DWS.

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DELTA COMPUTER MEMO NO. 17

Subject: Block Data Transfer

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The problem of transferring a block or a large number of words of information from one location in memory to another location in memory is one of considerable importance. Within the STRETCH concept, the problem has been reduced in magnitude as far as transferring blocks of data for processing by providing an almost unrestricted quantity of memory spaces and extreme flexibility for address modification which includes indexing and indirect addressing.

The importance of Block Data Transfer is sustained by the fact that memories of three basic speeds are provided, namely the 2.0 us, 0.5 us and 0.2 us memories. Preliminary analysis of machine operating characteristics indicates that to maintain a high degree of machine efficiency instructions and important factors should be contained within the higher speed 0.5 us and 0.2 us memories which are also the lower capacity memories (fewer words of storage). The data to be operated upon as well as the areas for input, output, and editing are assumed to occupy the bulk, 2.0 us memory.

Program instructions must presumably enter the computer from some input device, be it tapes, ram or cards, etc., which would put program instructions in the large 2.0 us memory. When the program is to be executed, it may be desirable to transfer the program to the higher speed memory to increase the computer operating efficiency.

One reason why it may not be desirable to Block Transfer the program to the higher speed memory is that the process of Block Transferring may cost more, or take more time than the time lost by the inefficiency incurred in executing the program instructions from the bulk storage. Any Block Data Transfer method provided must be fast enough so that the Block Data Transfer time is a fraction of the difference in time of program execution when calculated for the high capacity and high speed memory areas, or the process of Block Data Transfer must be accomplished at the same time the Computer is productively occupied.

Different techniques of accomplishing a Block Data Transfer were considered and analyzed with regard to the requirements already mentioned and are summarized as a part of this memo. None of the methods considered had distinct advantages and almost all had distinct disadvantages. The technique for effecting a Block Data Transfer presently favored is a compromise of a method that is reasonable although by itself, insufficient to fulfill the requirements stipulated. The effectiveness of the method can be increased to the point where substantial advantage can be realized if the method if combined with proper programming and the two computers of system made to work together efficiently.

The method of Block Data Transfer suggested is the technique of programming the Delta Computer to transfer data a word at a time utilizing the streaming features of the Delta Computer. The size of the block of data to be transferred may exceed the built-in limits of streaming, in which case, the Computer would transfer stream limited size blocks per each instruction and the number of actual instructions involved would be dependent upon the ratio of the sizes of the stream limit and the desired transfer block, once the streaming type operation had been set up. Implied in the statements made is the concept that the high speed memory should be split logically meaning that as Sigma is executing instructions from one section of the high speed memory, the Delta Computer can be block transferring data or instructions to another section of the high speed memory.

This scheme of bringing about a Block Data Transfer has the distinct advantage of costing nothing additional in hardward since the streaming facility is already considered for other types of operations. Some effort will be required to arrange programs properly and to organize a system so that the two computers will work harmoniously to realize a maximum efficiency.

The different schemes for bringing about a Block Data Transfer that were considered include:

1) Data transfer through the Exchange unit simulating a combined out put, input operation with no peripheral unit involved.

2) Effective data transfer by logically altering addresses on memory boxes without actually handling the data.

3) Data Transfer through a streaming type operation under control of the Delta Computer.

4) Data Transfer by automatic action of the memories, the memory control system and busses when specifically instructed or assigned by a computer.

Some of the characteristics of each of the considered systems will be listed to present the case for substantiating the recommendations of this memo.

1) Block Data Transfer through the Exchange unit immediately brings about the realization that if any high speed input-output operation is in progress the data transfer execution must be deferred, secondly if the Exchange is able to execute a data transfer assignment the time per Exchange transferral per word might be in the order of magnitude of 54 us which is grossly inadequate for the need specifying block data transfer. The time per word transferral can be reduced if special provision and circuitry is made in the Exchange at the cost of restricting or limiting the Exchange's capability of handling other input-output devices.

2) Altering the addresses of memory boxes seems at first to be an excellent approach to solving the problem of block data transfer, but when the following list of items is considered thoughtfully, enthusiasm for the method wanes.

   a) The prime reason for wanting block data transfer is to move data into a faster memory, if data is in a 2.0 us memory, changing the address of the memory box still leaves the data in a 2.0 us memory.

   b) The address of a block cannot be changed unless the block is equal in size to a memory box (the smallest physical memory unit) since only the box distinction and not the entities within a box are capable of being altered.

   c) The concept of interleaving word addresses between four memory boxes to reduce effective access time must be discarded or at least four memory boxes must have their designation altered implying that many addresses must be altered beyond the range of limits of the block of data.

   d) The address changing since it can affect only the box entity restricts data transfer to a one to one address relationship, and not a truly versatile address change e.g., something like 04 091 changed to 12 091 will be permissible but 04 091 cannot be changed to 12 187.

3) The streaming method of realizing a block data transfer has been discussed to some extent. However, in summary, it can be stated that the technique by itself is inadequate, but combined with programming, it can be made to do reasonably well.

The cost of hardware is negligible since the streaming facilities have been defined for other applications. It may be considered that the block data transfer operation is an argument to substantiate the streaming facilities presently defined for the Delta Computer.

4) Data Transfer by automatic action of the memories upon assignment by a computer implies an extremely costly and complex control system being built into the memory and bus control system. Some of the characteristics of the system are implied by listing a few of the problems to be met, solved and controlled.

a) The system must have the facility to control data flow over the bus system, interpreting priorities and suspending data transfer cycles when a higher priority is identified (I/O).

b) The system must be capable of starting at any address and advancing addresses through successive memory positions terminating on either a count exhaustion or final address comparison. The starting at any address and advancing must be provided and controlled for both of the two memory locations.

c) Specific protection must be provided against block data transfer operations within the same section or same box of memory. (Cannot come out of one box of memory and re-enter the data into the same box in a different position).

d) To prevent loss of computer efficiency the system might have the ability to interleave computer references to memory with block data transfer references or else suppress one or the other when requests for references arrive concurrently.

e) The system must have the ability to transfer data from memory operating at a different rate of speed. Three modes of operation are possible where speed of $A < B$, $A = B$, and $A > B$ implying extensive control and logic.