Modern Data Acquisition Recording

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The recording technology available for collection of flight test, sensor data, range telemetry signals, telecommunications, video, radar, IR, and EO imagery has undergone a paradigm shift. With that change comes the ability to reach performance levels and provide features never before deemed practical using traditional tape based recorders. Today's latest data acquisition recorders are based on inexpensive non-volatile solid state memory devices (FLASH) and compact high capacity hard disc drives (2.5" and 3.5") developed for commodity consumer or server applications. Of particular significance is the ability to provide network connected data acquisition recorders that store and retrieve packetized data across shared networks, including the partitioning of the storage device to share data collected or data downloaded into the storage device from other data bases relevant to the mission. The combination of these latest storage technologies coupled with standard high speed network connections using compact environmentally robust implementations enables support for many new recording applications.

The Technology

Two (2) storage media technologies, FLASH memory and small magnetic disc drives, are being successfully applied today in support of data acquisition applications that formerly could only be satisfied using ruggedized tape recorders such as the Ampex DCRsi 240 and the Enertec 6411. In some cases, modern FLASH based data acquisition recorders can support environmentally challenging applications that were impossible to satisfy using tape recorders. The evolution of data acquisition recorders from magnetic tape based storage to FLASH and disc based storage is the result of recent rapid declines in the media cost per Gigabyte for these technologies due to their widespread use in "commodity" products such as PCs, digital cameras, PDAs and mobile phones. Rapid improvements in the data rate, capacity, and cost effectiveness of these media types, driven by insatiable consumer demands, will assure a corresponding future technology growth path for data acquisition recorders.

The choice of whether to use FLASH memory based recorders or disc based recorders depends on the level of environmental stress that the recorder must operate under and survive. FLASH memory based recorder products, although the most environmentally robust, are substantially more expensive than disc based recorders. Several of today's airborne applications and most of today's ground based data acquisition applications can be fully satisfied using modern disc based recorders, such as the Ampex DDRs 440 and the Enertec DS 4100 recorder. For today's most demanding tactical data acquisition applications on high performance aircraft, the preferred solution is to use FLASH based recorders. It is reasonable to implement a disc based data acquisition recorder that

operates from -20C to +50C at 60,000 ft. and supports 6 g (rms) of random vibration, while it is also reasonable to expect a FLASH based data acquisition recorder to operate from -40C to +70C at 70,000 ft. and support 14g (rms) of vibration. No matter which media solution is selected, today's FLASH and disc acquisition media are not suitable for long term data archiving due to their high cartridge cost and low volumetric density compared to magnetic tape. Data acquired on FLASH and disc based recorders must be downloaded in a Ground Station and transferred to low cost tape media for long term storage, a step not required when using traditional tape media.

Most manufacturers of Flash or disc based data acquisition recorders have chosen to separately package the media in a Removable Memory Module (RMM) that in many ways replicates the functionality of a tape cartridge. These RMMs contain the FLASH memory chips or small 2.5" or 3.5' disc drives packaged with required control electronics in a robust pluggable cartridge that can be easily inserted or removed from the recorder chassis. Each manufacturer has a different level of functionality in their RMMs and some even define the RMM as the entire recorder. As an example, Figure 1 below shows Ampex's DSRs 400B Recorder and its associated 576 Gigabyte FLASH memory based RMM. Commercially offered RMMs can vary in storage capacity from a few Gigabytes up to the Terabyte range. Data rates can be scaled up into the Gigabit/sec range, depending on the manufacturer's target market.

Figure 1 FLASH Memory Based Recorder with RMM

The Applications

Ruggedized data acquisition recorders are called upon to support varied applications. These applications fall into several broad categories such flight test, ISR, ASW, and more recently, airborne server applications. In many modern applications, ruggedized data acquisition recorders are also expected to provide full data playback functionality, expanding their role into a general purpose storage and retrieval device. In certain ISR and ASW applications, it is desirable to play the data back at the highest data rate

possible to minimize the time required to transfer the data down to the Ground Station or to a companion Command and Control Aircraft through a high speed data link. Other ISR applications may only require playback of short time segments acquired during a long mission or selected channels of interest within a wideband signal. In the case of flight test applications, several different signal types may need to be combined using a multiplexer before the data is recorded. Such varied signal inputs as RS-170 video, audio, PCM, analog, ARINC 429, RS 232, bit-parallel (8, 16, 32), Mil STD 1553B, FPDP, and Ethernet must be accommodated. To encourage interoperability, considerable effort has been expended on trying to standardize the logical output data packet format provided by the various multiplexer manufacturers. One particular example is the advent of the IRIG 106, Chapter 10 packetized data format which is gaining significant momentum with manufacturers and customers. A particularly attractive aspect of this format is that it lends itself well to software demultiplexing, eliminating the need for expensive hardware demultiplexers. Several recorder manufacturers have made public commitments to support the IRIG 106, Chapter 10 data format and independent compliance testing is planned to certify that vendors meet the standard.

Network Attached Data Acquisition

There have been great strides made in the implementation of computer based mass storage systems at ground computing centers over the last decade. Simple dedicated tape and disc based file servers have been replaced by NAS and SAN architectures that allow any user on the network to access any storage device, and therefore, any data files stored on that network. Sophisticated software tools, high speed networks, and widely supported network protocols have accelerated the general acceptance of network connected storage architectures at most modern computing centers.

It has been the dream of many airborne systems architects to someday have a network attached “server in the sky”. The advent of random access based FLASH memory and disc based data acquisition recorders to replace sequential access tape based data acquisition recorders plus the commercial availability of very powerful small form factor ruggedized CPUs has hastened the possibility of implementing such a recorder. To be successful, such an airborne recorder should support standard network Gigabit Ethernet interfaces, record all messages received through the network fabric, use TCP protocol for network transport of extracted data, support simultaneous extraction of data while performing uninterrupted data recording, and support a general purpose file oriented storage and retrieval interface using FTP protocol. Other desirable features include support of multicast groups on the airborne network, support of UDP/IP, and the ability to transmit data to any TCP/IP target on the network. Support of metadata, S.N.M.P., and multiple RMM media data partitions are all possible using this new technology. With these many desirable features possible to implement today, it will only be a matter of time before one or more recorder manufacturers makes such a product generally available for ruggedized airborne applications giving the airborne systems engineer the added functionality that he has long desired.

The concept diagram below in Figure 2 shows the general approach of how such a recorder could be integrated into an airborne NAS or SAN architecture.

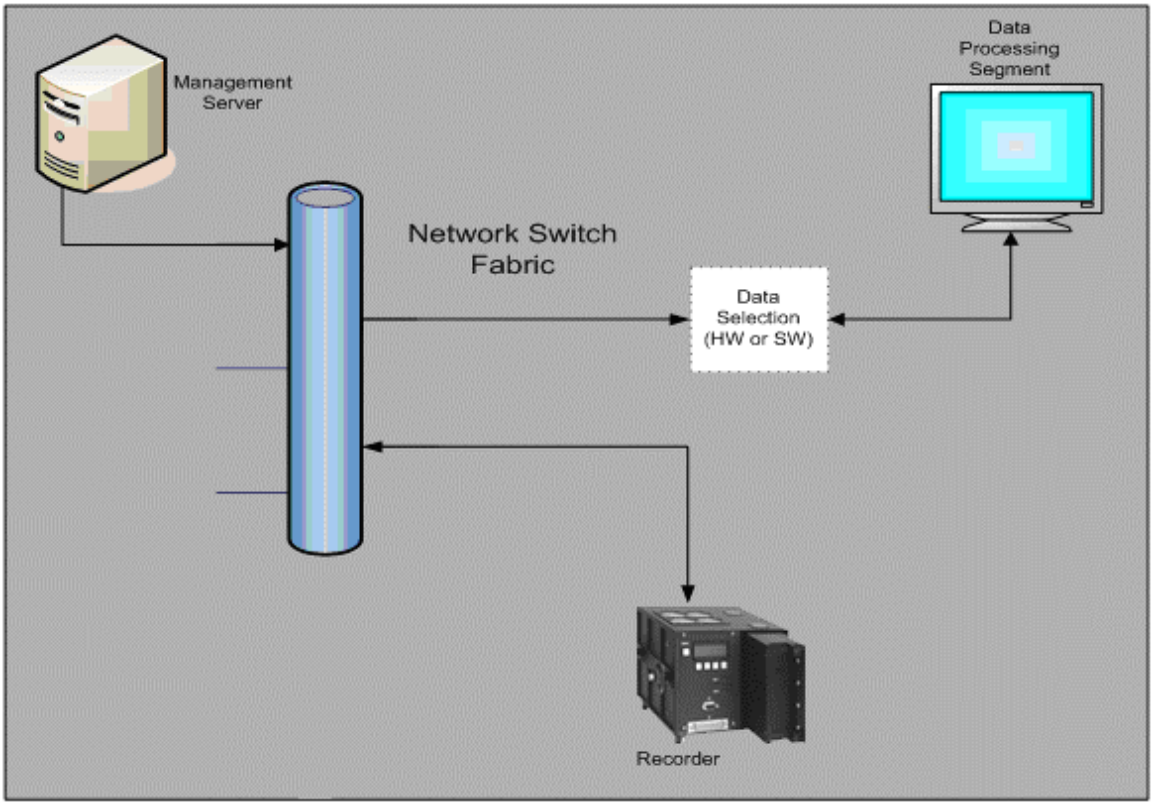

Figure 2 Network Attached Ruggedized Airborne Recorder

The architecture depicted above can be tailored to accommodate any of the traditional airborne applications such as flight test, ISR and MPA data collection and playback. For these applications, the sensor manufacturers will need to also evolve their design implementations to support a generalized network interface implementation like the recorder described above will have, including digital time stamping when required.

Future Trends

Today, FLASH memory chips are commercially available with capacities of up to 8 Gigabits each, currently available 2.5" disc drives can store up to 100 Gigabytes each and 3.5" disc drives can store up to 300 Gigabytes each. The large commercial markets driving these technologies assure that these individual media capacities will continue to double every twelve (12) to eighteen (18) months and that media device data rates will scale accordingly. The evolution of ruggedized data acquisition recorder designs away from traditional "streaming" application implementations towards random access and network attached architectures is rapid and inevitable. Ampex, as well as many other companies, are actively developing such recorders to fill this market need.