RELIABILITY OF THE SYSTEM

We have here considered the reliability of the system with respect to the results actually produced. We have not, however, considered the price it is necessary to pay to ensure correct operation. Due to computer failures, we may expect to lose on average some 10 minutes in every 8 hours. In addition, we may be called upon to allow for up to 2 or 3 hours of maintenance work on the machine, on the basis of a schedule set out by those maintaining it. Although the unscheduled failure amounts to very little on average, it does not, in practice, usually occur in small doses. A normal system of operation should envisage an occasional failure of up to 2 hours' duration. With the possible exception of applications of the computer to payroll problems, this would not normally prove serious. Another problem in reliability, which may concern us, is that of the possibility of the recording medium losing vital information whilst it is being stored. Whilst the majority of fast storage in the computer is volatile, and the information on it is destroyed when the computer is switched on or off, this is not true of magnetic tapes or of magnetic drums. Furthermore, the magnetic tape can normally be removed from the computer to a place of safety. However, whilst the tape is attached to the computer, there is always the possibility that an error on the part of the computer will wipe off the vital information on that tape. For this reason it is usual to retain records of previous transactions on the magnetic tape from which current records can be rebuilt if necessary. It so happens that it is normally convenient in any case to program so that both the old record and the new are left on different pieces of tape.

CONCLUSION

From the foregoing discussion I think we may conclude that the use of computers for book-keeping is possible, that service to customers can be maintained at least at its present level, that labour and time are likely to be saved, and that both the reliability of the information produced and the security of records kept can be made of the highest order. The important question that remains unanswered is whether in any particular application the use of a computer is economic or not.

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Computers and Commerce: 3—Stock Recording and Control

by A. S. Douglas

Summary: In this article the problems of recording and controlling stock using a computer are considered. The implications of the time limits on stock recording set by businesses with a large daily turnover are discussed with particular reference to the use of magnetic tape for storing records in these circumstances. The points made are illustrated by an example, and a method of programming such an operation is suggested. Some of the difficulties of carrying out stock control directly by the computer are considered.

INTRODUCTION

There are three principal reasons for recording transactions in stock. Firstly to ensure that losses of stock are detected; secondly, to check that goods specified for dispatch from stock are available, and that suitable action is taken to inform the customer or user-department if they are not; and thirdly, to provide information about stock levels, rates of turnover, and average demand for use in controlling production or transport, and in determining when and how much material to re-order. In so far as the operations of recording are similar to accounting procedures, the discussion in the preceding article is applicable also to stock records. Indeed, the actual record kept is usually of a simple nature, involving the keeping of a set of running balances, an operation which was dealt with there in some detail. However, there are some differences which render stock accounting of special interest. These differences are introduced by the requirement that items should not be specified for dispatch if they are not available, and by the necessity for early warning of deficiencies arising so that a correction can be applied in time to avoid shortages.

FROM ORDER TO INVOICE

Let us consider the implication of the requirement that the availability of stock is checked before giving instructions for its dispatch. A typical system of operation now in use would be to check the orders against the stock records manually, altering entries in the records and on the orders as are necessary, and prepare the invoices from the corrected orders. Goods would then be assembled in the warehouse on the basis of the invoices. Such a recording and checking process is not simple to mechanize with a punched-card system, and may be awkward to organize using manual labour, since repetition of the same item on several orders will tend to reduce the speed of checking to that of a single girl or machine, which may well be inadequate. Furthermore, the error rate of manual recording is not negligible and increases with the volume of work handled daily.

Computer operation does not suffer from these difficulties, except in so far as access to individual records may be slow. In general it is normal to have many girls or punched-card machines working simultaneously on problems of this kind. However, computers as now constructed have facilities for carrying out only a single operation at a time. This implies that they must have very rapid access to records if they are going to be usable. If we consider a case where a total of over a million different stocks are held, the average time taken to locate a specific record on magnetic tape may well exceed three minutes, which is usually too slow. We must, therefore, examine the problem in more detail to find ways of carrying out recording and checking which do not involve seeking out the records item by item. Alternatively, if the latter procedure cannot be avoided, then a more expensive solution can be sought by the use of adequately large drums, or by engineering devices such as RAMAC. Fortunately, however, the restrictions necessary to program the solution on normal tape mechanisms are not severe, and will be discussed below.

TIMING CONSIDERATIONS

One way in which time for consultation of the records can be shortened is to carry out a frequency analysis of items in orders, and to arrange the sequence of records so that the most frequently demanded items refer to records conveniently placed on the tape. Such a frequency analysis can be updated in parallel with stock recording, and the records could be rearranged from time to time in accordance with forecasts from the system. This method can be generally regarded as an acceleration technique. Its value will depend on the accuracy with which forecasts can be made of frequency, and the disturbance it will cause to sorting procedures may well make it of marginal usefulness in some cases.

Given a random distribution of items among orders, the average time of consultation of a particular stock record on one tape is proportional to $\frac{1}{2}N$, where N is the total number of records. If more than one record is consulted at a time, and assuming that the records required are to be extracted and returned in a suitable sequence, the average time will not exceed $2N$ in similar units, since we may suppose at worst that we must rewind the tape and amend each consulted record. Thus we can decrease the time needed to search for the stock records and amend them by aggregating items over several orders and sorting them into a suitable sequence before actually consulting the records.

Aggregation of information is, however, only permissible in stock recording if precautions are taken to provide for reference back to orders containing items which run out, so that these orders can be dealt with specially. Since reference of this kind is, as a rule, lengthy, it is best to have some assurance that the procedure is only used in exceptional cases, so that we wish to be certain that the majority of stocks will not run out on account of the information aggregated. The choice of a period over which information is collected and not sorted thus depends upon the probability of the drawings expected being kept less than the stock level at the beginning of the period. In many staple lines, where the demand is heavy and severe fluctuations are rare, it is quite easy to ensure this, since reliable figures are available from previous operations. However, where occasional small numbers of items are in demand, or where demand is such that there are severe fluctuations, depending on unpredictable factors such as the weather, accurate forecasting is impossible, whilst it would be uneconomic to hold at all times sufficient stocks to meet every situation that can arise. It should be generally possible to divide stocks between categories for which aggregation of information is permissible over considerable periods and those for which it is not permissible. It is to be noted that this procedure is often followed in practice with existing systems, but the computer should allow greater flexibility than normal clerical operations.

Another factor in choosing the period of aggregation is the necessity to match the parts of the series of operations involved in preparing and processing the data and printing out the results. Tape or card preparation can proceed simultaneously with machine operation, and with printing (e.g. direct from magnetic tape). However, whilst the preparation is more or less continuous, collection of information for the computer can best be done at intervals, the reservoir of cards or tape formed at the input site being kept as small as possible to avoid handling difficulties. Similarly, printing is continuous, except for changes of stationery and of tape feeds. If the latter are not controlled from the computer or it is desirable to retain the taped records, then the handling time from computer to printer mechanism must be considered. Such a change-over may take one or two minutes per reel, and if reels are filled more rapidly than this the system would be wasteful.

A further important consideration is the initial delay in the system. When the scheme envisaged above is in full operation a continuous flow of output can be maintained, and this is essential if the invoices produced are to be used immediately for assembly of goods at the full rate of output. However, when the system is first set in operation there will be a delay before production of the first invoice, and this must clearly not be too long if that invoice is to be used as soon as it is produced, otherwise assembly staff will be idle.

Example

In a practical case, let us suppose that an output of 5,000 invoices per hour, each containing, on average, 10 items distributed over 10,000 different stocks, is required. We may suppose that the 10,000 stock balances are recorded on about 60 ft. of magnetic tape. Random access to a particular balance might be about $3\frac{1}{2}$ seconds, and at this rate 50,000 items would take about 50 hours to deal with, even if input, adjustment of balances, and output times are ignored. However, if we suppose the 10 items on an invoice to be correctly sequenced and deal with these as a set, each invoice might take a little more than 5 seconds to prepare for output. The procedure is still too slow, but the total time has been reduced to 7 hours from nearly 50. Aggregating the orders over, say, 10 minutes, and making some assumptions about the amount and speed of input, we find that times might work out as follows:

Input 3–4 minutes.
Processing 4–5 minutes.

We note that whilst this implies that the computer now has a sufficient speed for dealing with the orders presented to it, we have still to ensure that the overall operation of invoice production is sufficiently fast. Thus we must provide for data preparation and printing. The former can be carried out in this instance by several operators working simultaneously on relatively slow apparatus, such as card punches or keyboard tape punches. The number of stock items is a little large for the manual selection of prepunched cards to be attempted, but this is a rapid method of preparation which is worth consideration. If the information is to be aggregated over 10-minute periods before processing, then the preparation arrangements must ensure that 800–900 orders are ready prepared at the start of each 10 minutes. Similarly printing of 800–900 invoices, if done as a parallel operation not interfering with computer operation, must not exceed 10 minutes. This also can be achieved by relatively slow printing apparatus if several units can be operated at once; problems associated with this will be discussed in a later section, but the requirement can certainly be met in this way. We can readily see that the initial delay after the first batch of orders is received in such a system is about 30 minutes, and this may or may not be tolerable.

One way to overcome this difficulty is to have a special procedure for starting up which allows a trickle of invoices to appear during the first half-hour, building up to full speed later. The effect of this, however, would be to delay reaching full speed production, even if additional punching effort is available during the initial stage; this effort would later become redundant. An alternative solution is to maintain a "cushion" of invoices, prepared on the previous day but as yet unfilled, so that the assembly staff are not dependent on immediate production of invoices from the computer. Yet another alternative is to stagger working hours for computation and assembly staff. In this connection it must also be borne in mind that a preventive maintenance period must be normally allowed for, between the time a computer is switched on and the time it is used. Unless shift working is carried out, working hours for the maintenance engineers must thus always be staggered relative to those of the users, if delay is to be avoided.

RELIABILITY

The more important aspects of the reliability of a computing system were discussed in the preceding article. It was there concluded that the standard of accuracy of the results produced can be assured to a degree substantially higher than can be achieved by any other system. We may thus be virtually certain that invoices produced as correct are exact reproductions of the orders made, and that the stock specified thereon exists (or ought to exist!) in the warehouse. Furthermore, we can hope to query not only those orders specifying items not in stock, but also those likely to be incorrectly prepared. The latter object can be achieved by either a test of reasonableness or by redundancy in input, or both, as described in the previous article. But, if redundancy is used, a larger allowance of input time is necessary than was instanced in the example given above.

Whilst we are assured of the reliability of the invoices produced, we are less certain that they will actually be produced at a given time, and yet time may be of the essence of a stock recording procedure. This implies that, in any system devised, proper allowance must be made for breakdowns in operation of up to 1 hour at a time, with very occasional breakdowns lasting for considerably longer. This condition can usually be readily met by assuring that the capacity of the system is sufficient to catch up again, if such an interruption occurs, before the close of the day's operations. Typically, if operations are from 8 a.m. to 5 p.m., the required capacity should be met, if possible by, say, 4 p.m. or, better still, by 3 p.m. When no breakdown occurs the resulting time should be put to use on work not tied closely to a time schedule.

Even with such a margin of capacity, however, the system is vulnerable during the early part of the day, unless some "cushion" has been artificially created at the start of the day by holding over invoices or by staggering working hours. A possible method of insuring against complete stoppage of assembly due to failure of the computer is to arrange to by-pass the recording system altogether if required. This can be achieved by arranging the input to the computer in a form similar to the output, and using equipment which will print the input directly on the invoices. The drawback to such a procedure is that invoices reaching the assemblers will not be without error, and will clearly be in a worse state than if normal hand-recording procedures are used. Nevertheless, this might be tolerable for a short period, especially since the bad invoices can later be recalled and replaced when the computer is again in operation.

SOME TECHNICAL REMARKS ON PROGRAMMING

In the example given in a previous section above, an aggregation of data over some 800 orders was envisaged before consultation of the stock records, and an assumption was made that the procedure of consultation could be followed within a strictly limited time by selection of any invoices requiring alteration due to the absence of stock. Since the items sent to the output must clearly be in the sequence in which they appear on invoices, whereas consultation of the records will involve their being sorted into a very different sequence, it is not at once obvious how the invoices affected can be selected sufficiently rapidly once an absence of stock has been detected.

A suggested procedure is as follows. On reading in the data relating to the orders, this information is at once changed (if necessary) into a form suitable for output, and stored in this form on magnetic tape. At the same time an index is constructed indicating against each item the identification of every invoice containing a reference to it. In the example given such an index could not involve more than 8,500 items with, at most, 800 invoices associated with any one such item. On average we might suppose that no item would be associated with more than 8 to 10 invoices and that a maximum of about 6,000 different items would in fact be involved. Of these latter perhaps only 60 or so might lie among items the stock for which was less than the expected demand on 800 orders. Thus a practical index might not exceed 600 entries, and could then readily be kept on a small drum or in some other immediate access store.

In addition to constructing the index, it would be necessary to sort and aggregate items prior to the consultation of the records. This would take perhaps 3–4 minutes, including the necessary rewinding of tape, and would be followed by a single pass through the stock records checking against them and amending them. If any item is shown to be out of stock, a reference would be available to all the affected invoices through the index. For the example given, it would probably be best not to take immediate action, but to continue to the end of the pass through the records, aggregating the set of items out of stock. Reference to the index would enable a comprehensive list of affected invoices to be prepared. The potential invoice records could then be moved to the final output tape, affected invoices being directed to a different place from invoices relating to goods immediately available for dispatch. The extracted invoices would be dealt with subsequently as special cases. In this way a very rapid method of processing might be achieved, provided that the number of invoices needing special treatment is not too large.

OUTPUT AND PRINTING

It has been assumed in the foregoing general analysis that printing is to take place simultaneously with computer operation. This entails having an "off-line" system of printing—a method now in use on many computers. The method actually envisaged for the example given would involve printing from magnetic tape independently of the computer. This can take place on a separate apparatus, or can be controlled from within the computer itself. The former solution is used at present by most computers that have an independent facility.

In the example it will be noted that the rate of production of invoices, namely 800 in 10 minutes, would involve printing at least 800 lines a minute, which is faster than any presently projected apparatus, and about ten times as fast as normal tabulation speed. It might, therefore, appear necessary to have as many as three expensive fast printers working direct from magnetic tape. However, the information contained in one invoice might well be stored on, say, three cards, and an output of 240 cards a minute is available, although this is faster than most standard equipment. The cards could then be split between several tabulators of the normal speed.

Since printing apparatus is less reliable than electronic apparatus at present, the output and printing is the part of the system most vulnerable to failure. A number of slow printers of tried and tested design are thus to be preferred, other things being equal, to a small number of fast printers. It is to be hoped that the latter will be made substantially more reliable than their slower predecessors, for only if this is achieved will they prove worth developing, even if the cost of one such machine is less than that of several slower ones with comparable capacity. These remarks are, of course, also applicable to output apparatus working direct from magnetic tape, whether cards, printers or other devices.

STOCK CONTROL

In the preceding sections we have dealt exclusively with the problems of stock recording and the production of invoices. These comprise only a part of the procedures related to stock. There is, however, little to be said about the entry of incoming stock to the records, since this may be supposed to arrive in bulk, and the problems of recording raised are similar to those involved in normal book-keeping. Nor is there anything the computer can do about stocktaking. It is not, of course, equipped to examine the stock itself, although it can supply figures against which actual stock is checked. Such total figures should be more reliable than those normally produced from the books, but discrepancies between the books and the stock will continue to exist due to faulty assembling, loss of stock, deterioration and so on.

The stock figures from the books are also used by those responsible for controlling the movement of stock. The actual decisions made in controlling this movement are matters of judgement, and, as such, depend upon the individual. Nevertheless, many such decisions are made, in practice, by rule of thumb on the basis of (1) existing stock levels, (2) expected stock arrivals, and (3) anticipated demand. The existing stock levels are available within the computer and can be printed out when required. However, a full record may take a considerable time to extract, and occasional queries on the stocks of particular items may be awkward to fit into an invoice production schedule, besides being relatively uneconomic in computer time. It is, therefore, desirable to avoid printing out more than is essential.

An obvious possibility is to adopt a technique of printing out indications of only those stocks which have fallen below a minimum level. If some aggregation of data is carried out in normal processing, records would in any case be kept of those stock levels falling below the expected demand for the aggregation period. Similar records could be kept and printed out for stock levels falling below the total expected daily demand. Both these techniques require an assessment of anticipated demand. This is normally supplied by the sales department and could, of course, be fed to the computer by way of a semi-permanent record, changed only occasionally. In order to assist in the preparation of such an estimate, the computer might supply an analysis of orders and actual dispatches according to any scheme favoured by the sales department. It is of the greatest importance in this connection to hold records of actual demand, as well as those of supply, since the latter do not take account of the unsatisfied demand occasioned when stock runs out for a particular item. Furthermore, once an item is out of stock and a particular customer has been so informed, it may be assumed that he will not attempt again to order that line, but will switch to another. Forecasting demand, therefore, even from reliable order analyses, is by no means simple and cannot readily be codified even for standard products with little fluctuation in demand.

If the computer is given information about the expected arrival of new stock as soon as such information is available, and some procedure for assessing expected demands is established, the computer will have at its disposal all the information that is in the possession of a stock controller. If a further procedure is devised for using this information, then the actual re-ordering and control of stock movement can be done by the computer.

I do not wish to minimize the difficulties of finding appropriate procedures both for assessing expected demand, and for deciding how much stock to re-order and when to do so. I wish here only to emphasize that such procedures must be devised in a quantitative form before stock control can be handed over to a computer, for this poses the fundamental problem in all mechanical control procedures. There is, of course, no reason why the computer should not operate closely in co-operation with a controller, deciding all those things which can be reduced to quantitative form and throwing up queries, together with appropriate data, in those cases where it has not been programmed to give a decision. Indeed, I regard this as the first step on the road to achieving complete mechanical control in any context; this theme will be discussed further in the next article.

First British Computer Society Conference

As already announced, planning is now proceeding for the First Conference of the British Computer Society to be held in Cambridge 22–25 June 1959. This will immediately follow the conference being held in Paris by UNESCO, and it is anticipated that some visitors from overseas participating in that conference will also take part in the B.C.S. conference.

It is intended that the programme will include papers and symposia on

- The UNESCO Conference
- The State of the Art
- Selection and Training of Programmers
- Production Control
- Operational Research
- Automatic Programming
- Logical Design
- Numerical Analysis
- Auditing Problems
- Experiences with the use of Magnetic Tape.

Registration forms will be distributed to members in October.