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NOTE FROM THE EDITOR

After an absence of two years we are happy to announce that we are now in a position to continue the publication of *Quaestiones Informaticae*. The first Volume of QI consists of three numbers, and appeared during the period June 1979 till March 1980 under the editorship of Prof Howard Williams. Because Prof Williams took up a post at the Herriot-Watt University in Edinburgh, he had to relinquish his position as editor. The Computer Society of South Africa, which sponsors the publication of QI, appointed me as editor, whereas Mr Peter Pirow took over the administration of the Journal. The editorial board functions under the auspices of the Publications Committee of the CSSA.

The current issue is Number 1 of Volume 2. It is planned to publish altogether three issues in the Volume, with most of the papers coming from the Second South African Computer Symposium on Research in Theory, Software and Hardware. This Symposium was held on 28th and 29th October, 1981. At present it appears that most of the material published in this Journal comes from papers read at conferences. We invite possible contributors to submit their work to QI, since only the vigorous support of researchers in the field of Computer Science and Information Systems will keep this publication alive.

G WIECHERS

November, 1983

The Relative Merits of Two Organisational Behaviour Models for Structuring a Management Information System

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Abstract

The basic 'model' usually applied to the structure of MIS is that of Anthony. This paper investigates the use of the Paterson model as an alternative. This is approached from the theoretical standpoint, and reference is made to some practical situations requiring MIS. The paper discusses the relevant merits of the two models in each situation.

1. What is information?

1.0 Communication and Information

When human beings organise into groups, the motivation behind such a move is usually the achievement of some goal. Although this paper is primarily directed at the organisation of human beings within business enterprises, it can apply to any organisation. Any group is usually task orientated, and sets goals and objectives to be achieved in respect of the task. The performance of the task allows for the achievement of goals and objectives. Depending upon the degree of instability and complexity of the organisational environment the organisational subunits will adopt a relevant degree of specialisation and integration. This integration can only be achieved through some form of intra-organisational communication, both personal and non-personal. The consideration of communication is therefore fundamental to the design of management information systems.

1.1 The Nature and Function of Communication

Simon [20] defines communication as 'any process whereby decisional premises are transmitted from one member of an organisation to another'. The process involves both the effective assimilation of information by the decision-maker, and the dissemination of such information to others in the organisation who require the information for effective decision-making. The process of gathering information and utilising the necessary information for specific decisions is important at different times and places within the organisation. The relative importance of knowledge gathered within the infrastructure also changes with time.

In order to gather relevant information and knowledge for effective decision-making to occur, organisations may utilise various 'sensory organs' (e.g. market research), or employ individuals with specific knowledge relevant to the potential decision to be made. Knowledge may develop from the job itself or knowledge may even be the knowledge that the decisions have been made.

What is common to all situations is that an individual gains information that is relevant to particular decisions that must be made for the benefit of the organisation. It would be ideal, therefore, to structure an organisation so as to allow individuals to make those decisions for which they possess the relevant information. In practice, however, it is rarely the case that one individual possesses all the relevant information for making a particular decision. Hence a communication link must be set up to allow for information to pass freely between various organisational sources of information and the decision-makers. The essence of a good communications network, therefore, is to allow information to reach some central point, be assimilated into the decision-making process, and then be transmitted to those areas of the organisation where it is most effectively used.

Ference [7] defines the communication system of an organisation as 'the process by which requests for information proceed

to the point of calculation, and by which the information is transmitted back to the person requesting it'. He defines the communication network as 'a particular set of persons or groups within the communication system who may gather, combine, transmit, apply or otherwise manipulate information'. The nature, size and method of operation of the communication system will depend upon the age, size and nature of the organisation.

1.2 Formal versus Informal Communication

Within any organisation there will be both formal and informal communication channels, and the degree to which they are utilised depends primarily upon the structure of the organisation. Formal systems are those which have been divisionally structured for the purpose of gathering and transmitting information. Highly organised bureaucracies provide an example of formal communication processes and illustrate a high degree of specification concerning the initiation of messages.

1.3 Media for Formal Communication

1.3.1 Oral Communications

The system of formal communication implies that oral communication will take place primarily between individuals and their immediate superiors or subordinates. The formal organisation may also limit the ease with which upward communication occurs. Individuals at the upper levels of the organisation may be relatively inaccessible to all except their immediate subordinates.

1.3.2 Memoranda and Letters

Memoranda and letters are generally subject to more formal control in organisations than oral communication. Frequently, 'clearance' rules require that copies of communications be sent up the regular channels when the communication itself cuts across lines. The report generator is notified of the occasions for which the records and reports are required and also what information he is to include in them. This relieves him from continually deciding what part of the information should be passed on to other members of the organisation or in what form.

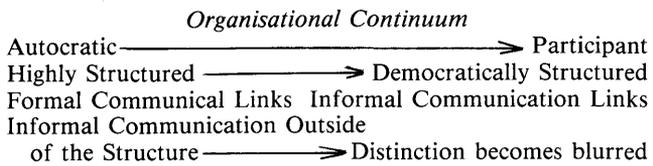
Manuals serve the purpose of communicating those organisational practices which have relatively permanent application. Extensive use of manuals increases the degree of centralisation in decision-making.

1.4 Informal Communication

Working alongside the formal channels, are the informal communication networks, which are usually socially orientated, and based upon such functions as physical appearance, peer-group relationships, etc. In more democratically structured organisations, these informal relationships tend to become internalised and 'meshed' into the formal communication links. Hence different organisational structures will have different types of com-

communication links and will require different data and information inputs at various stages of the decision-making process. In bureaucracies, information usually travels upwards, and commands downwards, whereas at the other end of the management continuum, in more participant organisations, the information-command links are very much more flexible and adaptable to contingencies.

This may be represented in the following diagram:-



The informal communication system is built around the social relationships of the organisation's members. Friendship between two members creates frequent occasions for 'shop talk'. Further, an authority relationship may be created if one of the members comes to accept the leadership of the other, resulting in 'natural' leaders.

Information transmitted in casual conversation is not entered into formal communication files and does not imply an irreversible commitment to action on the part of the participants. In the initial stages of problem solving activity, informal contact therefore predominates.

Personal motivation may have great influence upon the growth of the informal communication system. Individuals may deliberately develop this system as a means of increasing their own power and influence in the organisation. In addition, the transmitter of information will generally be aware of the consequences that its transmission will have for him and will tend to suppress information that will have unpleasant consequences (for him). A major communications problem is thus that much of the information required for decisions at the upper organisational levels that originates at lower levels may never reach the higher levels. However, as mentioned, an important function of formal records and reports is to transfer the responsibility for deciding what information is to be transmitted upward from subordinate to superior and, in so doing, provide the communication system with stability.

2. Frameworks for Information Systems

2.0 The need for a Framework

As organisations become more complex and the need for information for decision-making support grows, a formalised management information system (MIS) framework becomes essential. The key to good MIS design is a thorough understanding of the major decisions managers make at various levels in the organisation. It is these decisions that define the kinds of information required, and hence define the basic design parameters of the system itself. In practice, however, most companies have failed to plan their system keeping in mind the essential parameters of management support. For example, few of the earlier installations of computers into organisations resulted in any significant impact upon the way in which decisions are made by management [21,18]. What is needed is a framework to put into perspective the broad field of information systems, in order to maximise the potential of a computer installation, and to provide support where and when it is needed. Without such a framework the installation becomes extremely costly in terms of physical and human resources, and no organisations can afford such extravagance. Therefore, an attempt must be made to isolate the specific information requirements of individual decision makers which relate to the nature, frequency and inter-relationships of the major decisions made in the company. The framework must allow for the provision of information that makes the individual decision-maker's task easier and better.

The ultimate purpose of MIS is to make decisions at all levels of operations based upon the information flow. The essential element involved is that of choice between alternative courses

of action to be followed by the decision-maker. Thus, in order for a framework to be developed, it is essential to look at the nature of decisions and types of decisions involved in various organisational activities.

2.1 The Nature of Decisions

In order to generate alternatives, the process of altering, exploring and analysing information is necessary before the final decision is reached. Simon [22] defines the whole process as decision-making and not merely that portion involved with choosing amongst alternatives. Hence it is apparent that the process of decision making is synonymous with managing. Pateron [16] sees the decision process as involving four phases:-

- i) *Information* — the reception and categorisation of stimuli.
- ii) *Conclusion* — assessment of the problem, if any, and appreciation of possible courses of action.
- iii) *Decision* — selection of a course of action, and decision to act on it.
- iv) *Execution* — Analysis of the possible methods of carrying out the selected course, and the decision to act in the chosen method.

2.2 Programmed and Non-Programmed Decisions

The terms programmed and non-programmed are referred to by Simon [20] to explain the complexity of decision-making at different levels in the organisation. 'Decisions are programmed to extent that they are repetitive and routine, to the extent that a definite procedure has been worked out for handling them so that they won't have to be treated "de novo" each time they occur.' In short, these decisions can be automated, and rely upon previously specified alternatives. For programmed decisions to be fully effective, Simon required three phases to be fully incorporated into the process. These are:-

- i) *Intelligence* — using decision rules to find the problem.
- ii) *Design* — finding and analysing alternative courses of action.
- iii) *Choice* — selecting the best solution.

For programmed decisions, this process is highly structured and perfect for automatic decisions, usually at lower levels of the organisation hierarchy.

Non-programmed decisions are usually made higher up in the organisation, and unless they are at a very primitive level, cannot be automated. They usually relate to one-off problems, where a formalised routine decision model cannot be, or has not been, developed. Hence, they are heuristic in nature and require contingent informational input from the system. Decisions are non-programmed to the extent that they are novel, unstructured and consequential. There is no tested method for handling the problem because it has not arisen before. Examples are:- acquisition and merger considerations, board-member selection, advertising budgets, etc.

The procedure and techniques required are different for handling programmed and non-programmed decisions. It should be noted that the two types of decision described above are clearly at the extremes of the hierarchy — in practice the majority of decisions is between the extremes.

2.4 Traditional Decision Making

2.4.1 Traditional Techniques for Programmed Decisions

i) *Habit*

When new employees join an organisation they are provided, through training, with a repertoire of skills required in order to do their jobs. Their skills are repeated and internalised so that they become habitual. The organisation may, however, select new employees who have already acquired the desired habits in educational and training institutions or in previous jobs. These habits and skills are valuable to the organisation. One of the main costs in personnel turnover is involved in having new people acquire the habits of the organisation and the job.

ii) *Standard Operating Procedures*

These procedures are closely related to habits, but begin as formal written programmes. Standard operating procedures enable the new members to be indoctrinated into the habitual organisational patterns and provide a means for reminding old members of behaviour patterns which have not become habitual due to infrequent use.

iii) *Organisation Structure*

The organisation structure establishes a set of expectations as to which members are responsible for which classes of decisions. It also establishes a set of organisational subgoals which serve as decision criteria in various parts of the organisation. Finally, the structure itself effectively assigns the responsibility for monitoring and collecting information from a particular environment and for communicating events which require attention to appropriate decision points to different organisational units.

In the past, management has concentrated its efforts largely upon these techniques, i.e. upon improving knowledge, skills and habits of employees through training programmes; upon developing better standard operating procedures and ensuring adherence to them and upon redesigning the organisational and subgoal structure and responsibility allocation.

2.4.2. Traditional Techniques for Non-Programmed Decisions

Executives generally say that they exercise judgement, intuition and creativity when dealing with situations requiring non-programmed decisions. Making such decisions depends on psychological processes that are not well understood. It is known that non-programmed decision-making can be improved by training in orderly thinking. For example, one can acquire the habit of asking, when confronted with an unstructured situation, "What is the problem?" One way around this problem is to recruit those people who have demonstrated their capacity for non-programmed decision-making. Thus, we rely on selection as the principal technique for improving complex decision-making skills in the organisation. However, the selection techniques themselves are not always reliable predictors of success on the job. Because man has the ability to learn, professional training and planned experience are used as a means of improving managers' powers of non-programmed decision-making in the organisation as they advance in a career. Finally, the organisation structure provides buffers for protecting non-programmed activity from the pressure of repetitive activities through the establishment of specialised organisational units to undertake these.

It should be noted that, in practice decisions by managers are influenced by a wide variety of factors, most of which they are not aware of. Murdick [15] classifies them as Psychological, Social and Cultural.

- i) *Psychological Factors*: A decision-maker may not try to maximise his satisfactions, but settles for satisfactory solutions that suffice. What is satisfactory depends on his level of aspiration, which probably in turn depends on his past experience.
- ii) *Social Factors*: Decisions in an organisation must be made with due regard to acceptance by members of the organisation, otherwise implementation will suffer.
- iii) *Cultural Factors*: Cultural varies between firms, geographic regions of a country and between countries. Decisions are, therefore, influenced by cultural factors and environment.

3. Levels of Management Activity

3.0 Categories of Activity

A framework for management information must not only consider the nature and motivation behind the decision processes, but should also consider the various levels of management activity in the organisational hierarchy together with the divisional activities that relate to these levels. This leads to a study of various decision-making frameworks. The most fre-

quently quoted framework in Management Information literature is that of Anthony [3].

Anthony separates the process of management into three distinct areas, each requiring distinctive supporting information systems.

3.1 Anthony's Three Categories

i) *Strategic Planning*

'Strategic planning is the process of deciding on objectives of the organisation, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use and disposition of these resources.'

Strategic planning is a process that determines the character or direction of the organisation. It is often complex and irregular. The data required for strategic planning is externally orientated, imprecise and depends largely on the type of the problems under review. The strategic planning activity is future orientated and not all problems can be foreseen. Hence, the nature of the data required tends to be varied and unpredictable. The strategic planning process typically involves a small number of higher level people so that communication between planners is fairly simple. It should, however, be noted that misunderstandings are common due to a lack of uniform definition of terms.

ii) *Management Control*

Management control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organisation's objectives. Note that Simon's definition is worded in terms of effective and efficient utilisation of resources rather than conformance to plans. This is due to the fact that actual events will differ from the events that were assumed under the strategic plan. Under this process, objectives, facilities, organisation and financial factors are more or less accepted as given.

The management control process is less complex than the strategic planning process since it occurs within a framework of policy and plans already specified. It also tends to be rhythmic as it follows definite repeating patterns and timetables.

The management control process generally has an underlying financial structure since it encompasses the whole organisation. Money is the only common denominator that can relate the various heterogeneous elements of inputs and outputs of the organisation, e.g. hours of labour, type of labour, quantity and quality of material, kind of products produced, etc.

Estimates used in management control are more likely to be closer to actual, and hence the requirement for uniform definition of terms is vital.

iii) *Operational Control*

This is the process of assuring that specific tasks are carried out effectively and efficiently. The basic distinction between management control and operational control is that operational control is concerned with tasks whereas management control is generally concerned with people. There is considerably less judgement to be exercised in the operational control area since the tasks, goals and resources have been carefully delineated through the management control process.

Operational control data are generally non-monetary since each control system is designed for a specific area of application such that it is possible to use that basis of measurement which is most appropriate for the given area, e.g. manhours, number of items, kg of waste, etc. Operational control data are in real time and exact, whereas data in management control is either prospective or retrospective and only approximate. It is not generally necessary for people concerned in an operational controlled system to understand how it works in order to achieve effective performance.

Dearden [6] notes that framework also implies that:

- a) there can be several levels of the above management functions. For example, strategic planning and management control can take place at the corporate, group and divisional levels of a company. However, each level would be subject to the constraints placed on it by the group above.
- b) in small organisations the same individual may perform the strategic planning, the management control and the operational control.
- c) the distinction between the three processes is not completely determined by the company hierarchy. Even in large companies, top management frequently perform functions that could be classified operational, e.g. top management decides how to spend the advertising budget.

Even though the boundaries between the three categories are often not clear, there is no doubt that in the past they have been useful in the analysis of information system activities.

Gorry and Scott Morton [10] add the dimension of Structure to Anthony's framework. This improves the usefulness of the model for designing Management Information Systems. An example is given in the following diagram.

	Operational Control	Management Control	Strategic Planning
Structured	Accounts Receivable	Budget Analysis	Tanker Fleet Mix
Semi structured			
Unstructured	Cash Management	Sales and Production	R & D Planning

3. Decision-Making Within Anthony's Framework

Decisions above the dividing line are largely structured (programmed) while those below are largely unstructured (unprogrammed). Two points should be noted:-

- i) Most of the so-called MIS activity to date has occurred in the structured half and specifically in the operational control area. However, the areas below the line, i.e. the unstructured decisions, are the areas of greatest concern for management.
- ii) The line separating structured from unstructured decisions will tend to move down over time as the mechanisms of particular unstructured decisions become understood, and decision rules developed. To the extent that any given decision remains unstructured, the organisation will depend on the manager to undertake the required analysis. Thus, a problem may be broken down into a set of related sub-problems, some of which may be automatically solved by the system and the rest by the manager. For example, in a marketing advertising campaign, models can be used to select the optimum media mix, while management takes care of the creative aspects.

4. An Alternative Model

4.0 Paterson's Framework [16,17]

Paterson considers the decision process as being made up of the following four stages:-

Information → Conclusion → Decision → Execution

Paterson utilises this process to describe the areas in the organisation where various decisions are made. He has six major categories of decision-making, hierarchically organised in terms of importance to the organisation. His categories relate to decision levels, and not organisational levels, and are more specific than the categories of Anthony. Essential to Paterson is that the higher the level of decision-making, the more freedom of choice is allowed. This assists MIS design, in that the information required at the various levels needs to be specific to that decision level. The greater the freedom of choice the greater the amount of information which must be assimilated. Hence, the higher the decision level, the more unstructured and non-

programmed the decisions made. From this point of view Paterson's approach should provide a better basis for MIS design than Anthony's, particularly in large companies.

4.1 Paterson's Decision Structure

(i) Policy Decision (Band E)

(Having the greatest freedom of Choice). These are associated with board level management, and involve corporate, strategic policy setting relating to the goals of the organisation and the direction which it follows. The limits set on the decisions are wide, and in many cases specified only by the laws of the state.

(ii) Programming Decisions (Band D)

These are made by senior management in the organisation, and involve deciding the plan for execution of the policy which sets the constraints with which the decisions are made. Decisions concerning resource procurement are a pertinent example.

(iii) Interpretive Decisions (Band C)

These decisions are usually made by departmental heads — middle managers. Their function is to interpret the plans formulated by senior management, and allocate organisational resources effectively. These decisions require a degree of creativity because often major situational analysis is required. Exception reporting is often the norm at this level.

(iv) Routine Decisions (Band B)

At this level there exist rules as general guidelines for the skilled personnel who make these decisions. These decisions involve the processes to be used in carrying out interpretive decisions.

(v) Automatic Decisions (Band A)

Here the semi-skilled personnel uses specific responses for a given situation. He knows exactly what decision to take in the light of his job situation.

(vi) Defined Decisions (Band O)

This is the lowest level of decision-making, and one performed by unskilled labourers. Here, not only is the process specified, but also the operations — the operator has no freedom of choice except in the speed with which he carries out a function.

The decisions carried out at different levels are dependent upon the complexity of information required and the type of choice the operator has at each level. Using Paterson's model of decision-making the Information and Conclusion processes involve staff management, whereas the Decision and Execution phase are line responsibility. Paterson's system can be used to explain the total decision-making process of the organisation and can therefore form the basis of a Management Information system designed to assist the decision making process.

It is interesting to note that in both the Anthony and Paterson models the information requirements differ substantially between the various levels or bands. Gorry and Scott Morton [10] suggest that only a few situations arise where it is sensible to connect systems directly across boundaries. Aggregating detailed accounting records (used in Operational Control or Band B) to use as a base for a five year sales forecast (strategic planning or Band E) is expensive and information could be obtained by sampling. What this implies is not that lower level data bases should never be used for high level decisions, but rather that lower level aggregation may not be the optimal solution. The costs of aggregating from lower levels are continually decreasing so this should be reviewed periodically¹.

1. Based on the costs of running benchmarks a 1947 Rolls Royce would cost R8 if car technology had advanced at the same rate as computer technology.

Mason [13] suggests 5 approaches to the design of an MIS which are based upon the decision-making processes within the organisation and which integrate well with both frameworks:-

- 1) A source consisting of the physical activities and objectives which are relevant to the business.

The observation, measurement and recording of data from the source.

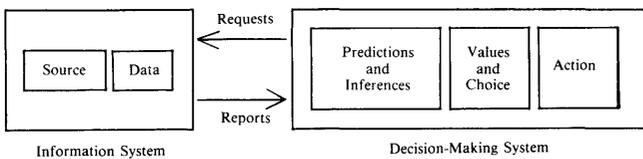
- 3) The drawing of inferences and predictions from the data.
- 4) The evaluation of inferences with regard to the values (objectives or goods) of the organisation and the taking of the course of action.
- 5) Taking the course of action.

This definition is very similar to Simon's. Mason splits the total decision making process defined above into two parts, viz. the 'information system' and the 'decision-making system'. The 'information system' implies programmable activities while the 'decision-making system' implies human judgement and non-programmability. It must be realised that all decisions are based on assumptions.

5. The use of Frameworks for Management Information

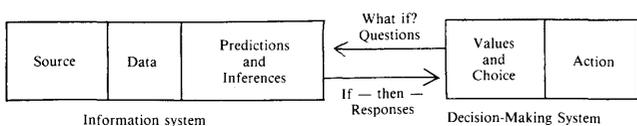
The use of frameworks may be considered at various decision making levels as follows:-

5.1 Databank



The responsibility of the 'information system' is just to "observe, classify and store any item which might be potentially useful to the decision-maker. It is incumbent on the user to request the data items he needs and to determine what their implication is for the decision problem he faces. This means that the databank information system is only a fact generator". This requires assumptions about which phenomena occurring should be monitored, selected, classified, etc., and in what way. The data bank is most applicable in situations where the nature of the required inferences is not known with any precision beforehand, or where the structure of relationships (between conditions in one area and events in another, or between a given point in time or a later period), and the assumptions about the system preferences are rapidly changing. Application of the databank is thus most suitable in the area of 'management control', although different databanks could be used to support decisions in the three areas (i.e. strategic planning and operational control). The danger of this system is that a failure to properly relate the databank to the decision process will result in much irrelevant data being collected and the omission of items important for decision-making. A second drawback is that the decision-maker has the burden of performing the necessary calculations to determine the alternative and the best course in action.

5.2 Predictive Information Systems

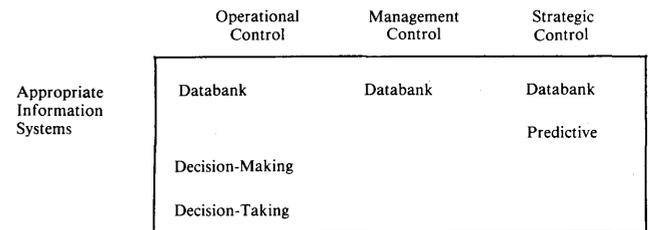


In this process certain evidential relationships are assumed to exist. "The decision-making system in effect inquires as to 'what if?' certain actions are taken and these assumptions are true. The system responds in the vein 'if' he does that 'then' this is what he can expect to occur. No attempt is made to

evaluate the outcome." The model of the problem provides the predictive system. Much of the recent MIS development has been in this area. An example is financial planning simulation models where the decision-maker is informed of what is predicted to happen under a given set of circumstances. The danger of this system is the possibility that inferences are based on invalid assumptions in the model and that these assumptions are hidden from the decision-maker by the information system design.

5.3 MIS Structure

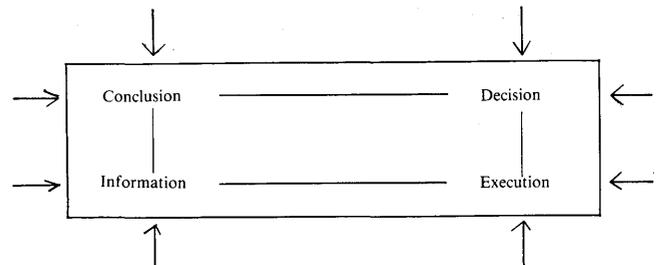
The type of information system required will depend on the assumptions that can be made regarding each of the decision phases. In each management activity (i.e. strategic planning, management control, and operational control) certain assumptions will in general hold which make a particular design of Information System more appropriate as at this point in time. This is illustrated in the following diagram.



Mason [13] suggests that the system designer and the manager should jointly examine the assumptions being built into a system and should strive to integrate, "the system into a cohesive whole — one which reflects the basic values of the participants involved. Without such an integrative structure a collection of data is little more than a potpourri of isolated fragments".

5.4 Combining the various Frameworks

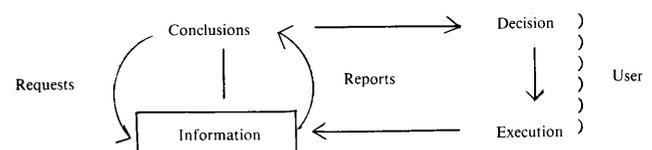
Work carried out at the Witwatersrand Graduate School of Business Administration [9,4] has successfully integrated these ideas in a two-dimensional model to describe the four stages of decision-making.



The Decision Complex

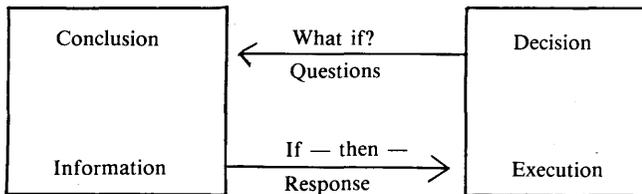
The process flow is not one way, but is an open system with elements of both feedback and feedforward. The arrows show elements of input from the environment. An analysis of the information system — Decision-making system interaction in terms of Paterson's framework gives the following basis for the design of information systems:-

(i) Databank Design



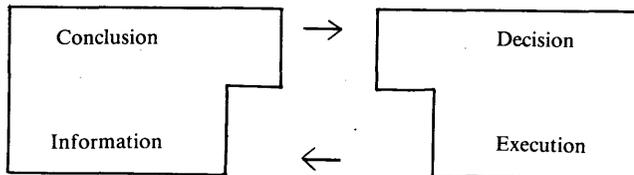
Here the information system stores and classifies information and is essentially the fact generator.

(ii) Predictive Information Systems



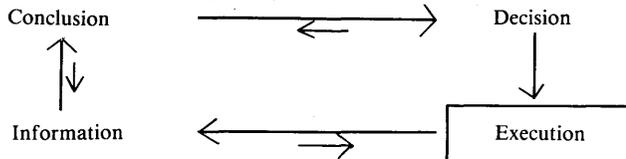
The system provides alternatives.

(iii) Decision-Making Information System



The information system makes choices.

(iv) Decision-Taking Information System



The system provides feed back (usually negative).

6. Applications and Conclusions

6.1 Applications.

A collection of over 600 computer application case studies has been collected by the author [18, 19]. Many of these have been designed to provide management information and many have used Anthony's model. Only five have however attempted a comparison of the alternatives [9,8]. Two of these were small companies in the engineering and transport businesses respectively with a turnover in the R2 000 000 to R5 000 000 range, one was a medium sized retailer, (turnover R120 000 000), one a medium to large industrial company (turnover about R250 000 000) and one was a large banking institution. Whilst each of these cases is an extremely interesting study on it's own, this detail cannot be reported here. In all cases the use of a model provided management with an insight to their problem areas that they found useful. The Information Services Department (Computer Department and Data Processing Department in the two smaller firms) was able to use the models to assist in the structure of their data bases.

In all five companies both frameworks were regarded as useful. In the two smaller companies Anthony's framework was regarded as better. The large industrial company voted unhesitatingly for Paterson. The two other companies felt that a combination was most effective with the Paterson model providing a more useful base.

6.2 Conclusion

Whilst most texts on Management Information suggest that Anthony's model should be used to structure a Management Information System for organisations it has been shown that in some cases the use of Paterson's model is preferable. There are a number of practical and theoretical arguments which favour the Paterson model.

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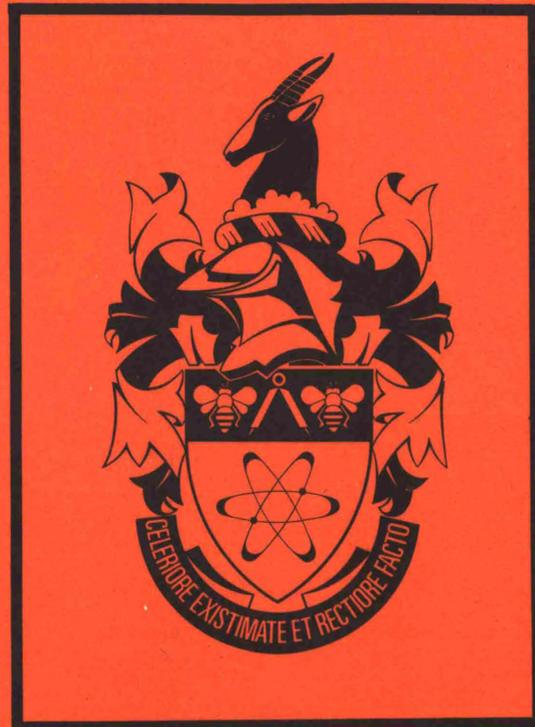
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