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CONF-880364--36

DE89 001872

ATF Data Management'

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Abstract

Data management for the Advanced Toroidal Facility (ATF), a stellarator located at Oak Ridge National Laboratory (ORNL), is provided by DMG, a locally developed, VAX-based software system. DMG is a data storage and retrieval software system that provides the user interface to ATF raw and analyzed data. Data are described in terms of data models and data types and are organized as signals into files, which are internally documented. The system was designed with user accessibility, software maintainability, and extensibility as primary goals. Extensibility features include compatibility with ATF as it moves from pulsed to steady-state operation and capability for use of the DMG system with experiments other than ATF. DMG is implemented as a run-time library of routines available as a shareable image. General-purpose and specialized data acquisition and analysis applications have been developed using the DMG system. This paper describes the DMG system and the interfaces to it.

*Research sponsored by the Office of Fusion Energy, U.S. Department of Energy, under Contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

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Introduction

Data management for ATF, which recently became operational at ORNL, is quite different from that for earlier ORNL confinement experiments, even though ATF is now operating in a pulsed mode and uses some of the hardware and software developed for the earlier Impurity Study Experiment (ISX-B) tokamak. ATF is a stellarator, which, unlike a tokamak, has inherent capabilities for supporting steady-state operation.¹ Since plans are to move toward steady state, the data management system must be prepared for varied operational modes. A flexible time base, multiple acquisitions during discharge, acquisition asynchronous with discharge, and compatibility with both short-pulse and steady-state operations are some of the conditions that must be supported. The DMG system was designed to provide the necessary flexibility and upward compatibility.²

Data management for ATF, Fig. 1, includes access to and management of three distinct types of data: raw experimental data, analyzed waveform data, and highly analyzed scalar data. The main component of ATF data management is DMG, a data storage and retrieval software system that provides the user interface to the first two types of data, identified in Fig. 1 as ATF data files. It is assumed that the only access to these data will be through DMG. Data acquisition programs use DMG for data organization and storage; data analysis and display programs use DMG for retrieval and data conversion.

At this early stage in ATF operation, there is not a large volume of highly analyzed data. All such data currently reside in VAX Record Management Service (RMS) indexed sequential access method (ISAM) files. LOCUS, a graphics and analysis interface to scientific

data developed at Princeton Plasma Physics Laboratory, is used with these data.³ Data management plans include the use of a commercially available relational database management system instead of RMS. A LOCUS interface to such a system will be developed to provide continuity to users.

DMG Design

The main component of DMG is a run-time library of routines, available as a shareable image. The layered design of DMG is illustrated in Fig. 2. At the lowest level, the system consists of PASCAL routines, which use VAX RMS block I/O operations. An intermediate level of PASCAL routines packages the data for storage and retrieval. This level performs two distinct functions: signal management and file management. All data are addressable as signals that have well-defined attributes and structure. The signal management routines organize the data into the structure of the signal space. File management routines impose further organization through the grouping of signals into files that also have well-defined attributes and structure.

Over the PASCAL nucleus is a layer of FORTRAN routines that give the user (in many cases a person conversant only with FORTRAN) a callable interface for creating, writing, and reading ATF data files.

Basic to DMG is the experimental context, which is established at run-time through the use of the logical name DMG.EXP. This logical name has as its equivalence string the experiment's identifier, in this case ATF. Thus, DMG can be used with different experiments even on the same computer. The definition of DMG.EXP is the data file

name extension and is the prefix for other logical names used by the DMG in determining file location and experiment-specific processing.

File Organization and Structure

Data are organized as signals and described in terms of data models and data types. Signals may be measured or calculated, a single byte to eight megabytes, real data or virtual data. A virtual signal is a calculated signal defined by a user-written routine, which is incorporated into the DMG shareable image and is automatically invoked at run-time when a user requests a virtual signal.

Individual ATF data files are created by each diagnostic or diagnostic group, one diagnostic file per machine discharge or discharge-related event. Raw data files and analyzed data files are structurally identical. The same processing options apply—with one exception: raw data files cannot be modified. Analyzed data files may be extended by adding new signals or by modifying an existing signal. In the latter case, the earlier version of the signal is retained; the file is extended by the addition of a new version. The user may request a specific version; the default is the latest version.

DMG data files are internally documented. The file header is of fixed length (45 bytes) and contains descriptive information pertaining to the pulse, event, diagnostic, and file processing options. The file header is followed by the signal table, a variable-length space with an 18-byte entry for each signal stored in the file. A table entry includes signal name, pointer to the signal space, length of signal space, and a 2-byte table link for hashing. Depending on the number of signals in the file, the signal table is organized sequentially or by hash key.

The signal space for each signal consists of a signal header followed by the data. The signal space is of variable length, depending on data model, data type, and number of data elements. The signal header contains descriptive information about the signal and descriptive information about any independent variables (if they exist). Data model, data type, number of data elements, signal time, conversion factors, units, a variable-length comment, and version number are some of the information associated with a signal in a DMG data file.

Application Development

The DMG shareable image is complemented by system-wide DMG-specific logical names and a text library containing definitions, parameters, and DMG-defined messages. These components are also distributed to microVAXes used for ATF data acquisition and analysis.

DMG storage and retrieval routines offer the user a range of complexity and sophistication in constructing a request. Signal data and independent variable are described separately and may differ in data type and number of elements. Because such descriptive information is retained in the file, the user who wishes to retrieve data need know very little about the data. It is possible to retrieve data converted to physical units by specifying nothing more than pulse number, signal name, and the desired number of data points. On the other hand, it is possible to tailor the request in a variety of ways (e.g., retrieve particular data elements from an array, retrieve descriptive information only, retrieve raw data as counts or as volts, etc.).

All ATF data acquisition systems use DMG for organizing and storing data. This gives uniformity to the ATF data, even though the different diagnostics have unique requirements and characteristics. Because of the common data management, retrieval can be accomplished through generic programs.

Three general-purpose programs are used by ATF researchers in data analysis. One of these programs, IDL, is a commercially available product from Research Systems, Inc. Its capabilities include data analysis, plotting, and image display. In addition, it is extendable. For use with DMG, IDL has been extended with locally written FORTRAN procedures that implement an interface to DMG. IDL is used for interactive display of ATF data during machine operation. It is also an integral part of analysis for some ATF diagnostics.⁴

The other two programs, PLOTCH and DMGTOI, are locally developed programs. PLOTCH is a display program based on Advanced Graphing II from Tektronix. DMGTOI retrieves data from DMG data files for requested shots and signals at a specified x value or over an interval about the x value of interest. Data may be analyzed in a variety of ways by applying functions provided by users and linked into the DMGTOI image. The resulting output is written to a relational database, at present an ISAM file, which is subsequently accessed by LOCUS for scaling studies and graphing.

Conclusions

DMG is the core of data management for ATF. It is the means for data storage during machine operation and data retrieval during analysis. The DMG design provides growth potential to meet the inevitable demand for new features and increased functionality during the evolution of ATF. Maintenance of the system is simplified by its modular and layered architecture. DMG application programs will be enhanced and developed as usage requires.

The top level of experimental data—that is, data not included in the scope of DMG—is currently organized as ISAM files. Plans include conversion to a relational database management system.

Acknowledgments

The authors thank D. E. Greenwood and W. R. Wing for their valuable contributions to the design of DMG.

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Figure Captions

Fig. 1. ATF data mangement design.

Fig. 2. DMG software design.

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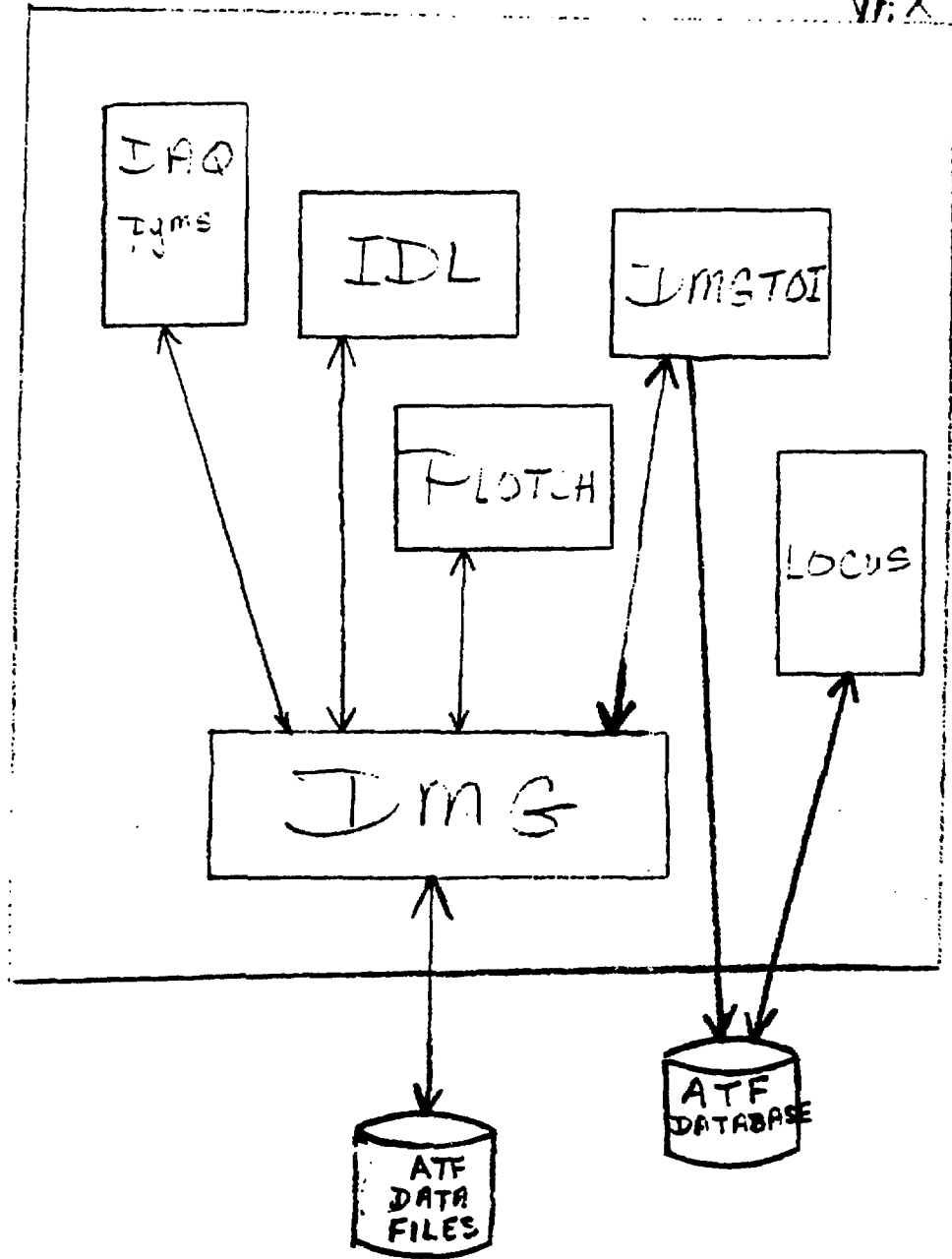
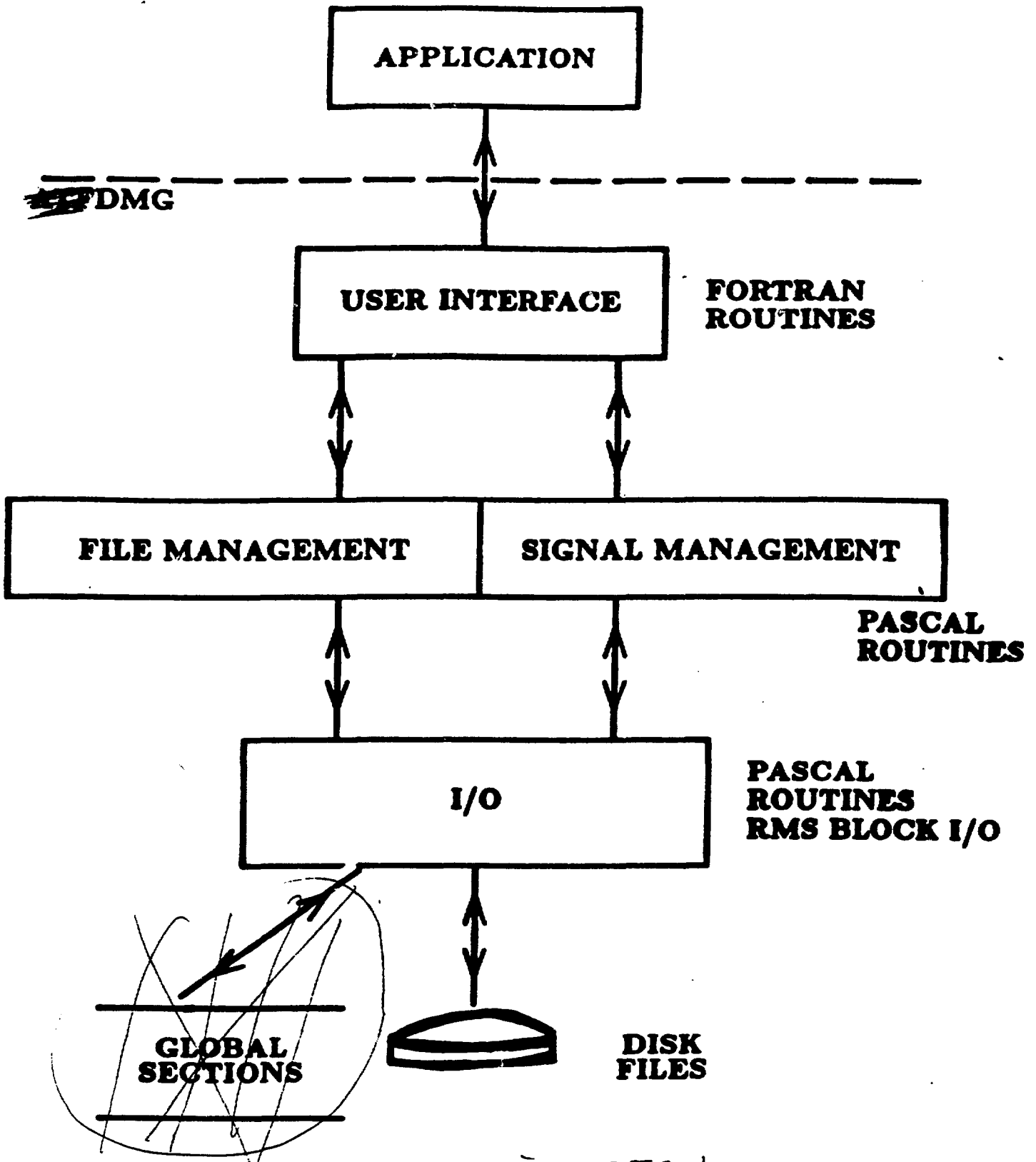


FIG. 1 ATF Data Management Design

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*for paper
& poster*



DESIGN
Fig 2. DMG SOFTWARE ARCHITECTURE