THE DARHT DATA ACQUISITION, ARCHIVAL, ANALYSIS, AND INSTRUMENT CONTROL SYSTEM (DAAAC), AND NETWORK INFRASTRUCTURE.*

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Abstract

The Dual Axis Radiographic Hydrodynamic Test Facility (DARHT) at Los Alamos National Laboratory is the world's most advanced weapons test facility. DARHT contains two linear accelerators for producing flash radiographs of hydrodynamic experiments. High-speed electronics and optical instrumentation are used for triggering the accelerators and collecting accelerator data. Efficient and effective diagnostics provide basic information needed to routinely tune the accelerators for peak radiographic performance, and to successfully monitor the accelerators performance. DARHT's server and network infrastructure is a key element in providing shot related data storage and retrieval for successfully executing radiographic experiments. This paper will outline the elaborate Data Acquisition, Archival, Analysis, and Instrument Control System (DAAAC), as well as the server and network infrastructure for both accelerators.

INTRODUCTION

The DARHT facility consists of two accelerators, DARHT-I and DARHT-II. The data acquisition systems are elaborate and heavily instrumented with beam and pulse power diagnostics. Since accelerator data storage and retrieval is crucial in monitoring and executing radiographic experiments, the server and network infrastructure must be isolated and reliable.

DATA ACQUISITION SOFTWARE

DARHT-I and DARHT-II use the Data Acquisition, Archival, Analysis, and Instrument Control System (DAAAC, V4.0) software package from Voss Scientific [1]. This software is used for automating remote instrumentation setup and control, documentation, data archival, and data analysis. The DAAAC software runs on computers running the Windows XP operating system.

The user interface consists of five modules; Archive, Acquire, Analyze, CalMan, and NetCom which operate as one system (see Figure 1).

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The Archive module is the database management tool which allows users to select databases, import or export data, and organize and transfer data. This module manages the various databases that have been created under DAAAC. It provides access to waveforms, images, single point data, informational notes, and accelerator diagnostic data logs that have been stored into a particular database. The Analyze module is the data analysis display tool which is used for examining and processing waveforms, single point data, images, informational notes, and accelerator diagnostic data logs.

Raw and processed data is shown by this module after the data is captured by the Acquire module and processed by the CalMan module. Once the data is displayed by this module it can be examined using tools that apply directly to the data presentation. These tools include such mechanisms as cursors, combining data into single plots, sub-sampling data or computing Figures of Merit (FOMs). In addition to FOMs, there are other tools for performing various mathematical functions. The Acquire module manages instrumentation communication, and controls acquisition sequence and automatic data processing. The CalMan module is used for documenting every channel's signal path, providing a graphical display of the test setup, and organizing the signal line components. The NetCom module is the mechanism that coordinates actions between the other DAAAC modules and the Microsoft Structured Query Language (SQL) Database. The DAAAC architecture uses inter-process communication (IPC) to exchange information between the five modules to operate as a single integrated system [1].

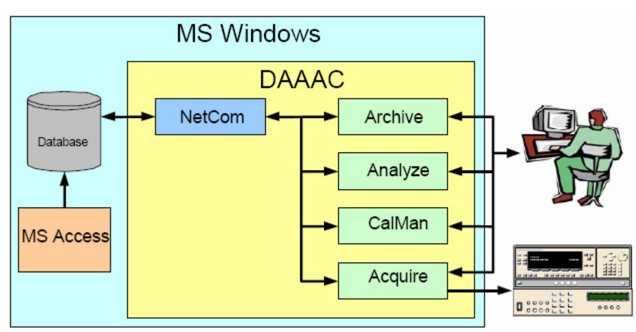

Figure 1: The DAAAC modules.

An additional DAAAC embedded piece of software is the Data Migration tool which migrates data from each accelerator SQL database into Microsoft Access database files. This migration allows for remote users to access the data without having SQL software to poll data from the SQL database elevating the risk of data loss and corruption of the database. The migrated Access databases are also used as a backup to the SQL database. If the accelerator's SQL database data becomes corrupt or lost it can be fully restored using the Access databases causing minimal accelerator down time. DARHT-I and DARHT-II DAAAC software produces binary data files (FlatFiles) on a per shot basis for further analysis using software created with IDL, a data visualization and analysis software development tool. These FlatFiles are available on a website for user specific access which allows internal and external laboratory collaborators to access accelerator data.

Both DARHT-I and DARHT-II run DAAAC in "Networked" mode which supports several data acquisition stations, each running its own copy of DAAAC (see Figure 2). Each data acquisition station controls and acquires data from its own set of connected instruments. DARHT-I has seven dedicated data acquisition stations and DARHT-II has nineteen dedicated data acquisition stations. Each accelerator has a test director which is the primary DAAAC station that instructs the other stations to perform an acquisition and to transmit data. All data is acquired by data acquisition stations and stored in a database. DAAAC stations running the Analyze module retrieve data from the database for analysis and display. Running DARHT-I and DARHT-II in networked mode allows the test director to perform ganged calibrations on the remote dedicated data acquisition stations. The capabilities of running in a network mode with a test director allows for modifications to the accelerators timing sequence through the test director to the associated data acquisition equipment.

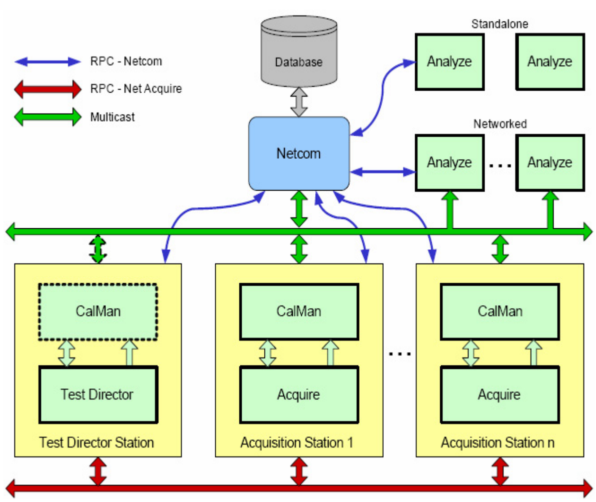

Figure 2: Networked dataflow and communication protocols.

Communication protocols used by Netcom and NetAquire is inter-process communication (RPC) technology that allows a computer program to cause a subroutine or procedure to execute in another address space (commonly on another computer on a shared network) without the programmer explicitly coding the details for this remote interaction. Multicast is the delivery of information to a group of destinations simultaneously using the most efficient strategy to deliver the messages over each link of the network only once, creating copies only when the links to the multiple destinations split. Internet Protocol (IP) Multicast is a technique for a one to many communication over an IP infrastructure, which the implementation occurs on the IP routing level.

DATA ACQUISITION HARDWARE

The Data Acquisition system for the DARHT accelerators is elaborate and heavily instrumented. Table 1 and Table 2 illustrate the amount of instruments we are using for recording data from and controlling instruments on both DARHT-I and DARHT-II accelerators.

Table 1: DARHT-I Data Acquisition Hardware

Server	1
DAAAC Acquire Stations	7
DAAAC Analysis Stations	5
Recording Instruments (45 DC271 Digitizers, and 11 TDS684 Digital scopes)	56
Digital Delay Generators	29

Table 2: DARHT-II Data Acquisition Hardware

Server	1
DAAAC Acquire Stations	19
DAAAC Analysis Stations	9
Recording Instruments (70 DC440, 32 DC282, and 140 DC271 Digitizers)	242
Digital Delay Generators	28

The type of equipment used for the accelerators are the Compact PCI 21 and 8 slot Acqiris crates from Agilent Technologies which are populated with DC271, DC440, DC282, and DC271V digitizer modules. These crates communicate to our DAAAC Acquire stations using high speed MXI-3 interfaces. The DC271 is a 4 channel, 1 GHz bandwidth and 1-4 Giga Sample per second (GS/s) sampling rate Acqiris digitizer with oscilloscope characteristics. The DC440 is a high-resolution, high-speed dual-channel digitizer for frequency domain applications (2-channel, 100MHz, 400 MS/s and 4 Mpoint acquisition memory). The DC282 is a 4 channel, 2-8 GS/s high-speed digitizer. We also use Stanford Research Systems (SRS) Digital Delay Generators (DG535) for accelerator triggering and timing. These DG535s use the general purpose interface bus (GPIB) communication protocol for interfacing to the DAAAC stations. In addition to the DG535s we use Tektronix TDS 684 oscilloscopes on DARHT-I which also use the GPIB communication protocol.

DARHT diagnostics provide basic information needed to routinely tune the accelerators for peak radiographic performance. Beam position monitors (BPMs) are used to measure beam current and position for both accelerators. DARHT-I has a total of 26 BPMs, and DARHT-II has a total of 31 BPMs which are used on every beam shot. In addition to the BPMs both accelerators use cell voltage monitors (CVM) which are used to measure induction cell accelerating potential. DARHT-I has a total of 64 CVMs, and DARHT-II has a total of 74 CVMs which are also used on every beam shot.

Information needed to monitor the accelerators performance is provided by our diagnostics. DARHT I and DARHT II both have 20 Injector diagnostic parameters including voltages and currents which are used on a per shot basis.

DARHT SERVER/NETWORK INFRASTRUCTURE

Storage and retrieval of DARHT accelerator data is crucial in monitoring and executing radiographic experiments. The server and network infrastructure must be isolated and reliable.

DARHT-I relies on a data storage server running the NetCom module which is the interface between DAAAC and the Structured Query Language (SQL) Database. This server is running a Microsoft SQL 2005 database which is the repository for DARHT-I diagnostic data and station configurations. DARHT-I and DARHT-II severs are Microsoft Windows 2003 servers which are configured with 1 terabyte of data storage, 4 gigabytes of memory and has a 3.7 gigahertz dual core processor.

DARHT-II also relies on a data storage server running the NetCom module. This server is running a Microsoft SQL 2005 database which is the repository for DARHT-II diagnostic data and station configurations.

DARHT-I and DARHT-II also have a server running a Microsoft SQL 2005 database for storing and retrieving accelerator controls data. These accelerator control parameters such as; pulse power, magnet, and vacuum controls data for both accelerators for monitoring performance.

There are over 90 controls and data acquisition stations throughout the facility. The servers and stations are on a local are network (LAN) (see Figure 3). They are isolated from the outside network. The DARHT accelerators have two domain controllers which are running the Microsoft Windows 2003 Server operating system with Active Directory service installed. Active Directory enables centralized, secure management of the DARHT facility local area network. This network was established to enhance and secure crucial accelerator data and to avoid other network traffic. All diagnostic and control systems within the DARHT facility local area network are on a 1 gigabit per second fiber network which allows for speedy storage and retrieval of accelerator data.

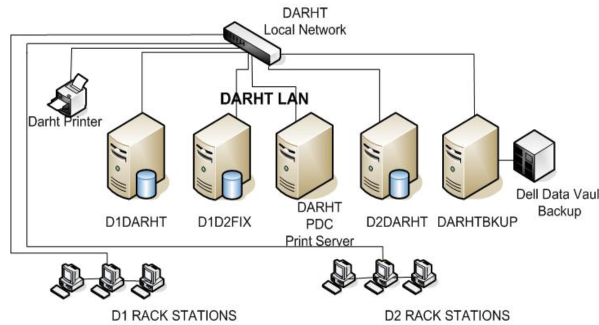

Figure 3: DARHT accelerators local area domain.

A bridge server (see Figure 4) was added as part of the DARHT facility local area network to allow specific users on the Los Alamos National Laboratory open network and the Windows Active Directory (WIN) Domain to access a copy of the accelerator's diagnostic and controls data. This data on the bridge server is synchronized with the data on the data acquisition servers using PeerSync commercial software. To accomplish data storage and retrieval across the DARHT facility local area network and the Laboratory open network the bridge server is configured to operate with dual 1 gigabit per second fiber network interfaces. This bridge server is a Microsoft Windows 2003 file server which is configured with 6 terabytes of data storage, 4 gigabytes of memory and 2.3 gigahertz quad core processor. To insure proper data storage we maintain our own backup system via a tape library storage unit which uses 800 gigabyte (compressed) tapes.

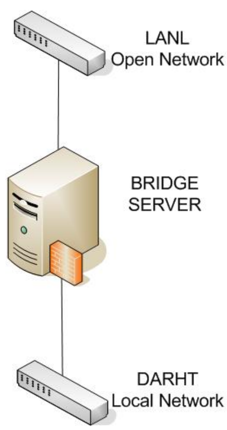

Figure 4: DARHT accelerators bridge and file server.

SUMMARY

The DARHT accelerator's triggering and data collection is elaborate and heavily instrumented with state-of-the-art diagnostics, server, and network equipment. Efficient and effective diagnostics, server, and network infrastructure is crucial for successfully executing radiographic experiments at DARHT.

REFERENCES

[1] Voss Scientific Inc., "DAAAC 4.0 User's Manual." Voss Scientific Inc., New Mexico, August 2007, pgs. 1-170, http://www.vosssci.com.