COMPUTERS IN THE MANAGEMENT INFORMATION FIELD

BY

COMMANDER P. F. MARTIN, O.B.E., C.ENG., M.I.MECH.E., R.N.

Aim

The aim of this article is to define some of the concepts that may help in making a rational approach to examining how computers can best be applied to the derivation of management information.

Introduction

Often, the approach to the design of management information systems has been to ask the various areas of management to give their requirements for information, at the same time implying in a rather ill-defined manner that somehow the computer in meeting those requirements will 'improve' management decisions and also be 'cost effective'.

The approach has been further confused by attempting to use familiar viewpoints (like costs) for making assessments. These might be applicable to a problem of, say, deciding whether the purchase of a new machine tool or the provision of a bacon-slicer will show a profit if the capital cost is offset by the labour cost savings (and perhaps in the latter case the better economies of even slices). In these sorts of area, it may be possible to accept that a single artificial index (money) can sufficiently represent the whole problem for management decision purposes, though, even in this case, the limitation of the index as a basis for judgement can be recognized.

In the case of the bacon-slicer, it is possible to detect many or most of the ancillary costs because specialized knowledge is not needed in order to appreciate fully the implications. It is clear that the machine has to be maintained and logistically supported; it may also be readily realized that more expensive, boned supplies of bacon might have to be provided. Any ordinary person as a party to discussion can form a complete concept of the function of the machine without unusual training or experience. There is also often a fall-back position even after introduction of the new device, i.e. bacon can again be sliced by hand if the machine fails (provided the labour has not been dispersed).

Although this analogy is mundane, it is simply not sensible to put the business of studying the implications of a new device of such power, sophistication, and management impact as the application of computers into terms that would be appropriate for considering the purchase of a bacon-slicer. The management finds itself groping in the dark because it is asked to state its requirements and, what is more serious, to quantify the benefits, while still at the stage of barely understanding the power, the potentialities, or even the basic management mechanics of the device.

The development of understanding in this field has not been helped by the fact that the earliest application of computers has been in the field of accounting. Although these applications have been relatively easily understood because they represented simple mechanization of earlier clerical processes, the concepts arising from these early applications have led to some unfortunate side effects.

Firstly, the yardstick for assessment has tended, typically, to be seen in terms of a possible reduction in the total labour force involved in the operation. This has often not been achieved and disillusionment has resulted.

Secondly, in accountancy, computers were applied in an environment where the input was already established and was conceptually in the right form, and the degree of detail or the accuracy of the data was likewise a simple pre-established idea. For example, in cash accounting, the lowest units and their impact on the whole were understood and, although some minor conceptual changes in rounding up or down were required, the problem was simply understood. In areas which involved stock control, the units of stock were likewise tangible concepts and the accountancy principles easily established on rigid systematic lines. The application of the computer to deal with masses of simple operations was a simple concept and the outputs for higher management could be seen in terms of requirements such as annual synopses or trends. These tended to be primarily synoptic at progressively higher levels and not involving constantly changing, repeated access to primary data for correlation or selection purposes.

Thirdly, the influence of the accounting approach has led to a bias towards trying to translate information for more general management purposes into the terms of accountancy ideas, such as comparison of absolute totals or displaying numeric differences. While such concepts may, in some cases, be applicable, there are other ways of presenting facts which may equally constitute valuable management information.

Thus, the background is an unfortunate one and considerable effort is needed to break away from it. Part of the problem has been generated by the 'Top Down' approach to which the design of simple clerical accounting systems is amenable. In such an approach, firstly it is decided what outputs are required from the system and, from this, the necessary input data is determined; the whole system is then designed. For this type of system, this is an entirely valid concept.

In simple accountancy, determining the input data has simply amounted to changing the way of presenting data which existed in unambiguous form in the original manual system. Seldom is it necessary to change radically the outlook or the concepts of the human-being at the input. In the case of cash, for example, it is not too difficult to contrive that the figures (which have always been written) are placed in a 'box' on a stylized form.

Although, in the design of an ADP system in an accounting environment, there can be conflict in systems identification and in alternative requirements for aggregation of information, in cash accounting systems the aggregation hierarchies are often well established by historical precedent and problems are relatively easily dealt with because they remain entirely within the accounting area. In stock control problems likewise, the units of supply and the hierarchies are relatively easily defined.

Discussion

Moving to the more general case of applying ADP to the provision of management information, many of these simplifications no longer apply. Furthermore, it is often dangerous to use analogies taken from the accountancy field. The principal differences are:

(*a*) The potential basic data has not necessarily hitherto been recorded at all.

(*b*) There is a large number of conflicting hierarchies of identities, functions, or activity groupings.

(*c*) The output requirements of the system, although in part identifiable at the outset, must embody the ability to retrieve information for meeting *ad hoc* questions; these, from the point of view of system design, are random in subject, content, nature, and structure and will only be defined fully at a date in the future.

Ad hoc questions can, of course, be asked of a rigidly designed system, even of the accountancy type systems. The recent SPAREDEX study was an example of this: here, special programmes were devised and run using data in the machinery spares accounting field, the data so arranged that subsequent manual processing could yield information on the performance of the spares supply system, eventually leading to proposals for change in allowances of spares carried on board.

Interaction between Management, Information Needs and Sources: Existence of Potential Data

In approaching the derivation of management information in a general sense, the first areas of study should be those areas in which records are made for the purposes of day-to-day line management because:

(*a*) If such records are already entered into a computer to meet existing management requirements, then any further information that can be derived (without enhancement of the working records) can be obtained by programme at minimum cost;

(*b*) If the records exist but are at present handled only manually, at least they represent potential data and could, if necessary, be structured for computer entry if required.

Considering data potential, it is a fact that very few acts of management take place without someone at some time committing to paper the intention or the executive authority. The most obvious occasions on which a record is made are in respect of the act of planning, the act of requisition, and the act of change of custody; many other acts, such as the act of changing configurations by modification, are committed to paper, however, as part of the executive actions of management.

Management may be considered as the exercising of discretion by a human being who, in the limit, provides the executive decision that releases the carrying out of an activity. The activities range from simple transportation of an item from one place to another through activities on or using material to activities that change the nature or arrangement of an existing configuration. The activities do not happen spontaneously. At some stage they are under the control of human beings who generate or respond to instructions which may be given verbally or which, in many cases, are recorded. Any point in the control process at which human discretion is exercised is a potential data-generation point. The points at which instructions are verbal can only generate data at additional cost and effort but, at the points where written messages or other records are normally required by the management process, mere structuring or mechanization of the present records can provide data which can be taken into a computer system.

Quite apart from any information needs which may be met, there are a great many management needs which can automatically follow. For example, a given executive action often affects the state of a large number of related configurations and so the action record should stimulate the updating of a great many associated records; at present, however, this consolidation either is not done or is attempted as block amendment of some sort long after the event. Besides any requirements for more general management information, there is a strong case for taking into a system at the outset initial executive

records direct from excutive management and contriving subsequently that all updating activities can be automatically stimulated or done.

Practicability of Establishing Management Information Systems

The first requirement is to determine the points within the management system at which the executive decision function is exercised. The decisions may be at macro-, mini-, or micro-level. For example, management decisions in respect of supply may be made at many different levels. On the one hand, a complete supply transaction might be the result of a decision to supply ten-thousand components to Devonport Dockyard. This decision is at macro-level in the supply system. The further history may be followed by mini-level decisions to supply from Devonport Dockyard to a demanding service, followed by micro-level decisions.

Some or all of these decisions may be supported by paper or other records. In some cases, the decision function may be implied rather than actual. For example, a stores supply demand may in many cases be satisfied automatically and the executive authority to supply may be implied. In other cases (continuing the above analogy), some human authority may be exercised for transactions above a threshold value. Likewise, at some of the lowest levels, where it has been shown that the cost of manual recording is uneconomic when compared with the value of the item, no written transaction records are produced at present. However, with the increasing potential provided by mechanized data entry devices and a growing appreciation of the potential benefits from accurate information, the balance may in time sway back towards further coverage of transactions.

A study of the decision points establishes the existence of potential data; a study of what is recorded for management reasons (and what is not recorded) determines the degree of resolution of the potential data for computer input. It is essential to start at the data end when considering the problems of obtaining management information; this is because reliable data can only be obtained where records are required for performing the management function. Any requirements for extra recording means injecting an artificial additional activity that performs no function in the local context; it will, therefore, often not be done.

The second requirement to be established is whether for any reason whatsoever, as a release for a necessary management function, the potential data must be taken into a computer. The prime reason for doing this would be that such action is cost effective in the local management context. This may be because:

(*a*) essential local accountancy is most effectively carried out thus;

(*b*) the data not only has significance in respect of the local management action it represents, but also because the fact of the action needs to be linked with others either in the simple accountancy of (*a*) above or because the action causes a change of state of material or resources which, in turn, needs to be taken into account in a wider context;

(*c*) the data needs to be manipulated with other data very rapidly (even in a real time context), for example, as in an air-line passenger booking system where the state of the bookings is constantly changing in response to the input from booking agencies all over the country.

At the outset, therefore, there is often a practical requirement in respect of (*a*) and a vital area for consideration in (*b*) or (*c*), both divorced from 'higher' management information requirements.

The total practical data potential arising for essential management communication reasons can be, and should of necessity be, established before any

further considerations of a management information system can be effective. A way of doing this would be to establish an algorithm of the executive function of the line management concerned.

This statement does not imply that willy-nilly all records should be entered into ADP. There are clear reasons which can guide selections. They are that records should be entered if:

(*a*) the facts in the record establish a precedent, i.e. that the facts are the first or 'master' record of a management executive decision which causes action;

(*b*) the action is of significance in a local context or produces an effect or requires other resultant actions outside the local environment. The point can be illustrated by considering an action which produces a change of material configuration or, alternatively, an action which involves expenditure of resources. From the former follows the need to update records of state throughout the management system, and the latter requires action elsewhere to replenish or to make future provision.

The limits of resolution of detail of what is available for entry into the computer are set by the material levels at which transactions take place. Typically, the lowest level would be set by the lowest unique item of supply, but there could of course be transactions at a variety of levels from piece part up to assembly. The level is set by the nature of the events taking place and will vary according to the field of activity and circumstances at the time. When there is a line management requirement for a record (in this case as a supply requisition), this in turn means that there will be a very rapid corrective feed back. If the action resulting from the record is incorrect, it will be clear that the data that has been entered was corrupt and it can therefore be corrected. In effect, this feed back establishes integrity in the data base. The limits of the resolution of what needs to be entered are set by meeting:

(*a*) management functional requirements at all levels;

(*b*) the needs for management information.

Thus it is considered that the aim of headquarters and fleet management in approaching the problems of deriving information should be to discover where the 'master data' originates, i.e. associated with the executive actions. In any case, it may often be relevant to maintain a 'master' executive action or decision log for reasons such as updating within line management, and to do this by ADP because of the difficulties already existing and inherent in any pre-computer approach.

For purposes of developing information, the records must be accepted in the languages of the line management system, recorded at the levels which arise 'naturally' in the management system. Any attempts to influence artificially the occasion for record or the nature of the record tend to destroy the integrity of the data base and are counter productive. In the long term, if there is to be rationalization of that which is recorded, it must be rationalization of the line management specifically to meet management needs, not changes simply for the purpose of information generation.

It is likely that discharging line management functions—perhaps more efficiently than hitherto by stating executive decisions in suitable format—will in addition establish an active data base for other information purposes.

Application of Potential Data to Information Requirements

In general, information requirements can be released by a knowledge of:

(*a*) Records of events.

(*b*) Records of executive decisions.

(*c*) Records of compliance with decisions.

(*d*) Identification information and numeric data on resource allocation and time, associated with any of (*a*), (*b*), and (*c*) above.

(*e*) Relationship statements, e.g. hierarchical information.

Although in some cases it may be possible in advance to state routine requirements which may, because they are repetitive, justify programming action *ab initio*, the aim of the general case must also be to meet *ad hoc* requirements, particularly on a historic basis.

Methods of Deriving Information from the Data Base

Data may be considered to have two main components into which elements may conveniently be grouped:

Label—These are statements which identify and situate the subject of the report.

Numeric Data—These are numbers which describe behaviour.

The information process may be thought of as comprising three phases, the first two being carried out as a routine and the third partly routine and partly *ad hoc*:

(*a*) The first phase is concerned with raw data and its conversion into forms suitable for input to the computer.

(*b*) The second phase is concerned with storage of the input and arranging it to enable flexible retrieval. In this phase, initially simple arithmetic or statistical processes (such as summation or calculation of mean values, etc.) can be performed on the *numeric data;* secondly, the data can be filed, ranked, and cross-indexed in a great many alternative ways by using either features of the *label* or parameters in the raw *numeric data* or parameters from the arithmetic processes. The files may be either produced only on demand or produced and held in the computer, or may be printed as hard copy to enable further manual processing.

(*c*) The third phase is the generation of information to aid management decision. In the simplest cases (such as stock control), routine decision material can be programmed but, in the more general case, information generation is required to meet *ad hoc* questions and involves either:

(*i*) manual examination and analysis of those processed data files which hold data in a most convenient form, or

(*ii*) running specially directed programmes to arrange the data in further alternative sets to enable further manual processing and professional consideration.

Either (*i*) or (*ii*) are followed by analysis and presentation of the information in a form aligned to a decision dichotomy.

As already indicated, the approach to information systems so far has been prejudiced by ideas arising from simple accountancy and the ADP associated with such systems. The generation of management information should be regarded as an intelligence-gathering and operational-research operation. An analogy would be to consider the military or commercial parallel in which it is accepted that the enemy cannot be required to structure the data exactly as required by the opposing intelligence system. Nevertheless, information requirements are to a very large extent able to be met.

In approaching management information from supposedly friendly sources, it is ill-advised to adopt an overbearing attitude to structuring and definition in the data areas. For example, the study of what packages of material or activity cross the boundaries between ship and shore can yield a great deal of information. Blending any available cardinal (absolute) and ordinal (relative) statistics can also contribute to this. In the limit, because the intelligence operation in this case is being carried out not on the enemy but within a total coherent management organization, problems can be resolved by co-operation in limited but vital areas where no other solution can be effective.

There are problems in deriving information arising from a data base which is management structured because the line management concerned with the various separate areas of the total activities will necessarily operate using the hierarchical structures most appropriate to their handling of material or activities. These problems are discussed in other papers available through the SMA and also in 'Organizational Planning and Control Systems' by James C. Emery (MacMillan). In general, hierarchical structures should be made as mutually compatible as possible, but where they differ for sound management reasons, then the aim should always be to include in the *label* the lowest units of identity. Whether or not this is done, it is often possible to obtain comparative intelligence at high levels in the hierarchy, but, if the lowest levels of identity are carried, more complete translations between hierarchies are possible.

The design of the intelligence system will be influenced by the data available from the line management systems in being and by the postulated questions to which answers are thought to be required. What must not be overlooked is that, as the intelligence released from the mass of data becomes apparent to the users, it is inevitable that the originally postulated questions will become less significant. Therefore proper scope must be given to this evolutionary action. Great care is needed initially in making certain that the postulated questions are valid and will not subject the designed intelligence system to uneconomic and unnecessary constraints which will subsequently limit the process of evolution.

For example, a statistic often currently requested is 'mean time between failures (MTBF)'. In such a case, a 'mean time between reported events' might suffice. MTBF implies that there is an exact scientific design process, but this 'exact' process often incorporates factors of safety (or ignorance) applied quite extensively even in areas which broadly speaking are amenable to measurement of dimensions, loadings, etc. In other words, it is necessary to be intelligently critical of the demands put on an information system, particularly at this early stage of development. In practical information terms, it may be more relevant to be 'roughly right' than to be 'exactly wrong'.

Summary

Management information systems should tap natural line management communications in order to employ the most trustworthy data source. The approach to information requirements should be through data arising at the decision points in line management and through the records made to enable it to function.

The identification of data should be such as to fit naturally into line management communications, and the requirements for special measures in data structuring and collection at the outset should be avoided.

System design should aim to allow evolutionary development of input and output with experience, in preference to over reliance on a premature concept of input and output potential.

Problems arising from hierarchical conflicts should be recognized—they will inevitably arise and remain. They should not be accorded such importance as to constrain line management because evolution is likely to provide pragmatic solutions where these are actually neccessary.