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# Software architecture for the ORNL large coil test facility data system*

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## ABSTRACT

The VAX-based data acquisition system for the International Fusion Superconducting Magnet Test Facility (IFSMTF) at Oak Ridge National Laboratory (ORNL) is a second-generation system that evolved from a PDP-11/60-based system used during the initial phase of facility testing. The VAX-based software represents a layered implementation that provides integrated access to all of the data sources within the system, decoupling end-user data retrieval from various front-end data sources through a combination of software architecture and instrumentation data bases. Independent VAX processes manage the various front-end data sources, each being responsible for controlling, monitoring, acquiring and disposing data and control parameters for access from the data retrieval software. This paper describes the software architecture and the functionality incorporated into the various layers of the data system.

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## I. INTRODUCTION

The Large Coil Program (LCP) at Oak Ridge National Laboratory (ORNL) is an international collaboration to test large prototype superconducting toroidal field coils. Six coils are configured in a compact toroidal array in a cryogenic test facility known as the International Fusion Superconducting Magnet Test Facility (IFSMTF). U.S. industrial participants provided three of the coils under the direction of the Large Coil Program at ORNL; the remaining coils were designed and built by EURATOM, JAERI, and SIN. Each coil embodies a different design and fabrication approach. ORNL experiments that compare and contrast the different coils will guide future design efforts. The LCP data system has been described at earlier stages in its evolution.[1,2]

## II. DATA SYSTEM ARCHITECTURE

The LCP data system consists of three primary layers of functionality: the LCP data application layer, the LCP data management system, and the LCP data acquisiton system. Programs residing in the applications layer generally perform high-level data display and analysis functions, extracting experimental data and information by using the LCP data management system rather than directly accessing the data acquisition layer. This paper concentrates on the data management and data acquisition layers.

Functionality implemented in the data management system isolates applications from inherent differences between the various front-end data acquisition systems and performs units conversions for data retrieval operations. Functionality implemented in the data acquisition layer provides the intelligence to manage, control, and acquire signals from a diverse collection of front-end data acquisition hardware, and dispose this signal data to the appropriate data sinks. A common collection of data disposition mechanisms and a common set of data structures within these mechanisms define the interface between the data acquisition layer and the data management layer; data sinks in the data acquisition layer are data sources for the data management layer.

## III. DATA BASES

The LCP data system uses a collection of data bases to describe the configuration of the instrumentation at any point during the experiment. The test configuration file (TCF) correlates sensor topology and control parameter data bases across all front-end systems. TCF records are identified by a unique test number; each record defines a channel assignment file (CAF) number, calculation assignment file (CAC) number, and a parameter block number for each front-end.

Each front-end data acquisition system (DAS) interprets these three data base files to configure hardware and software for the acquisition of analog signals. The CAF and CAC data bases describe sensor topology for the front end. Multiple CAF and CAC files exist for a front end; TCF assignments determine which are valid to describe a given sensor-to-channel mapping. A single parameter block file (PAR) exists for each front end. Each record contains information such as the active channel range, various sampling rates, and transient sample sizes. The CAF, CAC, and PAR record structures are the same across all front-end systems. The TCF number, CAF number, and CAC number are stored within the context of each data sink utilized by the front-end DAS; the LCP data management software depends on this information to correlate sensor-to-channel assignments in performing sensor units conversion.

Two additional data bases are used in the LCP data system: the sensor assignment file (SAF) and the intrinsic calibration file (ICF). The SAF is the master data base of sensors for experiment; it provides information used when sensor assignments to front-end channels are changed. The ICF contains calibration data used for sensors that require a nonlinear units conversion. Each record identifies a conversion algorithm and calibration constants required by the algorithm. Presently some ten calibration models are supported.

## IV. DATA ACQUISITION SYSTEM

Four front-end systems provide the data acquisition function. Each of these systems is managed by a VAX data acquisition program (DAS). The LCP data-acquisiton operator may set parameters, issue control commands and examine parameters via the DAS Operator (DASOPER) utility. The VAX data acquisition systems are: the fast front-end (FFE and FFEDAS), the slow front-end (SFE and SFEDAS), the facility front-end (FAC and FACDAS), and the refrigerator front-end (REF and REFDAS). Fig. 1 presents a block diagram of the LCP data acquisition environment.

The VAX data acquisition programs utilize a software architecture that provides a high level of data accessibility from the user's perspective, and a high level of maintainability from the software perspective. The DAS functionality is partitioned into three distinct layers: DAS-independent functions, DAS-dependent functions, and data flow management functions. The structure of a typical DAS is depicted in Fig. 2.

The DAS-independent functions include the DAS control sequencing, implemented as a finite-state machine model, and a collection of common routines providing event management, operator interface, timer management, and signal management services. The DAS-dependent functions are implemented through a collection of so-called event-service routines. Each front-end DAS has its own event-service routines designed to act upon generic DAS events within the context of front-end specific interface requirements. Various conditions within a DAS environment give rise to events, which are posted to the event queue. Event-management software dispatches these events to one of the front-end specific event-service routines.

Data flow management implements the protocols required to communicate with the front-end system(s), the intelligence to manage CAMAC communications and signal acquisition modules, and the intelligence to dispose data in the proper manner. Three sinks are available for the acquired data: real-time data is deposited to a global section, scan data is deposited to time-correlated files, and transient data is deposited to event-correlated files.

## V. DATA RETRIEVAL SYSTEM

The LCP data management software provides integrated access to all acquired data. The implementation is layered, designed to isolate application programs from the inherent differences among front-end systems, to decouple applications from the data sources, and to make transparent the addition of new data acquisition systems or the replacement of hardware in existing systems. A block diagram of the data retrieval software is shown in Fig. 3.

The top two layers of the data-retrieval software, the so-called transparent and non-transparent layers, provide a parallel set of data-retrieval primitives available for use in application interfacing. Access to data through each of these layers has advantages and disadvantages, as described below. Applications may retrieve data by specifying a list of front-end and generalized sensor name pairs; the generalized sensor concept allows users to access real sensors, pseudo-sensors, primary/secondary sensor pairs, or front-end channels. Users control the level of units conversion performed; conversion levels include ADC binary values, ADC input voltage, sensor output voltage, and sensor engineering units.

Use of the data management software is simple. First, the SETUP_DATA primitive is invoked with a list of front-end and generalized sensor names, along with information used to select data source characteristics and the units conversion level. SETUP_DATA establishes a data-retrieval context containing both data source and units conversion context; this information is used for subsequent data and information requests. GET_DATA operations return converted sensor data from the retrieval context. Sensor and source-specific information may be extracted from the retrieval context via the GET_INFO primitives. DETACH_DATA disengages the retrieval context, terminating all data source connections, resetting all units conversion context, and releasing all context-associated memory resources.

## VI. CONCLUSIONS

The LCP data system architecture has proven to be flexible and most accommodating from the end-user perspective. A core-set of LCP data display applications programs satisfies the immediate needs of most users, providing numerous formats of data presentation along with access to real-time data, scan data, and transient data sources. A high level of data accessibility and ease of use characterize the LCP data-management software, as evidenced by the growing number of end-users becoming actively involved in the development of data analysis and display tools. The LCP data-acquisition systems have proven to be very robust in operation, due to the layered implementation; data acquisition is also efficient, consuming less than ten percent of the VAX-11/780 on a continuous-mode basis.

## VII. ACKNOWLEDGMENTS

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## FIGURE CAPTIONS

FIG. 1. LCP data acquisition system.

FIG. 2. LCP data acquisition architecture.

FIG. 3. LCP data management architecture.

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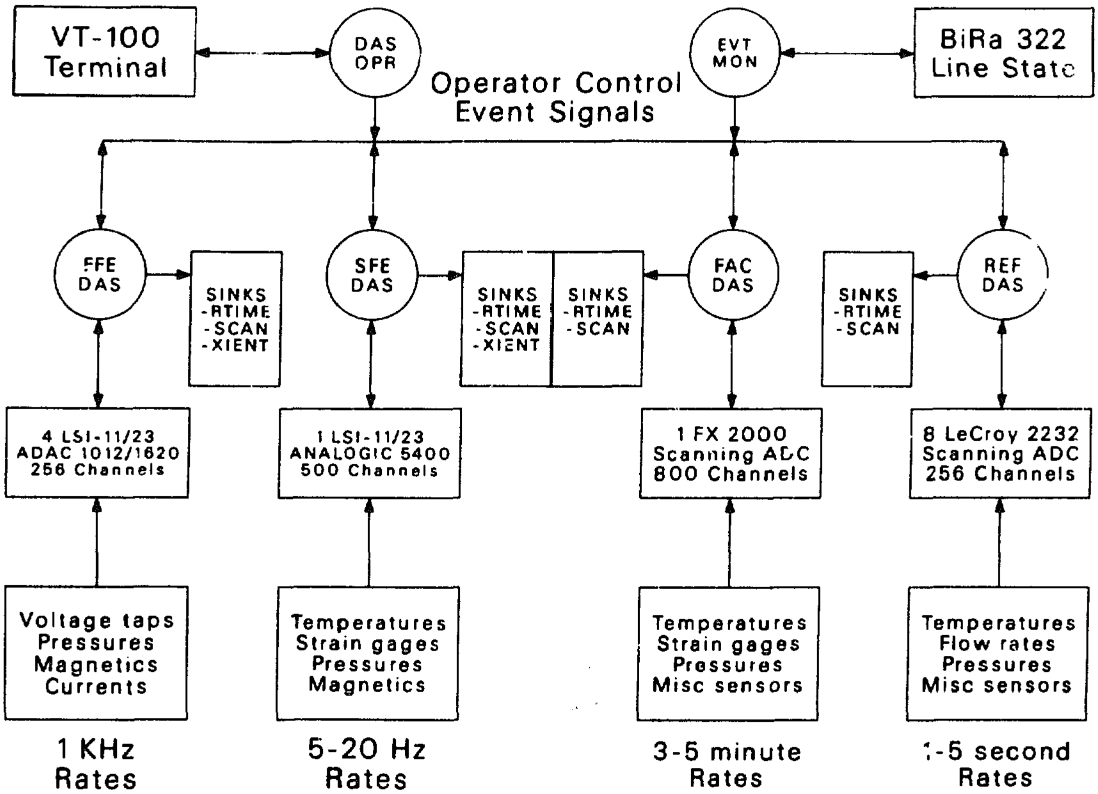

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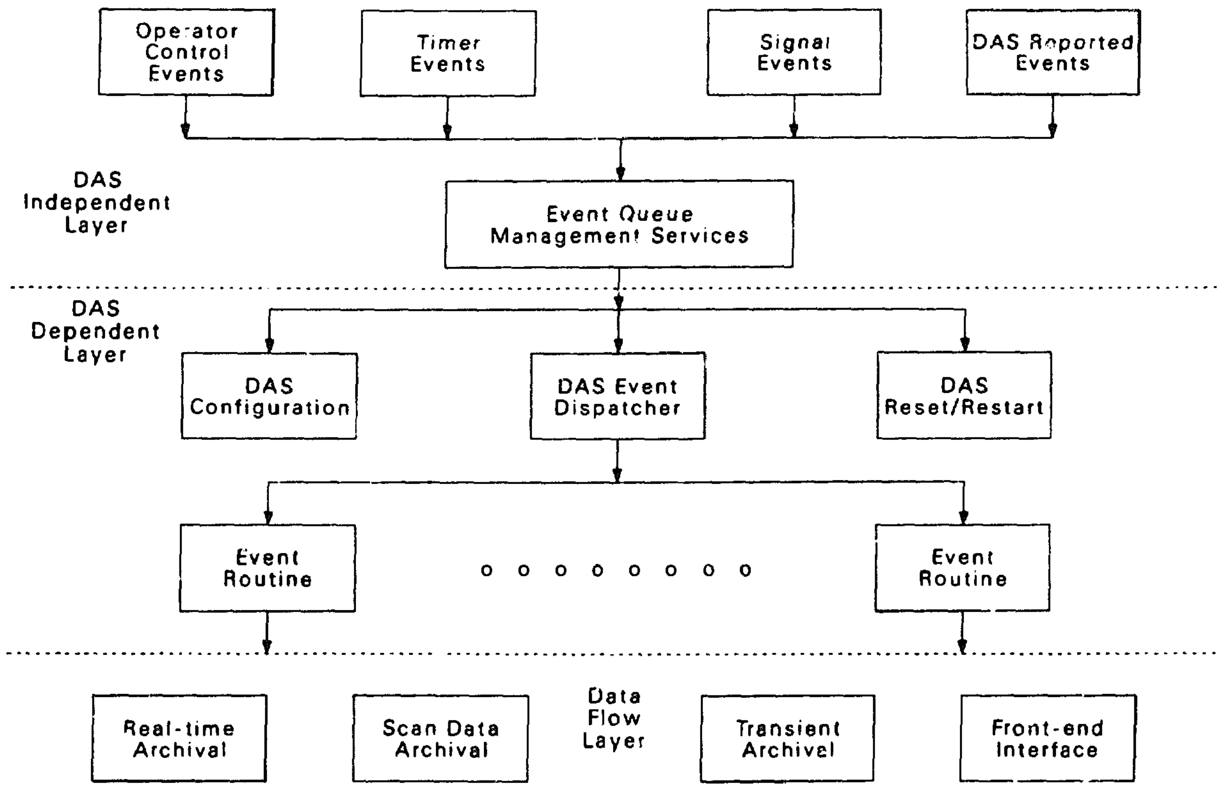

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