COMBINING GPS AND PACKETIZED TELEMETRY CONCEPTS TO FORM A WIDE AREA DATA MULTIPLEX SYSTEM

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ABSTRACT

As testing requirements on the ranges require ever more sophisticated cross correlation of data from multiple data acquisition sources, it becomes increasingly advantageous to collect and disseminate this information in a more network oriented fashion. This allows any of the data collected at physically separated sites to be used simultaneously at multiple mission control or data reduction centers. This paper presents an approach that maximizes the use of legacy communication paths and data reduction systems to support an evolutionary migration toward the day when testing can take full advantage of commercial communication protocols and equipment such as OC-3, ATM, etc. One key element of this approach is the packetizing of data at each reception point to provide virtual circuit switching using packet routing. Based on the newly adopted IRIG/RCC 107-98 standard, the system may even be expanded all the way back to the actual sensors. The second key element is the use of the readily available time and timing pulses based on GPS to establish a uniform sampling interval that will allow the cross correlation of data received at different points spread over a wide area.

KEY WORDS

Wide Area Multiplexer, Data Cross Correlation, Packetized Telemetry, Global Positioning System, Multiplexer/Demultiplexer.

INTRODUCTION

This paper addresses the problem of collecting telemetry and other test range information from multiple tracking sites and providing the ability to disseminate this data to multiple reduction and control centers without the need to implement a zero based solution. In the case where there are multiple telemetry down links of various forms (PCM, FM, 1553), a data distribution system must be capable of handling a wide range of applications without the need to reconfigure. An intelligent or adaptive system would seem in order.

An additional requirement to be addressed is the need to establish and preserve timing information to facilitate cross correlation of the data sets. In order to accommodate existing telemeters that do not provide embedded time data, or where there is no correlation to source timing, a time of receipt stamp provides this minimum capability. However, to support legacy systems of data display and reduction that will receive multiple data sets, a mechanism must be established that permits reconstruction of the original data streams with their data aligned as received.

This mechanism must be capable of being sustained over a variety of existing and future links between the acquisition sites and the control center. Hardwire, fiber, microwave and commercial carrier links each present unique transmission requirements and delay environments. Lastly, the system must be able to provide filtering of unused data sets and the collection of the resulting data into a single stream from which multiple reduction and control facilities can pick and choose.

In summary, this paper addresses the need to construct a Wide Area Data Multiplex system that links existing acquisition systems, transmission links and end user systems with a minimum of impact on those systems.

DESIGN GOALS

Time Tagging

At each acquisition site, each data stream should be capable of adding time of receipt information to the data. This should be done in a standard way that will allow the maximum use of this information. With cross correlation of data being a key requirement of the system, both for computer ingest reduction and real time strip charting for example, it may be more important to establish a universal reference interval and time tag the data at that marker rather than at each individual data set boundary which can be widely separated, both in time and repetition rate.

Grouping Data Into Time Slots

By transmitting data in groups that correspond to this Sample Interval marker, stream to stream time skew can be minimized at the end system's reconstruction process, thus preserving the cross correlation of data.

Expandability

To the greatest extent possible, the system should not preclude the inclusion of future data types by designing a system based only on current requirements. The system must be a data transport system, decoupled of pre- and post-processing requirements. Likewise, the type of link between acquisition stations and the collector or concentrator site must not be required to be a specific type. This will allow use of existing link facilities as well as permitting future upgrades to be optimized per the new requirements. This applies to the final distribution link of the composite data as well. It should support more paths and higher data rates as required. This link must be readily upgradable without the need to rework the entire system.

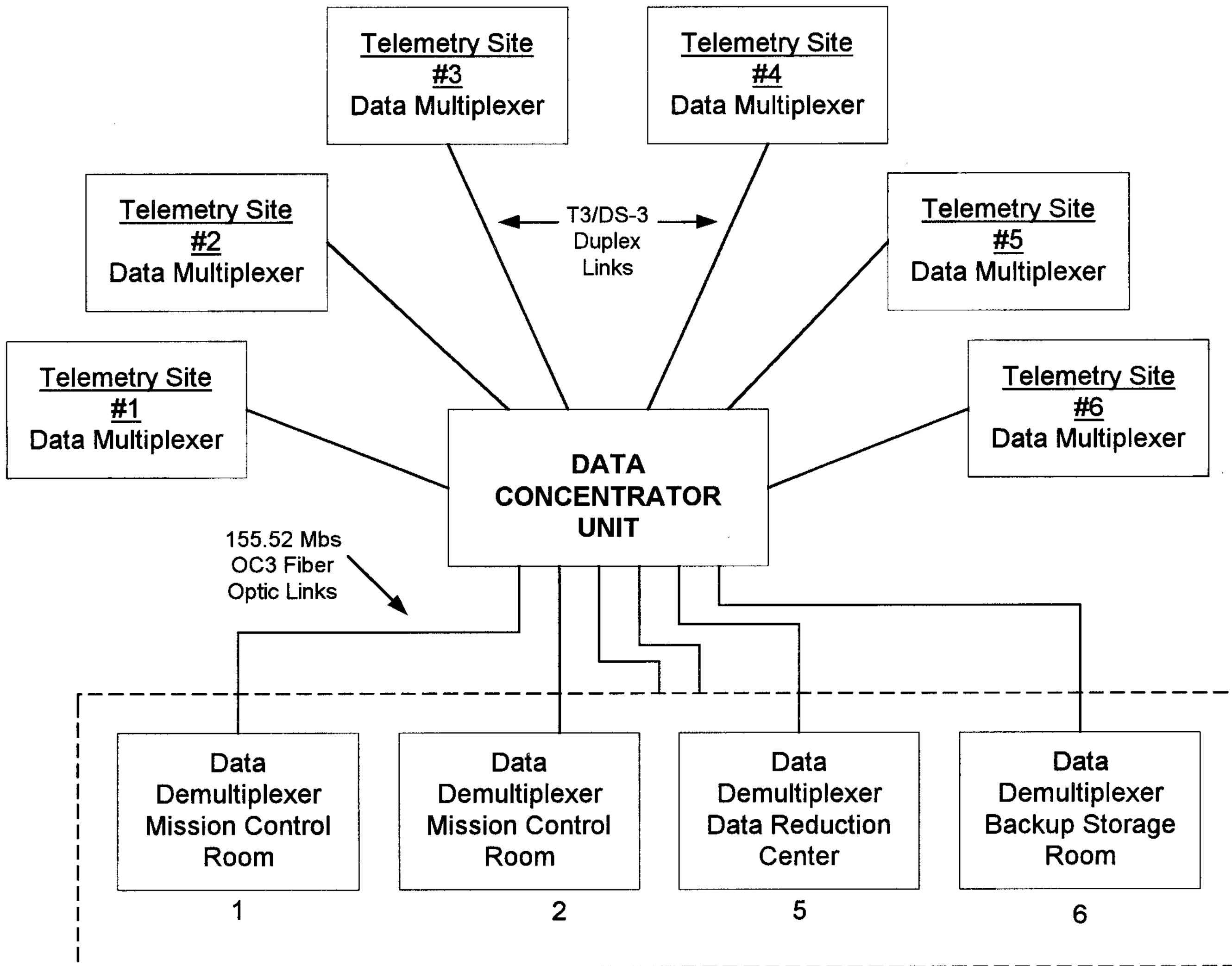
Use of Standards

The two existing standards applicable to this system are GPS timing and Packetized Telemetry Data transport techniques. The GPS System provides uniform time data and timing pulses to the globe and certainly meets the wide area criteria. GPS equipment is inexpensive and expansive. It can be found at almost every acquisition site either as equipment directly available or as the source of IRIG Standard timing signals used at the site. In fact, the most widely used timing form, IRIG-B, is based on a 1KHz carrier that can function nicely as a Sample Interval. A period of 1-2 milliseconds is a generally acceptable system throughput delay for both data and range safety.

Packet Telemetry techniques are based on the CCSDS recommendation [1] and have been successfully used to transport a variety of data types over a variety of communication circuits. The RCC107-98 standard [3] adopted this technique for use in newer generation airborne record systems and permits CPU ingest or data signal reconstruct. It has also been used in high rate record systems for NASA to support orbital and sounding rocket programs. As illustrated in Ref. [2] Packet Telemetry Services, CCSDS 103.0-B-1, as long as data can be placed into digital form, Packetized Telemetry techniques can be an effective transport mechanism.

SYSTEM DESIGN

Figure 1 presents an overview of a straightforward star configuration. Others are possible, but this paper will detail the operation of this system. At each acquisition site, several types and quantities of inputs are accepted. As each data is received, it is placed into a ping-pong type of buffer. A typical approach might have been to align the data format with the buffer and transmit the data at the end of each data frame. Rather than use such a Buffered Service model [2], this system design is required to time align all the different input formats and signals. To do this, the buffer is filled and emptied as controlled by the system's Sample Interval (1 ms.). Thus the first data in all the buffers are time aligned and if the Sample Interval is GPS based, ALL the data sets across the Wide Area are time aligned. Therefore, each millisecond the system is transporting the data received from all the sources allowing for cross correlated reconstruction. To support computer ingest and



NEW RANGE COMMUNICATION NETWORK FOR FLIGHT TEST TELEMETRY DATA

FIGURE 1

reduction, each packetized sample can be tagged with the time of the Sample Interval to one of three resolutions according the CCSDS recommendations [4].

Now that all the data has been encapsulated into a Source Packet [1] (whose length is determined by each input's data quantity per millisecond), these packets can be collected into a Transfer Frame [1]. The purpose of the Transfer Frame is to establish an easily transmitted data format that can be applied to a wide number of transmission medium. To accomplish this, the Transfer Frame format is fixed, its bit rate is fixed and its length is fixed. Transfer Frames are transmitted in a synchronous manner. Thus, as the input bit rates change from mission to mission, or sources go on and off line, there is no operator intervention required as the Transfer Frame generator can dynamically insert and delete fill packets to make up for unused link bandwidth. Typically a Transfer Frame can be serialized as an 8192 bit frame with 32 bit sync marker.

Since the Transfer Frame includes Fill data as required, there is no connection between the input data rates and the transmission link, other than sufficient link bandwidth must be available to handle the maximum data rate of all the active channels. This transfer frame data can then be randomized for microwave radio, fiber optics, or hardware transmission. It can also be placed as payload data in DS1/DS3 or HSSI frames, ATM and OC3 communication links. At reasonably low rates, it can be cost-effectively transmitted by an Inverse Multiplexer over ‘n’T1 links [5].

The next element of the system is a data concentrator. This accepts multiple site link inputs, then buffers and aligns the data based on the Sample Interval. Each source packet received from the various sites contain an identifier field which defines what input port supplied the data. Additional information is available in the Transfer Frame header which contains a ‘spacecraft ID’ field useable as a site identifier. By using both of these fields a data concentrator can implement a pass/drop decision on the arriving data. Data to be passed can be reassigned a new source packet ID and then combined with data from other sites into a new, single Transfer Frame for distribution to the end user sites. The end processors can base process/drop decisions on the new IDs. This provides the data concentrator function with a mechanism to provide data routing when other system topologies are implemented.

Through all this, each element buffers and operates on data sets of the same millisecond period.

The final element of the system receives a copy of the concentrated data. It is programmed to route selected data to its output reconstruct ports. Each port operates a ping-pong buffer technique similar to the input multiplexer. While one set of source packets are being sequentially loaded into each of the buffers, the output sections are outputting smoothed, original rate, channel-to-channel aligned data.

An interesting fall out of this approach occurs when a data recorder interface is added to this unit. All the live traffic can be captured to a disk or tape recorder and subsequently replayed. If the replay is designed to reconstruct the bus transfers accurately, playback will be indistinguishable from real time operations. Besides providing a backup capability, simulations and training exercises based on actual data can be performed.

CONCLUSION

It has been shown that a wide area multiplexing system can readily be implemented that will accept a wide range of data types since no decomposition of the individual streams is required. The system is based on proven practice and technology readily available. Transfer frames have been successfully used with and on a variety of links and recording devices [6]. Data reconstruction after each transmission is currently in wide application of equipment at the test ranges producing a smooth output PCM stream without loss of bit count integrity. Bandwidth efficiencies of 95% to 97% are typically achieved using these techniques. By designing the system within a modular approach that approximates the layered OSI/CCSDS/IRIG 107-98 architecture models with individual printed circuit modules, a cost effective system is realized that can be tailored to work with existing acquisition, transmission and data reduction equipment.

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