THE COMMON ELEMENT APPROACH TO TELEMETRY PROCESSING SYSTEMS

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Summary This paper postulates a complete computerized telemetry processing system which has only one basic hardware module as the system building block. A discussion of the technology incorporated in the system and its effect on systems cost and complexity is included.

Introduction Traditionally the computerized telemetry processing system has been configured from a myriad host of special purpose black boxes, programmable devices and general purpose computers. Inherent in a heterogeneous mixture of hardware such as this is at least a subset of the following problems:

- Systems maintenance responsibility
- Cost of system maintenance
- Training of new personnel
- Cost and time involved with software development on multiple hardware units
- Systems mean-time-to-repair Lack of systems flexibility

The capability, achievable within the state-of-the-art, to configure a system in which the basic hardware module is the keystone element satisfying every functional requirement should alleviate most, if got all of the above problems.

The paper defines basic functional requirements, discusses the attributes the basic hardware module must have, demonstrates that the functional requirements may be allocated to versions of the basic hardware module.

Discussion Currently most (1,2) telemetry system architects are advocating the use of microprogrammable processors as the general purpose central processing computers in a system.

At least two authors (3,4) have analyzed the use of microprogrammable processors to replace special purpose units in telemetry configurations. Without addressing specific architectural shortcomings, it suffices to say that the conclusions drawn in this respect have done little to solve the problems stated in the introduction of this paper.

However, the way has been pointed, I feel, to the solution of the problem. Several systems, among them theSamtec Telemetry Decom Validation System (TDVS) (5) have successfully utilized the microprogrammable processor in several functional areas.

FUNCTIONAL DESCRIPTION This section of the paper will depict a typical computerized telemetry system for PCM data acquisition and processing. This hypothetical system synchronizes incoming data, executes algorithms against the data and sends the data to a general purpose computer for further software analysis, display, and recording. Each of these functions will be described briefly, setting forth the requirements and thus the specifications for our "Common Element" system.

Synchronization The synchronization capability for this systems discussion will be limited to word, mainframe, masterframe, and multiple (up to 4) asynchronous subframe synchronization.

At the current time, the author is not aware of any attempt in the industry to accomplish bit synchronization in any unit other than one specifically designed for this task.

The strategy used in the sync-function should be fully programmable and if possible, be of an adaptive "Best in Frame" strategy. As a minimum, all IRIG standards should be satisfied by the synchronization logic in the system.

Decommutation The functional capability must exist to decommutate the incoming data according to IRIG standards. The current standards make it imperative that word sizes be variable on a word to word basis from 4 to 64 bits. Because of the incompatibility of computer single precision word sizes with the maximum telemetry word length (64 bits), the capability must exist in the system to syllablize the data words (i.e., dissect a word into more manageable lengths).

Algorithm. Processing The system should have the capability to execute algorithms at the incoming word rate. This programmable capability would be utilized to edit and apply an engineering unit conversion or to compress the data using varying techniques such as zero order prediction.

General Purpose Computational Facility The last major hardware functional unit in our system is the general purpose computer. This device is used to control and load the other functional units in the system, execute analysis software in support of data reduction tasks, and record and/or display the data.

This then is the list of functional units necessary to satisfy the requirements of our system:

- Synchronization unit
- Decommutation unit
- Algorithm unit
- Computational unit

Figure 1 depicts a typical configuration.

Basic Telemetry Unit Now I feel we have enough information to establish the baseline specifications for the basic hardware module that is to be the keystone building block for the system. From this point on I shall refer to this module as the BTU (Basic Telemetry Unit).

The BTU must be a programmable device occupying a minimum amount of rack/floor space because of the potential number of them in a system.

The BTU must be an extremely high speed device to cope with the current 2.0+ mega bit data rates. The speed necessary is a function of basic word size and the telemetry word size. For example: An 8-bit machine processing a high-low limit check on 10-bit data values must access his memory two times the frequency at which a 16-bit machine must. Pugsley, in his paper on microprogrammable telemetry processors (3), showed that a minimum speed of 200 nanoseconds per instruction was necessary for even the most menial task.

The BTU must have the hardware assists necessary to compensate for those functions that must occur at a frequency greater than the bit rate. The decision to describe this capability as a hardware assist was made after a market study analyzed the feasibility of a cost effective sub 100 nanosecond standard processor. It was determined that the addition of a few hardware boards to the basic hardware unit was technically and economically sound.

The BTU must have a simplistic, fast method of BTU to BTU communication for data and control. There are three methods currently utilized in the industry that satisfy this specification; a data bus (6) or common memory modules (5), or a combination of both.

The BTU must be capable of executing a general purpose computer instruction set.

The above is, in reality, a general subset of the complete specifications for a BTU but will suffice for this document.

APPLICATIONS TAILORING The hardware assist which I specified earlier I refer to as the Applications Tailoring of a general purpose microprogrammable processor. Control Data Corporation has been very successful in utilizing this technique in the development of special function hardware (5), as well as peripheral and communications controllers.

Basically the method involves the integration of special purpose hardware boards into the chassis and the backplane of the general purpose processor. The one constraint on the BTU is that its design is in consonance with this philosophy i.e., the internal bus structure, etc., is readily available for interfacing.

THE SYSTEM Keeping in mind the functional units required in our system and the data rates that they must operate at, the configuration in Figure 2 is a conservative approach.

Each of the three functional units is built from a BTU. One of the units must have applications tailoring. A second unit may also need the hardware assist depending on whether floating point (real) computation is desired.

The formatting synchronization unit has hardware assists for those functions that occur at a frequency greater than one syllable/word time. As a minimum these functions consist of serial to parallel conversion, mainframe pattern digital correlation, MSB to LSB conversion, word synchronization (if required) and parity checking. The firmware in the BTU controls the action of the hardware assists, controls the memory list structure, routes data to other systems units and performs all of the strategy associated with main, master, and subframe synchronization.

All communication between this BTU and subsequent BTUs is through common memory and an interrupt bus structure.

The next functional unit in our system is the algorithm unit. This unit may optionally utilize hardware assists in the area of floating point Ax+b hardware for polynomial expansions of telemetry data.

Basically this unit performs one or a series of algorithmic operations on the incoming data. Typically these algorithms are compression, limit check or engineering units conversion.

The last functional unit in the string is BTU number three which has its function the execution of a general purpose computer instruction set. This unit performs the remaining tasks defined for the system such as data reduction and analysis.

SUMMARY The system depicted in this paper would be constructed of MOS memory modules, three standard microprogrammable processors, approximately 5 special purpose printed circuit boards, peripherals, and fit into two standard RETMA racks.

The basic premise of this paper was that a telemetry system constructed with a common element as the basis for the various functional units should alleviate the typical systems problems in an operational environment. Let's discuss each identified problem and determine the "Common Element" effect on them.

Systems Maintenance (Cost, Responsibility, MTTR) These problems are solved by the reduction of logistics support required in the way of spare parts, training, and having one single supplier for the whole system. Since all of the BTU's are identical, sparing of different card types is kept to a minimum, people are familiar with the total hardware system thus decreasing MTTR and therefore real cost.

Since the BTU's are a standard off-the-shelf product, all of those maintenance problems attendant to one-of -a-kind black boxes are missing.

Software (Cost, Responsiveness) The off-the-shelf nature of the BTU assumes a large software product support base, thus lessening the amount of software to develop.

Programmers need only be trained in one language on one machine architecture. Proper firmware development could lead to the generation of one set of common routines to perform the basic functions for each functional unit.

Flexibility Since the BTU is a programmable device, all of the functional units in the system are inherently flexible. The advent of read/write micromemory allows the capability to change firmware as easily as software.

The state-of-the-art memory technology typically allows the addition of processors to memory modules thus allowing horizontal growth (i.e., dual stream operation, etc.) necessary to achieve systems flexibility and growth.

Conclusion The "Common Element" approach shows definite potential for the reduction of costs and complexities inherent in the modern high rate telemetry processing system.

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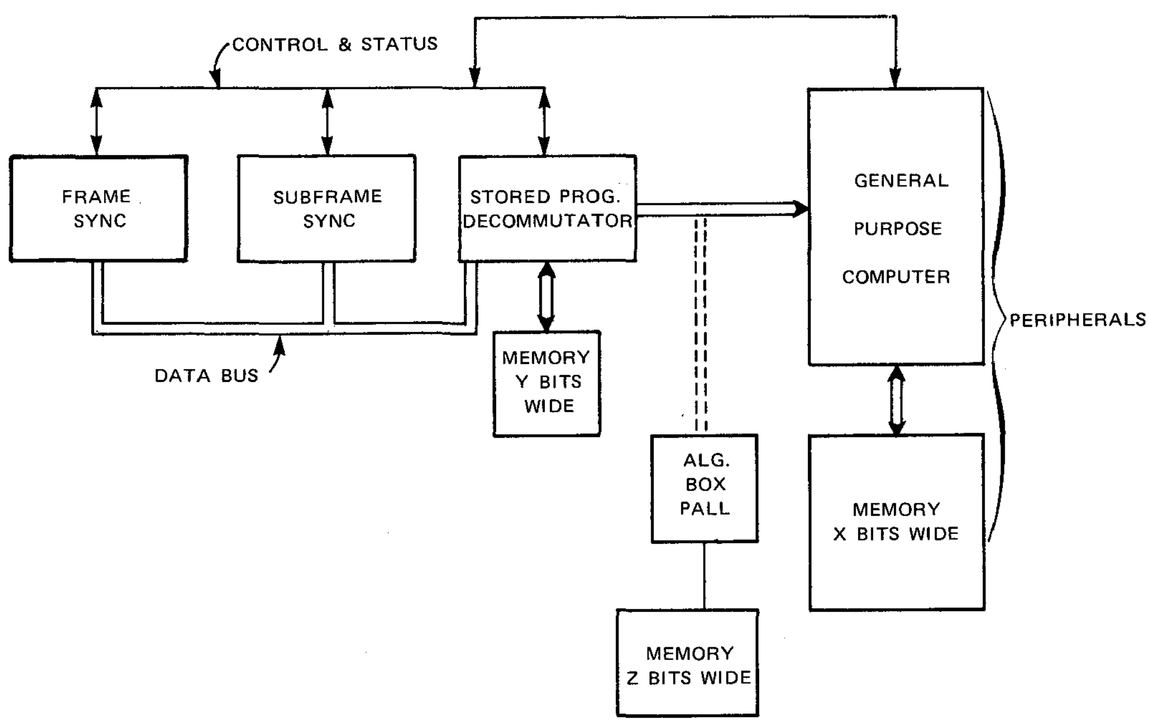

FIGURE 1.

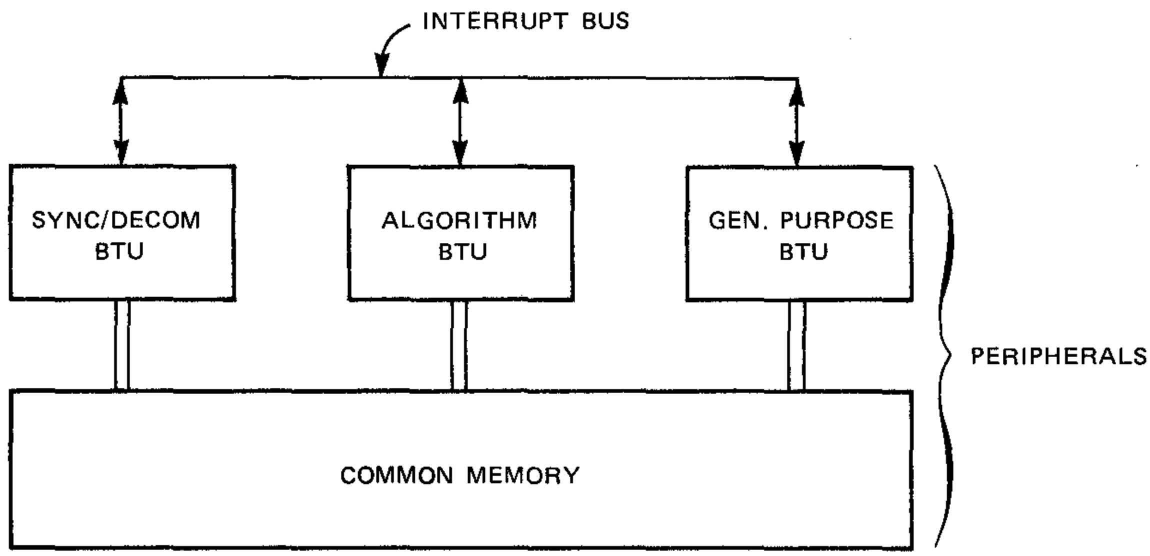
INTERRUPT BUS
SYNC/DECOM
BTU
ALGORITHM
BTU
GEN. PURPOSE
BTU
PERIPHERALS
COMMON MEMORY

FIGURE 2.