"A Decision Support System (DSS) for Forward Housing Planning"

S. Assaf
University of Al-Baath
College of Architecture
Homs
Syria

ABSTRACT

This paper presents a specification of a Local Housing Strategy Decision Support System (LHS-DSS) (Conceptual and Physical model design). Emphasis throughout the design process is laid on the techniques that provide housing planners with accurate rapid assistance during the preparation process of local housing strategy. Relevant knowledge (descriptive, procedural, reasoning) and data about each step of the process, options for each situation as it arises, and a record of decisions made with underlying reasons are provided to system users. Three main components are identified to shape up the LHS-DSS: the language system for addressing housing problems; knowledge system which is responsible for gathering and accumulating the housing knowledge required; and problem processing system (an inquiry system) which produces suitable and effective recommendations to support the strategy preparation process.

1 INTRODUCTION

Information about the housing system provides the raw material for the housing strategy (forward planning) preparation process. Manipulating this information judiciously is the central function of the Local Housing Strategy Decision Support System (LHS-DSS) described in this paper. It is assumed for the purpose of this paper, that the processes of preparing local housing strategy include: data acquisition, data analysis, goal identification, policy formulation, plan alternatives, plan selection, and strategy documentation. These stages form the basis for guiding the process of DSS design.

Three types of knowledge can be identified as significant for such a DSS: i) descriptive describing the decision-making environment; ii) procedural about the best ways of carrying out analysis; and iii) reasoning concerned with conclusions to be drawn when certain situations exist. A system which is able to process all these three types in a coordinated integrated fashion, can be thought of as intelligent (Whinston et al., 1985).

This paper presents, the conceptual framework of the LHS-DSS. This includes, the design of each component and the integration of these parts into a single system.

2 PRELIMINARY CONSIDERATIONS

Prior to examining the design process of the LHS-DSS main components, it is essential to briefly elaborate on the following significant areas: i) user characteristics and associated needs, and expressed requirements of the housing information system; ii) relevant lessons drawn from current approaches; and iii) the optimum approach for addressing the housing planners' needs and requirements.

2.1 Housing Planners Characteristics and Associated Needs

It has been observed in most local housing authorities that the technical staff ranging from senior planners right through to lower level of employees, have little or no previous knowledge in programming or operating a computerized information system. It may be assumed, therefore, that any new computerized system should be counterproductive unless it were designed for non-programmer users who can access data through appropriate software interfaces.

Most housing planners interviewed expressed their needs as follows: i) to be involved in every step of the local housing preparation process (i.e. verifying and exploring data, formulate and modify strategy components, observe the outcome of the procedure execution, provide intuitive insights); ii) expect not be able to operate a DSS tool (lack of confidence, limited mathematical and computer background); iii) acquire new analytical and functional capabilities; iv) to gain a better view of how to approach the LHS process more systematically; v) to access a variety of technical methods (e.g., projecting, estimating, analyzing….etc.); and vi) to have improved access to the requisite housing data.

All in all, the foregoing present the salient user characteristics and associated needs of housing planners in local authorities investigated (Birmingham, Newcastle-Upon Tyne, Liverpool, Sheffield, Leeds). The findings indicate housing planners' low level of knowledge with respect to programming, housing data structuring and model building activities. It is essential to accommodate these needs and characteristics in the LHS-DSS in order to derive maximum benefit from the system.

2.2 Requirements of LHS-DSS

Interviewees expressed their requirements of the LHS-DSS to include: i) allowing the management of housing data at aggregate level (e.g., repair, arrears, homeless, households, land, ..etc.) without any concern for programming or data structuring; ii) providing analytical techniques such as headship rate and ratio methods; iii) having the capability of interfacing with other hardware and software packages; iv) supporting a consultation process to guide them in their strategy formulation; v) being transferable between different computers, reliable, forward looking, providing timely support and cost effective.

The requirements highlighted here indicate that the main characteristics of the LHS-DSS should subsequently encapsulate the capabilities for data management, models functioning to provide advice and support.

It is worth mentioning here that the software packages available in the local authorities visited are diverse, ranging from word processing to graphical software. The basic software packages importance for the LHS-DSS include, word processing, drawing, a programme language that supports mouse use, windowing, and pull-down menu drivers, spreadsheets, integrated software including a data base, chart making, and spreadsheet software, and graphical software (Whinston et al., 1985). The availability of these software packages contribute significantly to the effectiveness of LHS-DSS.

2.3 Useful Lessons from Existing Systems

By applying the experimental systems reviewed by several authors (see Morton Scott, 1984: Projector; Keen, 1977a: GPLAN; Revell, 1986: Energy Management DSS) to the environment in which local housing strategies are prepared, a comprehensive scenario of a typical LHS-DSS's architecture can be drawn up. In this structure, three main vital areas can be clearly identified; i) a module for reporting local housing problems through a variety of outputs such as reports, graphs, charts, etc.; ii) a module for accumulating the required housing knowledge; and iii) a module for guiding the systematic procedure identified for preparing housing strategies.

2.4 Conceptual LHS-DSS Design

Based on the aforementioned criteria, the highest level of conceptualization is to describe the LHS-DSS as comprising the following components: a language system (LS), a knowledge system (KS), and a problem processing system (PPS). These components are described as follows.

2.4.1 *Language System (LS)*

This is a unit for representing the semantics of local housing problems. It determines what can or cannot be requested from a problem processor component, and supports the housing planner in communicating with the system by providing various interface styles for stating problems. Generally speaking, these include menu-guided, form-filling, command-oriented and question-answer (conversational) methods to deal with problem specifications. This is termed by Sprague (1982) a user dialogue generation and management system.

2.4.2 *Knowledge System (KS)*

This is the unit for accumulating local housing knowledge. Its knowledge can be classified into three types: descriptive, procedural, and reasoning as elaborated in the following.

Descriptive Housing Knowledge

This category includes quantitative and qualitative housing facts (data), and information related to each local housing authority. The requirement to draw on a substantial volume of complex housing data calls for a data base module in the LHS-DSS. A relational data base is proposed (see Al-Assaf, 1996) to enable the housing planner to make regular comparisons between the housing situation in different areas. The extent of housing needs, the incidence of repairs, HIP expenditure, rent arrears, voids, and time lags, for example, can be constantly reviewed by housing planners against comparable situations, and any shortcomings can be identified. Housing area needs can be aggregated, in the relational data base, so that local housing needs can be checked and reviewed in a reliable manner. Moreover, comparable statistics from other schemes and housing programmes can be called on to enable the housing planner to make decisions as to whether they are facing the same problems and whether the relevant initiatives would be of value in the current situation. The size of this relational data base will vary from one local housing authority to another depending on the extent and complexity of the urban area.

Procedural Knowledge

This embraces the analytical models used by housing planners in local authorities (population and household projections, housing stock estimation, land forecasting, and so on). These models and their relevant techniques (headship rate methods, ratio methods, ..etc.) are employed to facilitate the housing analysis phase, allowing planners to concentrate their efforts on interpretation of the results. These are quantitative procedures which can be represented by a model base. Since different local authorities employ varying sets of models for analyzing housing problems, this model base has to be designed with flexibility, in order to allow for additions, amendments, modifications and indeed for removal of models.

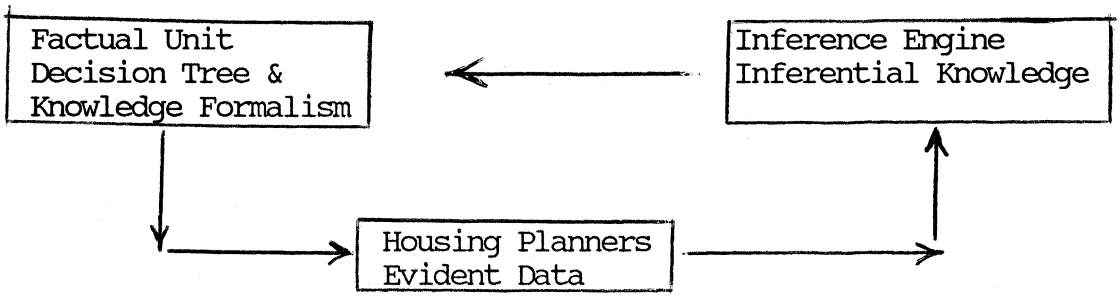
Reasoning Housing Knowledge

The logic that determines the conversational dialogue with the housing planners is to located in this section. The main purpose of this type of knowledge is to augment housing planners' expertise in: i) digesting ill-structured housing problems (at this level the problem encountered in decision making cannot be fully defined and do not exhibit clear criteria for choosing a best solution); and ii) selecting the best plan or appropriate alternatives.

It is significant that housing planners, after identifying problems in their locality, consult an independent "expert" who can assist and advise them on the appropriate components for formulating their strategies. The reasoning base component to the LHS-DSS can be thought of as the independent "expert" that provides a consultation facility with regard to the strategy components to be followed and the order in which to implement them (i.e. goals, policies, plans, programmes). It comprises a declarative hierarchical knowledge structure for qualitative inferencing. Conceptually, it consists of two basic elements as set out below:-

(1) A Factual unit (knowledge Base) as part of the knowledge system represented by: i) a housing strategy components content tree; and ii) a production rules formalism for representing the knowledge of this tree context.
(2) An inference engine (reasoning unit) which is applicable to the above factual knowledge on the evidence and data provided from consultation with the housing planner (figure.1).

Figure 1: **Reasoning Base's Main Components "Conceptual Model"**



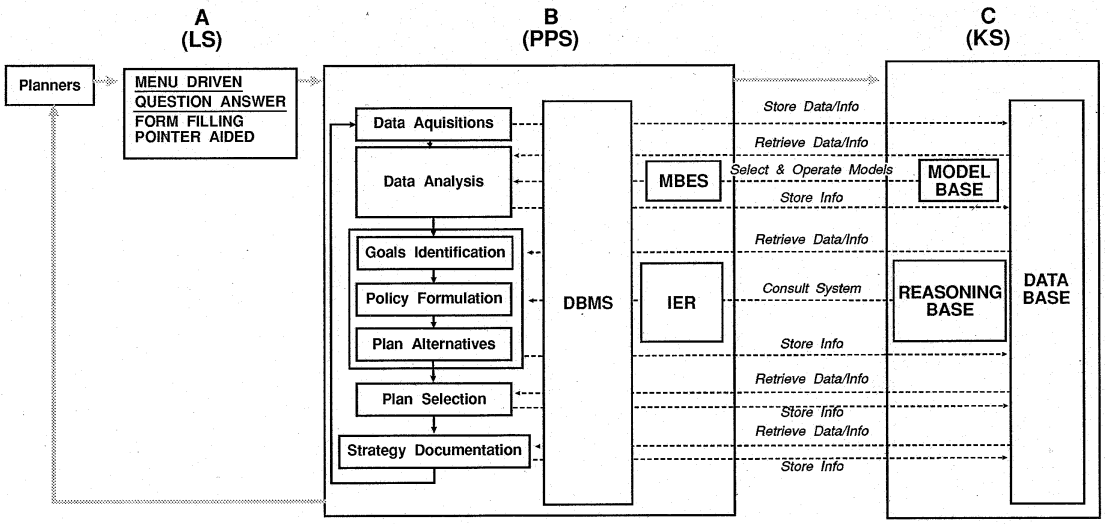
In addition, the basic proposed functional capabilities are classified into the two functions of consultation and explanation. These include: i) detect priorities of housing goals, related policies and subsequent notions (programmes); ii) determine appropriateness of the above linked components; iii) evaluate evidence; and iv) recommend (advise) the best course of action.
The reasoning base is written in Prolog Language since it is a readily available and flexible tool for low cost micro-computers.

In principle the knowledge system attempts to integrate several software components into one system, termed by Whinston et al (1985) as "systematic integration".
It must be borne in mind that for control purposes (i.e. easy access into a specific area in the knowledge system) of the above three knowledge bases in handling all the required housing data and information, the techniques of classification and cataloguing will be adopted. Accordingly, the system incorporates a data catalogue and information catalogue for defining the housing data and information structures.

2.4.3 *Problem Processing System (PPS)*
This is the active software component of LHS-DSS. With regard to the knowledge system, corresponding knowledge processing abilities must exist in the problem processing system (Holsapple, 1986). In consequence, the PPS software includes; a database management system (DBMS), a model base execution system (MBES) and inference engine reasoning (IER). This combined problem processor (or inquiry system) with synergistically integrated capabilities, including facilities for housing knowledge formalism processing is characterized by Holsapple (1986) as an artificial intelligent DSS.

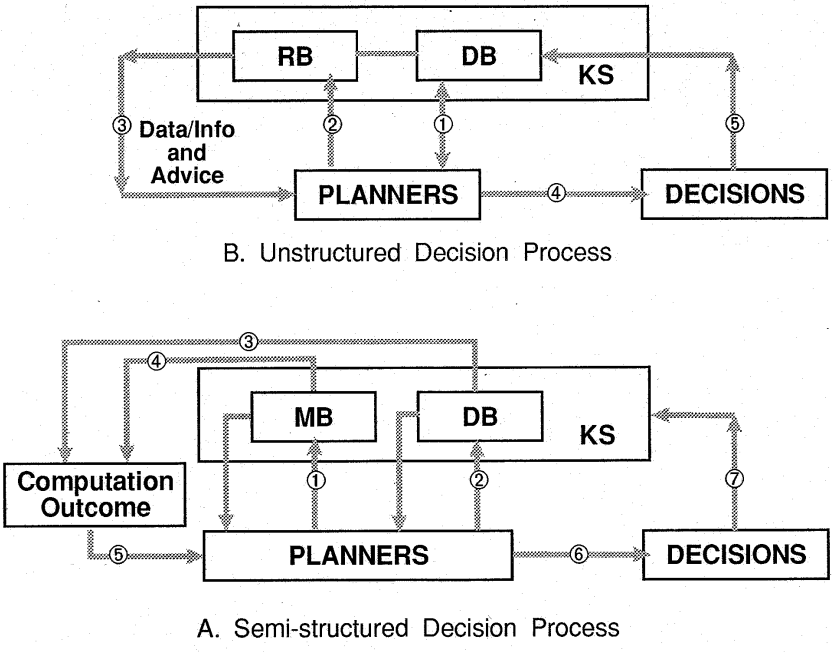
When the components described above are applied to the housing strategy preparation process, a conceptual LHS-DSS model as described in figure.2 emerges. The content of the problem processing system interface function is summarized in the figure.

Figure 2: **LHS-DSS Conceptual Model**



The content of the PPS box shows the strategy preparation model cycle in which three different parts can be distinguished. The first, relates to housing problem exploration and definition, as well as future trends (data acquisition and analysis, semistructured tasks); the second relates to the formulation of alternative solutions (stages 3, 4, and 5 of the process, unstructured tasks); and the third, relates to the selection and evaluation of alternatives (stage 6). These stages correspond to Simon's three major stages of the decision process (intelligence, design and advice, see Simon, 1970). From the point of view of decision analysis and methodology, two features of the LHS-DSS can be clearly recognized as shown in figures.3a and 3b. These figures indicate a typical planner-LHS-DSS interaction in the local housing preparation process.

Figure 3: A **Typical Planner-System Interaction in Local Housing Strategy Preparation Process**



The LHS-DSS conceptual framework described here therefore systematically converts the stages of preparing local housing strategies into planner-machine interface dialogues. These dialogues generate briefs, facts or expectations, guidance and advice for future housing strategies.

The conceptualized LHS-DSS breaks the strategy process into an “open” “flexible” menu of selected modules, each of which can be understood, modified, adjusted and controlled by housing planners, and interwoven into the standard step by step human processing sequence. This model is, in connection with the above analysis, intended to be: i) easy to use by non-programmer planners; ii) easily maintained by high-level language programmers; iii) easily supported selective interaction dialogues (menu-selection, conversation “question-answer”); iv) easily integrated with required software packages such as graphics; v) capable of advising housing planners; and vi) flexible and compatible with regard to the parts available within the different authorities and various planners. I will need to be able to support variations (across implementing housing authorities) in: (a) housing data and information (analysis) structures; (b) analytical models; and © hierarchical strategy components.

The next section moves from conceptual to physical design.

3 PHYSICAL LHS-DSS DESIGN

This section elaborates on the above conceptual model components, examining two areas; first, the design of the parts of each component of the LHS-DSS, and then the most effective way that these parts can work together.
It is envisaged that the design of the LHS-DSS, should render it adaptable and applicable to most local housing authorities, enabling housing planners to: scan data and information rapidly; highlight problems and key trends; identify priorities for any future housing development; and focus on the overall situation rather than on details isolated in their own context.

3.1 Files

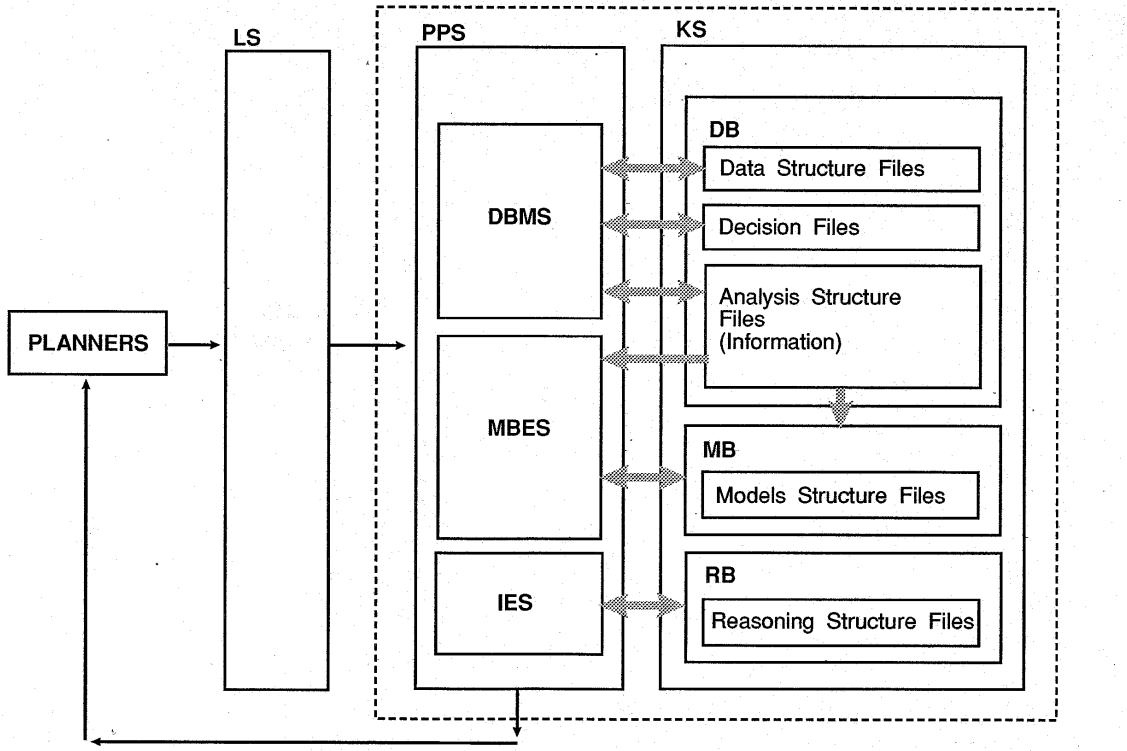
Prior to discussing the design details of each component in the LHS-DSS (KS, LS, PPS), this section examines the type of files forming the basis of the system. This is an essential step in designing the mechanisms of data storage, retrieval, and consultation.

Based on the requirements identified in the previous exposition, a command file approach is proposed to enable the planner to access a wanted area of the LHS-DSS with maximum ease. This is seen as having two main functions as follows: i) Creating housing data and information catalogues. As a result of the enormous variety of housing data and information relating to preparation of local housing strategies, there is a need to create a source of central intelligence which will efficiently identify relevant housing data. The objective of this function is to bring together into a comprehensive catalogue a full description of all relevant data holdings in the system. ii) Building a file access method with regard to each base identified in the knowledge system.

The basic types of files to be used in this approach are:-
(i) housing data structure files;
(ii) housing analysis (information) structure files;
(iii) housing model files;
(iv) housing reasoning structure files; and
(v) housing decision files.

The LHS-DSS components provide the main connecting channels between the housing planners and the above five types of file. Access and modification for the above type of files must be essentially simple and straight forward, in order to render the LHS-DSS immediately suitable for a specific situation without making the change in its main structure. The relationship between the five types of file and the LHS-DSS components is shown in figure.4 below. In this figure, every type of file, related to its own base, can be accessed through the adopted menu-driven style in the language system. The access mechanism which depicts the relationships shown is illustrated by examining each type of the file command approach.

Figure 4: **The Applications of the Command Files Approach into the LHS-DSS Components**



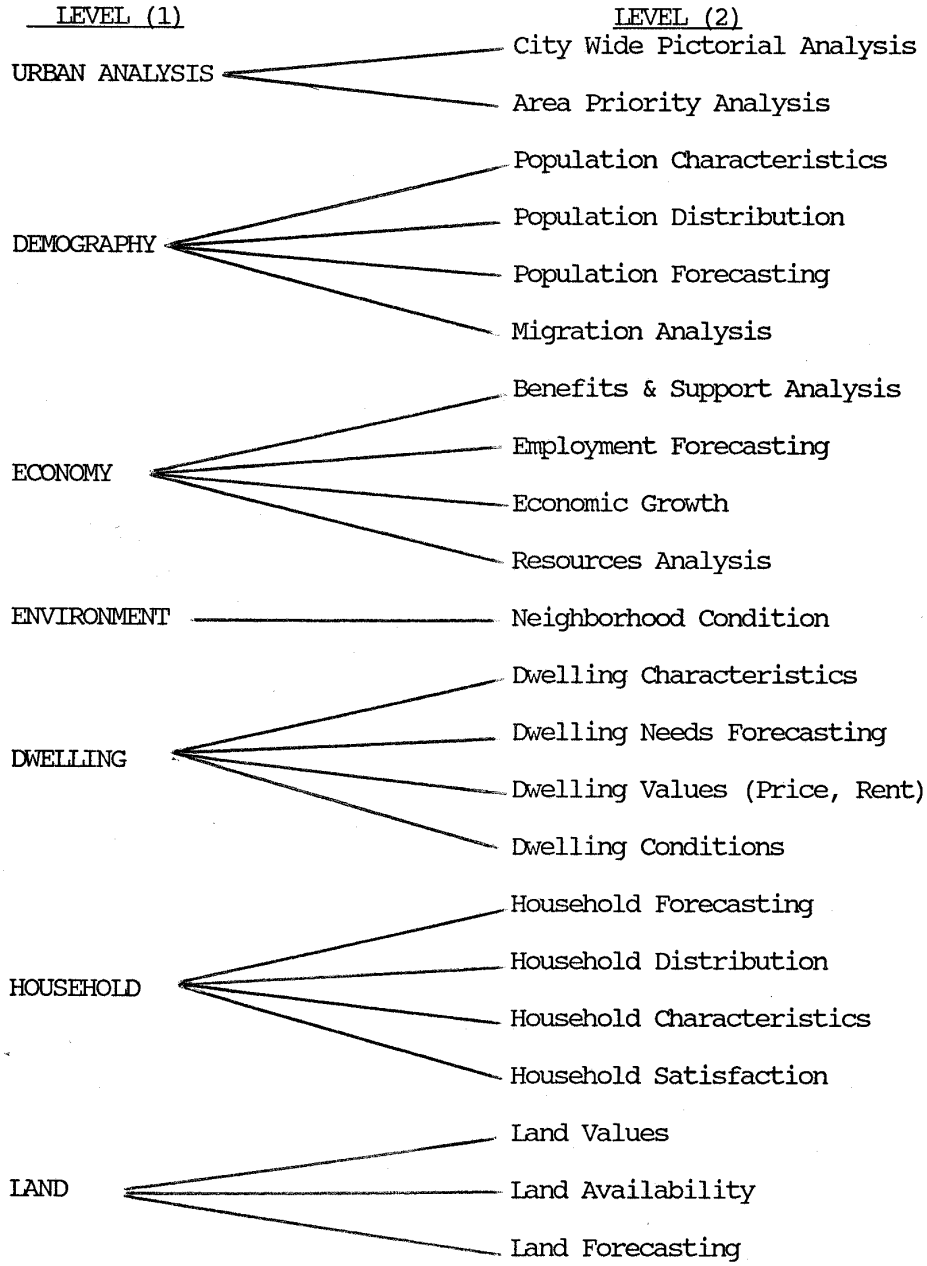
(i) Base Data Files

These files are constructed in a relational data base that includes five relation: development (goals and policies); programmatic (plans and programmes); activity (dynamic transformation entities); descriptive and demographic (housing main entities). These files are held in the knowledge component. The PPS will offer, in turn, a menu containing the five relational housing data categories, so that the housing planner can access any relation directly. The contents of each relation have been fully depicted in Assaf (1996).

(ii) Analysis Files

This is organized by adopting a tree structure technique involving two hierarchical levels (figure.5). This hierarchical structure reflects the analysis (information) base of the LHS-DSS data base structure. The PPS will provide here a menu containing the six analytical categories (level 1) of which each one is linked with another menu listing the related sub-categories (files). These files which contain the output of housing analysis can be accessed directly by the housing planners.

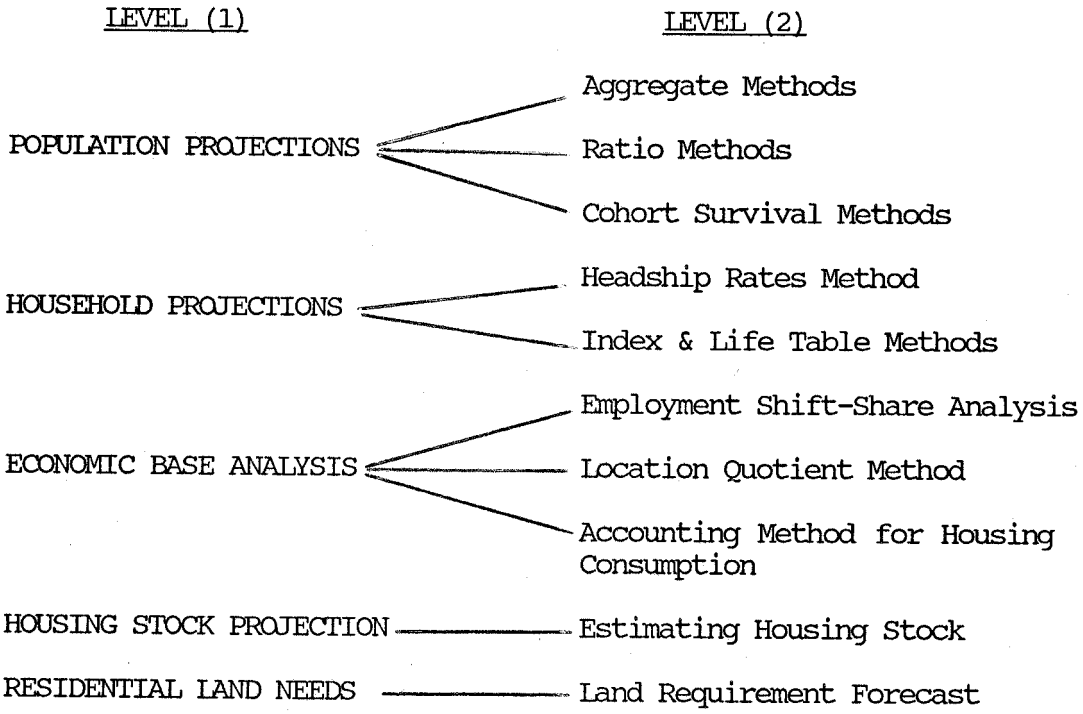
Figure 5: **Two Levels of Housing Analysis "Hierarchical Structure"**



(iii) Housing Model Files

This contains a list of models employed by local housing authorities for carrying out analysis tasks. Likewise, two levels are prepared to depict the identified models and their related technical methods. These two levels reflect the model base in the knowledge system (KS) (figure.6). Accessing each model and related methods is also facilitated by menu as above.

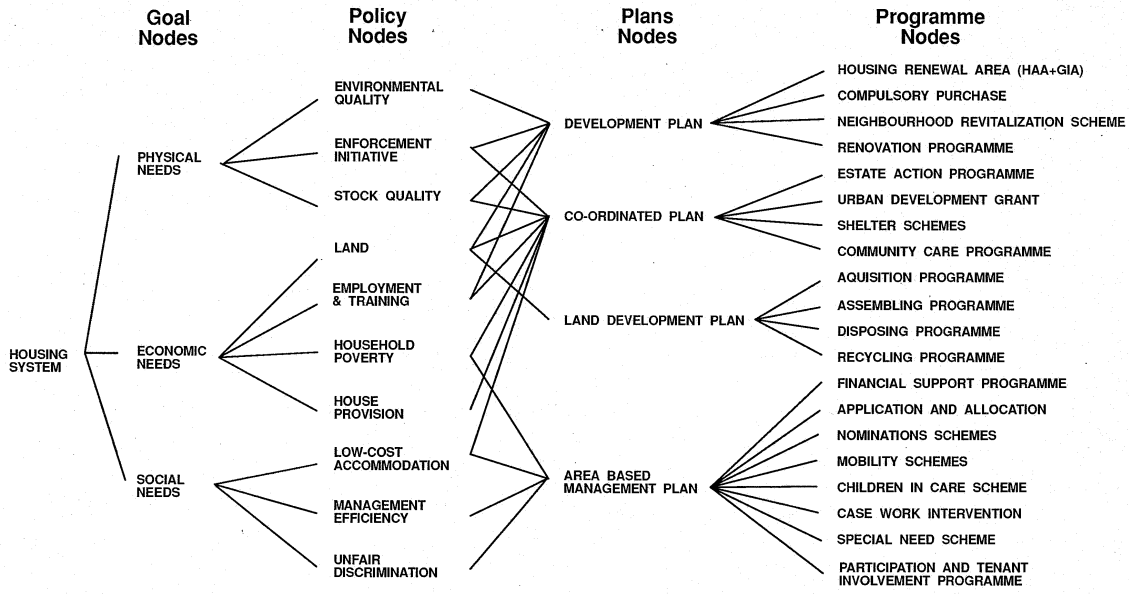
Figure 6: **Housing Models and Related Techniques**



(iv) Reasoning Files

Based on the foregoing factors that strategic housing decisions are potentially unstructured, housing planners typically express the need for animation in decision making and the nature of the knowledge can be described as well-bound technical, an attempt is made in the following to formalize the process of strategic housing management using decision tree suitable for automated reasoning. In this decision tree the existing local housing goals, policies, plans and programmes are organized into a hierarchical structure, in order to generate a tool for intelligent planning. According to Harty (1972), constructing a goal hierarchy can be considered as an effective way of generating an intelligent plan. Wyatt (1988) carried this argument further in maintaining that, when constructing goal hierarchies, there is a need to start with the most abstract ideal possible and then gradually move to more specific goals as one succeeds through the levels. In order for strategic housing management to proceed in a logical, consistent and intelligent manner, two prime factors are to be considered when constructing the hierarchical strategy components structure. The so called decision tree representing a strategy should be acceptable to users and be comprehensive. Figure.7 represents the housing strategy components context tree (or decision tree).

Figure 7: **Proposed Local Housing Strategy Decision Graph**



Four types or families of nodes are shown in this tree viz, housing goal nodes, housing policy nodes, housing plans nodes and housing programmes nodes. These nodes are connected to each other in a general structure. The arcs drawn between the tree nodes represent connections that have been derived after analysis of the different local strategy documents collected during an examination of existing strategy formulation processes. In order to avoid over complexity some weak connections between the different families of nodes have not been drawn, although they will be considered later in formalizing an appropriate knowledge base. This knowledge may be represented in a file or several files. The files which depict the knowledge of the decision tree shown here will be reflected in the reasoning base as part of the knowledge system (KS). The above structure presents a clear picture of what a local housing strategy tries to achieve through the relevant components (goals, policies, plans and programmes). Its main function will be that of advising housing planners to prioritize goals and related policies, and specify appropriate plans and programmes for such a proposed development.

(v) Decision Files

These files are the bases for storing and retrieving agreed decisions between housing planners and other housing bodies (e.g., community groups, banks, building societies, national and local housing associations, etc…). This type of files is stored in the LHS-DSS data base.

The foregoing file structure provides a sound basis for developing and organizing a physical model of the LHS-DSS knowledge system.

3.2 Physical Specifications of LS, KS, PPS

The main objective of this section is to provide an integrated LHS-DSS physical model illustrating the integrated relationships among its components.

3.2.1 *The LHS-DSS Knowledge System's Physical Structure*

Three different representation techniques were identified and delineated earlier in this paper, notably the database, model base, and reasoning base. This section is concerned with a discussion of the physical structure of these components. The structure of the knowledge system has been chosen in such a way as to reflect the structure of housing data, analysis, models, goals, policies, plans and programmes in the local housing authorities investigated.

1) LHS-DSS Knowledge System Data Base

This is the main mechanism here for storing housing data and the processed information thereof on computer. This data base is actually a combination of two main integrated parts. The first representing the related data base with all its identified entities (i.e. dwellings, households, land, population, homeless, activities, programmes, plans, policies and goals) and their descriptors (predicates), which hold the data required by housing planners (see Al-Assaf, 1996). The second relates to the processed housing information which is the result of such analysis as well as the information as regards various decisions taken during the preparation process (i.e. analysis and decision files). A discussion of the physical storage description of this data base files will now follows, together with an exploration of the areas for selecting the appropriate mechanism used in organizing these files.

It is assumed that the LHS-DSS would used floppy as well as hard disks, as the mechanism for storing housing data, information and files of decisions taken to be used as precedents.

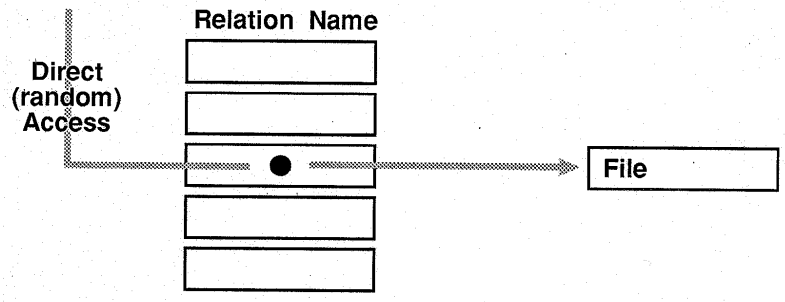
There is a considerable choice of methods of organizing files (e.g., serial, sequential, indexed, random,…etc., see Dean, 1985). The direct access method has been adopted in this present research as providing a faster method in accessing a file.

Within the data base, access to housing data and information files is guided by data and information catalogue files. These two files which are created in tabular form provide a summary of knowledge of all extant data and information files on a subject together with relationships with other models and reasoning files. The contents of these catalogue files are as follows. i) Housing data file catalogue: data type number, relation name, file code, location, data update, comments, relevant model name, relevant reasoning formalism structure. ii) Housing information file catalogue: information type number, analysis name, sub-analysis name, file code, location, data update, comments, relevant model name, relevant reasoning formalism structure.

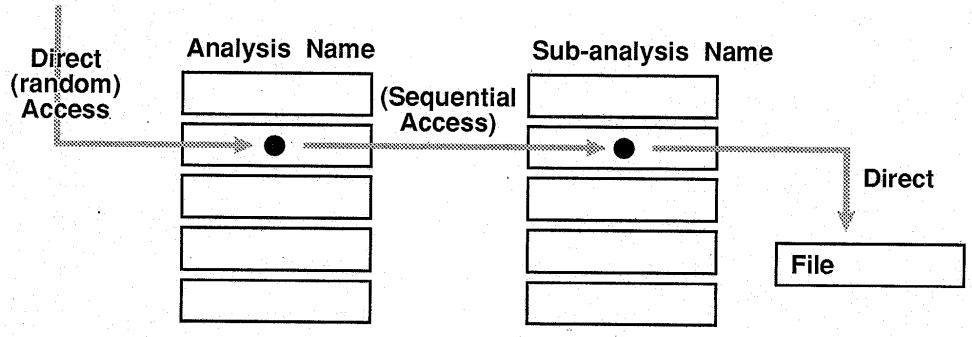
Two methods are employed in the data base (figure.8); i) a direct (random) access method which is required to find any relational and catalogue file; and ii) direct and sequential methods for allocating a piece of information or a decision file.

Powers et al (1984) comment that the sequential technique is appropriate for any application where there is a need for both logical sequential access and direct access.

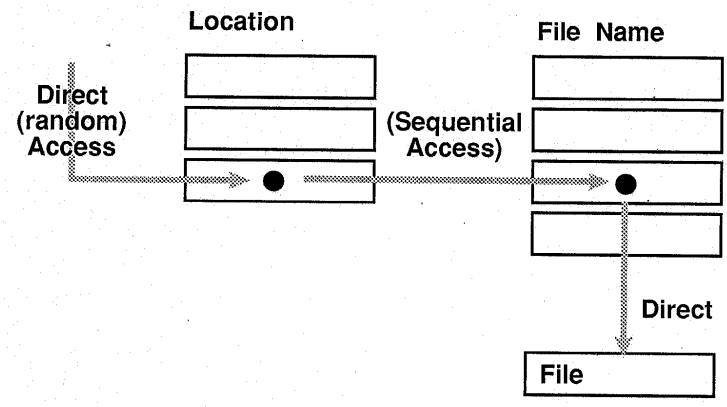
Figure 8: **Mechanisms for File Access in Data Base**



i. Accessing a Housing Data File



ii. Accessing a Housing Information File



iii. Accessing a Housing Decision File

2) LHS-DSS Knowledge System Model Base

This includes the analytical models and their related methods that are identified in figure.6. Storage mechanisms for these techniques are similar to those described in the foregoing files. The direct access method can similarly be used for accessing a technical method from the model base. Since models are computer programmes, it must be emphasized that changing a model is only possible through modifying the computer programme.

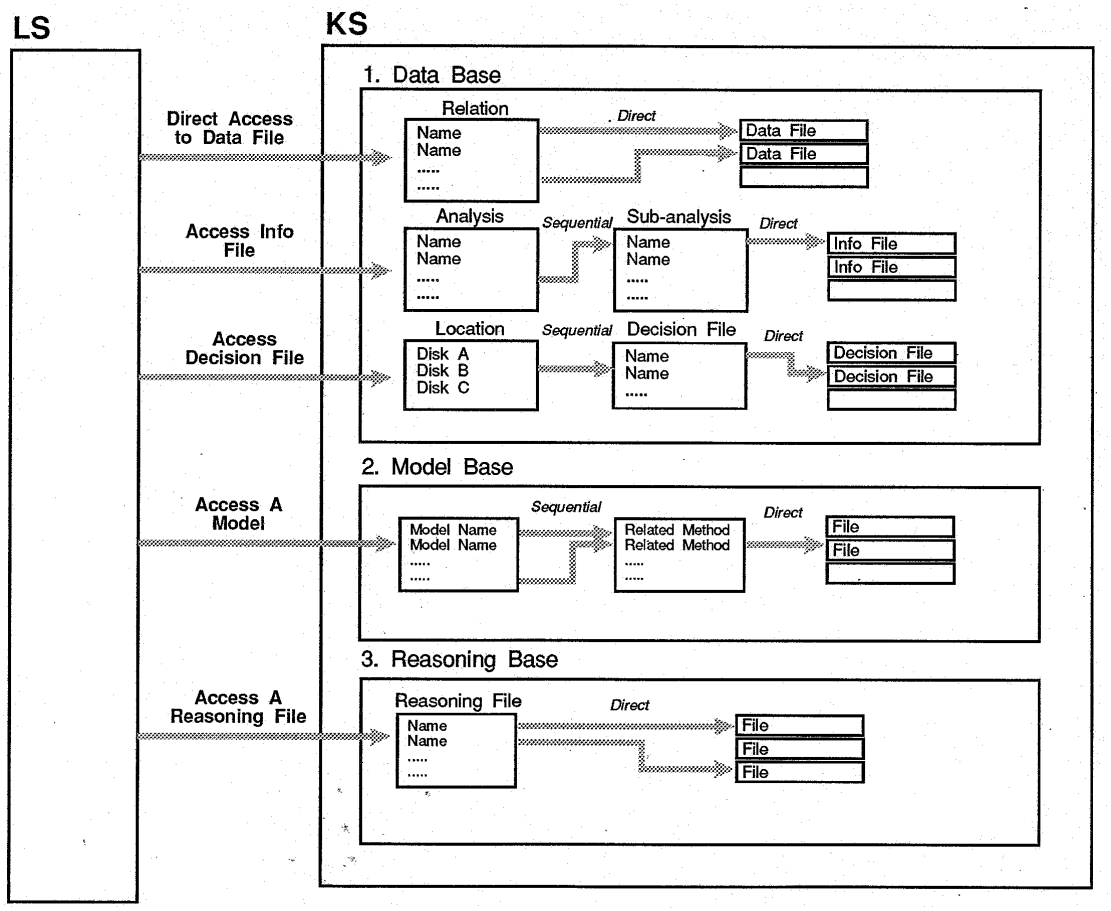
3) LHS-DSS Knowledge System Reasoning Base

The main objective here is to create knowledge (reasoning) files which represent facts, relationships, procedures and afford an exposition of descriptive attributes concerned with the housing strategy components i.e., goals, policies, plans and programmes. The knowledge structure is formalized here in a production rules technique. The storage

mechanisms are similar to those outlined in the previous section; the direct (random) access method is also employed in this reasoning base too.

The scheme proposed above, brings the LHS-DSS knowledge system to the construction stage, and figure.9 summarizes the structure of the physical model originating from the command approach mentioned earlier.

Figure 9: **The Knowledge System Design Structure "Physical Model"**



3.2.2 *The LHS-DSS Language System Physical Structure*

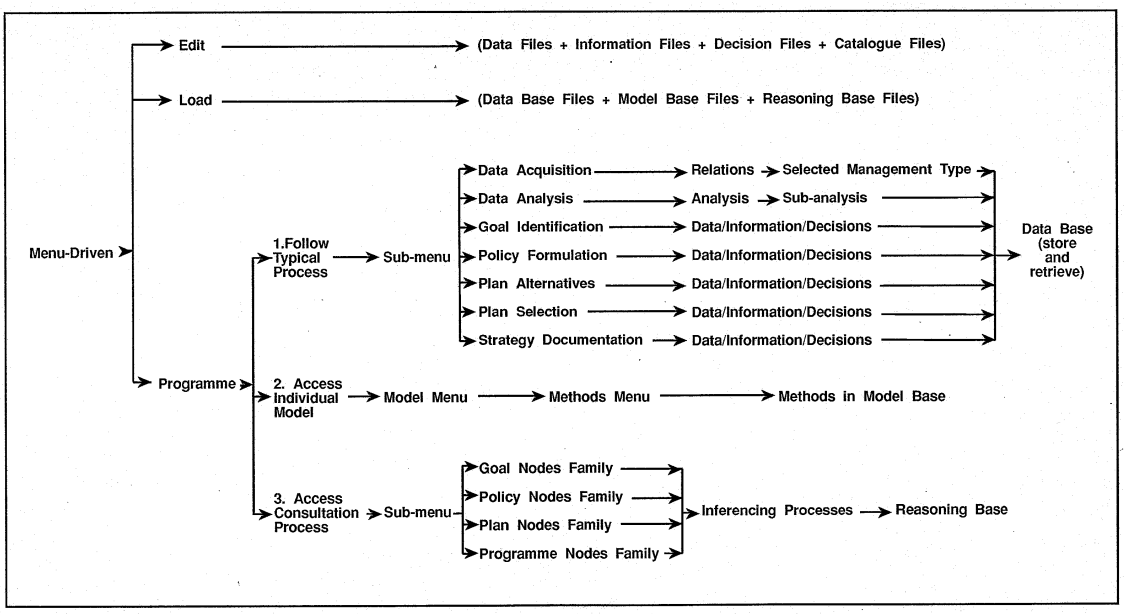
This structure is composed of software that interfaces between the housing planners and the LHS-DSS. It encompasses retrieval and computational capabilities through the dialogues provided. Its main function is to organize strings of symbols according to its syntax. These symbols are used together with the KS symbols through the PPS software components (which are discussed later), in order to produce information in support of the housing strategy preparation process. To achieve this, two interfacing techniques, for representing housing problems, are employed:- i) a menu-driven technique for a process guidance; and ii) a question-answer (conversational) technique for data input.

Figure.10, illustrates such a design framework using the above two techniques. Several standard options are offered for the housing planners to carry out their tasks: i) selecting a programme; ii) loading a file (database, decision); and iii) editing a file (catalogue file, ordinary file).

Furthermore, when considering a programme option, for example, three other identified sub-options are provided namely to: i) follow up a standard defined process; access individual analytical techniques; and iii) access an advisory unit through the menu option. This provides the planner with a consultation display process through its conversational techniques for analytical purposes.

This flexibility is considered highly desirable in designing the menu contents, with a view to the housing planner being able to compose his/her own dialogue process style.

Figure 10: **Menu Contents Design in the Language System Software Dialogue**



3.2.3 *The LHS-DSS Problem Processing System: Physical Structure*

This is defined by Bosman (1983) as the interfacing mechanism between expressions of knowledge in the KS and expressions of problems in the LS.

1) Data Base Management System (DBMS)

The main function of this system is to manipulate housing data, information and decision input and output in the data base. This manipulation is achieved by means of two main tools; a powerful data manipulation language (DML) and a screen manipulation language (SML) (Bonczek et al., 1983). These provide the DBMS with the capabilities of creating, editing, displaying and selecting a file.

2) Model Base Execution System (MBES)

Its main function is to process the housing data by means of the computational models. A Model manipulation language (MML), and a Screen manipulation language (SML) are used for this function. These tools direct the planner in selecting and operating the required models for analytical purposes.

3) Inference Engine System

This is defined by Barrett and Beerel (1988) as a set of routines which carry out deductive reasoning by applying the know-how in the knowledge file of a reasoning base. Its main function in the LHS-DSS is to use the adopted production rules formalism (which is not the subject of this paper) and facts in the reasoning base to advise housing planners in selecting the most appropriate goals, policies, plans and programmes for the local housing strategy. The two main strategies of inference are backward and forward chaining.

i) Under the backward chaining approach, the planner for example, might set the following goal: "is housing improvement programme A suitable for area X". Using the backward chaining, the advisory unit would use a planner's know-how about how to choose between various options plus data about the area and various context parameters in order to deduce whether or not programme A is suitable.
ii) In the forward chaining, to continue the above improvement example, the planner might state: "Public stock is physically bad in area A, so what?", the planner is seeking for a reaction, testing to see what conclusion might emerge from the above information.

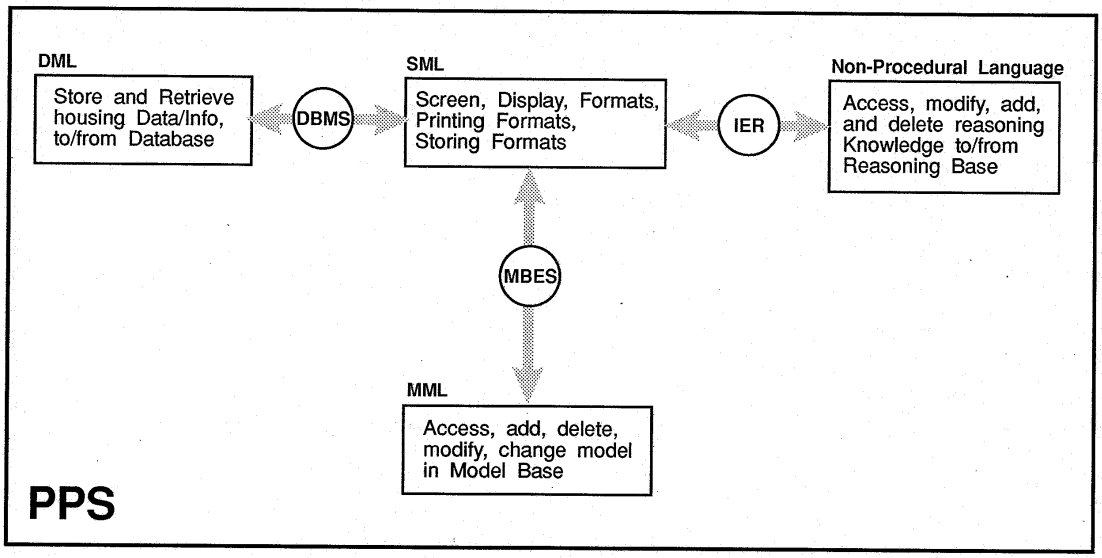
The backward chaining strategy shows more relevancy to the knowledge context of strategy components than the forward chaining strategy. This is due to the fact that:

i) its mechanism complies with the way planners think of eliminating inappropriate components;
ii) the imposed link between the strategy components (goals, policies, plans, programmes) which requires solving inquiries (problems) with more start states at every family level; and
iii) the intention to use prolog software which makes it easier to develop because of its backtracking feature.

To implement the above reasoning processes, two tools are used: a screen management language (SML); and a non procedural language of which planners can state their inputs in a non-procedural sense, and the system will extract data, handle linkages, and do all other necessary steps in order to provide the recommendations (advice).

To conclude, the foregoing discussion has shown that the three elements of the problem processing system DBMS, MBES, and IER possess an extensive repertoire of knowledge processing capabilities which are indispensable to housing planners. The overall structure of these capabilities is shown in figure.11.

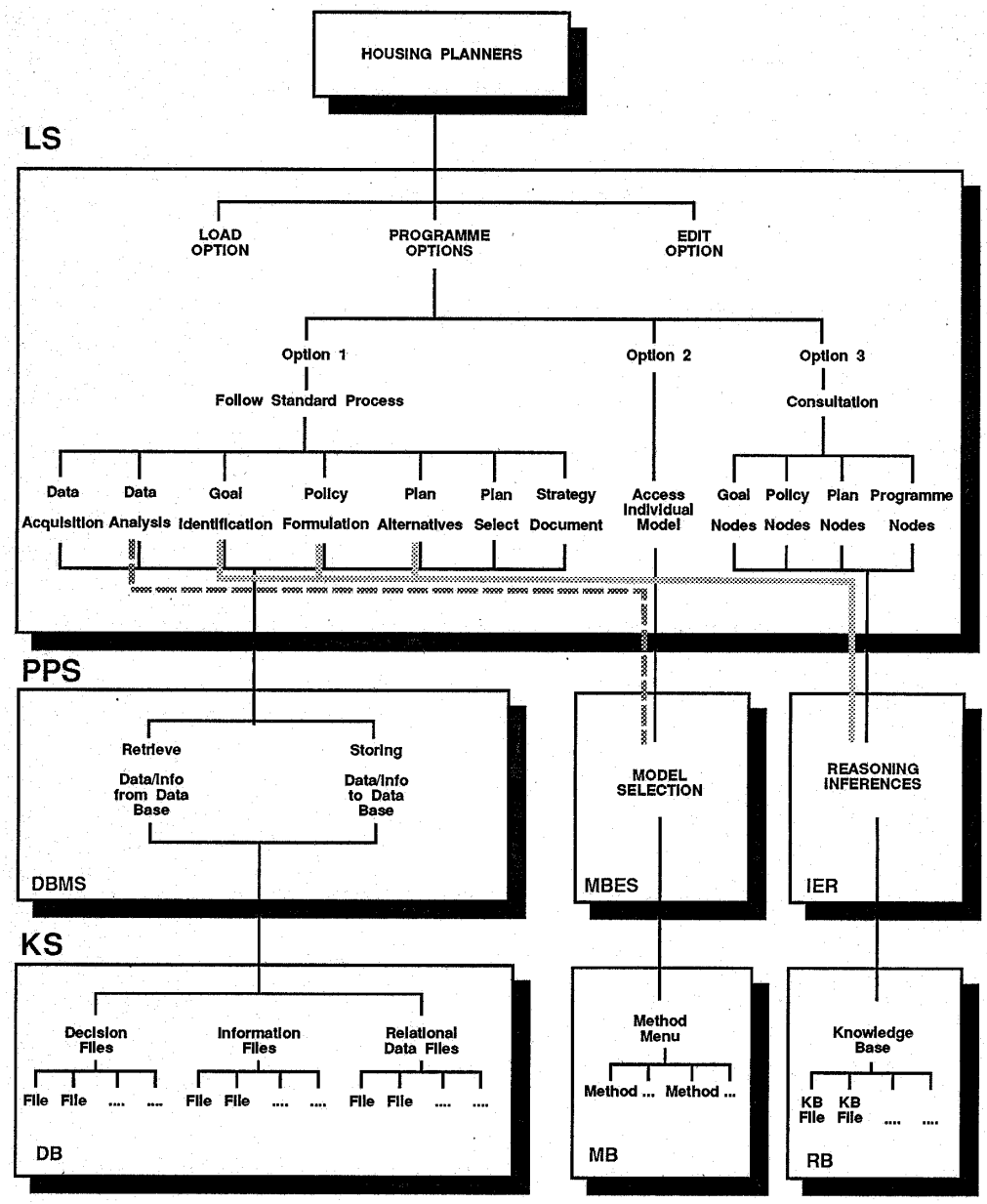
Figure 11: **Capabilities' Structure of the PPS "An Integrated Approach"**



3.3 A Final Integrated Framework

Having examined the structure of the LHS-DSS by each of its components, the architectural design can now be specified clearly indicating the interrelationships among its components which together perform an integrated approach to achieving the objectives of an LHS-DSS. Figure.12, illustrates the components interrelationships. These interrelationships reflect Methlie's observation (1986) that " a good system is the one which processes data through analytical procedure before being used in the inferential logic of the reasoning system".

Figure 12: **The Physical Model of the LHS-DSS "An Integrated Interrelationships"**



4 CONCLUSION

In the first part of this paper it was suggested that the majority of housing planners are non-programmers who prefer a flexible system using a microcomputer PC. In the second part, several lessons for designing the LHS-DSS were presented. Three main areas were identified: addressing housing planners inquiries and problems intelligently (LS); gathering and accumulating the required housing knowledge (KS); and producing suitable effective responses to support the strategy preparation process (PPS).

This paper has been about the conceptual and physical design of a LHS-DSS which provides assistance in the following functional areas:

i) identifying potential housing problems though data and information scanning in the data base;
ii) understanding the problem area through the analysis stage;
iii) advising on selection of alternative component options for the housing strategy; and
iv) monitoring the consequences of earlier decisions.

5 REFERENCES

Al-Assaf S, 1996, "**An Intelligent Spatial Data Base for Strategic Housing Management"**, Journal of the Institute of Middle East Studies "Almamun", Issue1, March 1996, pp. 41-62, Greece.

Barrett M.L, and Beerel A.C, 1988, **"Expert System in Business: A Practical Approach"**, Chichester: Ellis Horwood.

Bonczek et al., 1983, **"The DSS Development System"**, Proceedings to 1983 National Computer Conference, pp. 421-435.

Bosman A, 1983**, "Decision Support Systems, Problem Processing and Coordination"**, In: Sol H.G, (ed.), Process and Tools for Decision Support, North-Holland Publishing Company, IFIP, pp.79-90.

Dean S.M, 1985**, "Principles and Practice of Database Systems"**, Macmillan Press, London.

Harty H.P, 1972, **"Criteria for Evaluation in Planning State and Local Programmes"**, In: Robinson I.M, (ed.), Decision-Making in Urban Planning, Beverly Hills, California: Sage.

Holsapple C.W, and Whinston A.B, 1986, **"Decision Support Systems: Theory and Applications"**, Verlag Berlin Heidelberg, New York.

Keen P.G.W, 1977a, **"The Evolving Concept of Optimality"**, In: Starr et al., (ed.), Multi-Criteria Decision Making, The Institute of Management Sciences (TIMS) Studies in the Management Sciences, Vol.6, pp.31-57.

Methlie L.B, 1986, **"On Knowledge-Based DSS for Financial Diagnostics"**, In: Holsapple and Whinston (ed.), Decision Support System: Theory and Applications, pp.335-373.

Morton M.S. Scott, 1984, **"Expert Decision Support Systems"**, Paper presented at a Special DSS Conference, Planning Executive Institute and Information Technology Institute, May, New York, pp.21-22.

Powers et al., 1984, **"Computer Information Systems Development: Analysis and Design"**, South-Western Publishing Co., Cincinnati, Ohio.

Revell N, 1986, **"Decision Support Systems: A Case Study in the Use of DBMS Technology in Energy Management"**, In: Holsapple and Whinston , (ed.), Decision Support Systems: Theory and Applications, pp.391-411.

Simon H.A, 1970, **"Management and Decision Making"**, In: Taviss I (ed.), The Computer Impact, Englewood Cliffs, Prentice-Hall, New Jersey, p.59.

Sprague R.H, and Carlson E.D, 1982, **"Building Effective Decision Support Systems"**, Englewood Cliffs, Prentice-Hall, New Jersey.

Whinston et al., 1985, **"The Use of Synergistic Integration"**, Working Paper, Prudue University, West Lafayette, USA.

Wyatt R.G, 1988, **"An Advisory System for Strategic Planning"**, In: Newton P., Sharpe, R, and Taylor M.A.P, (ed.), Desktop Planning, Hargreen, Melbourne.

Wyatt R.G, 1989, **"Intelligent Planning: Meaningful Methods for Sensitive Situations"**, Unwin Hymen Ltd., London.