J E Griffi

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Exchange Memo # 16 COMPANY CONFIDENTIAL

Subject: Increasing Simultaneous Operation in the Exchange

By: R. P. Fletcher

Exchange memo # 15 states that the Exchange provides 12 channels for simultaneous operation. Whether or not 12 channels is enough seems questionable at this time. In order to provide more simultaneous operation, or to allow for faster I/O units if more channels are not needed, the following modification has been incorporated into the Exchange.

Each medium speed input-output unit will have 2 dataword storage locations in Exchange memory instead of one as proposed previously. When word A is full, word B is used to assemble bytes; when word B is full, word A is used to assemble bytes. (For ease of explanation, only input operation is considered). The Exchange transfers the full dataword to main memory before the other word is full. Figuring 8 bytes per word and a rate of 40 used per byte, the Exchange has 320 usec to transfer the full word to main memory.

With the above modification the Exchange provides 20 channels for simultaneous operation. This figure was arrived at in the following manner. The worst timing condition the Exchange can get into occurs when all channels are busy and each channel requires a new control word during the same 320 usec. period. Although this condition will rarely occur, it must be considered. During the above worst condition the Exchange must execute the following operation for each byte channel.

1. Eight bytes must be transferred from the channel to the proper dataword in Exchange memory. With a 1 usec. memory this takes eight 1 usec. cycles for a total of 8 usec.

2. The full dataword must be transferred to main memory. This requires two 1 usec cycles in the Exchange; a cycle to read out the control word to obtain the main memory dataword address and a cycle to read out the dataword. Although these two cycles consume only 2 usec, additional time must be allowed for obtaining access to main memory. At present it looks like this will add between 1 and 2 usec, therefore, it will take a maximum of 4 usec. to transfer a dataword to main memory. This 4 usec. figure will be used until more is known about the timing relationship between the Exchange and the main memory.

3. A new control word must be transferred from main memory to Exchange memory. This operation is very similar to step 2 above and requires the same amount of time; 4 usec.

By adding the time in the above three steps it can be seen that 8 usec. + 4 usec. + 4 usec. or a total of 16 usec. must be spent on each channel during the 320 usec. period Thus, the Exchange can service a maximum of 20 byte channels.

If 4 of these channels are word type channels (as proposed for x10 tape), then the Exchange can service 22 channels This is because the 8 usec. of byte accumulation time is not needed in conjunction with each word channel because the byte accumulation is done at the input-output unit.

It should be pointed out that the above is the very worst case. In the majority of 320 usec periods only a few channels will need new control words and therefore there will be spare time in the 320 usec. period. This time is used by the Exchange to give attention to an instruction from the computer or to scan the Exchange memory for a unit that needs a channel.

To summarize; by adding 64 more words of storage to Exchange memory and possibly a few more controls, the capacity of the Exchange has been increased from 12 channels to 20 channels. If 20 channels do not provide enough simultaneous operation, then the following alternatives exist.

1. Increase the speed of the Exchange memory. This is not very feasible as this memory is already a .5 usec memory operating in a 1 usec cycle.

2. More parallel transfer of information between the input-output units and the Exchange. Unless this parallel transfer is increased to the point where no dataword accumulation is needed in the Exchange (full words transferred), there would be only a small increase in the number of channels. If the I/O units are required to send full words, then the dataword accumulation must be provided in each byte type I/O unit. This could be very expensive if there are many byte type units.

3. Faster transfer of words between the Exchange and main memory. Assuming that the two limiting factors are the main memory speed and gaining access to main memory, then the main memory would have to be a faster memory or a special section of the main memory reserved for the Exchange so that the Exchange does not have to wait for access.

4. A fourth alternative is to limit the speed of the input-output units. If more than 20 channels are necessary, then this may not be a great sacrifice.

Decreasing the speed of information transfer between the Exchange and the input-output units has the following effect. If bytes are transferred at a 25 KC rate (40 usec per byte), the Exchange can service 20 byte channels. If bytes are transferred at a 20KC rate (50 usec per byte), the Exchange can service 25 byte channels. If bytes are transferred at a 15KC rate (67 usec per byte), the Exchange can service 33 byte channels.