A DECISION SUPPORT SYSTEM FOR A PUBLIC SECTOR ORGANISATION: CONCEPT AND METHODOLOGY

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ABSTRACT

Decision Support Systems, first introduced in the early 1970's, have bloomed into a subject of academic and professional interest. The principal objective of a DSS is to support the manager as a decision maker in illstructured situations. Whilst the term DSS is now widely accepted and many systems that have claimed to have used the concept have been described in the literature, it is not yet well understood. Experience from an attempt to apply the concept to public sector decision making in the Treasury Department, Ministry of Finance Malaysia suggested that a number of issues need to be resolved. The literature on DSS lacks conceptual and theoretical frameworks to help in understanding DSS as well as approaches to help in DSS application. This results in the difficulty of finding suitable methods and techniques to be used in DSS development; most applications in the literature are small and adhoc and the nature of problem domains are not complicated. This thesis presents and describes a number of important aspects that need to be considered in the development of conceptual and theoretical frameworks for DSS. It builds on the concepts and theories that have been developed in such disciplines as "decision making theory", "organisational study and

system theory" to help in the development of such a conceptual and theoretical framework. An approach to the DSS application is proposed. The use of this approach in the public sector decision making mentioned above as well as in the development of a information system for university administration is presented. The thesis concludes with the description of the novelty of the works presented. Follow up research that is being carried out and future research to be carried out is also described.

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LIST OF ABBREVIATIONS

DSS	Decision Support Systems
MIS	Management Information Systems
FSR	Financial Relationship between Federal and State Government
ES	Expert Systems
NEP	New Economic Policy
EPU	Economic Planning Unit
TD	Treasury Department
PSD	Public Service Department
NEC	National Economic Council
NAC	National Action Commitee
SDPC	State Development Planning Commitee
SAC	State Action Commitee
NFC	National Finance Council
NDPC	National Development Planning Commitee
AGI	Aid-Giving Instrument
SAGI	Statutory Aid-Giving Instrument
GDP	Gross Domestic Product
MRD	Monitoring and Reviewing Department of Treasury
FDT	Financial Department of Treasury
SERU	Survey and Evaluation Research Unit

MAMI'U	Malaysian Administration and Manpower Planning Unit
EDT	Economic Department of Treasury
OR	Operational Research
IPA	Institute of Public Administration
ICU	Investigation and Coordination Unit
AGP	Accountant-General Department
TPS	Transaction Processing Systems
LS	Language System
KS	Knowledge System
PPS	Problem Processing System
AI	Artificial Intelligence
MS	Management Science
DA	Decision Analysis
DC	Decision Calculus
DR	Decision Research
GST	General System Theory
HAS	Human Activity System
RD	Root Definitation

INTRODUCTION

1.1 Background

There are a number of factors that trigger the need for more effective decision making. These include increasing competition, limited resources and the need to provide better service to customers. Accordingly efforts have also been put into the development of formal decision aids to help enhance the effectiveness of the decision making process. Fields such as Management Science, Economics and Management Information Systems(MIS) are at the frontier of the development of these decision aids. In the early 1970's Keen, in association with others at the Sloan School of Management, introduced a new concept in the use of computerised information processing systems in organisations, which later became known as Decision Support Systems(DSS). DSS aim to support Senior Managers in high level decision making in ill structured situations. Since then the DSS concept has attracted a lot of attention from academics as well as users from business organisations. The literature abounds with accounts of systems that are claimed to have incorporated some of the basic ideas of DSS.

One of the major attractions of DSS is that they are concerned with factors that are useful for the development of decision aids to increase the effectiveness of the decision making process in public sector organisations. Such systems need to coexist with the present characteristics of the organisation. Improving effectiveness of decision making may require the introduction of prescriptive models into the organisation. Coexistence implies that prescriptive models should match the requirements and constraints imposed by the present characteristics of the decision making process.

Environmental, Organisational and Individual factors represent the dimensions by which the descriptive aspects of decision making process can be understood. Environmental factors represent aspects of the environment whose characteristics influence public sector decision making. Organisational interpretation of these influences will determine how the organisation in general and individuals within it in particular make decisions concerning objectives to be achieved, constraints to be satisfied and models and information to be used. Individual interpretation of these objectives, constraints and models, together with their cognitive and decision making style and their academic background will determine how the individuals will make decisions. In general terms, identification of the characteristics of the decision making process and their incorporation into a DSS model is one of the major concerns in the development of DSS. In particular it implies the need to have a proper understanding of :

* the decision making process from an empirical viewpoint,

* the characteristics of the prescriptive models to be introduced into DSS.

1.2 The Importance , Objective and Contribution of the Research

The major characteristics of the DSS systems developed in the beginning to the mid 1970's are that they contain quantitative models and a user friendly interface for easy updating and manipulation of these models ie carrying out "what-if " analysis. These systems were quite radical, judging from the level of hardware and software technologies at that time, and any systems that had these characteristics could justifiably be considered as DSS. But now with the advance in hardware and software technologies, systems which contain models and friendly interfaces can be built quickly. This makes the differentiation between DSS and other computerised information systems blurred and weakened , as Keen(1987) put it:

"For a period during the early 1980's, it looked very likely that there would be no need to retain the term DSS. Some commentators saw it as a subset of office automation, others equated it with end user computing and some just relabelled what they were doing in the area of data base management, management science and jumped on a bandwagon that had the advantage of having no consensual definition to limit entry and interpretation"

Most of the earlier applications of DSS were based on simplistic models of decision making derived from Simon's[Simon(1960)] model. Keen(1987) wrote

"The broader purpose of scholarship is to provide paradigmatic frameworks that are theory-laden, but not 'theories' to guide research; they must have intuitive appeal plus intellectual coherence. The early progress of DSS was dependent quite heavily on borrowings from Simon 's works on decision making and from cognitive psychology. They provided a useful intellectual base for the era of individual and traditional support. Obviously we must extend and enrich that intellectual base; much of it relates to putting D (decision) back in DSS"

The basic problems of providing paradigmatic frameworks for DSS revolve around identifying theories to be loaded into the frameworks and the use of those frameworks in the methods and techniques for DSS development. The limitations of the existing methods and techniques triggered the need for new techniques and methods or modification to the existing ones. In this respect attempts need to be made to identify the conceptual and theoretical frameworks of DSS and also to develop methods and techniques to help in the application of DSS. Elam et al(1987) posed the following questions which are important for DSS applications:

"(1) What decisions really do matter in an organisation and how should we build better environments to help decision makers handle them ?

(2) How should we formulate and help solve "wicked" problems that require representing values, ethics and aesthetics ?

(3) How do creative people learn ? How should we design our DSS tools to facilitate a real dialogue that stimulates learning ?

(4)What is the role of modelling and quantitative methods in fostering creative thinking ?

(5) What is the technical architecture for evolving DSS in a context of increasingly integrated technologies ?

(6)How should we study and measure effectiveness, quality of decision making, learning and changes?"

The first question implies that any system built should help in improving those decisions which are considered to be important for an organisation. How can important decisions be identified ? Decisions can be classified into a number of categories, for example those that affect the financial performance of an organisation; those that are important for maintaining stable relationships with the environment and those that are important for pleasing certain individuals in the organisation. But the most important thing to bear in mind is that in order for DSS to be worth the investment put into their development the decisions they support should be consensually important for the organisation. In general this set of questions reflects the need for more research to be carried out into the conceptual and theoretical understanding of DSS.

In order for DSS to have a significant impact on public sector decision making, efforts also need to be put into the development of approaches to DSS design and implementation. The objective of this research is to develop such an approach and to evaluate its potential contribution to public sector management in the section " Financial Relationship Between Federal and State

Government(FSR)", in the Treasury Department, Ministry of Finance, Malaysia. The function of FSR is to provide financial aids to the States and to devise the strategies to be used in providing those aids, subject to the constraints imposed. FSR will be described in Chapter 2.

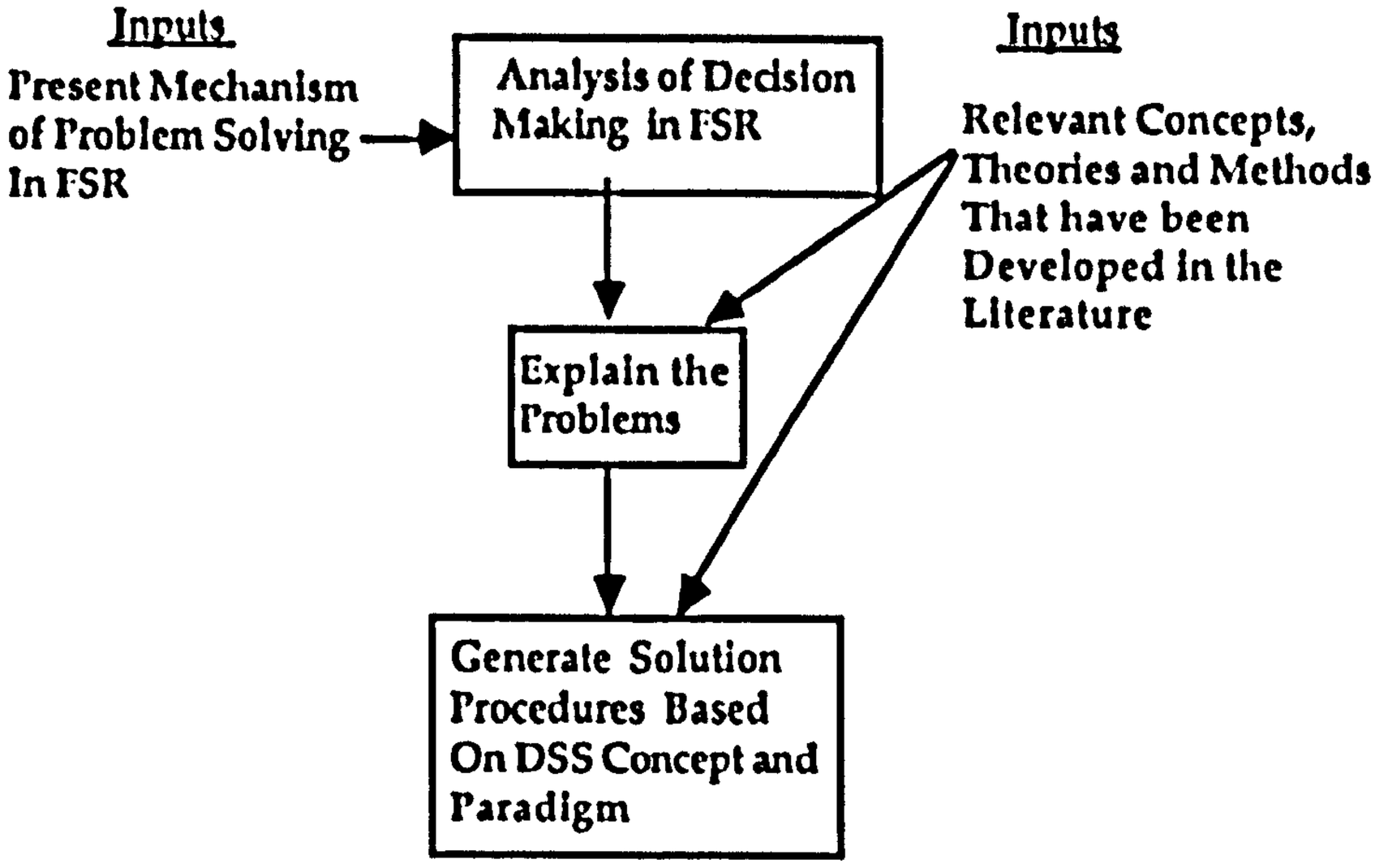
The contribution of this research is the provision of conceptual and theoretical frameworks to help in current understanding of DSS as well as an approach to DSS development. The approach proposed in this thesis enhances the one suggested by Keen (1978). It uses soft system methodology (Checkland 1981) in the development of DSS. A number of limitations of soft system methodology have been identified and the thesis describes an improvement to the methodology in order to make it useful for the development of DSS. The development of an approach to DSS application in general and in the context of one organisation in particular constitutes an important research activity. Whilst many systems have claimed to have some useful impact on the decision making, they were not useful enough to provide frameworks to help in the development of DSS. Applications of DSS in private sector organisations are far more common than in the public sector (these will be described in chapter 3). In this respect methodological approaches adopted in the development of the working DSS and the nature of their basic construction were based on an understanding of the decision making process in private sector organisations. The nature of the decision making in public sector is different from the private sector, in terms of the decision problems, complexity and environmental constraints (this will be described in more detail in chapter 2). The approach proposed in this thesis has

also been applied in the development of information systems for the National University of Malaysia (see appendix 6).

1.3 Research Approach

Most of the findings reported in this thesis emerged from the need to find solution procedures to improve the decision making process in FSR. Before the concept and paradigm of DSS were found to be useful in FSR, two other alternatives were considered. The first alternative revolves around the use of an operational research technique based on goal programming[Zeleny (1975)]. But this off-the-shelf technique was found to be inappropriate due to the complexity of the decision making process in FSR. The second alternative considered was the use of an Expert Systems(ES). Whilst the use of Artificial Intelligence techniques in general and ES in particular were found to be useful and even suggested as part of the emergent technology to be used in the development of DSS for FSR, the application of an ES per se in FSR decision making process was not appropriate. An ES application assumes the existence of human experts in the domain of application whose knowledge needs to be modelled into the knowledge base. In the context of FSR, the decision domain is so complicated that what constitutes the best decisions and how to go about arriving at these decisions, namely models and information to be used, is open to discussion. The following research approach was adopted.

Diagram 1.1: Research Approach



Information gathering methods used in the case study were the following:

* personal interviews with the senior official responsible for FSR and with other senior government officials in the Ministry of Finance,
* observation of the working methods of these officials,
* study of relevant reports, working papers, management manuals and other relevant documents.

Depending on the task domain involved, information gathering can be very difficult. While DSS stresses the importance of semi-structured tasks, the development of methodologies and strategies to be used in understanding the task receive less attention in the literature. The personal interviews conducted in FSR were based on a structured questionnaire (see appendix 1) and free discussion. The purpose of interviewing senior officials from the Finance Ministry was to get their view on the nature of decision making in public sector in general as well as on those aspects that have direct bearing on the understanding of FSR in particular. Other officials involved are the Directors of the sections responsible for " Investigation and Coordination" and " Natural Resources".

The choice of these Directors was not arbitrary. It was based on the nature and characteristics of the tasks their sections have to perform. For example two of the main tasks performed by the Investigation and Coordination section are to approve and monitor the projects submitted by the Operating Agencies and to deal with all aspects of computerisation in the Treasury. The Natural Resources section is involved in some aspects of planning and monitoring social projects and one of its important tasks is to prepare Cabinet Papers. In understanding ill-structured tasks, those directly responsible act as essential sources of information but some useful information can also be obtained from outsiders by virtue of their informal relationship with the tasks concerned and those responsible for them. The importance of informal systems in information systems development is well known, but the approach and methodology to be used in understanding

the role of informal systems still remains an art. In FSR they voice their concerns and consult their colleagues from other sections informally.

There are some limitations to the information gathered from personal interviews that need to be reported. The information given may have intentional meaning but not extensional meaning. An intentional statement is a reflection of desire and aim in the mind of the provider which can not be verified. An extensional statement on the other hand has meaning directly related to reality which can be verified [Vazsonyi (1973)]. For example there were statements generated during interview and discussion aimed at impressing the analyst (the author of this thesis) which have normative meaning but not descriptive meaning. Normative statements reflect what ought to be and descriptive statements reflect the ways things really are. For instance the following statement, obtained during informal discussion, " the function of FSR section of Treasury Department is to devise good and rational methods of giving aid to the poor states in the Federation" is normative. It expresses what FSR ought to be doing but is not necessarily descriptive in the sense that it reflects what FSR is actually doing. The limitation of information gathered from personal interview and informal discussion can also be described in terms of Argyris's Espoused theories of action and theories -in- use[Argyris (1978)]. Espoused theories of actions are those that people report as a basis for action. Theories-in-use are the theories of action inferred from how people actually behave. Formal corporate documents such as organisation charts, policy statements, and job descriptions often reflect a theory of action(the espoused

theory) which conflicts with the organisation theory-in-use [Argyris (1978)].

In order to overcome some of the above limitations personal interviews need to be supplemented by examining the officials' working methods. Observation of officials' working methods involved being with them while they solved actual problems. This approach is used by many research workers in Expert System development. An opportunity was given during the investigation to observe the solution of two problems: decisions on capitation and road grants. While the information obtained from these two problems was helpful, it was limited because it involved well established problems where the solution procedures are well cataloged and understood by the officials concerned.

Past reports, management manuals, working papers and other relevant documents represent important sources of information which are not only useful for validating the knowledge gathered during personal interviews and observation but also contained general philosophy and goals of FSR, guidelines, procedures and rules , past records of how decisions were made and the consequent results. These documents also useful for identifying the problems faced by FSR and the limitations in the present problem solving mechanisms. Where some of these documents may be normative, they can also be used as the frame of reference for designing DSS.

As reflected by diagram 1.1 (Page 8) a number of relevant works were critically reviewed and extended to form models that describe various important

aspects of decision making. Theoretical and practical works in the domain of decision making, organisational theory, information theory and management science were found to be useful as building blocks.

1.4 Limitations of the Research

The empirical study took about three weeks during which information about FSR was collected, using interviews, observation and through studying relevant documents. Whilst good cooperation was given by the Treasury Department, there was no guarantee that full commitment would be given by the staff concerned, furthermore during that time they were busy with the preparation of the annual government budget. A subsequent visit was made to FSR two years ago. By then new staff had taken over the responsibility of managing FSR(it is normal for civil servants to be transferred from one department to another). But it was observed during this visit that no changes took place in terms of information and rules used in providing financial aids to the States. In this respect there is some limitation in the empirical information collected. The conceptual frameworks and approach suggested in this thesis are quite general but the application of this approach is confined only to the FSR. This thesis proposes a general DSS architecture for FSR. A simple prototype was developed but will not be described in this thesis. The findings reported in this thesis also serve as the basis for the current developmental works being carried out by the author and not reported in this thesis. The objective of the current works involves the development of software tools to help in realising the functions

suggested in the DSS architecture proposed for FSR(this architecture is presented in chapter 6). The current developmental works also involve follow-up information gathering from FSR.

1.5 Outline of the Thesis

An analysis of the decision making process in FSR will be presented in chapter 2. This chapter will highlight those aspects of the decision making in FSR which would reveal the characteristics of its complexity, how FSR solves its decision making problems, namely the models and information used. The constraints which influence the present decision making in FSR will also be presented in this chapter. In chapter 3 a critical review of the DSS concept and paradigm will be made. The objective of this review is to identify the philosophy, objective and the basic characteristics of DSS. A number of conceptual and theoretical works that have produced DSS and an analysis of DSS applications will be presented in this chapter. Analysis of the DSS application will be made in terms of the following characteristics: nature of the problem to which they are being applied, nature of technology used, nature of supports provided by DSS and benefits claimed from the use of DSS concept. The relationship between DSS and Management Information Systems(MIS) and Management Science will also be presented in chapter 3. Chapter 3 will also discuss the status of achievement of DSS applications, the attraction of the DSS concept and paradigm in general and with respect to the FSR in particular. Important aspects of the decision making process that have direct bearing on

DSS application in FSR will be presented in chapter 4. These include the inputs to the DSS application as well as impacts which the DSS application is perceived to have. Aspects considered include Environmental, Organisational and Individual. Whilst aspects considered in this chapter are those especially relevant and useful for explaining the problem situation in FSR, an attempt will also be made to tie these aspects into a useful conceptual and theoretical framework for enhancing the ongoing understanding of DSS concept , paradigm and application. This thesis will then propose an approach to DSS development. This will be presented in chapter 5. Frameworks to help in identifying decision aids will be presented in chapter 6. The application of the proposed approach in the context of FSR represent the subject matter of chapter 7. Chapter 8 contains the conclusions and suggestions for further work.

CHAPTER 2

CASE STUDY

2.1 Introduction

Malaysia is a federation of thirteen states. She is a multi-racial nation of Malays, Indians, Chinese and several other ethnic groups. The thirteen states in the federation vary in terms of economic and social well being. This is due to various factors, such as their geographical location, availability of natural resources and the policy of the former colonial master which gave more attention to certain parts of the Federation in economic and social development programmes. Given this situation and the major political and social problems that can be created by the imbalance in economic and social well being of the States, the Federal Government devised various measures and steps to help alleviate the problems. The intentions of the Federal Government is highlighted in the Malaysian New Economic Policy(NEP), which serves as a framework and guiding principle for all economic and social development programmes in Malaysia. The goals of NEP are:

* Eradicating poverty by raising income levels and increasing employment opportunities for all Malaysians irrespective of race. This is to be achieved by

programmes aimed at raising the productivity and income of those in low productivity occupations, the expansion of opportunities for intersectoral movement from low productivity to higher productivity and the provision of a wide range of social services especially designed to raise the living standard of low income groups.

* Acceleration of the process of restructuring Malaysian society to correct current economic imbalance, so as to reduce and eventually eliminate the identification of race with economic function. Programmes for this purpose include the modernisation of rural life, the rapid and balanced development of urban activities, the establishment of new growth centres and the creation of a "Malay" commercial and industrial community in all categories and at all levels of operation. The objective is to ensure that Malays and other indigenous people will become full partners in all aspects of the economic life of the nation.

The responsibilities of policy making, planning, implementing and controlling these programmes are vested in Central Agencies, Operating Agencies and State Corporations. These Agencies and Corporations are interrelated and by the virtue of the roles they play they influence or are influenced by others. One of the strategies adopted by the Federal Government to speed up the achievement of the NEP goals was to provide financial assistance to the States, especially poor States. This financial assistance came under the heading of " Financial Relationship between Federal and State Government" (FSR). Managing and implementing the tasks specified under FSR is the responsibility of the "Local and State Government" section of the Budget

Department division of the Ministry of Finance Malaysia. But in order to determine the overall role of FSR in economic and social development programmes and the complexity of its task environment the relationships between FSR with other participating Agencies need to be analysed.

2.2 Policy Making, Planning, Implementing and Controlling Economic and Development Programmes

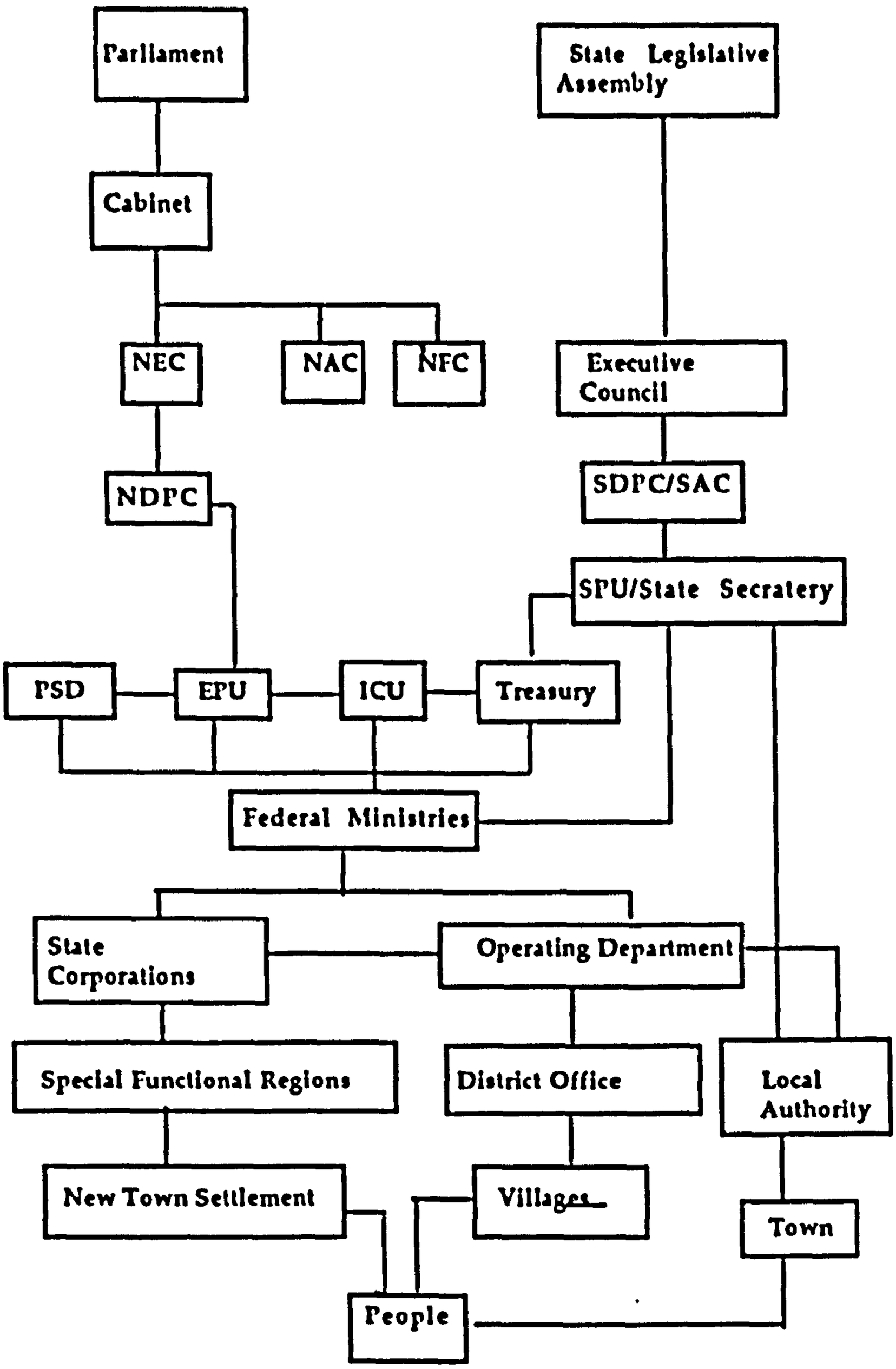
The overall picture of the major bodies participating in the administrative machinery of the Federation, and the States is depicted in the diagram 2.1(page 19). National policy making in Malaysia involve bureaucrats and politicians and where the bureaucrats normally play dominant roles.

" the fact is that the Malaysian political leaders, for various political, social, historical, institutional and personal factors are as a rule more inclined to rely on the administrative apparatus rather than political and other institution to carry out the twin tasks of socioeconomic development and nation building" [Omar (1980)].

Policy formulation is done at various levels. The supreme policy making body is Parliament. The Prime Minister chairs the Cabinet, reporting to which are various committees and councils, down to ministerial and departmental levels. Formal and informal flow of information for policy development is depicted in diagram 2.2 (page 20). In Malaysia planning is done at the Federal level (macro) and States and operating agencies (micro). States and operating agencies submit their proposals and plans for the approval by the Federal Government and later to be

included in the Master Plan. It is not necessary for States to submit their proposals to the Federal Government for approval when they intend to finance the projects from their own resources. But in the normal course of events, the amount of financial resources involved and the complexity of projects make the States dependent on the Federal Government. Therefore the States need to satisfy the requirements imposed by the Federal Government and hence to submit their proposals and plans for Federal approval. At the Federal level, planning, implementing and controlling all economic and social development programmmes involve four main central agencies: Economic Planning Unit (EPU), Implementation and Coordination Unit (ICU), Public Service Department(PSD) and Treasury Department(TD). EPU, ICU and PSD are within the Prime Minister's Department, and TD is within the Ministry of Finance. The involvement of these agencies in various functions of economic and social development is shown in diagram 2.3 (page 21).

Diagram 2.1 : Major Bodies Participating in Administrative Machinery



Keys:

NEC: National Economic Council
NAC: Natiqnal Action Council
SDPC: State Development Planning
SAC: State Action Comitee
PSD: Public Service Department
NFC: National Finance Council
NDPC: National Development Planning
EPU: Economic Planning Unit

Diagram 2.2: Channel of Information Flow for Policy Development[Omar(1980)]

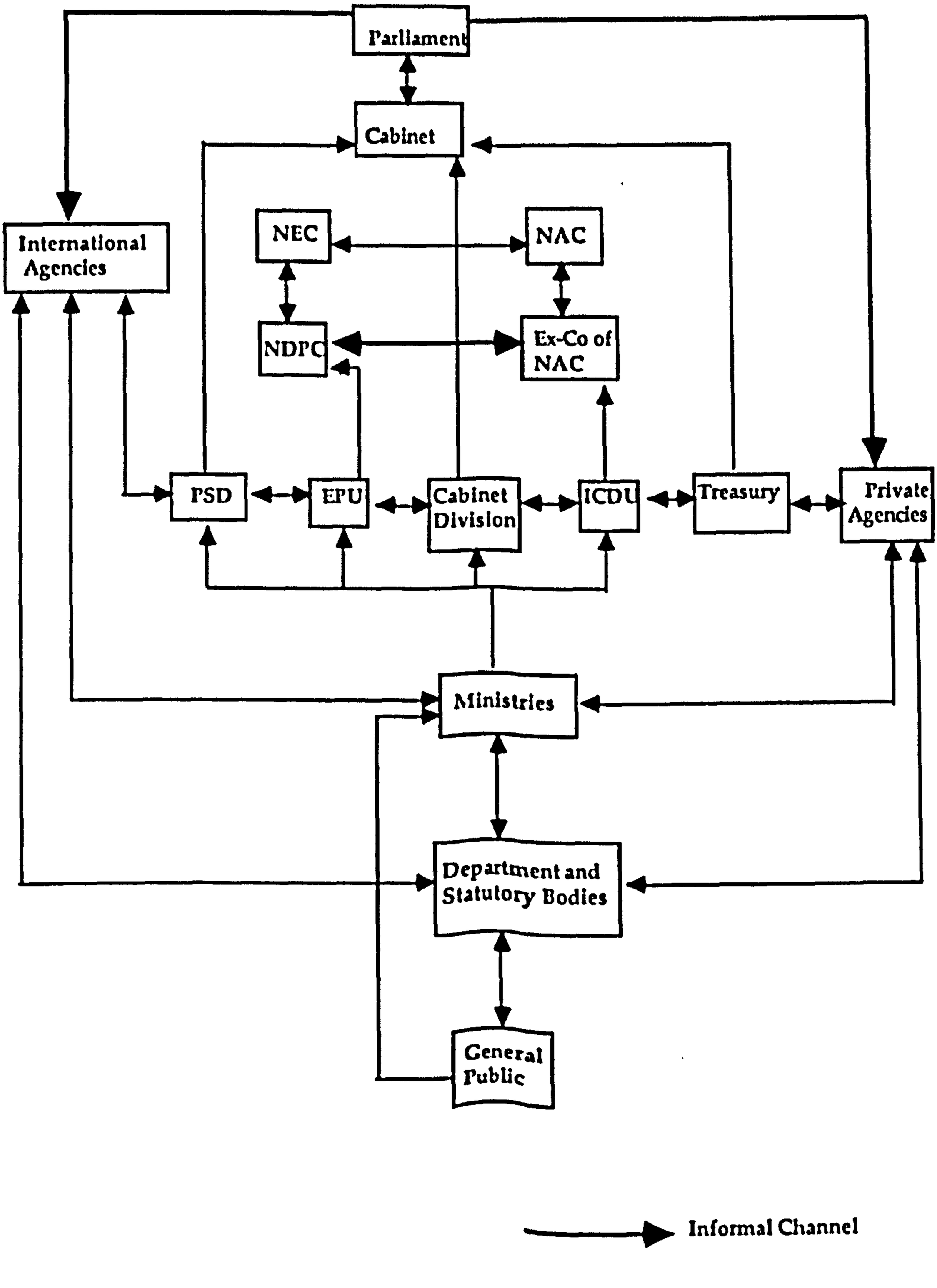
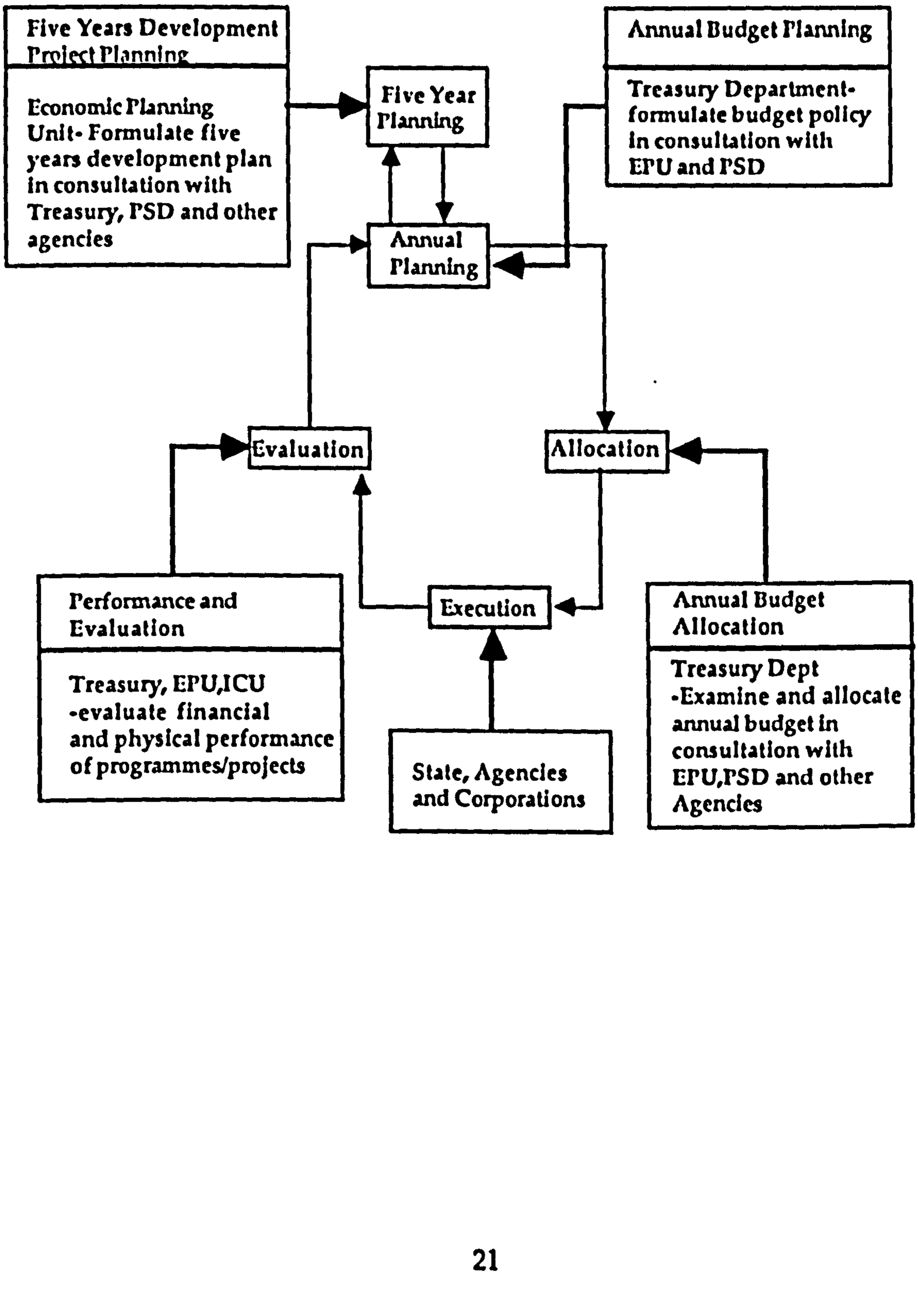


Diagram 2.3: Roles of Agencies in Planning and Evaluation



2.3 Financial Relation Between State And Federal Government (FSR)

The financial provisions of the Malaysian Constitution include the articles that describe the responsibility of the Federal Government in providing financial assistance to the State Governments in meeting their operating and development expenditures. The goal of FSR is " ensure balanced economic and social well being of the thirteen states in the Federation". There are three major activities in FSR:

(1) Administration of financial aid to the State Governments. Financial aid takes the form of grants, short term advances and long-term loans to help the States in financing social and economic development programmes. At present these aids are administered through 16 Aid-Giving Instruments(AGI), which are classified under two categories, Statutory and Non-statutory. A Statutory AGI(SAGI) is either established in the Federal Constitution or by Act of Parliament and comes under charged account of the Federal Government. A Non-statutory AGI (NAGI) is created to meet special needs of a state government. NAGI take the form of advances and loans to the States. The decisions involved in financial aid giving activities are:

* decision on the level of grant to which a State is entitled (referred to here as decision of type-a),

* decision on how much advance should be given to the State (decision of type-b),

* decision whether a loan should be approved and its size (decision of type-c).

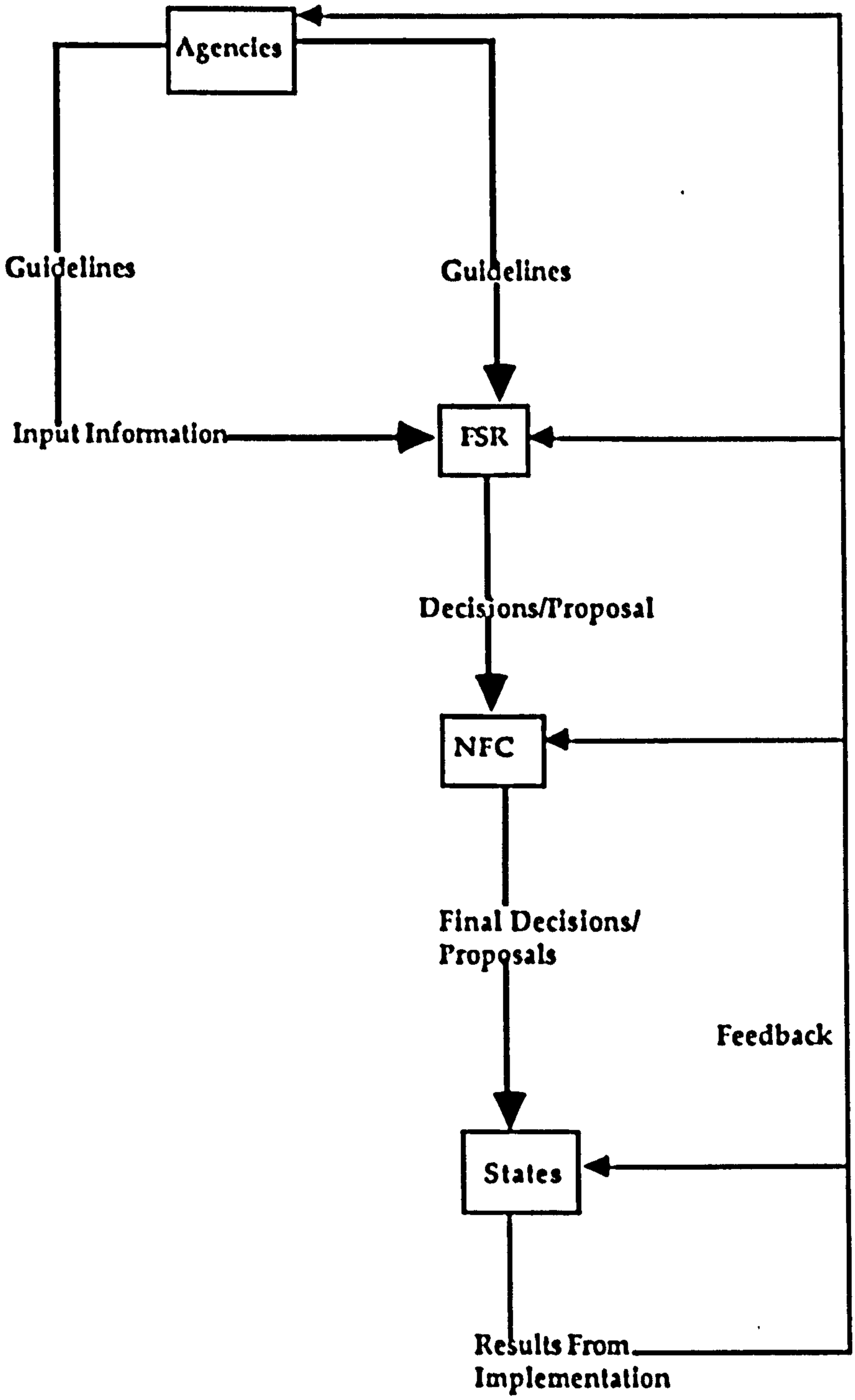
(2) Determining the Federal workforce requirements of the States. The Federal Government is an important employer throughout the Federation. The decision involved is on the size and composition of the Federal workforce in the State(decision of type-d).

(3) Proposing changes or modification to the rules or models that govern the activities (1) and (2) above (decision of type-e).

There are twelve Agencies outside FSR which affect its activities. The role of these agencies is to provide some input information and guidelines which will be used by FSR in carrying out its decision-making activities. Some of these Agencies are also involved in overseeing the performance of FSR. The involvement of these Agencies in FSR decision making is shown in diagram 2.4 (page 25). Three senior officials are directly responsible for FSR: the Director of the Budget Division, Senior and Assistant Directors of the 'Local and State Government' section. FSR provides reports to the National Financial Council(NFC), which was established under Article 108 of the Constitution. The NFC comprises the Prime Minister, such other Ministers as he may designate, and one representative from each of the State Governments, appointed by the Ruler or Governor. The Minister of Finance or his representative is always present at the meetings. In practice, much of the work of the NFC is concerned with financial relationship and problems between the State Government and Federal Government. In particular NFC is responsible for

approving the decisions concerning all aspects of FSR. The State Governments, either individually or collectively, invariably ask for more financial assistance to be diverted to them. These requests are noted and if possible adjustments are made accordingly. NFC has become an effective instrument in persuading the Federal Government to provide more funds to the States and also the instrument used by the States to express their feelings of dissatisfaction with certain aspects of FSR. The role of FSR in general and those officials responsible for it in particular is to recommend or otherwise the necessary adjustment.

Diagram 24: Decision Making Cycle in FSR



2.3.1 Present Problem Solving Mechanism in FSR

FSR uses formal and informal models and information in decision making. The information is either directly used as the input to the models used in Aid-Giving or as the input for the models or rule used in recognising problems and evaluating alternative decisions to solve the problems. The following tables 2.1 and 2.2 show inputs information used in various Aid-Giving Instruments(an example of a model used in SAI is shown in appendix 2).

Table 2.1: Inputs Information used in SAI

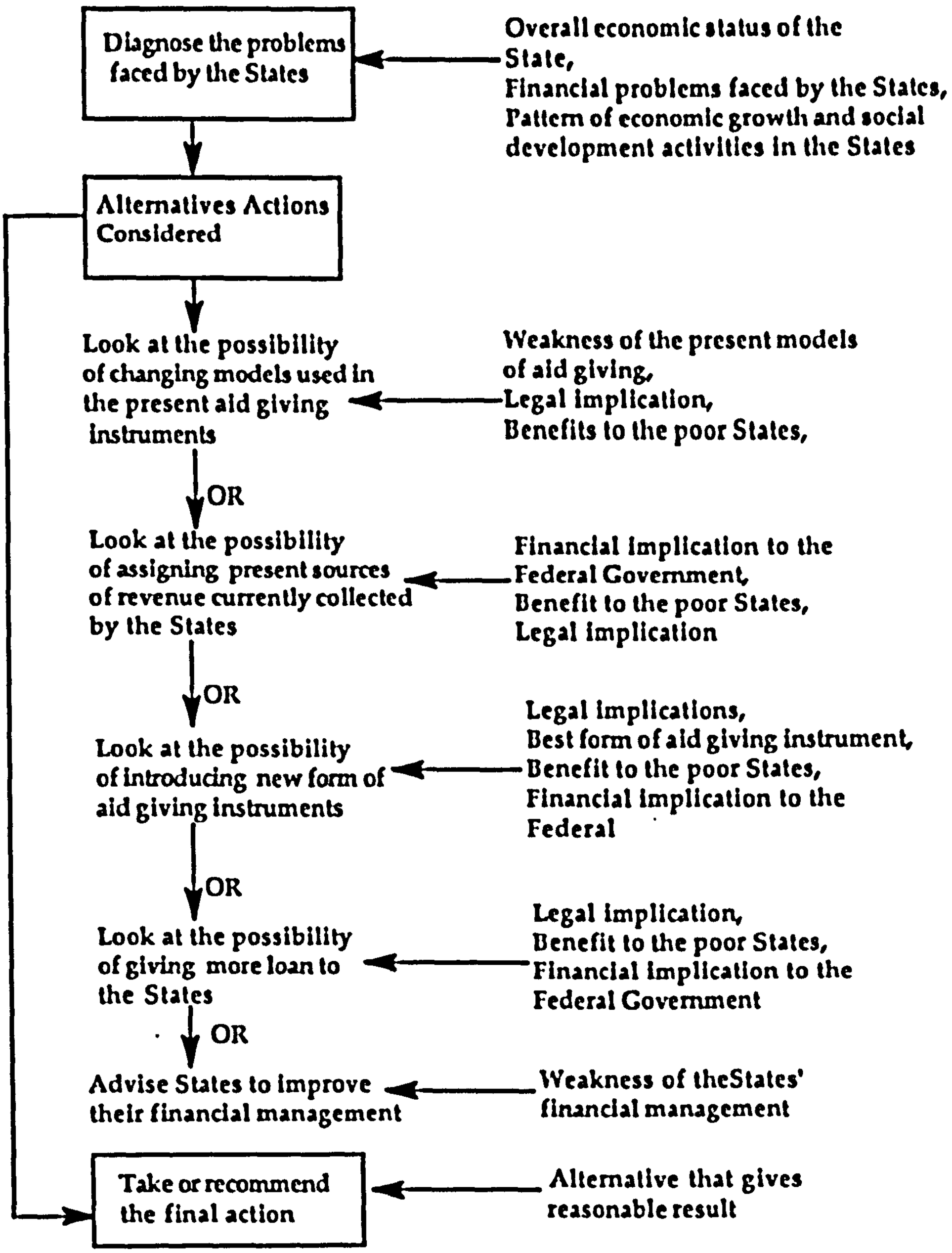
Instruments	Input Information
Capitation Grant	Population Estimates for the Year Concerned
Grant Based on Economic and Social Well Being(GES)	Road Information, Economic and Social wellbeing Indicators of the States, Project Proposals From the States.
Properties In Lieu of Rate	Estimate of the Federal Properties Under the Local Government
Grant Based on Revenue Sharing	State's Population Estimates, State's GDP and National GDP.
Annual Grant to Local Authority	Population Estimate, Financial Statements From Local Authorities
Assignment of Revenue From Export Duty On Tin Produced by the States	Estimate of revenue From the Export Duty From the States
Assignment of Revenue From Export Duty On the Iron Produced by the States	Estimate of revenue From the Export Duty From the States
Assignment of Revenue From Export Duty On Mineral Produced by the States	Estimate of revenue From the Export Duty From the States

Table 2.2: Inputs Infromation Used In NSAI

Instruments	Inputs Information
Advanced From State Revolving Fund	Cashflow Projections Of the States, Financial Statements of the States
Special Aids to Local Authority	Project Proposal From the Local Authority.
Aids to Low Cost Housing Projects	Project Proposal From the States
Loan to the States	Project Proposals from the States, Status of the Old Projects, Economic Prospect of the Federal Government
Aids to the Federal Projects Undertaken by the States	Project Proposals from the States
Aids to the Projects in Rural Areas	Project Proposal from the States
Allocation of Federal Work Force	Proposal from the States

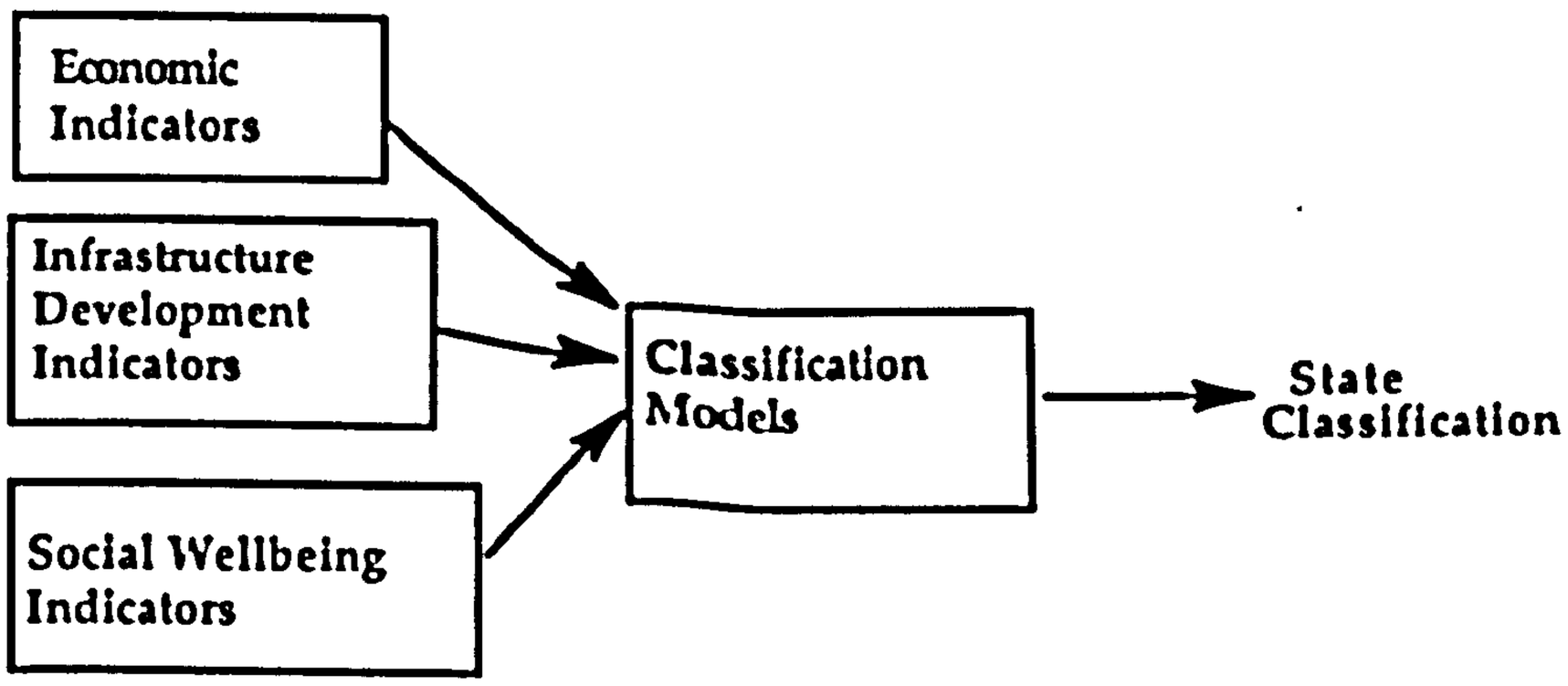
Problem recognition triggers the decisions on the strategies or actions that need to be formulated to improve the situation. The following diagram 2.5 represents an example of the logic used by FSR in selecting strategies or actions to increase aid to the State.

Diagram 2.5: Logic Used In Decision to Increase Aids to the States



It was found during the study that in recognising the problem, economic, social wellbeing and infrastructure development indicators were used as the basis for classifying whether a state is "poor" or not as in diagram 2.6. Non numerical rules were used by FSR in arriving at the classification in diagram 2.6(the rules used by FSR will be described in chapter 7).

Diagram 2.6: Indicators Used In Classifying States



In fact the schema in diagram 2.6 was discovered to represent an instance of a more general "schema" used by FSR in recognising the overall status of economic and social well being of the States. This general schema is shown in the following diagram 2.7.

Diagram 2.7: Schema Used In Determining Overall Economic Status of the States

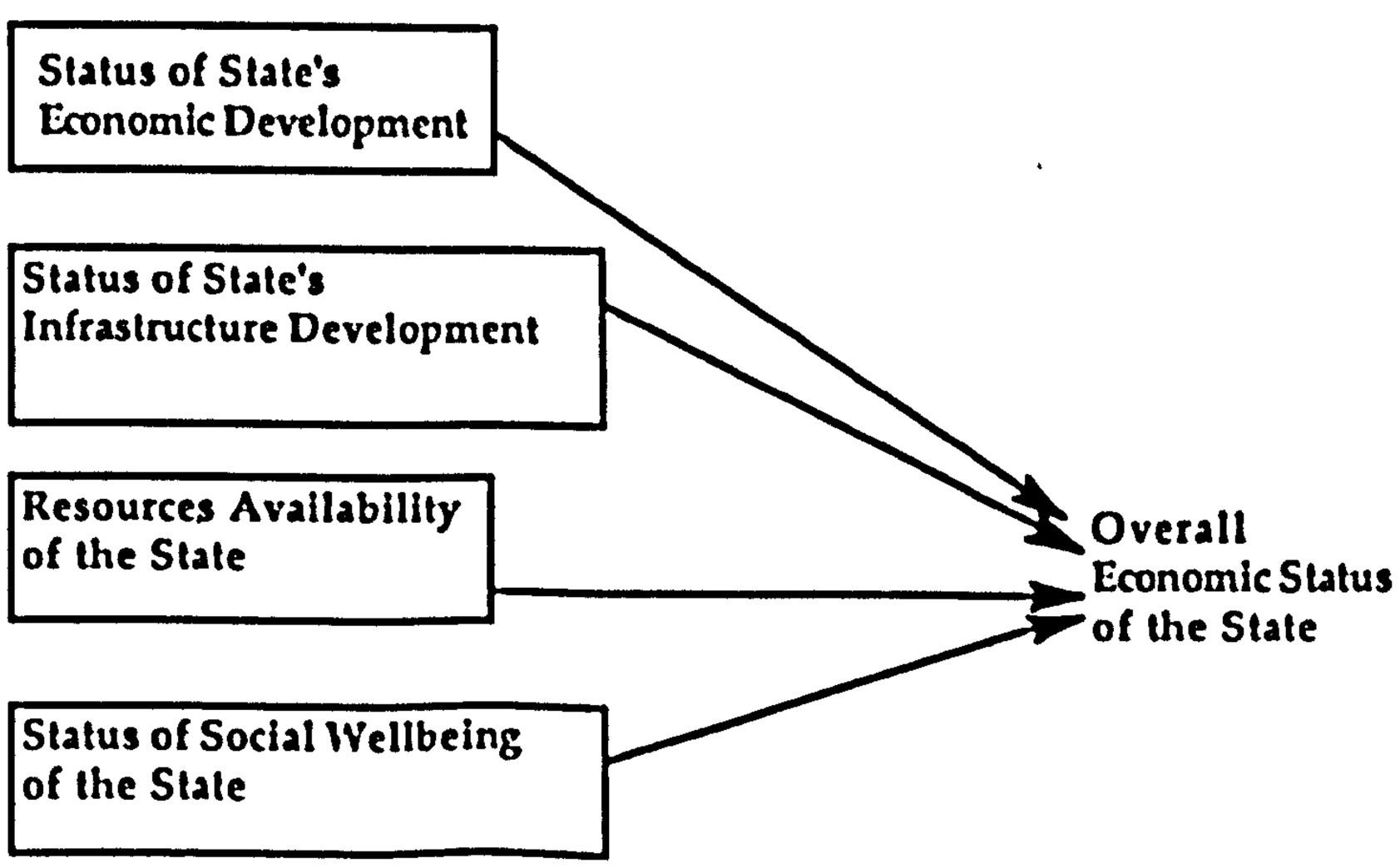
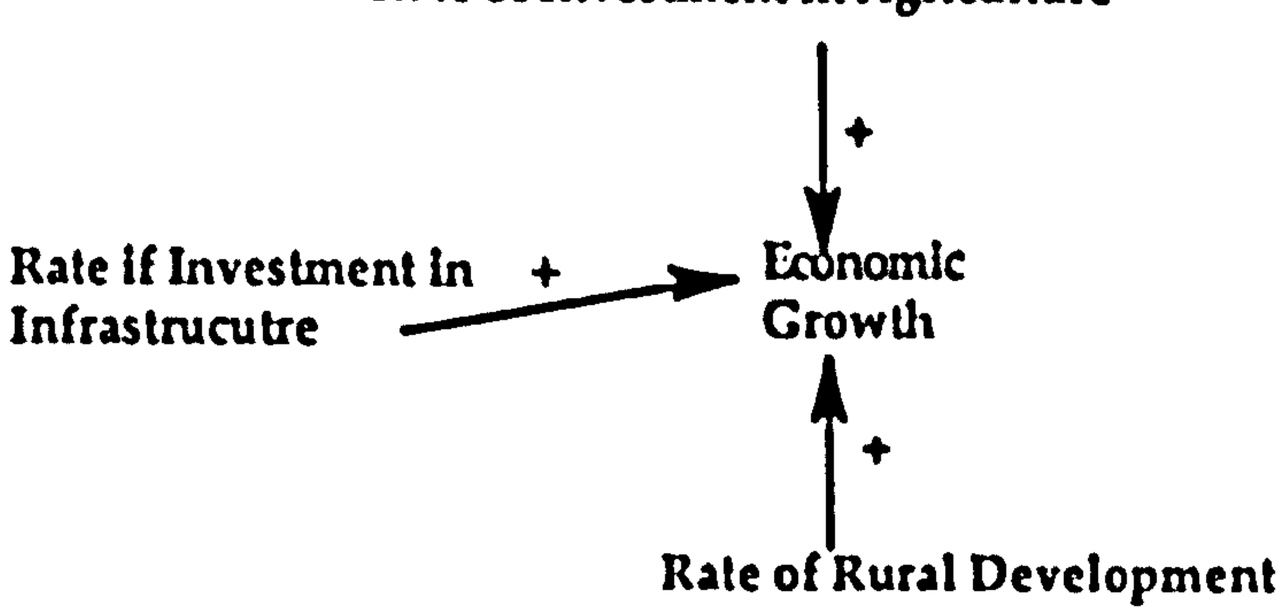


Diagram 2.8 show a general schema used in describing factors that contribute to the State's economic growth.

Diagram 2.8: Schema Used in Determining Factors Contributing to the Economic Growth of the State



+ Indicates relationship in Positive Direction

The schema is defined here to be a network of related entities that guide the thinking process. As entities have attributes, we differentiate between general schema, such as diagram 2.7(page 31), and operationalised schema. Operationalised schema are those in which all the entities involved have been defined in terms of concrete attributes and their relationships have been defined in terms of models or rules. For example table 2.3(page 33) shows the attributes of three entities in diagram 2.7, namely economic development, infrastructure development and social and wellbeing of the State, defined by FSR in terms of indicators.

Table 2.3: Economic, Social wellbeing and Economic Indicators

Status of Economic Development indicators :

Gross Domestic Product of the State

Employment in the Industrial Sector

Employment in Agricultural Sector

Revenue percapita

Employment in service sector

Employment in other sectors

Status of Social Wellbeing Development indicators

Percentage of poor household

Percentage of illiterate

Rate of stillborn per 1,000 population

Number of doctors per 10,000 population

Number of primary teachers per 100,000 population

Percentage of population in rural area

Status of Infrastructure Development indicators:

Population without water facility(urban)

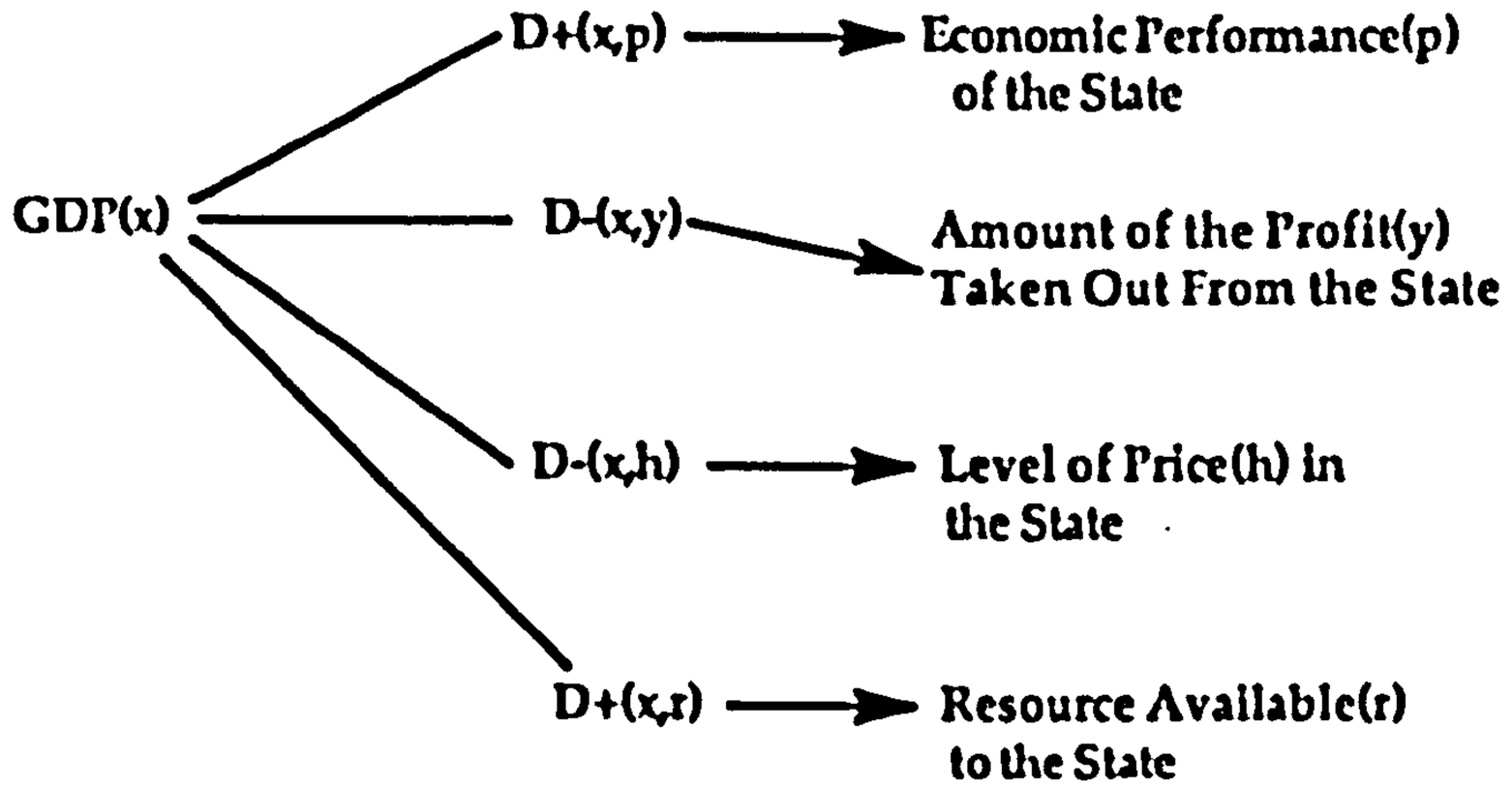
Population without water facility(rural)

Road length in Km per 100 population

Electricity consumption per year in Kwh

These indicators were used by FSR as the basis for classification in diagram 2.6 (page 30) and in this context diagram 2.6 represents an operationalised schema. The changing of these indicators for a particular State to the better or worse would be taken by FSR to reflect the improvement or otherwise in the economic and social status of that State, The schema in diagram 2.9 was used by FSR in arguing the weakness or otherwise of the Gross Domestic Product(GDP) as input information to the present model used in Aid-Giving Instrument, namely the schema used in looking at the possibility of changing the present model of aid giving in the decision making in diagram 2.5 (page 29).

Diagram 2.9: View On the Strength and Weakness of GDP



D+(x,z): Relationship indicates z respond directly to a change in x in the same direction

D-(x,z): Relationship indicates z respond directly to a change in x in the opposite direction

The role of the various Agencies and Departments in providing information to the decision making process in FSR is shown in table 2.4.

Table 2.4: Role of Agencies In providing Information to FSR

Agencies	Information Provided
Statistics Department	Population Projection of the States, States' Financial Statement, Manpower Requirements, Adhoc Requirements
MRD	Guideline On Project Evaluation,
EPU, FDT	Five and Yearly Plan
ICU,SERU	Economic and Social Wellbeing Indicators
SERU,PSD,MAMPU	Guideline On Workforce Employment
EDT	Economy of the Nation
Investigation,Coordination and Evaluation section ,Treasury Department	Guideline on Project Evaluation
FDT	Guideline on Loan and Project Evaluation
Ministry of Public Works	States' Road Information
Ministry of Land and Natural Resources	Information on States'Mineral Resources

2.3.2 Limitations of the Present Problem Solving Mechanism

It was found during the empirical study that discovering the problems or difficulties faced by FSR and the limitations of the present problem solving mechanism was a difficult task. Those involved in FSR were more at ease and more confident in describing what they did than in describing what problems they faced and how to go about improving the situation. The approach adopted in discovering the problems or difficulties faced by FSR and the limitations of the present problem solving mechanism was to study the relevant documents, such as management manuals, working papers, meeting agendas, conference papers as well as interviewing those outside FSR who have an indirect involvement in the decision making in FSR. The documents were to supplement information gathered from personal interviews with those directly involved with the decision making in FSR. The documents were found to be useful for inferring and identifying the problems faced by FSR and the limitations of the present way of working.

Basically the problem or difficulty faced by FSR is to produce decisions or actions that satisfy the requirements from the States and also satisfy the stipulated objectives and constraints. The constraints include political, legal ,social , governing value systems ,norms and ideology. At the macro level the present ability of FSR to generate decisions that satisfy these requirements, objectives and constraints can be used to represent general criteria to measure the weakness or otherwise of its decision making. At the micro level, the weakness and limitations of FSR in promoting effective decision making can be examined against a number of factors. In this approach the following factors were examined: availability of information,

use of modern methods, techniques and technology in management and also the availability of necessary knowledge, skill and experience to use new technology, methods and techniques.

It was discovered that the lack of relevant information was prominent in decisions of type-e. As implied by the previous description in section 2.3 type-e decisions are important as they affect the rest of the decision making activities in FSR. This mean that their improvement is vital. The lack of relevant information typifies the general problem faced by public sector organisations in Malaysia. Major policy issues such as New Economic Policy have been formulated in a situation of uncertainty and lack of information. Decisions are essentially based on "common knowledge" rather than a comprehensive set of data that has been systematically collected . The problem of policy planning in Malaysia is related to the availability of information in terms of sufficiency, relevance and accuracy. Central Agencies in Malaysia depend on each other for information. This implies that there is often controversy among Central Agencies and even among departments within the same Agency regarding the relevance, accuracy and sufficiency of information. The seriousness of the lack of sufficient, relevant and accurate information is reflected by the following statement by the Chairman of the National Economic Consultative Council on the need to have a common data base for new economic policy:

" the National Economic Consultative Council will establish a common data base for further deliberations to prevent its members from "quarreling" over different statistics" [Star (1988)].

The Treasury Department was among the first Public Sector Organisations to use computers in Malaysia. But it was discovered during the study, and confirmed on a recent revisit to FSR, that computers are still not being used in FSR. The potential use of modern methods and techniques in management are not being fully exploited in FSR. Heuristic models are heavily used in decision making. The use of modern methods and techniques such as operational research in the Malaysian Public Sector has been reported to be quite small. According to a sample survey 5 out of a total of 26 public sector organisations which participated in the survey were found to have used operational research techniques [Kwan (1986)]. Computer simulation, regression analysis, financial forecasting and PERT/CPM rank amongst the most used OR techniques in Malaysia(see also the following table 2.5).

Table2.5: The Problems in the Uses of OR in Malaysia and Singapore[Kwan(1986)]

Difficulty/Problem Encountered.	Frequency of Mention
Lack of OR Expertise	15
Complexity of Modeling	14
User Awareness and Acceptance	7
Input Availability	6
Computer Capacity	6

2.3.3 Complexity of Decision Making in FSR.

One of the reasons for the difficulty of FSR in finding information and formulating models or rules to help in generating decisions that satisfy the requirements and stipulated objectives and constraints is the complexity of its problem domain. Generally problems can not be explicitly stated or or at best elude precise definition, ie they are unstructured. The complexity of the decision making in FSR can be inferred from the characteristics of a number of aspects: goal of FSR, its information focus, measure of performance of its decision making, multiplicity of roles in its decision making and decision making calculus used. Governing environmental factors, such as social, economic, politics and legal shape the general philosophy, goals and objectives of economic and social development programmes

in Malaysia. These will contribute to the complexity of the problems faced by organisations participating in the planning and implemention of them. One of the problems emerged from the goal of FSR which is to ensure balanced economic and social well being of the thirteen States in the Federation was measuring the effectiveness of its decision making process. What constituted a measure of the effectiveness of FSR was difficult to conceptualise.

In general, measuring the effectiveness of Public Sector decision making is not easy. Outputs from the Public Sector service are difficult to define and measure adequately and a multiplicity of measures need to be utilised [Ostrom (1973)]. This leads to the measure being defined in different ways and using abstract concepts or ideas as the follwing examples. Omar (1980), based on extensive interview with civil servants from various levels, described the effectiveness of the civil service in terms of the following:

* ability to provide good advice and adequate/timely information to the cabinet,
* ability to manage departments and agencies,
* ability to be responsive,
* ability to institutionalise, namely ability to establish the credibility of the authorities.

Following an article in a local newspaper [Hassan(1988)] the Chief Secretary to the Government of Malaysia was quoted to have said that to ensure excellence in the Civil Service, government servants had to abide by three main principles:

* Efficiency - to ensure cost and time effectiveness;

- Responsibility- to ensure a civil service which has integrity, trustworthines and a high sense of accountability ;
- Responsiveness - to ensure the service could change with time and cater for the needs of people and country.

He was also quoted to have said that in line with these aims all organisations have been told to give priority to strategic planning and to implement new technology and management procedures. In the public sector, decisions as what services to produce are not motivated by financial return. Effectiveness measures how well the demand for the service is satisfied, i.e the adequacy of services relative to the need of the people and the country. An example of a measure of the effectiveness of the health programme in Malaysia is its effect on the mortality rate. Another important measure of effectiveness that can be deduced from the goals of Malaysian economic policy revolves around the notion of equity, or fairness, impartiality or equality of service. In the context of Malaysian New Economic Policy, equity stresses the restructuring of Malaysian society, namely toward reducing imbalance in social and economic well being between races. Equity has been a major concern of political scientists [Savas (1978)].

Decision making in the environments represented by diagram 2.1(page 19), 2.2(page 20), 2.3(page 21) and 2.4 (page 25) correspond to the multi-role process, in which the different Agencies involved can be assumed to have different roles, power, influence, interests and perception. These result in multiple objectives set by multiple actors or by those that have direct interests in the solutions to the problems. The existence of a number of actors creates potential source of conflict. The empirical study conducted by Schwenk(1990) in United States showed that high conflict is associated with high quality for executives of non-for-profit organisations but with low quality for executives of for-profit organisations. Not-for-profit organisations executives must make decisions which meet the needs of diverse groups rather than merely maximising financial performance. Conflict means that implications of different groups views and goals need to be made clear [Schwenk (1984), Tjosvold (1985)]. The existence of power in multi-role decision making process gives rise to the influence that may affect the final decision. The empirical study conducted by Robey(1989) showed that participant influence affects conflict and its resolution. Public sector organisations in Malaysia get their power from and their responsibility is ultimately to a legislative Assembly or Parliment. This implies that Parliment plays an important role in setting up general goals and guidelines. These goals and guidelines are sometimes abstract and encompass the inspiration and political interest of the present governing political party.

It was inferred from the empirical study that the major information focus of FSR revolves around the formation of information indicative and predictive of the social and economic well being of the States. Table 2.3 (page 33) and some of the

information in diagram 2.7 (page 31) reflect this . Due to this focus FSR found it difficult to find relevant information for its decision making activities. Defining social and economic indicators is difficult [Carley (1981)]. Two important characteristics of social and economic indicators are that they are surrogates as well as measures. As surrogates they do not stand by themselves, rather they represent abstract and unmeasurable economic and social entities or concepts, and as measures, the indicators translate entities into operational terms that allow analysis of the entities. For example "Poor State" was translated into operational indicators as shown in table 2.3(page 33). The abstractness of the entities used and the difficulty of translating these into operational terms contributes to the complexity of the decision making in FSR.

As described in the previous section heuristic models are heavily used in FSR. This can be attributed to a number of reasons, one being the complexity of the decision making process. In a complex and ill-structured environment there is a small proportion of cases in which decision problems can easily be identified and ready-made solutions prescribed. In this domain the problem needs to be recognised, requirements and constraints need to be determined, models or theory has to be developed and evaluation criteria have to be agreed upon. The decision making process in a complex domain involve inconsistent, incomplete and uncertain information, lack of established models or theories, methods and techniques. This is what Hogarth et al (1980) called "Procedural Uncertainty". The existence of procedural uncertainty lead to the use of heuristics, which rely on limited information, simplifying strategies, judgment and common sense. Heuristics are

justifiable and sometime unavoidable due to the complexity of the problem. It provides a time-pressured decision maker with a simpler and shorter way of dealing with complex problems. This leads to saving in time , effort and cost, as limited information is collected and used. Heuristics also arise due to the need to keep decision consistent or correspond with, for example, the present organisational norm and values system or any other reinforcer. The complexity of the three major activities in FSR can be summerised in the following table 2.6 .

Table 2.6: Characteristics of decision types in FSR

	DECISION TYPES				
Decision characteristics	(a)	(b)	(c)	(d)	(e)
Complexity	Complex	Complex	Complex	Complex	Complex
Nature of model used	Heuristic	Heuristic	Heuristic	Heuristic	Heuristic
Model understanding	well understood and cataloged	well understood and cataloged	well understood and cataloged	not well and cataloged	not well and cataloged
Prior guidelines	Well specified	Well specified	Well specified	Not well specified	Not well specified
Personal judgment	Less	Less	Less	More	More
Interaction with environment	Less	Less	Less	More	More

2.4 Government Efforts Toward Improving Decision Making

The intention of the Federal Government to encourage the use of modern methods and techniques, new technology, such as information technology and to encourage the development of skill and knowledge in management is reflected in the formation of the Malaysian Administrative And Management Planning Unit (MAMPU) and Institute of Public Administration (IPA). This intention is also reflected by the statement from the Chief Secretary to the Government given in section 2.3.2. Information technology has been used to a certain extent in the public sector and at present is an important subject on the agenda. Government response to the use of information technology has resulted in the formation of a steering committee for information technology. According to the Prime Minister's department the committee was set up to formulate a comprehensive national information technology policy [Kumar (1988)].

The extent of use of computers in the public sector is similar to the private sector. Based on a computer usage census, there was a 74% increase in computerisation from 1986 till 1989 [table 2.7(page 46)]. Malaysia is ranked fourth in Asia behind Japan, Singapore and Korea in term of computer usage [Kumar(1988)]. According to MAMPU the government will spend 150 million Malaysian dollars a year over the five year period 1988-1993 on information technology in the public sector [Kumar (1988)]. The objectives of computerisation in government are improving efficiency in the government administration and enhancing managerial effectiveness. Information Systems to cater for these objectives currently form the core of computer applications in government [Shafie (1990)]. The 74 percent

increase in the number of computers in the public sector reflects a positive vision and action on the part of the government to introduce new technology into public sector management. With respect to the utilisation, about 68% of the computer systems are used for routine administrative purposes, 1.5% for security , 3.6% for research and the balance for economic , agriculture and education purposes[Rahman (1990)].

Table 2.7: Distribution of Computers (not including personal computers) by Agency Types 1986 and 1989[Computertimes August 23, 1990]

Agency Type	No of agencies	No of Computers 1986	No of Computers 1989	% Increase
Ministries	24	13	14	8
Federal	73	60	81	37
State Dept and Local Authorities	370	68	72	6
Statutory Bodies	169	85	225	165
Total	636	226	393	74

The problem with the present installations is that they are still under utilised, as the Director of MAMPU put it:

The present installations are also under-utilised. In the same census it was established that in 85.4 percent of the installation found in 1984, the operating time of the machines were below 50 percent" [Kumar (1988].

Two computerised information systems were claimed to have capabilities to support high level decision making. One system, situated in the ICU, integrated information from EPU, TD, ICU and Accountant-General Department(AGP) into a data base. The system provide information on project planning, land acquisition, construction of infrastructure and building and disbursement of fund. Another system,located in the Prime Minister department, is meant for the cabinet members and top civil servants. An example of the information provided by that system is the budget allocation for the respective ministries.

2.5 Conclusion

This chapter has presented a number of factors which are important for understanding the decision making process in FSR. The approach adopted in unifying some of these important aspects into a coherent framework for understanding the decision making process in FSR match the system approach. The potential use of system approach in understanding large and complicated system is well described in the literature [Churchman (1969), Emery(1969), (1976)]. The fundamental premise of the system approach is that systems, regardless of their specific context, share a common set of elements. The elements include the following:

* The environment , which is the set of entities and conditions outside of the system boundry that affects the system or is affected by it. The entities in the environment may be affected by the system, but are not controlled by it,

* The role , which is the function or objective of the system. System's role represent its intended impact on its environment,

* The components and arrangement of these components. System's components represent its functional building blocks. The arrangment of the system's components concerns the links among the components and between them and environmental components in such as way that it will enhance the ability of the system to perform its task and to interface with a particular aspect of the environment,

* System resources, which are the elements used in building and operating the system. Resources include people, raw material, capital, knowledge, tools and techniques.

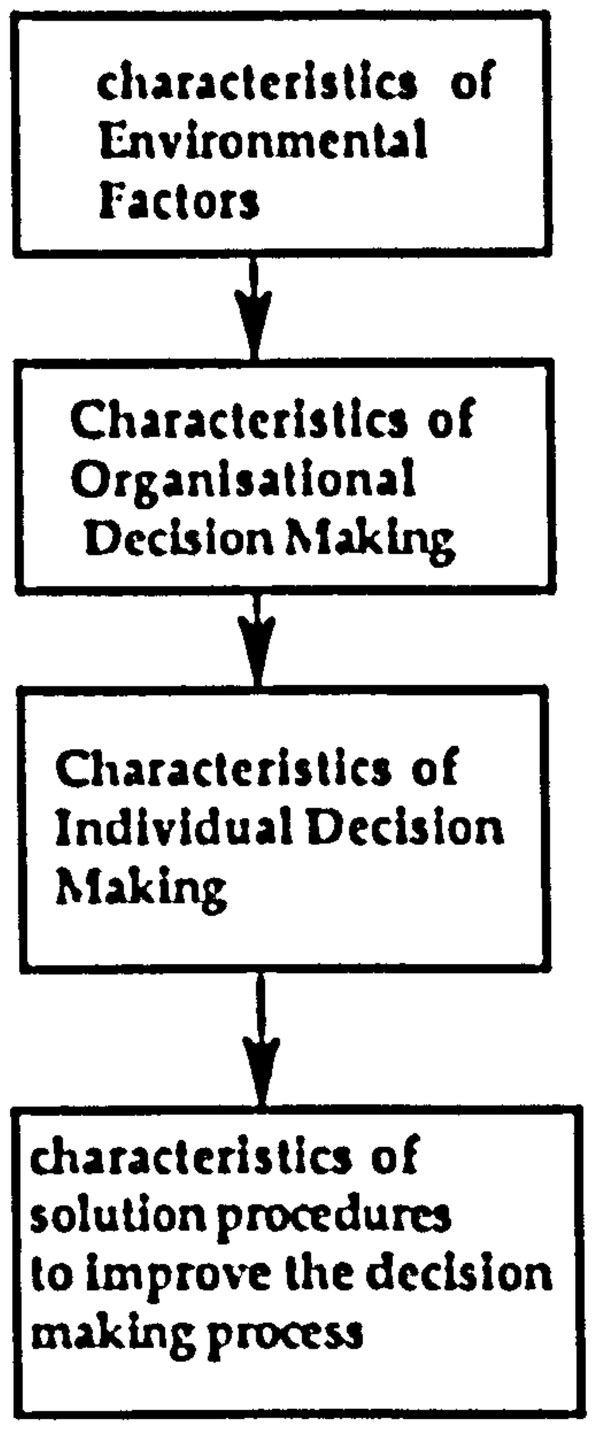
This chapter has provided some systemic understanding of the decision making processs in FSR by identifying those important environmental factors such as role multiplicity, social , economic and political conditions. One of the important implications that can be derived from this understanding is that these environment factors influences the characteristics of FSR's role , for example organisational goals, organisational effectiveness and also the complexity of the organisational task. These organisational characteristics will in return determine the characteristics of individual decision making process, such as individual decision making problems and their complexity.

Systemic understanding of the decision making process in FSR is also useful because it has a direct bearing on the development of solution procedures, namely information, models, tools and techniques, to improve the effectiveness of its

decision making. Environmental factors ,organisational and individuals characteristics of the decision making process of the FSR are structural, in the sense that they are inherent in FSR . These factors and characteristics act as the constraints to the decision making process in FSR. Intelligent design of appropriate solution procedures can not be made until declarative factors are well understood , namely understanding of declarative factors is prerequisite to the design of solution procedures. Designing solution procedures will also bring into focus the important system elements: components, their arrangment and system resources. The discussion of the present problem solving mechanism in FSR and the limitation of this mechanism provides an initial picture how FSR organise its components and resources to match with the task it need to perform. In general terms designing solution procedures enables the introduction of actions to improve the present system components, their arrangment, and system resources of FSR.

In summary the importance of systemic understanding of decision making process in general and in FSR is reflected by diagram 2.10. A number of conceptual, theoretical and methodological issues have yet to be pursued in the development of solution procedures to help improve effectiveness of decision making in FSR. Discussion of these issues will be the subject of the chapters to follow.

Diagram 2.10: Influence of Environmental Factors on Organisational and Individual Decision Making



CHAPTER 3

DECISION SUPPORT SYSTEMS: CONCEPTION TO PRACTICAL REALISATION

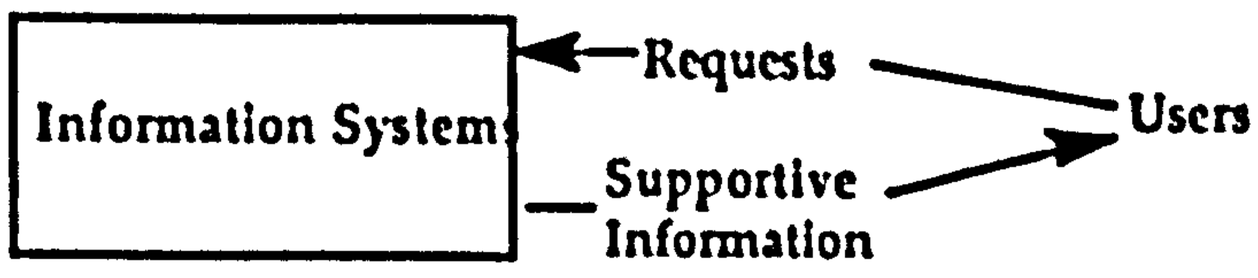
3.1 Introduction

The purposes of information systems are to maintain files of data about the organisation, process these data and produce information (reports or other outputs) to assist those concerned with efficient and effective problem solving and decision making [diagram 3.1(page 52)]. Information systems have enjoyed improvement in terms of their application areas, type of users they support as well as conceptual and theoretical knowledge, methods and techniques in their development. Information Systems applications can be described in terms of three categories: Transaction Processing Systems(TPS), Management Information Systems(MIS) and Decision Support Systems(DSS).

TPS are the lowest level information systems in organisations and are aimed at improving the efficiency of routine business activities. Other major characteristics of TPS are that their embedded transaction process, namely set of procedures for handling the transaction, is not that complicated and they normally include activities such as calculation, storage and retrieval, classification,

summarisation and sorting of information. Similarly the transaction processing and the data involved in TPS are normally easy to identify and model, because they are well understood. Example of TPS are payroll systems and billing systems. Transaction Processing Systems are commonly associated with the operational level of an organisation.

Diagram 3.1: Role of Information Systems



In general, Management Information Systems(MIS) assist management in problem solving and decision making

"as the term generally understood, is an integrated, man/machine systems for providing information to support the operation, management, and decision making function in an organisation. The system utilise computer hardware and software, manual procedures, management and decision model, and a data base

[Davis(1974)]"

Davis's definition reflects explicitly the objectives of MIS to make available a broad base of comprehensive and accurate information for a wide range of management functions in organisations, by utilising computer technology to help

in the creation of large data bases that could be shared by many applications and also more sophisticated data retrieval and processing facilities, and incooperating management and decision models of the organisations. MIS recognise the importance of information as a basic resource of an organisation. Despite their popularity, MIS have been criticised for their failure to support decision making in complex and unstructured environments [Parker (1986), Watson(1983)]. Various reasons for this have been put forward , for example:

* MIS are best for structured tasks where standard operating procedures decision rules and information flows can be reliably defined,
* MIS are "data rich" but "information poor",
* users are unfamiliar with their decision making environment,
* users can not specify their requirements except through an interactive process,
* information requirements will change with changes in decision making environment.

Mintzberg (1973) has also provided empirical evidence to support the failure of MIS.

"Traditional information systems were not designed for the manager. They provide internal, historical, precise information of an aggregated and reference nature, whereas he seeks in large part of external, current, speculative information of trigger nature. Hence manager is forced to rely on his own monitoring system, which is necessarily crude. By coming to understand the manager's actual use of information, the analyst can help design and operate a more effective monitoring system-- formal but probably not computerised, which would provide the manager with much of information he seeks ".

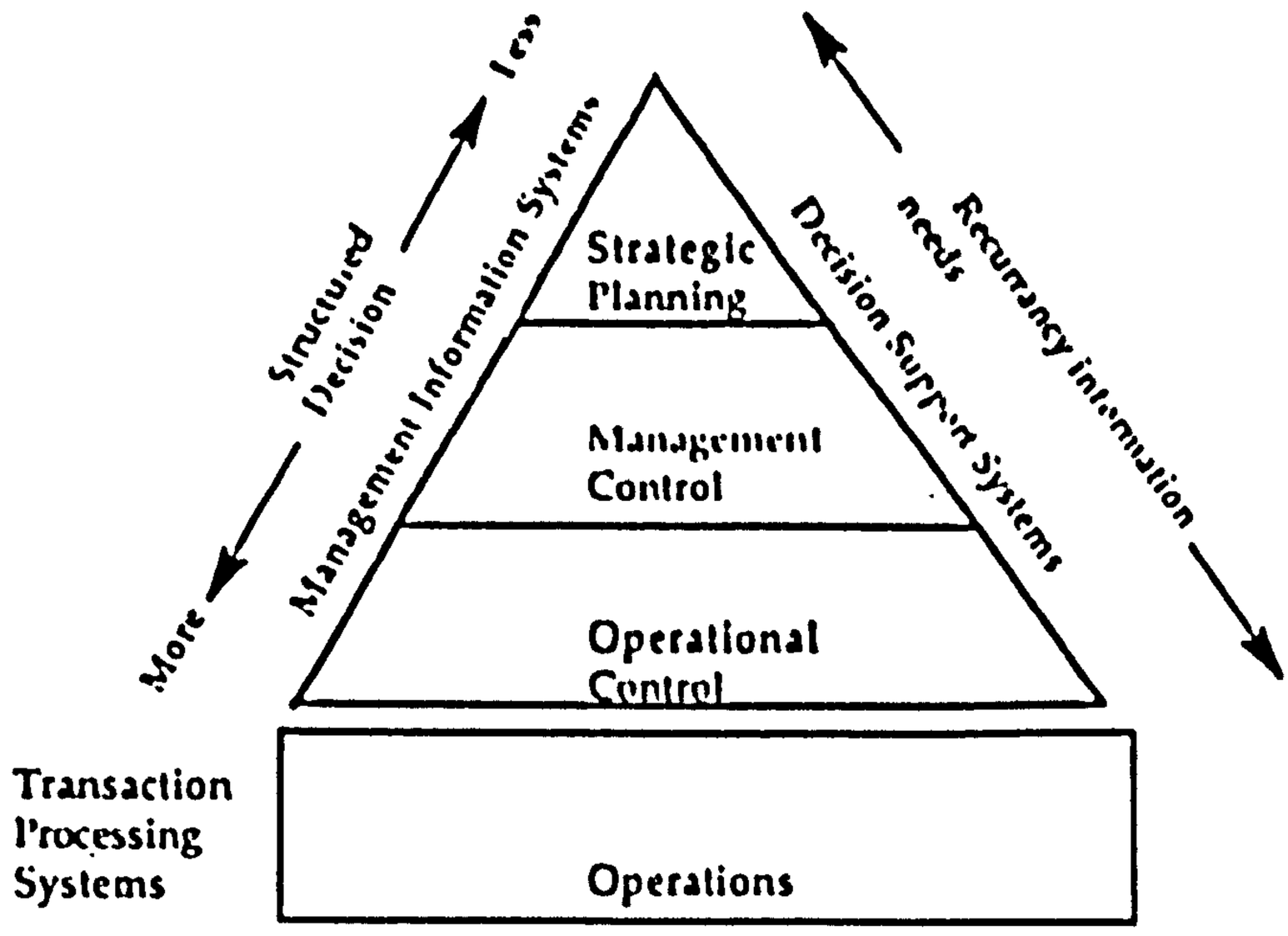
A decision is considered unstructured if the procedures and factors to be considered can not easily and readily be identified in advance. In this respect manager's judgment plays a vital role. The category of information systems to support manager in this situation is known as Decision Support Systems(DSS). The DSS concept was introduced by Keen, in association with others at Sloan School of Management, in the 1970s [Wagner (1981)]. The concept is claimed to be different from other information systems applications, such as MIS. It stresses the use of the information systems in conjunction with the power of human judgment in ways that help improve effectiveness of decision makers in semi-structured tasks without reducing the autonomy or replacing the judgment of the decision maker.

In summary the basic difference between these three categories of information systems can be represented in table 3.1(page 55), and in relation to the various organisational functions their applicabilities can be represented as in diagram 3.2(page 56). But in order to determine the novelty and uniqueness of the DSS concept the characteristics of the works that have claimed to have used the concept need to be analysed and compared with the characteristics of other information systems applications.

Table 3.1: Categories of Information Systems

Categories of Information Systems	Characteristics
Transaction Processing Systems	Substitute computer-based processing for manual procedures, deals with well structured routine processes, including recordkeeping applications
Management Information Systems	Provide inputs to be used in the managerial decision process. Deal with supporting well structured decision situation in which typical information requirement can be anticipated.
Decision Support Systems	Provide information to managers who must make decision about particular situation. Support decision makers in situation that are not well structured

Diagram 3.2: Relationship of Information Systems to Level of Organisation (Senn(1989))



3.2 DSS and Reality

The DSS concept is now widely accepted and has attracted a lot of attention from academic researchers as well as users from the business community. DSS are normally been defined in terms of a set of characteristics or attributes but most authors usually avoid adopting a definitional approach to the subject. The most common set of characteristics of DSS quoted in the literature revolve around those based on Keen and Scott Morton(1978) and Sprauge(1982):

* support users in their decision making process in illstructured tasks,
* support and enhance rather than replace managerial judgment,
* improve the effectiveness of decision making process rather than its efficiency,

* attempt to combine the use of models or analytical techniques with traditional data access and retrieval functions,
* specifically focus on the features which make them easy to use by noncomputer specialist in an interactive mode,
* emphasize flexibility and adaptability to accommodate changes in the environment and decisionmaking approach of the user.

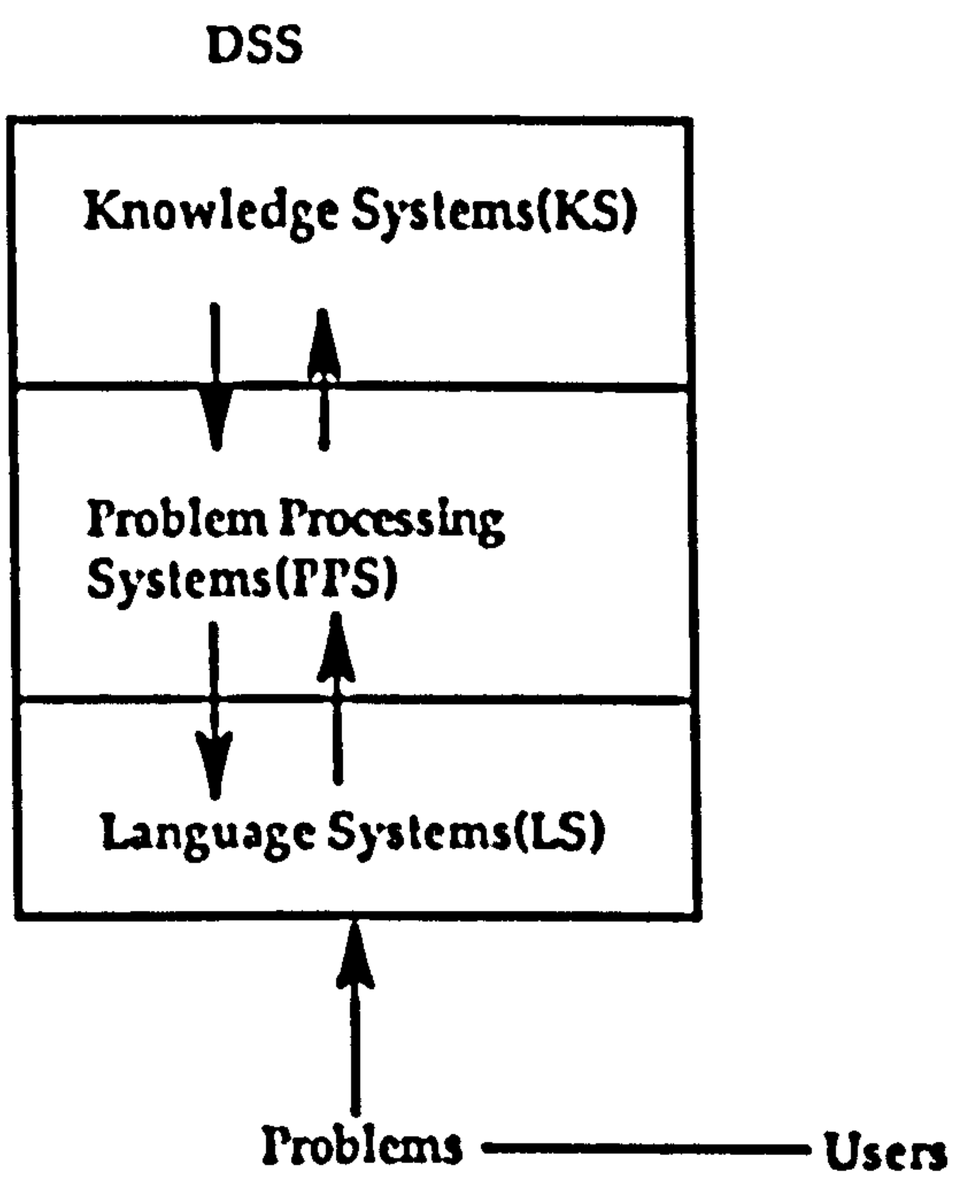
In order to have such characteristics DSS should have certain capabilities. Keen et al (1978) express these in terms of their abilities to mimic the way a manager thinks; be flexible and adaptive through ease of modification; support a complex process of exploration and learning;evolve to meet changing needs, knowledge and situation. Keen also proposed a set of design criteria that would realise the above capabilities, they include flexible development language that allow rapid creation and modification of systems for specific application; a system architecture that allow quick and easy extension and alteration; an interface that protects the user from the "computer" and allows a dialogue based on a user's concepts, vocabulary and definition of the decision problem; a communications device and output generator. A review of the current literature has identified the following major categories of DSS works:

* Development of conceptual and theoretical frameworks to help in understanding the DSS concept,
* Development of working systems to solve real life problems,

3.2.1 Conceptual and Theoretical Frameworks

There has been much interest in the conceptual and theoretical background to DSS. A summary of the conceptual and theoretical works on DSS can be found in Keen et al (1978). Since then the number of works in this direction has been quite encouraging and there have also been improvement in the ideas, concepts and theory. Basically conceptual and theoretical works on DSS are concerned with the identification of those important aspects that have a direct bearing on understanding the DSS concept and also on the development of methodologies for DSS applications. The importance of these works can be understood in terms of the generic description of DSS proposed by Bonczek (1981) as summarised in the following diagram 3.3:

Diagram 3.3: Major Components of DSS [Bonczek et al (1981)]



The Language System(LS) in diagram 3.3 refers to the linguistic facilities made available by the DSS for the users to state their problems. LS may encompass either or both retrieval language and computational language. A language system is characterised by the syntax that it furnishes to the users, by the statements, commands, or expressions that it allow the users to make. Knowledge System(KS) refer to a decision supports system's body of knowledge about a problem domain. Problem-Processing System(PPS) represent an interface between KS and LS and its function is to take the problem statement from LS and relevant piece of knowledge from KS and produce information that supports a decision process.

Research has been carried out to help understand the nature of the components in diagram 3.3. The conceptual and operational issues are well described in Bonczek(1981). The potential uses of Artificial Intelligence techniques in realising the components in diagram 3.3 is a popular topic in the DSS literature. Artificial Intelligence(AI) is the study of ideas that enable computer to be "intelligent"[Winston (1984)]. Research in AI focuses on aspects that make intelligence possible, such as understanding, learning, problem solving as well as knowledge representation. Knowledge Based Systems(KBS) have emerged from practical application of research in AI. KBS represent computer-based information processing systems which embody "knowledge" of a particular domain and an inference capability to use the embedded knowledge in problem solving. The need for synergy between DSS and KBS has been expressed by researchers such as Henderson(1987) and Turban et al (1988). For example in research into knowledge representation techniques, reasoning and natural language understanding, help in

realising KS, PPS and LS respectively. The techniques of knowledge representation are cataloged by Brachman and Levesque (1985). Potential uses of knowledge representation techniques in modelling KS have also been suggested, for example by Gorry et al (1983). Aspects of reasoning are important in the development of DSS, especially in realising the PPS component. The use of logic for modelling and reasoning in DSS is described in the DSS literature [for example see Kimbrough et al (1988),Scott(1988), Lee(1988), Hooker(1988), Widmeyer(1988)] Aspects of representation and reasoning with uncertain knowledge are important for the development of DSS to support decision making process in complex environment. Representation and reasoning with an incomplete knowledge base is described by Levesque (1984). The use of fuzzy logic to handle uncertainty has also been described by Zadeh(1973) and Dutta et al (1986). Bonczek et al (1981) and Dutta et al(1984) describe the use of predicate logic formalism in model management and Liang(1985) provides a general framework for model management which helps in model creation, modification and use. As implied by diagram 3.3, DSS need to have access to a knowledge base. But the need to have a PPS in DSS requires enhancement to the capability of data base model resided in the knowledge base. At present there are three popular data base models: relational, network and hierarchical [Date (1979), Martin (1980)]. Efforts have been made to link the relational data base model with logic base formalism, for example Reiter(1984) and Bonczek(1981). Dell'aquila(1989) proposed an architecture of a relational DSS. The use of logic programming for data based inference, namely for routine access and access for information that require combination with other informational and computational resources, has been described by Lee(1985). DSS have also triggered research on theoretical aspects of

decision making for example Moore et al(1986) have developed a model of decision making in terms of optimal information gathering and decision strategy.

3.2.2 Development of Working Systems

Eom et al(1990) have compiled a bibliography of 203 specific DSS applications appearing in the literature. 27% of these was published during 1971 to 1980 and the remaining 73% were published during 1981 to 1988. Eom et al have also made an analysis of these articles based on a number of aspects which include the following:

* areas of application,
* distribution of the underlying models used in DSS,
* classification of applications based on Alter's scheme(see below)
* classification of the applications based on task interdependence (personal support, group support and organisational support).
* management level (operational, tactical, or strategic) for which the DSS was designed,

Of the 203 articles 48 are associated with public sector applications. More details are in the following table 3.2.

Table 3.2: Summary of DSS Applications in Public Sector[adapted from Eom et al (1990)]

Areas of Applications	No of Applications
Agriculture	3
Education	7
Government	10
Hospital and Health Care	7
Natural Resources	12
Urban and Community Planning	6

Mathematical models are heavily used in the applications as shown in table 3.3(page 63). Alter (1980) provided a classification scheme, based on the 'degree of action implication of system output'. Eom used this as the basis for analysing the DSS applications. A summary of the findings is in table 3.4(page 64). In terms of the level of task interdependency 94 applications were developed for personal support, 65 for group support (group of individuals, who are engaged in separate, but highly interrelated tasks) and 44 were developed for organisational support (focusing on organisational tasks involving a sequence of operations and actors). As to the level of management about 24 % of the applications were developed to support strategic decisions.

Table 3.3: Underlying Models Used in DSS Applications [Eom et al (1990)]

Nature of Models	Number of Applications
Deterministic Models	
Linear Programming	18
Transportation Model	6
Goal Programming	9
Network Models	15
Inventory Models	8
Integer Programming	19
Nonlinear Programming	6
Dynamic Programming	4
Stochastic Models	
Queuing Models	3
Markov Process Model	6
Simulation Models	41
Decision Tree	8
Game Theory	1
Forecasting and Statistical Models	40
Others	
Multiple Attribute Decision Making Models	5
Multiple Objective Linear programming	5
Artificial Intelligence	12

Table 3.4: Summary of DSS Applications Based on Alter's Classification

Category	Number of Applications
Data Analysis Systems	
on line data retrieval, manipulation,display of current and historical data, summary and calculation	15
Analysis of Information Systems	
manipulation of internal data from TPS and argumentation with external data using statistical packages to provide management information	23
Accounting Models	
used for deriving consequences of planned actions on the estimate-of-income statements,balance sheet and other financial statements.	14
Representational Models	
used to estimate the future consequence of action based on partially nondefinational models	81
Optimisation Models	
used to generate optimal solutions consistent with constraints	57
Suggestive Models	
models suggest decision for a family of structured tasks. The models perform mechanical calculation and there is little scope for managerial descreation	13

An analysis of articles published between July 1988 to 1990 found that DSS applications were mostly based on management science models, especially optimisation models. DSS applications, for example, based on linear programming models can be found in Andrew et al (1989) and Constantopoulos (1989); an application based on linear goal programming can be found in Elger et al (1990) ; DSS based on multiobjective linear goal programming are described in Korbonen et al(1990) and Siskos et al (1989). AI techniques have also been used in DSS development. Lee et al(1988) use pattern recognition and inductive learning techniques in the development of DSS to assist in time series modelling. These systems have the capability to classify pattern into autoregression moving average and also the capability to learn, by the use of the technique of linear discriminant analysis, to discriminate one pattern from another. Shaw et al (1989) describes the use of induction learning techniques in the development of DSS for commercial loan approval applications. An application of DSS in the public sector is described by Hamalainen (1988). The users of the systems are the Members of Parliment in Finland. The system assisted members to choose between three alternative power plants, by providing a simple model of energy decision hierarchy and also facilities to manipulate the model.

3.3 Commentary: Are DSS really useful and novel ?

The DSS concept was received with mixed reaction from users in the business community as well as academics. There are those who still are critical of the concept and view DSS as no more than a fashionable repacking of the MIS concept and

management science. Naylor(1982) in his provocative paper questioned the uniqueness of DSS concept in comparison with MIS and model-based computer assisted applications.

".....I find it impossible to ascertain what is either new or unique about DSS. Although there are people in management science who specialised in solving highly structured optimisation problems, there are many others who use techniques such as computer simulation, heuristic programming, and artificial intelligence to analyse and solve unstructured problem.s Although third-generation software for corporate planning and modelling is much more powerful and easy to use than early software systems, the concepts embedded in systems such as CUFF, EXPRESS, and IFPS all owe their origin to management science and MIS. In other word why do we need a new term or new field to describe the use of interactive computer to support unstructured decision making ?"

However the novelty and usefulness of DSS needs to be analysed in a wider perspective, ranging from the concept itself, and the works that have claimed to have used the concept or help in enhancing its understanding. For instance one can look at the novelty and usefulness of DSS from the following angles:

- the characteristics of the conceptual and theoretical works that have been done in DSS.
- the characteristics of the working systems. These include the nature of the decision making environment and problems in which DSS are applied, the nature of support provided the and models used by DSS.

Blanning(1983) in defending the DSS concept has identified five useful research areas as the direct result of the emergence of the DSS concept: construction

of knowledge-based interactive systems; the development of frameworks for model management systems similar to those of data base management systems; the integration of data management and model management to produce an emerging science of information management. Some of the related works have been described earlier. There are also enhancement of current concepts in information economics to provide relevant criteria for evaluating proposed or existing DSS[Sutherland (1983)]. The investigation into the behavioural issues, such as decision styles, relevant to the design and implementation of DSS have also been investigated [Alvi et al(1981), Bariff(1977), Benbasant et al(1978) Keen et al(1978)] . Watson(1982), defending the DSS concept, felt that a sufficient conceptual framework in an area such as methodology for developing DSS plus the methods for evaluating its proposed application, the organisational roles associated with it and the hardware and software used to build it, exist in DSS to serve both practice and research.

As described earlier DSS are found in a variety of applications. The main characteristics of the working systems are that they contain numerical data bases, quantitative models and graphics facilities. They also have "humanized" interfaces that enable the users to easily create, access and modify the model. Many of these systems support the users by allowing them to perform "what-if" analysis. The novelty of the earlier systems is attributed as much to their attempts to translate the characteristics of DSS into working systems as to their ability to provide the software capabilities for their implementation, judging from the state and the availability of the software and hardware technology at that time . The common characteristics, namely numerical data base, quantitative models and humanised

interfaces, are also prevalent in the later works on DSS. With the emergence of AI techniques in general and Knowledge Based Systems(KBS) in particular there was a trend in the use of these techniques in DSS development.

Much of the conceptual and theoretical work in DSS overlaps with work in KBS and Management Science(MS). Most importantly the use of quantitative models in most DSS applications[table 3.3(page63)] blur the difference between DSS and MS applications. The difference can be explained in terms of a number of important aspects, such as the objective of introducing models into the decision making process, the role of the models and the major issues of the decision making process considered in the model development. In other word the difference in paradigm used in the development of DSS and MS. In particular MS is concerned with the development of optimisation models, simulation models, and also to a lesser degree, with heuristic models. Numerous applications of MS have been reported in the literature. A survey conducted by Fabozzi and Valente(1976) indicated heavy use of MS in both production and finance. Applications of MS techniques in the public sector domain are well catalogued in the literature, for example see Jennergren et al(1980), Coverdale et al (1980), Lathrop et al(1982), Wilson (1981), Bevan (1980) and Corneille et al (1983).

MS does not seem to fall short of the "methodological" paradigm. It has a well articulated approach to modelling and the approach incorporates, most, if not all, of the following characteristics [Markland et al (1987)]:

- Use of the scientific method,
- Use of a systems approach,
- Use of a team concept,
- Extensive use is made of the computer.

Various factors have contributed to the successful application of MS: for example, applications are usually to structured problems which can easily be modeled and there is a good availability of relevant data. There are domains where the applicability of MS models is in doubt. These include problems involving behavioral , political and social issues, such as policy making and strategic planning. MS's commitment to the "scientific method" and development of mathematical, especially optimisation, models gives it less appeal for complex strategic problems. It has floundered on problems that are perceived to be important see, for example Dando et al(1981). Tinker and Lowe (1984) argued that whilst Management Science methods and techniques are able to provide models(mathematical) with predictive and explanatory (analytical) capabilities, the break down of the Management Science paradigm is due to its failure to focus on what they called black box problems. Black box procedures precede scientific activity of prediction and explanation; they are concerned with the philosophical and sociological questions of how theories(models) are (and should be) constructed and evaluated [Tinker and Lowe(1984)]. Black box problem-solving procedures are required when a problem is in a pretheoretical, "immature" or incomplete state (when the elements, variables, their characters, magnitudes or interaction are undefined). Nagel(1984) relates the likelihood of favorable use of Management Science in public policy making to the

following factors: bipartisan support, sensitivity to compromise, no overwhelming opposition, some interest group support, sensitivity to jurisdictional matters, sensitivity to alternative government procedures, and congruence between societal, group, and individual goals. How far has DSS eliminated the weakness of the MS paradigm ? In order to provide an answer to this question one needs to analyse DSS in term of the paradigm on which their research and development rests. The DSS paradigm can be described in terms of three schools: Decision Analysis(DA), Decision Calculus(DC) and Decision Research(DR) [Stabell (1987)].

Decision Analysis (DA) attempts to provide a methodology for both structuring the decision situation and making a rational choice. The basic techniques used are micro economic and statistical theory. Many well established works, such as White(1975) , Keeney et al (1976) and Holloway(1979) are useful for the development of the techniques. The methods and techniques proposed in DA are general and independent of the content and context of the decision making situations. In DA decisions need to be defined in terms of goal, alternatives, outcomes, state of nature and probability measures. A number of DSS have been developed based on DA for example Alternative Ranking Interactive Aid Based On Dominance Structural Information Elicitation (ARIADNE), developed by Sage (1986). This was based on the hypothesis that people are able to evaluate alternative plans and decisions efficiently and with low stress when a clear dominance pattern exist that allow the establishment of a sufficiently discriminatory priority structure. ARIADNE contains a model to assist users in organising information for decision support as well as selecting the preferred alternative. This is made possible by helping the users in the

following aspects: determination of dominance alternatives and displaying them; determination of bound or attribute weight implied by the partial or holistic preference supplied by the decision maker; identification and recommendation of preferred alternative; sensitivity analysis. ARIADNE requires prior knowledge of alternative actions, possible outcomes, utilities and probability distribution of outcomes. Multi Attribute Utility Decomposition(MAUD), developed by Humphreys (1982), is an iterative system based mainly on the concepts and techniques that have been developed in multi-attribute utility theory. The systems support the users in structuring, decomposing and recomposing of preferences between multi-attribute alternatives. But in order to use the systems the users are required to have prior knowledge and understanding of the problems to be solved, alternative actions, outcomes and utilities. An example of the use of MAUD in a career choice problem was described by Humphreys et al(1982).

Decision Calculus (DC) is a model-based set of procedures for processing both data and judgment [Stabell (1987)]. In this context models are developed that would be simple and easy to understand, easy to control and communicate with, namely permitting immediate and interactive modification of all input, complete on important issues and adaptive, i.e easy to update new information. The decision maker's judgment and experience are used to calibrate the parameters of the model. DC is the oldest and most popular paradigm in DSS development. Examples of early well known systems are PROJECTOR, BRAINAID and PAM [for a summary of these systems see Keen (1978)]. In fact the common feature ` Models + Humanised Interface' which characterise most DSS result from the need to realise the DC

paradigm.

Decision Research (DR) views DSS development as an effort to improve the effectiveness of the manager's decision making process. The major concern of DR is not model building nor computer-based information systems as such, as they represent only one possible means to improve decision making. In its early stage the DR school was influenced by the concept of `bounded rationality' [Simon (1960), (1976)]. Bounded rationality recognises the constraints internal to the decision maker as the information processor. This recognition serves as the basis for identifying conceptually the objective and roles of any approach to improve the effectiveness of the decision making process. According to Stabell(1987) the development of DSS based on DR paradigm requires:

* multiple models along with an empirical method for applying them, to map current decision making behavior,
* models and methods should be based on decision behavior,
* DSS should support existing decision making process.

The differences between the three schools is given below in table 3.5

Table 3.5: Comparison of alternative DSS School [Stabell(1987)]

	Decision Analysis	Decision Calculus	Decision Research
Type of situation	single shot	repetitive	repetitive
Focus in decision process	choice	problem solving choice	whole cycle
Primary aims	consistent decision	better decision	effective decision process
Learning	conditional probability	model of the decision situation	decision process
handling lack of structure	impose structure	structure	explore lack of structure
Focus in DSS process	analysis	design	analysis
Reference	micro economic	MS	decision analysis in organisation

Do any of the above schools point to significant differences between DSS and MIS or any other information systems application ?. The areas in which DSS have been applied, their underlying mathematical models and the level of management for which they are designed play very little role in revealing the difference. Even classification of DSS applications based on Alter's taxonomy and level of task independence, as described earlier, is not that informative and useful. In table 3.4(page 64) data analysis and analysis of information systems represent typical concerns of MIS application. Similarly optimisation and suggestive models in table 3.4 point to little difference between DSS and MS applications. This leads to the question of whether it is necessary to continue using the DSS label; or are there any

special characteristics that make DSS distinctive from other computer-based applications? The same questions are implied by the following statements by Keen (1987). These support Naylor's argument against the uniqueness of DSS concept

"All in all, the message for DSS is clear: technology is not the bottleneck any more. What is the news for the next decade? The question is central, not peripheral, since the first and very distinctive promises about the application of technology to decision making have been realised. If the main innovations of DSS were and will be in the area of systems development and use, the term is redundant. It takes little difference whether an adhoc financial model is called 'Personal Computing', 'end user computing', or 'financial modelling'. If the technical base for a DSS is a LISP machine and the application is to build an expert system for product planning, why not call it an expert system"?.

Keen continues

"For a period during the early 1980's, it would very likely that there would be no need to retain the term DSS. Some commentators saw it as a subset of office automation, others equated it with end user computing and some just relabeled what they were doing in the area of data base management, management science, computer science .....".

To relate the concept with the technology used or with the characteristics of the working systems that have claimed to have used it would not be very helpful. While it is true that the difference between DSS and MIS was blurred by many applications, the novelty and usefulness of DSS should be looked at from the perspective of the paradigm on which their research and development is based. The DSS paradigm is useful as it provide an intellectual contribution to the understanding of the decision making process. As reflected especially by the DR school, DSS represent key issues that need to be considered and included in their

development [table 3.5(page 73)]. In this respect the DSS concept is useful as a discipline for research and practice. The research should stress on aspects which are important for understanding the decision making process,such as its environment. As Keen(1987) put it

"DSS is concerned with intellectual as well as computer-related technologies. It is our interest in decision-making rather than the computer which make Decision Support Systems distinctive. We need to have a more ambitious view of decision making now than we can afford to pay less attention to the nuts-and-bolts of technology".

The research questions in DSS should revolve around an agenda of applying intellectual and computer-related technologies to amplify creativity and learning in decisions that really matter (Keen 1987). DSS trigger a number of research questions which include the following:

- What factors encourage or discourage creativity and learning in decision making?
- How can one go about modelling the decision making process in an ill-structured environment in such as way that it may serve as a useful basis for DSS development?
- What is the nature of support to be provided by DSS and what general capability they should have in order to assist in amplifying creativity and learning in decision making?
- How to prepare users to take over the systems?
- How to determine whether the systems deliver the services envisaged?

The important issues involved in the above questions as they apply to the decision making process in general and FSR in particular will be discussed in the chapters that follow.

3.4 Conclusion

Basically there are three related principal reasons contributing to the evolution of the applications of formal information systems in business organisations: advances in knowledge and understanding of the problems faced by the users in business organisations and their needs, advances in knowledge and understanding of the potential roles and values of formal information systems in the decision making process, advances in software and hardware technologies.

Ever increasing competition, the number of environmental factors to be taken into account and decreasing resources have contributed much to the complexity of the decision making problems in organisations. Efforts have been made to understand this complexity and to suggest ways and means of helping organisations cope with it. The emergence of formal information systems such as MIS and DSS result from these activities. In practice Management Science, MIS and DSS are implemented in the form of computer-based information processing systems. Advances in information technology in general and in computer technology in particular have contributed much to the design quality of these systems. Today new development in software technology provides tools to build increasingly sophisticated and humanized systems. Many MIS and Management Science

applications today have software facilities on a par with or even more advanced than earlier or even recent works that have claimed to use the DSS concept. Moore et al(1980) view DSS as an enhancement of MIS, with a focus on decision support at higher organisational levels. The result from the surveys conducted by Connell et al(1988) supported Moore's stance. But the survey also provided little evidence of models being used interactively; the use of the model's outputs exceeding use of the model *in situ*.. The decision maker just receives from subordinates outputs from the DSS without having much input into the modelling process. In this respect not much use is made of " What-if" type of analysis by the target user, namely the top level decision maker.

But DSS have gained momentum in recognition, eventhough their theoretical and methodological understanding have not yet reached full maturity. This is reflected by the fact that there is still debate about the novelty and usefulness of DSS. But DSS paradigm also implies a somewhat broader range of aspects of the decision making process in general and FSR in particular that need to be identified and understood . The novelty and usefulness of DSS can be enhanced if they are tested in real life complex problems and found to be useful in improving the effectiveness of the decision making. But before DSS can be applied to FSR a number of important issues need to be resolved, one of them concerned with the approach to DSS development. In general terms any approach to DSS development should have the capability to identify and incorporate aspects that are important for resolving the research questions described earlier. In particular the approach should incorporate the following:

• the nature of decision making environments, this includes type of potential user(s), nature of decision problem faced and nature of constraints, political, organisational etc, prevailing in the present decision making environment. These are important because the applicability or usability of the DSS depends very much on how well we understand the nature of the environment prevailing in the decision making process.

• There are many factors contributing to the ineffectiveness of the decision making process, these include poor data, information, models or procedures used, lack of knowledge and understanding of the problem domain. In this respect there is a need to investigate the nature of present data, information, models or procedures used and their limitation. This will lead to the modification or extensions to the current data, information, models or procedures.

• Development of procedures used to measure the success or otherwise of DSS application.

The next chapter will present and describe some of the aspects which are important for understanding the decision making process.

CHAPTER 4

UNDERSTANDING THE DECISION MAKING PROCESS: DSS PARADIGMIC APPROACH

4.1 Introduction

The concept of a decision and the study of the decision making process is at the centre of several intellectual disciplines: economics, sociology, politics, organisational behaviour, psychology and management science to cite the main ones. These disciplines stress different issues, use different assumptions about what may affect, behaviorally and procedurally, what individuals do and how they make decisions. Consequently these disciplines arrive at different conceptual frameworks, which can be described in terms of various models of decision making. The paradigm of DSS as described in chapter 3 stressed the need for understanding the decision making process, as well as the development of systems to help in improving the effectiveness of the process. The DSS paradigm poses a number of questions: What aspects of the decision making process implied by the DSS paradigm need to be understood ? It is clear that any attempt to identify these aspects will be difficult and claims of comprehensiveness of the aspects covered is impossible. Close examination of the DSS paradigm results in the need to consider

and understand the following four basic aspects:

* Individual's model of decision making process
* effectiveness of the decision making process,
* complexity of the decision making,
* formal supportive aids.

In chapter 2, some of the above aspects, for example the factors that influence decision complexity such as multiple-role decision making process, goals , norms and value systems have been described in an attempt to understand the characteristics of decision making in FSR. These characteristics serve as useful inputs for the DSS development. In order to enhance understanding of the decision making process in FSR and its requirements and strategies to help toward improve its effectiveness, the aspects described in chapter 2 need further critical examination. In this chapter the first three aspects will be presented. Formal supportive aids to the decision making process will be presented in chapter 6.

4.2 Behaviour of Public Sector Administrators: An Overview

Ahmed(1975) made an extensive study of Public Sector Administration in Malaysia. According to him a number of aspects can be used to describe the behaviour of Public Sector Administrators in Malaysia:

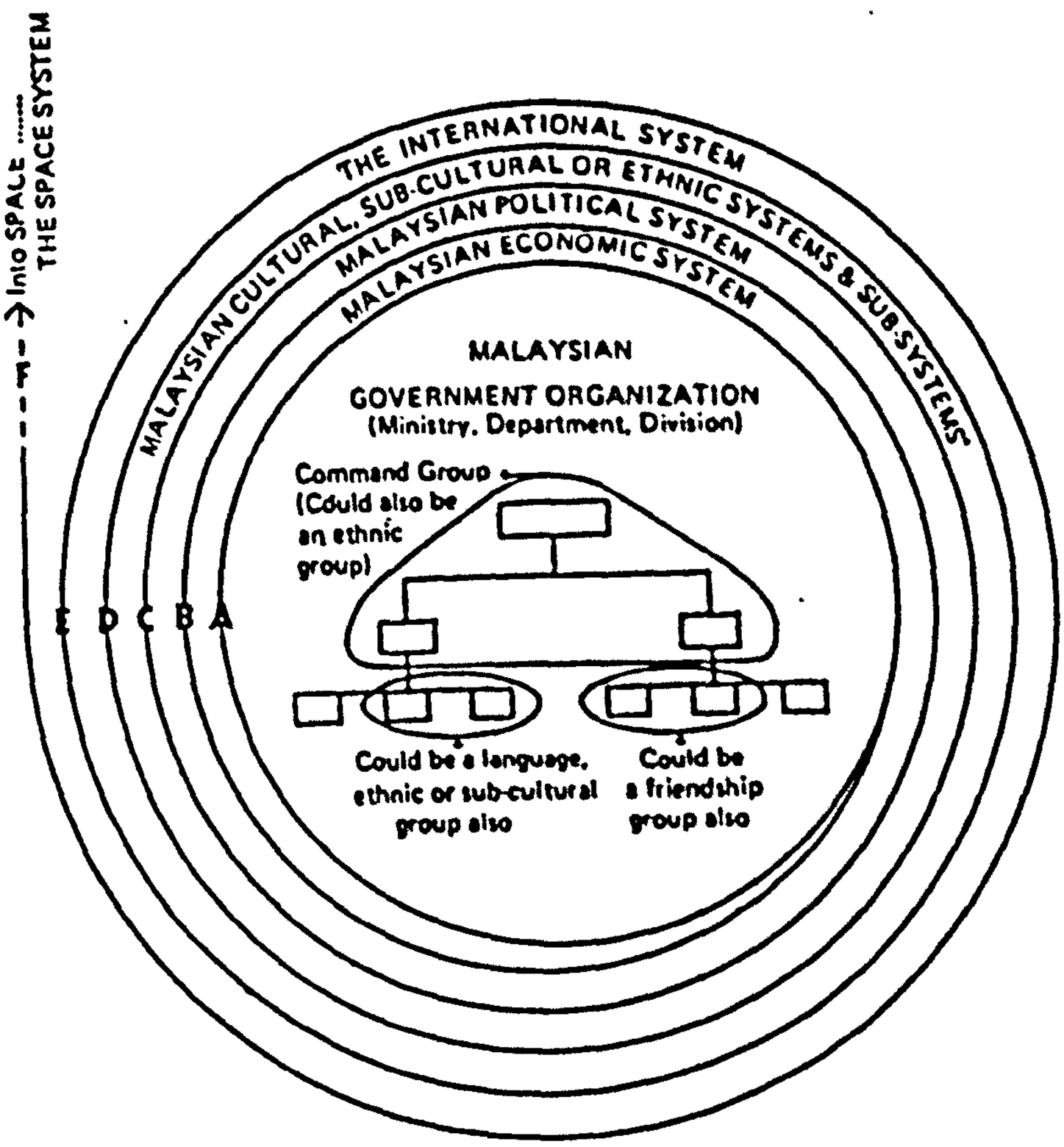
* administrative behaviour,
* organisation behaviour,
* political behaviour,

• cultural behaviour,

Administrative behaviour concerns official(administrative) behaviour expected of the Administrators by the virtue of their role in the organisation. According to Ahmed a number of factors could identified that account for the behaviour of Public Sector Administrators. These include *personal perception* of their role and what they need to do to fullfil it. *Public perception* is also part of the picture. There may not always be an agreement between the public and Administrators about is expected. Members of the public and political leaders who meet and interact with administrators normally come with "certain" expectations. Changes in policies, problems and techniques may affect these expectations.

People working for various organisations in Malaysia develop and practise behaviours that need to be analysed and understood in the context of the internal and external environment of these organisations, namely their *organisational behaviours* [Ahmed(1975)]. Organisations, especially in the context of public sector administration, need to be understood in terms of the following: outside influences, internal process, feedbacks and interaction between organisations and their outside environment. In the context of Malaysia , the relationship between Government organisations and environments can be shown in the following diagram 4.1

Diagram 4.1: Relationship between Government organisations and environments[Ahmed(1975)]



In Malaysia, people working for government follow, by and large, the patterns that are laid down officially and formally by the organisations. That is they generally act in conformity with the policy, rules, regulation and all other formal demands of their offices, departments and ministeries. This reflects the role of *formal organisation*. It was also found to be common in FSR. But *informal organisation* is also important [Ahmed(1975)]. This results in unofficial arrangments and behaviours. Individual needs, belief, ambitions, group favour result in informal organisation. In extreme cases individuals will pursue their own self-interest even though it conflicts with the objectives of the organisation. The role of informal organisation needs to be taken into consideration in understanding the decision making process in FSR. The abstract nature of some of the formal rules in FSR creates loopholes which attract informal behaviour. Complexity of the decision making process, as in the decision of type- d and e in table 2.6(page 44), might also attract informal behaviour. Officials who have the professional and technical ability to make decisions and whose leadership, involvement and expertise are privately and unofficially accepted by crucial members of the organisation may be given "*formal* " right to make decisions. For example during an interview with the Director of the Budget Ministry of Finance, he gave the impression that the officials responsible for FSR have sound professional and technical ability to carry out their duty. Exhibition of informal behaviours by officials responsible for FSR was discovered during the empirical study.

Senior Civil Servants in Malaysia have to a large extent to deal with "politicians". Many of the administrative problems arise from this and it could be

used as a basis for explaining their *political behaviours*. Political influence on FSR is quite significant as some of the important members of National Finance Council are politicans. In this respect how politicians *perceive* reality will influence to to certain extent the behaviour of the officials in FSR.

Culture also plays a role in influencing the behaviour of public administrators in Malaysia. Malaysia is a multi racial country. Malaysian cultural is the customary and traditionalised way in which Malays, Chinease and Indians feel and act, as individuals or small groups. Culture becomes part of not only people's actions but go deeper and sits tightly in their emotions. It controls behaviour from even the subconscious level. An empirical study conducted by Zahari(1983) showed a very high degree of differences in managers' perceptions in decision making between Malays, Chinease and Indians. There are basic determinants of Malaysian cultures and cultural behaviours. These include *rural behaviours* and *urban behaviours* [Ahmed 1975)]. There are Malaysians who have had to rely historically ,or even now, on the rural economy in making their living. Rural behaviours result from this. Malaysian urban behaviours are related to the commercial and industrial settings of Malaysia. Similarly rural and urban behaviours play a certain role in shaping the behaviours of the public administrators in Malaysia. For example during this empirical study it was discovered that some of the officials placed great stress on poverty eradication in their description of the goals, objectives, strategies and actions of FSR. This was attributed to the rural background and upbringing of these officials. Barret(1976) indicated that cultural differences can be demonstrated in areas such as work values, motivation and attitudes, supervision management,

work relationships and organisational structure.

It is useful at this stage to understand the behaviours of the public sector administrators in Malaysia in the light of the conceptual models of decision making process that have been established in the literature. These models contain assumptions, observations and major elements which can be used to get better conceptual understanding of the decision making process in FSR. This understanding can serve as a useful basis for identification of requirements and strategies to help toward the effectiveness of the process.

4.3 Models of Decision Making Process

One of the well described models of the decision making process is Rational Economic Model [see for example Macgrew and Wilson eds(1982)]. The model is based largely on the classical economic theory of optimal choice and assumes the following:

* definition of a concrete goal and the means to achieve that goal,
* complete understanding of the possible alternatives and outcomes and knowledge of the likelihood of their occurance,
* ranking of utilities and criteria for final decision are well understood.

The Rational Model can be criticized as unrealistic in the light of the complexity of the task environment, limitations of human knowledge and cognitive ability. These factors limit the practicality of the complete knowledge

assumption of the Rational Economic Model. This implies, for example, an inability to specify a complete range of alternative actions to achieve the goal, an inability to specify relationships between actions, potential outcomes and criteria to be used in the final selection. These are the characteristics of Bounded. Rationality[Simon (1960), (1976)]. Furthermore relevant information to help in the decision making process is normally incomplete, ambiguous and costly to collect. Recognition of decision making in general as rational in a bounded sense leads to Bounded Rationality Models of decision making. These models give rise to a number of behavioral and procedural implications: to solve a problem, the decision maker just looks for a satisficing solution, that is a solution which is good enough for the purpose at hand. In the process of arriving at such a solution the decision maker concentrates on a simple set of alternatives whose outcomes can be evaluated in the short term.

The Bounded Rationality Model is cognitive and individualistic in nature, it looks inside the "head" of the individuals. An alternative to it is provided by the Skinnerian or Reinforcement Model [Bollas (1967), Skinner (1971)]. This model also stresses the important of psychology in decision making. What makes it different from cognitive-based models is that it relates decisions to the element of motivation, namely it views the decision as the result of specific reward that has strengthened or reinforced that particular decision in the past. Campbell(1976) described the characteristics of effective reinforcers as follows:

* the most effective reinforcers are those which are directly connected to the decision, both in terms of the latency between response and reinforcement (the

shorter the better) and in terms of getting to the heart of the individual's needs,

* behavior is maintained at a much stronger level if a particular response is reinforced intermittently rather than each time it occurs,
* positive reinforcement is much more effective than negative.

The Bounded Rationality Model still depicts the decision maker as a systematic person. Reaction against this assumption and also against the Rational Process Model, and the assumption that humans are risk-and-mistake avoiders resulted in the Incremental Model[Lindblom (1970), (1979)]. In this model decisions are reached as the results of a decision maker adopting a strategy of "disjointed incrementalism". This strategy emerged from the need to be adaptive to change, to scale down the problem, limit the information search, restrict choice and shorten the horizon. Decision making is based on the objective and action which is incrementally different from what recent actions or decisions have shown to be realisable.

The majority of writers share the belief that organisational influences might fundamentally change the nature of the decisions made by the individual within the organisation. This is due to the characteristics of the organisation itself. An organisation can be considered as having a set of related roles tied together to form a system that acts as an information processor . This argument form the basis for the Organisational Process Model[Macgrew(1982]. Organisations have well-ordered common goals, a set of general guidelines and feasible means to achieve these goals which its members are dedicated to. These goals, guidelines and means represent a shared body of knowledge for the organisation. This shared knowledge results from

a compromise between those roles in the organisation that have a direct interest in the outcomes of any decision and, as the roles are information processors themselves, arise from different information processing capabilities. Shared common knowledge acts as a constraint that influences, procedurally and behaviorally, its owners in decision making.

The Rational Model explains decisions as the results of the application of well-thought rational procedures. The Bounded Rationality Model recognises the influence of cognitive limitation on the decision making . The Organisational Model views decisions as the outputs from well defined goals and standardised procedures. The Political Process Model[Macgrew(1982] on the other hand assumes that the dominant factors that influence decision making process are powers, interests and influences. In this context the final decisions and the process of arriving at them result neither from individual nor organisational choice as such but simply from those who have the power to make decisions.

4.3.1 Generality and Usability of Models

These issues of model generality involve questions of whether the key concepts, assumptions and arguments embedded in the model can be used as the basis for discourse about a particular decision process. Some of the descriptive models of the decision making process described above emerged as the result of the need to

offer alternative explanations to the existing ones. There were useful empirical findings to support the models [McGraw (1982)]. But the generality of the models can not be deduced from these findings, as the idiosyncracsy of organisations make it impossible for two decision making processes to be similar in all respects. When considering the factors that influence the behaviours of the public sector Administrators in Malaysia, it became obvious that it covers too much ground to be dealt with by one descriptive model.

Whilst it is inconceivable that any particular decision making process fits, behaviorally and procedurally, into one of the above models; any process should be explainable in terms of more than one model. It can be argued that these models can be thought of as offering non-competitive alternatives. They may be used simultaneously rather than exclusively; they provide essential key concepts that help in the analysis. No model can claim to represent the truth and exhaust the meaning and understanding of decision making phenomena better than the rest. One model might be better than another for explaining the decision making process in one particular context, but not in another. The major contribution of these models is to add partial understanding and explanation. Their usefulness can be enhanced by applying them to a new decision making process. In the context of the decision making process in public sector organisations in Malaysia in general and FSR in particular , decision making models were found to be useful for understanding the process at the macro and micro level.

Organisational Models are useful for macro level understanding of the decision

making process in FSR, namely for understanding possible essential factors, external and organisational, that may influence an individual decision maker within the organisation. External factors influence the Organisational-Task-Environmen ,namely its objectives, measure of performance and complexity of the organisational decision making process. Organisations are processors of materials and information [Miller (1972)]. Similarly FSR can be thought of as an organisation and hence as an information processor. Thus it has tasks to carry out, goals or objectives to achieve, measures of performance and consciousness of how to achieve the goals and satisfy the performance envisaged. An organisation can also be considered as a structure of roles tied together by lines of communication. Each role can be thought of as a description of an information processor that takes the input from the environment or another role and produce outputs to the environment or to another role. Viewing an organisation as a collection of roles also implies that Organisational-Task-Environment is distributed among these roles. This distribution defines the role's task environment, information channels and level in the organisational hierarchy. The nature of the information channel determines the information input to the decision maker and the level of organisational hierarchy determines the range of decision problems which the decision maker encounters and also various decision procedures which operate.

Another important characteristic of an organisation is that it has a history [Knight et al (1979)] which influences the decisions made in the organisation. Organisational history is shaped not only by the requirements from its task environment but also by the organisational tradition and the consensus of the

individuals within it. Organisations capture much of their history in rules and guidelines, statements of philosophy, objectives and records of past decisions. These constitute Organisational Knowledge. Organizational Knowledge is "shared' knowledge, which acts as a frame of reference that constrains and guides individual decision makers within the organisation. Organisational Knowledge is high level, it disregards detailed specifications of implementation. It serves as subframes of reference for individual decision makers. For instance during the FSR study the following three statements were inferred during the analysis:

Statement(a)

Balance in the economic and social well being of the thirteen States in the Malaysian Federation helps to alleviate some of the problems stemming from a multi-racial society.

Statement(b):

Providing aids to the states in general and poor states in particular is a step toward reducing imbalance in economic and social well being of the thirteen states.

Statement(c):

Any form of Aid-Giving Instrument to be introduced or recommended should give maximum benefit to the poorer states, reduce economic and social imbalance but not at the expense of the richer states.

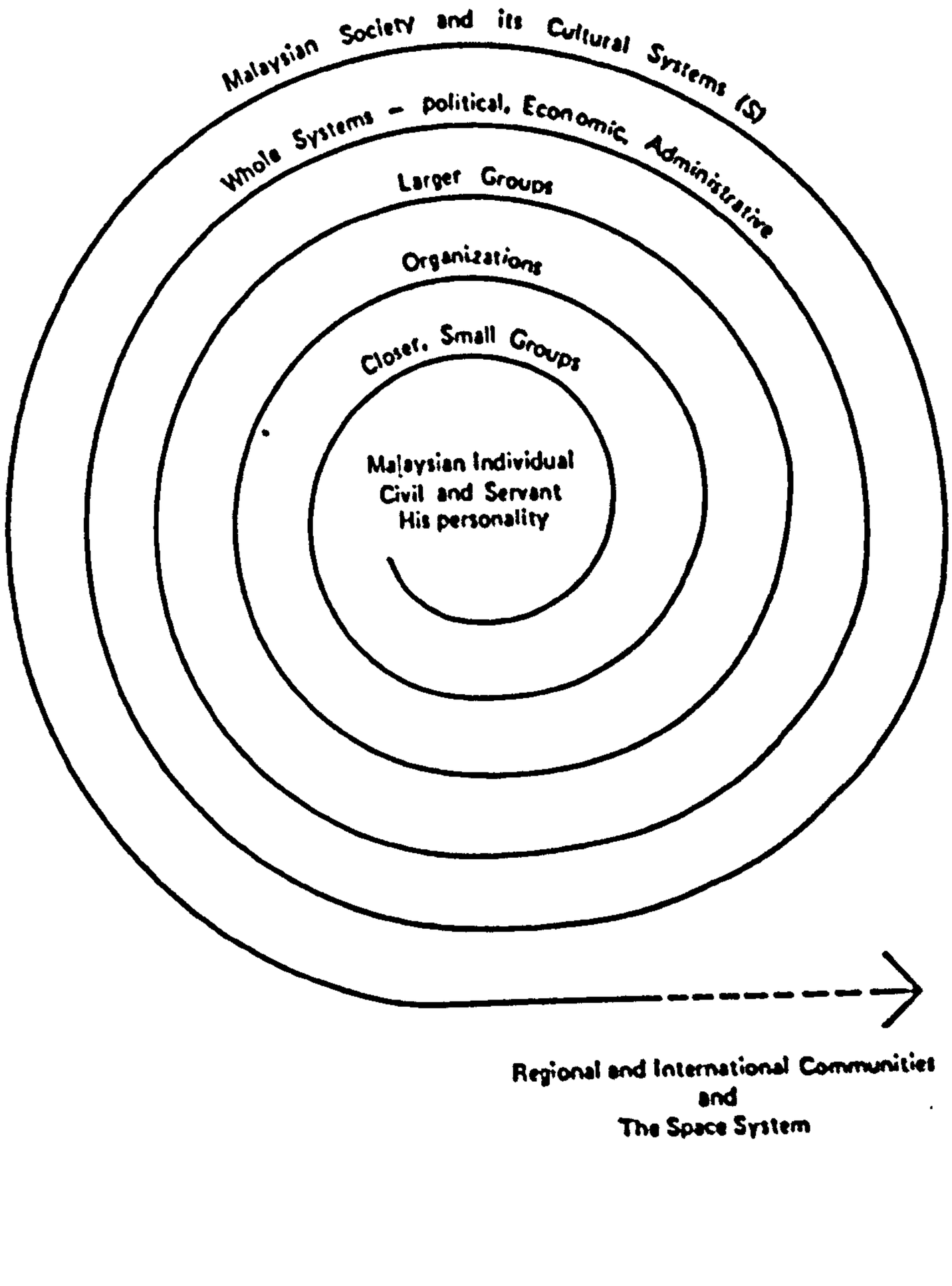
The above statements reflect the norm for FSR's goal[statement (a)], norm for the

FSR process i.e how to go about achieving the goal[statement(b) and norm of what constraints to be satisfied[statement(c)]. These statements also notify the entities of interest, such as "Economic Well Being", "Social Well Being", "Poor States", "Rich States", "Social Problems" and their relationships, such as the relationship between economic well being and social problems. But the descriptions of these entities, and their attributes and relationships, are still at a high level.

One can say the above organisational characteristics will influence to some extent the *personality* of the individual members engage in problem solving. As stressed by Greenstein(1969), personality depends on many factors. Personality is a concept that is useful at the level of the individual public administrator and his personal intiative as it is concerned with micro level understanding on an individual basis [Ahmed(1975)]. In problem solving individuals need knowledge about a particular domain and the ability to process this knowledge. Knowledge is stored in the memories of the individuals and takes the form of hypotheses, theories, propositions, rules, facts obtained through observation or inference, heuristics and know-how accumulated from past experience. Individuals' translation of their consciousness into knowledge and their use of this knowledge for problem solving is a rationalisation process. The questions of what to observe and what to accumulate from the past experience is dependent on what individuals rationalise to be important, in the light of the of the Task-Environment faced. But what individuals rationalise to be important depends, among many related factors, on organisational factors. For example organisational knowledge provides general principles that direct organizational decision making in FSR in general and

individuals' decision making in particular. The importance of understanding organisational knowledge in the development of DSS, besides manager's cognitive processes in sensing, formulating, and solving problems, has been stressed by Ciborra(1987). Understanding organisational knowledge brings to light collective and organisational issues related to the sharing of knowledge and the implications they pose for individual knowledge processing [Ciborra, (1987)]. In the context of Malaysian public sector Administrators, major influences on personality can be depicted in the following diagram 4.2.

Diagram 4.2: Influences on the personality of public sector Administrators[Ahmed(1975)]



Experience in FSR that organisational factors, which include organisational structure and individual roles, the level of organisational hierarchy, information channels and the academic backgrounds of the personnel did influence the nature of the cognitive experiences of individual decision makers. The nature of the information channels determines the information input to the decision maker; his personal background gives some hint as to how his memory is structured and the level of organisational hierarchy determines the range of decision problems which the decision maker encounters. The influence of the organisational hierarchy on individual cognitive style can also be described in terms of Steinbruner's (1982) three models of thinking: **Grooved Thinking, Uncommitted Thinking** and **Theoretical Thinking**.

The major characteristics of the Grooved Thinker is that he relies on a small number of well defined concepts or variables pertinent to decision problems. The categories of concepts used are determined by ranges of values on critical variables. The decisions are normally programmed so that once certain categories have been identified as relevant, the decision follows without question. Grooved thinking results from long experience over an extended sequence of decisions. The existence of well established ready-made solutions provides powerful analogies for new decisions. Grooved thinking is normally adopted by decision makers at lower levels in an organisation. Uncommitted thinking appears in response to problems at higher levels in the organisation hierarchy, where the information channels carry more abstract, aggregated information. The range of problems presented and their scope is much greater than that at lower levels of an organisation. The

Uncommitted Thinker uses generalised concepts which are embedded in larger, theoretical belief structures and are not simply determined by a small number of specific variables. He lacks experience of any particular decision domain and is normally vulnerable to uncertainty and relies mostly on the problem structuring done by others. The decisions made are not consistent nor stable over time and normally lack commitment. The Theoretical Thinker has very abstract and extensive belief patterns which are internally consistent and stable over time. This person is active in imposing an extensive pattern of meaning on immediate events. A decision will be justified using concrete alternatives, an extensive pattern of calculation and inference. The characteristics of theoretical thinkers are most striking under conditions of uncertainty since they have buffered themselves from the impact of uncertainty by establishing their belief systems on grounds relatively independent of reality.

These three models of thinking use different concepts, information and reasoning logic; they have different world views of what aspects of reality are important for decision making processes. This is important in the development of DSS as they impinge on the nature of DSS to be developed because they need different supports. The existence of uncommitted decision makers is observed in FSR. This is due to the fact that FSR is dependent on other agencies for information(as described in chapter 2) and also key personnel in FSR are subject to change, either because of promotion, internal or interdepartmental reshuffle, every three years. This renders them more reliant on their permanent staff and domain experts.

The literature also contains conceptual frameworks which are useful for micro level understanding the individual problem solving, for example concept of *Human Information Processing*. Research into human cognitive information processing has attracted a lot of attention. The literature is concerned with two aspects: cognitive process and cognitive style. Cognitive process deals with the elements of the activities carried out in the process, such as perceiving and recognising stimuli, remembering and searching information, inducing rules, recognising patterns, formulating concepts and applying all these in solving problem and make decision. Cognitive style focuses on what influences a person's cognitive information processing. Many conceptual and theoretical frameworks and models have been developed to understand and describe the process and its elemental activities. For example Brunwick's model of pattern recognition process [Hammond (1980), Sage(1981)] and Piaget's logical-mathematical -structure(LMS) conceptual model of information processing structure for intellectual development process[Piaget (1974), Ramaprasad(1987)].

An example of work into cognitive style can be found in Kilmann et al(1976). They describe individual styles of decision making in terms of two selected dimensions of Jungian Personality Topology: "Input-Output" and "Problem Solving". Combining Input-Output with Problem Solving resulted in the following form of Jungian Personality types:

*Sensation-Thinking(ST),

*Sensation-Feeling(SF),

*Intuition-Thinking (NT),

*Intuition-Feeling(NF).

These personality types influence the style adopted in reaching decisions. For example ST relies mostly on rigorous scientific investigation, stressing precision, specificity, objective analysis, logical and orderly reasoning. SF and NF rely more on qualitative analysis based on personalistic and subjective value judgments which normally incorporate ethics and allow values to direct and determine what should be investigated and done. NT stresses conceptual and qualitative analysis aiming towards impersonal objectivity and specification of variables or factors and their relationship. The relationship between personality type and style adopted can be represented in the following table 4.1

Table 4.1: Relationship Between Personality Type and Style Adopted

Personality Type	Style Adopted
ST	-rely on rigorous scientific investigation, stress on precise, specific and objective analysis, -logical and orderly reasoning
ST,NF	-rely on qualitative analysis based on personalistic and subjective value judgment, -normally incorporate ethic and value in the analysis
NT	-rely on conceptual and qualitative analysis, -aim toward impersonal objectivity and specification of variables or facts and their relationship

Cognitive process and style are recognised as having certain roles in the development of MIS/DSS. Ramaprasad(1987) argues the importance of cognitive process in MIS/DSS and suggests the use of Piaget's model as a basis for design. The reason being that cognitive process is based on comparatively clear and specific subject matter and the thrust of MIS/DSS design should be to augment human cognitive process, namely to help ,for example, in problem sensing and solving. But cognitive style has also been argued to be important for MIS/DSS development. The relevance of decision making styles to the design and implementation of DSS have been investigated[Maryam et al(1981), Bariff(1977), Benbasant et al(1978), Keen et al(1978)].

While the importance of cognitive style in system development and design has enjoyed much recognition it is still not well understood. Its role and usefulness in the development of DSS in practical situations is still unclear[Huber(1983)]. Huber has cast some doubt on the usefulness of cognitive style as a basis for MIS and DSS design. He concluded that the currently available literature on cognitive style is an unsatisfactory basis for deriving operational guidelines for MIS and DSS design, and further cognitive style research is unlikely to lead to operational guidelines for MIS and DSS. His conclusions are based on a series of arguments, the most important ones being:

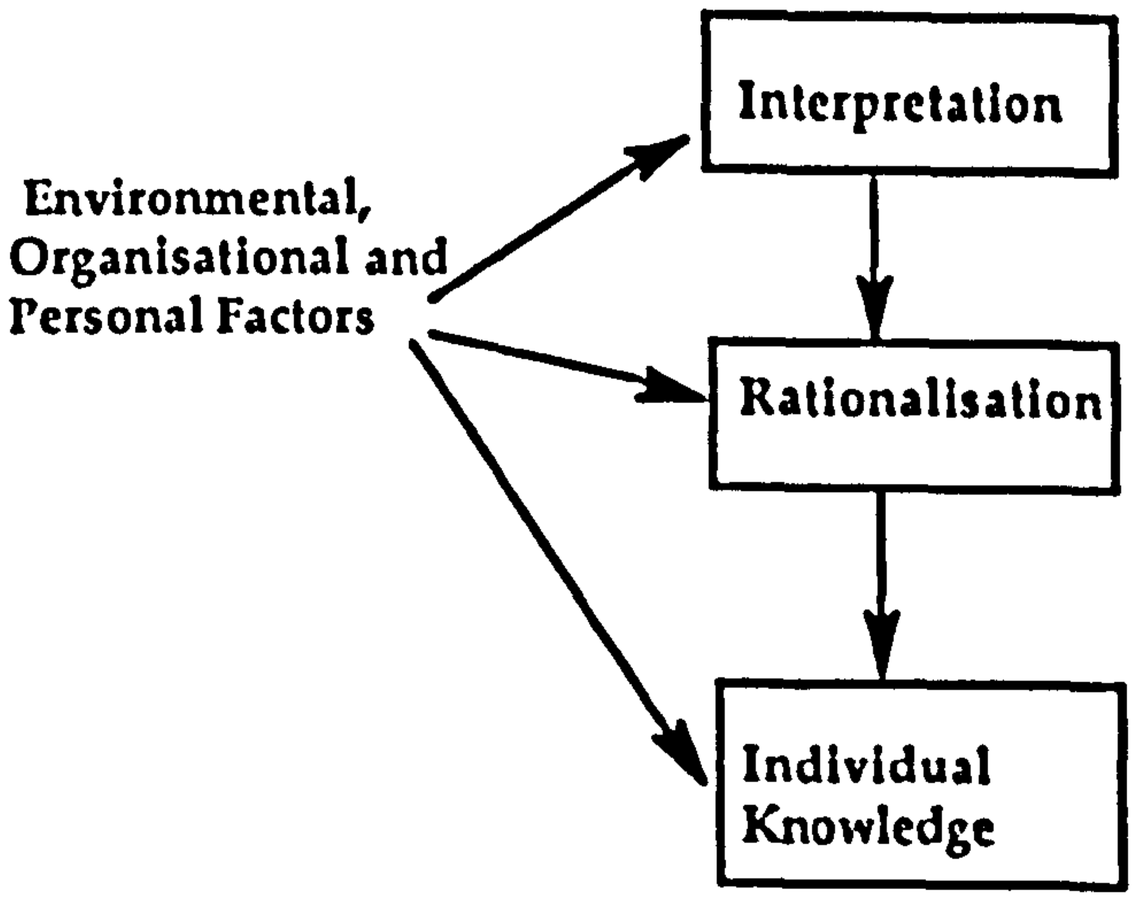
- the literature on cognitive style is weak and inconclusive,
- practical significance of cognitive style is small,
- cognitive style is one of many differences that may be relevance for MIS and DSS design,

* design based on cognitive research may not be admissible and credible in the eyes of managers,
* the development of empirically-based bodies of knowledge in cognitive science is so slow that by the time a scientific set of findings is established the technology, such as DSS Generator, is so advanced and flexible that users can easily change their style thus rendering the finding obsolete,
* there is a lack of understanding as to whether the design should conform to user's cognitive style or should complement the style.

High generality, broad coverage, lack of focus, knowledge and understanding in the current frameworks developed in research in cognitive style constitute the main reason that make them unsuitable to serve as a basis to help in information system development and design in general and DSS in particular. Huber(1983) catalogued individual differences that are related to human information processing and decision making behavior. These include the response to uncertainty, cognitive complexity, response to organisational norms of rationality, need for achievement, risk-taking propensity, academic background, intelligence, previous training or familiarity with the particular task or instrumentation. It is unlikely that all the individual differences would be positively correlated with one another either in general or especially in the case of any one decision-maker. Therefore it is also unlikely that DSS design guidelines that might follow from a particular decision-maker's cognitive style would not be in conflict with at least some of the guidelines that might follow from other characteristics [Huber (1983)]. But it is argued here that cognitive process, style and individual differences serve not as competing but

complementary aspects for the development of DSS. They constitute personal factors that influence, besides environmental and organisational factors, the formation of individual knowledge as in the following diagram 4.3.

Diagram 4.3: Major Influence on Individual Knowledge Formation



4.4. Decision Complexity

Decision complexity represents one of the major aspects implied by the DSS paradigm. DSS are meant to support effective decision making in complex environments. This implies that the complexity of the decision making needs to be understood. The descriptive models described in the previous section provide different frameworks for understanding complexity and its role. The Bounded Rationality and Reinforcement Models provide frameworks for understanding how the individuals , behaviorally and procedurally, react to and cope with complexity.

Organisational and Political Process Models on the other hand assume the important of environmental and organisational factors in determining the decision complexity. The complexity of the decision making in FSR emerges from its multi-actors nature, as described in chapter 2. The major actors involved in the FSR decision making process are classified into the following categories:

(a) **Observers**: people not directly involved in the decision making process but whose attitude, behavior and reactions may affect the decision. Examples include the general public, Members of Parliament and other central agencies,

(b) **Decision-Maker**: the individual or group that has the final authority to make the decision. In the case of FSR this is the National Finance Council(NFC),

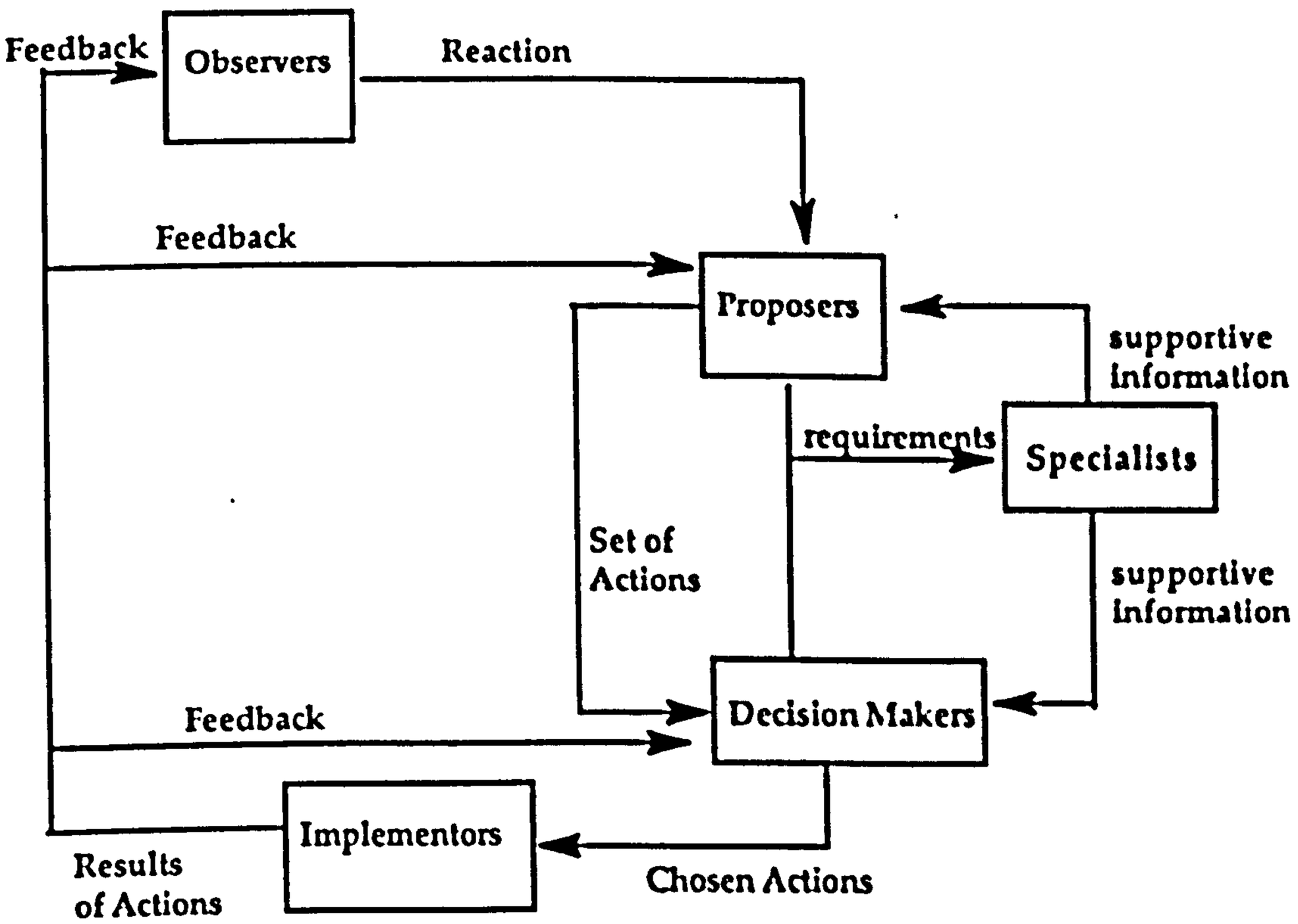
(c) **Proposer**: the individual or group that originally proposed the course of action being considered by the decision maker. This role is generally played by FSR staff,

(d) **Specialist**: individual or group that provide the proposer or decision-maker with advice on various decision making aids. This may take the form of providing supportive information. These specialists occupy various roles such as accountant and economist. FSR needs to obtains advice from agencies, such as the Economic Planning Unit, Manpower Modernisation Unit and Implementation and Coordination Unit of the Prime Minister's Department,

(e) **Implementor**: those responsible for implementing the final decisions. Implementation of the final decisions is vested in the State Governments, namely their Agencies and Corporations.

These roles and their possible relationship are shown in the following diagram 4.4. In individual decision making the roles of proposer, decision-maker and specialist in the diagram 4.4 are taken by the same person. But for decision making in large organisations, especially public sector organisations, this is not usually the case. The actors in diagram 4.4 can be considered as information processors. Hence they have their own interests and perceptions of what objectives should be and what should be considered as important.

Diagram 4.4: Role Relationship In Multi-actors Decision Making Process



The multi-actor nature of the decision making process in FSR gives rise to the following important environmental factors: individual interests, power, group interests and consensus. In general term these factors will contribute to the complexity, uniqueness and dynamism of the decision making in FSR. Environmental factors will define norms for FSR's goals and its performance. FSR's goal, namely "balanced economic and social development of the thirteen States in the Federation", reflects the consensus of those involved. But the goal is abstract. It was inferred from the empirical study that this abstract goal secured consensus because what is implied by the goal was agreed by those involved in FSR as theoretically true in principle. Complexity of the decision making in FSR revolves not only around formulating and recommending strategies for achieving this abstract goal but also in assuring these strategies satisfy the interests of those involved in FSR. The abstractness of FSR's goal and multiple-actor nature of its decision making means that in practical terms the goal will be subjected to many interpretations, and will generate a number of novel problems that need to be recognised and objectives and strategies that need to be formulated to solve the problems.

4.5 Effectiveness of Decision Making

The multi-actor nature of the decision making process in FSR also gives rise to a number of implications that are important for assessing the effectiveness of its decision making . The fact that FSR is tightly coupled with the environment leads to the existence of the informal monitoring systems that oversee its performance from the outside and in this respect it also influences to some extent the definition and

the formulation of the criteria for effectiveness. In the context of FSR, effectiveness is concerned with how best to achieve the existing goals and objectives and how best to keep its performance within the range specified by the existing norms. The abstract nature of FSR's goal,which has led to the dynamic of its decision making process, makes the definition and formulation of criteria for measuring the effectiveness of FSR decision making difficult.

Understanding effectiveness of organisational decision making in general is important for the development of DSS because it will provide the basis for determining the impacts of DSS on the organisation. Organisational effectiveness is a subject that has attracted a lot of attention from researchers. This has resulted in the development of various models. Most describe effectiveness in terms of the following frameworks: the models assume, conceptually and theoretically, possible key organisational characteristics and match them with a set of relevant attributes or variables to be used to predict or indicate the effectiveness, as in the following diagram 4.5. Quinn et al (1983) arrived at "spatial model" of organisational effectiveness [diagram 4.6(page106)]. Using the conceptual framework provided in diagram 4.6 , Lewin et al (1986) spatially maps various effective criteria proposed in the literature into table 4.2(page 107).

Diagram 4.5: Black Box Model of Organisational Effectiveness

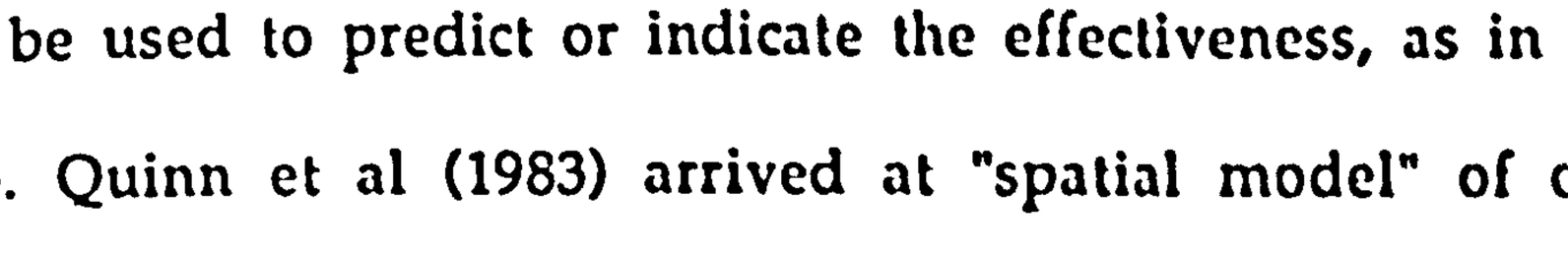
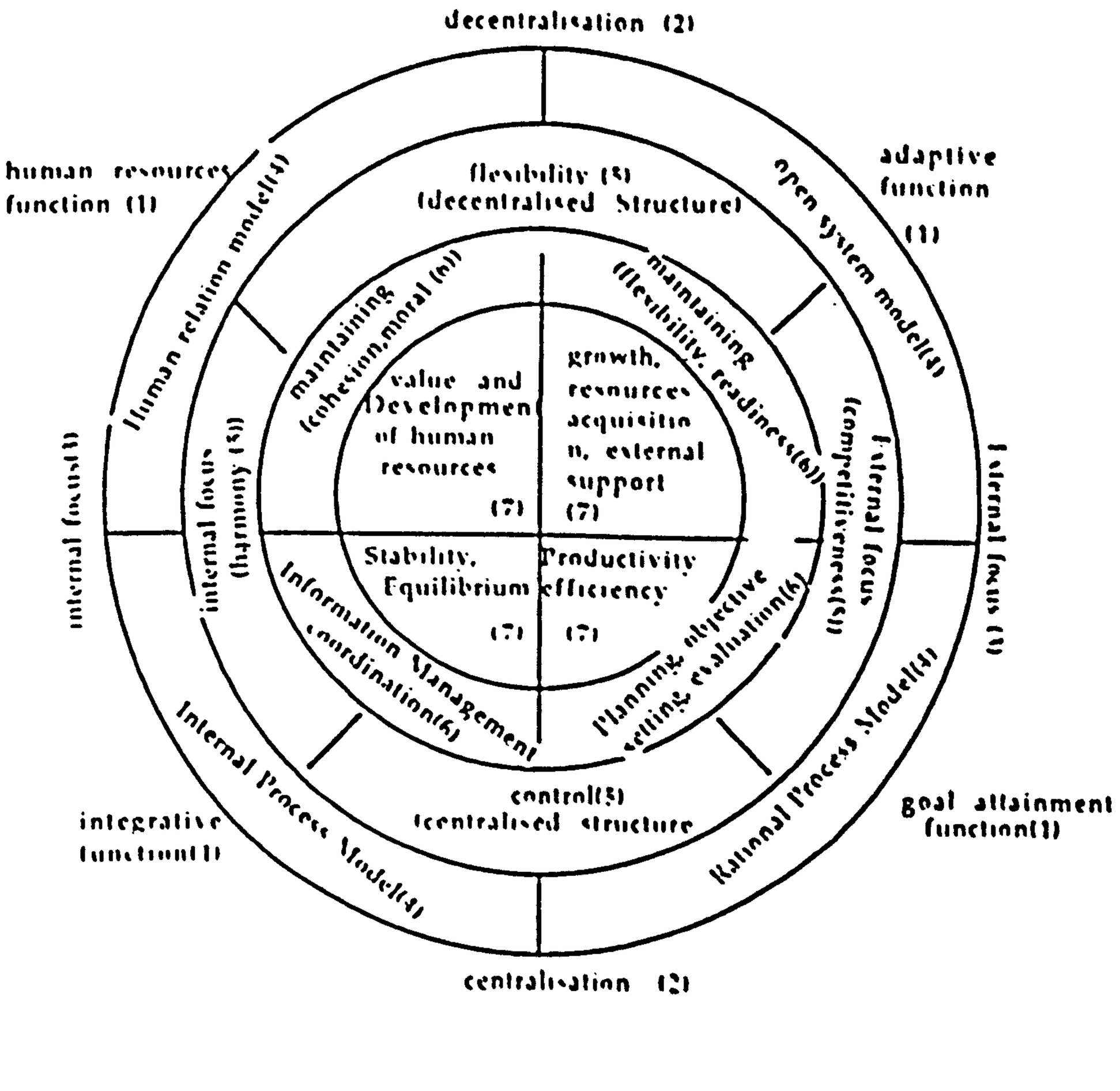


Diagram 4.3: Spatial Model of Organisational Effectiveness

[Quinn et al (1953)]



Legend:
(1) Major Organisational Function
(2) Range of Structural Alternative
(3) Breadth of Organisational Attention
(4) Organisation Model
(5) Organisational Value
(6) Organisational Means
(7) Organisational Ends

Table 4.1: Spatial Mapping of Historic Criteria
[Lewin et al (1986)]

Human Resources Function	Adaptive Function
equity (2) stability and initiative(2) esprit de corp(2) productivity through workers satisfaction(3) satisfaction through attention to need(3) employee satisfaction(7) cohesion(7) loyalty(7) openess(7) productivity through people(13)	structure/ strategy congruence(6) organisational growth(6) environmental control(6) flexibility and adaptation(6) Differentiation of errors(8) integration error(8) organisation/environment fit(8) timely implementation of change(8) leadership/contingency fit(8) adjustment to external conditions(10) bias of action(13) close to customer(13)
Integrative Function	**Goal-Attainment Function**
Clear authority and discipline(2) unity of command and direction of order(2) congruence of internal processing(4) efficient information processing(5) communication(7) internal equilibrium(10 efficiency through economic of scale(11) simple structure, simple rule(12)	product maximisation(1) cost minimisation(1) technical exellence(1) optimal use of resources(1) tasks specialisation(1) division of work(2) rational goal development(5) competitive attainment(6) productivity(7) survival(9) return of investment(11) attainment of objectives(11) profitability(12)

Legend:

(1) Taylor
(2) Fayol
(3) Mayo
(4) Trist and Bawforth
(5) Chandler
(7) MacGregor and Likert
(8)Lawrence and Lorch
(9)Hannan and Freeman
(10)Barnard
(12) Townsend
(13) Peter and Waterman

There are certain assumptions governing the applicability of the model in diagram 4.6(page106). For example the Rational Goal model is useful when there is a clear consensus and measurable objectives together with a clear set of actions and criteria for evaluating and selecting them. The Internal model assumes a clear connection between input and performance. Even though the subject of organisational effectiveness has become a popular topic in the literature, the concept is not yet fully understood. Cameron (1986) lists the following themes, that have been accepted as having consensus status in terms of organisational effectiveness:

- Despite the ambiguity and confusion surrounding it, the construct of organisational effectiveness is central to organisational science.
- Because no conceptualisation of an organisation and its effectiveness is comprehensive, neither the definition nor any appropriate model of organisational effectiveness is comprehensive.
- Consensus regarding the best, or sufficient, set of indicators of effectiveness is impossible to obtain. Criteria are based on the value and preference of individuals, and no specifiable construct boundaries exist.
- Different models of effectiveness are useful for research in different circumstances. Their usefulness depend on the purpose and constraints placed on the organisational effectiveness investigation.

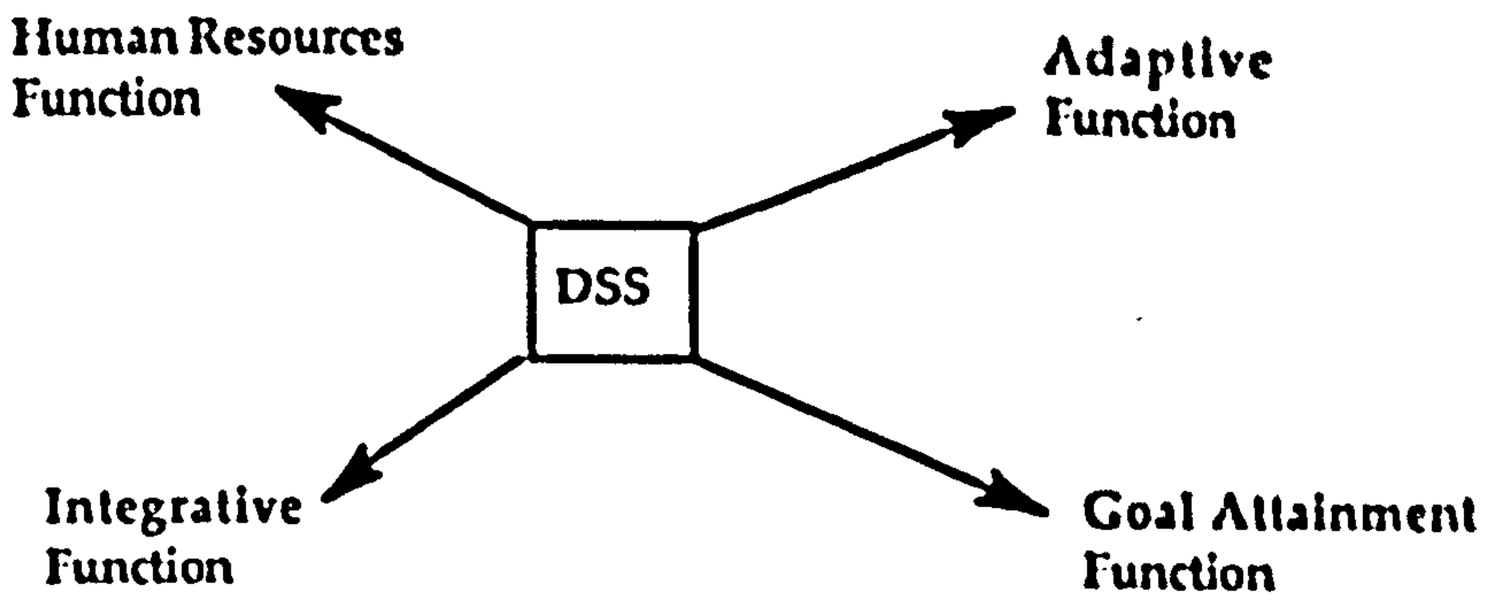
The above issues represent many of the areas of conflict in organisational effectiveness . Evaluators of effectiveness often select models and criteria arbitrarily in their assessment, relying primarily on convenience; indicators of effectiveness

selected by researchers are often too narrowly or too broadly defined, or they do not relate to organisational performance [Cameron (1986)].

In summary the concept of organisational effectiveness is important but it is difficult to realise in practice. In the spirit of diagram 4.5(page 105), the difficulty centers around identifying and measuring the elements in sets A and E. But despite this problem many useful insights into organisational effectiveness have been provided by conceptual and theoretical frameworks described above and they can be used for identifying a particular organisation under consideration with the models in diagram 4.6(page 106) . In particular the frameworks help in assessing the likely impacts of DSS on organisation and the criteria that can be used in assessing these impacts. This is shown in diagram the following 4.7. But the key organisational characteristics in diagram 4.6(page 106), such as organisational functions and organisational models, can not be considered as competing alternatives because they together can be used to model the effectiveness of a particular organisation. For instance the need to produce decisions or actions that satisfy the requirements from the States and stipulated constraints implied by the present legal, political, social, norms and values systems, characterise the openness of FSR decision making process. But FSR decision making is also goal-directed, namely it is expected to provide aids to the States and to ensure these help toward achieving the stipulated goal. In this context decision making in FSR can be described in terms of the Rational Goal Model. Measures of excellence of the Civil Service in Malaysia, such as described in chapter 2, reflect not only these two models but also the Human Relation Model. The criteria in diagram 4.7 provide a general basis for discussing the

likely impacts of potential DSS on FSR.

Diagram 4.7: Possible Impact of DSS on Organisational Effectiveness



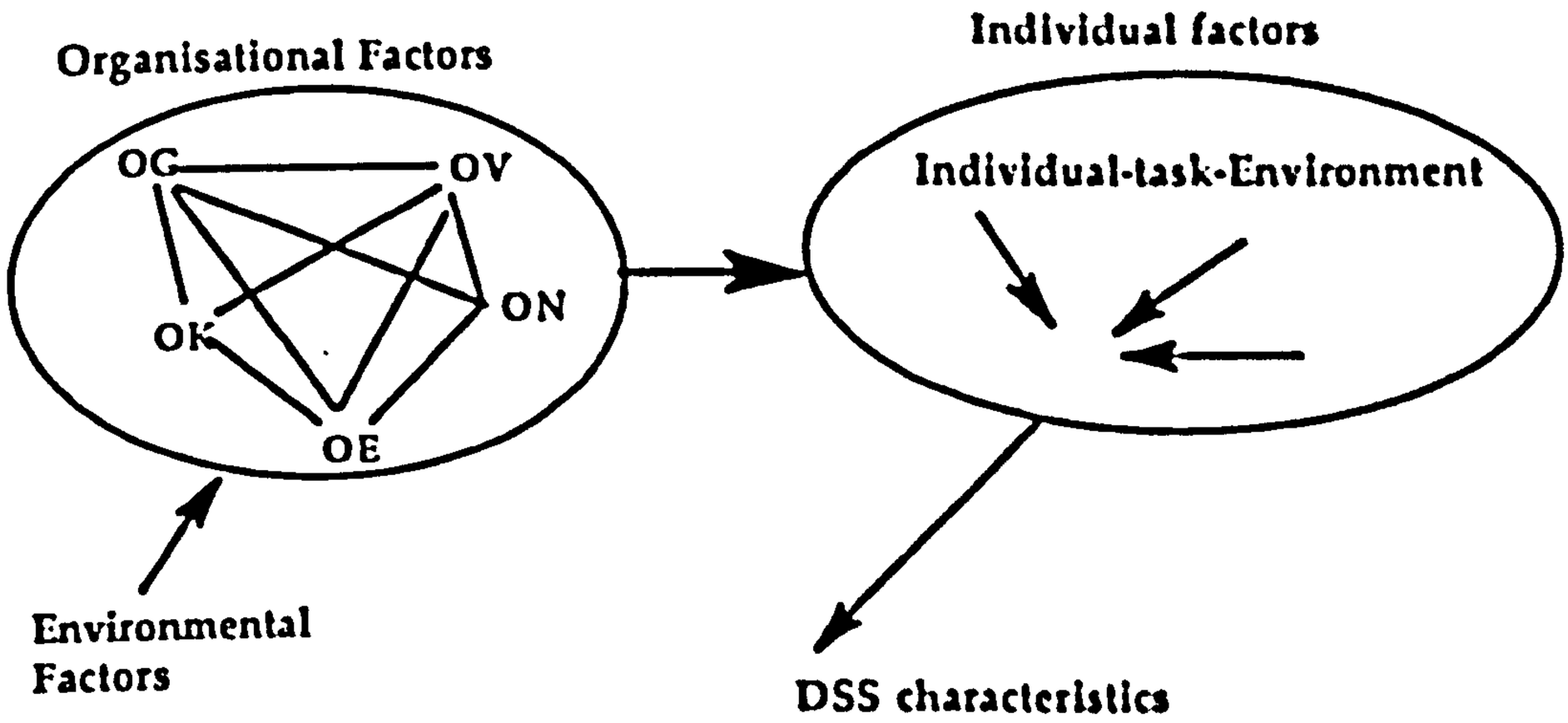
4.6 Conclusion

Decision making is a complex subject. In reality the way individuals make decisions needs to be interpreted both in the light of constraints and of the influence generated by organisational and individual factors. This chapter has presented conceptual and theoretical frameworks for understanding these factors. Organisational factors considered in this chapter include organisational goal (OG), governing norms (ON), value systems(OV), organisational effectiveness(OE) and organisational knowledge(OK). All of these will determine the nature of individual-task-environment which, together with individual roles within the organisation(IR) and personal factors(PF), act as constraints on the individuals decision making process. Working within these constraints leads to the formation

of one of the important resources for problem solving, namely individuals knowledge(IK), both empirical and theoretical.

The factors considered in this chapter act as important inputs to DSS development. In particular understanding them helps in proper understanding of the following major characteristics of DSS: its role and function, its major components, and knowledge, data and models to be embedded in DSS. Proper understanding of the organisational and individual factors will also enhance usability and acceptability of the DSS. Similarly understanding these factors in the context of decision making process in FSR helps in understanding the characteristics of the DSS to be designed. A summary of what has been described in this chapter and their importance for understanding the characteristics of potential DSS is shown in diagram 4.8.

Diagram 4.8: The Relationship Between Factors in Decision Making Process and DSS characteristics



As described in section 4.3.1, an organisation can be considered as information processor. The usefulness of the factors considered in the above diagram 4.8 is that it identify a model for this information processor. Models not only help in pinning down the major elements and boundry lines of organisational and individual behaviours involved in information processing, but also in measuring and formulating strategies to help toward its effectiveness. In order to be effective organisations in Malaysia should be adaptive to the changes and needs of the environment[Ahmed(1975)]. For example in order to accomplish its goal effectively and efficiently an organisation. as an information processor, should have the ability to know something and learn. An organisation may be said to know something and to learn if it is a cognitive enterprise undertaken by individual members [Argyris(1978)].

DSS can play a useful role to help toward the effectiveness of organisational and individual problem solving. The formal process of DSS design, implementation and use represents one of the important aspect of DSS. It is argued here that a good design process should have the capability to incorporate some of the factors described in this chapter. The need for system approach in understanding FSR has been stressed in chapter 2. The usefulness of system approach in understanding organisations in Malaysia in general has also been stressed by Ahmed, as he put it:

" modern organisation theory has to be adapted to Malaysia. Its clear comparative advantage over neoclassical and classical theory is its emphasis and insistence on the system approach"

Modern organisation theory can provide a potential tool for understanding

organisations in Malaysia and in designing strategy to help toward improving their effectiveness. This is more so due to Malaysia being a *transitional* societ [Ahmed(1975)]. The vision to change Malaysia to an Industrialised Nation by the year 2020 reflects this transitionality. Systemic understanding of the decision making implies the need to understand the following: various parts involved in the system and their interaction, the linking of process and goals of organisation. For example from the discussion in this chapter, the individul and his personality that he brings to organisation, the formal and informal organisation , their fussion in the form of roles that people play inside organisation, are examples of interacting parts. These parts not only interacted with each other but also outside world. A system based approach to the development of DSS is proposed in the next chapter.

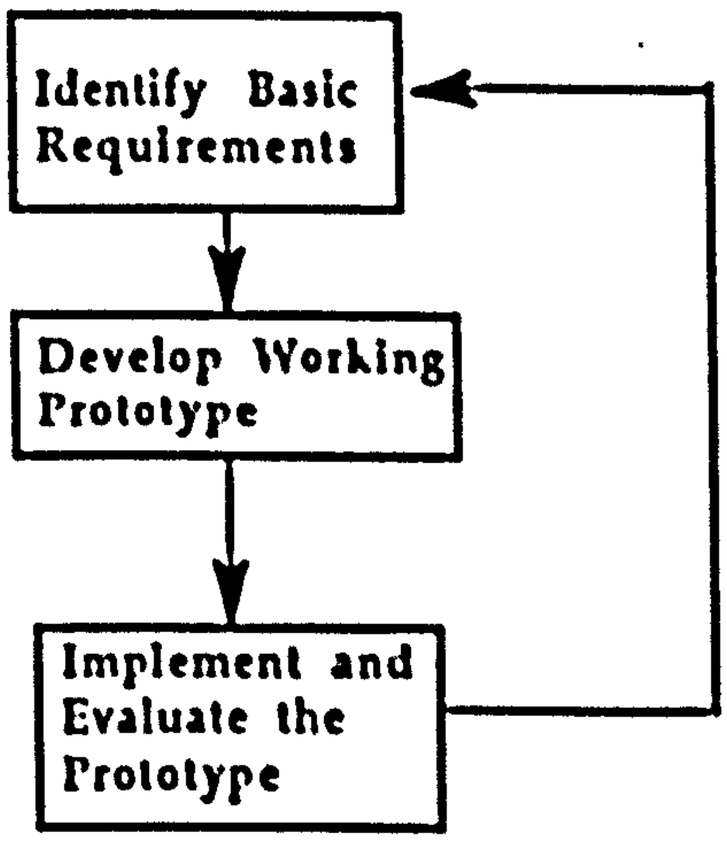
CHAPTER 5

AN APPROACH TO DSS DEVELOPMENT

5.1 Introduction

The complexity and novelty of the decision making process make the nature of the DSS to be developed to support the process imprecise. Imprecise systems occur when it is not possible to start with a `right' definition of the problem and solution procedures to solve the problem. This suggests that the DSS development process can not be thought of as a sequence of well-defined steps. A number of popular approaches have been developed to help in the DSS development, one of them is prototyping. No concrete definition can be attached to prototyping. Prototyping is well described in the literature [for example see Boar(1984)]. Basically prototyping involves four steps as in the following diagram 5.1:

Diagram 5.1: Basic Steps in Prototyping



Prototyping has its rationale and advantages. Floyd (1984) classified prototyping into Exploratory, Experimental and Evolutionary. The emphasis of exploratory prototyping is on clarifying requirements and the desirable features of the system. The aim of experimental prototyping is to determine the adequacy of a proposed solution before investing in a large-scale implementation of the target system. In evolutionary prototyping the aim is to adapt the system gradually to the anticipated changing environment. Law (1985) suggested two more classifications : Performance prototype and Organisational prototype. In performance prototype the application is run with a simulated workload. The aim is to see whether the target system will be able to handle its anticipated workload. In organisational prototyping the prototype is put in its intended operating environment, namely in the user's normal workplace. This is done in order to ascertain whether the user's requests are met and also to clarify the needs of the surrounding environment. Prototyping seems to be applicable to the development of a system for a complex domain in which the user requirement is difficult to define. It also act as a reference point where users and designer can discuss the problems and opportunities early in the development process [Dearnly et al (1983), Brice et al(1983)] ; in this respect it also encourages user participation. Securing active user participation represents one of the requirements in prototyping. In summary aims of DSS popular approaches are:

* to satisfy user requirements,
* to secure active use of the system by the users,
* to secure active participation by the user in the design,
* to secure system adaptability to changing need,
* to assist user learning,

5.2 Criticism of DSS Popular Approaches

DSS popular approaches have been criticised for a number of reasons. Prototyping is difficult to manage and control [Dearnley et al (1983)]. this is due to fact being an evolving system designed with limited understanding of the user's requirements make planning and budgeting difficult. Furthermore the number of iterations needed before user satisfaction is obtained is unknown. Prototyping involves the need to develop an initial working model. One of the major issues that needs to be solved is how comprehensive the model should be. Sutherland(1983) has also criticised development approach based on user-defined requirements. The need to tailor the DSS design to the whims of the individual decision makers concerned falls short of the conceptual and theoretical frameworks, formal methods and techniques that have been developed in disciplines such as information science, organisational theory and management science. The approach might consider only local criteria. In this respect no comprehension of the system and its overall problem is made before proceed to the design. The approach might pose the prospect of management systems that are even more highly disaggregated and ill-articulated[Sutherland (1983)].

The need for DSS technology to reflect the way decision makers themselves prefer to think underestimates the capability or fails to take the opportunities offered by modern methods and techniques that have been developed to help decision makers deal with ill-structured problems. The general criterion used in determining the usefulness of working DSS entirely based on user-acceptance is

reasonable , as the users can be assumed to be the best judge, but it can also be unacceptable for a number of reasons: the "adhocness" by which the criterion is set by the users; and their naivety and inability to understand the problem and measure how effective their solutions are. As consequence DSS in aggregate imply a capital investment whose upper limits remains unspecified and whose real impact can not be subjected effectively to objective measurement [Sutherland (1983)]. Sutherland's arguments emerge from his dissatisfaction with the lack of a universal approach to DSS development. He is sceptical of the ability to generate useful and meaningful working DSS based on user-defined problems and requirements. This is quite radical, it challenge the usefulness of the popular paradigm embedded in the current philosophy of DSS development and design. He has suggested a number of conceptual and theoretical frameworks to help in realising this radical approach to DSS development and design. Approach, such as prototyping , also pose a number of risks to system's performance [Alavi (1986)]. This is due to the lack of proper documentation, good models, data security, inconsistent problem specification and modelling error; due to the multiple roles played by the user, namely analyst, programmer and data entry operator; due to the lack of data management, namely to make data accessible, reliable, consistent and secure.

There is an element of truth in some of the arguments put forward by Sutherland, especially on the need for a comprehensive approach to DSS development and design. But it is argued that the embedded characteristics of DSS popular approaches, such as prototyping, are appropriate due to the existence of the structural factors described in chapter 4, especially due to the following:

- because an organisation is effectively unique in terms of the problems it faces and the environmental factors involved, the DSS to be developed should in effect be unique.
- within an organisation, the DSS should focus on individual decision makers or individuals within the group; in this respect the facilities provided by the DSS must be tailored to the analytical and procedural predilections of the individuals,
- given that the ultimate client is an individual decision maker, the only legitimate basis for resources allocation, system accountability is user-acceptance.
- the need to incooperate user's decision style in the design and to encourage learning and user acceptance means the DSS has to have facilities for fast prototyping and easy adaptation.

As prototyping can be used to clarify requirements and identify the desirable features of a system, it is useful for the development of DSS for ill-structured environments. In ill-structured environments it is difficult to start with a right definition of the problem and solution procedures to solve the problem. A feature of ill-structured decision making is the reliance on soft information, namely information that lacks objectivity, and which is generally qualitative [Finlay(1992)]. Brookes(1985) has listed a number of problems that arise in efforts to build DSS that can handle soft information, these include:

- its existence is often not known to those who need it;
- its owners often place tight constraints on its distribution;
- its interpretation is intimately linked to the context in which it is received;
- it tend to have a very short lifespan.

But it is essential for the development of large DSS that prototyping should be preceded by comprehensive understanding of the decision making process, namely the nature of the problem, its general solution procedures and decision making environment. This understanding will serve as the basis to guide proper development of a prototype system. Comprehensive understanding of the decision making process helps in the identification of DSS architecture functional specification of which can be used as the basis for prototyping. In the following sections attempts will be made to suggest an approach that can be used in initial understanding of the decision making process.

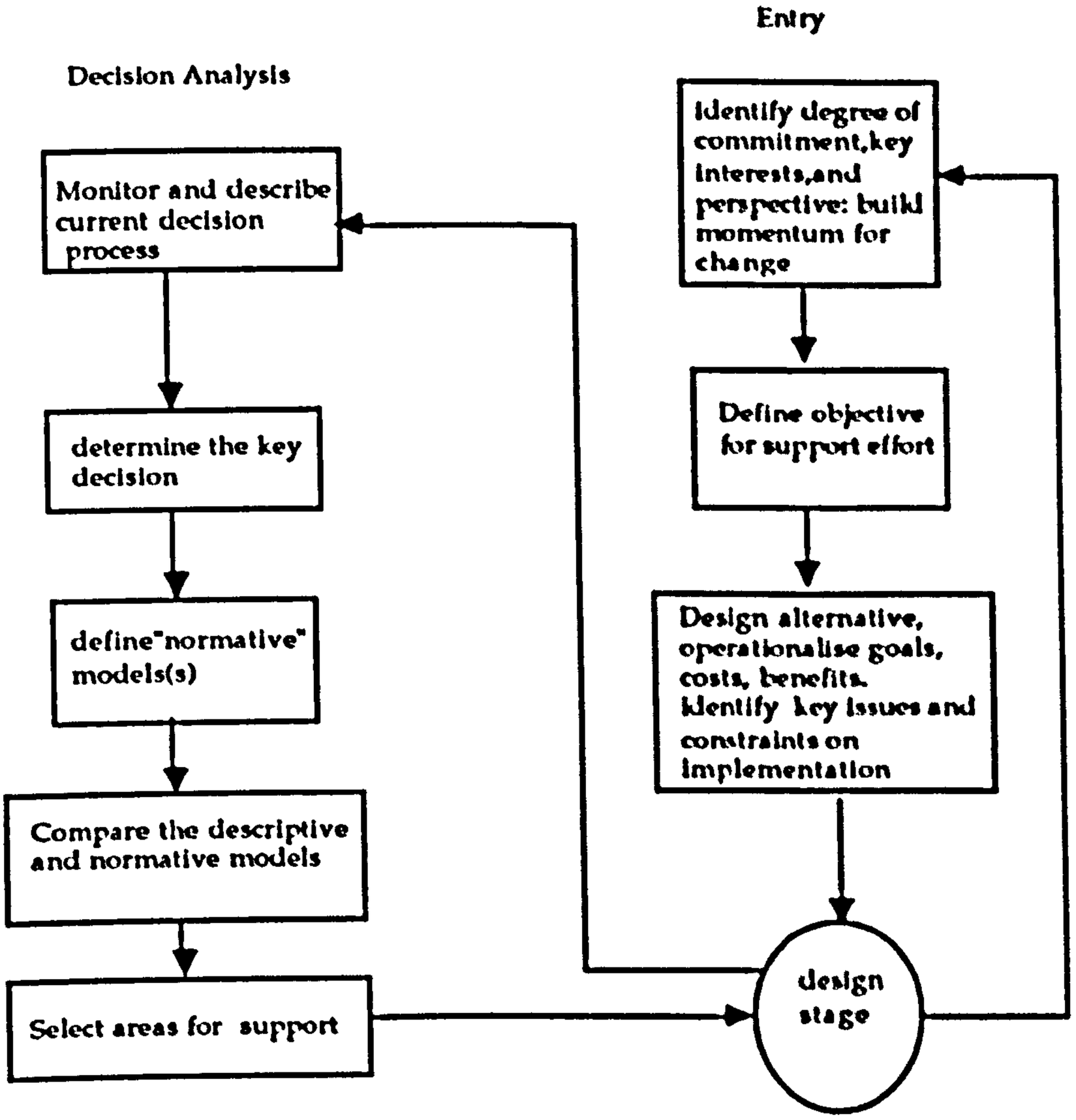
5.3 DSS Development Life Cycle

Keen(1978) suggests a pre design cycle of DSS as in diagram 5.2. This pre design cycle provides a good framework for discussing the approach to DSS development. The entry in the diagram 5.2 relates to essential initial steps in the implementation process, namely building momentum for changes and developing a contract for action that involve realistic, mutual expectations and commitment among the parties involved[Keen(1978)].

The essential steps involved in the entry suggest the need to understand those aspects of the organisation which are important for the activities involved in the steps, such as organisational objectives, role and environment, as well as to identify stake holder, their roles, responsibility within the organisation and their expectations of what DSS can do. These are the declarative aspects of the decision

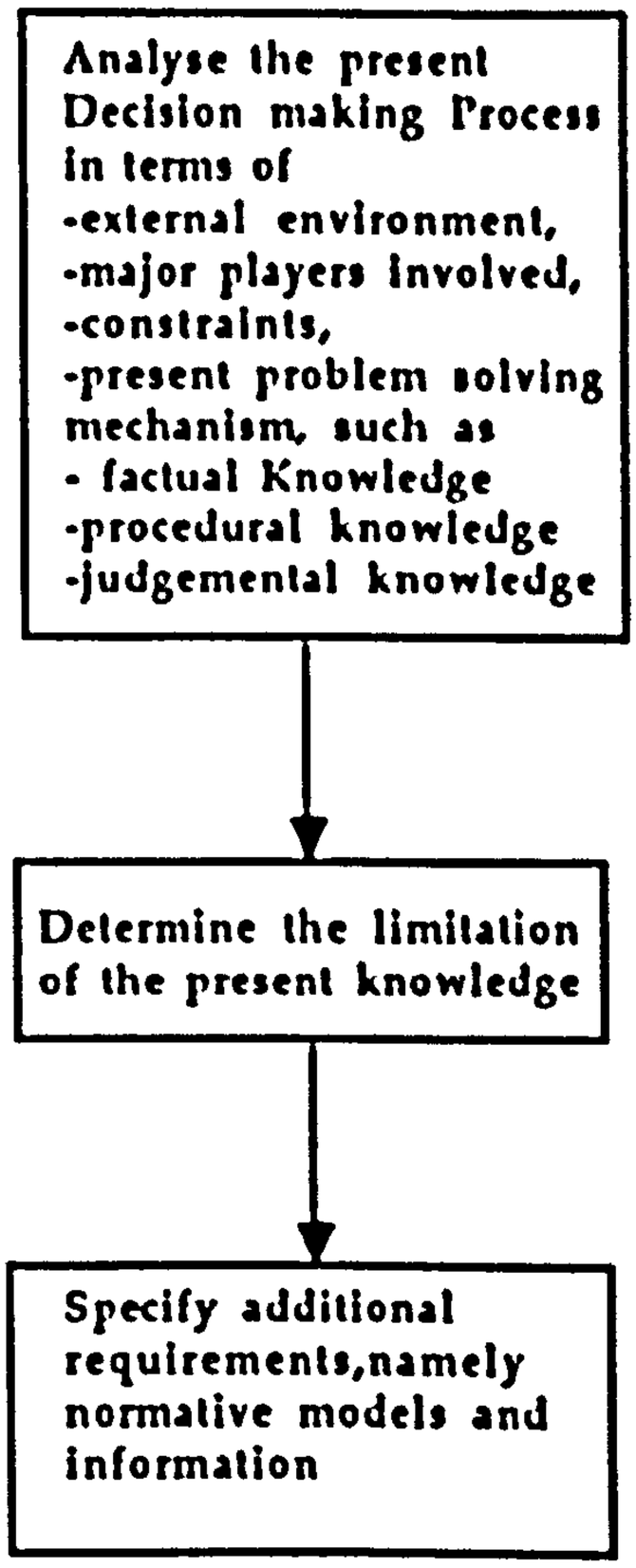
making process and they act as constraints and will determine the usefulness or otherwise of the DSS application. Many of these declarative aspects have been described in chapter 2 and chapter 4. Essential steps in the diagram 5.2 also impinge on the nature of approach and methods to be used in DSS development. In the context of the case study aspects described in chapter 2 provide essential information for describing the current decision making process and the key decisions involved: decisions on grant to the States and decisions on strategies to proposed to NFC to help toward improving the present mechanism of aid giving.

Diagram 5.2: DSS pre design Cycle
[Keen (1978)]



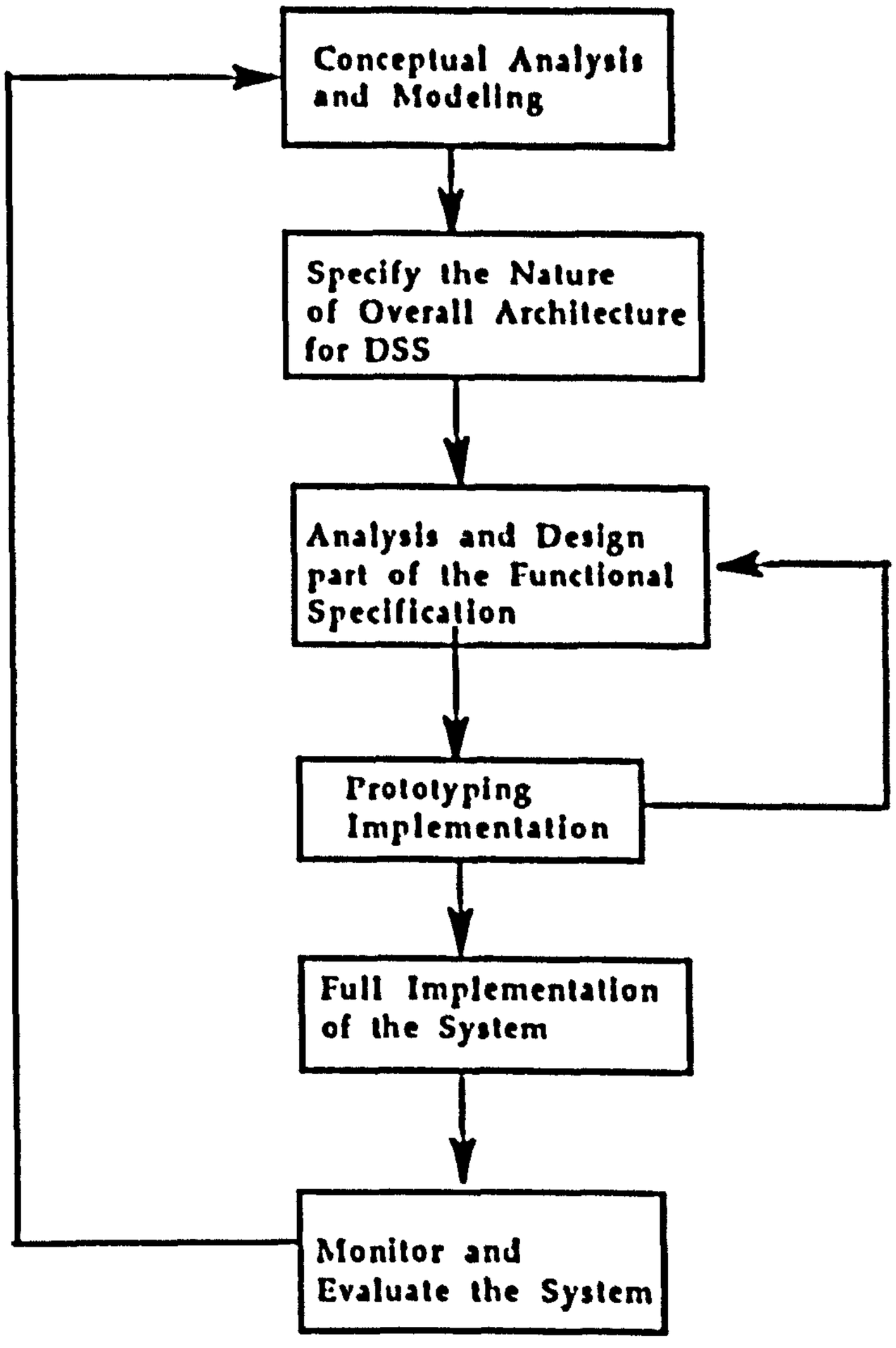
One of the major aims of the predesign cycle in diagram 5.2 is to make sure that the right problem is worked on and appropriate solution procedures proposed. But to determine what constitutes the right problem and how to go about proposing its solution procedures in an ill-structured situation is not easy. Normative models in diagram 5.2 represent solution procedures thought to be useful in the light of the problems defined for a particular decision making process, namely they are proposals for changes[Keen(1978)]. For instance if scheduling has been identified to be applicable , then the linear programing model(normative), with an optimum solution and complex sensitivity analysis, might be useful . In ill-structured situations and allied with the idiosyncrasy of the decision making process, such as in FSR, the definition of normative models is difficult, hence the activities involved in the subsequent stages, namely comparing the descriptive models and the normative models, is also difficult. Even if the normative models can be defined, it might be difficult to introduce them into the DSS. In ill-structured decision situations a series of alternative models need to be identified and proposed. Decision analysis in diagram 5.2 concerns requirements analysis where the diagnosis of the limitations of the present problem solving mechanism needs to be carried out . The diagnosis process implies the need to understand the present knowledge used in problem solving. The following diagram 5.3 depicts the general steps that need to be taken in diagnosing the limitations of the present problem solving mechanism and in defining proposals for changes(normative models).

Diagram 5.3: Process of Diagnosing and Defining Normative Models



By labelling essential steps (entry and decision analysis) in diagram 5.2(page 120) and diagram 5.3 as Conceptual Analysis and Modelling and incooperating essential steps involved in the design stage, the DSS development life cycle can be depicted as in diagram 5.4. Imprecision of the system to be developed is reflected in the loop of diagram 5.4.

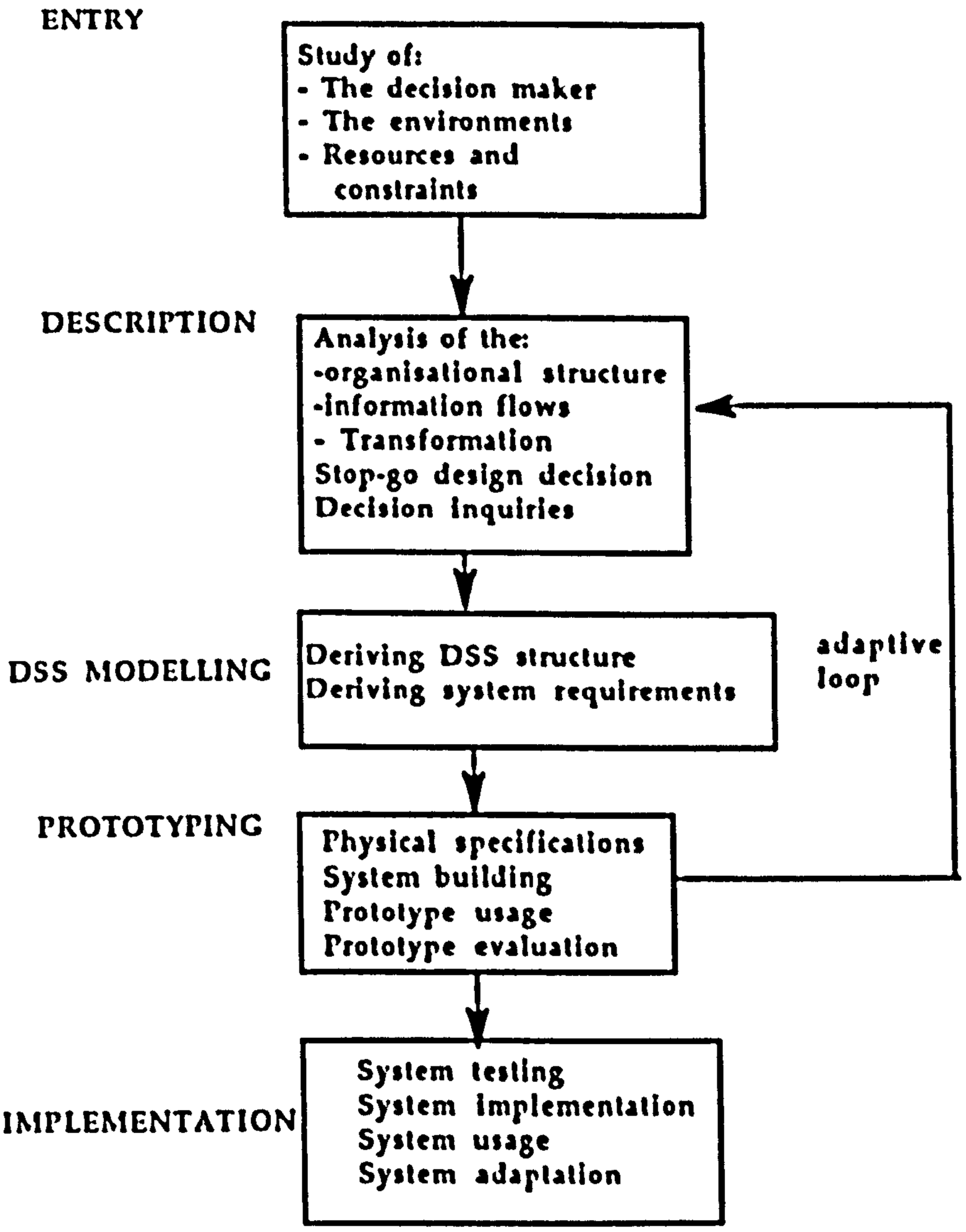
Diagram 5.4: DSS Development Life Cycle



Life cycle in diagram 5.4 is similar to the Waterfall Model of system development [Royce(1970)]. But the stress here is not on the life cycle as such but on the approach used in carrying out the activities implied by each phase in the life

cycle; whether the approach suit the complexity of the problem under consideration and capture the essential aspects important for understanding and providing solution to the problem. Arinze(1989) presents the following stages in the DSS development:

Diagram 5.5: Stages of the DSS Methodology
[Adopted from Arinze(1989)



Basically the Entry and Description stages in the above diagram 5.5 are similar to Conceptual Analysis and Modelling stage in diagram 5.4(page 123). Decision inquiries and Stop-go decision are two aspects in the Description stage of the diagram 5.4(page 123) worth discussion at this point. Decision inquiries are requests from the DSS that the decision maker views as important to the decision-making process[Arinze(1989)]. Arinze classes decision inquiries as three types: the state decision inquiries, the action decision inquiries and projection decision inquiries. The state decision inquiry concern information sought about the state of the world. He classifies this information based on Land's(1985) taxonomy: descriptive element, subjective element, temporal element, explanatory element and normative element. The action decision inquiry represents a request for a set of actions to be taken in the world in order to achieve a specified end-state. The projection decision inquiry asks for the consequences of taking user-specified actions on the part(s) of the world. This concept of decision inquiries is similar to the `Requests' in the diagram 3.1(page 52) and the responses from these inquiries are similar to the `Supportive Information' in the same diagram. The concept of decision inquiry determines the range of supportive information that can be provided by DSS and in this context also it determines the usefulness of DSS and comprehensiveness of its design. A stop-go decision determines the applicability of DSS techniques in light of the effectiveness that may be offered by other methods [Arinze(1989)] . This is a common activity in the system development life cycle in which the decision to proceed or otherwise with the development depends on the feasibility (technical, operational and economic) of the proposed systems. In fact this activity may be added to the Conceptual Analysis and Modelling stage of the diagram 5.4(page 123).

5.3.1 Methodology

Providing appropriate methods to be used is one of the important issues need to be resolved in applying any approach to the DSS development. Whilst the decision maker's views on aspects [information, models or critical success factors Keen(1978)] which he thinks of as important for decision making process, are essential for the DSS development , they might not be comprehensive. This is due to the fact that in complex environments, the decision maker experiences difficulty in knowing what information and model to use to enhance effective decision making. This difficulty also manifested itself in the FSR. It follows that without appropriate methods there will be difficulty in determining the feasibility of the DSS to be developed as well as in the development of an initial working model for prototyping. Methods to be used should have the capability of helping not only in understanding and modelling decision problem and user requirements but also in providing appropriate solution procedures.

The complexity and existence of the declarative factors in the decision making process as described in chapter 4 and the need to provide the decision aids to assist toward the effectiveness of the process in the light of the constraints imposed by the declarative factors, such as organisational and individual factors, impinges on the nature of the approach and methods to be used in DSS development. Declarative factors of a particular decision making process can also be understood in terms of its "Subject System", the major components of which includes the following:

* purpose or mission of Decision-Making task,

- the owner of the system: those who have the power to discourse about the Decision Making Process,e.g. to create problems, control and monitor their performances,
- the ultimate players, viz those directly responsible for the Decision-Making, together with the nature of their responsibilities and authorities,
- nature of the decision making problems.
- the environment, political and social, in which the decision making process takes place.
- characteristics of present data, information, rules and procedures used in making decision, namely characteristics of individual mode of problem solving.

The need to understand the subject system suggests that the approach to be used should have:

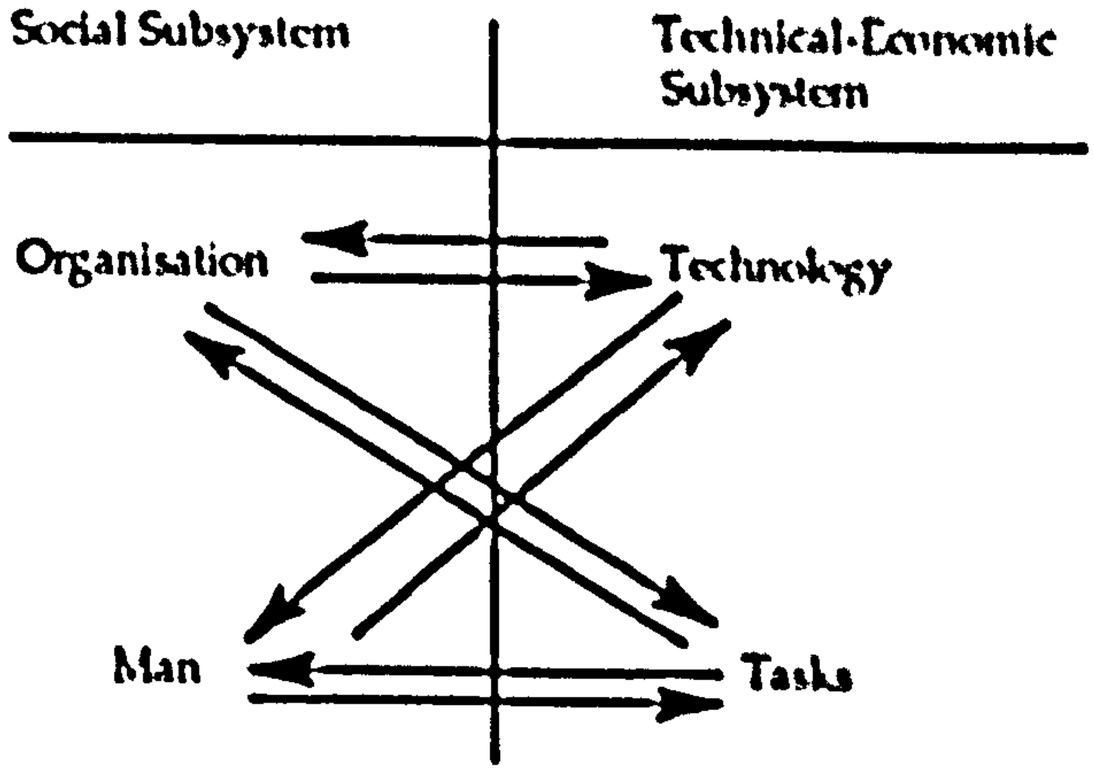
- Have the capability to structure and model ill-structured problem in a way that helps to lead to a solution,
- Have the capability for high level understanding and modelling of decision making,
- Have the capability for low level modelling of decision making,
- Have the capability to monitor the solutions generated, i.e capability for learning,
- Be easy to use.

5.3.1.1 Methods of System Analysis

There are many popular approachs that have been developed for systems analysis. One of the objectives of this section is to analyse the characteristics of these approaches, their commonality and suitability for the development of DSS. The characteristics of these approaches can be described in terms of a number of dimensions: their paradigm, conceptual models , namely aspects of reality being expressed by these approaches and nature of problems for which they are most suitable and their objectives.

To get better understanding of the organisation represents one of the major aims of most information system development approaches. One of them is Socio-Technical Approach[De Maio(1990)]. This approach stress the need to consider social and technical-economic subsystems of the organisation and to include their interactions in the information system development as in diagram 5.6(page 129). The importance of the social subsystem of the organisation has been described in chapter 2 and chapter 3 and again stressed in the conceptual modelling phase of diagram 5.4(page 123). Understanding the social subsystem as well as the technical-economic subsystem, will help alleviate the possibility of information systems failure, due to a poor understanding of users' needs leading to only partial acceptance by them.

Diagram 5.6: Social-Technical System Variables
[De Maio (1980)]



A number of approaches have been developed to realise the aim or some of the requirements embedded in Socio-Technical Approach , for example Participative Approach . This approach is attributed to Mumford, Land and Hawgood (1978). The aim of this approach is to legitimise a value position in which the future users of computer systems, at all organisation levels, play a major role in the design of these systems, and to persuade them to become involved in the design of computer systems. The Participative approach is important because it provide an avenue for users to specify their job satisfaction objective beside technical and operational objectives. This approach also assists in enhancing the acceptance of the systems by the users. The scope of involvement can be at three levels[Mumford (1979)]:

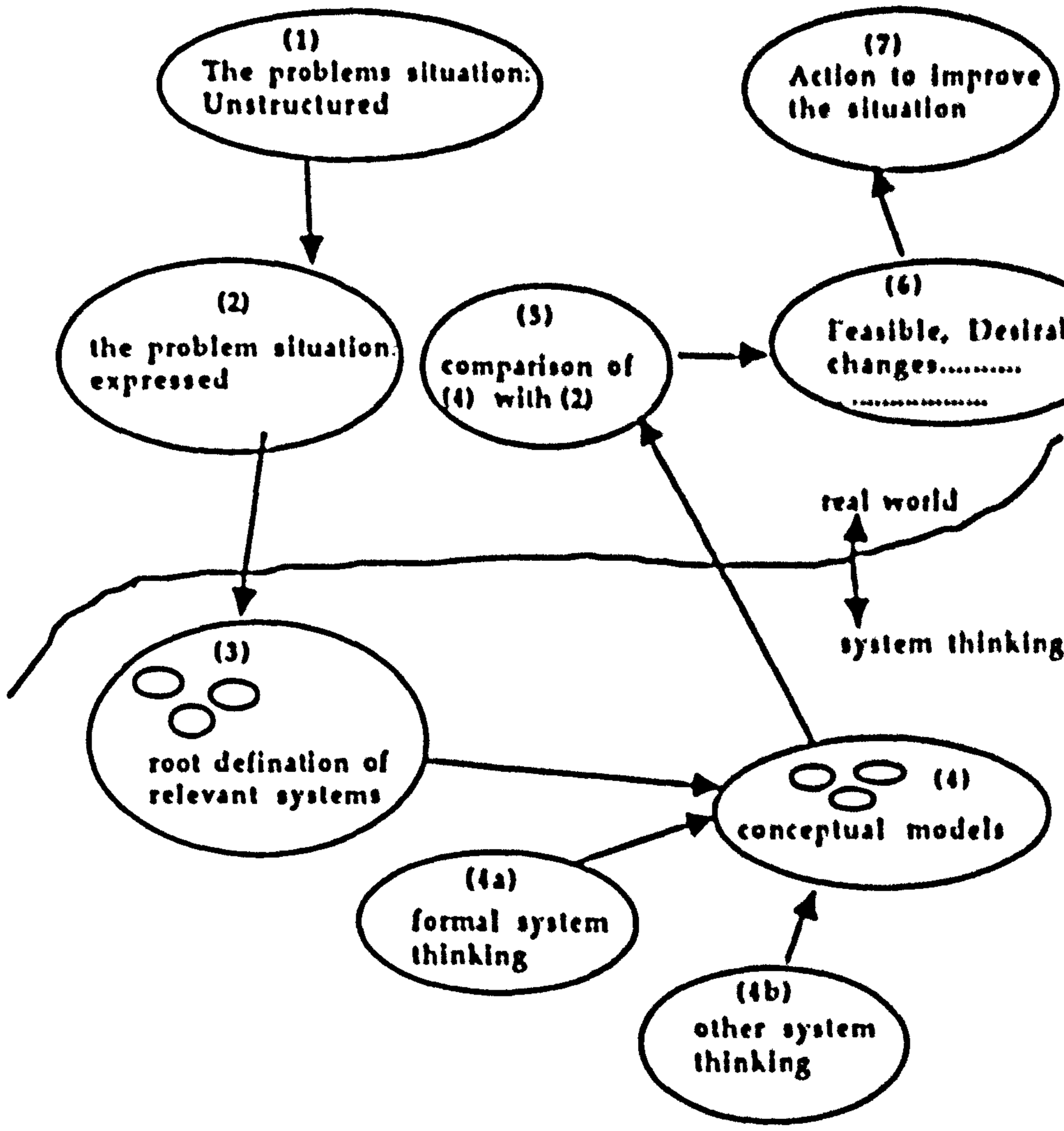
- Consultative Design, in which users provide information about problems, weaknesses and ways of improving the present systems,
- Representative Design, where the design team contains users elected to represent

all prospective stake holders of the new systems,

- Consensus Design, where prospective users are innvolved in the process of deciding alternative concepts for information systems and the form of organisation in which it will be embedded. These concepts will serve as the basis for system design and implementation by the professional system designer.

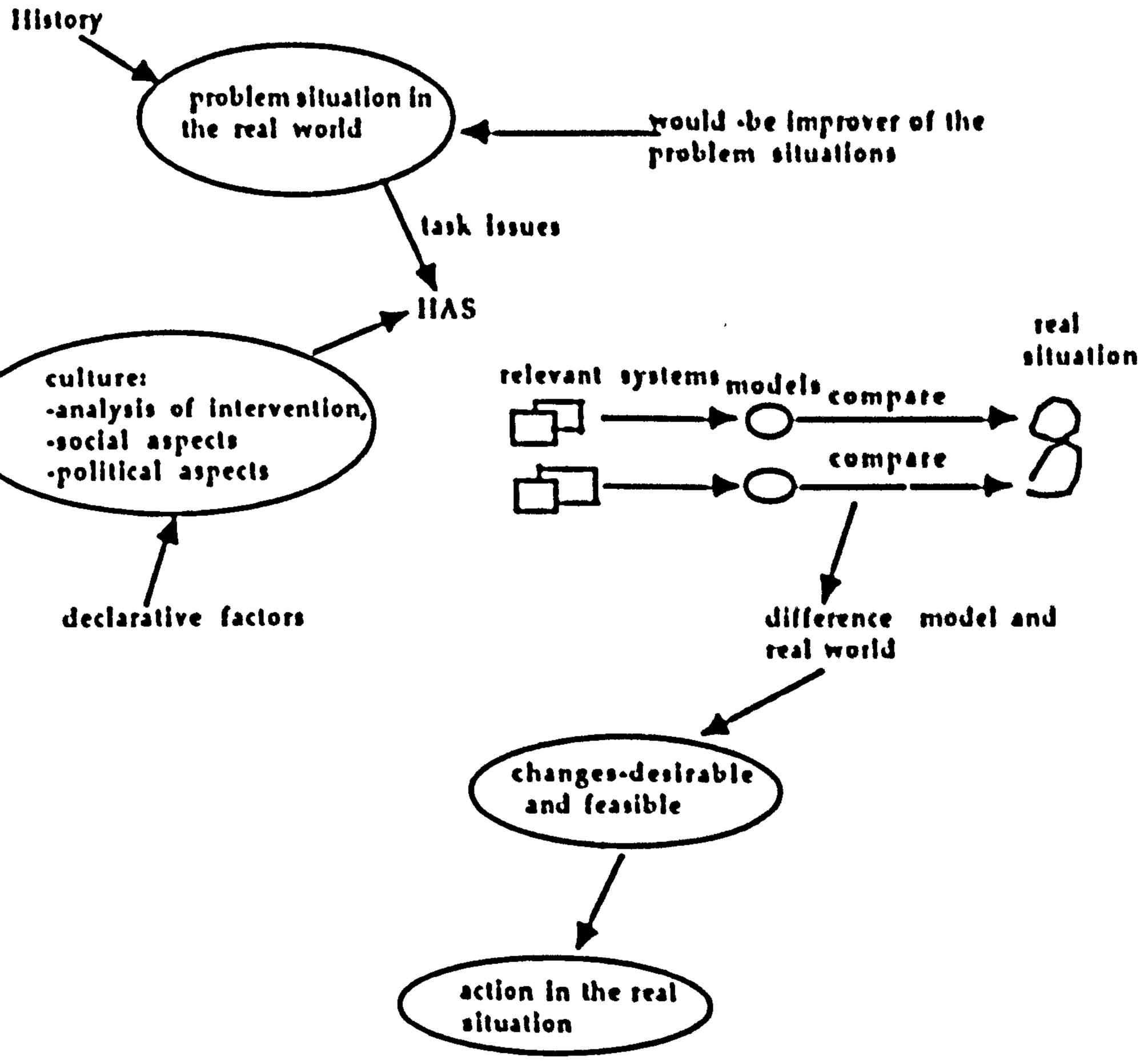
The Soft System Approach owes much to the work of Checkland(1981). In this approach the stress is on problem definition and the translation of this problem into a Human Activity System(HAS), which represents a purposeful "machine" consisting of related activities useful for providing solutions to the problem. The approach has been used in many applications [Checkland(1981), Wilson(1984)]. A general outline of the Soft System approach can be seen in the following diagram 5.7.

Diagram 5.7: General Soft System Approach
(Checkland (1981))



Another version of the approach which highlights the need to incorporate declarative factors is shown in the following diagram 5.8.

Diagram 5.8: Incorperating Declarative Factors into Soft System Approach[Checkland(1987)]



Basically the approach is a learning process looking at the objective definition of the problem rather than direct solving of the problem. Hence there is a need to find out the problem situation beforehand from people holding various opinions who have a direct interest in the solution to the problem. This is performed by the carrying out of step 1 and step 2 in the approach. The result of these steps forms the basis for defining the various Weltanschauungs (world views) of the problem situation. The culmination of these stages is the defining of the following entities:

Customers: those who would be the victims or beneficiaries of the solutions to the problems,

Actors: those who would be involved in problem solving,

Transformation Process: which changes some input into some output,

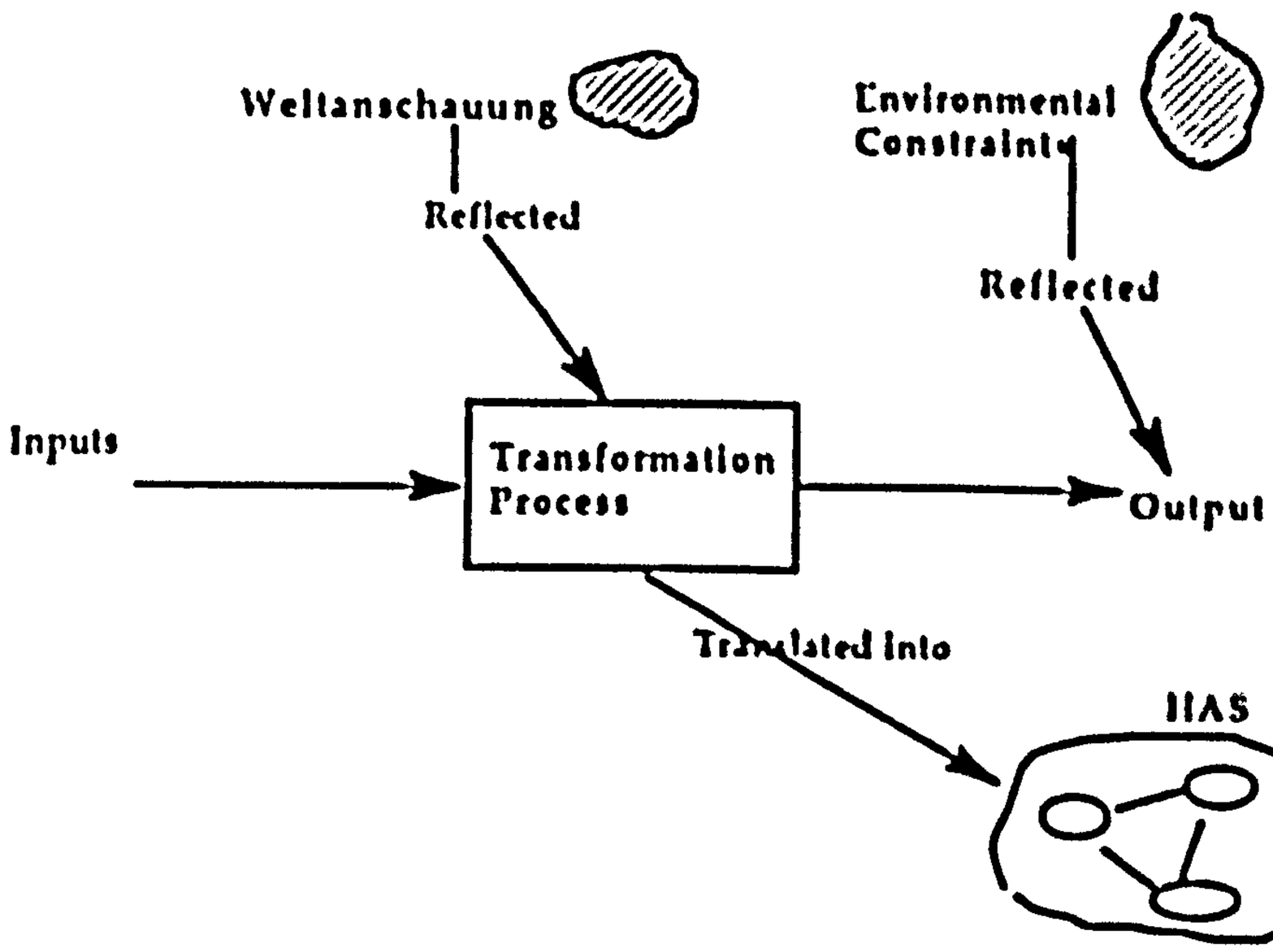
Weltanschauung: world view that make problem the definition and transformation process meaningful,

Owner : those who own the system

Environmental Constraints : environmental aspects that need to be considered.

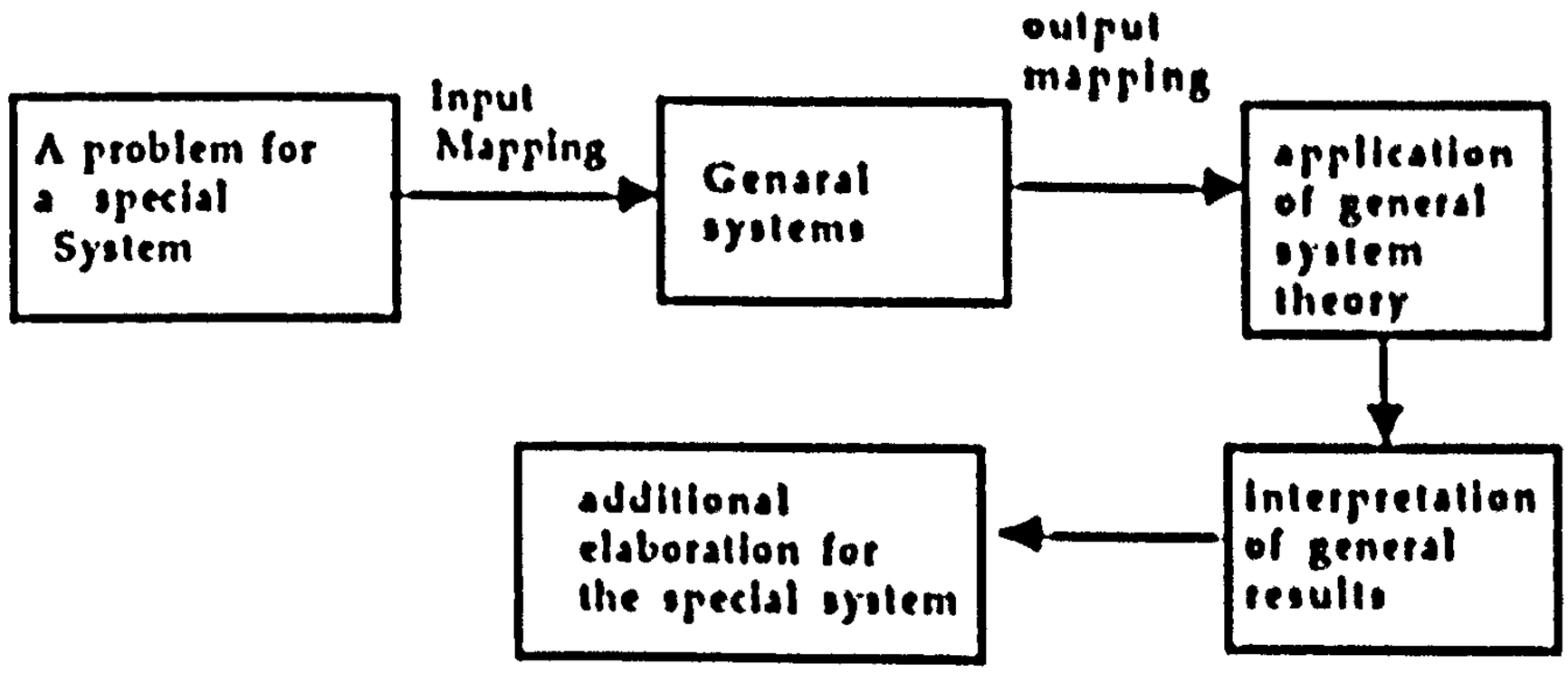
These entities are grouped under the mnemonic **CATWOE**. The CATWOE is used as the basis for defining a set of Root Definitions (RD), which is basically a verbal statement of the objectives, points of view, environmental constraints and transformation process, which combined make the statement a meaningful system. The RD is translated into a conceptual model of a Human Activity System (HAS). Basically HAS represents a set of purposeful activities to deal with the input to the transformation process, the transformation process itself and the outputs from the transformation process. The general outline of HAS formation is shown in the following diagram 5.9.

Diagram 5.9: General Outline of HAS Formation



One of the important requirements of the Soft System Approach is to check the validity of HAS against System Thinking . One of the major concerns of System Thinking is to generate conceptual and theoretical frameworks useful for understanding the nature and general characteristics of "Systems". For example the concept and meaning of General System Theory(GST)[Bertalanffy (1968)]. GST was based on the assumptions that there exist models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relationship or "forces" between them. The subject matter of GST is the formulation and derivation of those principles(universal principles) which are valid for systems in general. Basic objective of GST is understanding, and interpreting the problem. GST approach can be shown in diagram 5.10 (page 136).

Diagram 5.10: The use of General System Theory
[Klir(1969)]



In diagram 5.10 the general system represents an abstract model into which a particular system under consideration is translated. The abstraction of fundamental traits and salient features of a particular system is used as the basis for its translation into a particular general system. For example if a particular system under consideration has traits and features of an adaptive control system it can be translated into a general model of adaptive control system to which the theory of adaptive control system can be applied, such as the theory that has been developed in the discipline of Cybernetics [Ashby(1964)]. A number of classes of general systems have been developed to help in understanding real life systems. For example the view of organisation as the human nervous system is implied by the work of Beer(1980). A number of conceptual and theoretical frameworks describing "systems" in general can be found in Emery (1976).

There is a category of approaches that have been developed based on the assumption that there exist problems that need to be identified and defined and

computerised information systems will be used to assist activities in a particular application. Traditional Approaches such as those described in Lee(1979), Fitzgerald(1981), Hawryszkiewycz(1988) and Senu(1989) fall into this category. In the Traditional Approach design concerns modelling inputs, outputs, files and processes to produce these outputs. Computerised systems to assist in information processing of the present(manual) systems will be implemented. There are approaches which assume the building blocks of a system are data(entities and their attributes). In this Data Analysis Approach the system understanding comes down to the classification and identification of the relevant data set that exist in the system, and the requirements analysis results in the functional specification and application on these data. This approach is associated more with work on conceptual and practical understanding of Data-bases[Date(1979), Atre(1980), Clifton (1990)]. StructuredAnalysis[deMarco(1978),Gane(1979)] provides enhancement to the traditional approach by providing tools , such as the data flow diagram and data dictionary. These tools are useful for system modelling and have been used in many applications [deMarco(1978),Gane(1979)].

The characteristics of the above approaches are summarised in the following table 5.1:

Table 5.1:Characteristics of Approaches to System Analysis

Approaches	Aspects Included	Objectives
Soft System Approach	Objective of the system is not defined initially. Aspects considered are Actors, Clients, the problems environment	Better understanding of the organisation as well as providing frameworks for problem solving
Social-Technical Approach (Participative Approach)	People, needs, the works environment, namely organisational structure and work task.	Better understanding of the organisation which lead to the proper understanding of the role of formal system and technology to be used
Traditional Approach	Organisation is considered in terms of functions and the breaking up of these functions into subfunctions	To understand the functions and their information and information processing requirements
Data Analysis	Stress on data modelling, namely attributes and their relationship	Better understanding of the data required for defined application and problem
Structured Analysis	Stress on functional representation of the problem, data output from these functions	Better understanding of the application and problem in terms of functions, input and output of these functions

5.3.1.2 Usefulness of the Methods

Selecting a suitable approach provides a major problem for the analyst. Common sense dictates the need to select an approach best suited to the characteristics of the problem under consideration and the final objective of the investigation. Whilst there are variations in emphasis in the Soft System and Participative Approaches (which will be referred to as high-level approaches) they have a common objective, namely to help in understanding of the organisation and provide frameworks for the solutions to the problem. A Social-Technical Approach such as Participative Approach is quite general in that there is no insistence on a methodology. Any approach that incorporates aspects stressed in the Social-Technical Approach can be considered as belonging to this approach.

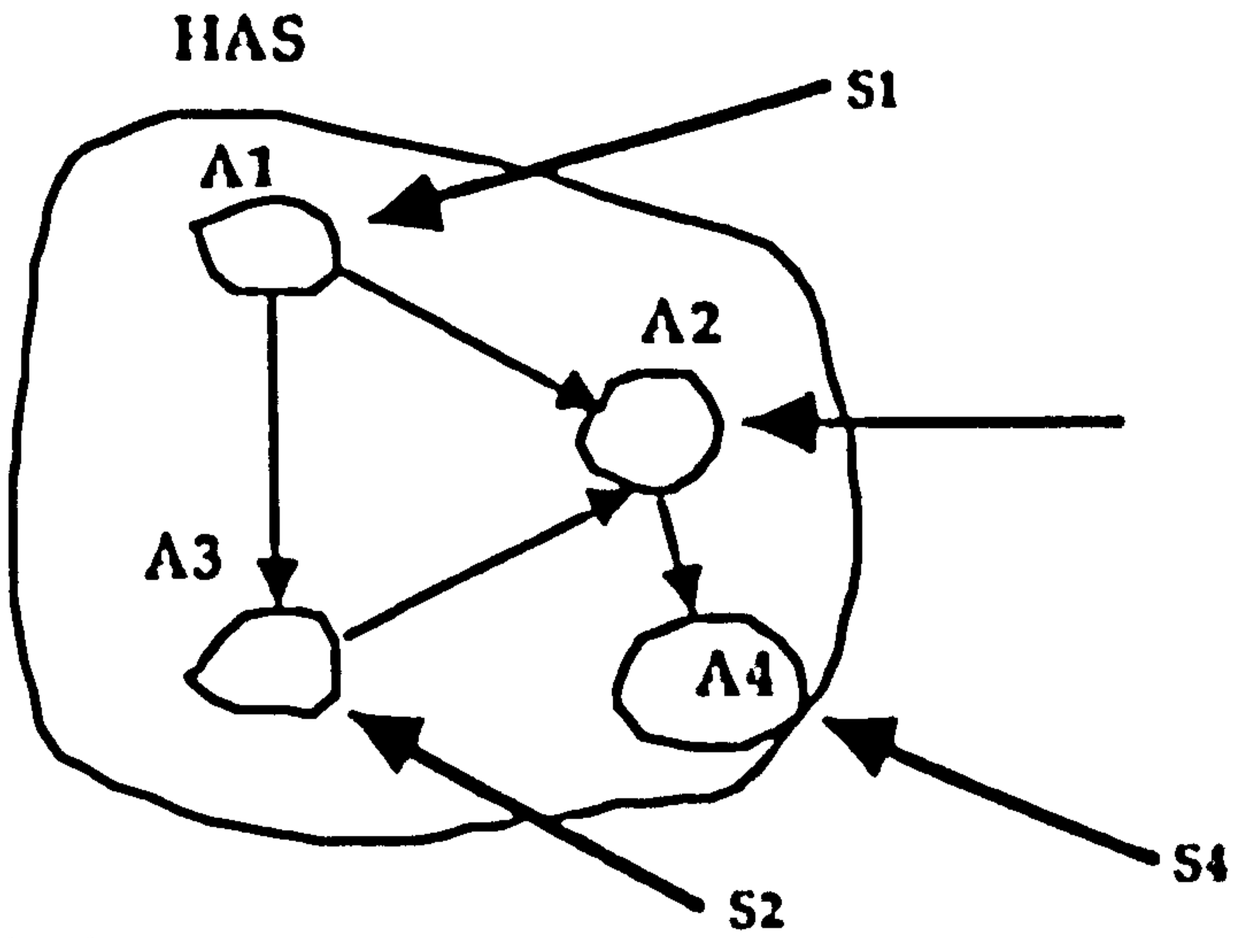
In terms of method the Soft System Approach is quite rigorous and well established. The approach also facilitates the inclusion of those aspects stressed in the participative approach. It provides a framework useful for understanding those aspects relevant for improving effectiveness of decision making. In particular it is useful for the conceptual analysis and modelling phase of the diagram 5.4(page 123) . A Root Definition defines the general problem that needs to be solved. The inclusion of the declarative factors, such as multiplicity of roles, norm and value systems is stressed at the very beginning of the problem definition as reflected by the components of CATWOE. This inclusion also reflects the ability of the approach to facilitate user participation. Comparing models with the problem situation (activity (5) in diagram 5.7 page 131) helps, even in the early stages of the development, to

facilitate learning and communication of ideas between those involved in the decision making process and analyst. The need to have this facility has been stressed by advocates of the experimental approach to information system development, for example Guitierrez(1989). Activities in HAS define subproblems, each of which need to be solved in order to solve the whole problem. How these activities are currently being carried out in the organisation can be used as the basis for determining the limitations of the present problem solving mechanism.

Providing and implementing necessary decision aids to help improve the activities embedded in the modelled HAS represent one important step towards improving the effectiveness of the decision making process. For instance the decision aids that need to be provided to assist toward the effectiveness of the activity " Appreciate the problems or needs of the States" embedded in HAS defined for FSR (this will be described more in chapter7). In theory what decision aids are to be provided and how to implement them depends on the nature of the problem (i.e its complexity) and requirements(information, models) implied by HAS and also the nature of declarative factors embedded in the organisation (Organisational or Individual constraints). Different activities need different types of decision aids as in diagram 5.11. For example decision aids to be provided for activity " Appreciate the problems of the States" would be different from those to be provided for activity "Devising the Strategies for Actions". Recommending and implementing necessary decision aids represent step(6) and step(7) in diagram 5.7(page 131) . But the approach on how these can be carried out is not well described by Checkland. In the discussion that follows general frameworks for providing decision aids will be

presented. These frameworks are useful for defining normative models which represent an important activity in diagram 5.2(page 120).

Diagram 5.11: Possible Supports for Activities in HAS



Ai is activity i
Si is support for activity i

Traditional Data Analysis and Structured Approaches(which will be referred to as **low-level** approaches) assume the existence of concrete information or knowledge in the system which can readily be used as the basis for modelling. These approaches are suitable for the development of computer-based information systems, where the present data flows between functions are used as the basis for modelling. Low-level approach, such as Structured Approach, deal with the specification document itself rather than with the process that leads to the document[Shemer(1987)]. A flaw in these approaches lies in their basic assumption that the organisational problems are well understood and the knowledge of how to

solve them can readily be modelled. In ill-structured decision making this is rarely possible.

"This type of information (Modelling approaches-added) is not at all what is needed in handling the organisational decision problems typically faced by management within the organisation, for whom the problems do not usually come "neatly packaged"(Humphreys(1986).

Humphreys continues:

"At the outset problems are likely to be unstructured: one does not know what to model; type of intelligence required is that which will help one to look for alternatives, think in terms of dynamic processes and find appropriate support for different actors ....."

Humphreys's statement implies the need for a procedural approach to support the decision maker in structuring and modelling ill-structured problems. This need emerges from the assumption that the decision maker facing an ill- structured problem experiences difficulty in understanding what the problem really is and difficulty in knowing how to go about solving it. These are the characteristics of " Procedural Uncertainty", namely uncertainty concerning the means to process the decision(specifying the nature of uncertainty, knowing what information to seek, and from whom, how to invent alternative , assess consequences). Capabilities to resolve Procedural Uncertainty and for modelling problems at a high conceptual level are useful characteristics of any approach to be used in the conceptual analysis and modelling of the decision making process in ill-structured situation. However the Traditional Approach and Data and Structured Analysis on the other hand are useful for low level structuring and modelling of well defined decision making processes or where issues of problem definition and of what model and information to be used to solve the problem have been resolved.

Based on their major characteristics in table 5.1(page 137) , potential uses of high-level approaches and low-level approaches to help in the DSS development life cycle are presented in table 5.2.

Table 5.2: Potential Uses of System Analysis Methods in DSS Development

Major Phases in the Development	Appropriate Approaches
Conceptual Analysis and Modelling	Soft System Approach, Social-Technical Approach (Participative Approach)
Design and Implementation	Data Analysis, Traditional Approach, Structured Analysis

Soft System approach is attractive for a number of reasons described earlier . Many aspects emphasized in System Thinking are based on conceptual and theoretical frameworks and assumptions that are easy to understand but are not so useful for practical purposes and others are too complicated to apply. For example attempts to adopt approaches based on General System Theory(GST) have been notably unsuccessful [Berlinski(1976), Lilienfeld(1978)]. As Wood-Harper (1982) put it

"the reason for the lack of success is that the very generality of GST makes it difficult to use and to develop a methodological solution; and where a solution is arrived at it is often one which requires a revolution to implement. It is not a process which often recommends small incremental change but one which more usually result in the complete reassessment of structure, roles and behavior"

But many concepts and models that emerged from System Thinking, such as concept of Viable System[Beer(1960)] and model of control system, were found, used in conjunction with HAS, to be useful for the development of DSS. The use of Viable System and control model in the development of DSS for FSR will be described in chapter 7.

5.4 Monitoring and Evaluating of DSS

Empirical investigations into the benefits of DSS have also attracted attention in literature[Keen (1981), Wagner (1981), Money et al (1986)]. But for DSS to be considered a distinct concept, the benefits they provide to the decision maker should be different from those provided by MIS and TPS. In abstract terms the benefits to be provided by DSS should revolve around " providing supportive information to help decision maker to make effective decisions in illstructured tasks".

Benbasat et al (1990) provide a useful framework for understanding DSS benefits. They reviewed empirical studies of the effect of use of decision aiding techniques on management support systems(MSS). They defined MSS to include DSS, group decision support systems(GDSS) and expert systems(ES). Two of their conclusions are that a wide range of interpretations, using different aspects, have been used to measure the effects and most of the research strategies used in measuring these effects were based on laboratory experiments, often using Graduate Students. Due to a wide range of interpretations attached to the effects of decision aiding techniques on MSS and the adhocness of the research strategies used, the results from the

empirical studies are naturally inconclusive and limited. Whilst some studies have claimed that decision aiding techniques did improve the performance of the decision making, in several of these studies unaided users performed as well as aided users [Benbasat et al (1990)].

Many factors contributed to the performance or otherwise of the decision making beside those that might be attributed to the decision aiding techniques such as the complexity of the decision domain and the knowledge of the users. Whether the claims about performance have any validity in real life situations in which users faced with the practical problems is questionable. Most empirical research covered by Benbasat pointed to the fact that GDSS enhanced decision quality with difficult tasks. But the important point to bear in mind is whether the performance of the decision makers was improved due to the decision aiding techniques or due to the presence of the group itself. The deduction that can be made is that the group itself might improve the decision making due to the presence of multiple knowledge and experience.

Keen (1981) described a more comprehensive set of benefits [see table 5.3(page 145). In general measuring the effects of DSS and their embedded decision aiding techniques on decision making is a difficult task. Effectiveness involves identifying what should be done and ensuring that the chosen criterion is the relevant one, it also requires adaptation and learning(Keen et al 1978). At the theoretical level the difficulties lie in identifying an appropriate set of measures, and at the implementation level of realising these measures. Keen et al (1978) account for the

difficulty of evaluating DSS benefits as follows:

* lack of adequate definition of objective and criteria or "success" and "failure",
* evaluation embraces social(qualitative) aspects, which can not easily be transformed into quantitative measures,
* evaluation is intrinsically subjective, based on different value judgments
* as the user requirements evolve and change over time, the initial system objective, if it could ever be set, would be different from the final objective.

Table 5.3: DSS Benefits[Keen (1981)]

1 Incerase in number of alternatives

2.better understanding of the business

3.fast response to unexpected situations,

4. ability to carry out adhoc aanalysis,

5. new insight and learning

6. improved communication,

7. control,

8. cost saving,

9. better decisions,

10.more effective teamwork,

11.time saving,

12.making better use of the data resources

The benefits of DSS are difficult to assess a priori. They include support of organisation change, support of individual learning and improved management of technological growth of the organisation[Henderson et al(1983)]. Evaluating the costs and benefits of information systems in general is a subject that has attracted a lot of attention in the literature. For example major crucial issues and important aspects for understanding the nature of information systems evaluation, theoretical frameworks for describing underlying theory and logical design of information systems evaluation and empirical investigation of information systems evaluation are well addressed in Bjorn-Andersen (1986). Information systems evaluation describe benefits in terms of efficiency as well as effectiveness and make use of sets of measures based on a number of dimensions. As a DSS is a form of information system these works can be used as a basis for evaluation. The conceptual and theoretical framework on organisational effectiveness described in chapter 4 can also be used to evaluate DSS.

5.5 Conclusion

The need to help the decision maker arrive at better decisions in an ill-structured situation is the raison d'etre of DSS. In order to be effective DSS need to incorporate social , political and human aspects of the decision making process into their design. The ill-structuredness of the situation implies that the solutions obtained will be ephemeral. This is becaues they are based on incomplete understanding of the situation and they will be changed or improved through learning. As with any

information system, DSS also requires investments of manpower and time, thus their development should also be subjected to proper project management and control. Raison d'etre of DSS also suggest that the nature of approach and method to be used in their development should be different from those used in developing information systems for structured problems in which the most important operating constraints, procedures, models and information for defining the problem, formulating alternatives solution, defining the criteria for evaluating the solution outcomes can be easily derived from the existing systems. Ill-structuredness of the situation suggests that the approach and method to be used in the development should help in the problem exploration, effective solutions identification and generation. This also dictates the need for the approach to have a learning capability.

This chapter has presented a development life cycle which serves as a basis for an approach to DSS development. In the development of an approach with the characteristics envisaged in this chapter, reference was made to a number of well established approaches in system analysis. The characteristics of these approaches, namely aspects they consider and objectives they attempt to achieve, were critically analysed and compared. This chapter has highlighted the attractiveness and potential of the soft system approach for the development of DSS. The Soft system approach facilitates the inclusion of some of the decision making factors (environmental, organisational and individual) into the DSS development process. HAS generated by this approach help in identifying high level solution procedure to complex problem. But HAS itself is limited. A number of important aspects need to

be considered and understood in order to carry out effectively the activities embedded in HAS. Chapter 6 will present frameworks to help in understanding these aspects.

CHAPTER 6

FRAMEWORKS FOR PROVIDING DECISION AIDS

6.1 Introduction

The DSS paradigm implies that formal decision aids can play a useful role in supporting effective decision making. Providing decision aids corresponds to the third activity in diagram 5.3(page 123). Decision aids include any model, strategy, action, technique and tool for problem solving that is thought useful by the decision maker concerned in improving the quality of the decision reached. The introduction of decision aids gives rise to a number of important issues that need to be resolved. As described in chapter 4, declarative factors have a direct bearing on both organisational and individual decision making. They imply that the introduction of decision aids into an organisation poses two major questions: how to coexist with the governing declarative factors as well as serving as instruments to help towards improving the effectiveness of decision making. The coexistence of decision aids is realised if they match the constraints and characteristics implied by the present declarative factors.

As described in chapter 4 declarative factors constitute much of the complexity of the problem and environment in which decision making takes place. Decision making in complex domains involves inconsistent, incomplete and uncertain information, lack of established models or theories, methods and techniques. This is"Procedural Uncertainty" as described in chapter 2. The existence of procedural uncertainty leads to the use of heuristics or adhoc solutions to the problems, which rely on the use of limited information, simplifying strategies, judgment and common sense in problem solving. Heuristics are also used in the situations in which the optimum solution to the problem can not be obtained by analytical means due to the impossibility or impracticality of the complete enumeration of all possible solutions. For example heuristics are used in FSR (as described in chapter 2). It was inferred from the study of the decision making process in FSR that heuristics were justifiable and sometimes unavoidable due to the complexity of the problem. They provide a time-pressured decision maker with a simpler and shorter way of dealing with a complex problem. This leads to a saving in time , effort and cost, due to limited information being collected and used. Heuristics also arise due to the need to keep decisions consistent or correspond with, for example, the present organisational norm and values system or any other reinforcer, as described in chapter 4.

Heuristics may produce a satisficing or partially satisfying solution, but also may create bias in decision making. A biased decision can result in serious and

systemic errors. Sources of bias in decision making are well cataloged in Bazerman (1986), a summary of which is shown in table 6.1. Improving decision making requires the enhancing of the creativity and intelligence of the decision maker. Enhancing creativity means reducing bias, improving judgment and reducing ambiguity. Decision aids will be useful if they provide support in these respects. Improving decision making also implies that decision aids are normative or prescriptive in nature. In this respect reference needs to be made to the normative concepts, theory, methods and techniques that have been established in the literature and their identification into useful frameworks for providing decision aids to help towards effective decision making in general and decision making in FSR in particular.

Table 6.1 Description of biases
[Bazerman(1986)]

Biases	Descriptions
Biases due to the retrievability of instances	Individuals judge instances that are more easi retrieved from memory to be more numerous than a class of equal frequency whose instances are less retrievable.
Biases due to the effectiveness of a search set	Individuals are biased in their assessments of t frequency of events based on how the structure memory (e.g alphabetical) affects the search pr
Biases due to illusory correlation	Individuals tend to overestimate the probability of two events co-occuring when they generate mutual occurence of the two events.
Insensitivity to prior probability of outcomes	Individuals tend to ignore prior probabilities when any (even worthless) representative information is provided.
Insensitivity to sample size	Individuals fail to appreciate the role of sample in evaluating accuracy of sample information.
Misconceptions of chance	Individuals expect that a sequence of events ge from a random process will represent the essen characteristics of that process, even when the sequence is too short for that expectation to be statistically.
Regression to the mean	Individuals fail to incorporate the statistical fact that extreme events tend to regress to the mean subsequent trials.

Table 6.1: Continued

Biases	Description
Insufficient adjustment	Individuals make estimate from an initial value (based on past events, random assignment, or whether else is accessible) and make insufficient adjustments from that anchor
Conjunctive and disjunctive events bias	Individuals tend to overestimate the probability of conjunctive events and to underestimate the probability of disjunctive events.
Overconfidence	Individuals tend to be overconfident in their falli'ble judgment when answering moderate to extremely difficult questions.
The conjunctive fallacy	Individuals judge falsely that conjunctions are more probable than a more global category, of which the conjunction is a subset. When the conjunction is more representative or available than the more global category.
The confirmation trap	Individuals tend to seek confirmatory information for what they think is true and exclude disconfirming information from their search process.
Hindsight	After finding out whether or not an event ocurred, individuals tend to overestimate the degree to which they would have predicted the event without the benefit of outcome knowledge.

6.2 Complexity of the Decision Making: Theoretical Understanding

As implied in chapter 4 one of the characteristics of the decision making process that has a direct bearing on providing Decision-Aids is its complexity. From the system-theoretic viewpoint complexity can be measured by the number of factors involved as well as the nature and the degree of interactions between these factors[Simon(1969)]. Obviously the greater the number of factors, whose states or conditions need to be forecast, and the more uncertain the interaction between these factors, the more complex the problem will be. Interaction generates causal loops that are a monotonically increasing function of the number of connections [Ashby(1964), Roseblueth et al (1968) and Taylor (1968)]. In Cybernetics the complexity of the problem is measured by its variety [Beer (1966), Espejo et al (1988)]. Variety signifies the number of possible states generated by the problem. In an ill -structured situation the difficulty lies in understanding the complexity itself, namely identifying what factors are involved and how they are related. The need to reduce complexity has resulted in the concept of the attenuator [Espejo et al (1988), Beer (1979)]. Conrath et al(1987) use the concept of variety in evaluating information in ill-structured decision environments. Lehman(1981) working in the context of software engineering, divided problems into a number of classes. An S-type problem is characterised by the existence of a complete and authoritative view of the environment. The impossibility of obtaining a complete abstraction of the environment represents the characteristics of a P-type problem. An E-type problem

is characterised by the need to predict the effect that the system will have on the environment but prediction itself is not perfect. The situation might be so complex that it is impossible to develop a model for the application. This characterises the U-type problem. These classes influence the nature of approach and methods to be used in the development of systems to assist those involved in problem solving. Operational research might be applicable in an S-type situation where the model can be developed to help in the transformation process. DSS concern P-type , E-type or perhaps U-type situations. Most tools and techniques that have been developed in software engineering are appropriate only for S-type situation[Land et al(1986)] and this justifies the need for DSS approach and methods to have the characteristics envisaged in section 5.3.

One of the important implications emerging from the complexity of the problem situation is that it gives rise to uncertainty and equivocality. Uncertainty measures the difference between the amount of information required to perform the task and the amount of information already available to the organisation [Galbraith (1977)]. Theoretically as information increases, uncertainty decreases. Any Decision-Aids would be useful if they help in reducing uncertainty. Equivocality is associated more with the ambiguity which results from the existence of multiple and conflicting interpretations of the situation faced by the organisation. High equivocality means confusion, lack of understanding, and an unclear field. In such a situation decision makers are not certain about what questions to ask; even if questions are posed, the

situation is ill-defined to the point where clear answers will not be forthcoming [March et al(1976)]. New data or information may not resolve anything when equivocality is high, it may even increase confusion and uncertainty [Daft et al (1986)]. Uncertainty and equivocality define an n-dimensional information space for an organisation[Marschak et al(1972), Baligh et al (1981)]. Uncertainty measures the ignorance of whether a variable exists in the space. Daft(1986) describes various information searching behaviors of the decision maker in the presence of equivocality and uncertainty (see the following table 6.2). These behaviours serve as useful frameworks for identifying decision aids.

Table 6.2: Information Searching Behaviours in the presence of Equivocality and Uncertainty [Draft (1986)].

High 1. High Equivocality, Low Uncertainty occasional ambiguous , unclear event managers define questions, develop common grammer, gather opinion	2. High Equivocality, High Uncertainty many ambiguous, unclear events, managers define question, also seek answers, gather objectives data and exchange opinions.
Low 3 Low Equivocality, Low Uncertainty clear, well defined situation manager need few answers, gather routine objectives data	4. Low Equivocality, High Uncertainty many well defined problems, manager ask many questions, seek explicit answer , gather new quantitative data

6.3 General Nature of Support

Decision making described in its declarative context provides the basis for conceptual understanding of the nature of support to be provided. For instance improving decision making processes involves the need to change the behaviour and procedural aspects of those involved. But behaviour and procedure is dictated by the environment in which the decision making process takes place. For example the assumptions embedded in the strong-rational model of decision making reflect the nature of general support that can be provided. Basically the support helps the decision maker towards making an optimal choice. The assumption of bounded rationality implies the limitation of the decision maker to solve problems in complex situations. This may lead to the satisficing solution or at worse suboptimal solutions(behavioural impact). Working within the definition of bounded-rationality in decision making ,the process can theoretically be improved by providing support to expand the bounded rationality of the decision maker. This can take the form of relevant information and decision-aids that assist the decision maker to formulate the goal and means to achieve that goal.

The major factor influencing the behavior of the decision maker and the procedures used in an organisational process model is the shared body of knowledge. The knowledge is peculiar to an organisation and it influences the decision maker both behaviorally and procedurally, by providing guidelines of what

to do, and in certain cases how to it. In this respect support can be provided to assist the decision maker find an effective solution to the decision problem implied by organisational requirements and constraints. Depending on the role and responsibility of the decision maker , support can also be provided to assist him find an effective solution that changes some aspects of the present shared body of knowledge by changing the present organisational objectives and procedures used in decision making. For example, in devising new effective strategies to be used in aid giving, FSR needs to look at the present ways of administering aids to the States.

In a political model an individual or group , inside or outside the organisation, may influence the decision making process in a number of ways: in selecting the information and procedures to be used and what objectives are to be achieved and constraints to be satisfied; in acting as watchdog that monitors the performance of the decision. For example in FSR, the decision making is influenced by members of the National Finance Council, the Cabinet and also those in the States and others in some of the Federal Government agencies. The Cabinet influences FSR by specifying objectives that need to be achieved and constraints to be satisfied. The National Finance Council is responsible for making the final decision between options recommended by FSR. Those in the States monitor the performance of decisions in FSR and provide feedback that will influence the future decisions. Some Federal Government agencies are involved in monitoring the performance of and in providing input information to the decision making process in FSR. In the political

model decisions are considered effective if they satisfy the expectations of those that have influence on the decisions. In this respect the political process model leads to the need for support to help decision makers make decisions that can effectively maintain the relationship with the major influential players. In particular support is required to help in making decisions that can effectively satisfy or justify current expectations of these players or anticipate new expectations.

6.4 Normative Decision Aids

The process of identifying normative decision aids involves a number of major concerns. Sutherland(1983) provides frameworks to help in understanding this process. One of the major concerns in this process is the mapping of decision aid technologies onto decision categories. This is shown in diagram 6.1(page 161). The decision categories in diagram 6.1 can be associated with well known levels of decision responsibility within organisations. For example directive correlation can be associated with the highest level authority and operational management with the lowest level. The diagram indicates the matching of each decision category with its possible decision process,i.e highest level authority may be concerned with with general programming or long range planning. It also indicates a possible decision aid technology best suited to support a particular decision level or decision process. Basically sequential-state instruments are useful to support those involved in or responsible for the development of the organisation over the long run, namely to

develop a plan that defines a desired sequence of stages that an organisation will pass through from its current state to a more favorable end state. Sequential-state instruments should have the capability to capture important aspects or variables, such as vision and general constraints, from those responsible into models useful for defining and analysing necessary development plan. Stochastic-state instruments help through projection of 'state' situation that have some significant probability of occuring and in evaluating the alternative responses that the organisation might attempt to isolate. Finite-state technology provides ready, disciplined responses to different values that might be assumed by key variables with which the organisation is concerned. Normally the general focus of finite-state instruments is the development of a functional(probabilistic) relationship between a set of premises A and a response set B. Discrete-state represents instruments for generating directed (analytic) solutions to routine or repetitive problems. A number of general techniques have been suggested for each instrument category as in diagram 6.1(page 161). Matching normative decision aids with the complexity of the problem represents another important aspect that needs to be considered. This issue can be discussed using the framework in table 6.3(page 162).

Diagram 6.1: Normative mapping of system facilities (instrument subset) onto generic managerial requirements[Sutherland(1983)]

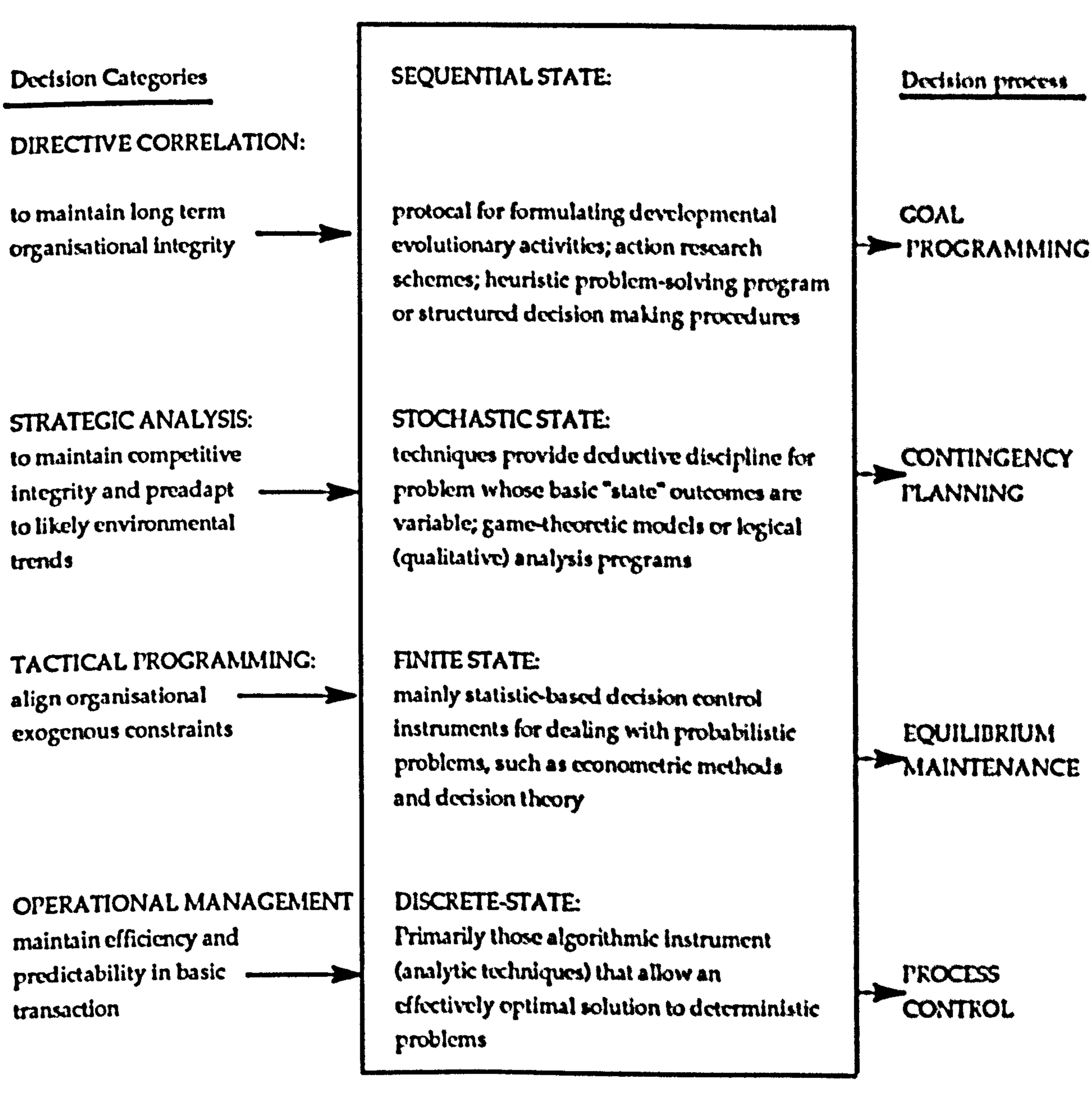


Table 6.3: Normative Analysis Congruent
(Normative Problem/Methodology Correlation)
[Sutherland (1983)]

INSTRUMENT CATEGORIES	GENERIC PROBLEM CATEGORIES			
	DETERMINISTIC	PROBABILISTIC	EQUIFINAL	INDETERMINISTIC
DISCRETE_STATE (OR and AI algorithmic etc)	positivist: use of decision premise derived from direct observation as input to optimisation process			
FINITE-STATE (statistical decision theory correlation, regression,etc		inductive use of empirical(historical) data for estimation (extrapolation/ projection) exercise: focus on objective probability		(domain of ineffectiveness analytical approach insufficient to resolve problem under consideration
STOCHASTIC-STATE (e.g adaptive and contingency programming)	(domain of inefficiency analytical approach overly sophisticated for the problem at hand)		Deductive: Shift to subjective probability consistent with decision premises derived from a priori sources(general theory, axiomatic or logical constructs) such used for purpose of preadaptation	
SEQUENTIAL-STATE (prescriptive or structured model building)				Heuristic: Initial decision premises are of methodological significance designed to discipline discovery process under some sort of action research protocol

One of the important aspects in the framework is the definition of complexity in terms of problem categories (each represent ideal-type problem context): deterministic, probabilistic, equifinal and indeterministic. Determinancy represents complete understanding of the phenomenon and the fully-elaborated tactic or response to be executed. Administration of annual grants to States is a routine activity carried out by the FSR. The decision on the amount of grant to be given to the states depends on a set of criteria embedded in a set of established models. This is an example of a deterministic problem. Probabilistic problems occur where variables are capable of assuming any value(with probability measure) over some range of alternatives. For example in order to administer the capitation grant, FSR needs to have the figure for the population of each State in a particular year. The figures are based on a projection from the last census and as far as FSR is concerned this contributes to the problem of administering the capitation grant. It was found during the empirical study that problems of this nature were common in grants based on models which used variables whose values were obtained through projection.

The concept of equifinality emerged from General System Theory. In the open system the same final state may be reached from different initial conditions and in different ways or processes capable of evoking two or more system states in response to any starting state(input or stimuli). This is the principal of equifinality [Bertalanffy(1968)]. The principle is also important in the context of decision making

in a complex environment,i.e the decision making process in the open system. In this context equifinality implies there is more than one way to achieve a goal/objective; more than one solution to a complex problem; more than one consequence follows from a particular action. For example if a State suggests that it has a cash flow problem then the Treasury Department, working within this problem definition, is asked to devise an appropriate action to alleviate the problem. The uncertainty, as far as the Treasury is concerned, is to determine the nature and the depth of the cash flow problem and on the response side the ambiguity concerns the acceptable action to be devised.

Indeterminacy represents the situation in which the available indicators(or knowledge) are insufficient to identify even the class of the problem to which the event belongs. This happens when the events or problems to be recognised are entirely unprecedented. On the response side indeterminacy occurs in the case where an entirely new order of response or solution is required. An example of the Indeterminancy problem can be cited from the FSR case study. In order to improve the economic and social performance of the State governments, the Treasury Department, through the National Finance Council, had been allocated a new sum of monies to complement the present annual allocations. The Treasury was asked to devise new rules for allocating this new sum subject to the stated objective. The novelty of this event, as far as the Treasury was concerned, was that beside the development of new rules, it needed to recognise new economic and social

problems faced by the States. The present economic and social indicators used for grant-giving are not comprehensive enough for this purpose. There were occasions where State Governments or the Treasury expressed dissatisfaction and suggested the need for changes to the present systems of grant- giving. In order for the changes to be justified the Treasury, using the present indicators, needs to map the present dissatisfaction into possible causes. The uncertainty revolves around the establishment of these causes,i.e whether they are due to increases in social expenditures or in economic activities or whether the States are simply acting inefficiently and ineffectively. There is also uncertainty as to what actions to take to improve the situation; whether to develop and introduce new models for grant-giving or change the existing models and what form the new or modified models will take.

These problem categories match with the classification of the problem situations described in section 6.2. For example Indeterministic category corresponds to U-type situation. Analytical bases (or epistemological alternatives), namely heuristic, deductive, inductive and positivist, in table 6.3(page 162) reflect the problem solving approach basically adopted, and they differ in terms of the sources of decision premises and the fundamental logic used. The Heuristic approach,for example, is deemed to be most congruent with the class of indeterminate problems and the Decision Aid technology most appropriate for this approach come from the Sequential-state category. The exact nature of support and what specific technical

instruments to be provided to a particular organisation and how to introduce and incorporate these techniques, would depend on the identified problem category. This involves a micro level diagnostic process and design. Sutherland suggests properties of decision aids which are useful for the micro level design as in table 6.4(page 169).

Another important implication which has emerged from table 6.3(page 162) has a direct bearing on the development of decision aids. Problem categories and epistemological alternatives reflect general assumptions that can be used in problem solving. For example problem solving in deterministic and probabilistic categories can be based on a positivist approach, namely where a scientific approach to problem solving and normal scientific criteria such as observability, measurability and experimentability are applicable. In other words the data to be collected can be specified and a scientific solution to the problem proposed. Problem solving in indeterminacy and equifinality categories requires long analytical mediation and highly indirect and intricate search pattern from problem recognition and structuring to problem solution. In these categories the decision making process should be understood as an open system. Problem solving in an open system involves non-numeric concepts and relationships which are mostly used to help in soft analysis of the problem, scenario building and evaluation of qualitative outcomes. Normal scientific criteria are not applicable to problem solving in an open system. This means that the data used is not complete and in arriving at

solutions to the problems references are normally made to the axioms, experience, judgment , norm value systems. Inapplicability of normal scientific criteria leads to the use of qualitative models and qualitative or common sense reasoning in decision making. Qualitative models and reasoning are useful for ill-structured and complex problems especially at the initial stage of problem recognition or understanding. Another rational explanation for the use of quallitative models is that most tasks in complex and illstructured decision making environment, such as formulating general policy; determining methods and process to influence individual and group behavior(Young 1983), can not be translated into mathematical models.

In addition to the formal methods suggested in table 6.4(page 169), there are a number of informal approaches and methods that have been developed to help in qualitative or commonsense reasoning. These approaches and methods emerged from common sense understanding of some of the characteristics of practical decision making process. Brainstorming and the Delphi method are examples that can be used [for detailed descriptions of these approaches and methods see Koberg(1976), Young(1983) and Bazerman (1986)] . De Bono's(1971) concept of lateral thinking also represents an attempt to provide an alternative method to help in creative problem solving. The role of informal techniques, for example Brainstorming, in the development of DSS is in the Conceptual Analysis and modelling stage in diagram 5.4(page 124) . For example Brainstorming helps in

the formulation of the Root definition. Problem solving in the Probabilistic, Equifinal and Indeterministic categories involves induction, deduction and heuristics respectively. These epistemological alternatives involve knowledge, namely knowledge which consists of empirical findings, general theory , axioms and experience. One of the important issues in providing decision aids to the decision making in these problem categories revolves around modelling this knowledge. In the following sections an attempt will be made to present a framework to help in this respect.

Table 6.4: Microlevel properties of categorical decision aids
(Sutherland (1983))

Dimension	Sequential State	Stochastic State	Finite State	Discrete State
PURPOSE (organisational impact)	secular(long term) integrity/directive correlation	competitive effectiveness	allocative efficiency	local/optima
DECISION-MAKER	goal formulation (end assessment)	feasibility criteria (mean assessment)	response requirements (budget constraints)	performance (throughput)
PREMISES: (staff/analyst)	environmental projection	strategic intelligence	coefficient estimate	point estimate (maximisation minimisation)
PROCESSING MODALITY	goal programming (concatenative)	realisation constructs	econometric models	analytic(black) models
(static):	multiobjective decision theory	axiomatic system theory	statistical decision theory	optimisation theory
(dynamic)	heuristic/dynamic goal programming	adaptive programming Markov theory (state transformation)	cybernetic control theory (perturbation)	automata theory (variances)
MODEL GENERA	expansion path (scenario)	hierarchical/network	input-output equation	deterministic algorithms
DISPLAY FORMAT	trajectory/vector models (contextual)	reachability matrices analytical hierarchy	curvilinear (asymptotic) convergence mapping	hyperplane (graphic approximation media/ postoptimality constructs)
MANAGERIAL REFERENT	long-term plan (longitudinal/ evolutionary prescription	threat recognition referents, preadaptive option(contigency)	decision rules (as codified in statistical decision control)	decision table rote transaction handling protocol (e g rule-based AD
INTERACTIVE (man/machine) computational	discursive: ordering of frame of references, universe of discourse; explication of a priority predicates	canonical: imposition of formal structure, exhaustiveness of event alternative	simulative: rapid analysis of 'If-Then' alternative factors	minimisation of average transaction time: number crunching automatic tree(via AD

6.5 Framework for Knowledge Modelling.

In order to solve problems individuals need knowledge about a domain and the ability to infer from this knowledge. Inference can be through the processes of induction, deduction or abduction. As described in chapter 4 knowledge can be thought of as a set of propositions, statements, facts, rules and conjectures. The building blocks of the knowledge are entities. Any object held by an individual as relevant to the domain of application can be described as an entity. Entities have attributes, which include size, property, class and status. In addition entities have relationships with other entities. The limitation of the individual as information processor implies a limitation of the range of entities and the descriptions of their attributes and relationships that can be conceptualised. In other words the conceptualised entities and their descriptions focus only on certain aspects of the domain. This lead to the Knowledge-Gap , which represents the difference between an individual's knowledge and what it should be in the light of the task-environment faced and the role and the responsibility held by the individual within the organisation. A Knowledge-Gap implies inadequacy of the present knowledge held by the individual and how it is used in solving decision problems. In theory knowledge is adequate if it capture all the essences, explicitly or implicitly, useful for discoursing about a particular domain of application. In the Artificial Intelligence community knowledge adequacy is known as " Conceptual richness" [Fox (1983)].

Conceptually rich knowledge forms the basis for intelligent problem solving by the individual. Determining the degree of conceptual richness of knowledge in a particular practical situation is not an easy task . If one knows what causes a phenomenon, what results from it, how to influence, control, initiate, or prevent it, how it relates to other states of affairs or how it resembles them, how to predict its onset and course, what its internal or underlying structure is, then to some extent one understands it. In other words in order to understand the phenomenon under consideration one should have a " working model" of it.

But in reality it is not fully understood how semantically rich should knowledge required for a particular domain of application be. The problem is normally reduced by the fact that the knowledge (working) is modelled within a "small world". In the context of a particular application, the conceptualised entities and their descriptions represent the components of the individual's model of the domain. In the model entities are translated into a set of defined concepts, the description of these entities into patterns. In theory what entities and their predications are to be considered depends on a number of factors. For example in order to be useful for problem solving the knowledge should be application or domain specific. Problem and domain will provide frameworks for determining the content of knowledge, namely what entities and their relationship to be considered. Knowledge should also have certain conceptual and theoretical characteristics independent of the application but useful for its modelling. These characteristics can be described in

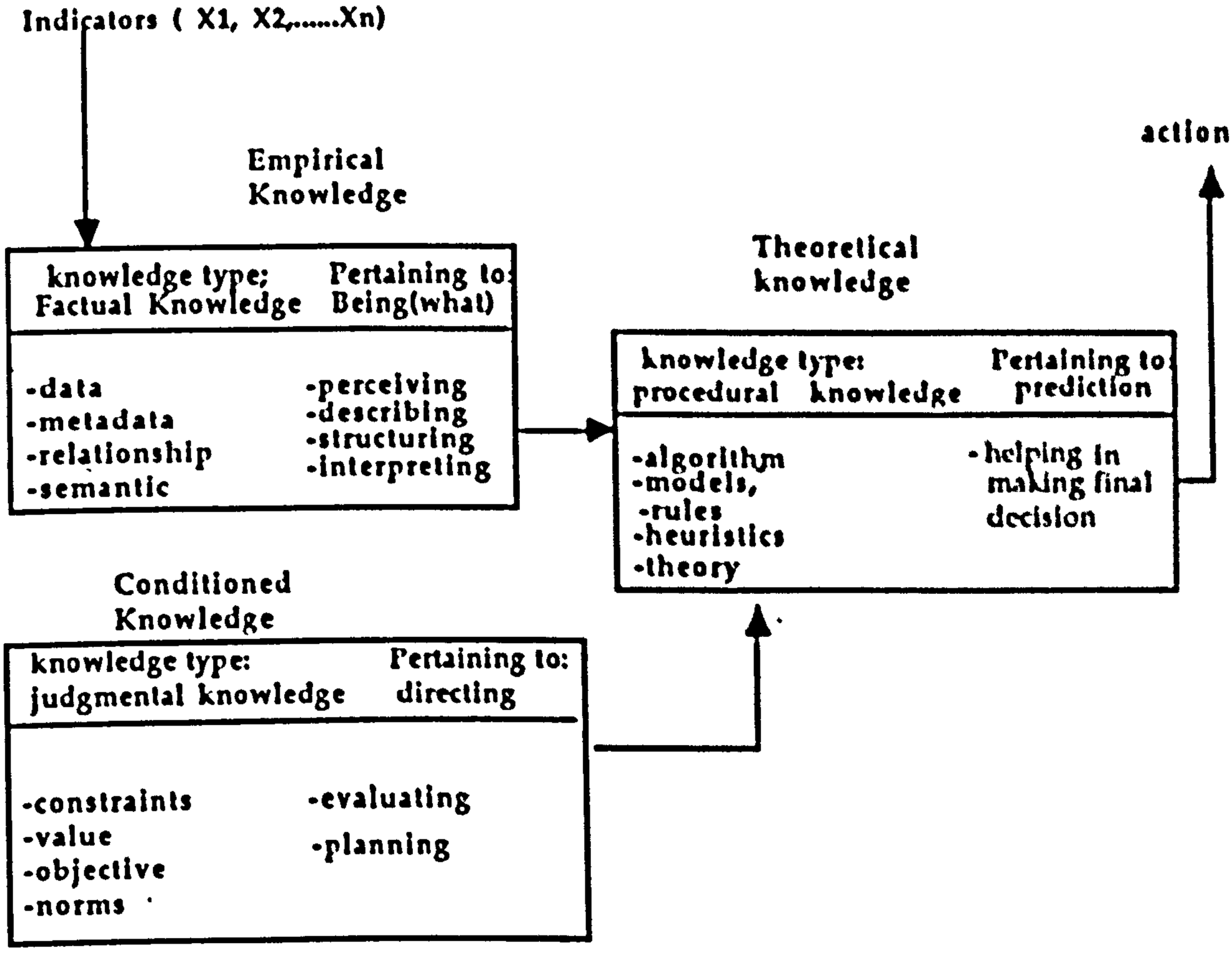
terms of the following: Functional Taxonomy, Predication Classification and Field of Observation.

6.5.1 Functional Taxonomy

Individuals need knowledge and the ability to process it for problem solving. The major influences on individual knowledge have been described in chapter 4 and these influences were divided into two categories: Organisational and Personal. In this context knowledge used by the individual can, theoretically, be described in terms of the following: Conditioned-Knowledge, Theoretical-Knowledge and Empirical-Knowledge. Empirical Knowledge, which is normally obtained through experience, is used to recognise the problems or opportunities and in particular to give meaning to the observed indicators, namely it pertains to perceiving, describing, structuring and interpreting the observed phenomenon. The meaningful events generated by Empirical-Knowledge merely direct attention. Theoretical-Knowledge, obtained through academic training or reading, on the other hand is used to arouse ideas about solutions or actions. Theoretical-Knowledge contains assumptions, hypotheses, laws, theories or models that are useful for generating or predicting solutions to the problems. The content of the Conditioned-Knowledge reflects individual interpretation of the declarative factors and their requirements, such as those implied by the Organisational knowledge

described in chapter 4. Conditioned-Knowledge act as constraints to be used for evaluating or planning the solutions or actions to the decision making problem. The function and type of this knowledge is represented in the following diagram 6.2.

Diagram 6.2: Functional Classification of Knowledge



Acquiring knowledge and modelling it into a knowledge base represents one of the major concerns of those involved in the development of knowledge base systems. Knowledge acquisition and modelling is difficult and especially so when

there is no proper framework for understanding the nature of knowledge used by the individual in problem solving. Diagram 6.2 provides a general framework for understanding the nature of knowledge, namely its type and role. A number of important implications follow from diagram 6.2 which are useful for the development of DSS or knowledge base systems. Conditioned-Knowledge reflects the constraints, norms and values system governing a particular organisation. Whilst Empirical and Theoretical knowledge are related to some extent to the Conditioned-Knowledge they are more individualistic because, as described in chapter 4, they result from the individual interpretation and rationalisation of what to do. In the development of knowledge base systems, especially Expert Systems(ES), this is assumed to be in the individual's head and the role of knowledge engineer is to acquire and model this knowledge. The technique of protocol analysis [Hayes(1989)] reflects this assumption. But in an ill structured environment one does not know what to model and what information to use[Humphreys(1986)] because problems do not normally come "neatly packaged"[Keen et al(1987)]. It is argued here that, in this context, any approach to DSS development should provide frameworks to help in general understanding knowledge, namely its form, what it should represent. The following sections will present these frameworks.

6.5.2 Predication Classification

Knowledge Modelling concerns identification of a set of entities(E) and a set of predications(P). Predication are the assertions that can be made; assertions about attributes, procedural properties effecting the behavior of the entities and the relationship between entities. Assertions about relationships between entities can be classified into three abstractions: Taxonomical, Relational and Functional. Taxonomical statements capture vertical(taxonomic/inheritance) relationships between entities, for example " is-a" relationship. Basically taxonomical relationship segregates elements into sets according to whether they do or do not have certain properties. In algebraic notation it takes the form of $P \ni x$, where P is defined by its properties. for example in FSR, P represents set of all viable projects (x). A Relational statement takes the form of x R y or R(x, y, z,...) in case of more than two variables involved, where R signify some form of relationship asserted between x and y or between x and y and z.... In the FSR statement such as " High- Unemployment causes Social-Problem" represents a Relational statement. A more restricted version of a Relational statement takes the form of a functional relationship, which asserts a correspondence, either one-to-one or many-to-many or one-to-many, between elements x in X and elements y in Y. In the context of FSR, X represents set of projects and Y represent categories of grant.

Moore(1980) suggested the following criteria to judge whether any system is

adequate for representing the knowledge of an intelligent being. The system should be able to:

* say that something has certain properties without saying what thing has that property. For example there exist a project(p) being financed by grant of category x. In term of first order logic formalism this can be represented as:

  [(∃ x)Financed-By (p , x)]. This is a functional statement,

* say that everything in a certain class has a certain property e.g all projects(x) that generate high-cash-flow are viable projects:

  [(∀ x) high-cash-flow(x) ⊃ viable(x)]. This is a taxonomical statement,

* say that at least one of the two statements is true without saying which is true e.g a project(p) take economic-grant or social-grant i.e

  Take(p, economic-grant) V Take(p, social-grant). This is a functional statement,

* explicitly say that something is false e.g

  ~ [(∃ x) economic-viable(x)]. This is a taxonomical statement.

The questions of knowledge richness and its nature comes down to the issue of determining the range of entities and "Predications" to be attached to these entities(range of predications is called here as semantic universe). This raises a number of questions:

* What sort of model fits the domain ?

* Which primitive entities are to be included in the model ?. How can one be sure that none of the important entities have been overlooked ?
* What attributes do these entities possess also what are the relationship between the entities ?.

Entities and assertions about them can be used as building blocks for the formation of knowledge for decision making. Human experience, assumptions, hypotheses, laws, theory and models may be expressed as definitional properties of entities(Taxonomical statements). Taxonomical statements are useful when an individual needs to describe what he sees or understands about the environment. Perception involve relating sensation to other familiar things, that is classifying the various elements in the situation to form a pattern that is meaningful in terms of past experience. For instance in FSR economic indicators from various State Governments are used to form a perception of the economic performance of the State Governments. This perception is used as the basis for classifying States into wellbeing categories, poor-state, or rich-state. Taxonomical statements are useful in the formation of Empirical knowledge in diagram 6.2(page 172).

Another important issue that needs to be considered is the degree of certainty that can be attached to the statements. A statement can be deterministic, partially deterministic, probabilistic or correlative non-causal. Most functional statements can be specified deterministically i.e

deterministic
Project ----------> Category of Grant.

A partially deterministic statement reflects that the truth of the statement is conditioned on the governing" frame of reference", i.e norm. For example in FSR cash flow is used as a basis of classification of a project's viability. But cash flow is not used all the time for the classification. There were occasions where good cash flow was not the determinant of the project's viability. A probabilistic statement take the form of " given statement(x) then statement(y) with P, where P stand for probability measure. If statement(z) is causally related to statement(y) and also causally related to statement(x) then x and y are correlative non-casual. Partially deterministic, correlative non-causual and probabilistic statements characterise knowledge in complex and illstructured decision problems.

6.5.3 Fields Of Observation

The entities to be considered by the human information processor result from a process of active observation of those aspects of environment which the information processor has chosen to be his operating environment. Operating environment can be classified into three categories: External Operating Environment, Internal Operating environment and Inner-self. The External

operating environment represents a field of observation from which the entities relevant to social, economic. political and legal environment are collected. Entities and their predications are used to generate state of the world X and relevant messages. The External operating environment comprises people or organisations that have different objectives(a major use of entities from the external operating environment is for reaction or anticipatory adaptation to a situation). In the FSR case study, the Federal Constitution, political and social and economic systems of the nation are important aspects of the external operating environment. The Internal operating environment comprises people and organisations that are responsible for the implementation of the decisions . In the case of FSR internal operating environment comprises the States and Agencies that are responsible for the implementation of economic and social development programmes.

What aspects of the environment are to be observed and what entities are to be collected define the representational task of the observer. The knowledge to be used in decision making should contain entities and their predications of those aspects of operating environment that are relevant to the Individual Task-Environment and his role. Entities and their predications can be used to represent these three important descriptions about the environment: State-Description, Activity-Description and Programmatic-Description. These descriptions represent instances of the semantic universe described in the above section 6.5.2. The State-Description represents the result of performance of the implementation agents and it can takes

the form of < Identifier, State Description, Attribute Description, Metric, Time >. For example in the FSR one of the results of the performance of State Governments and various Agencies involved in the development of social and economic programmes can be represented as in the following table 6.5:

Table 6.5: State Description

Identifier	State Description	Attribute Description	Measure	Time
State X	Economy	Gross domestic product	$ Y	19..

An activity-Description, represents the performance of the activity and takes the form of <Identifier, Activity-State, Initial-Time-State, Final-Time-State>. An example of Activity-Description in FSR is shown in table 6.6.

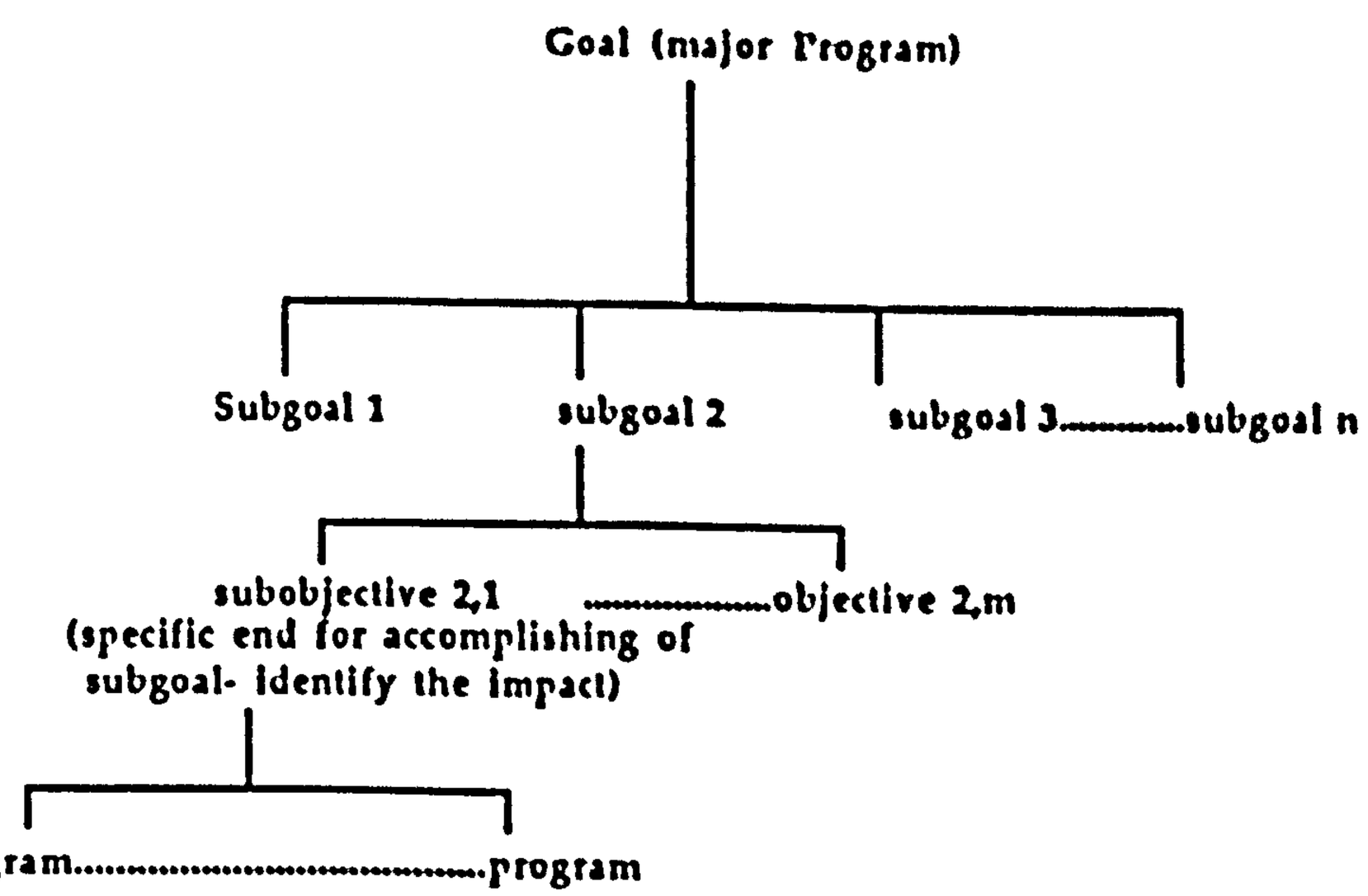
Table 6.6: Activity Description

Identifier	Activity	Initial time	Final Time
Project X in rural area Y	Build road	Road length in area Y	road length in area Y in 19..

The programmatic-Description represents the processes needed to achieve specific objectives. For example in the context of FSR, a programme to eradicate poverty. It involves a description of the programme objective, resources allocated to it and the rules and procedures used in carrying out the the programme. Programmatic-description matches with the use of the technique of Planning, Programming and Bugeting(PPB) which is used in economic and social development planning in Malaysia. An example of programmatic representation of program structure of PPB is shown in diagram 6.3.

The State, Activity and Programmatic descriptions are related: the achievement of the Program(project) objective is reflected in in the State-Description; an activity is a part of a programme to achieve the objective and its description is useful for knowing its effect on the objective. State, Activity and Programmatic descriptions are useful for integrative regulation and knowing the availability of resources and capabilities of those involved in the implementation.

Diagram 6.3: Program Structure in PPB



In order to solve problems intelligently and make effective decisions, a decision maker, as a Human Information Processor, should have the ability to learn. Learning involves not only representation of the current norms and rules, vis the representation of what existed in the Conditioned-Knowledge and current procedures, models , information strategies existing in Theoretical-Knowledge and Empirical-Knowledge [diagram 6.2(page 173)], but also the performance of this knowledge. As described in chapter 2 page 23 FSR needs to propose changes to some aspects of rules or models that govern its decision making in order to improve its

performance. This activity implies that FSR need to represent the models and rules it uses and observe their performance over time. The importance of learning in this context has also been described by Argyris under the heading of "Single-Loop" and "Double-Looped" learning[Argyris et al(1978)]. Single-Loop concerns learning to change the strategy of how to achieve the objective, namely learn to change the content of the Theoretical-Knowledge and Empirical-Knowledge. Double-Loop concerns learning to change the norms and objective itself. In the FSR both Single-Loop and Double-Looped learning are necessary as those concerned are required to change the norms and rules of Aid-Giving as the situation demands.

6.5.4 Knowledge Representation Techniques

The need to incorporate knowledge into the decision support systems requires that the knowledge be formally represented. The development of formalisms to represent knowledge is a subject that has attracted a lot of attention in the literature, for example see Brachman et al(1985). The common aim of formalisms is to provide a framework and techniques for structuring and reasoning with knowledge. Knowledge representation revolve around two dichotomies: declarative (representation of facts and assertions) and procedural (representation of action and consequences). Declarative and procedural representations have their own advantages and disadvantages. These have been widely described in the literature [Brachman et al (1985)]. But the use of these representations depends on the

application. The difference between declarative and procedural schemes can be illustrated by the following example: within FSR a project is considered to be feasible if it satisfies a number of criteria, such as good cashflow, creates employment etc. This assertion of project feasibility is declarative. On the other hand the written sequence of actions, as reflected in the management manual, indicating how to compute the cashflow for the project is procedural.

Many formalisms have been proposed for declarative representation including logic-based and relational models. A Logic-based formalism makes use of propositional logic and more popularly predicate logic. Relational models are represented in the form of tree, graphs,or semantic networks. Procedural formalism is usually implemented via rule-based (production) systems, which take the form of IF (condition) THEN (action). The limitation of first-order logic with respect to complex predicate formation has been described by Israel(1984). An extreme view was taken by Reiter who sees that a knowledge base consisting only of logical formulation and nonlogical formulation are just implementation alternatives[Reiter (1986)]. For example predicate logic formalism can be used to represent semantic networks[Kowalski(1979)].

The formalism used to represent a knowledge base will determine the nature of the "reasoning calculus" that can be used to reason with it. For example the reasoning calculus developed for formalism based on predicate logic is well

described in the literature, for example see Nilsson(1982), Robinson(1983) and Charniak et al(1985). Reasoning calculus based on predicate logic is of deductive nature, where a theorem is derived or proof from a set of axioms. Deductive inference is important for the deductive analytical base in table 6.3(page 162) . Logic-based representations , especially those based on first-order logic, are supported by many formalisms which make them attractive for knowledge representation and problem solving [for a more detailed account of the use of first-order logic in rule-based deduction see Nilsson(1982) and Kowalski(1979)]. First order logic formalism can be used for developing a query language for the data base[Kowalski(1979), Zaniolo(1986)]. Procedural representation is compact and easy to understand but has less flexibility in terms of adding and deleting knowledge whilst modification of knowledge expressed in declarative scheme is usually quite easy. In general the major advantages of a logical formalism are as follows:

- a clear syntax of what constitutes a well formed expression,
- a number of inference theories has been developed based on logical formalism,
- notion of correctness (nothing false can be derived or proved) and completeness (every truth is provable) are well stated in the logical formalism.

But it should be borne in mind that the above formalisms are concerned only with possible structure but not with content of the knowledge. In practical situations the major problem revolve around the identification of primitives,

namely entities , and their relationships, that serve as the basic building blocks for knowledge modelling.

6.6 Conclusion

Decision making in a complex domain requires creativity, judgment and intuition. Creative and intuitive problem solving matches well with open and complex problems which are characteristic of high level decision making. The broad charter of DSS should be to provide Decision Aids to assist decision makers make effective decisions in ill- structured or complex tasks by enhancing his creativity and intelligence. But a number of important aspects need to be understood in providing Decision Aids, such as the nature of problem and its complexity and the nature of support to be provided by the Decision Aids.

A number of possible factors that might give rise to complexity have been presented. Complexity contributes much to the uncertainty and equivocality in the decision making process. In a state of uncertainty or equivocality a decision maker resorts to heuristics. Complexity also might lead to poor understanding of the problem and its solution procedure by the decision maker. From a system theoretic paradigm system resources , such as knowledge, tools and techniques, are vital for achieving system's objective. Similarly it is equally vital in the development of DSS

to have proper understanding of the nature of support to be provided to enhance the present system resources and the role of knowledge, how it can be modelled , and the role of formal tools and techniques in this respect. This chapter has presented conceptual and theoretical frameworks to help in such understanding. The use of these frameworks as well as the approach in chapter 5 to help in the development of DSS for FSR will be described in the following chapter 7.

CHAPTER 7

IMPROVING DECISION MAKING IN FSR: DSS APPROACH

7.1 Introduction

Chapter 2 outlined the general aspects of the decision making process in FSR. These aspects suggest characteristics that have a direct bearing on the development of decision aids to improve the effectiveness of its decision making process. But the incorporation of these characteristics into the development of the decision aids gives rise to a number of questions. The DSS concept and paradigm provide useful conceptual and theoretical frameworks for understanding and improving the effectiveness of the decision making process. Whilst a number of DSS have been applied in real life situations the concept is still immature in terms of methodological development. In chapter 5 steps to DSS development were suggested[diagram 5.3(page (122) and diagram 5.4(page 123)]. The usefulness of popular approachs to system analysis to help in carry out activities implied by the suggested steps was presented in table 5.2 (page 142). In this chapter the application of soft system approach in the context of FSR will be presented. Accordingly this application helps toward illustrating the usefulness and generality soft system approach. The major concern of this

chapter will be with requirements analysis and the translation of these requirements into a DSS architecture. More detail description of how soft system approach can be used in conjunction with science based approach in the analysis and design of DSS ia presented in appendix 3.

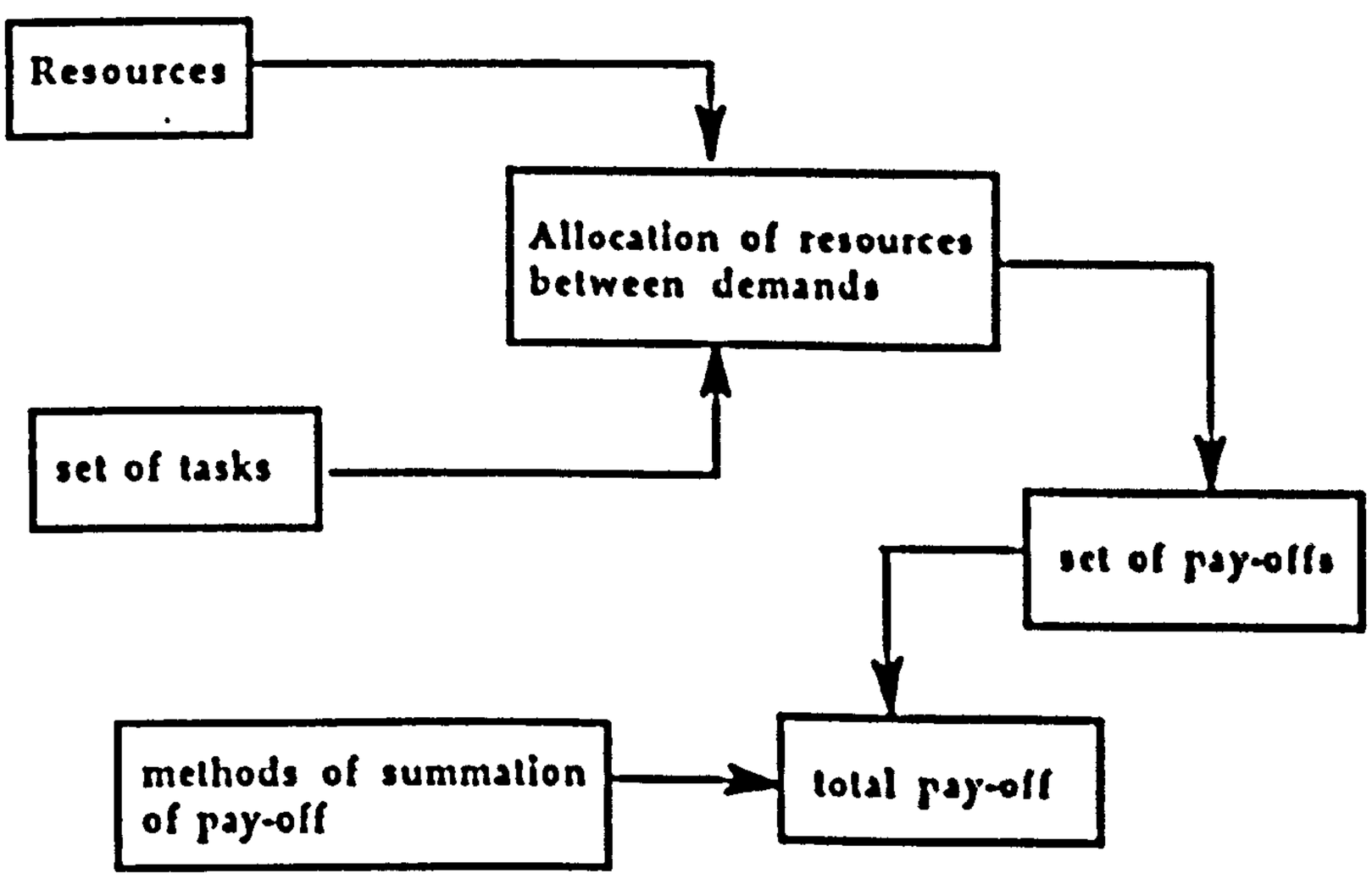
7.2 Requirements Analysis

The unstructured nature of the decision making process in FSR makes requirements analysis difficult. In FSR the problems can not be explicitly stated or at best elude precise definition. The existence of the problems is usually manifested in a feeling of unease or dissatisfaction. One of the characteristics of unstructured problems is that they generate subproblems. In the course of generating a solution, the problem needs to be interpreted and its subproblems identified. The number of subproblems generated may be large; the potential of these candidate subproblems to contribute to the solution of the problem can not be determined with certainty; the subproblems generated may be themselves unstructured. Structured problems can be explicitly expressed in a language which implies that a theory concerning their solution is available[Checkland (1981)]. Finding solutions to the type-e decision described in chapter 2 is an example of an unstructured problem in FSR. How much grant to be given to the State through various decision-aid instruments represents a more structured problem, namely of decision types a-d.

It is important in the requirements analysis to translate FSR decision

making process into a conceptual model that is useful for formal discourse about the limitation of the process and potential solution procedures to help toward its effectiveness. This implies the need to understand the process not only from an empirical viewpoint but also from conceptual and theoretical viewpoint. In theory the basic problem underlying FSR is " Resources Allocation ". An illustration of a resources allocation problem is given in the following diagram 7.1[Rivett (1980)]. But the FSR situation is more complicated than that can be accounted by such a simple description of the problem.

Diagram 7.1: Structure of Allocation Problem[Rivett(1980)]



7.2.1 Soft System Approach in Action

Checkland's methodology was found to be useful at the initial stage of the requirements analysis . In the context of FSR the CATWOE is presented below:

C: < State Governments >,

A: < NFC, Senior Officials in FSR, Participative Agencies >,

T: Needs of The States ——— Transform ——> Effective Rules and Procedures for Resources allocation

W: " Providing aids to the states in general and poor states in particular is a sensible steps toward helping to reduce the imbalance economic and social well being of the thirteen states in the Federation and to alleviate some of the resultant social problem in multi-racial society"

O: < Finance Minister, Parliament, Treasury Director, NFC >,

E: < Federal Constitution, Participative Agencies, Federal Financial Position, Political and social Systems >.

This definition of CATWOE represent the results of the finding-out process in Checkland's methodology, ie steps 1 and 2 of diagram 5.7(page 132). The root definition attempts to capture the view of the situation, as reflected in CATWOE, into a verbal expression of purposeful activities systems. A root definition applicable to FSR is given below:

Root Definition: A system for interpreting the financial needs of the States in order to devise effective Strategies/Actions for effective allocation of aid to the States to help toward eradicating the imbalance in their economic and social well-beings subject to the constraints(social, political, legal, financial) imposed"

There was no difficulty in identifying the Owners and Actors and determining what is the environment, but identifying what are the weltanschuung and root definition in FSR was difficult. According to one senior official, problem solving and decision making in FSR represents the most difficult task in the Treasury Department, hence to capture the "essence" of the situation into a good root definition requires a difficult process of inquiry and exploration. The first level HAS is shown in the following diagram 7.2 . Diagram7.3 (page 193) shows the second level HAS model of a particular component viz "appreciate the Needs of the States".

Diagram 7.2: IIAS for FSR

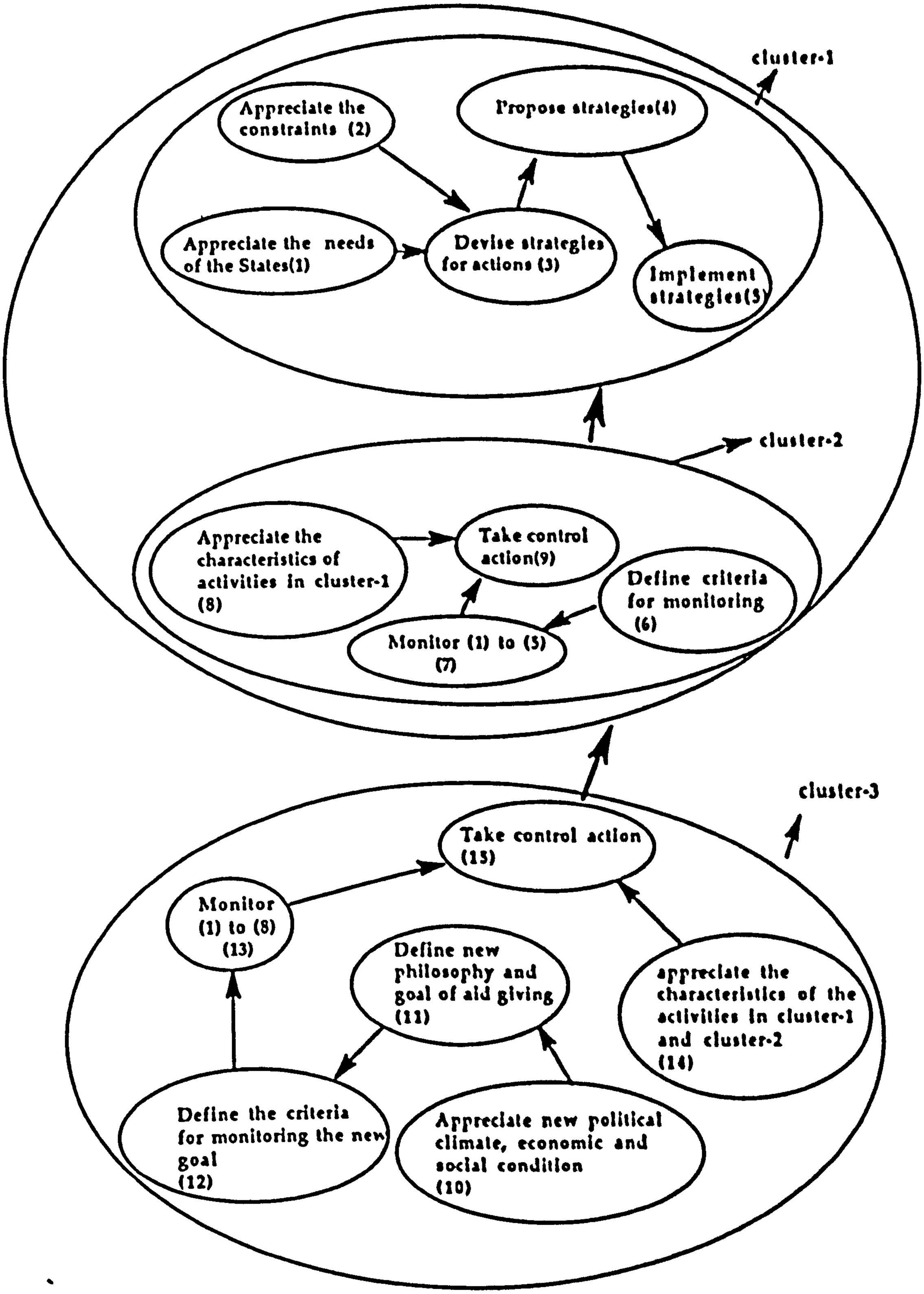
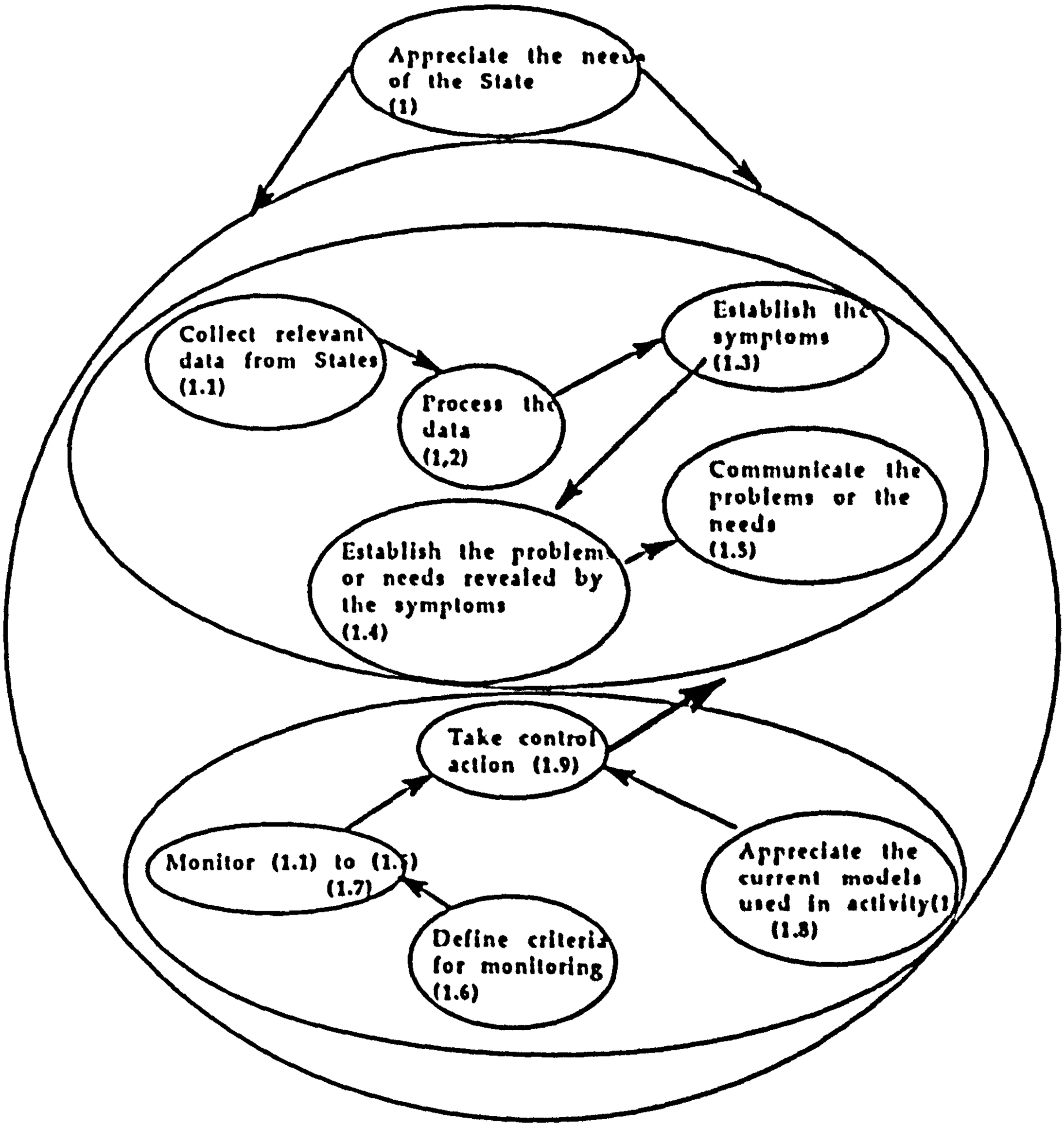


Diagram 7.3: HAS for Activity (1)



HAS model in diagram 7.2(page 192) serves as a useful basis for diagnosing the limitation of the present decision making in FSR and in recommending

feasible and desirable changes to improve effectiveness of the present decision making. In theory the decision making in FSR will be effective if all the activities and their subactivities described in diagram 7.2(page 192) exist and are carried out properly. Diagnosing the limitation of the present decision making in FSR implies the need for comparison with the HAS. Wilson(1984) has suggested four methods of comparison: (a)general discussion; (b)question definition; (c)historical reconstruction; (d)model overlay. In method(b) a coherent model is developed and used as the basis for generating questions about the existence or otherwise of the activities embedded in the model. This was used in FSR. The first step toward comparing the model with reality is to identify whether the major activities in diagram 7.2 exist in FSR or not. The tabular form suggested by Wilson(1984) can be used for recording the results of the comparison.

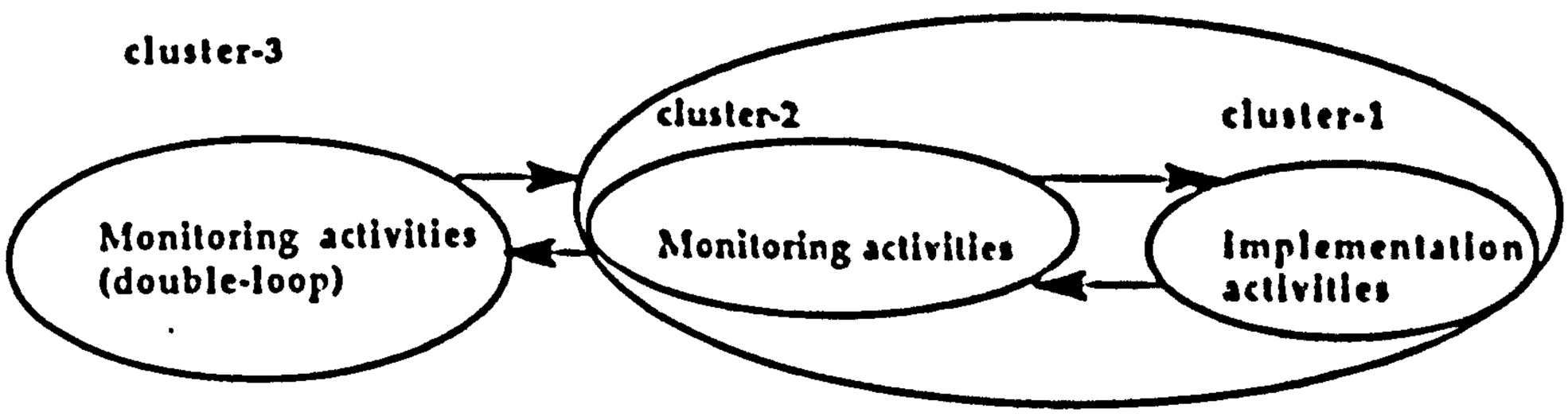
In general terms introducing some of the important activities in diagram 7.2 and providing necessary decision aids for them represents one of the important steps toward improving effectiveness of the decision making process in FSR. Some of the activities in diagram 7.2(page 192) can be formally associated with the present activities in FSR. Others have not been identified but were agreed by those involved to be important for the decision making process in FSR. For example activities in cluster-1 of diagram 7.2 matched with the current activities carried out in the decision making of type -c. The results of the activities in cluster-1 are reflected in the present models or rules used in aid giving. But those important activities in cluster-2 and cluster-3 did not exist

in FSR. The activities in cluster-2 and cluster-3 are very important for learning. Learning and effective actions are two concepts that go hand-in-hand. Effective action necessitates successive comparison between actions and feedback from the environment, which provides information for the next decision. Cluster-2 HAS exists in the situation in which there is the need for the organisation to have capability for "single-loop" and cluster-3 HAS for "double-loop learning [Argyris (1978)]. Single-loop learning reflects the intention of the organisation to remain stable with the range of objectives or goals set by the organisational norm and value systems, it involves modifying the present strategies and assumptions embedded in the current ways of doing thing. Double-loop learning is important when there is an occasion when a decision need be made not only to modify the present models or rules but also the norms and values systems that dictate the whole philosophy of decision making. Norm and value systems modification occurs as a result of the need to resolve conflicting requirements, changing economic and political conditions and changes in the perception of the measure of performance .

The relationship between activities in cluster-1 and cluster-2, namely the monitoring activities, is that the monitoring activities provide control actions that result, within the bound implied by the present norm and value systems, in changes in some aspects of activities in cluster-1 (single-loop learning). In order to do this, the monitoring activities need to know the requirements from the present norm and value systems as well as the result from the present implementation activities. The activities in cluster-2 are concerned with closed-

looped monitoring and control system for activities in cluster-1. Cluster-3 activities on the other provide control actions that will result in changes in some aspect of activities in cluster-1 and cluster-2. In order to do this cluster-3 activities need to know how the present activities in cluster-1 and cluster-2 are being carried out as well as the requirements from the environment. Activities in cluster-3 are typical of open-looped monitoring and control system and are important for the long term goal of FSR . These three clusters of human activities can be thought of as constituting three dependent systems which are coupled by communicative information as in diagram 7.4.

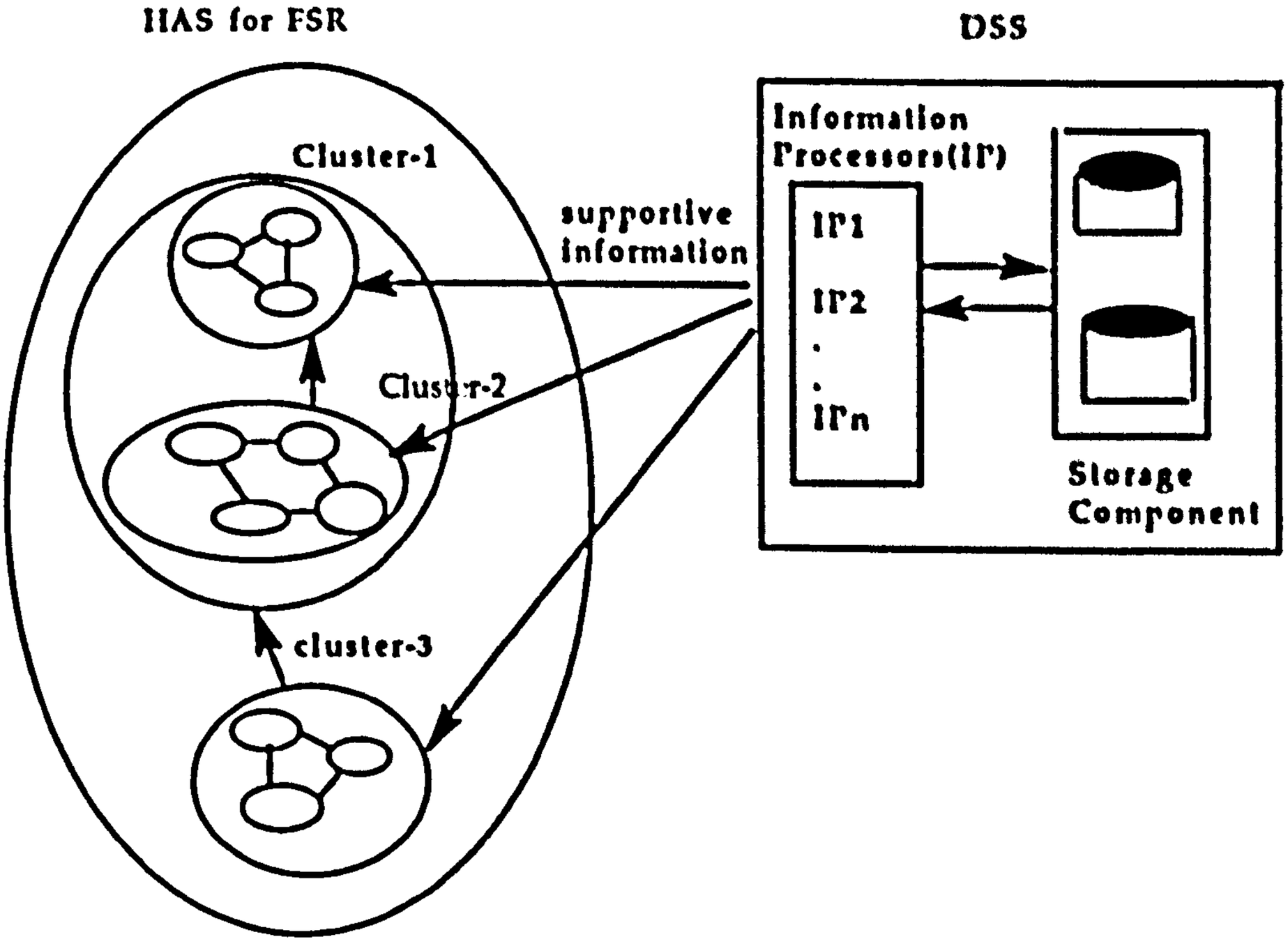
Duagram 7.4: HAS in terms of three dependent systems



The role of DSS as decision aids is shown in diagram 7.5(page 198). The nature of activities in cluster-2 and cluster-3 in diagram 7.4 suggests that two forms of DSS need to be developed. DSS to support activities in cluster-2 belong

to the class of Cybernetic Information Systems(CIS)[Mason (1981)]. CIS help in observing the effect of actions in the light of the targets set. This is done by measuring the effects and produce feedback which will show the degree of deviation from the target. This will help those involved in decision making to produce actions to correct the deviation. Class of DSS to support activities in cluster-3 belong to Systemic Information Systems(SIS)[Churchman(1981), Mason(1981)]. The aim of SIS is to help those concerned keep controversy alive, to use actions as experimens, to create problems whose study will increase understanding. The information and models in the systems have a tentative existence. The concept of SIS is important for the development of DSS in complex problem such as FSR as there are many ways of using the information and models to describe reality. SIS can be used to provide supportive information to help users reevaluate their assumptions or view-of-the-world(norm and values system) which underly their decision making.

Diagram 7.5: Role of DSS in FSR



The development of DSS based on HAS paradigm leads to a number of issues that need to be resolved. HAS defines what must happen in a system, via a particular Root Definition, in terms of a set of "Whats". In reality the information, models and procedures used in decision making or to be used in the development of DSS are described in terms of "Hows". The use of "What" as the primitive variable in HAS is an inherent limitation of Checkland's methodology. The distinction between "what" and "how" can be confusing [Wilson(1984)]. But the appealing feature of HAS is its generality. For example

consider the interpretation of "The Need of The States", in diagram 7.3(page 193). This can be translated in terms of a number of "Hows", i.e Information, models and procedures to be used. The appropriateness of these "Hows" needs to be debated and providing a framework for this debate represents one of the important contributions of activities in diagram 7.3.

Lower level analysis of the activities in diagram 7.2 (page 192) such as in diagram 7.3(page 193) and detailed understanding of these activities, namely how they are being carried out, what information and models used and what sort of improvement need to be introduced to improve these information and model represents one of the important steps in determining the nature of DSS in diagram 7.5. Much of the inputs to DSS design and implementation will be provided by this understanding. This reflects the activities that need to be carried out in the Decision Analysis stage in diagram 5.4(page 124) . Two conceptual frameworks were found to be useful for understanding "Hows" aspects of HAS in diagram 7.2 in general and in the development of CIS and SIS in particular: Beer's model of a viable system[Beer(1981), Espajo(1986)] and Management Control [Eilon (1971)]. The use of these frameworks follows from the requirement implied by Soft System Approach in diagram 5.7(page 132).

7.2.2 FSR in Terms of a Viable System

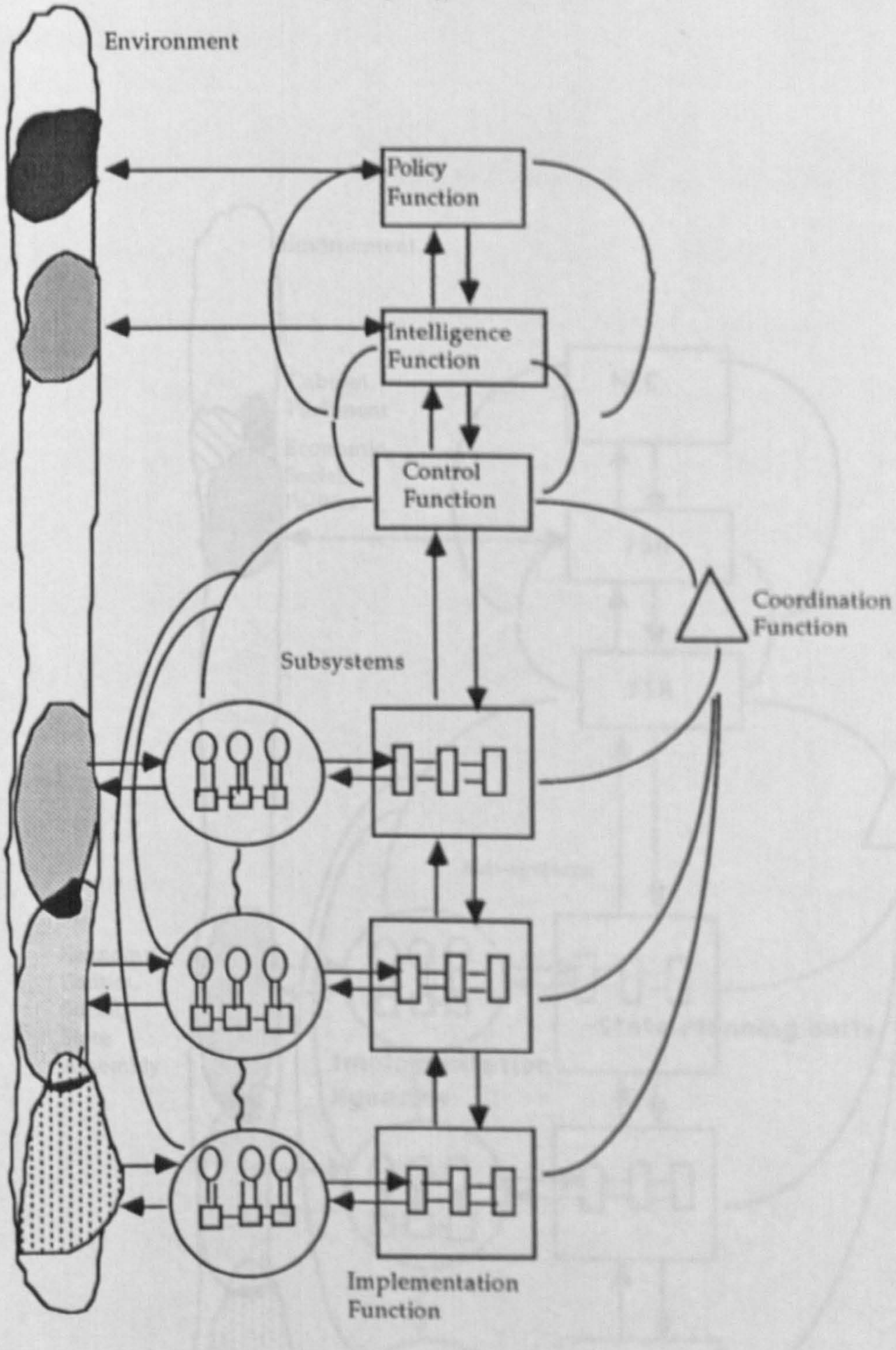
Diagram 2.3 (page 21) showed the functional role of the Treasury Department and FSR in the economic and social development in Malaysia. One of the important aspects useful for analysing the effectiveness of FSR is to view its

organisational role in the achieving the objective of the Malaysian Economic and Development Programmes in term of Beer's model of viable systems[Beer (1972), (1981), (1985), Espajo(1986)] . This states that an organisation is viable if it can survive in a particular sort of environment. A viable organisation should have the following functions: Policy, Intelligence, Control and Implementation functions [Beer(1981), Espajo(1986)]. This can be shown in diagram 7.6(page 202). The use of Beer's model to assist in organisational decision making is by matching the management role of that organisation with five basic functions embedded in the model. These basic functions need to perform different management tasks, need different information and models. For example the Policy function, the role that carries it out is responsible for choosing the possible response to the disturbance or request from the environment. The role responsible for the Intelligence function helps those responsible for the policy function by providing relevant information about the environment. Based on directives from those responsible for policy , those responsible for the Control function need to carry out resource allocation, monitoring and controlling the activities of those responsible for Implementation.

Beer has also introduced a framework for measuring the performance of the system . In this he introduced five interrelated concepts: potentiality, capability , actuality, latency and productivity[Beer(1972)]. What has been done by the system represent the actuality. But what could have been done if the present objectives and constraints are fully understood and resources are optimally organised defines system's capability. Comparing actuality with the

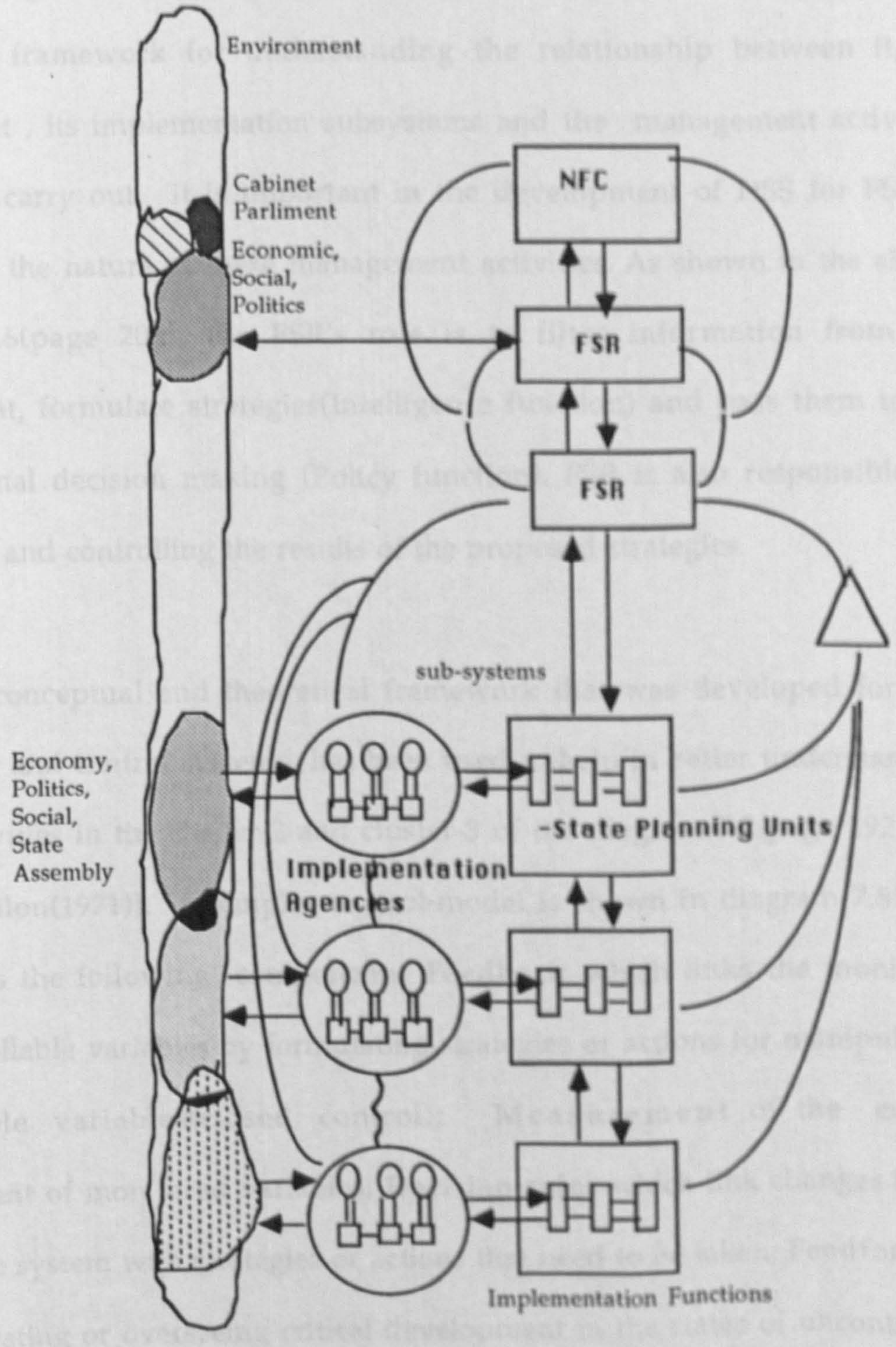
capability gives an index of productivity. If the present constraints are removed and resources are increased there will be in theory an improvement in the system's compared to the present capability. This represents its potentialily. Comparing potentiality with capabillity provides an index of latency, namely a measure of possible development considering the resources that are present but not yet active. In the context of FSR, productivity index shows how the State Agencies and Cooperations organise and use their system resources in carry out economic and social development programmes. Latency index helps in predicting possible effect of the increase in the amount of grant to the States. These indices assists FSR appreciating the constraints and devising strategies for actions, namely activity (2) and (3) in diagram 7.2(page 192). The FSR role in terms of a viable system can be shown in diagram 7.7(page 203).

Diagram 7.6: Beer's Model of Viable System
[Beer (1981)]



Each function is concerned with
different aspects of the environment
(as reflected by the different shades)

Diagram 7.7: FSR's role in terms of Beer's Model



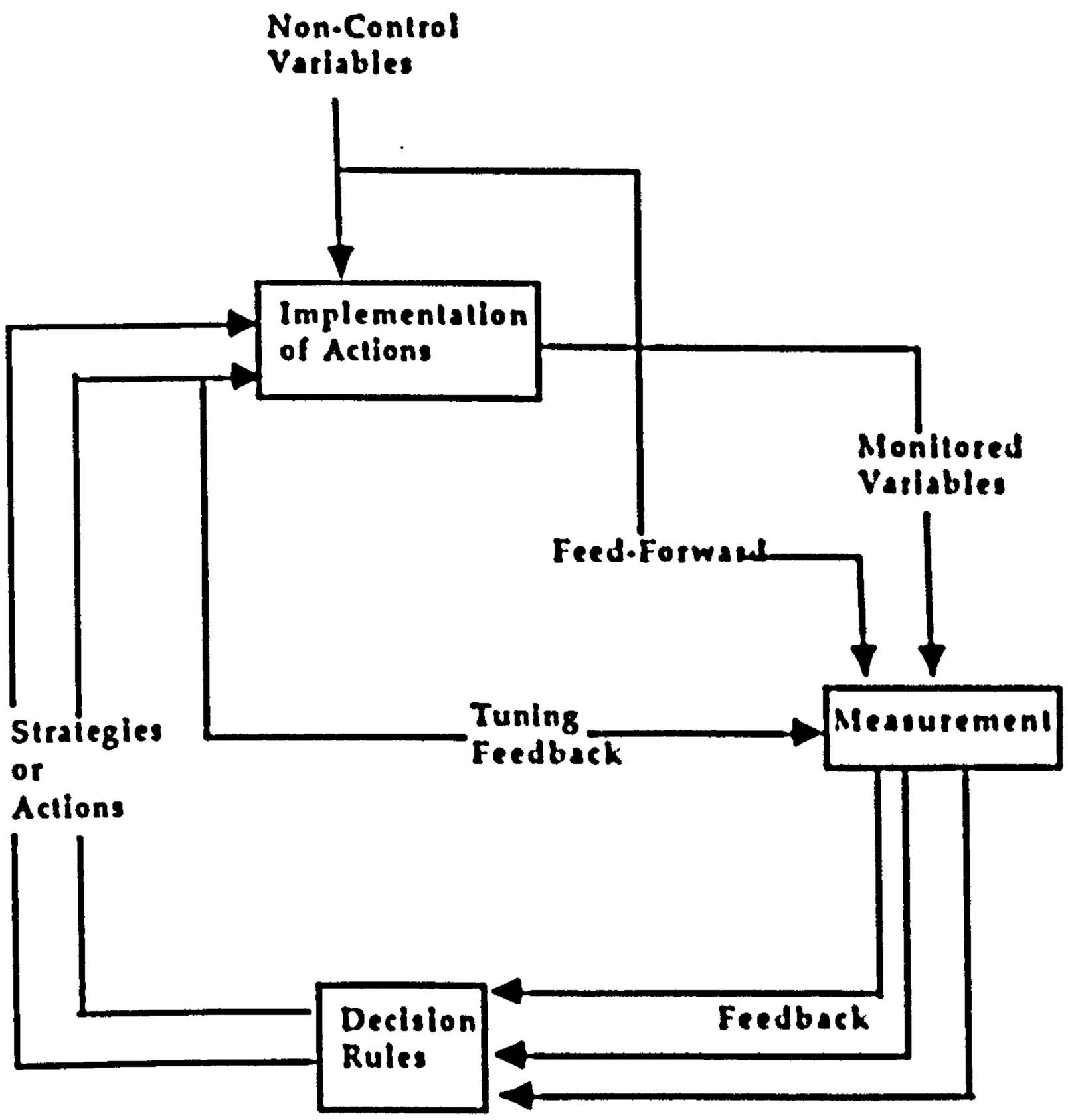
7.2.3 Management Activities in FSR

Viewing the role of FSR in terms of the functions it needs to perform provides a framework for understanding the relationship between it, its environment , its implementation subsystems and the management activities it needs to carry out. It is important in the development of DSS for FSR to understand the nature of these management activities. As shown in the above diagram 7.6(page 202), the FSR's role is to filter information from the environment, formulate strategies(Intelligence function) and pass them to the NFC for final decision making (Policy function). FSR is also responsible for monitoring and controlling the results of the proposed strategies.

The conceptual and theoretical framework that was developed for the monitoring and control systems has been used to help in better understanding of the activities in the cluster-2 and cluster-3 of the diagram 7.2(page 192) [for example Eilon(1971)]. A simple control-model is shown in diagram 7.8(page 205). It has the following components: Feedback which links the monitored and controllable variables by formulating strategies or actions for manipulating controllable variables(closed control); Measurement of the critical development of monitored variables; Decision-rules which link changes in the state of the system with strategies or actions that need to be taken; Feedforward for anticipating or overseeing critical development in the states of uncontrolled variables before they have an effect on the system(open control); Tuning

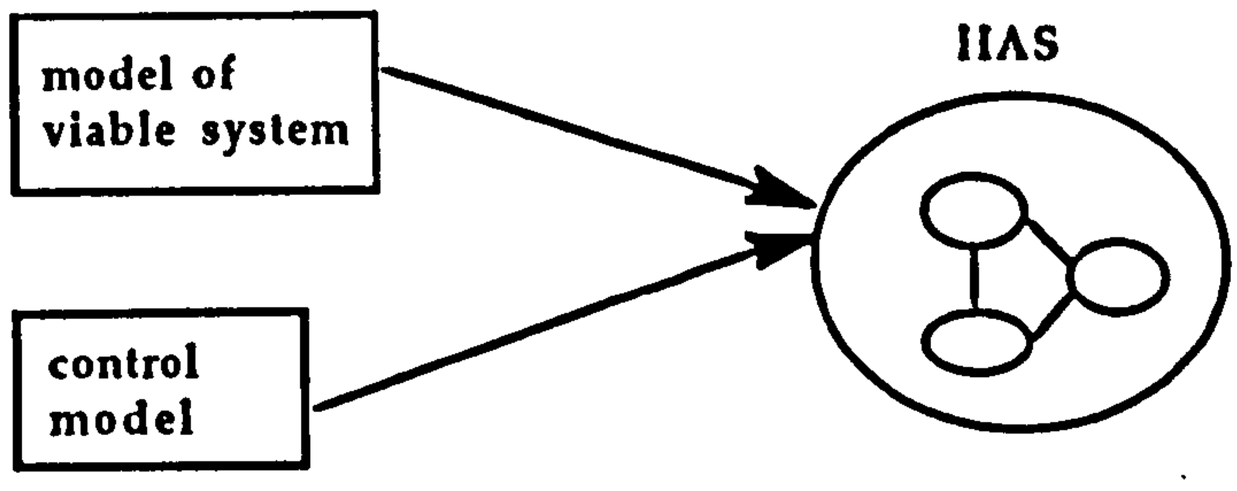
Feedback for smooth implementation of the chosen strategies or actions. For example in certain situations the chosen strategies need to be implemented incrementally and the effect on the controlled variable is observed in each increment. This approach is sometime essential to prevent oscillation of the system. In the context of FSR, Decision-rules need to be developed and feedback needs to be defined in term of indicators and variables (noncontrol, monitored and controlled) of interest.

Diagram 7.8: Model of Control Structure



The use of viable system model and control model in understanding "Hows" aspect of HAS can be represented in the following diagram 7.9:

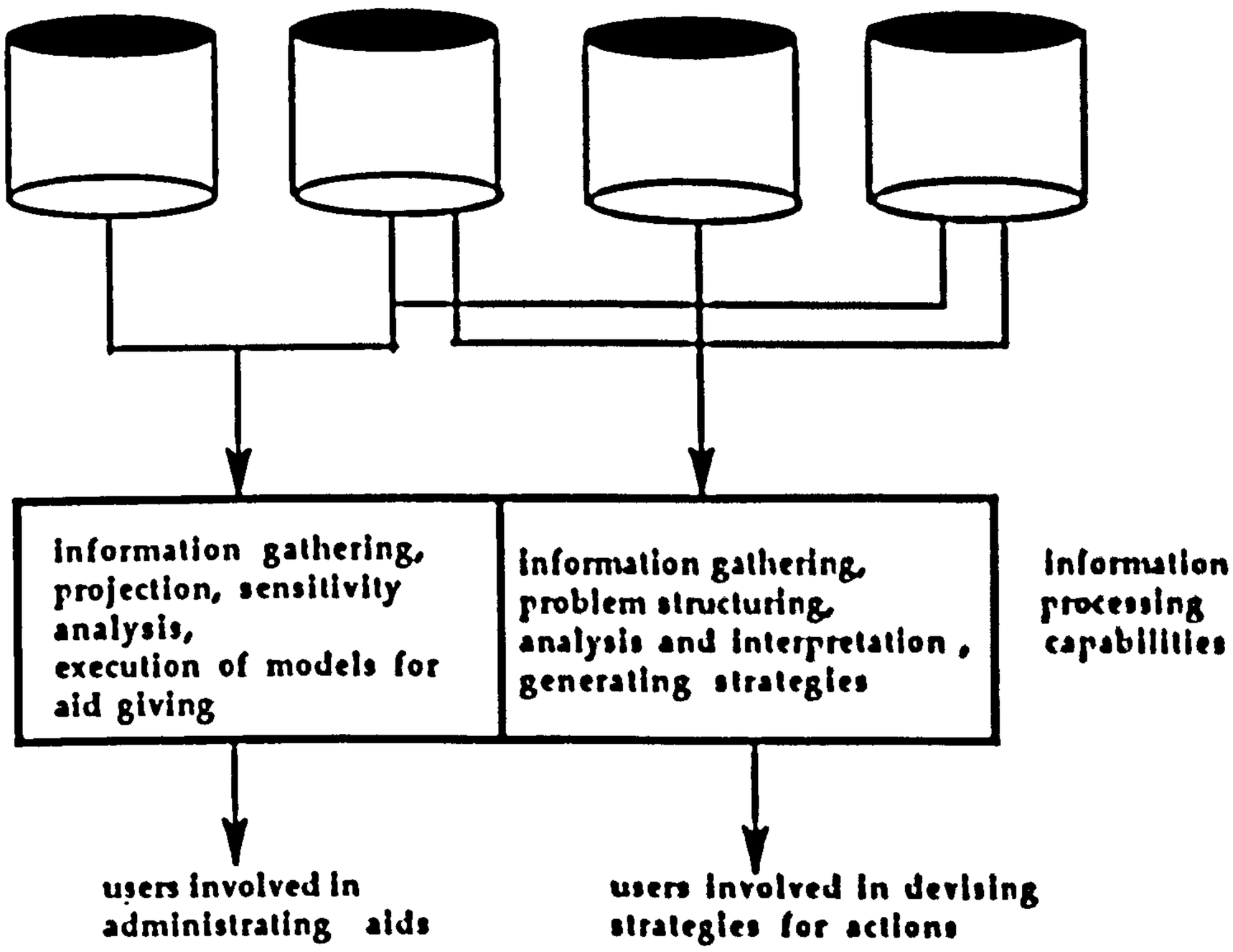
Diagram 7.9: The use of viable system and control model in understanding HAS



7.3: General Architecture of DSS for FSR

An architecture for DSS of diagram 7.5 is shown in the following diagram 7.10. The need to have this architecture follow from the logic of DSS life cycle in diagram 5.4(page124). The nature of storages and the function that need to be performed by Information Processors reflect the empirical(as described in chapter 2) as well as conceptual and theoretical (as described above) understanding of FSR's decision making.

Diagram 7.10: DSS architecture for FSR



7.3.1 Data Base

It is proposed that State Data Base should contain the following categories of information

* demographic information, such as population, income and race distribution,
* economic potential, such as availability of natural resources,

* infrastructure facility, such as roads and schools,
* economic activities,namely industry and agriculture,
* economic and social projects, namely present and future projects development,
* financial information, such as development accounts, operating accounts, loan accounts and revenue accounts.

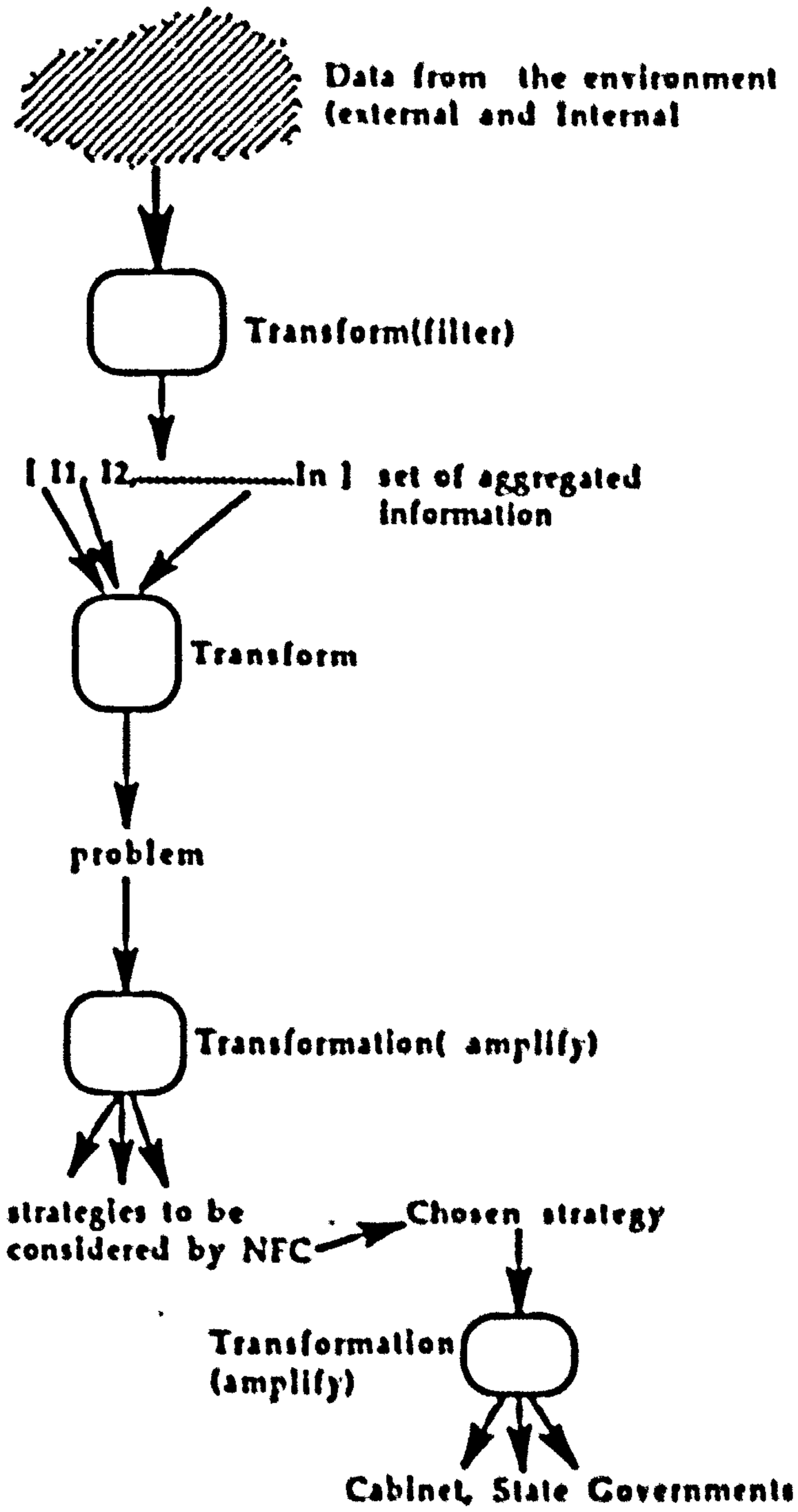
Some of these categories will enhance the present information in FSR[see table 2.3(page 33)].

7.3.2 Information Base

One useful concept introduced into the architecture is the Information Base. In general terms the emphasis of the Information Base is on storing information in multiple scenarios and in aggregated form . The nature of IIAS in diagram 7.2 (page 192) and FSR's role in diagram 7.4(page 196) suggest that the management in FSR need to monitor continuously the environment and the performance of its implementation subsystems. Monitoring implies transformation , where many possible states of the environment (external or internal) are filtered or reduced to a set of meaningful aggregated information This set of information will be used as the basis for problem recognition, namely "many to one" transformation of information into problem. Transformation of problems into strategies implies " one-to-many" and in the context of FSR the recognised problem is transformed into a number of strategies to be considered by NFC. FSR also need to amplify the chosen strategies in terms of their implications , such as what needs to be done to

implement the strategy, how it might achieve the objective and financial implications. This information is useful for the Cabinet and the State Governments which are responsible for the implementation of the strategies. These transformations can be shown in the following diagram 7.11:

Diagram 7.11: Filtering and Amplifying Information in FSR



Some data from the environment in diagram 7.11 are stored in the Data Base. The set of aggregated information constitutes the content of the Information Base. Aggregated information is important for understanding the environment and monitoring the performance of the implementation subsystems. The Information Base is useful for devising future strategies to improve the situation. The need to appreciate the present mechanism of problem solving is also implied by the diagram 7.2(page 192). Information about this mechanism(Inner-self representation as described in chapter 6) is also stored in the Information Base. In particular the Information Base contains:

*general summarized views of the data base, namely what entities and their attributes being stored; general summarized views of the model used in aid giving which are currently being stored in the model base, such the variables used and their functional relationships.

*aggregated or extracted information which is oriented towards understanding the performance of past actions,

*aggregated information which is oriented towards understanding the constraints, such as objectives , budget an legislation,

* aggregated information which is useful for understanding or predicting problems faced by the States,

It also provides:

* value-added information through the addition of appropriate current external data, and is constantly evolving.

7.3.3 Model Base

As shown in diagram 7.10(page 207) the Model Base stores models used by FSR. Models are used by FSR for administering grants. They also are required, for example , to help in the transformations in diagram 7.11(page 209). There are two categories of models in the Model Base : those currently being used and also those that might be useful in FSR's decision making. How FSR carries out activity (5) in diagram 7.2(page 192) (implementing the strategies) is reflected in the way it administers the Statutory and Nonstatutory Aid-Giving Instruments, namely the information and models used. The existence of recommended guidelines and models make some of the decision making process in administering grants to the States well understood [see table 2.6(page 43). Many Statutory-Aid-Giving Instrument(SAI) in table 2.1(page 27) and Non-Statutory-Aid-Giving Instrument(NSAI) in table 2.2 (page 28) have well specified models. Whilst this may be so it was discovered from the empirical study there are a number of problems encountered in using these models. As shown in tables 2.1(page 27) and 2.2(page 28), SAI and NSAI need information for input to the models. Some of this information was outdated. For example to administer the grant using "advance from State revolving fund" instrument, FSR used financial statements from the States which were four years out of date. A number of factors contributed to this, most importantly FSR depended on other Central Agencies for information collection. As shown in table 2.4(page 34) FSR depends on the Statistics Department for the population estimates. During the empirical study it was discovered that FSR used a population estimate for

1980 to administer a grant in 1984. It was also found that much of the input information used was derived from standard annual reports prepared by these agencies. These reports contained more information than required by FSR and time was spent wasted in analysing and digesting these reports. Accuracy of the input information is a major problem that needs to be resolved. Some of the input information in table 2.1(page 27), such as number of population, the revenue from the export duty from the States , cash flow and economic and social indicators were estimates. All instruments in NSAI, except " advance from State revolving fund", used project proposals as the input information.

The need to carry out other activities in diagram 7.2(page 192) leads to conceptualisation of the general nature of useful models for FSR. These models help to realise the information processing capabilities in diagram 7.5(page198). Models need to be developed to help in estimating the input information used by various models embedded in Aid-Giving Instruments in table 2.1(page 27) and 2.2(page 28). For instance FSR needs to have access to population forecasting techniques. The inaccuracy of the information used to administer grants requires the availability of sensitivity analysis tools. For example, the amount of grant given to the State via the Capitation grant instrument is sensitive to the variation in the population estimate(the parameter used in the model). The more populated the State, the more grant it is entitled to. Most of the benefit from this instrument goes to rich States because they have greater populations than poorer States. Further more, the margin of error in the population estimates for the rich States is lower due to superior infrastructure.

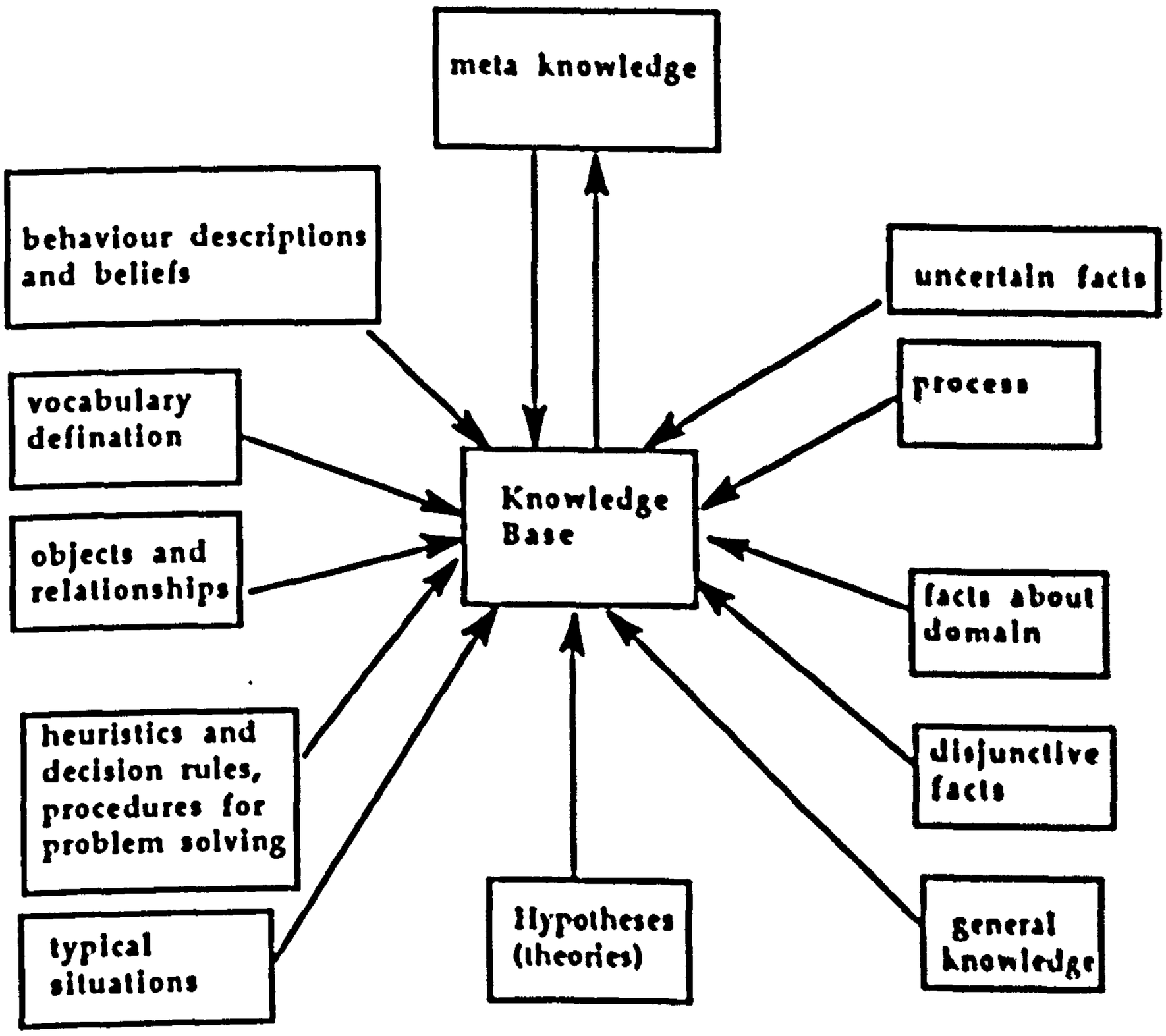
This makes population data easier to collect. In this respect the sensitivity analysis conducted on the model used in the capitation grant would provide valuable information to those involved in FSR.

As implied by diagram 7.7(page 203), models are also required to help FSR understand the requirements generated by its environment, both external and internal, and to provide solution procedures to satisfy these requirements. Such models should have the capability both to represent concepts and their relationships as well as to manipulate these concepts. A number of techniques can be used to construct such models, including structural modelling by Geoffrion[(1987), (1988)] and Warfield [(1973), (1974)], and other formal techniques such as cognitive mapping [Eden, Johns and Sim(1979)] and system dynamics[Forrester(1961), Wolstenholme et al (1982),(1983)]. Structural concept representation can be used in FSR , for example diagram 2.8(page 32) shows the schema used to determine factors that contribute to economic growth. Diagram 2.9 (page 34) represents the schema used for showing the weakness of GDP' . This schema is useful for arguing about the weakness of GDP' as one of the parameters to be used within the models of aid giving. Structural modelling is quite general and techniques such as cognitive mapping and system dynamics are specialised subsets of it. At present work is being carried out in the development of software to help in problem structuring and analysis based on structural modelling techniques [Yusoff (1991), Yusoff et al(1992)].

7.3.4 Knowledge Base

The description of knowledge in terms of its functions and types can be found in chapter 6[see diagram 6.2(page173)]. As shown in diagram 6.2 knowledge includes data and information. In terms of a specific domain , knowledge can be considered as a collection of specialised facts, procedures, and judgment rules[Turban (1990)]. Fikes and Kehler(1985) suggest the following types of knowledge be represented in the Knowledge Base:

Diagram 7.12: Types of knowledge in the Knowledge Base [Fikes et al (1985)]



Hypotheses (theories) and Behaviour Descriptions are useful knowledge types but experience in FSR indicates that they were not used in actual decision making. These knowledge types reflect personal viewpoints, namely they have only intentional meaning or express expoused theories of actions(as described in chapter 1). Whilst this may be so, it is argued here that these knowledge types are important to enhance the capability of DSS to provide more useful information.

Heuristics and Decision Rules and Typical Situations are two knowledge types used in FSR. For example before administering a grant under the NSAI instruments , the submitted project will be examined for its viability. Projects sumitted for NSAI grant will be examined for their Class-Viability. Only certain classes of project are considered for NSAI grant, for example:

* Projects without special allocation from the Federal Government,
* Road project,
* Bridge constructions,
* Water supply projects,
* Electricity supply projects,
* Agriculture projects,
* Building constructions,
* Local Authority projects,

FSR specifies a set of projects which are viable under each class. For example project-beneficial-to-farmers , irrigation-project, flood-prevention-project are

projects considered as viable under the class of agriculture project. Projects being considered for loans from the Federal Government will be examined for their Economic-Viability. Example of rules used in determining Economic-Viability are as follow:

For any project p,

Economic-viable(p) if use-local-resources(p),

Economic-viable(p) if create-good-cashflow(p),

Economic-viable(p) if create-good-employment(p)

Knowing the economic and social status of a State is important for appreciating its needs [activity (1) in diagram 7.2(page 192)]. For this purpose FSR has rules for classifying States. Example of these rules are given below:

For any State s,
Rich(s) If State(s) And
High-Economic-Development(s) And
High-Infrastracture-Development(s) And
High-Revenue(s)

Artificial-Poor(s) If State(s) And
Low-Economic-Development(s) And
Low-Infrastructure-Development(s)
And High-Revenue(s)
Poor(s) If State(s) And
Low-Economic-Development (s) And
Low-Infrastructure-Development(s) And
Low-Revenue(s)

Artificial-Rich(s) If State(s) And
High-Economic-Developmel(s) And
High-Infrastructure-Development(s)
And High-Revenue(s)

High-Economic-Development(s) If State(s) And
Total-Standardised-Score-Economic(s g)
And (g = `Low')

High-Infrastructure-Development(s) If State(s) And
Total-Standardised-Score-Infrastructure(s l)
And (l = `Low')

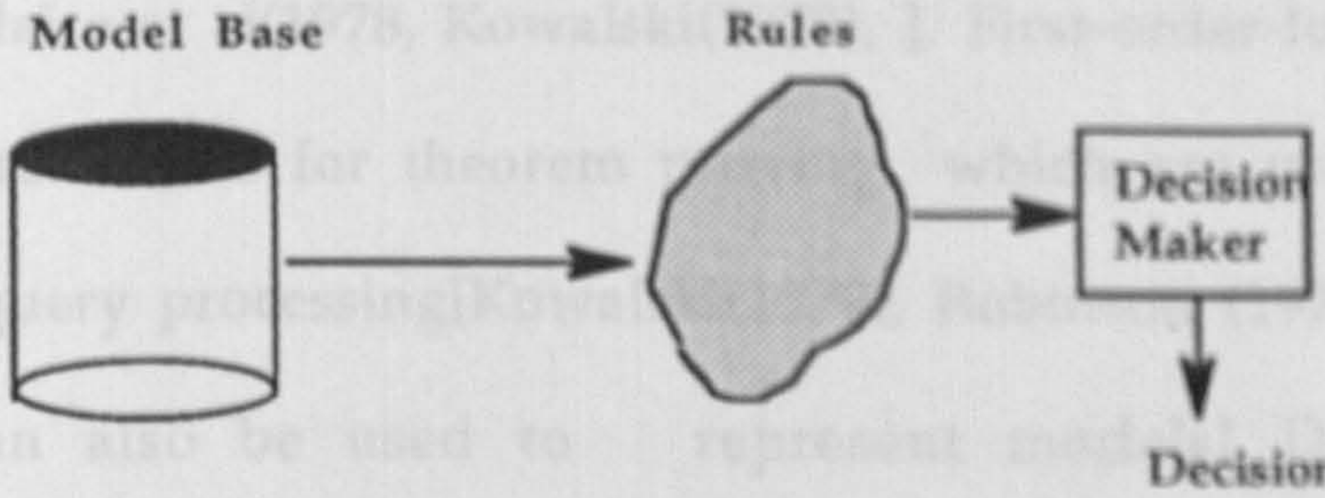
```
High-Revenue(s)  If  State(s) And
Total-Revenue(s r) And
( r = `High')

Low-Economic-Development(s)  If State(s) And
Total-Standardised-Score-Economic(s g)
And (g = `High')

Low-Infrastructure-Development(s) If State(s) And
Total-Standardised-Score-Infrastructure(s l)
And ( l = `High')
Low-Revenue(s)  If State(s) And
Total-Revenue(s r) And
( r = `low')
```

Observation in the use of rules in FSR leads to an issue which is important for the development of DSS. This issue revolves around the role and the relationship between quantitative models and rules. In arriving at the economic viability of a project its cash flow will be heuristically estimated. It was suggested , and seemed to be agreed by those concerned, whilst heuristics are feasible, perhaps better estimation of cash flow could be supported by formal models which use techniques such Net Present Value(NPV). In this respect "threshold" can be determined which can be used to classify project as having "good enough" cash flow or not. The use of a rule for classifying the economic and social status of the need to be supported by models which calculate the "Scores" for economic and social development of the States. These scores are stored in the Information Base and appendix 2 shows how the score is calculated. The role models(quantitative models) to enhance common sense reasoning in FSR can represented in the following diagram 7.13:

Diagram 7.13: Role of rules in FSR



7.4: Prototype System of Grant Administration

Prototypes were developed for administering grants based on Economic and Social Well Being Indicators , capitation grants (see appendix 5 for the flow of decision in administering these grants) . The prototypes were developed using Micro Prolog on an IBM-PC. Rules were expressed in terms of Horn Clauses which take the form of:

A if B1, B2, B3,.....Bn, where atomic formulae B's are conditions and A are conclusions (the above rules are represented in this clause).

There are a number of widely accepted methods for knowledge representation, for example production systems, semantic networks, frames and first-order-logic[Brachman et al eds(1985)]. These methods have their own advantages and disadvantages and each is well suited to specific types of

knowledge. First-order-logic, such as Horn Clause can be used to represent knowledge in a Semantic Network, as well as providing a framework for analysing, representing and manipulating a database, especially a relational database[Gallaire et al(1978, Kowalski(1979),]. First-order-logic also has well established procedures for theorem proving which are useful for problem solving and query processing[Kowalski(1979), Robinson (1978)]. Logic-based formalism can also be used to represent models[Dutta et al(1984), Bonczek(1981), Bonczek et al(1981)]. An example of the use of logic-based formalism to represent models is shown in appendix 4.

7.5: Conclusion

This chapter has presented an approach to the development of DSS for FSR. As suggested in chapters 2 and 4 , it is important in the development of DSS to have a descriptive understanding of the decision making process . Whilst this is so it is equally important to have a normative understanding of the process because much of the ideas of the nature of the DSS to be developed can be generated from this normative understanding. The novelty of the approach presented in this chapter is that it brings into focus a viable system concept , a model of a control system and HAS and linked them into a framework useful for normative understanding of the nature of the decision problem faced by FSR and the nature of its solution procedures. This normative understanding served as the basis for identifying architectural characteristics of the DSS, namely characteristics of the data base, model base and functional capability.

The information categories proposed in the architecture would enhance the present information used by FSR. The use of the information base would help enhance FSR's capability to monitor changes in the environment . As described in chapter 2 , quantitative models were used by FSR to administer grants to the States. But FSR also needs supplementary models to enhance its problem solving capability. In this chapter such models were proposed. These can be used , for example, for sensitivity analysis and forcasting. In FSR qualitative reasoning was used in conjunction with quantitative reasoning. The knowledge base suggested in the DSS architecture for FSR represents an attempt to incorporate this qualitative reasoning in the design.

CHAPTER 8

CONCLUSION

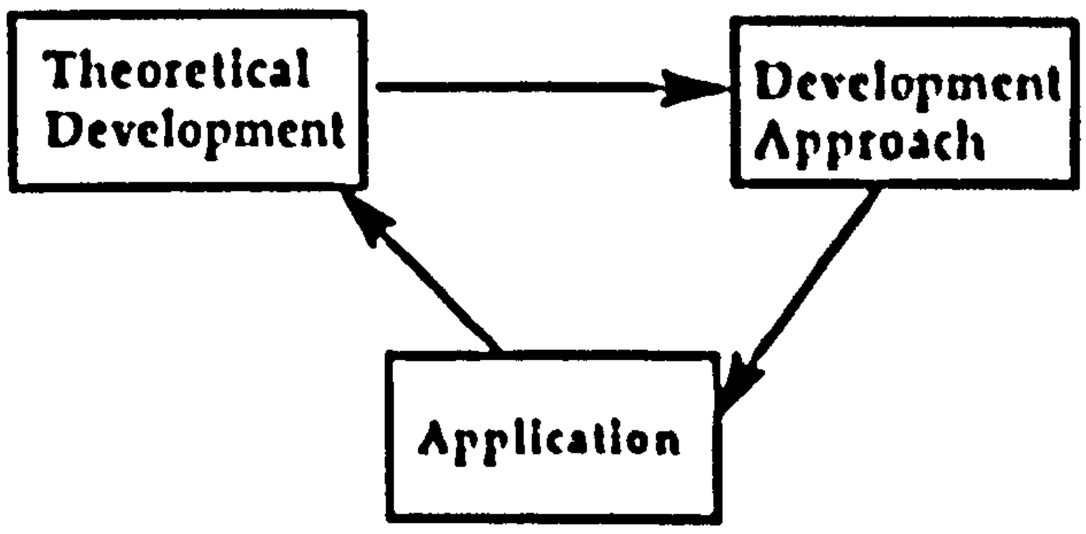
There is nothing more important for organisations and individuals within organisations than making effective decisions. One of the important characteristics of decision making in ill-structured environments is that decision makers are faced with procedural uncertainty, namely uncertainty about what information to seek and what procedures to use. Providing support for decision making in ill-structured environments is the primary purpose of the DSS concept. Initially the basic ideas of DSS were indeed novel:

" Here is a perspective on the use of computers and analytical methods that is very different from the traditional assumptions and practice of Data Processing and Management Science. It meshes human judgment and power of computer technology in ways that can improve the effectiveness of decision makers, without intruding on their autonomy"[Keen (1987)].

But what was originally considered novel about DSS might not seem so now. Advances in information technology make it possible to build Management Science models which incorporate characteristics envisaged in DSS. Furthermore the distinction between DSS and computerised Management Science models is blurred by the characteristics of DSS applications described in chapter 3. Discussion

about the need to improve decision making and methods of how this can be done are commonplace in the management literature. Basically this discussion is about helping people in organisations do their job better. It is argued here for DSS to become a discipline it must have both definition for understanding and definition for action. Definition for understanding means the understanding of what is implied by the DSS concept, such as the effectiveness of the decision making process and nature of support to be provided. Definition for action uses this understanding for the development of DSS for practical problems. This also implies that DSS should have distinct paradigms or cultural styles in theoretical development and design approach. Theoretical development involves definition of the objects of interest, definition and interpretation of relationships among the objects and testing of these relationships. A design approach involves the development of methods to help in requirements analysis, specification, design , implementation and testing of the systems. Theoretical development requires the development of methods to be used in the design approach. The application of this approach determines its usefulness and highlights its limitation. This result in the improvement of the approach and its embedded theory as in the following diagram 8.1:

Diagram 8.1: Learning cycle in improving DSS discipline

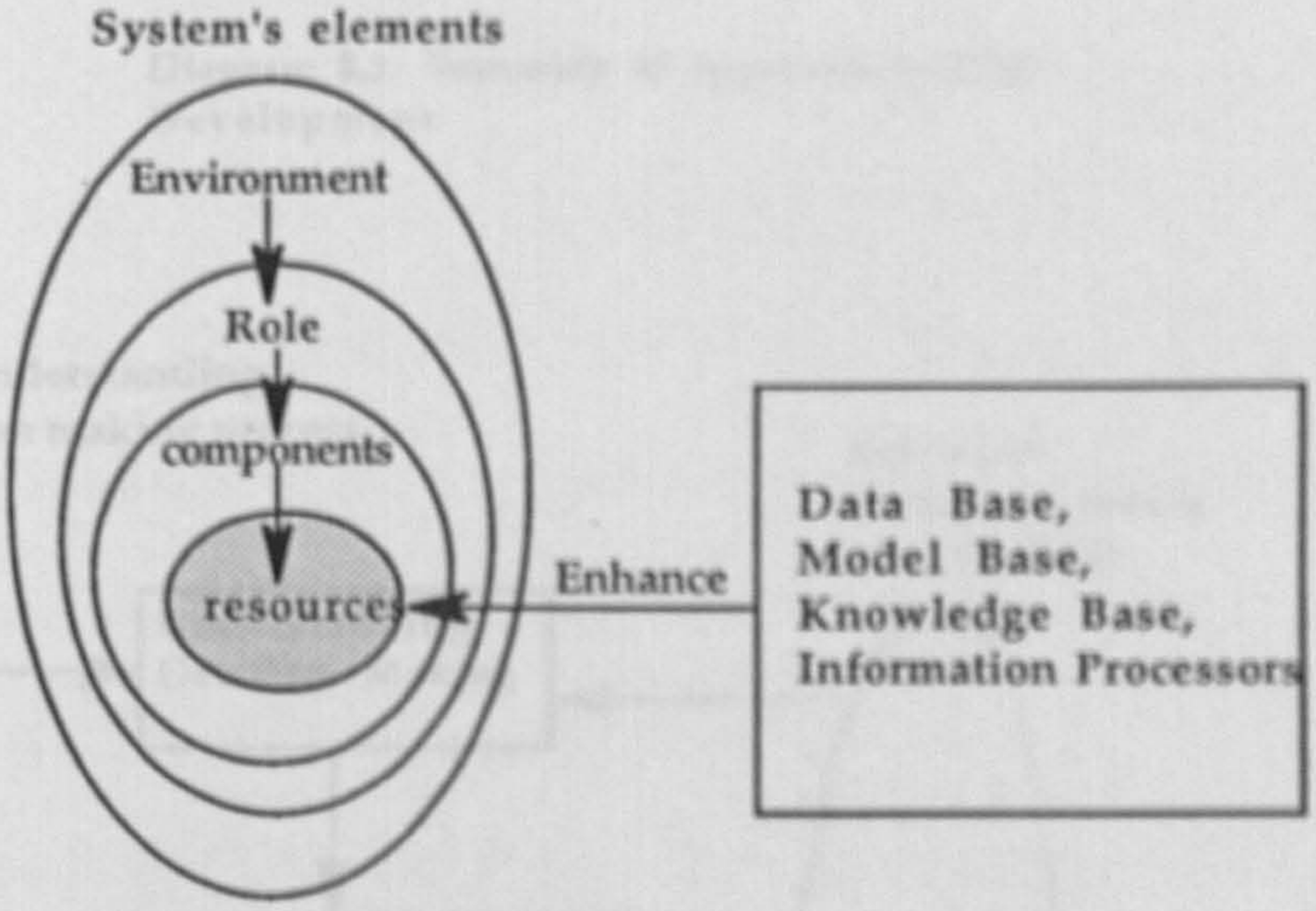


Summary of the Achievement of this Thesis

It is helpful at this stage to summarise the achievement of this thesis. The DSS literature has provided works useful for understanding the DSS paradigm(see chapter 3). But less effort has been put into effective integration of these works into the framework of diagram 8.1, namely the integration of theoretical understanding with design approach and application(this view was also expressed by Keen see page 4). Elam et al(1987) also express the need for research on this integration(see page 4). The approach adopted in this thesis is based on understanding of DSS paradigm through system theoretic viewpoints. Basically this approach places stress on systemic understanding of the decision making process based on its environment, role, components , their arrangement, and resources. The components and resources that exist in the decision making system reflect the system's interpretation of the requirements from its environment and role. Systemic interpretation of

decision making process is important for understanding the role of DSS. In general terms the role of DSS is to enhance the present resources , namely knowledge, tools and techniques, in the decision making system as in the following diagram 8.2:

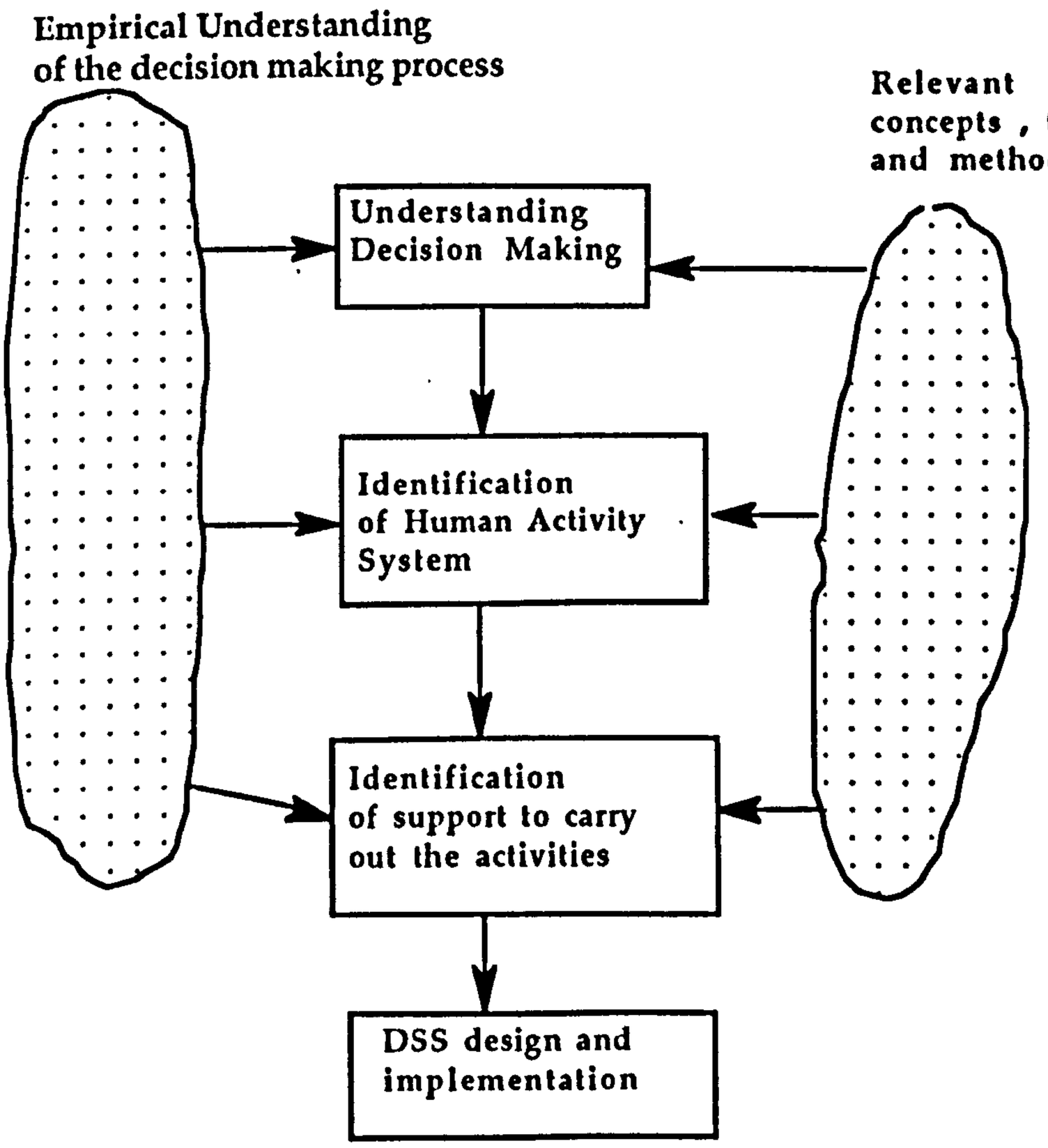
Diagram 8.2: Role of DSS in systemic terms



As reflected by diagram 8.2 a lot of work needs to be done in defining DSS resources. The system's elements need to be empirically understood (as in chapter 2). This would help in identifying constraints on the decision making and also limitations of the present resources used. Defining DSS resources also implies the need for normative understanding of the decision making process. Chapter 4, 5 and 6 provided conceptual and theoretical frameworks useful for normative

understanding of the decision making process. The concepts and theories in these frameworks can be used as inputs to the DSS development, especially in the development of an approach to help understand the domain of the DSS design. This reflects the need to link theoretical development with the design approach in diagram 8.1(page 223). The role of empirical and theoretical understanding of the decision making process in the development of DSS described in this thesis is summarised in the following diagram 8.3:

Diagram 8.3: Summary of approach to DSS Development



The generality and usefulness of the proposed approach can be described in terms of the concepts, theories and methods used. Examples include concepts and theories which describe organisational decision making processes, such as organisational effectiveness, organisational knowledge, role relationship, as well as those which describe the characteristics of individual decision making. The soft system methodology incorporated in the approach is quite general. It provides a more rigorous method which can be used for defining problems in ill-structured situations and also provides a framework for discoursing about potential solution procedures. It also facilitates inclusion of declarative factors of the decision making process into the DSS development as well as encouraging user participation. SSM has some limitations. In the context of FSR there was no difficulty in identifying the Owners and Actors and determining what is the environment, but identifying the Weltanschuung and Root Definition in FSR was more difficult. According to one senior official, problem solving and decision making in FSR represents the most difficult task in the Treasury Department, hence to capture the "essence" of the situation into a good Root Definition requires a difficult process of inquiry and exploration. The approach taken was to study the relevant documents, such as management manuals, working papers, meeting agendas, conference papers as well as interviewing those outside FSR who have an indirect involvement in the decision making in FSR. The documents were to supplement information gathered from personal interviews with those directly involved with the decision making in FSR. The documents and personal interview were also found to be useful for inferring and identifying the problems faced by FSR and the limitations of the present way of working. Another limitation of SSM is that HAS itself is

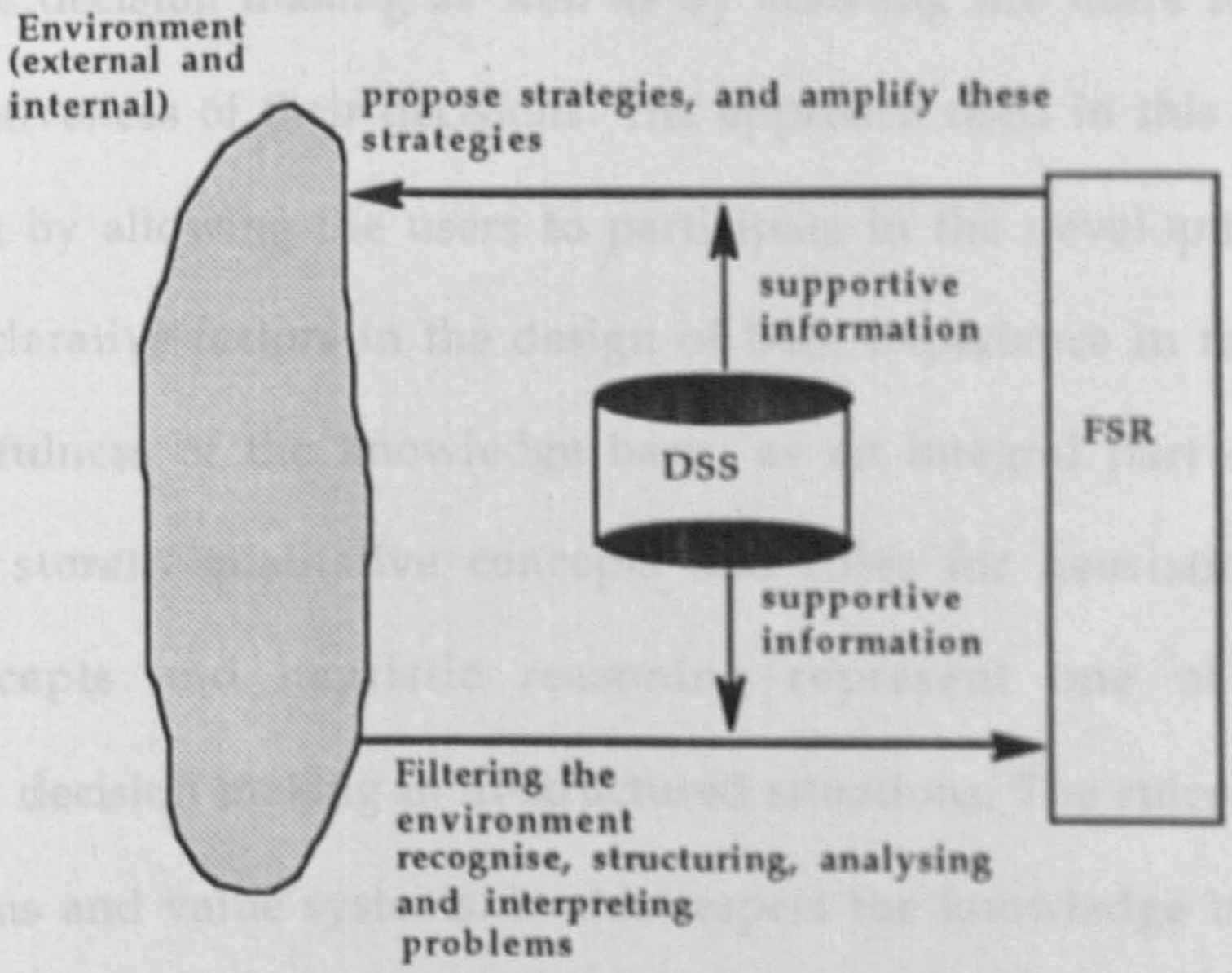
nonterminal, it only provides a set of activities which say "what" needs to be done but not "how", namely what information and models to be used in carrying out the activities. This is agreed by Ormerod (1992) according to whom, SSM provides no special assistance in moving from function to data, and what data could be used and required and whether or not this data to be included in databases is a question of design based on facts about the world, not an extention of the logic contained within the conceptual model of SSM. Much of the debate about the potential use of SSM in the IS has been theoretical in nature. This argument also results from the lack of understanding of the potential use of SSM in the development of Information Systems(IS) in practical situations.

This paper attempts to enhance this understanding by describing the role of SSM in the DSS development life cycle. Frameworks suggested for understanding normative decision aids and for knowledge modelling are useful for this purpose. The DSS approach proposed enhances the predesign cycle of Keen and Scott-Morton(1978) , see diagram 5.1(page 120). This approach incorporates empirical aspects, concepts and theory which are useful for carrying out the activities implied by this predesign cycle. The use of soft system methodology introduced formalism into the approach. This approach also facilitated prototype development of DSS.

The experience gained in applying the DSS to FSR has brought to light the usefulness of the proposed approach. The concepts and theory used by the approach help in identifying some key variables to be used in understanding the decision making process in FSR. This involves a lot of interaction with the environment. Its

major concern is producing suboptimal decisions that satisfy the requirements generated by that environment or decisions which may influence the environment. The role of DSS is to provide information and information processors capable of helping FSR in this respect. This is shown in diagram 8.4. An architecture for this DSS was proposed in chapter 6.

Diagram 8.4: Role of DSS in FSR



Institutionalisation is one of the issues that needs to be taken into consideration in the DSS application. The use of DSS is often discretionary and different users may use them in a variety of ways. In solving complex problems decision makers may use a multiple range of information sources. A DSS may only be one of these sources and will often be insufficient in complex situations. A survey conducted by Yusoff et al (1991) showed that a range of information sources were used in financial planning. Most important among them were daily newspapers and government publications. Successful institutionalisation of DSS can be accomplished by improving the ` fit ' between them and the declarative factors embedded in the decision making as well as by assisting the users learn how to improve the effectiveness of their decisions. The approach used in this thesis helps in finding this fit by allowing the users to participate in the development and by incorporating declarative factors in the design of DSS. Experience in the FSR also suggests the usefulness of the knowledge base as an integral part of DSS. The knowledge base stores qualitative concepts and rules for heuristic reasoning. Qualitative concepts and heuristic reasoning represent one of the major characteristics of decision making in ill-structured situations. The rules used reflect the present norms and value systems. In this respect the knowledge base helps in improving the `fit` , thus enhancing the acceptance of DSS by users.

DSS a Way Ahead

In order to implement the major components suggested in the architecture further research needs to be carried out. At present work is being carried out to

develop software to assist users in problem structuring[Yusoff (1991), Yusoff et al (1992]. This works is based on the concept of structured modelling[Geoffrion (1987), (1989)]. Scanning and filtering the environment suggests there is a need for the identification of the new information as suggested by the information categories in the data base of the proposed architecture. As described in chapter 2 one of the major information focuses of FSR revolved around the indicators for measuring the economic and social well being of the States in the Federation. These indicators have a number of uses in the decision making process in FSR. From the empirical study it was discovered that those involved in FSR expressed concern over the usefulness and the representativeness of some of the indicators used in measuring the economic and social well-being of the States. This implies that necessary research work needs to be carried out to arrive at better definition of indicators.

As far as Malaysia is concerned the pioneering work described in this thesis offers an unprecedented opportunity for other organisations . This approach has been applied to the development of information systems for the National University of Malaysia (see appendix 6). One of the results from a survey conducted in Malaysia[Yusoff et al (1991)] showed that one of the problems faced by most organisations(90% of the public sector organisations) in the development of information systems for financial planning was the inability to specify information needs. The ability to discourse about a complex problem and its solution procedure, in particular the information and model to be used, makes the proposed approach useful in Malaysia.

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APPENDIX 1

List of questions used in interview with the Director of Budget :

Q1: What are the objectives of the Budget Department,

Q2: What are the activities carried out by the Department to achieve the above objectives,

Q3: Which section or unit is responsible for each of the above activities,

Q4: What input information is used by this Department,

Q5: What outputs are produced by this Department,

Q6: In carrying out the activities to achieve Department's objectives some constraints may exist. What are these constraints and how do they affect the activities of this Department ,

Q7: Which constraints are most important,

Q8: Is there any measure of performance for this Department,

(if yes go to Q9 otherwise Q10)

Q9: How is the performance is measured,

Q10: What improvement you think necessary in order to improve the performance of this Department,

Q11: Does this Department use computerised information systems,

(if yes go to Q12 otherwise Q17)

Q12 What applications use computerised information systems,

Q13: What improvement need to be done in the present computerised information systems,

Q14: Do you intend to use computerised information systems for some other applications,

(if yes Q15 if not Q16)

Q15: What applications

(go to Q20)

Q16: Why

(go to Q20)

Q17: Do you intend to have computerised information systems in your Department,

(if yes go to Q18 if not to Q19)

Q18: For what applications

(go to Q20)

Q19: Why

Q20: In your opinion what role can computerised information systems play to help decision making in general and you works in particular and what characteristics should the systems have in this respect.

Q22: What factors in your opinion would constrain the development of such a system in the context of this Department

Q22: Who normally approves the final decisions recommended by this Department

Questions Used During Interview with Those Concerned with Specific Activity

Q1: What are the objectives of this activity

Q2: What are the inputs to this activity

Q3: Where do they come from

Q4: What are purposes of these inputs, namely useful information that can be derived from them which might be useful for problem understanding

Q5: How do you go about extracting information from the inputs, namely models or procedures used

Q6: Can these inputs always help you in understanding the problems

(if yes go to Q8)

Q7:What supporting information do you use and where are its sources

Q8: How do you go about solving problems in this activity:

(a): by using ready-made solution based on established procedures or model,

(b): by using procedures generated as situation demands, namely custom made solution

(if established procedures are used then Q9, 10, 11)

Q9: Sources of these established procedures, namely management manual

Q10: How long have these procedures been in use

Q11: What are advantages and limitations of these procedures

(Go to Q14)

(if use custom made procedures)

Q12: How did you arrive at the custom made solutions, namely from personal experience and judgment, academic journal etc.

Q13: Do you think you can improve your custom made solutions

Q14: What are the factors that influence or constrain the ways you work

Q15: Do you use computerised information systems to help in your current work

(if not go to Q19)

Q16: Where in your current work is this system being used

Q17: What change , if any, do you think should be made to this system to improve you current work

Q18: Do you intend to extend your computerised information systems to other applications in this activity

(go to Q22)

Q19: Do you intend to use computerised information systems in the future

(if not Q21)

Q20: In which applications

(go to Q22)

Q21: Why

(end of the question)

Q22: In your opinion what role can computerised information systems play in helping in decision making in general and your work in particular and what characteristics should the system have in this respect.

Q23: What factors in your opinion would constrain the development of such a system in the context of your current work

APPENDIX 2

Calculation and Interpretation of "Score" Based on Economic, Infrastructure and Social Well Being Development Indicators

The score is used by FSR in classifying States in economic and social status, namely whether States are "poor" or "rich". The score is also used in allocating grant. The calculation of score can be modelled as follows:

Let Iij represents indicators i (economic ,social) for State j. Standardised score for indicator i and State j is defined as:

$$Sij = \{(Mi - Iij)/SDi\} \times 10$$

where Mi = mean for indicator i

SDi = standard deviation for indicators i

$$Mi = Iij/n$$

$$SDi = \Sigma(Mi - Iij)/n-1$$

n = no of states in the Federation

From the mathematical expression above, Sij takes negative value if Iij > Mi and positive value if Iij < Mi. Sij can be positive or negative . As far as FSR is concerned this positive or negative value of S has different interpretations depending on what Ii represents. For example if Iij represent revenue percapita for State j negative value means that its revenue percapita for a particular year is above national average. But if Iij represent percentage employment in agriculture sector negative

value means that State j has more population employed in the agriculture sector than the national average. In administering grant using certain instruments certain indicators which has negative value of S would not be considered as one of the criteria to be included in the model the same goes to the indicators with positive value of S. For example those revenue percapita which have value above the national average would be used in the calculation of grant based on economic and social well being indicators.

APPENDIX 3

USE OF HAS IN THE ANALYSIS AND DESIGN

HAS can be used as the basis for analysis and design. For example consider the first level HAS in diagram 6.2 and take activities 1" appreciate the needs of the States" (A1) and 2 " appreciate the constraints" (A2). These activities take certain input and produce certain outputs and from the empirical study they can be represented as in the following diagrams:

Diagram AP1: Inputs and Outputs of Activity A1

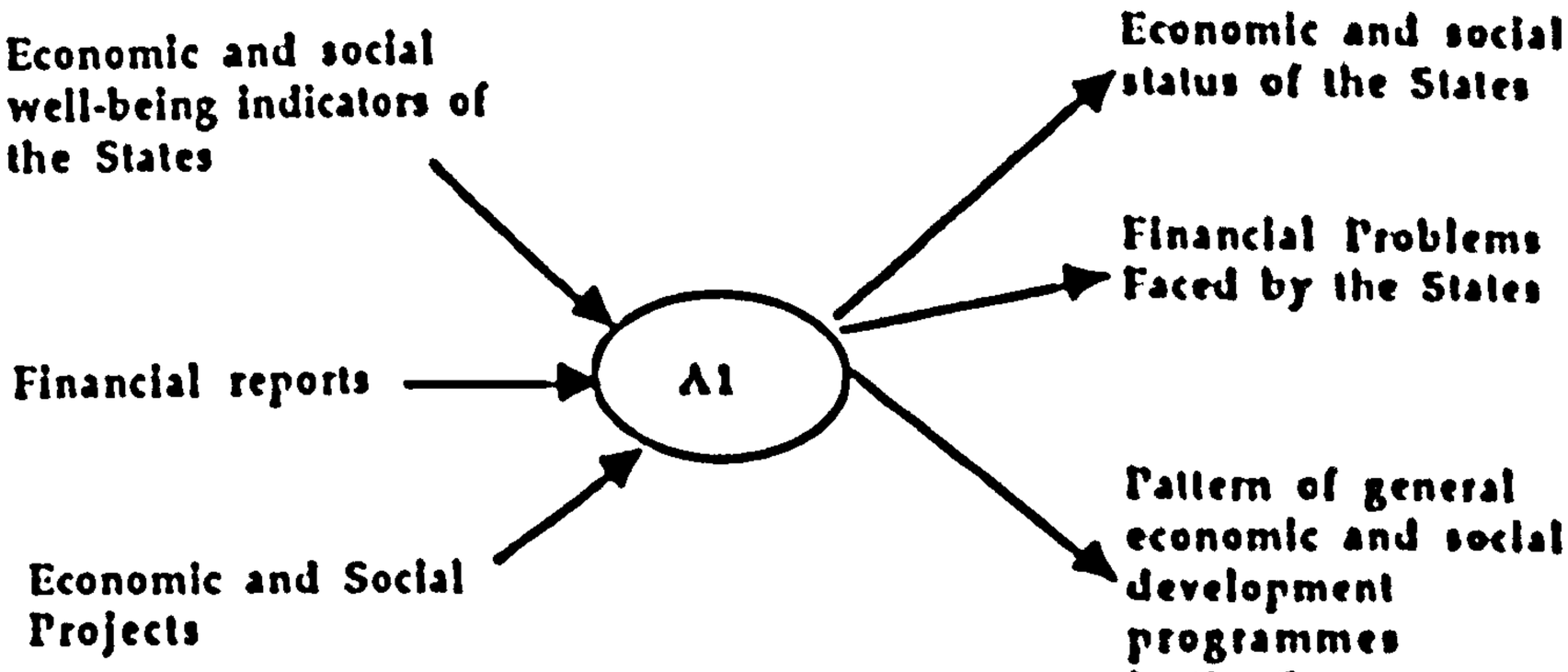
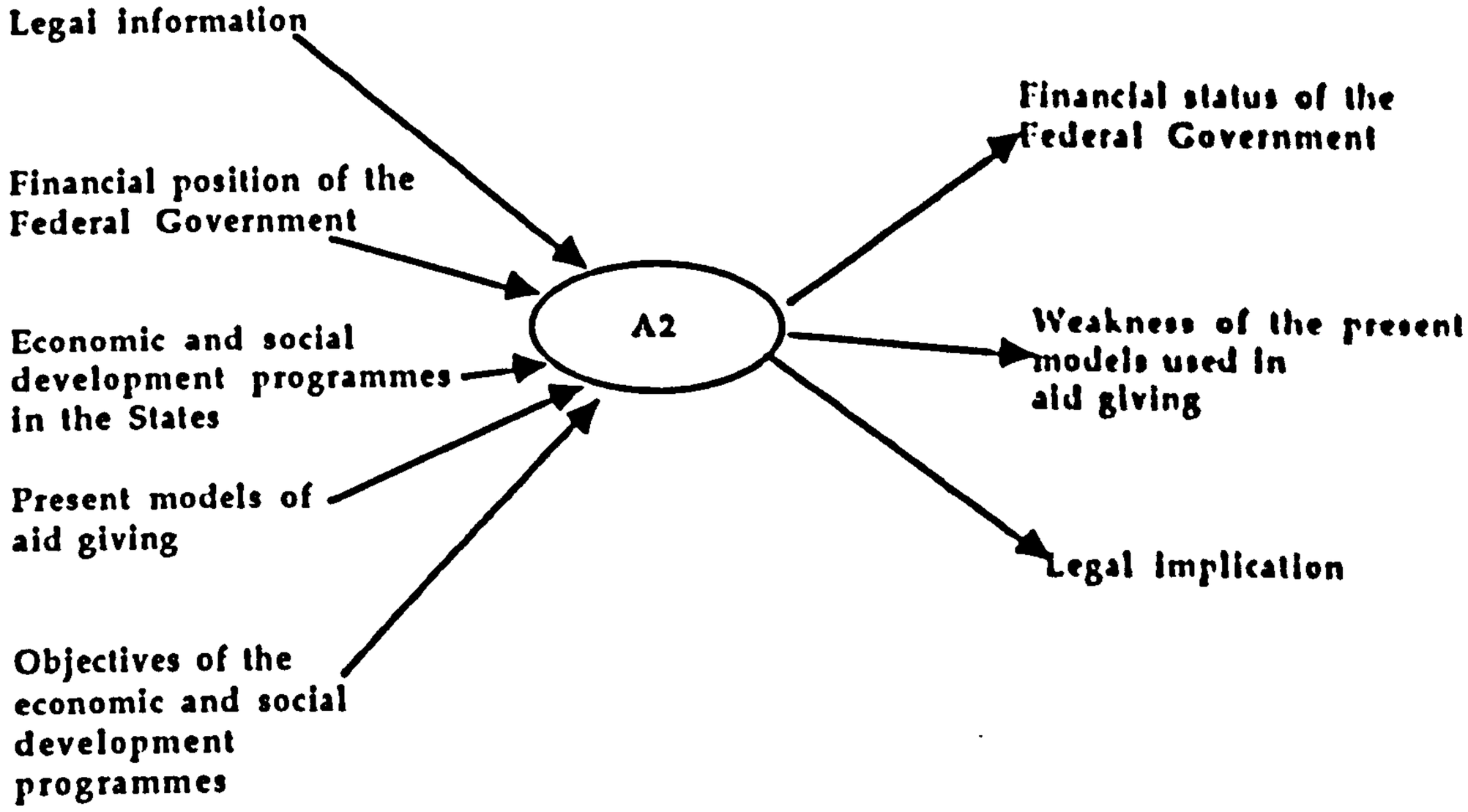
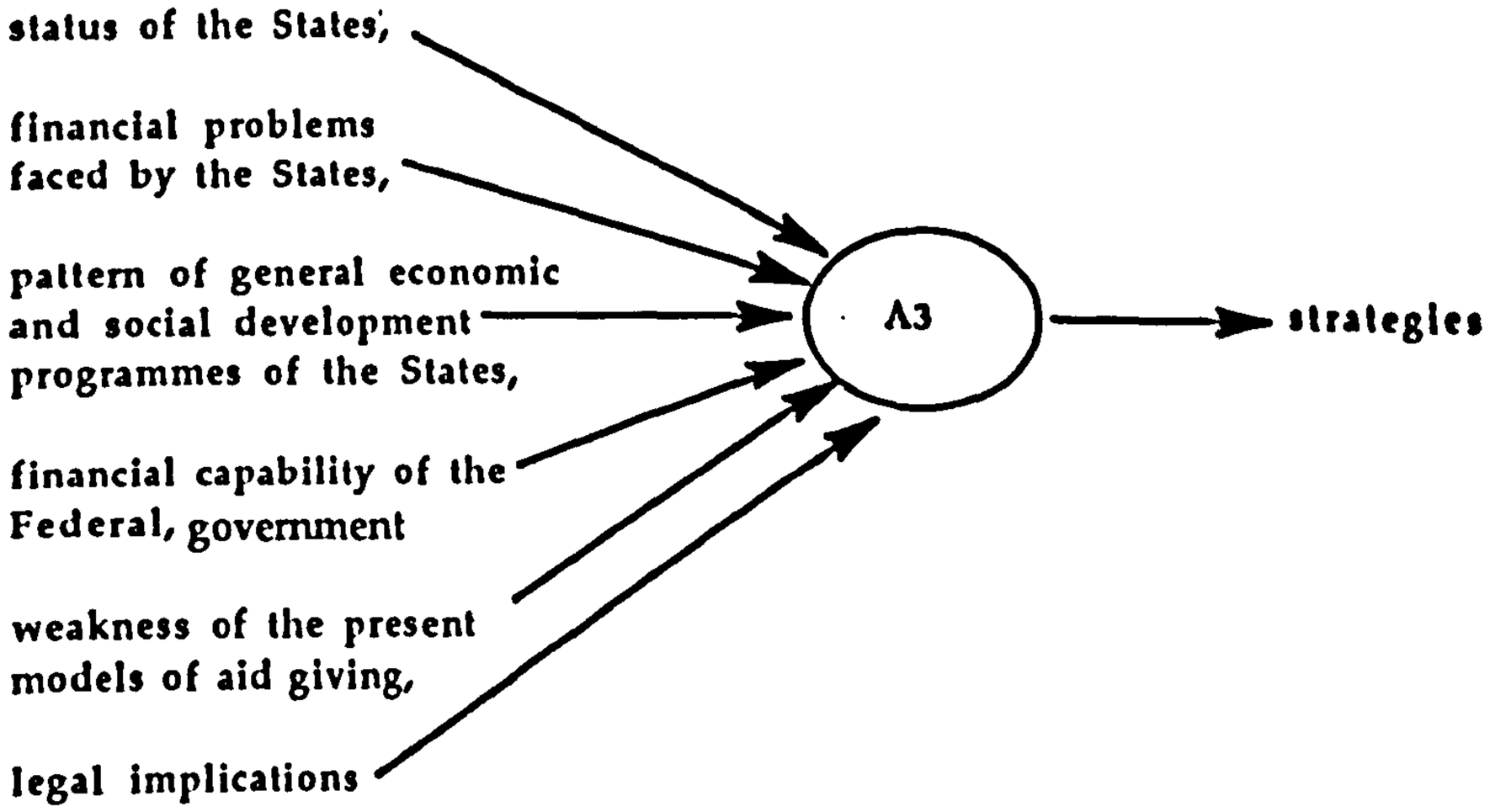


Diagram AP2: Inputs and Outputs of Activity A2



The outputs from activities AP1 and AP2 serve as input to the activity 3 " devise strategies for actions" (A3) as in the following diagram:

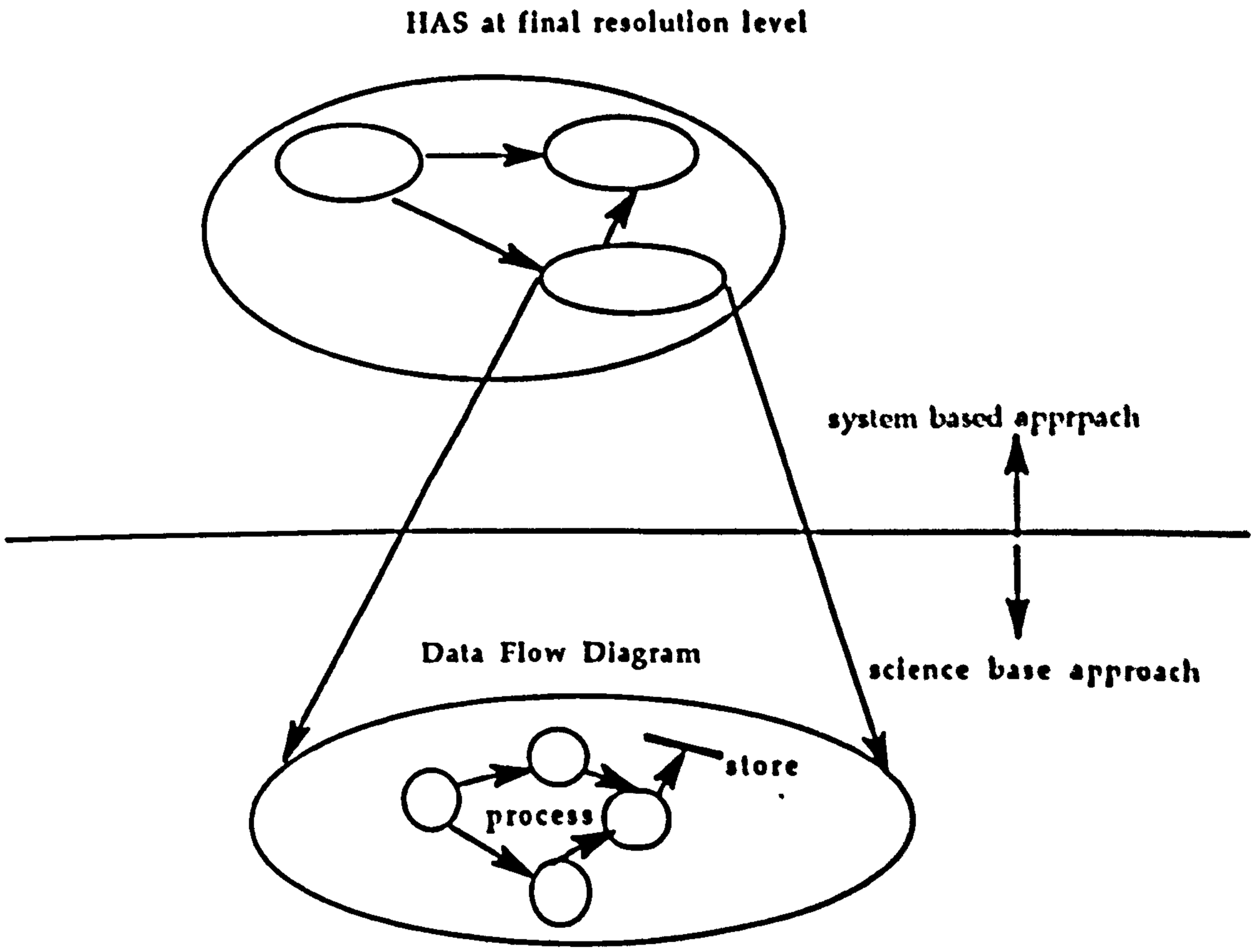
Diagram AP3: Inputs and Outputs



Inputs and outputs representation of activities at the first level of resolution provides a basis for the detailed analysis of the system. But in order to do this, there has to be representation of the activities at the lower level of resolution. For example diagram 7.3(page 188) shows the representation of activity A1 at the second level of resolution. There is no hard and fast rule that can be used to determine up to what level of resolution HAS needs to be represented. An approach suggested is to stop resolution process when the activities can be described in 1 or 2 pages. As reflected in diagram 5.8 support need to be developed for each activity and in the case of the this support takes the form of computerised information systems, this activity (represented at final resolution) need to be modelled in terms of information flows, processes and data stores. There are a number of techniques useful for this modelling and one of them which is suggested here is Data Flow Diagrams (DFD) [De Marco(1978)]. The potential use of this

techniques to augment HAS in the analysis and design is shown in the following diagram:

Diagram AP4: The use of DFD in modelling activities



APPENDIX 4

An Approach to Models Representation

Model can be represented in AND and OR graph and the use of this graph in representing models in FSR can be illustrated in the following examples:

Let capitation grant for State S in year Y be represented as a the following relation:

Capitation-Grant (S,Y, G),

where G is an amount of grant State s entitle to.

In order to determine the value of G, model which calculate this value need to be asessed and let express this model as:

Calculate-Grant (Ps,y, G),

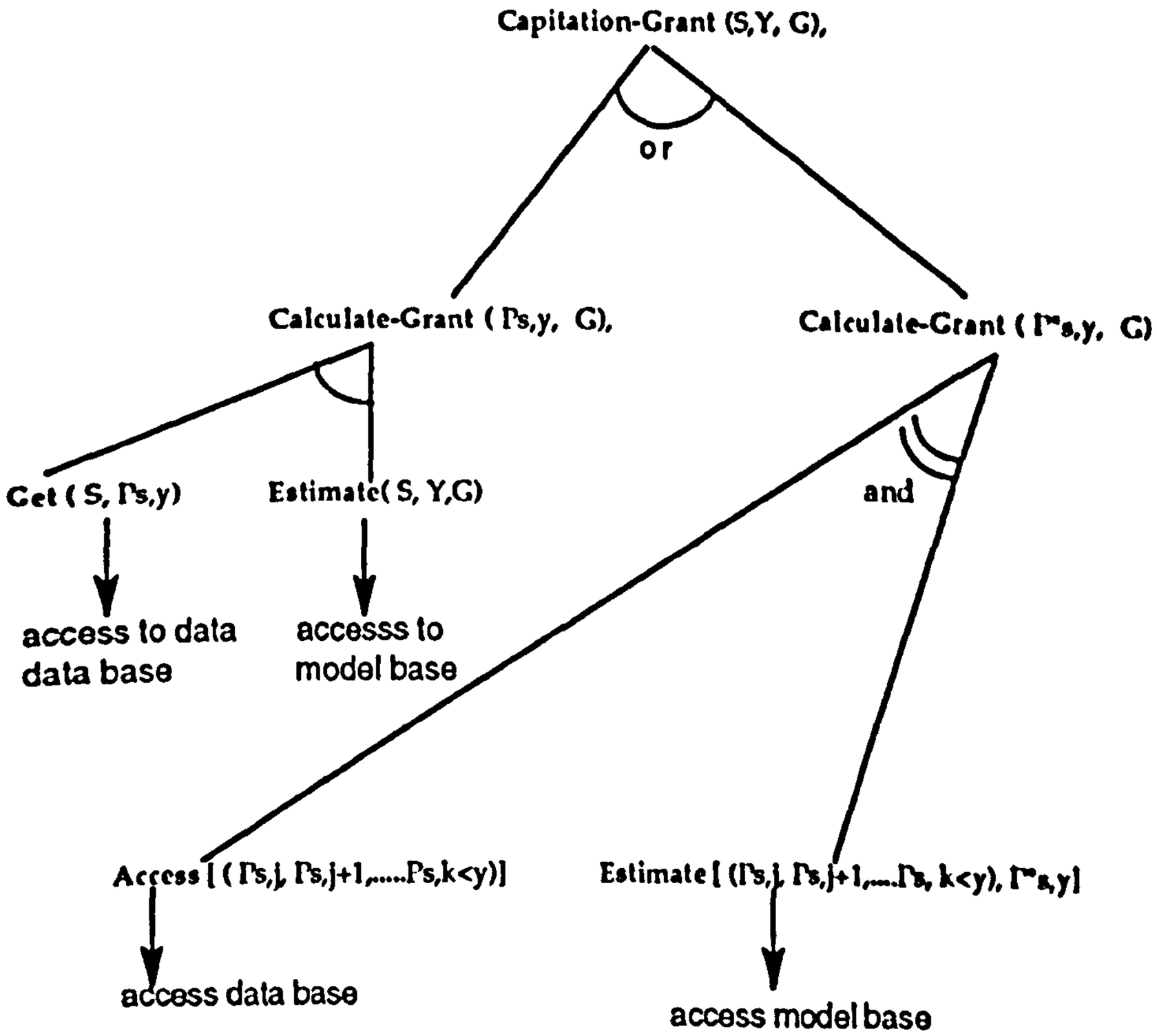
where Ps,y is the population of State S in year Y.

There are two possibilities: If Ps,y is known the grant can be calculated straightaway, but if Ps,y is not known it needs to be estimated using population data from the previous year. In this respect previous data needs to be accessible and forcasting model need to be trigerred. These can be represented as:

Calculate-Grant (P*s,y, G),
Access [(Ps,j, Ps,j+1,.....Ps,k<y)] and
Estimate [(Ps,j, Ps,j+1,....Ps, k<y), P*s,y], where

Ps,j.....Ps,k are previous population data and P*s,y is an estimate of the population of State S in year Y.

In terms of AND and OR graph capitation grant can be represented as:

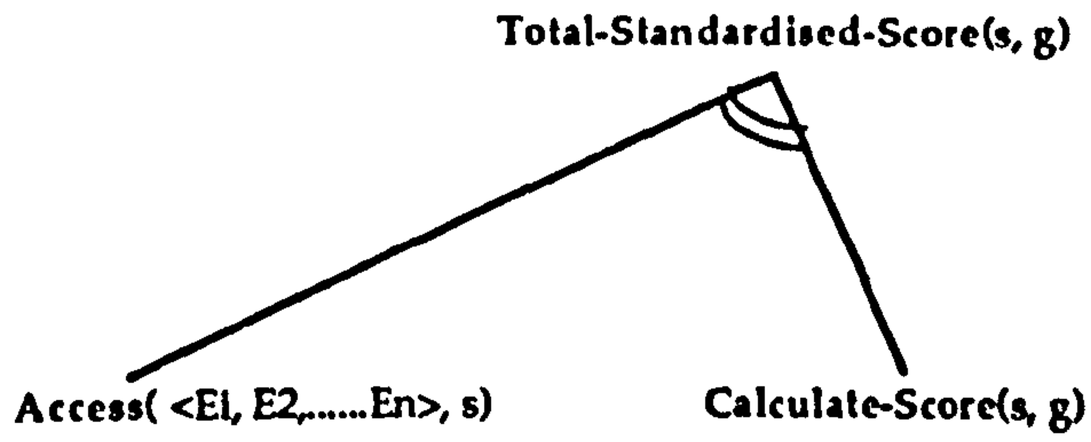


The above graph identifies subproblems that need to be solved in order to determine the amount of grant, G, for State S. Calculate-Grant (Ps,y G) will be trigered if its argument Ps,y is true i.e the population for State S in year Y can be directly obtained ffrom the data base, otherwise Calculate-Grant (P*s,y G) will be trigerred. The above representation help in the development of a system for model management, namely to manage the resources (data, functions and their accesses) which are useful for this model. The need to link qualitative rules with the quantitative model has been described in chapter 6. The above representation help in modelling this link. For example take the following rule:

for any State s,

High-Economic-Development(s) If Total-Standardised-Score(s, g) And (g ="high")

The relation Total-Standardised-Score(s, g) can be modelled as follow;

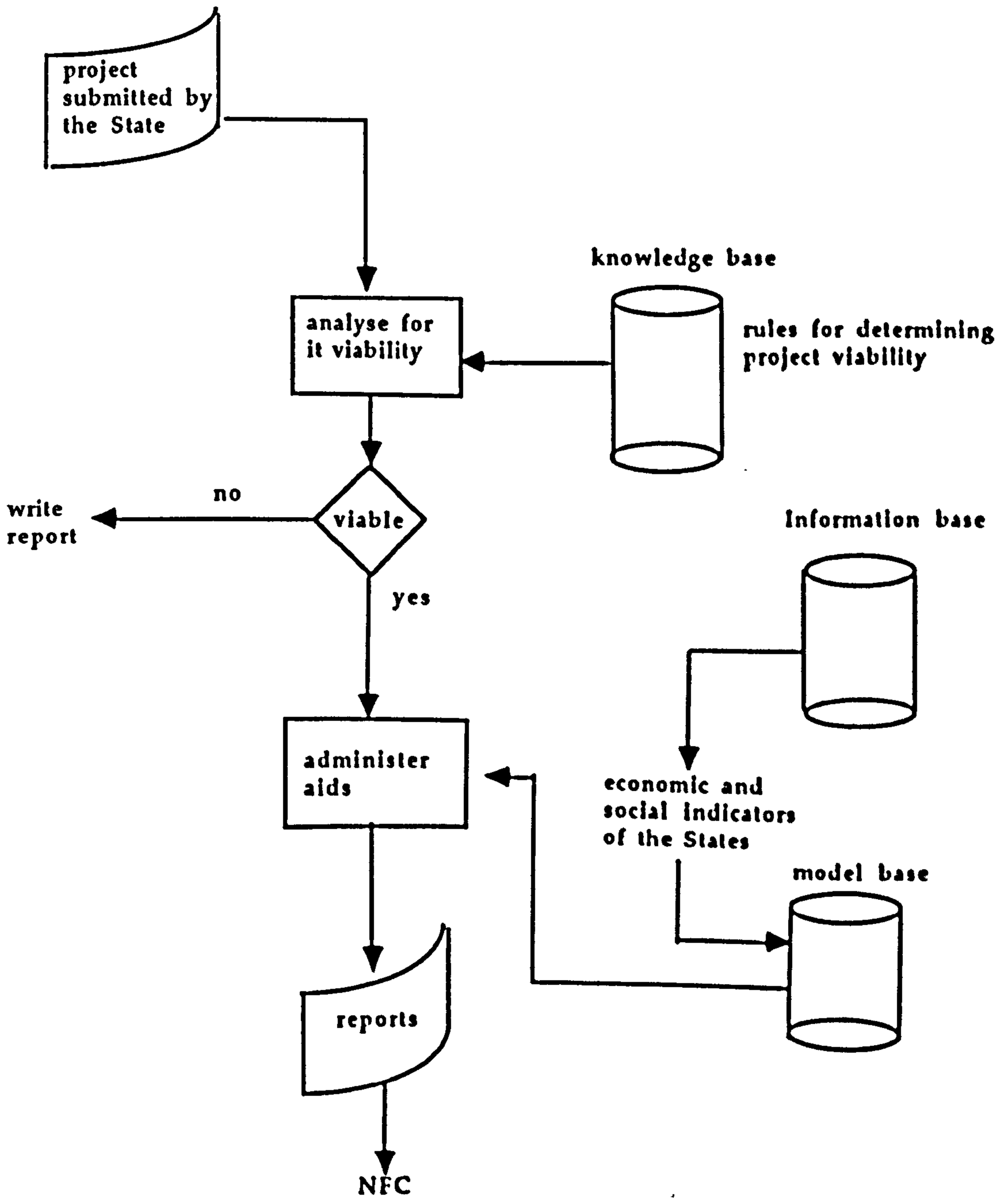


Graph representation can be translated into representation based logic formalism such as predicate calculus. This is useful for system implementation using language like Prolog using predicate calculus, calculation of capitation grant can be represented as:

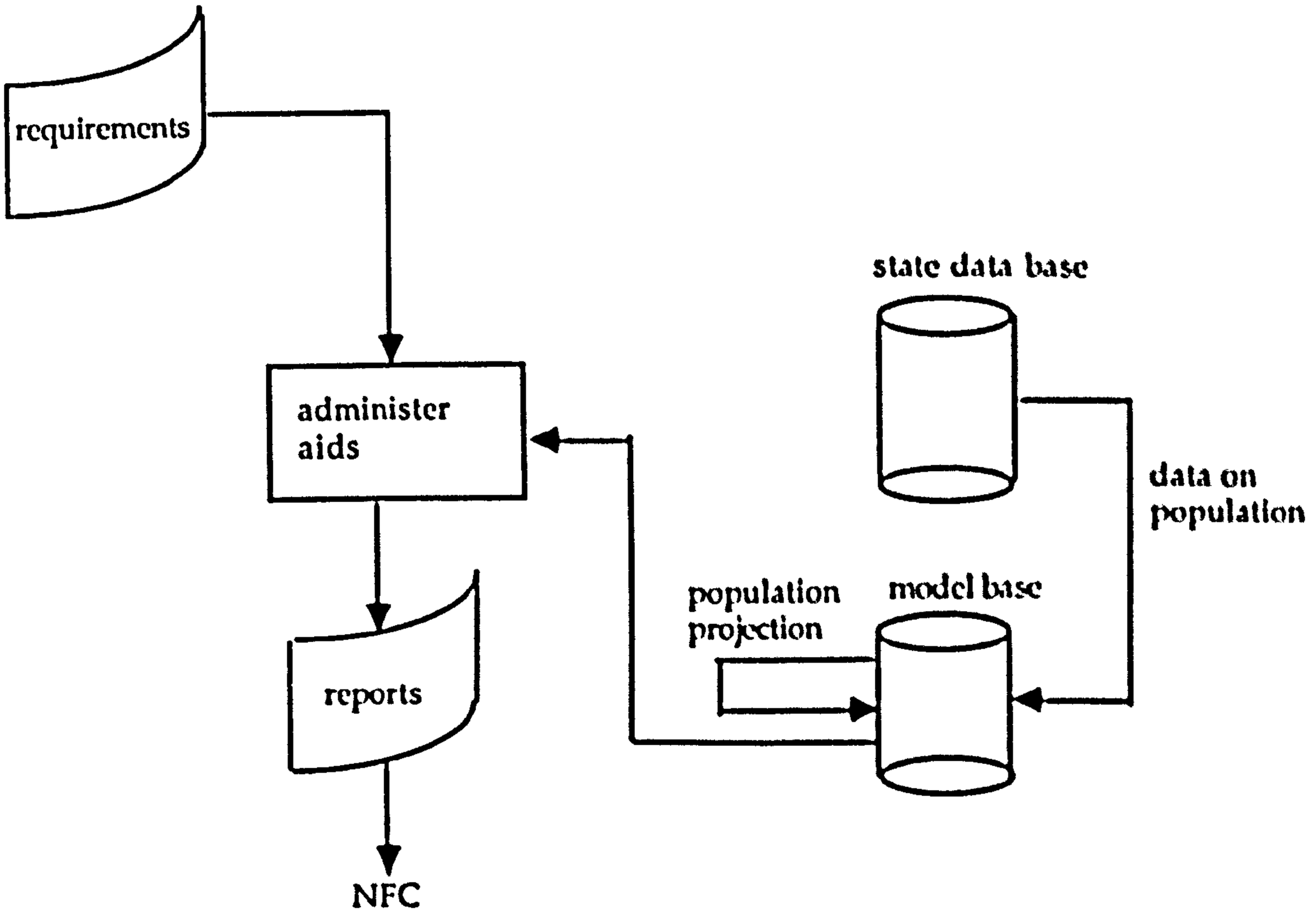
Capitation-Grant (S,Y, G) If Calculate-Grant (Ps,y, G) Or Calculate-Grant (P"s,y, G)

APPENDIX 5

Figure 5: Decision Process for administering grant based on economic and social well being status of the State



Flow of decision for administering capitation grant



APPENDIX 6

DEVELOPMENT OF AN INFORMATION SYSTEM FOR A UNIVERSITY ADMINISTRATION: FRAMEWORK FOR DESIGN BASED ON DECISION SUPPORT SYSTEM'S PARADIGM[1]

Introduction

At present the performance of the local universities is an issue that has begun to attract a lot of attention from the public, politicians, industry as well as university staff themselves. Similarly a number of suggestions on how local universities can improve their performance have been put forward. Some of these suggestions are useful but there are others which are too abstract and difficult to be implemented because they are based on assumptions which do not reflect proper understanding of the role and function of the university and the complexity of its environment. This paper does not intend to discuss these suggestions per se but to present an approach which may be useful for discoursing solution procedures that could adopted by the National University of Malaysia(NUM) in improving its performance. This approach is based on DSS paradigm and especially the concepts of Viable and Human Activity Systems described in the thesis

[1]This paper emerged from author's current involvement in the development of integrated information systems for the National University of Malaysia under the sponsorship of the university.

Performance of Local Universities

At present peformance of Public Sector organisations and local universities is a subject that has attracted a lot of attention. For example in a recent article in a local newspaper[2], the Chief Secretary of State has put forward a number of suggestions on strategies for enhancing the productivity in the Public Sector:

* Suggestion Systems: This is aimed at giving opportunities for upper and lower ranking staff to suggest or generate innovative ideas on how to improve the civil service;

* Monitoring system; this system will require all the heads of department to conduct constant checks of the staff and units under them to ensure they are doing their job properly and efficiently;

* Feedback system: this system requires every department to introduce a suggestion box for staff or the public to forward their comments on what needs to be done to improve the service;

* Information system: every department will be required to produce booklets outlining procedures such as the method of applying for permits and how to fill the forms.

In a wider context the above reflect not only the importance of enhancing the performance of organisations but also the need to find ways and means of how it can be achieved, monitored and controlled.

---

[2]M.Sahibullah Report in New Straits Times, Friday March 15, 1991

Changes in the political and economic condition of the country , expectations from the politicians, public and industries influence to certain extent the running of the local universities. Accordingly local universities are urged to produce graduates and set research direction and priority which satisfy the current needs of the nation. But they are also expected to conform to the traditional objective to be the centre of excellence in research to push back the frontiers of knowledge. Whilst all local universities are under Ministry of Education they each have their own individual philosophy. They need to be adaptive to the changing requirements of the environment. Translating these into working objectives, teaching syllabuses, research priorities is not an easy task. Similarly devising solution procedures in helping to measure its overall performance in general and individual academic staff in particular is a complex, difficult task.

In the context of National University of Malaysia, a number of criteria have been suggested to measure its performance. Student academic performance and research publication of the academic staffs are currently being used as the basis to " talk" about the performance of the university. Beside examination performance other qualitative measures of student quality have also been perceived to be important, as reflected in the following statement by the University Chancellor[3]

" Graduates should serve as an agent to disseminate technical and scientific knowledge to aid national development, productivity and quality of life of the people"

---

[3]reported in "Senada"(official bulletin of the university) No94, 31st August 1991

Examples of the factors used in measuring the performance of academic staff are the following[4]:

* teaching and supervision,
* research and publication,
* consultancy and expertise,
* services to the university,
* personality of the Lecturer,
* involvement in administration,
* report from referee and external assessor,
* fluency in National Language and English,
* academic and professional qualifications,
* involvement in conferences.

At present the university feels the need for a more comprehensive information system to help in its administration. During the system study two of its Deputy Vice-Chancellors expressed their concern over the lack of information on the student life cycle in the university which is useful for devising strategy for their welfare; lack of information to measure the performance of its academic staff its and response to the changing perceptions and demands from the environment. Most reports produced by its present information systems are quite limited for these purposes.

The use of Viable System and HAS concept.

Complexity in the management of a university make it difficult for those involved to identify the nature of information to be produced

[4]This factors were reported by Majzun.R in "Senada" (official bulletin of the university) No 92, June 1991

by the information systems . In the initial stage of system development two concepts described in this thesis were found to be useful: concept of **Viable** system and **Human Activity System(HAS).**

In terms of a viable system the organisation of NUM can be represented in diagram AP6(page 265). In inferring who should perform various functions in the viable system of the diagram AP6, reference was made to the present organisational chart and NUM Constitution. There is provision in the Constitution to make Statutes which specify the powers , duties and procedures of the Officers of the University. It was found during the system study that no such Statutes existed. This made the initial understanding of their requirements difficult. Accordingly during personal interview with two of the Deputy Vice Chancellors it was discovered that they could not convincingly specify their requirements, perhaps due to the complexity of the problem. Furthermore these Vice Chancellors are appointed for a period of two years.

The CATWOE for the University can be presented as follow:

C: [Students, Private and Public Sectors, Taxpayers],

A: [Academic and Nonacademic Staffs of the University],

T: [Demands from the Environment ----------> Graduates and Research Outputs that satisfy the] Demands ,

W: [University should play useful in the economic and social development of the nation] ,

O: [Ministry of Education, Parliament, Treasury Department, Public Service Department],

E: [Federal Constitution, Private and Public Sectors, Political and Social systems]

A root definition applicable to the University is given below:

" A system for interpreting the needs from the environment into effective strategies of providing teaching , formulating research and dissemination of knowledge for the benefit of the nation, subjected to constraints (social, political, legal, financial and manpower) imposed ".

In defining W and root definition various opinions on the role and function of the University were sought from senior administrators and fellow lecturers. Reference was also made to the present Constitution of the University. There were differences in opinion on factors that need to be included and stressed. Some of them were quite extreme and placed stress the need to include factors that match with the current philosophy of NUM: " **Integration of knowledge and religious faith , and theoretical knowledge with the practice** ". Finding a set of commonalities of these opinions, their objectivity and practicality, is important in the formation of W and root definition. But this activity is by no means easy. HAS for the above root definition can be represented in diagram AP 7(page 266). What strategies are being implemented by NUM is reflected in its current teaching curriculum and research focuses. The capability of its information system is reflected in the current reports produced . Better information systems for NUM are currently being developed.

A viable system helps in providing framework for the development of information system for NUM. Matching the various roles with the systemic functions they should perform helps in discoursing about the nature of activities these roles need to carry out and information they require. Viable system also provide this important basic concept that need to be understood in improving the performance: concept of implementation function as self-regulating system. A Self-regulating system implies that some degree of authority, independence and discretion should be given to those involved in the implementation

function in making their own decisions. In the context of diagram AP6 some degree of authority and independence needs to be given to the Deans and Lecturers. In this respect the performance of implementation function is based on the objectives it need to achieve. The formulation of good objectives and communication of them to those responsible for implementation concerns those in the intelligence and control functions. These objectives are important for activity 6 in diagram AP7 and one of the functions of information systems is to help them in this respect.

Five interrelated concepts: **potentiality, capability , actuality,** latency and productivity described in this thesis were found to be useful for discoursing about the performance of the academic and administrative staff of the university. What has been done by the academic staffs represent the actuality. But what could have been done if the present objectives and constraints are fully understood and resources are optimally organised is defined as their capability. Comparing actuality with the capability gives an index of productivity. If the present constraints are removed and resources are increased there will be in theory more increase in their performance than the present capability. This represents their potentiality. Comparing potentiality with capability provides an index of latency, namely a measure of possible development considering the resources that are present but not yet active. Understanding this framework is useful for activity 2 in diagram AP7. In particular it stresses the need to have feasible objectives. In this respect there is a need to understand the relationship between availability of resources and present constraints with the achievement of objectives. Much of the current debate on measuring performance of academic staff showed the lack of this understanding.

Diagram AP6: University in terms of Beer's model

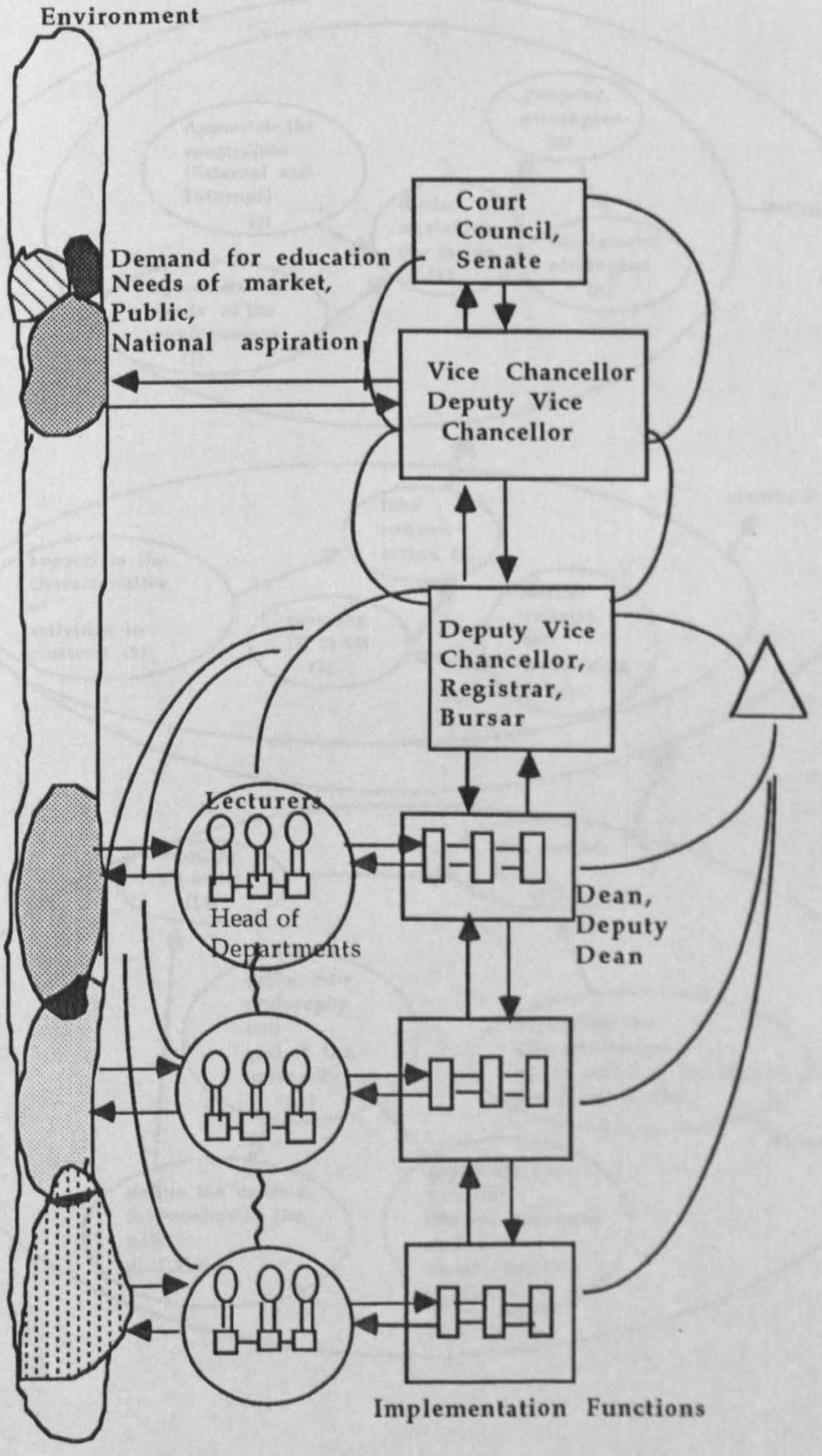
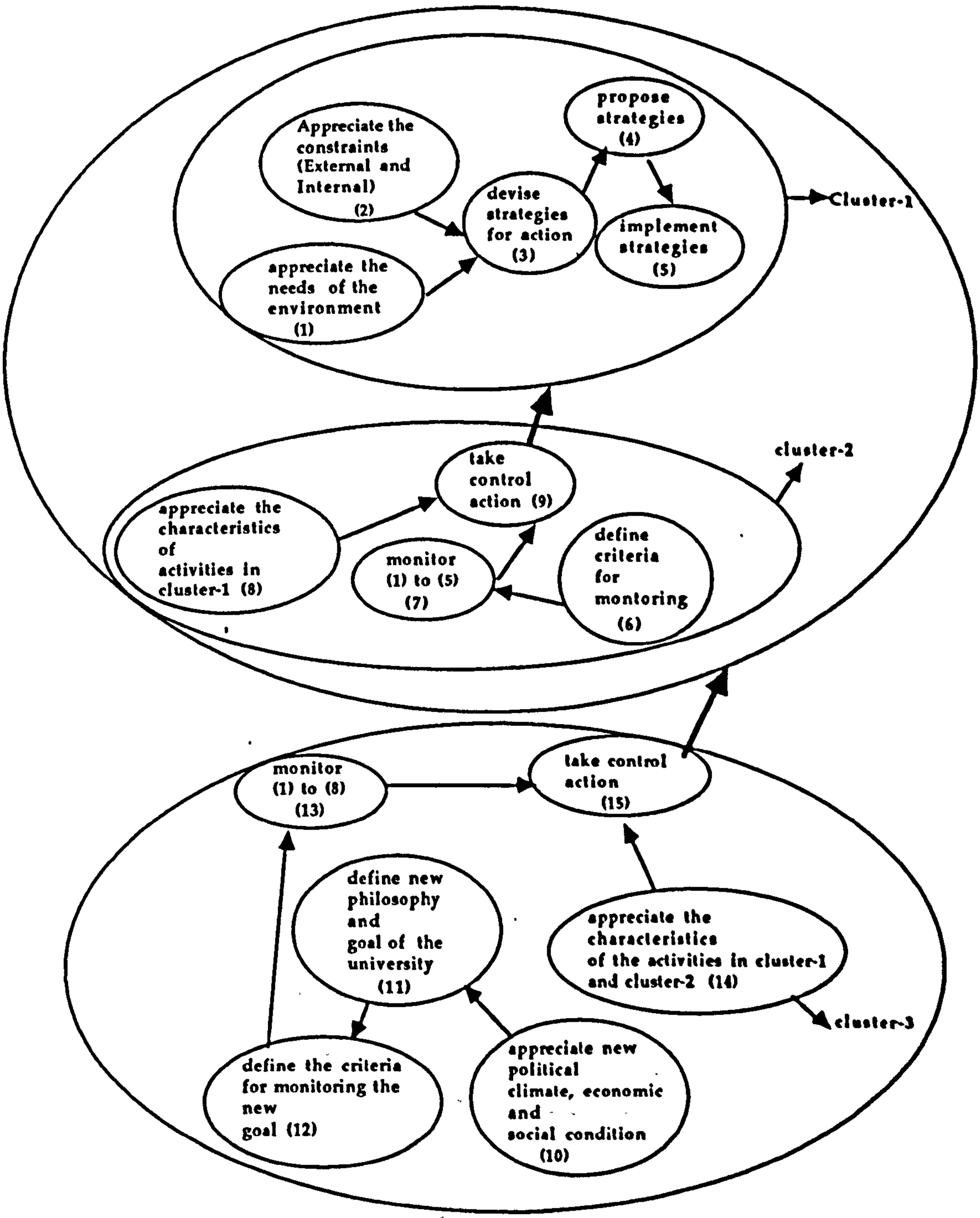


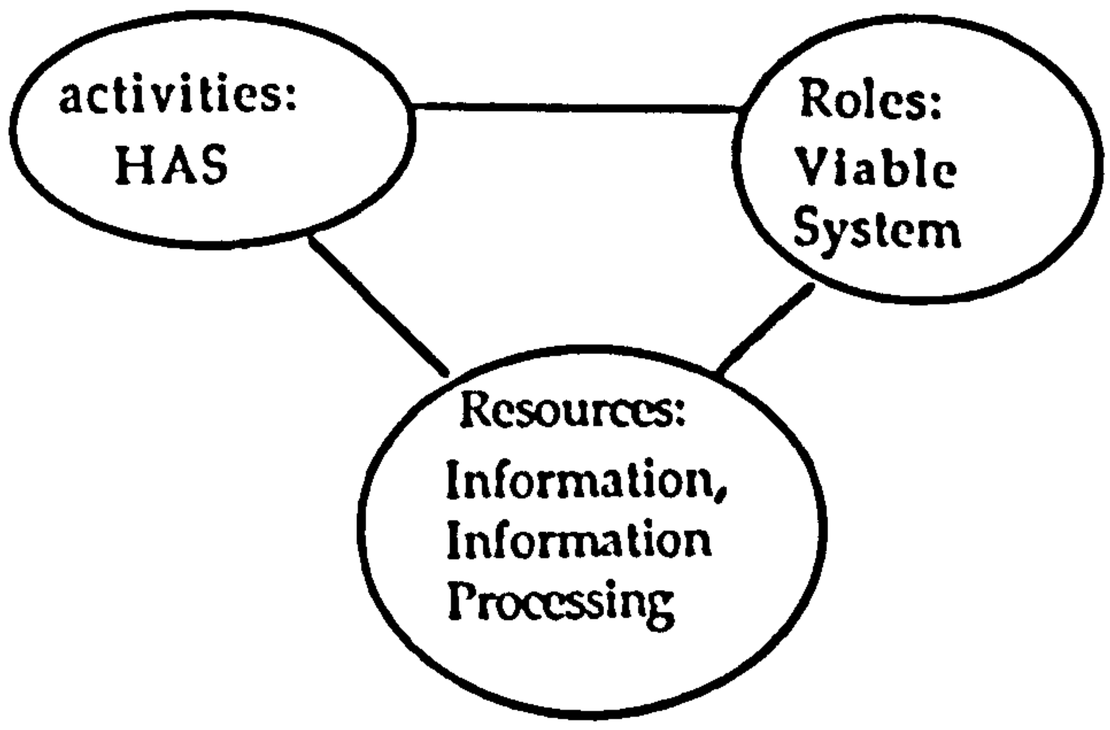
Diagram AP7: First Level HAS for the Management of University



Conclusion

Uncertainty as to what procedures and information to use to assist improving its performance in response to the changes in the environment constitutes much of the complexity of University Administration. Accordingly in the development of Information Systems for the Administration, efforts need to be put into identifying relevant procedures and information, who should be doing what and what information they need. This paper describes the use of the approach presented in this thesis to help in the development of such Information Systems. In particular the approach helps in modelling the University organisation in terms of three related basic entities: activities, role and resources. The activities are modelled in terms of HAS and role in terms of Viable Systems. The relationship between these three entities is shown in the following diagram AP 8.

Diagram AP8: Relationship Between Activities, Role and Resources



Activity relationships in HAS in diagram AP8 reflects exchange of information between activities and Role relationship reflects University organisational structure. An activity needs certain resources and this is reflected by the relationships between activity and resources. A particular role needs to carry out certain activities. This defines its functional specification.