we will be able to implement the new PC based EPICS to control the existing CAMAC I/O hardware. We also will be able to utilize a number of existing PCs to run the new control system. As a result, the overall cost of the such a control system upgrade can be minimized. INP use real time UNIX operating system LynxOS at PC. We choose to port EPICS to LynxOS platform. This variant constructs homogeneous environment for EPICS based on UNIX LynxOS which is shown in figure 2.
Instead of re-inventing an EPICS-like system on PC, we feel that the appropriate approach is to port the EPICS software to LynxOS/x86. By replacing the architecture dependent part codes with LynxOS routine calls, we plan to port different parts of the EPICS codes to LynxOS/x86 platform. The basic porting process includes the following steps:
first, we will port the channel access and a number of key OPI applications to LynxOS/x86 so that a LynxOS/x86 system will be able to communicate with any flavor of EPICS systems;
second, we will gradually port IOC core codes to LynxOS/x86.

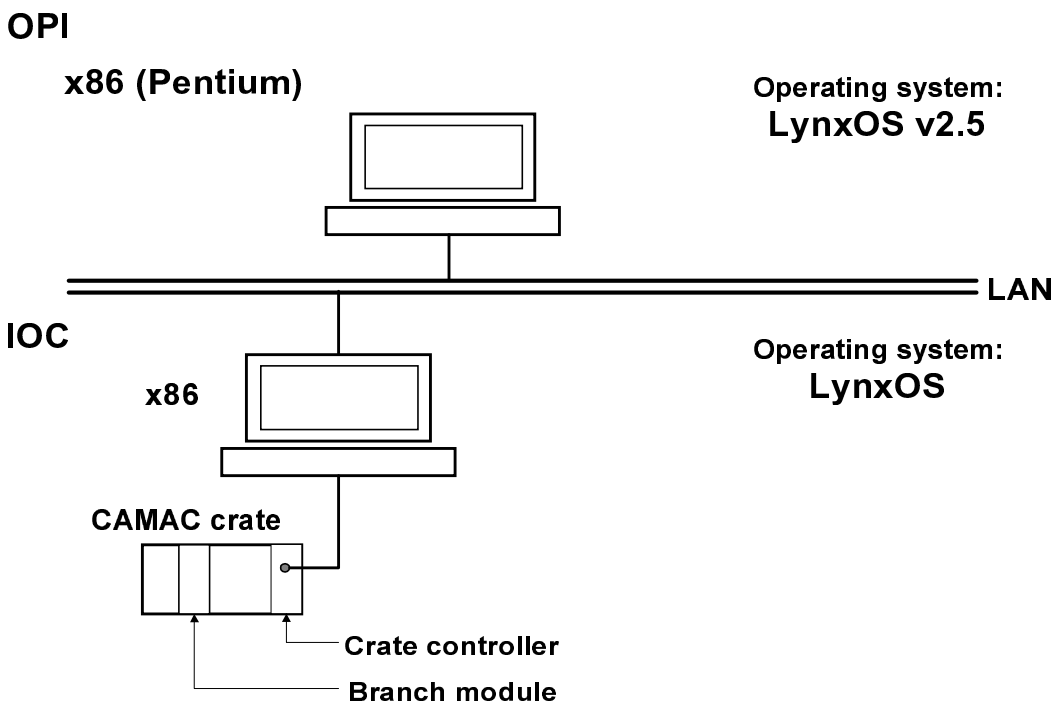

Figure. 2 Scheme of minimum set of EPICS hardware and software to be ported to the LynxOS platform.

There are a great number of EPICS record support codes, as well as device/drive support codes to be ported to the new platform. However, in the beginning, we will limit ourselves to port only those necessary for our basic implementation of the EPICS

system at INP. Upon its completion, this new variant of the EPICS system will operate in a homogeneous environment on PCs with LynxOS. Initial porting to LynxOS/x86 will be carried out at INP and the Duke FEL laboratory. However, we plan to seek cooperation with other interested parties within the EPICS community to speed up the porting process and share the overall cost. We believe that such a development not only will benefit INP and the Duke FEL laboratory, but also will benefit the other EPICS users in the community as well. We hope that this development will be completed within a two-year period. Figure 2 shows a LynxOs/x86 based EPICS control system after porting.

Milestones of porting EPICS

The proposed porting EPICS to LynxOS/x86 research will proceed through three stages:

1) EPICS will be commissioned in standard form at the INP with the use VME/SUN hardware. This will provide the INP staff with a benchmark standard for evaluation of the proposed PC-based derivative of EPICS .

2) The EPICS codes will be ported to LynxOS/x86 platform.

3) The performance of LynxOS EPICS system will be evaluated using the standard VME/SUN/VxWORKS system as a benchmark.

The first milestone will be achieved relatively easily if the hardware required to build such a system can be obtained on the time basis. Great effort will be required from INP, the Duke FEL laboratory, and other possible participants of the project to achieve the second milestone. However, the experience that INP staff already had with a test LynxOS/x86 station will prove to be very valuable for the EPICS code porting. With the completion of the second milestone, we hope that we will be able to control the basic accelerator tasks with the PC based system, and to operate such tasks via the ported basic EPICS OPI. To complete the third milestone, we will compare the performance of the LynxOS/x86 based EPICS system with the standard EPICS implementation by using these two different systems to operate the same control hardware for an accelerator subsystem or a complete accelerator.

INP has a long and distinguished record in the development of control systems for itis extensive accelerator-based high energy physics, synchrotron radiation, and FEL research facilities. INP is currently constructing a high power Free Electron Laser which will implement the LynxOS/x86 based EPICS control system to minimize the cost (see figure 3). The joint development of low cost control system based on the common interest of Budker INP and Duke FEL laboratory is one of many joint projects being pursued by the two institutes.

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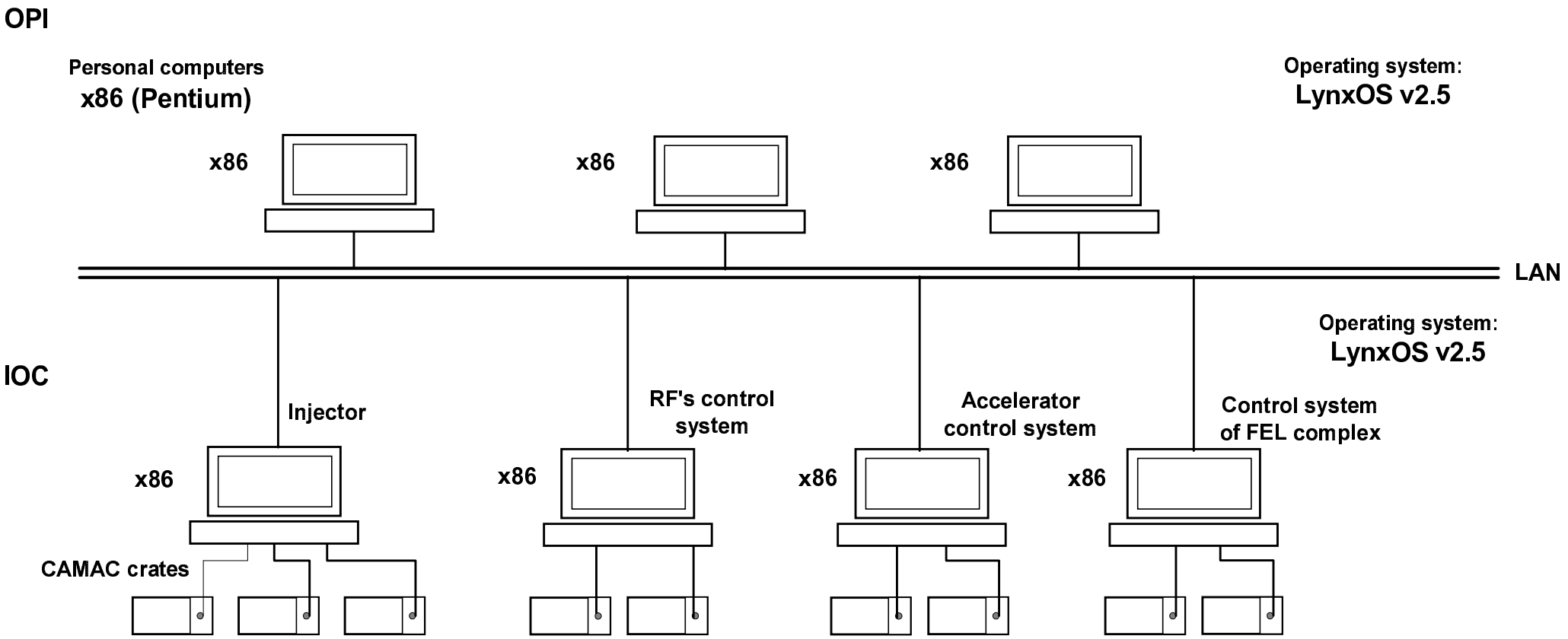

Figure. 3 The layout of the control system for Budker INP high power free electron laser.