Distributed Control System Requirements for LCLS

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This note describes the LCLS requirements for a distributed control system in order for it to support a number of different hardware interface systems and several different display and application program environments.

The LCLS control system requirements are bounded by several unique constraints. The accelerator must remain compatible with the existing Camac-VMS based control system, using the SLC Control Program (SCP), and yet must adapt to a variety of new control protocols for additional systems. The LCLS is a multi-institution collaboration where complete subsystems will be delivered to SLAC and expected to interface to the LCLS controls network. Consequently a number of different hardware protocols must be accommodated within the control system. The widespread use of commercial instrumentation also demands that a number of different industry standard networking protocols be available to allow them to connect to the LCLS control system.

The LCLS control system will therefore be a large, distributed network. There are several global considerations that need to be satisfied in the design of a large, networked system: It should be robust with respect to either local, isolated failures and with respect to recovery from power outages. In addition, the way in which the control system is distributed should be such that the network traffic does not become overloaded. The latter point in particular needs careful definition since any control system can be regarded as distributed if it is spread out over a large geographic area such as the SLAC linac. So in this sense, “distributed” refers more to processing power and data storage distributed into local self-contained units.

The controls hardware is distributed locally in crates, so the robustness issue can be addressed if each of these crates has a local processor and hard drive containing a full operating system and a full copy of the data configuration file for all the devices in that crate. The local system can then reboot and be operational without waiting for a central server on the network. Network traffic flow is reduced in this type of distributed system because more of the processing can be done locally. Data is stored locally and parameters can be history buffered locally, so the network is only used for backup copying of data files.

The present SLAC control system uses distributed camac crates each with its own microprocessor, but they are connected in a star network, on a single communication line, to a centralized VMS server. The central processor, shown in figure 1, has three levels of software: system support software, facilities software, and application software. The system support software controls the network connections to each of the remote microprocessors as well as providing the database access tools. The facilities software provides standardized control of major hardware systems such as magnets. The application software allows the user to read, view and do some online processing of the data. The database in this system is centralized and contains all the hardware parameter configuration data and the timing matrix, which determines what happens in the machine on a pulse-by-pulse basis. The precise pulse-by-pulse timing capability of the SLAC control system is one of the main features to be preserved for the LCLS. It is derived from the low level RF system and demodulated by camac modules at 119 MHz to give timing triggers with 8.4 ns resolution and stability at the few picosecond level. The timing matrix in the centralized database is broadcast for every machine pulse on the communication line to the camac hardware by the master pattern generator (MPG) microprocessor.

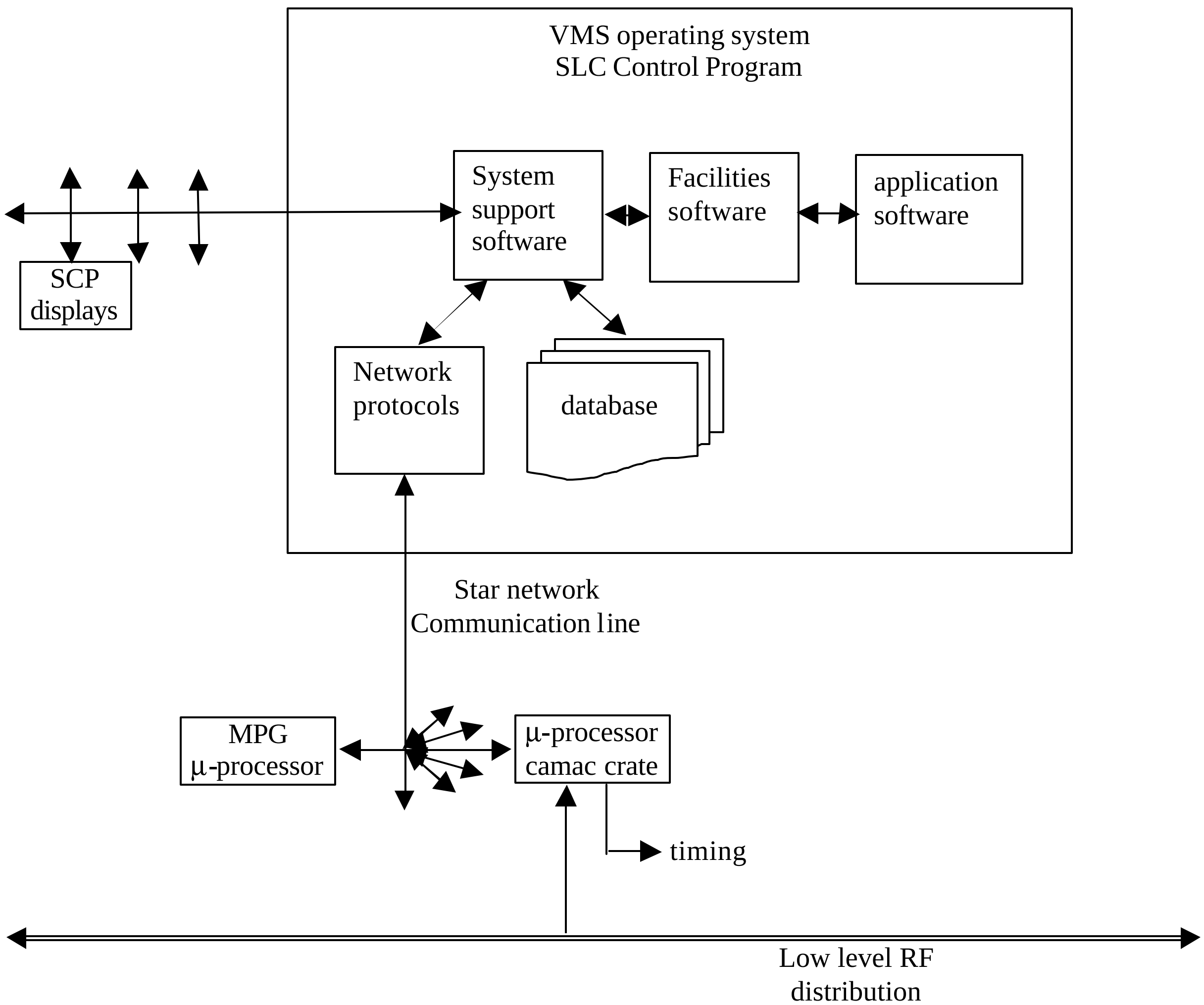

Figure 1. Simplified schematic of the existing SLAC control system.

A distributed control system like EPICS, shown in figure 2, distributes the processing over many networked computers. Unlike the SLAC control system all the timing information is carried on the same network connection as the data and lacks the precision synchronization with the RF system.

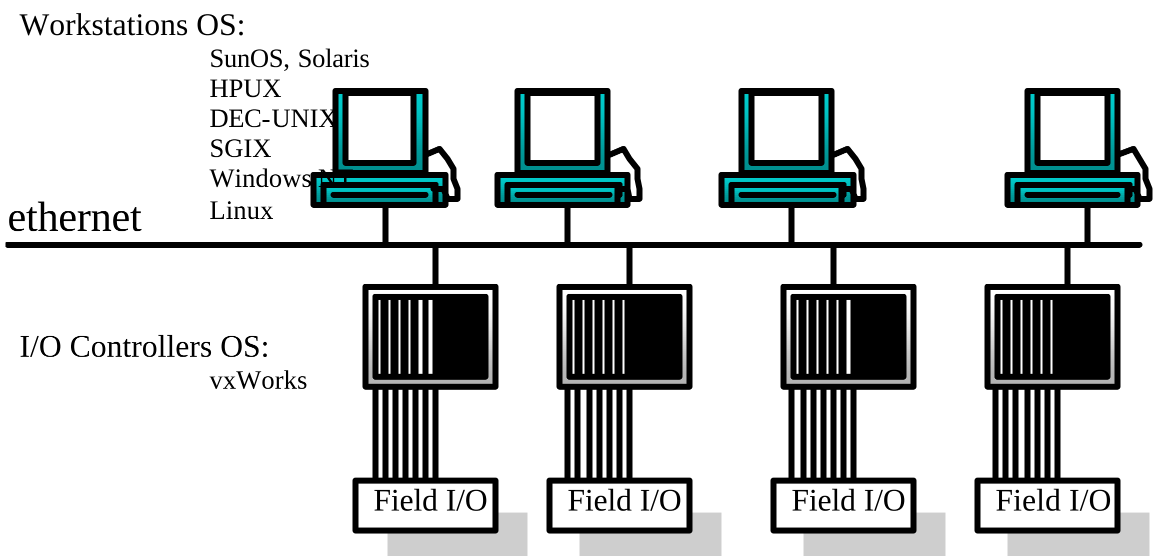

Figure 2 Distributed controls architecture of EPICS.

The goal of the LCLS control system is to combine the distributed nature of the Epics control architecture with the precision timing capabilities of the SLAC control system. In addition, one would like to preserve the legacy of high-level application programs for beam handling and analysis at SLAC as well as allow new, commercial software packages (Matlab, LabView etc.) to be integrated into the control system. In order to support, or merge, the different operating systems so that they can be accessed from within a single display program requires the implementation of a multi-protocol Application Program Interface. The API server would host a library of device classes for each of the systems to be supported. A LAN would serve as the dataway backbone, as shown in figure 3, but the precision timing signals would still be synchronized with the RF distribution.

The field I/O controllers are self-contained units such as VME crates with a processor and hard drive, to which Remote Procedure Calls (RPC) are made. The crate processor can copy the appropriate device class libraries from the API server. The existing camac crates can communicate with the network if given a new module to handle the RPC's. The EPICS devices already handle RPC's and have in addition channel access (CA) capability.

Numerous devices and hardware are connected to the network and are resolved by an Equipment Name Server (ENS). The Remote Procedure Calls were developed by SUN but can also be used by PC's running Linux. Image processing of profile monitor images could be done on remote PC's and processed in Matlab or LabView to avoid the need for shipping the entire image over the network.

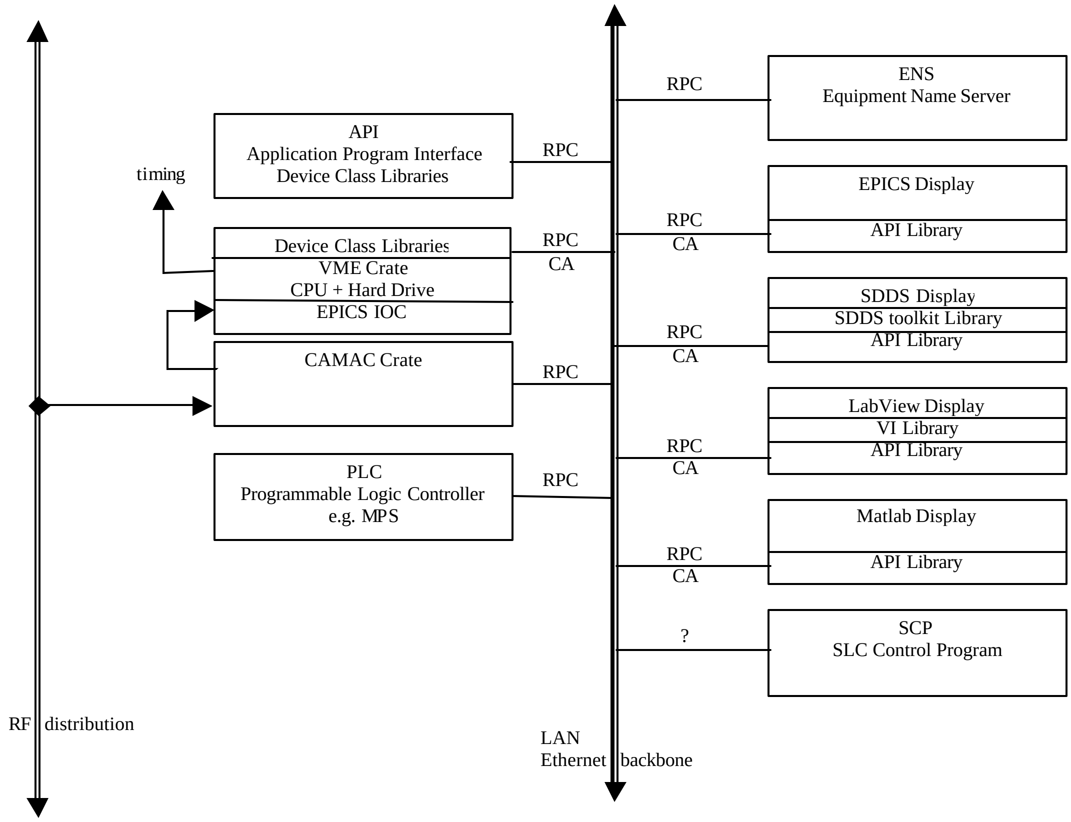

Figure 3. Schematic layout of a distributed control system for the LCLS with a LAN connecting multiple computer systems and multiple I/O controllers. Precision timing is distributed via the low level RF.