

STRETCH MEMO NO. 40

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Memory Word Length

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1. Introduction

The memory word length for STRETCH and LINK has been tentatively set at 60 bits, not counting whatever error detection and correction bits may be required. There are some sound arguments favoring this choice. There are also good reasons for considering a power of 2, such as 64 bits, as possibly a more appropriate choice. The purpose of this memo is to set down, for the record, considerations and questions which must be resolved to make a final choice of the memory word length. The present 60-bit word will be retained until further review.

2. 704 Experience

The 36-bit word of the 704 now appears to be too small for floating-point number representation (27-bit fraction, 8-bit exponent, and 1-bit sign). It appears that higher speed would, in any case, create a demand for longer word length, because, crudely speaking, round-off errors and overflow conditions tend to build up faster.

3. LINK and STRETCH

While the serial LINK Computer has some requirements of its own, including variable field length, its memory word length must clearly be identical with that of the high-speed parallel STRETCH Computer. Hence, both must be considered together.

4. Addressing

For table look-up and searching, it is advantageous to have not only binary word addressing, but also binary bit addressing. This implies a word length which is a power of 2, such as 64 bits. A 64-bit word would permit a completely binary address arithmetic.

With the current 60-bit words, it appears to be still possible to do these operations, but they require special modulo-15 address arithmetic and counters.

5. Input-Output

60 is a multiple of 1, 2, 3, 4, 5, and 6. Hence bytes of length from 1 to 6 bits can be packed efficiently into a 60-bit word without having to split a byte between one word and the next. If longer bytes were needed, 60 bits would, of course, no longer be ideal. With present applications, 1, 4, and 6 bits are the really important cases.

With 64-bit words, it would often be necessary to make some compromises, such as leaving 4 bits unused in a word when dealing with 6-bit bytes at the input and output. However, the LINK Computer can be equipped to edit out these gaps and to permit handling of bytes which are split between words.

6. Programming

When the length of a "stream" of information, such as a record, is not an integral number of memory words, it may sometimes be necessary to program address arithmetic modulo the word length. For instance, given the starting address and the length of a record, it may be desired to compute the final address.

With 64-bit words and the length expressed in bits, the address arithmetic is simply binary addition. With 60-bit words, one inevitably gets into mixed number systems. While this is not really difficult, it can be a source of confusion for the programmer.

7. Floating-Point Word Layout

Floating-point words may be divided in one of the following ways:

<u>Bits for Number</u>	<u>Bits for Exponent</u>	<u>Bits for Sign, Overflow, etc.</u>	<u>Total Bits</u>	<u>Comments</u>
48	10	2	60	Current proposal
44	12	4	60	Better for LINK with 60 bits
48	12	4	64	For 64 bits

LINK is expected to do serial arithmetic 4 bits at a time, so as to make decimal arithmetic compatible with binary. The second arrangement is preferable to the first because it keeps the exponent separate from the non-numeric sign digit on a 4-bits-at-a-time basis.

The 64-bit word, of course, permits more significant bits, and thus, it somewhat lessens the need to resort to multiple-precision arithmetic.

8. Memory Cost

Adding 4 bits to the word requires 4 more memory planes and associated equipment in each memory box. Although this is less than 6 per cent, the total cost of memory will be such as to make this amount a significant one.

9. Arithmetic Speed

The longer the word, the longer is the time to do arithmetic on the word, whether on a serial or parallel basis. The extra 4 bits will have some effect, though it is hard to predict how significant it will be.

10. Summary

The points may be summarized as follows:

(a) 60-bit words

Advantageous for input-output operations.
Some compromises needed for bit addressing.
No serious limitation known.

(b) 64-bit words

Advantageous for bit addressing and floating-point arithmetic.
Some compromises needed for input-output.
Some extra cost and, perhaps, a slight loss in speed.
No serious limitation known.

The "practical" reasons all favor the 60-bit word. The advantages of the 64-bit word are of the kind that appear more fundamental. The best that can be said for the 64-bit word is that "practical" considerations have a habit of disappearing in time. A better reason for making a change would be highly desirable.