RANGE UPGRADE FOR DATA RECORDING AND REPRODUCTION

Ingemar Nystrom
AerotechTelub Miltest AB
System Manager, Telemetry Computer systems
Box 64, S-942 23 Vidsel, Sweden

Tim Gatton
Applications Engineer
Veridian Systems Incorporated
44417 Pecan Court
California, MD 20619

ABSTRACT

Flexible data multiplexing that supports both low-speed (4 Mbps) to very high-speed output devices (networks and recording systems up to 480 Mbps), along with data network formatting, can greatly enhance the results of range upgrading.

KEYWORDS

Vidsel Test Range, FMV, IMUX, Fibre Channel, PCI, Analog Recording, Digital Recording, Disk Array, RAID, and DLT-7000.

INTRODUCTION

The FMV, or the Swedish Defense Materiel Administration, is an authority directly subordinate to the Swedish Ministry of Defense. The FMV, predominately in support of the Swedish Armed Forces, defines, develops, procures, and delivers the materiel systems of the Swedish Armed Forces. It is also responsible for in-service support and phase-out. FMV tests the systems—from preliminary studies to delivery and thereafter. They have installations in Stockholm, Arboga, Karlsborg, Linköping, and Vidsel.

The Vidsel Test Range is Western Europe's largest land testing ground for firing practice and for testing airborne and land-based missile systems. The test range is located in Lapland on a well monitored restricted site with hilly terrain that measures 70x35 km, which translates into 1650 square kilometers or

637 square miles. Its infrastructure is good, and its airfield has a 2300-metres runway that can accept aircraft corresponding in size to the C130 Hercules.

The test range includes a number of different target systems for testing airborne weapon systems against ground targets, as well as antitank missile systems against ground targets. Target missile systems and towed targets are provided for testing air-to-air and air-to-ground missile systems and automatic cannon firing systems. The infrastructure supports a wide array of testing. This infrastructure includes telemetry, tracking radar, Doppler radar, high-speed cameras, theodolites, photographic laboratories, and a robust communications network. The test range, as can be imagined, is excellent for low-temperature testing during winter months.

The remote and central test centers of Sweden's Vidsel Test Range have an increasing data storage requirement. The need existed to replace the aging analog solution and to provide increased bandwidth, increased recording time, improved speed for formatting data, and the ability to link data to the customer's unique processing environment.

The level of testing required today at the Vidsel Test Range has expanded from the simpler requirements of the last decade to the demands of newer generations of hardware. Both monitoring and recording requirements have progressed from the expensive 2 Mbps recording systems to systems that can handle 200+ Mbps operations. The new solution must also: a) fit the requirement of the "newer, faster, cheaper" call of Research, Development, Testing, and Engineering (RDT&E) markets, b) maximize the use of commercial-off-the-shelf (COTS) products for the best "bang per buck," c) be scalable so as to support both very low-speed and very high-speed recording systems, and d) support a data product that is easily readable by computer subsystems.

Veridian System's IMUX™ was chosen to meet FMV's requirements. As a fairly new product (approximately 200 systems have been shipped to date), it easily supports the "newer, faster, cheaper" requirement; furthermore, the system has in excess of 99% of the COTS components required to meet the COTS benchmark. For scalability at the data recorder, both high-speed, proprietary, emitter-coupled-logic (ECL) interfaces are supported as well as standard Ultra-SCSI interfaces. For scalability at the computer, network connections from 10 Mbps Ethernet to 1 Gbps Fibre Channel are supported with documented data structures.

At the highest level, the optimized data flow would look something like the diagram shown in Figure 1.

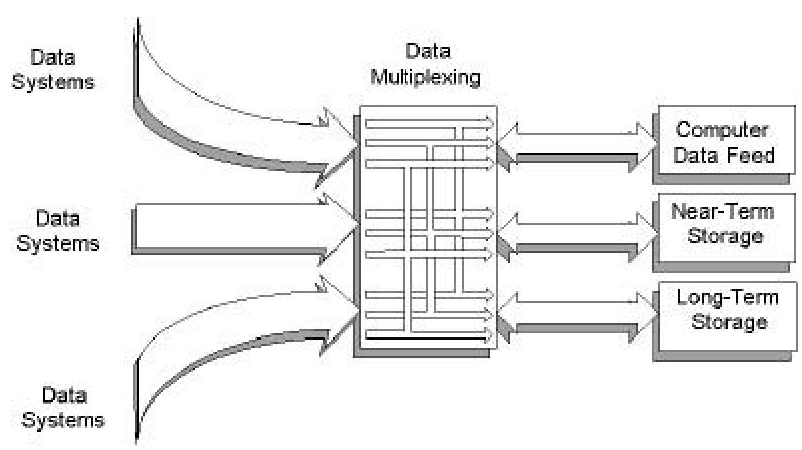

Figure 1: System Block Diagram

The role of near-term storage is to act as the first-line storage system for high data rate input. For Vidsel, that would be 200 Mbps. Once data is stored there, it is transferred to either the computer data center or to long-term storage. All of these functions will be discussed later in the paper.

MISSION SCENARIO

At Vidsel, the typical mission scenario involving the greatest number of input streams is depicted in Figure 2. Here, multiple antenna systems pickup the signal from a projectile and route the data back to the data center. The logical reasons for using multiple antenna systems are: 1) cost savings on the hardware and personnel requirements needed to man remote sites and 2) the overlapping coverage of several areas, which means that the 100% acquisition level of all signals has a higher probability of occurring.

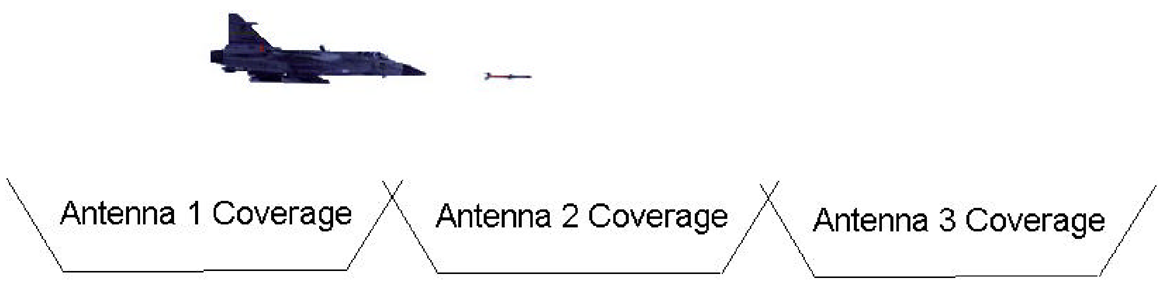

Figure 2: Sample Mission Scenario

As the data is picked up from the multiple zones, it is input into the data multiplexer and processed.

DATA MULTIPLEXER

The data multiplexer's real-time role is to:

- input an array of signal types (PCM, analog, and discretes)
- time-tag data to resolutions of 1 millisecond to 1 microsecond
- store data using low-cost COTS small computer system interface (SCSI) devices
- format data so that it can be fed to a computer for additional processing

In the playback role, the multiplexer supports the ability: a) to move data from the near-term storage equipment to the long-term/archiving storage and to the computer and b) to reproduce data in its original native format.

STORAGE

Storage requirements pose a difficult trade-off. For support in any locale, computer peripherals provide the most easily supportable media for the lowest cost. However, higher-cost proprietary interfaces often provide the highest bandwidth. The trade-off was to use two approaches, both were low-cost computer industry approaches and both were controlled by the data multiplexer.

Near-Term Storage

To provide the highest bandwidth for the initial capture of incoming data, a redundant array of inexpensive disks (RAID) was chosen. The 90 GB RAID (small by today's capabilities) uses an array of 18 GB disks, in a rack-mountable enclosure supporting RAID levels 0, 1, and 5. An operating system-independent (OS-independent) RAID was chosen so that the data multiplexer's central processing unit (CPU) would not be impacted and also to minimize integration risk. As an OS-independent solution, the RAID looks to the system as a large SCSI disk but, obviously, with a much higher bandwidth due to the "stripping" action of distributing data across multiple disk drives. For the interface, the choices were copper or fiber. Since the disk drives offering direct Fibre Channel interfaces are expensive and because most RAIDs today offer fiber interfaces with "fiber to SCSI adapters," direct fiber was seen as not necessary and not cost effective. (Note: If EMI/EMC issues were important, fiber to the RAID would have been a higher priority.)

In the mission scenario, data is stored to the near-term location first. From here it can be transferred to a workstation for analysis, and for long-term support, it can be transferred to the long-term storage media for archiving. Transfer actions to the archive are "bulk" in nature while the data transfer to the workstation can be done by session, stream, and/or time slice components.

Long-term Storage

The Quantum DLT-7000 was chosen for long-term storage for several reasons. First, it is a relatively high-speed tape device. Second, it is widely supported in the global market. Third, Quantum has a long history of support and improvements in DLT technology (DLT-4000, 7000, and now 8000). Finally, it is a very robust system used by many data acquisition systems in real-time modes of operation.

The DLT-7000 provides 35 GB native capacity and 70 GB compressed capacity. The compact media (roughly 4" x 4" x 1") is inexpensive (relatively speaking), stores well (in excess of 20-year storage life), and is supported by many vendors and just about all operating systems. (See Figure 3.)

COMPUTER DATA CONNECTIONS

To get the data from the RAID and/or DLT-7000 to the workstation at 160 Mbps, three approaches were considered: SCSI, Ethernet, and Fibre Channel.

SCSI was rejected due to the duel-master implications (part of the SCSI specification but not supported by any of the major manufacturers). Ethernet was considered to be the best solution, but since 100 Mbps Ethernet lacks the bandwidth to get close to the incoming rates, it was rejected. Standard 1 Gbps

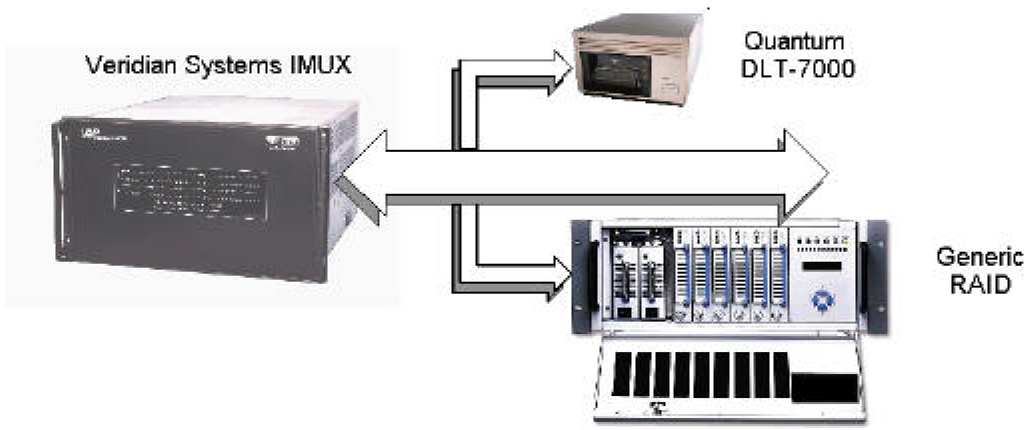

Figure 3: System Components: IMUX and Near- and Long-term Archiving

Ethernet is not widely available yet, and ATM protocols were not necessary, as the connections were "point-to-point." For this reason, it was decided to use a generic 1 Gbps Fibre Channel interface.

To support Fibre Channel in the IMUX and the personal computer (PC), minor system integration was used to support the PCI card in the PC. Additional integration was required for the PMC module that connects to the IMUX SBC. See Figure 4 below. (The IMUX runs pSOS, a real-time kernel that required the addition of COTS Fibre Channel support.)

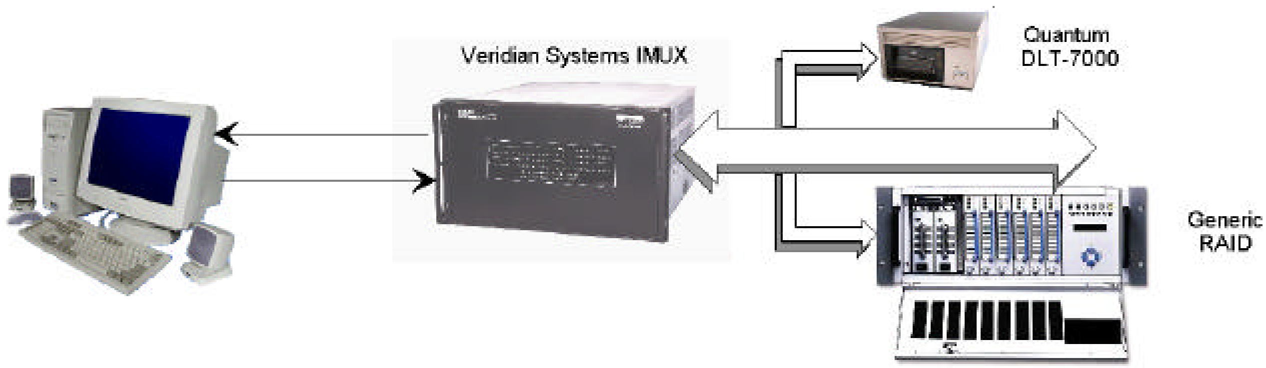

Figure 4: System Components with Fibre Channel

The vendor's requirement for Fibre Channel was to find a vendor with both a PCI-based interface (for use in the workstation) as well as a PMC-based interface, which would reside in the IMUX system (see the IMUX section for details). For this, the vendor Fibre Gear was chosen since both vendors: a) met the baseline requirements of PCI and PMC modules, b) have the NT drivers and embedded applications development software necessary for easy development and integration, and c) have successfully been integrated with the SBC in use within the IMUX.

IMUX OVERVIEW

At the center of the data collecting and multiplexing requirement is a standard Veridian Systems IMUX with an enhanced CPU. The IMUX is a dual-bus system with a wide array of input and output signal types, all based on a 6U VME hardware "footprint." For this customer's project, only analog, PCM, and discrete signals support was immediately needed; however, to anticipate for future needs, the standard product was required to support other signals such as MIL-STD-1553 and ARINC-429 (see Figure 5).

For Sweden's data acquisition project, the PCM/analog/discrete data flow would come in through the Quadraplex modules, go through the GME bus, and be routed through the Bridge/CPU combination to the SCSI bus. The requirement was for 200 Mbps support of incoming data, so the standard 50-60 Mbps capable CPU (a Motorola 68K series) used in IMUX was upgraded. The single-board computer (SBC) chosen was the Synergy VGMd unit, a 466 MHz PowerPC chip unit. Features of the SBC include two PMC sites, a PCI expansion connector, up to 128 MB of RAM, up to 9 MB flash-memory, auto-sensing 10/100Base-TX Ethernet, two serial ports, and SCSI.

A feature unique to the IMUX is data mapping (see Figure 5). The IMUX system has the ability to reproduce raw data in its native format; therefore, the system does not need one reproduce module per record module. Instead, the IMUX firmware allows a mapping of a large quantity of input channels to a lesser quantity of output (or reproduce) channels.

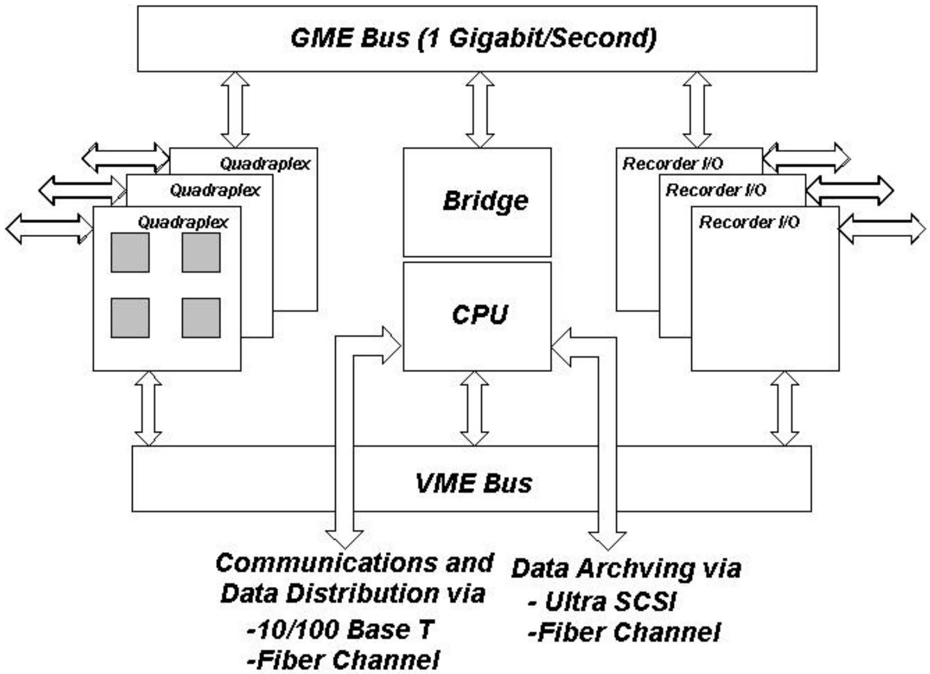

Figure 5: IMUX Block Diagram

FIBRE CHANNEL

One of the PMC sites had installed a 1 Gbps Fibre Channel card. Fibre Channel is a 1 gigabit per second data transfer interface technology that maps several common transport protocols including Internet Protocols IP and SCSI allowing it to merge high-speed I/O and networking functionality into a single connectivity technology. Fibre Channel is an open technology as defined by the American National Standards Institute (ANSI) and Open Systems Interconnection (OSI) standards and operates over copper and fiber optic cabling at distances of up to 10 kilometers. It is unique in its support of multiple inter-operable topologies including point-to-point, arbitrated-loop, and switching. It offers several qualities of service for network optimization. With its large packet sizes, Fibre Channel is ideal for storage, video, graphic, and mass data transfer applications. While Fibre Channel supports three classes, in this application, it is installed as a Class 1 dedicated point-to-point connection.

Mission Operation

Figure 6 shows the high level data flow with all of it's possible simultaneous data paths. In the Videl Test Range application, the data flow is a three-step process. In the first step, data is acquired and stored onto the near-term RAID system as the Unit Under Test (UUT) moves through the coverage zones. Once it is stored, data is transferred to the DLT-7000 tape system for long-term archiving. The third step transfers either pieces of data or the entire session of data to the PC..

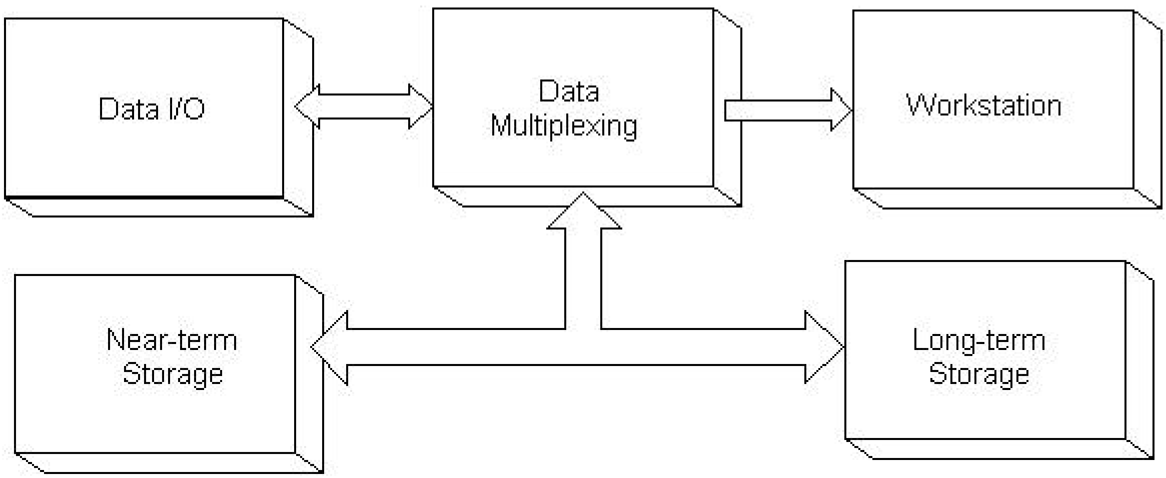

Figure 6: All Possible Data Paths

Let's review each of the steps more closely.

In the first step, data is accepted through the Data Multiplexing system and is stored in the near-term storage unit, which is the RAID system (note that the data arrows shown in Figure 7 are bi-directional).

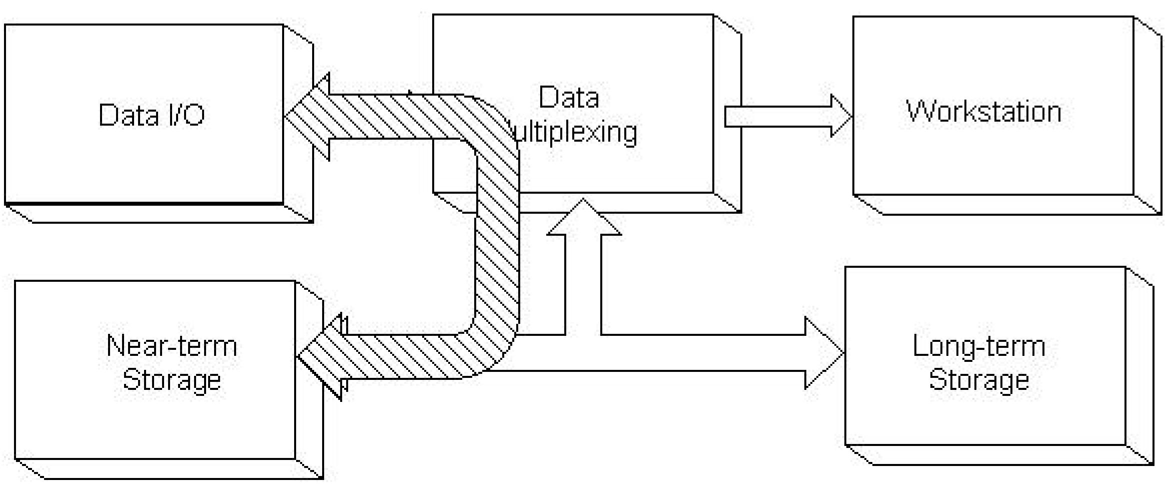

Figure 7: Step 1 – High Rate Data Storage

While the data could have been directly input into the long-term storage, the input data rates of 200 Mbps are above what the DLT-7000 can ingest.

In the second step as shown in Figure 8, the data is transferred to long-term storage for protection.

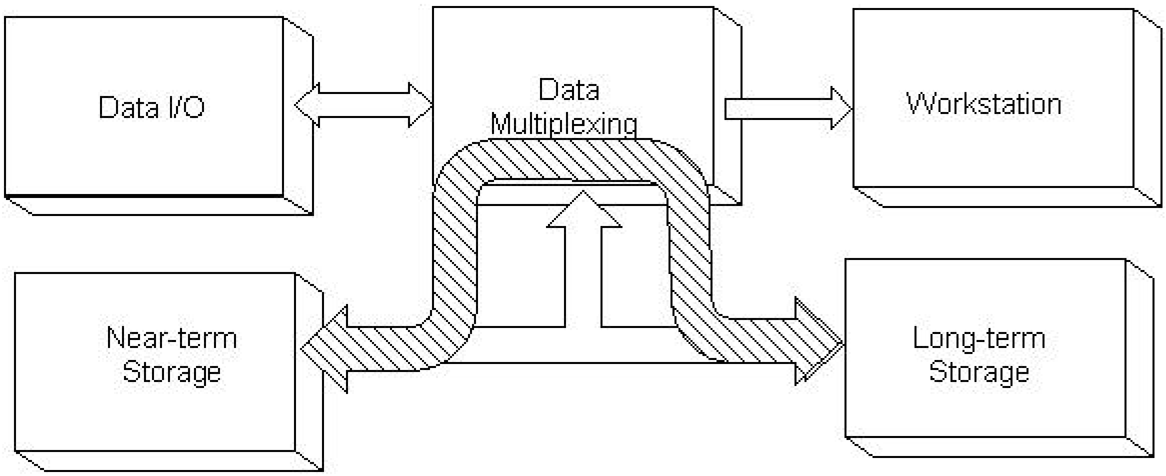

Figure 8: Step 2 – Data Transfer to Storage

Note that while the data does not go through the Data Multiplexer (it is a SCSI to SCSI transfer), the IMUX monitors, directs, and controls the data and has the ability to select the data set to be transferred by session number, by channel stream number, and by time slice (or any combination thereof).

In step 3 as depicted in Figure 9, after data is archived, it is transferred to the PC for user application processing and analysis.

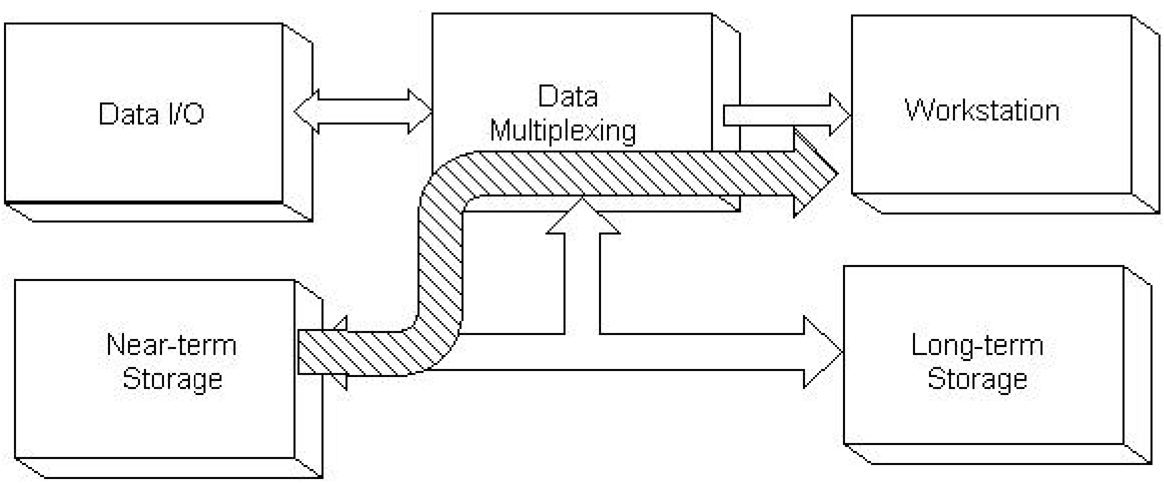

Figure 9: Step 3 – Data Transfer to Workstation

This data path takes advantage of the ultra-wide SCSI and the 1 Gbps Fibre Channel – the customer requirement is for 160 Mbps transfer. As in the long-term storage shown in the Figure 9, the IMUX has the ability to select the data set to be transferred, which is selectable by session number, by channel number, and by time slice (or any combination thereof).

It is important to note that in the previous scenarios, operating simultaneously, it is possible to put data to near- and long-term storage and to the workstations. However, a trade-off in throughput via the SBC and VME bus impacts systemic operations.

While the above steps present a simplistic view of the data flow, it is of note that it provides a wide bandwidth of access and a baseline system, which can be accommodated to fit future needs.

PC AND THE FIBRE CHANNEL

Transferring data at 160 Mbps from the IMUX to the PC was easily accomplished by locating a vendor of Fibre Channel gear with hardware and software for both the PC (via its PCI bus) and the IMUX (via its PCI Mezzanine Card or PMC). By choosing a vendor with cards for each of these interfaces, the risk was minimized. Standard drivers for NT were supplied with the hardware, while a development software kit was supplied for system integration of the PMC card.

NT SOFTWARE

The IMUX Control Panel software is tasked with being able to act as a remote control device while also being able to transfer data from the IMUX Storage System to the workstation. Also, part of the delivery is the documentation on the construction of the data messages/blocks. This is provided as a standard part of the IMUX system. These computer-readable formats easily support the Vidsel requirements. For quick-look and other analysis requirements and for processing Fibre Channel data, MATLAB is used. From there, data is then put on a CD or DVD for their customers in an Internet browser-accessible format. Also, standardized software from Veridian Systems is already available to support database management, parameter calibrations, alarm processing, and display environments to meet most user demands.

SUMMARY

In the past, high bandwidth recording was limited to high-cost proprietary devices. System integration with high-speed RAID devices, fiber optic data paths, and ultra-wide SCSI provide a low-cost approach to providing similar bandwidths at less cost. The IMUX, as the heart of the system, is configurable with up to sixty (60) channels of input and output, complete with multiple levels of throughput processing. In addition to the recording functionality of the IMUX, decommutation, network data distribution, and multiple redundant record processes provide a broad base of configurable system.