

POUGHKEEPSIE

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February 4, 1958

MEMO TO: Mr. Rex Rice

SUBJECT: Machine Organization Theory

Purpose: You have asked me to comment in writing on the work of the Machine Organization Theory (MOT) Committee as outlined in your presentation of 31 January 1958. This memo contains my comments divided into three major headings. Ground Rules: Comments on Material Presented and Recommendations.

Ground Rules: Because of the responses certain oral comments of mine aroused at the 31 January meeting, I feel it is necessary to state explicitly the terms on which my comments are offered. If these ground rules are agreed to, I will stand behind my specific comments and recommendations; if not, I feel the comments will be useless, and I shall withdraw this memo.

1. My comments are directed only to the material outlined in the presentation. I do not propose to pass on the competence of the committee or to speculate on the ultimate significance of the work done. The fact that the committee has been at work only a short time and feels that disclosure of its work may have been somewhat premature arouses my sympathy, but that fact is entirely irrelevant to purpose of this memo. The comments are meant to be constructive in terms of the work the committee already has accomplished, and there is no need for a defensive response to criticisms.

2. My comments are directed, for the most part, to substantive matters, not merely to nomenclative. At the meeting I raised a question as to whether "Sets of Processing Logic" was not more appropriate than "Processing Logic" in the model. You asked, "Would you be satisfied if we changed the name in the block. . . . ?" While I believe that my proposed wording would be more realistic, the answer is, "No, I would not be satisfied with changing the name in the block unless there is also some re-thinking of the significance of the new terminology on all the relationships within the model." There is an implication in your question that all I am asking for is a change in nomenclature. This implication does not do my comment justice. I am not questioning a name in a block on a sheet of paper; I am questioning the concept that a uniquely-defined processing logic is an appropriate one if your model. If my comments in this memo result merely in some hasty chartmanship, they will be valueless.

3. Where I have raised a question, I am not obliged to provide an answer. At one point in the meeting, a comment of mine was met with an invitation to submit a proposal to the committee. It is clearly impossible for me to devote much time to developing alternative proposals while fulfilling my regularly assigned obligations. If the committee is not prepared to consider my suggestions seriously on this basis, it should either not invite them in the first place or it should take steps to have me assigned to their jurisdiction; it should not dismiss them by simply throwing them back at me. Under the present circumstances, I believe my obligation to the committee is limited to making my comments and recommendations clear, specific, and unequivocal.

Comments on Material Presented: In general, I am in agreement with the objectives of the MOT Committee. It can be immeasurably valuable to IBM to have a more precise understanding of the relationship between machine design and machine purpose. What has been presented thus far is a simple conceptual model of this relationship. This model has some weak points but also some very promising features. I will discuss both the weak and the strong points.

1. It is not clear how one obtains "Process Logic" from "Overall Process Requirements". Surely the logical portion of the overall requirements must be expressed in some language. If this be so, why not use the original expression, or a portion thereof, as "Process Logic"? But if a portion is to be used, how is it to be selected from the whole?

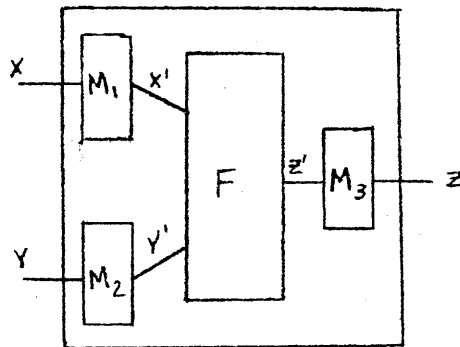
2. It is not clear how one makes the transformation from "Process Logic" to "Machine Logic". At one point it was suggested that there is a one-for-one relationship between process steps and machine functions. But such a relationship does not account for "housekeeping" functions. I understand the one-for-one relationship has since been abandoned in the model. This correction makes the model less inaccurate, but it does not answer the question of housekeeping instructions. A given set of processing logic certainly implies a fairly limited range of alternative machine logics for a given machine, but can it imply an objective logic to be used as a specification for machine design? To put it another way, how could it be determined within the model whether index registers are a desirable feature? And if so, how many? What combination of processing logic implies "load index registers"?

3. The notion of a heirarchy of instructions (a better term than "spectrum" in this case) seems to have fruitful implications. I presume that the function-vs.-time grid notation will be refined into a tool for use by machines in assisting designers. The possibility of automatically substituting lower-order functions for higher ones as more explicit statements are required is very desirable. If the means for doing this are as yet unformulated, at least the objective is clear.

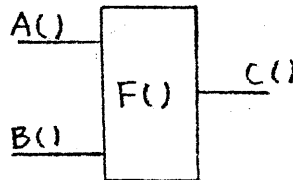
4. Similarly, the notion that "extraction" as an operation has a common meaning for taking a bit from a byte and for taking a record from a file (or other analogous operations) may prove to be a valuable generalization. In both cases a subset of information is removed from an inclusive set. Whether this generalization will be ultimately useful remains to be seen, but it is certainly worthwhile pursuing it further. Two problems occur to me in this area.

a. How do you distinguish "extract next record (whatever its ordinal number may be)" from "extract fourth record (or some other ordinally numbered record)"?

b. Is extraction really different in any way from other two-operand functions? In the diagram of a function you showed masks (or filters, or whatzits; it doesn't matter what you call them) between the combining block and the input and output lines, like this:



Yet the same result could be obtained simply by selecting suitable simple combining functions and extending the transformation over several sequential steps, like this:



1. $F_1 (A (x), B(M_1)) = C (x^1)$
2. $F_2 (A (y), B(M_2^1)) = C (y^1)$
3. $F_3 (A (x^1), B(y^1)) = C (Z^1)$
4. $F_4 (A (z^1), B(M_3)) = C (Z)$

Before adopting one or the other scheme some justification for the choice should be obtained.

5. It was pointed out that some method of evaluating the contents of the "System Synthesis" block is required. Presumably the contents of the block could be hypothetically transformed into dollars-of-machine-time-per-dollar-of-problem-value, or something like that. But then how do you know whether this evaluating function is at or near a minimum? In other words, what tells you that it pays to go around the loop again?

6. Even if you can tell that another iteration around the loop should be made, what do you do in the "feedback" path? By what transformation of "System Synthesis" or "dollars....per....dollar...." do you obtain a new set of "Process Logic"?

7. Granting that all these questions are worth pursuing, I wonder whether a Product Development Laboratory is the proper place for these investigations. By all means, certain phases of the whole job can best be handled by an engineer with machine design experience, and certain phases promise relatively quick return to the machine designer. These parts of the whole model could certainly be justified as a Product Development project in a forward-thinking direction. Other parts of the model require the efforts of a formal logician and a theoretical economist. The problem of a multi-dimensional utility function is quite similar to the one of evaluation of overall machine performance measured by several criteria. I would be surprised if a Product Development Laboratory could make a profound contribution here unaided.

8. Unless the investigation is directed toward categorically practical ends, it might die from oxygen starvation. I invite you to consider the sad fate of the method for describing business activity developed by Thomas Ress of the Systems Research Department. Ress' scheme is well thought out and seems to be complete, but in spite of an obvious need to reduce business activity to some objective language, nothing has been done to adapt the scheme and apply it to practical cases. I think that for one thing, his scheme suffers for being too all-inclusive. It would have had a better chance had it solved a limited but very pressing problem.

Recommendations: These recommendations summarize specifically what I would do if further direction of the MOT project were in my hands. They are fairly detailed because I do not believe in making equivocal recommendations. Obviously, I am not in a position to possess all the facts, so I do not expect that these recommendations will (or should be) followed precisely. The recommendations are based on the considerations outlined in the previous section, and I believe that any substantial departure from them will result in a waste of IBM's resources.

1. Management must agree that it is a proper project for a Product Development Laboratory.

2. Management must agree to spend at least \$50,000 (but certainly no more than \$100,000) per year on this project for about five years.

3. The next two months (and certainly no more than three months) will be spent by the committee in carrying the overall conceptual model as far as possible. After this period, all formal work on the overall model will end, although any individual who feels he has a hot idea in this area may be encouraged to develop it.

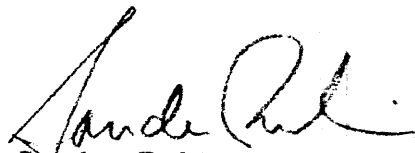
4. The model developed during this period will be evaluated to determine both its overall suitability and which parts show the most promise. The work will be published in an IBM Report and the Research Department will be invited to take over further development of the "big picture."

5. Those parts of the model which are most fully developed and which show the best chances for practical application will form the basis for further development effort (e. g. perhaps a method for cataloging diverse machine logics).

6. These efforts will be reviewed periodically and further work on an overall model taken up only when the work on the promising parts nears completion.

If you have read me properly, you will understand that I believe IBM should be active in MOT, but I am opposed to massive attacks on large problems. The patient methods of piecemeal research and engineering are the only ones economically justified. If we cannot first reach the limited objective of reducing the best-developed parts of the model to practice, we have no business trying to tackle the whole thing at once. I am genuinely glad that the committee has served to stimulate the laboratory to enter this highly important line of inquiry.

Finally, let me suggest a bit of immediately useful information. When building overall conceptual models of the sort involved here, do not overlook the work of W. R. Ashby, and refer to his paper "An Intelligence Amplifier" published in "Automata Studies" by Princeton University Press.



Sander Rubin

SR:bea

cc: Mr. G. F. Craner
Dr. A. B. Credle
Mr. W. R. Elmendorf
Mr. R. A. Gregory
Mr. L. R. Harper
Mr. W. McDermid
Mr. M. Zucker