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Memorandum M-1407

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: WHIRLWIND II MEETING OF FEBRUARY 15, 1952

To: Whirlwind II Planning Group

From: N. H. Taylor and R. P. Mayer

Date: February 26, 1952

Members Present: D. Brown, R. Everett, J. Forrester, H. Grosch, W. Hosier, J. Hughes, J. Jacobs, R. Jeffrey, N. Jones, W. Linvill, R. Mayer, B. Morriss, W. Papian, N. Taylor.

N. H. Taylor opened the meeting with a discussion of WW I 1/2 and a review of M-1319. Whirlwind I 1/2 is to be a prototype for WW II, but since it will be a functioning computer and not just a modern version of the five-digit multiplier, we are calling it WW I 1/2. It should be as small as feasible and should be built in one year, but it should be big enough to test the proposed WW II logic and circuitry (switching, control, etc.) to see what we are up against. R. R. Everett has suggested that 12 binary digits would be a minimum number of digits per word. Since 16 bits is not much more, WW I 1/2 will probably have 16 bits because of the great advantage of matching WW I so that WW I 1/2 can be put to good use after it has provided the test data required. It should, however, be built so that more digits can be added easily if desired. (This may not be easy when control is involved.)

In order to simplify the problem of building equipment, it may be desirable to exchange time for equipment. This leads us to a single register computer such as discussed in M-1319. It may be desirable to use another register (making a 2-register machine), like WW I's Program Register, as a buffer between storage and everything else. (Since we are interested in obtaining data about storage, we should check storage thoroughly--perhaps using a parity check.)

The speed of operation of the one-register computer described in M-1319 was estimated as follows:

A mettalic-core memory with 10 μsec. access was assumed, although faster operation is expected. The ca order outlined in M-1319 was observed to require an access to storage on 8 of the 12 steps. Steps 2, 4, 7, and 9 1/2 would take 1 µsec. each. (Step 9 1/2 refers to the omitted step of setting SR to 0-1.) Thus, the time for ca would be 84 µsec. Orders like multiply would, of course, take considerably longer.

The remainder of the meeting was taken up mostly by a description and discussion of R. P. Mayer's suggestion for putting control in storage. The following discussion reviews the reasoning which led us to two conclusions:

1. The Control Switch should be separate from the Storage Switch.

2. The memory section containing the order decoding cores should also be separate but may use the same technique as the main memory.

The single register computer can be simplified by placing the control matrix in storage. When storage is read-out the result will be gated to the bus or to the command-pulse lines, depending on the function being performed. Thus, when a storage register is read out to the command-pulse lines, the presence of a "1" in any digit-column will cause the corresponding command to be performed. Each time-pulse of each order will be specified by its own register of storage, so that 32 kinds of orders each 10 time-pulses long would require 320 storage registers for the control matrix. Each register must have as many digits as the kinds of command-pulses required in the whole computer. This corresponds to the 120 CPO Units of WW I. Actually, WW I requires only about 60 command lines, and the single-register computer would require even fewer. R. R. Everett pointed out that the control matrix makes decisions in a 3-dimensional lattice:

Input 1. Order being performed. (ca, cs, ad, ts, ----)

Input 2. Time pulse being performed. (TP1, TP2, TP3, ----)

Output 3. Command required. (AC clear, AR clear, add, ES Write ---)

With the control matrix in storage, the full lattice is available, but there are ways of modifying the lattice. For instance, the WW I lattice has been modified and works as follows:

Any command is assumed to occur only at a specified time pulse and if some order requires it at some different time pulse, it must be built as an entirely new, different command. This is why the 60 commands of WW I actually require about 120 CPO Units. The lattice is thus only two dimensional: 1) Order, 2) Command.

It does not appear possible to compress the lattice in an additional dimension, but it can be compressed in slightly different ways from that used in WW I. Any of these compressions, however, reduce the flexibility available in designing new orders.

In order to make such a control method work rapidly enough, it would seem to be almost imperative to use a non-destructive read-out (assuming that this would require less time than a destructive read-out with the following necessary re-write). It would also seem desirable to use two storage switches, one for standard use and one for use as a control matrix selector. The control storage switch would receive the address of time pulse "one" of the order desired and would count along until a new address is inserted. If the control storage switch is designed to select any register in storage, then the programmer has complete flexibility concerning where in storage to locate the control matrix or any additional special orders he may desire.

N. H. Taylor pointed out that this method uses more storage-switch circuitry than necessary. This is undesirable because, although the storage elements themselves are quite cheap, the selection switches are relatively expensive. It was suggested, therefore, that if the general system is used at all the storage switch and control switch should not overlap. That is, the storage for the matrix should be entirely separate from that used for storage proper. An alternative method is to time-share the selection switch, so that two switch <u>registers</u> would be used to alternatively drive <u>one</u> decoding switch-matrix.

The remaining discussion was primarily concerned with the relative desirability of the above system.

H. R. Grosch pointed out that if the computer is to be special purpose with a single, known, program then there would be no need for a flexible control matrix. On the other hand, if the computer is to be completely general purpose, it may only be confusing to the programmer if the complete flexibility of the above system is allowed. He also pointed out that it would seem as though WW II falls between these two classes and that although it will be used for a rather specific purpose, the program is not now known so that the additional flexibility of the above system might be desirable. There is some question as to whether the above system should be used in WW I 1/2, but since WW I 1/2 is to be a prototype for WW II it should contain at least one order position of the control switch arranged to make use of this flexibility in order to help evaluate its usefulness.

R. R. Everett pointed out that as far as flexible operation for the computer is concerned, it is not sufficient to have a flexible control matrix, but it is even more important to have the remainder of the computer designed so that the possibly desirable commands can be performed (i.e., shifting, cyclic shifting, cyclic shifting among several registers, etc.). Once these various commands are built into the computer, it would be possible to design all the possible orders making use of these commands and if this does not result in an overwhelming number of orders, it might be desirable to build all these orders into the computer so that they will always be available instead of making it necessary for them to be read into storage each time they are desired.

It would be necessary, of course, to provide some special system for initially reading the control matrix, as well as the instructions, into storage.

In addition to the above consideration, and perhaps more important, it is necessary next to obtain the opinions of people who do programming as to whether this ability to change the nature of an order is of any real advantage. If the engineering group can instrumentize such a system by any of the above methods, we do not know whether such flexibility would do much good to a machine user. H. R. Grosch agreed to make a study to find out whether this idea would be of any use in the Air Defense job.

It was generally agreed that the design for WW I 1/2 should be frozen in two or three months so that an independent group could go to work and build the frozen design. Otherwise, with people getting new ideas, WW I 1/2 would drag on and on and not provide any of the information that is desired concerning how WW II should be built.

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