A Program System for the Use of Magnetic Tape Units in Scientific Computation

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1. *Introduction*

In the use of a digital computer, the information is usually stored in the main memory, and processed there. But, when the quantity of information is too much to store in the main memory, it is necessary to use the secondary memory as an auxiliary device. For such a case, I invented a new way of programming as follows.

The information in the secondary memory is divided into a number of groups, and each of them may be called a *macro-word* or *mW*. A *mW* which consists of instructions, is called a *macro-order* or *mOd*, and a *mW* which consists of data words, is called a *macro-number* or *mNo*. Here the secondary memory plays the part of main memory, therefore the secondary memory is called the *macro-memory* or *mM*.

To handle these *mW*s as ordinary instructions or data, the main memory is partitioned into a set of grouped memories. Each member of the set is called a *macro-register* or *mR*. The *mR* is classified, according to its function, into *macro-order register* (*mOdR*), *macro-operation register* (*mOpR*), *macro-program control register* (*mCR*) and *macro-temporary register* (*mTR*).

As a computation is carried out under the control of a group of routines stored in the *mCR*, this group of routines is called the *macro-program control program* or *mCP*.

I will call the structure of the program established by the programming concept mentioned above, the *macro-program system* or *MP system*, and the program controlled by the *mCP* the *macro-program* or *MP*.

2. *Macro-program Control Program*

Now, I will describe briefly the process of the *MP* and the function of the *mCP*, which remains in the main memory during computation and plays an important part in the *MP* system.

Before the execution of the *MP*, it is necessary to read-in the whole information and to store it in the *mM*. This is carried out by a routine

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of the *mCP* called the *initial read-in routine.*

When all the information is stored in the *mM*, some *mW*s are transferred to *mR* in order to start the computation. Such a process is called the *loading process* or *LP*, and is carried out by a routine of the *mCP* called the *loading process routine.* This routine reads out the first *mOd* and some necessary *mNo*s from *mM*, and set them in *mOdR*, *mOpR* respectively.

After the *LP*, the execution of the *MP* starts, and the *mOd* in *mOdR* is executed. A *mOd* is a closed routine, and the instructions of the *mOd* are executed one after another till the exit of the *mOd*. When the execution of the *mOd* is accomplished, a routine of the *mCP* called the *fetch cycle routine of mOd* reads out the next *mOd* from *mM* and sets it in *mOdR*. In this way, the execution of the *mOd* continues. During the execution of the *mOd*, the necessary transfer of the *mNo* between *mM* and *mR* is carried out under a temporary control of read-in and read-out routines in the *mCP*. Such an execution of the *MP* is called the *production process* or *PP*.

When a computation is interrupted before its completion, some information which is necessary to restart the rest of the computation, must be recorded. This is carried out by a routine of the *mCP* called the *stopping process routine*, and this process is called the *stopping process* or *SP*.

3. *Problems in the Use of Magnetic Tape Units as mM*

When the magnetic tape units is used as the *mM* in the *MP* system, the long access time of the magnetic tape units is a grave disadvantage. But, when the searching operation can be carried out simultaneously with other operations of the computer, the overall efficiency of computation may be increased. Nevertheless, the *MP* system makes the programming easy for the large scale problems which require the use of the secondary memory.

4. *Example of Scientific Computation by MP system*

An example of scientific computation by *MP* system using the magnetic tape units will be found in a paper by H. Yamada, R. Yamamoto and T. Miyano [1], and the detail of its program for the *KDC-I*, Kyoto University Computer [2], is available in a report by T. Miyano [3]. Only a brief summary of this example is given here.

For theoretical calculation of the meteorological high water in Osaka Bay (Typhoon Jane, 1950), the dynamical equations:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-9.8\frac{\partial}{\partial x}(0.0102\cdot p+\zeta)+(4.05\times 10^{-6}\cdot q_x-0.0018\cdot u)/h,$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-9.8\frac{\partial}{\partial y}(0.0102\cdot p+\zeta)+(4.05\times 10^{-6}q_y-0.0018\cdot v)/h$$

and the equation of continuity:

$$\frac{\partial \zeta}{\partial t}+\frac{\partial}{\partial x}(h\cdot u)+\frac{\partial}{\partial y}(h\cdot v)=0$$

are used.

The symbols in the equations are:

x, y =horizontal co-ordinates (m),
t =time co-ordinate (sec),
u, v =components of mean velocity (depth mean) in x, y directions respectively (m/sec),
ζ =elevation above mean sea-level (m),
h =bottom depth from mean sea-level (m),
p =atmospheric pressure at the sea surface (millibar),
q_x, q_y=components of squared wind velocity in x, y directions respectively (m^2/sec^2).

This initial-boundary problem was solved by finite difference methods with certain initial and boundary conditions, changing at intervals the meteorological data q_x, q_y and p.

The program for the nonlinear simultaneous difference equations was constructed in *MP* system, and the computation executed with the *KDC-I* using the magnetic tape units.

The memory system of *KDC-I* consists of magnetic drum memory (4000 words of normal access stores, and 200 words of quick access stores), magnetic core memory (50 words), and two auxiliary magnetic tape units.

Magnetic drum memory and magnetic core memory were used as the *mR*. About 1000 words of normal access stores were employed for the *mCR*. Magnetic core memory and a half of quick access stores were employed for the *mOpR*. The rest of quick access stores were employed for the *mOdR*. The rest of *mR* were used for miscellaneous uses as the *mTR*.

Only one magnetic tape unit was used as the *mM*.

The *mCP* consisted of ten routines, and the whole information was divided into 279 *mW*s (36 *mOd*s and 243 *mNo*s) of 50 words each.

References

[1] YAMADA, H., R. YAMAMOTO AND T. MIYANO, Theoretical Calculation of Meteorological High Water in Osaka Bay, unpublished paper in Japanese.

[2] *KDC-I Manual, 1, 2* (in Japanese).

[3] MIYANO, T., Computation of Meteorological High Water in Osaka Bay—Example of the Application of Magnetic Tape Units, *KDC-I Report*, MT-002/SP-001, 1963/006 (in Japanese).