MULTIPLEXING AND RECORDING IN THE DIGITAL AGE

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INTRODUCTION

The evolution to digital multiplexing and recording technology has seen new applications emerge that were previously outside the purview of traditional analog recording. The exponential increase in storage capacity, flexibility in storage media options, and reduced cost have resulted in a high demand for products like IMUX for use in commercial and defense satellite communications systems, data routing and distribution networks, remote tracking and data transmission, and other modern data acquisition systems.

The widely diffuse operations, division of labor, and extended windows of uninterrupted processing within these communities demand that modern multiplexing configurations be more flexible and better able to handle and discriminate large volumes of data with greater tape fidelity. With the specter of budget reductions always looming over today's data acquisition environments, there is the additional onus on modern programs to accomplish these objectives in a cost-effective manner. Consequently, today's multiplexer systems must meet the following criteria:

FLEXIBILITY

IMUX offers a combined product that provides full multiplexing and demultiplexing as well as a real-time data driven processing and display environment. A properly configured IMUX gives the user the option of having a single system that records all input data, with the option of simultaneously functioning as a full feature test and analysis ground station. The user can invest in a multiplexer today, and grow the system into a complete ground station with field installed options.

These options include RF receivers, PCM bit synchronizers, multi-user graphic workstations, data simulation, post-test analysis software, and a complete project database environment. IMUX can be configured as a data acquisition system that provides a growth path for network interfaces (such as Ethernet or FDDI), as well standard cards and software from the Veda Systems product line and others. These products include bit syncs, multiple time sources, and high-level data analysis software.

The system can ingest up to 60 downlink streams of high-speed data of various types for data recording and transmission and routing. Examples are digital phone lines, downlink from satellites or test ranges, analog or discrete signals, or TCP/IP streams. With the added feature of software decommutation, the price-to-performance ratio can be weighed against

hardware decommutation. Relegating the decommutation functions to a PC workstation can obviate the attendant costs of front-end decommutation. But it's not an either or proposition. Parameter extraction for example, can be divided into multiple layers of processing. The use of a complete computer architecture provides both the low cost of commercial-off-the-shelf products and the high power of today's rapidly expanding computer processors, essential to meet the demands of today's modern telecommunications systems.

Although systems with superficial similarities were available in the past, IMUX offers much higher throughput, adaptable processing to conserve transmission bandwidth, and much lower cost. With the OMEGA software, the system is capable of processing the data in real time for monitoring data validity during recording, and is able to process the recorded data files without demultiplexing if desired. This allays the cost of expensive ground station equipment in many applications.

DATA DRIVEN PROCESSING FOR EFFICIENT RECORDING

In satellite applications the lines of communications between ground stations and the flotillas of orbiting satellites have to function 24 hours a day. Contemporary multiplexing systems must have higher data storage capacities, a more efficient means of transferring the data to tape, and more media options (CD, tape, RAID, et al.).

Prior to a recent procurement, a major launch vehicle and satellite contractor was spending large amounts of money ($30K a week) and labor on analog tapes with a twenty-minute tape capacity. Long-term recording was an expensive and high-maintenance operation. The subsequent transition to digital tapes with eight-hour recording capacity means 24 times the storage capacity at a fraction of the cost, and a more self-sustained multiplexing and recording environment.

One of the biggest discriminators between an Analog recording system and a digital recording system is that a digital system is capable of incremental motion. The job of today's multiplexer is to ensure that it preserves this capability. To meet the demand of extended recording periods, multiplexer systems should record only when data is presented to the system.

Among the features that distinguish IMUX is its very efficient use of tape bandwidth. The satellite control community for example absorbs data from numerous satellites, which means they frequently switch from one satellite to another. This can involve numerous clock rate changes. If a clock rate for a particular satellite is one megahertz and they switch to another clocking in at 500 kilohertz, the IMUX will automatically adjust to the new rate. If competing systems didn't recognize the rate change, they would continue clocking in at the faster speed and make up for the additional space with fill words, which would result in a lot of wasted tape. IMUX will adjust to the new rate to accept the input data. No fill words need to be added to IMUX channels to allow the system to run synchronously when reconstructing a stream. Fill words are an inefficient use of tape bandwidth because data is being inserted on top of actual measurements.

QUICK AND EASY ACCESS TO DATA

As the transition continues with digital recorders replacing analog recorders, one of the greatest benefits the user community will realize is the wide-ranging means in which the recorded data can be accessed. No longer is it necessary to play data back through analysis hardware. Provided that the multiplexer designer has developed data structures, which can be easily manipulated, the data can be accessed and analyzed by basic computing systems.

IMUX incorporates a computer readable tape format designed to provide immediate access to data and simultaneous distribution of the data within telecommunications networks. With most other systems, the tape can only be played back through the ground station system. This means sending the data through the demultiplexer, and routing the channels through decommutators and other native format analysis tools. With IMUX conversely, the tape recorder hooks into any commercial-off-the-shelf workstation where the decommutation and analysis can be done in a purely software environment.

With the addition of OMEGA Toolkit, end users will be able to read the tape and generate all the reconstruction timing necessary to display the recorded information at their own computer. The data structures are put on the tape in such a way that the data is written to the tape as it's received. The software is capable of determining for example, that a particular 1553 message occurred before an ARINC message, or vice versa, by looking at the tape. There isn't a block of 1553 and a block of ARINC and now you've got to figure out how they shuffle back together. It's absolute time coherency. The structures are friendly and easily manipulated by users of typical data processing systems.

USER FRIENDLY/AUTOMATED MULTIPLEXER CONTROL

One of the biggest challenges with multiplexer and recorder systems is the requirement for a man machine interface that provides the user with all the functionality required to operate the system. This interface should provide recorder control capabilities as well as multiplexer control in a project-oriented environment.

Hosted on a Sun workstation, a HP workstation, or on a PC running Windows NT™, the IMUX GUI interface provides quick-look, point-and-click displays for recording. The status display screens will indicate recording in progress, which channels are active, time and footage used, remaining tape, indications of successful recording for each channel, as well as the multiplexed stream, tape search parameters, and system health and fault state. The GUI provides substantial visual feedback to the user and continuous displays for set-up and control functions (VCR-type controls and radio buttons for configuration) and monitoring the status of the system, the tape recorder, and the input modules.

Furthermore, to avoid critical recording errors or tapes running out in the middle of the launch, the IMUX GUI has the

ability to “Ping-Pong” between two recorders. The way this mechanism is controlled is through a user generated strategy file. In this file, the user can define which recorder is recording, what system conditions the GUI should switch to a different recorder, and what user alerts are provided in each case. The way the IMUXs are configured, the first recorder will start; with the second unit automatically placed in a "ready state" awaiting a command to start. When the end of the first tape is approached, the first recorder will send a command to the second recorder to begin, with a window of duplicate recording provided during this critical transition. When the end of the first tape is reached, the first recorder will be stopped and a new tape loaded. Another IMUX system will serve as a hot spare to provide an additional level of redundancy. All of this will be controlled from a workstation.

Of course, not all configurations will support a full blown workstation for multiplexer and recorder control. Consider flight testing. In this environment, where tape space is at a premium, often times there is not enough room for a control station and/or a control operator. In these cases, it is necessary for the multiplexer and recorder to operate autonomously. The IMUX has a built-in autonomous mode of operation that can be enabled prior to integrating the system into the aircraft. Once this mode is enabled, the multiplexer and recorder will power-on and begin recording data immediately with no user intervention. While this satisfies most of the applications there are instances where the user wants some control of the record function. For this, the IMUX can be equipped with a “Record/Pause” switch. This allows the user to pause the system whenever desired. This saves valuable tape capacity in an environment no conducive to replacing the recording medium.

ADAPTABILITY TO DIFFERENT RECORDING DEVICES

Since each user has different requirements dictated by cost, data rates, media needs, and recording environment today’s multiplexer must be capable of operating with a wide range of recording devices. It is also imperative that the functionality across all recorders is maintained. As an example, searching data based on time-of-day is a capability some recorders provide inherently. Others do not. In all cases, this is a feature that users want and rely on. The IMUX provides this basic functionality across all the recorders it has been integrated with. In some cases, inherent recorder functions are accessed and in other cases the mechanism has been designed into the multiplexer.

In one particular application the user had requirements for a system in an environment not suited for a tape based system, but needed to maintain the ability to remove the media. This user chose the IMUX coupled with a ruggedized optical recorder. The system was integrated into the U.S. Navy’s shipboard telemetry receiving system. Once in-place, this system will collect real-time data from intercept missiles and enable post mission relay of the data to land-based installations via military satellites. The system has been configured to provide high-speed multiplexing, demultiplexing, and recording of multiple data input sources to removable optical media. With shipboard conditions, for example, the attendant humidity, condensation, and vibration can degrade the recording process of conventional rotary-head tape devices.

Using laser technology, the internally shock mounted optical disk drive keeps recording despite the elements and ensures the integrity of the data under the most rigorous conditions. These particular systems are controlled via an RS-232 link with any standard personal computer capable of running Windows™ software. The independent PCM input and output modules can operate simultaneously to provide real-time record feed-through operation.

CONCLUSION

While it would be an overstatement to say that the migration to digital multiplexing and recording technology is the death knell for analog equipment, the days of analyzing digital tapes using the tools developed for analog recorders are behind us thanks to IMUX. In support of this transition, the IMUX provides a system poised to provide users with a cost effective, integrated multiplexer/recorder system complete with analysis tools and user control interfaces. New applications have emerged as a result of this transition from a hybrid operation to purely digital systems, with their attendant increase in storage capacity, flexibility in media storage options, quick and easy access to data, and adaptability to the most rigorous environments. Most notable are commercial and defense satellite communications systems, data routing and distribution networks, remote tracking and data transmission, and other modern data acquisition systems.