Hospitality Unit Diagnosis - An Expert System Approach

Volume 1

Submitted by

Andrew J. Balfe

B.Sc (Mgmt),

H.DIP (Hotel and Catering Management),

MIHCI

in fulfillment of the requirements for the Degree of Master of Science

To

School of Computer Science,
Dublin City University,
Dublin 9.

Supervisors of Studies

Ciaran MacDonaill, Ph.D
Peter O'Connor, H.Dip, B.Sc, M.Sc.
Dublin Institute of Technology
Cathal Brugha St.

December 1998.

Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Master of Computer Science, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my own work.

Signed: ________________ ID No.:DIT.012.94

Date: December 1998

Abstract

Formal methods of management problem-solving have been extensively researched. However, these concepts are incomplete in that they assume a problem has been correctly identified before initiating the problem-solving process. In reality management may not realise that a problem exists or may identify an incorrect problem. As a result, considerable time and effort may be wasted correcting symptoms rather than the true problem.

This research describes the development of a computerised system to support problem identification. The system focuses specifically on the area of hospitality management, encompassing causes and symptoms of prominent problems in the hospitality industry. The system is based on knowledge rather than data.

Research has shown that Expert Systems allow reasoning with knowledge. As a result, Expert Systems were selected as an appropriate technology for this application. Development is undertaken from the perspective of a hotel manager, using appropriate software development tools.

The required knowledge is generally obtained from either expert interviews or textbook analysis. Gaining commitment from sufficient industry experts proved too difficult to allow the use of the former method, and therefore the latter method was utilised. However, knowledge acquired in this manner is limited in both quality and quantity. In addition, essential experience based judgmental knowledge is not available from this source. To counteract this, the personal knowledge of the author, a qualified hotel manager, was used.

When developing an Expert System, knowledge acquisition and representation are of paramount importance. In this research, these issues are problematic due to the broad inter-disciplinary nature and scope of hospitality management. To counteract this problem, some structure was required. Finance, Marketing, Personnel, Control, and Operations were selected as important functions within the hospitality business and therefore were represented within the system for diagnosis. A modular approach was used with modules being developed for each functional area. An initial top level module performs a general diagnosis, and then separate subordinate modules diagnose the functional areas.

This research established that the knowledge required for incorporation into such a system is not available. The possibility of acquiring this knowledge is beyond the bounds of this research. However, sufficient marketing knowledge was sourced to facilitate the development of the Expert System structure. This structure demonstrates the application of the technology to the task and could subsequently be used when more knowledge is elicited.

The research findings show that the development of a modular diagnostic system is possible using an Expert System Shell. The major limiting factor encountered is the total lack of the relevant knowledge. As a result, further research is recommended to establish the factors influencing diagnosis in the hospitality industry.

Table of Contents

Acknowledgements

The author would like to acknowledge the following for their assistance in the completion of this research.

His supervisors, Dr. Ciaran MacDonaill and Mr. Peter O'Connor for their assistance through out the course of this project.

The librarians of DIT Cathal Brugha St., especially Ursula, Irene and Aidan for their help and patience.

The academic staff of DIT Cathal Brugha St., especially Josephine Brown, Alex Gibson, Michael Mulvey, Anto Kearns, Barbara Nolan and Joseph Hegarty for their knowledge and guidance.

The administration staff of DIT Cathal Brugha St. especially Brendan, John, Maurice, Clare and Beverly for their continuous help.

Michael, Gerry, Farhad, Daire, Peter, and Siobhan for their support and encouragement.

Andrew J. Balfe

September 1994

List of Illustrations

List of Tables

List of Abbreviations

AI	Artificial Intelligence
DSS	Decision Support System
EIS	Executive Information System
ES	Expert System
ESAD	Expert System-Based Analysis and Diagnosis
GNP	Gross National Product
GPS	General Problem Solver
HRM	Human Resource Management
KA	Knowledge Acquisition
KB	Knowledge Base
KE	Knowledge Engineer
MIS	Management Information System
MSPA	Market Segment Profitability Analysis
PC	Personal Computer
TPS	Transaction Processing System

Trademarks

Crystal is a registered trade mark of Intelligent Environments UK.

Lotus 1-2-3 is a registered trade mark of the Lotus Development Corporation.

Excel is a registered trade mark of the MIcrosoft Corporation.

Quattro Pro is a registered trade mark of Borland.

Supercalc is a registered trade mark of Computer Associates International Inc.

List of Appendices

Introduction.

Research Outline

The purpose of this research is:

1. To identify the limitations of the presently utilised problem-solving support mechanisms and to develop a computerised tool to counteract those limitations. This system may be applicable to any business; however, this research will concentrate on the hospitality industry. A diagnostic or problem identification system is proposed as an effective solution.

2. To investigate the quantity and quality of knowledge available, to develop such a system. The knowledge required essentially involves the prominent problems which exist within a hospitality unit and their inherent causes and symptoms.

3. To develop a prototype of the system using an appropriate developmental tool. This approach is designed to investigate the ability of a hotel manager to produce an effective system without using programming skills.

This project is the combination of two areas of research: firstly, the development of more comprehensive approach to problem-solving and secondly, the development of an effective computer system to support the proposed problem-solving approach.

Rationale

Both decision-making and problem-solving are processes which have been carried since the beginning of mankind, although subconsciously for a long time. However, in the last few decades these processes have been the topic of increasing interest, especially in the business community. This is due to the fact that business managers encounter many problems. The ability to solve problems effectively will have long term benefits for the company[1]. Research has been carried out to investigate how decisions should be made and who should make them. Consequently, the findings of such research have made their way into numerous textbooks and articles. As a result, much knowledge has been made available to both educators and practitioners to aid the development of problem-solving and decision-making processes.

Considering this, two significant points should be made. Firstly, although seen as synonymous by many authors, decision-making and problem-solving are in fact separate processes[2]. Although related, the two are significantly different. Problem-solving is defined as the identification of a gap between a desired state and an actual state, and the subsequent taking of an action to resolve the difference[3]. Decision-making, although important, merely supports the overall process, being used to collect relevant data, analyse the important information and select the most appropriate solution. Decision-making does not, however, comprise the totality of the problem-solving process since, in addition, skills are required for the creative development of alternative solutions and their implementation[4]. As a result, decision-making and problem-solving should be approached differently.

Secondly, the process of problem-solving is generally described in terms of problem definition, diagnosis of causes, development and selection of alternatives, and the implementation of the selected alternative. For the majority of the above elements, many models and aids have been developed to support the manager in the overall process. However, the author argues that one of the most important elements has been largely overlooked. That element is the area of the *actual* definition of the problem. This defect in the process may result in problem-solving being carried out on an apparent (but wrongly identified) problem. A more comprehensive analysis of this element, prior to the adoption of a formal, time-consuming process, may provide the management with a more complete view of the problem situation. Too often, management tackle the wrong problem, using management time and company expense, only to find that the problem is not resolved[5]. This situation is analogous to a doctor treating the symptoms of an illness rather than the illness itself.

Considering the above, it is the author's opinion that computer systems developed to support problem-solving may be limited in their effect. If a process is deficient, computerisation of that process simply increases the speed at which the deficient process is carried out[6]. If this is the case, then such systems which include Management Information System (MIS), Decision Support System (DSS), and Executive Information Systems (EIS), are merely the automation of a process which has not been fully evaluated. Although they may be useful in supporting problem-solving, and the inherent process of decision-making, little benefit can be claimed if they are being utilised on poorly defined problems.

As an example, consider the reaction of a management team becoming aware of a dramatic decrease in sales revenue. It is possible that much time and effort will be spent analysing the sales mix, the distribution channels, the choice of media usage in advertising to various market segments and in the mean time, emphasis may be placed on cost cutting in an attempt to offset the effects of the drop in revenue. Computer systems may be utilised to provide the required information for decisions-making . This reaction may seem to some to be justified. However, the decrease in revenue may be due to growing customer dissatisfaction with a product suffering from decreased quality standards caused by poor purchasing control, ineffective recruitment and training of staff or inefficient management of the physical assets. Because the incorrect problem was identified, an inappropriate rescue solution was implemented. Costs are cut, possibly escalating rather than resolving the problem.

The above example illustrates the need for techniques which are capable of supporting the problem identification or "diagnosis" element of the problem-solving process. As opposed to positioning the utilisation of the techniques within the overall problem-solving process, it is suggested that such techniques would provide more benefit by being used iteratively, outside the formal problem-solving process. In many cases, management, not only unable to correctly identify a problem, are unaware that a problem even exists[7]. If such techniques could be incorporated into a computerised system, they could from part of an automated early warning system for business. Because industries have different characteristics and as a consequence, different problems, separate systems could be developed to service the needs of each. The industry under specific investigation in this research is the hospitality industry.

The "traditional" way to develop a computer system is to have a computer specialist discuss the problem with an expert in the target area, in this case the hospitality industry. For this research, a different approach is investigated. Part of the project is to evaluate if a hospitality expert (the author) who has a good knowledge of computing (but is not a computer scientist or other computer specialist) can develop a system using currently available software tools. The approach is examined as a solution to the problems which exists within the software supplier to purchaser relationship. These problems are: 1) the high cost of having computer system developed to exact specifications, 2) the inadequacy of mass produced systems for individual needs and 3) the problem of confusion associated with specifying exact requirements to developers who may miss many of the subtleties of the business in question.

Available technologies which may be used in this approach include spreadsheet applications, database management systems or expert systems shells. Although each may be applied with varying success to the task, expert system shells are identified as the most appropriate of the technologies. Expert systems are computer programs which are used to attempt to imitate the reasoning process of humans. As opposed to being data-based, as are the other software packages, expert systems are knowledge-based. That is, they use domain specific knowledge to reason with information and data in an attempt to provide a solution to a problem. As opposed to providing the correct solution, expert systems are capable of reasoning with inexact and incomplete data, often resulting in an acceptable, yet not absolutely perfect solution. For these two reasons, expert system technology has been selected as the tool for the development of the above solution.

Objectives

The objectives of this research are as follows:

1. To critically examine problem-solving and decision-making processes both in theory and in application.

2. To establish the shortcomings of the present approach to problem-solving and decision-making within the hospitality industry.

3. To identify the prominent problems which currently exist within the hospitality industry.

4. To develop a model of a hotel unit for the representation of such problems in a structured manner.

5. To determine whether a comprehensive set of rules relating to solving these problems can be sourced from either industry professionals or written industry material.

6. To evaluate the effectiveness of available technologies toward the task of developing a diagnostic software package for the hospitality unit, from a hotel manager's perspective.

7. To develop a prototype diagnostic software package capable of the analysis and diagnosis of a hotel situation.

8. To evaluate the application of Expert Systems to a broad domain area.

Methodology

In order to evaluate the development of a computerised tool or system for the diagnosis of a hospitality unit, the process of problem-solving is firstly analysed. This is carried out using a literature review of available textbooks and journal articles. The objective of this is to identify the shortcomings of the present process and subsequently establish the requirements for a more effective process.

Following the specification of these requirements, a model of the hospitality industry is developed. This model enables the structuring of knowledge into a form amenable to collection. The model is developed from a literature review of the hospitality product and the industry structure.

The major part of the research is concerned with the elicitation of the knowledge required for the development of such a system. This elicitation is carried out in two ways:

1. Unstructured interviews with relevant educators in the hospitality industry. Educators from the fields of finance, marketing, personnel operations and control are interviewed to identify the problems which exist within their respective subject areas.

2. The second form of knowledge elicitation concerns an investigation into the causes and symptoms of the problems identified in the above process. Further interviews and reviews of textbooks and articles in both the general business and hospitality fields are utilised to do this.

The knowledge gained from the above methods is then used to develop the prototype of an Expert System based analysis and diagnostic package. The development serves to evaluate both the ability of an hotel manager to develop an effective system using modern Expert System development tools, and the effectiveness of the technology toward the task.

An iterative prototyping approach is utilised, whereby features are developed, utilised and subsequently re-developed as many times as is necessary to ensure an effective system. Consideration is given to simplicity of use, time efficient utilisation, comprehensive consideration of important problems, a logical flow process and effectiveness in problem identification.

Chapter Outline

Chapter One introduces the process of problem-solving as used by management today. Decision-making is identified as an element of the over-all problem-solving process. The shortcomings and limitations of this process as described in the literature are identified. Diagnosis is identified as an element largely overlooked by most support techniques, yet essential in the effective resolution of the many problems facing businesses presently. This chapter establishes the need for a more comprehensive support tool for the diagnostic element of problem-solving i.e. that of problem identification.

In order to develop such a tool, consideration must be given to how problems are solved and decisions are made. This is carried out by investigating the approaches to problem-solving and decision-making. In addition, difficulties inherent in the problem-solving and decision-making processes are identified. Uncertainty, the combination of quantitative and qualitative information, and heuristics are found to be issues which must be considered when developing a computer system to support the problem-solving process.

Chapter Two introduces the hospitality industry which is the specific industry under consideration in this research. The hospitality industry is, firstly, described in terms of the product characteristics and the industry structure. The objective of this chapter is to develop a comprehensive model of the hospitality unit and identify specific industry-related problems which cause concern for the management of hospitality units. These problems are identified by examining the early warning signals, internal causes of distress and prominent problems which exist within the boundaries of the hotel unit model. Appropriate problems are established as those most important for inclusion in the diagnostic software package.

Chapter Three is concerned with the introduction of appropriate technologies for the selected task i.e. the development of the prototype system. The concepts of data, information and knowledge are introduced, followed by the technologies used for the processing and reasoning with these components. Management Information Systems, Decision Support Systems and Artificial Intelligence are described from a selection point of view. This chapter concludes by showing why Expert Systems, a branch or the artificial intelligence arena, was selected as the appropriate technology.

Expert Systems technology is described in detail in chapter Four. Expert Systems, as available today, are discussed, including their structure, how they developed and what tasks they have been used to address. The various techniques for acquiring, representing and reasoning with the knowledge are described. Lastly, the techniques which will be utilised for the development of the diagnostic software package for the hospitality industry are established.

Chapter five is concerned with the pre-development analysis for the proposed diagnostic software. This analysis follows a process recommended for the development of expert systems. Firstly, the task problem is clearly defined and justified as being appropriate for expert system application. Secondly, the requirements necessary for the system are investigated; this is of utmost importance, considering expert system development differs considerably from other, more traditional, systems. The third element of this chapter concerns the conceptual design of the system. This is developed primarily from the findings of chapter one. The final element of this chapter considers the software and hardware selection options.

Using the information and knowledge made available from all of the previous chapters, Chapter Six discusses the development of the prototype of the expert system based analysis and diagnostic software package. The development is discussed chronologically. This allows the effect of changes in the development to be associated readily with their cause.

References

1 Stoner, J.A., and R.E, Freeman, "**Management.**" 4th. Ed., Prentice Hall International Editions. NJ. USA., 1989.

2 Pearse, J.A., and R.B. Robinson, "**Management.**" McGraw Hill International Editions, Singapore, 1989.

3 Op. Cit. (1).

4 Op. Cit. (2).

5 Jauch, L.R., and W.F.Glueck, "**Business Policy and Strategic Management.**" McGraw Hill International Editions, Singapore,1988.

6 Manley, P., "**Technology and Hospitality.**" Presentation to the Hospitality Information Technology Association Conference, Dallas, June, 1994.

7 koontz, Z.H., and H. Weinrich, "**Management**", 9th. Ed., McGraw Hill International Editions, Singapore, 1988.

Chapter One

Problem-Solving Theory

Most ailing organisations have developed a functional blindness to their own defects. They are not suffering because they cannot solve their problems but because they cannot see their problems. **John W. Gardner**[1].

1.1 - Introduction.

The prime functions of management are problem-solving / decision-making, planing and control. However, problem-solving and decision-making can be argued to be the key to all planning and control activities. All the other activities carried out by management - information gathering, analysis and follow-up - flow around this central core[2]. Organisations find themselves constantly in situations that involve problem-solving which in turn call for decision-making. The problems range in importance from major issues such as the future direction of the organisation to smaller decisions relating to unpunctual staff.

This chapter establishes the process of problem-solving and its inherent problems. Decision-making, often seen as synonymous with problem-solving, is identified as being merely an element of the overall problem-solving process.

Diagnosis is discussed in terms of the limitations generated by its positioning within the problem-solving process. It is suggested that this element be placed in a separate process, possibly benefiting by the application of computerisation to the task.

1.2 - Problem-solving.

Anthony's taxonomy[3] defines three broad categories that encompass all managerial activities:

- Strategic planning - the long range goals and the policies for resource allocation;
- Management control - the acquisition and efficient utilisation of resources in the accomplishment of organisational goals;
- Operational control - the efficient and effective execution of specific tasks.

The three different types of activities, due to their nature, require varying levels of management problem-solving capabilities.

Problem-solving can be defined as the process of identifying the difference between an actual and a desired state of affairs within one of the above areas, and then taking an action to resolve the difference[4]. In most organisations, streams of such problems appear and therefore must be tackled, generally causing executive life to be a continual round of switching from one problem to the next[5]. Fortunately for the business community, comparatively few problems have the kinds of implications that raise them to a strategic level, where a resolution would call for a change in the company's strategy. Those that have are full of complex decisions and as a result require more management time[6]. More regularly, smaller less complex problems occur. However, these seemingly minor problems must also be tackled to ensure they do not escalate into larger ones.

Large and small problems, by their very nature, are varied in complexity and importance[7]. As a consequence, it is possible that each problem-solving situation will require varying levels of skill and time. For example, if there are precedents against which the problem can be compared, it will generally be easier and quicker to solve and a similar solution can be applied, as long as no obviously disastrous consequences occurred the previous time[8].

An example of such a problem is the process of planning. This process involves the most significant and far reaching problem a manager can face - the process of establishing objectives and suitable courses of action before taking action[9]. The entire planning process involves managers in a continual series of problem-solving situations. The quality of their decisions within the process plays a large role in determining how effective their plans will be. Although of great importance, the problem of planning does not generally cause much concern for management. The process is ongoing, has been tackled before in a systematic manner and is largely uncomplicated. Therefore a precedence has been set which can easily be followed. In addition to having precedents to work against, management have an additional advantage. With their education and experience, they generally realise the importance of planning and therefore are aware of the need to tackle this problem. However, most problems which require direct action by high level managers do not have clear precedents and, therefore, solutions are not obvious[10].

1.2.1 - Problem classification.

As stated, types of problems can differ dramatically. The differences can cause varying level of concern for those involved in their resolution. As a classification for these problems, Bronner suggests that sufficiently separable problem-solving situations may be identified[11].

Everyday Problems.

Typical problems of this type are tackled by consumers when purchasing low-priced daily necessities. Because of the small amount of mental conflict with the respective objects of choice, decisions, in this case, are made quite easily. They are labeled as "cognitively relieved decisions". Within these problems a distinction can be made between limited, habitualised and impulsive processes. In the first case, the problem is simplified so that only little information is used as a basis of action. With habitualised problems, routine behaviour is in the foreground and the decision maker takes recourse to patterns of action which in the past have proven to be successful. Impulsive decisions are mostly unreflected, action being nothing more than a reaction to key stimuli.

Political problems.

All problems that occur in connection with military, economic and societal developments are assigned to this type of problem-solving situation. These problems are characterised by a far-reaching anonymity of preferences as well as the fact that an adequate choice of action is unclear. The problem-solver is distanced from the people it affects and an appropriate solution which will satisfy all interested parties is difficult to achieve. As a result, this area of problem-solving is more complex than others.

Management problems.

Problem situations of this type encompass decisions as made in companies to determine part or all of the product, personnel, market, or finance strategies. Management problems require entirely different forms of mental and organisational approaches than everyday decisions[12].

Considering this classification of problems, it must also be noted that the latter category can again be further classified. Management problems will obviously vary in their complexity and importance, varying from everyday problems, such as labour scheduling, to problems occurring either infrequently or once-off, such as crisis management (see table 1.1).

Strategic Level	Long term, high risk, uncertain, poorly structured infrequent decisions.
Tactical level	More medium term, medium risk and more re-occurring problems
Administrative or clerical level	Short term low risk, re-occurring problems
Operational level	Very short term, extremely repetitive, minimal risk.

Table 1.1 - Classification of management problems[13]

According to Simon, problems fall along a continuum that ranges from highly structured (sometimes referred to as programmed) to highly unstructured (non-programmed) problems[14]. Structured processes refer to routine and repetitive problems for which standard solutions exist. Unstructured processes are "fuzzy", complex problems for which there are no cut-and-dried solutions.

1.2.2 - Management Problem-solving

As it would be impossible for senior managers to handle every problem that arises in daily business life, it is important for them to learn how to establish priorities for problems and how to delegate to subordinates responsibility for taking care of the minor ones[15]. Thus when managers are presented with problems, consideration should be given to the following points:

- Is the problem easy to deal with? Some problems are difficult and expensive to deal with, other are not. Most problems require only a small amount of the manager's time. If the decision turns out wrong, correcting it will be relatively speedy and inexpensive. To avoid getting "bogged down" in trivial details, effective managers reserve formal decision-making techniques for problems that require them.

- Might the problem resolve itself? Managers find that a number of time-wasting problems can be eliminated if they are ignored.

- Is it their decision to make? Problems may be encountered which although affecting a particular manager, may be under the control of a different manager.

Bearing this in mind, once a problem, which will not resolve itself, has been established by the manager concerned and has a major significance to the company, action must be taken.

1.2.3 - Approaches To Problem-Solving.

To solve the problems, some managers may rely on informal methods such as acting based on past experience and past trends. Some may look to an expert or a higher manager. Some may use *a priori reasoning* - assuming that the most superficially logical or obvious solution to a problem is the correct one.[16]

These approaches to solving problems are categorised as follows[17]:

- The *political - behavioural* approach considers a variety of pressures from people affected by the decision. It attempts to merge the demands of all stakeholders to form a coalition of interests which will support the decision. The main criticism of this approach is that the objectives of the stakeholders may not correspond to those of the company[18].

- The *intuitive-emotional* approach relies on experience and instinct rather than on logical analysis. Problem-solvers consider all possible alternatives, randomly jumping from one-step in the analysis to another and back again[19]. Critics of this approach point out that intuitive decision makers often fail to consider the consequences of implementing a chosen solution. In addition, the lack of emphasis on the use of analytical tools reduces the probability of making a successful decision[20].

- The *rational - analytical* approach. The problem-solvers, acting on their own, consider all possible alternatives and selects the solution which will produce the optimum results. The consequences of implementing the solution are also analysed. This approach prescribes a rational, conscious, systematic and analytical approach to decision-making. However this method is subject to criticism for, primarily, two reasons. Firstly, decisions makers rarely act alone. Instead they tend to work within a team. Secondly, they seldom have access to enough information to consider all possible alternatives[21]. As a result many decision makers tend to choose courses of action which result in a satisfactory, as opposed to the best possible solution. This issue of "satisficing" is discussed later under the section “rational decision-making”.

No approach to problem-solving can guarantee that a manager will always select the right solution, but managers who use a rational intelligent and systematic approach are more likely than other managers to come up with high quality solutions to the problems they face[22]. In addition, experience and intuition also increase the probability of producing "good" solutions[23].

1.2.4 - Rational Problem-Solving Process.

Although many authors have developed problem-solving processes, the majority are relatively similar. They involve: defining and determining the sources of the problem, gathering and analysing the facts relevant to the problem, developing and evaluating alternative solutions to the problem, selecting the most satisfactory alternative and converting this alternative into action (see Figure 1.1).

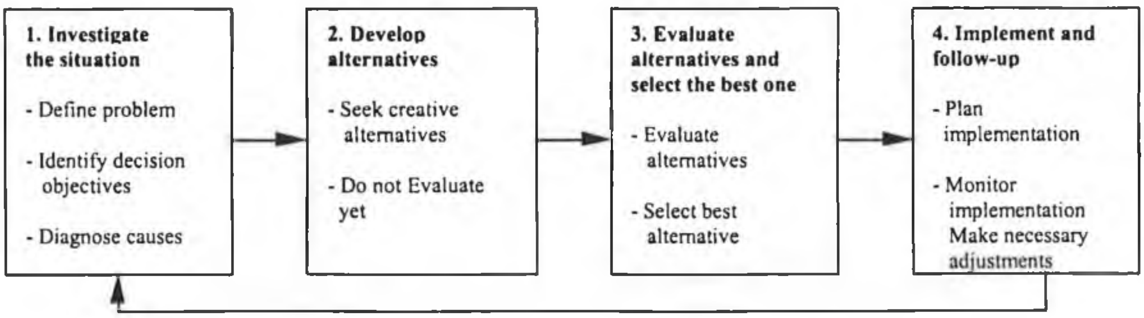

Figure 1.1 - Rational Problem-solving process [24]

- *Investigation of situation.*

The problem-solving process begins when the problem has been identified. The manager's first task is to search for all factors that may have created the problem or that may be incorporated into the eventual solution. A thorough investigation has three aspects - problem definition, identification of objectives and diagnosis.

A) Define the problem - Confusion in problem definition arises in part because the events or issues that attract the manager's attention may be symptoms of another more fundamental and pervasive difficulty. This can be argued to result in two problems. Firstly, it is possible that symptoms may be corrected, allowing the main problem to escalate. Secondly, managers may not be aware a problems exists. This phase will only be utilised if a problem-solving process has been initiated.

B) Identifying the decision objective. Once the problem is defined, decide what would constitute an effective solution. For example, how will things be different when the problem is solved? Which parts of the problem *must* be solved and which parts *should* be solved? Most problems consist of several elements and one solution is unlikely to work for all. If the solution enables management to achieve the organisation's objectives, it is a successful one. More ambitious objectives, however, may be appropriate. The immediate problem may be an indicator of future difficulties that a manager can prevent by taking action early.

C) Diagnose the causes - When managers have found a satisfactory solution, they must determine the actions that will achieve it. But first they must obtain a solid understanding of all the sources of the problems so that they can formulate hypotheses about the causes. Causes, unlike symptoms, are seldom apparent and managers have to rely on intuition to find them. Different individuals whose views of the situation are inevitably coloured by their experience and responsibilities, may perceive very different causes for the same problem. It is up to the manager to put all the pieces together and come up with as clear a picture as possible. It is this process which causes much difficulty. Although problem-solving and decision-making have been the topic of much research and literature, a formal diagnostic method has been consistently overlooked.

In addition, it could be argued that this process is poorly positioned. Diagnosis is carried out after the problem has been defined[25]. More effectively, diagnosis should be carried as an element of the problem definition. At that point, an analysis would ensure that the correct problem is identified as opposed to a symptom of a deeper problem being tackled. It can also be argued that the process of diagnosis be carried out iteratively. This would ensure that managers are kept aware of problems materialising, being then able to avoid the problem rather than solve it.

Although the remaining elements of the problem-solving process are equally important, it is the first element in which the author is most interested. Although the need for this stage has been identified, little research has been carried out and few hospitality organisations utilise a formal method for systematically and comprehensively carrying out this activity[26].

1.3 - Rational decision-making.

In conjunction with rational problem-solving, a separate process occurs, that of decision-making. Much confusion exists between the terms "decision-making" and "problem-solving". They are often seen as being synonymous. It has already been shown that problem-solving is the process of identifying a difference between an actual and a desired state of affairs and then taking an action to resolve the difference. For problems important enough to justify the time and effort of careful analysis, the problem-solving process generally involves the steps as seen in figure 1.1. "Decision-making" as opposed to being the same process, occurs constantly within the first three steps of the problem-solving process[27]. The decision-making process ends with the choosing of an alternative, which is the act of making the final decision. However, it should be noted that many individual decisions have had to be made while defining the problem, diagnosing the causes, developing alternatives, and so on. Figure 1.2 shows that the last area of problem-solving is not included in the decision-making process. This is not meant to diminish the importance of these activities, but to emphasise the more limited scope of the decision-making as compared to the term problem-solving. However, as problem-solving is essentially the combination of many decisions, it is this decision-making process which requires most consideration. As a chain is only as strong as its weakest link, a problem's solution is only as effective as the worst decision made.

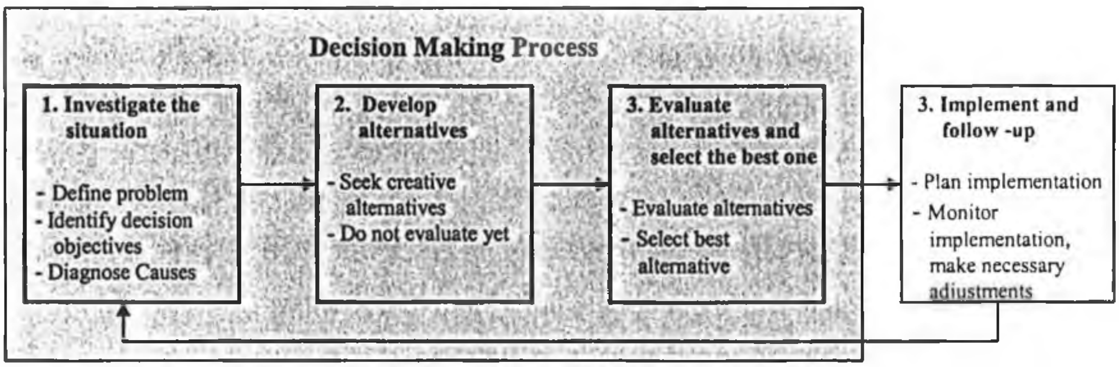

Figure 1.2 - Decision-Making Element Of The Problem-solving Process

1.3.1 - The Nature of Managerial Decisions.

Decision-making, as stated, is an important part of the problem-solving process. Managers make different types of decisions under different circumstances. Similarly, the amount of information available to the decision maker varies[28]. As a result, managers have to vary their approach to decision-making depending on the particular situation. For example, where to build a new hotel and how to implement a human resources policy, are both important managerial decisions, yet are largely different in the information required for resolution. The specific management problem that this research is concerned with is that of establishing causes of concern within a hotel unit. This problem, i.e. the analysis and diagnosis of a hospitality unit, is comprised of many different decisions. For example, what information is required? What relationships exist between a perceived problem and an actual problem? Is the finding of the diagnosis correct?

Similarly to problem-solving, different types of decisions have been identified. A particular decision is placed into one of either category based on factors such as the availability of information, the frequency of the problems and whether a solution is quite clear[29].

- *Programmed decisions.* - These are solutions to routine problems determined by rule, procedure or habit. Every organisation has written or unwritten policies that simplify decision-making in recurring situations by limiting or excluding alternatives[30]. Routine problems are not necessarily simple ones; programmed decisions are used for dealing with complex as well as uncomplicated issues. If a problem recurs and if its component elements can be defined, predicted and analysed then it may be a candidate for programmed decision-making. These policies, rules and conditions by which programmed decisions are made free the time needed to work out new solutions to old problems, therefore allowing more time to other more important activities. Ultimately managers use their judgement in deciding whether a decision calls for a programmed decision[31].

- *Non-Programmed decisions.* - These are specific solutions created through an unstructured process to deal with non-routine problems. If a problem has not come up often enough to be covered by policy or is so important that it deserves special treatment, it must be handled by non-programmed decision-making. Most of the problems that a manager will face will require non-programmed decisions[32].

1.3.2 - Rational Decision-Making Process

The rational model of decision-making parallels the rational problem-solving process (see figure 1.3)[33]. Although similar to the process of problem-solving, the decision-making process described occurs continuously within the overall process of problem-solving.

The first phase, known as the intelligence phase, consists of scanning the environment for conditions calling for decisions. Data is obtained, processed and examined for clues which might identify problems and opportunities.

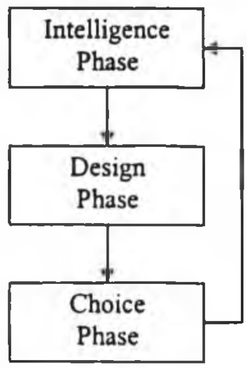

Figure 1.3 - Simon's Model of Decision-making

Once a problem is identified, the design phase begins. This involves inventing, developing and analysing possible courses of action or solutions for the decision. These solutions are subsequently critically examined to form a list of feasible solutions.

The final (or choice) phase involves the selection of a solution from the alternatives generated by the previous phase. Usually knowledge, judgement and experience will be used to decide which alternatives are most appropriate.

Combining the problem-solving process and the decision-making process, for the purpose of this research, produces a more complete model (see figure 1.4).

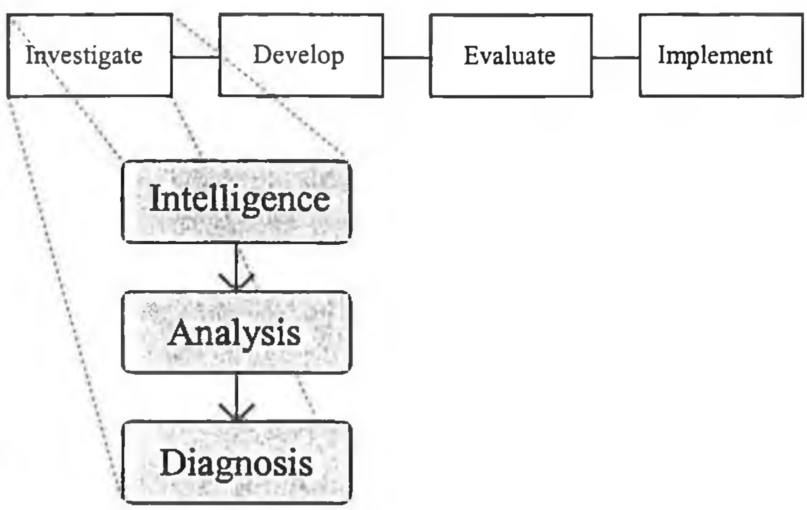

Figure 1.4 - Adaptation of Problem-Solving and Decision-Making models.

In this model the investigation phase is substituted with a formal diagnosis element. This is an iterative process of collecting the required intelligence, analysing the information and carrying out a detailed diagnosis (i.e. the true problem is identified, not simply a symptom of a deeper more serious problem). Using this model, the remaining elements of the problem-solving process are only used after a problem has been correctly identified and requires action. In addition, it can be argued that if a problem can be broken down into its individual components, solution selection is simplified. For example, a problem of decreased revenue could be broken down into constituent problems of decreased quality due to poor recruitment and training. As a result, the solution to the principal problem, although not apparent prior to the comprehensive diagnosis, is the implementation of a human resources policy.

Although a simple example, this demonstrates how an effective diagnostic process could simplify the problem-solving process. However, certain characteristics of decision-making present difficulties to the problem-solver and therefore must be considered.

Simon's model of bounded rationality points out that decision makers must cope with[34]:

- Inadequate information about the nature of the problem and its possible solutions.
- The lack of time or money to compile more complete information.
- Distorted perceptions of the information available.
- The inability of the human memory to retain large amounts of information.
- The limits of managers' own intelligence to determine correctly which alternative is best.

Compromised by the above points, instead of searching for the perfect or ideal decision, managers frequently settle for a decision that will adequately serve their purposes. In Simon's terms[35], they "satisfice" or accept the first satisfactory decision they uncover rather than maximise or search until they find the optimal decision. Managers lack the time to do all of the calculations required by the rational model, especially for the routine decisions. It is important to try to follow the rational model when making major decisions but it would be foolish to go to the same lengths for every management decision. The so-called rational model of decision-making is probably the exception and not the rule. However, to deal with the above difficulties, several concepts have been developed.

1.4 - Certainty, Risk And Uncertainty.

Managers make decisions in the present for actions that will be taken and goals that they hope to achieve in the future. All important decision-making situations contain some aspects that are unknowable and very difficult to predict[36]. Although uncertainty exists in many situations, the amount of uncertainty varies greatly. There are two possible sources of uncertainty[37]. First, there may be external conditions partially or entirely beyond a manager's control. Second, the manager's access to information about those conditions may be limited. The manager may not be aware of all the information available about a set of conditions or the necessary information may not exist. In either case the manager's ability to predict the future is impaired. Certainty, risk and uncertainty describe different positions along the uncertainty continuum which ranges from predictable situations to situations extremely difficult to predict[38].

Under conditions of certainty, we know what will happen in the future. Under risk, we know what the probability of each outcome is. Under uncertainty, we do not know the probabilities and perhaps even the possible outcomes. Under conditions of certainty, there is accurate, measurable, reliable information available on which to base decisions. The future in this case is highly predictable. Where predictability is lower, a condition of risk exists. Complete information is unavailable but a good idea of the probability of particular outcomes exists. Under conditions of uncertainty very little is known. Conditions of uncertainty generally accompany the most important decisions. Managers do have tools available to make the unknown future a little more comfortable to anticipate and deal with problems.

In any attempt to computerise the problem-solving or decision-making process, it is important for these conditions of uncertainty to be considered.

1.5 - Quantitative Analysis And Decision-Making.

Figure 1.5 shows an alternate classification of the decision-making process. In this diagram, the first three phases of the decision-making process are combined under the heading of structuring the problem and the latter two phases under the heading of analysing the problem. Figure 1.6 considers in more detail how to carry out the set of activities that make up the decision-making process. In this diagram, the analysis phase is shown to take on two basic forms: qualitative and quantitative. Qualitative analysis is based primarily on the manager's judgement and experience; it includes the manager's intuitive feel for the problem and is more an art than a science. Where the manager has little experience with similar problems, or if the problem is sufficiently complex, then a quantitative analysis of the problem can be a very important consideration in the manager's final decision.

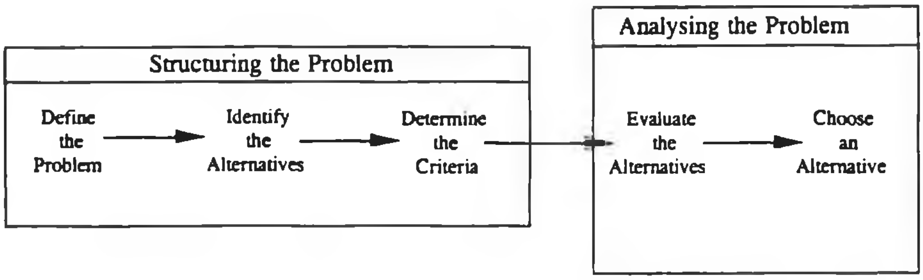

Figure 1.5 - Alternative Decision-making Process[39]

When using the quantitative approach an analyst will concentrate on the quantitative facts or data associated with the problem and develop mathematical expressions that describe the objectives, constraints, and relationships that exist in the problem. Then, by using one or more quantitative methods, the analyst will provide a recommendation based on the quantitative aspects of the problem.

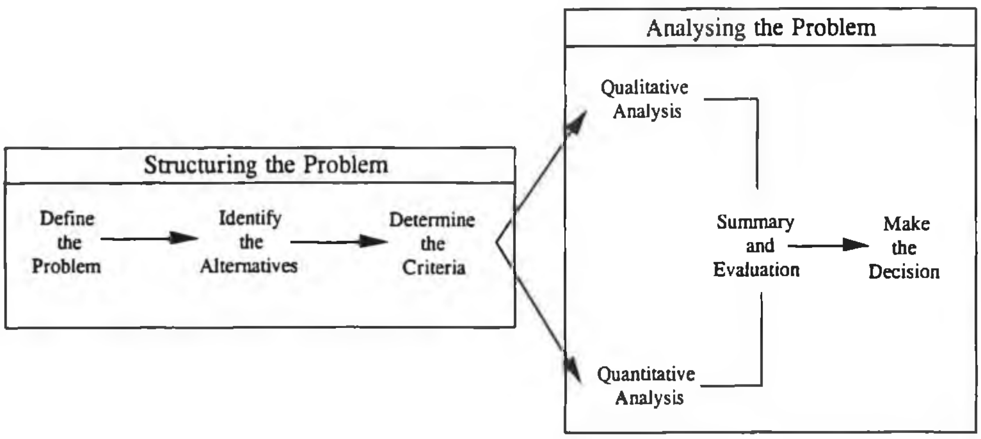

Figure 1.6 - Qualitative and Quantitative Decision-making Process.[40]

While skills in the qualitative approach are developed in the manager and usually increase with experience, the skills of the quantitative approach can be learned only by studying the assumptions and methods of management science. A manager can increase decision-making effectiveness by learning more about quantitative methodology and by better understanding its contribution to the decision-making process. The manager who is knowledgeable in quantitative decision-making procedures is in a much better position to compare and evaluate the qualitative and quantitative sources of recommendations and ultimately to combine the two sources in order to make the best possible decision.

Again these components of decision-making must be considered when analysing the problem-solving process towards the development of a more effective system.

1.6 - Heuristics And Biases In Decision-Making.

Research by Tversky and Kahneman has extended Simon's ideas on bounded rationality. They have demonstrated that people rely on Heuristic Principles, or rules of thumb, to simplify the process of making decisions[41]. For example, one manager, faced with decreasing sales may implement a formal problem-solving process, while another manager may only see the decrease as a problem if it is greater than ten percent on the previous period. The second manager has used a rule of thumb to screen problems which call for action. While heuristics are great time savers and often produce good results, they can lead to systematic biases in decision-making. People are often unaware of the heuristics upon which they rely. They are overconfident about the quality of their decisions because they do not appreciate the weaknesses of their assumptions or the extent of their ignorance.

There are three heuristics that show up repeatedly in human decision-making[42]. These are not specific rules, but general cognitive strategies that people apply to a wide variety of situations because they make intuitive sense.

- *Availability* : People sometimes judge the likelihood of an event by testing it against the information stored in their memories. Thus events that are more readily "available" in memory are assumed to be more likely to occur in the future. This assumption is based on the experience of a lifetime, and it seems reasonable enough. However, the human memory is affected not just by the frequency of an event but also by how recently it has occurred and how vivid the experience was.

- *Representativeness* : People also try to assess the likelihood of an occurrence by trying to match it with a pre-existing category; for example, matching a decrease in revenue with a similar decrease which occurred previously. However, it is possible that the second decrease occurred in a highly different economic climate, and therefore similar solutions may be inappropriate.

- *Anchoring and Adjustment* - People do not pull decisions out of thin air. Usually they start with some initial value, even if it is randomly chosen, and then make adjustments to that value in order to arrive at the final decision. Depending heavily on the single factor of initial value tends to obscure relevant criteria. In addition, different initial values lead to different decisions. For example, the issue of a required increase in revenue may cause a manager to take the previous year's increase as a starting value, this figure might be 5%. The decisions presently under consideration are then made to achieve a similar increase. However, supposing the industry has grown by 10%, the selected increase in revenue actually results in a decrease in market share.

Bearing these biases in mind, it is important that any study of problem-solving or decision-making considers them. Most decisions made will contain some element of bias and therefore must be reflected in the overall process.

1.7 - Human Problem-solving: An Information Processing Approach

An analogy using information processing to explain human decision-making has been suggested. This approach is based on the belief of Artificial Intelligence researchers that problem-solving can be understood as information processing. It is based on a cognitive approach that uses a qualitative description of the ways in which people are similar in their approach to solving problems, and the manner in which people reason.

Allen Newell and Herbert A. Simon[43] proposed a model of human problem-solving that makes use of the analogy between computer processing and human information. The following is a description of this process offered by Turban[44]. The human information processing system consists of the following subsystem: a perceptual subsystem, a cognitive subsystem, a motor subsystem and an external memory. Figure 1.7 illustrates the system including the memories and processors included in each subsystem.

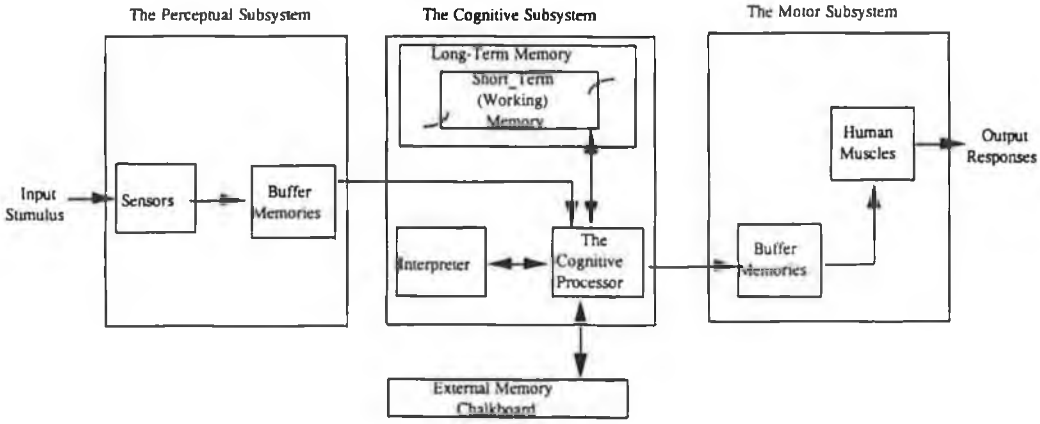

Figure 1.7 - Human Problem-solving Subsystems.

The perceptual subsystem.

External stimuli are the input for the human information processing system. These stimuli enter through sensors like eyes and ears. The perceptual subsystem consists of these sensors along with buffer memories that briefly store incoming information, while it awaits processing by the cognitive subsystem.

The cognitive subsystem.

Whenever there is need to make a decision, the cognitive system selects the appropriate information from the buffer memories. The cognitive processor evaluates the information and then stores it in another memory.

The processor contains three parts: the elementary processor, the short term memory, and the interpreter, which interprets part or all of the program of instructions for problem-solving. The program used by an individual will depend on a number of variables such as the task and the intelligence of the problem solver. In the simplest tasks, the cognitive system merely serves as a point for transferring information from the sensory inputs to motor outputs. Habitual tasks, such as picking up a pen, are like this. There is little or no deep thought involved, in fact the thinking that does occur is often impossible to recover. More complex tasks involve more information. That in turn calls for more elaborate processing. To accomplish these tasks, the cognitive processor will draw on the second memory system: long-term memory.

Long-term and external memory.

Long-term memory consists of a large number of stored symbols with a complex indexing system. There are competing hypotheses about what the elementary symbols are and how they are arranged. In the simplest memory model, related symbols are organised into temporal scripts. Another view is that memory consists of clusters of symbols called "chunks". A chunk is a unit of stored information - it can be a digit, a symbol, or a word associated with a set or pattern of stimuli. Chunks are hierarchically organised collections of still smaller chunks. In this conception, memory is a vast network of chunks. It requires only a few hundred milliseconds to read from long term memory, but the write time is fairly long.

Human beings can support the decision-making process with another memory, the external one. The external memory consists of external media like a chalkboard. The processing, retrieval, and storage of data by computers can be thousands, perhaps millions of times faster than that of humans. Humans are also limited in their ability to generate, integrate and interpret probabilistic data.

The long-term memory has essentially unlimited capacity. The short-term memory is quite small. It holds only five to seven chunks. However, only about two chunks can be retained while another task is being performed. This suggests that part of the short-term memory is used for input and output processing. This is one of the major limitations of the human compared to computers.

Motor output.
After scanning and searching memories, the processor sends information to the motor subsystem. Motor processors initiate actions of muscles and other internal human systems.

Considering this approach, it is possible to see that if information processing and human problem-solving are analogous, computers should have the ability to support the human process. This is due to the fact that both entities employ similar methods when processing data. The computer, however, is capable of carrying out calculations more quickly and is not limited by the number of pieces of data under consideration at one time. This issue, the application of computers to supporting management problem-solving, is a central theme throughout this thesis.

1.8 - Summary

This chapter has established that problem-solving is an important element of a manager's work. However, the process as established to date is limited in its effectiveness. Firstly, managers may neglect to tackle problems using formal methods when they are relatively minor. As a result they are allowed to escalate into problems of greater seriousness and complexity. Secondly, the formal method of problem-solving is generally utilised only after a problem is identified. It is possible that a problem may be in existence for some time before it is recognised. This again may result in the problem escalating, causing seriousness long-term damage before it is tackled. Thirdly, the process of diagnosis is carried out after the problem is defined. It is possible that the diagnosis is concerned with the problem as defined, not the actual problem. The defined problem may only be a symptom of what is really wrong in the company. The actual problem should have been clearly diagnosed prior to initiating a problem-solving process.

In addition, this chapter addressed the area of decision-making versus problem-solving. It was identified that each problem is comprised of many decisions. Each decision has a solution process similar to the overall problem-solving process. Considering this point, the author argues that in order to support the problem-solving process, support is required for the constituent decisions and that one of the most important of these decisions is the identification of the "correct" problem prior to the commencement of the problem-solving process. This research is concerned with the development of computerised a system capable of supporting one of these decisions. The exact decision under consideration being "What problems, if any, are occurring within the hotel unit? The internal element is most significant as, in the majority of cases, business problems are internally generated[45]. In most situations where the management is open-minded enough to pay heed to the signals, it will be possible to head off at least a good portion of the outside factors which created the crisis. External factors, such as a condition of scarce money, a condition of high interest rates, a condition of faltering sales, or a combination of those things, are merely the triggering mechanism that suddenly makes things that formerly worked no longer work. These external problems work on the internal problems until the company declines or the internal problems are corrected.

This specific subject matter being researched (i.e. the identification of the cause of problems) requires the collection of relevant data about the decision situation i.e. the hotel unit, the analysis of that data for the design of the solution, where the solution is the identification of the real problems. At this point, it would be necessary for the hotel manager to select the problem which is most likely, and then initiate a formal problem-solving process for its solution. It is suggested that this decision should be made regularly, in order to avoid problems escalating and causing company failure.

Although time consuming if the diagnostic process is carried out manually, it is proposed that the process can be tackled using a computerised system. The system would be capable of scanning the internal environment for factors which may suggest a problem is in existence. In order for an appropriate system to be developed, it must replicate the same methods a human would use making the decision. Both a rational-analytical and intuitive-emotional approach should be utilised as this combination offers a higher chance of success in solving the problem. As the decision is relatively ill-structured, the system must allow for insecure informational bases, consider uncertainty and risk, employ both quantitative and qualitative analysis techniques and utilise heuristics similar to those used by humans.

The development of such a system would relieve the human decision makers and enhance the quality of decisions made. This is a result of the fact that computers can carry out complex analysis quicker with none of the memory limitations experienced by humans.

References

1 Gardner, J.W. , **"How to prevent organisational dry rot"**. Harper's Magazine, October 1965, p. 24.

2 Owen, D.E., **"Delivering on the promise of management information systems."** IMC Journal, September / October 1987. pp. 56-78.

3 Anthony, R., **"Planning and control systems: a framework for analysis."** Harvard Business School, USA, 1965.

4 Stoner, J. A, and R. E Freeman, **"Management"** 4th. ed. Prentice Hall International Editions. NJ, USA, 1989.

5 Cohen, M. D., J. G. March and J. P. Olsen, **"A garbage can model of organisational choice."** Administrative Science quarterly, Vol. 17, USA, 1972, pp. 1-25.

6 Hickson, D.J., *et al*, **"Top decisions - strategic decision-making in organisations."** Basil Blackwell Ltd., England, 1986.

7 Op. Cit. (2)

8 Tomkins, C., **"Corporate resource allocation, financial, strategic and organisational perspectives."** Basil Blackwell, 1991.

9 Op. Cit. (3)

10 Ibid.

11 Bronner, R., **"Decision-making in complex situations - results of German empirical studies."** Management International Review, Vol. 33, 1993, pp. 7-25.

12 Trenkle, T., **"Organisation der vorstandsentscheiding."** Lang, Frankfurt, 1983.

13 Op. Cit. (2)

14 Simon, H.A., **"The new science of management decisions"** Rev. Ed. Prentice-Hall, USA, 1977.

15 Op. Cit. (3)

16 Bridges, F. J., K. W. Olm , and J. A. Barnhill, **"Management decisions and organisational policy.** "Allwyn and Bacon, Boston, 1971.

17 Jauch, L.R., and W.F. Glueck, **"Business policy and strategic management."** 5th. Ed., McGraw Hill, Singapore, 1988.

18 Murray, M., **"Decisions: a comparative critique."** Pitman, USA, 1986.

19 Mintzberg, H., **"Planning on the left-side and managing on the right."** Harvard Business Review, Vol. 55, July-August 1976, pp 49-58.

20 Murray, M., **"Decisions: a comparative critique."** Pitman, USA, 1986.

21 Simon, H.A., "**Administrative behaviour.**" Free Press, New York, 1957.

22 Hickson, D.J. *et al*, "**Decision and organisation - processes of strategic decision-making and their explanations.**" Public Adinistration, Vol. 67, Winter, 1989, pp. 373-389.

23 Jones, R.E., L.W. Jacobs, W. van't Spyker, "**Strategic decision processes in international firms.**" Management International Review, Vol. 32, 1992, pp. 219-236.

24 Op. Cit. (3)

25 Ibid.

26 Riley, M., and S. Jauncey, "**Examining structure in decision making in hotels.**" International Journal of Contempory Hospitality Management, Vol. 2,3, pp. 11-15.

27 Pearse, J.A., and R.B. Robinson, "**Management.**" McGraw Hill International Editions, Singapore, 1989.

28 Op. Cit. (21)

29 Adair, J., "**Management decision making.**" Gower Publishing, UK, 1985.

30 Op. Cit. (25)

31 Op. Cit. (26)

32 Op. Cit. (5)

33 Simon, H.A., "**The new science of management decision.**" Harper and Brothers, New York, 1960.

34 Op. Cit. (3)

35 Simon, H.A. , "**Model of man: Social and rational.**" Wiley, New York, 1957.

36 Op. Cit. (3)

37 Knight, F.H., "**Risk, uncertainty and profit.**" Harper and Brothers, New York, 1920.

38 Ancher, S.A., "**The structure of management decision theory.**" Academy of Management Journal, No. 4, December 1964, pp. 269-287.

39 Turban, E., "**Decision support and expert systems.**" 2nd. Ed., Maxwell Macmillan International Editions, Singapore, 1990.

40 Ibid.

41 Tversky, A., and D. Kahneman, "**Judgement under uncertainty: heuristics and biases.**" Science 18, 1974, pp. 1124-1131.

42 Tversky, A., and D. Kahneman, "**Availability: A heuristic for judging frequency and probability.**" Cognitive Psychology. Vol. 5, 1973, pp. 207-232.

43 Newell, A., and H.A. Simon, "**Human problem-solving.**" Prentice-Hall, USA, 1972.

[44] Op. Cit. (38)

[45] Bibeault, D.B., **"Corporate turnaround - How managers turn losers into winners."** McGraw Hill Book Company. 1992. USA.

Chapter Two

Hotel Unit - Analysis and Diagnosis

2.1 - Introduction

Diagnosis - a term borrowed from the field of medicine, has for many people the medical meaning, "to recognise symptoms of disease"[1]. Organisations, unfortunately, have few vital signs as precise as pulse, temperature, blood pressure and respiration which signal what shape they are in. It is necessary for this research that an equivalent is developed. From the characteristics of the hotel industry and product, several important functional areas of the business are established. Finance, operations, sales and marketing, personnel and control can form a categorisation of the "anatomy" of the hotel unit. Within these areas, it is important to distinguish symptoms which may point the "company doctor" in the right direction. Symptoms or combinations of them, will point to the causes and a diagnosis can be made.

This chapter begins by showing the importance of tourism and the hotel industry to the Irish economy. The product and industry characteristics are evaluated in relation to their affect on the hotel operation.

Based on this analysis, a diagnostic model of the hotel unit is developed. The areas of marketing, finance, human resource management, control and operations are selected as the important areas requiring diagnosis. Each of the areas is discussed with particular reference to the hotel industry.

Considering the "anatomy" of the hotel, the remainder of the chapter is then concerned with an investigation into the causes and symptoms of problems which exist within a hotel unit.

Finally, action research is identified as an appropriate method for developing the model into a comprehensive system for corporate diagnostics.

2.2 - The Irish Tourism Industry and the Economy.

Tourism is an area on which the hotel industry depends on for much of its business. Business travellers, holiday makers, both foreign and domestic, provide the means for increased revenues through increased sales[2]. Bord Failte, the Irish tourism board, has a great impact on the success of hotels by both controlling the marketing of Ireland abroad, and controlling and grading members of the hotel industry. The hospitality industry is seen as an area with great potential, offering employment and as a substantial revenue generator for economies world-wide. However, as well as a possible increase in performance of tourism, downward trends are also of great concern to the hotel operator.

In a report made by the Tourism Task Force in 1992, it was estimated that tourism accounted for three in every four net additional jobs in the period 1986-1991[3]. Tourism in general at that time accounted for one in every fourteen of all jobs or one in eight in the services sector. It was these figures which prompted Government policies to ensure that to increase employment, considerable effort must be given to tourism because it is so labour intensive and has shown capacity for such an increase. Of the 87,000 employed in tourism, 33,461 work directly in the hotel and guest house sector[4].

A particular point of tourism employment is that it is widely dispersed, often in areas where there is little other employment. For this reason alone, the industry has special social significance. Any industry which can create employment in underdeveloped areas is of prime importance to an economy[5].

As well as employment, the tourism industry contributes approximately 7% of Gross National Product (GNP) to the economy. Of the total increase in GNP between 1985 and 1990, tourism contributed £365 million (1985 prices) or almost 12%. In addition, economic models show that tourism has a very high GNP multiplier effect because its inputs are mainly domestic i.e. money spent by tourists multiplies in value as it is passed from hoteliers to suppliers of materials and labour and onto their suppliers[6]. In addition, where manufacturing is basically local, tourist spread their expenditure all over the country.

There has been a positive and accelerating balance of payments between tourism inbound and outbound since 1986 until 1992. In that year the travel balance reversed for the first time in six years with a substantial relative increase in expenditure on outward travel (figure 2.1)[7]. Although this reversal was due primarily to the Gulf War because there were less American tourists in Ireland, its occurrence highlighted problems within the hotel sector of the tourism industry. As stated in chapter one, this external condition triggered other internal problems for hoteliers.

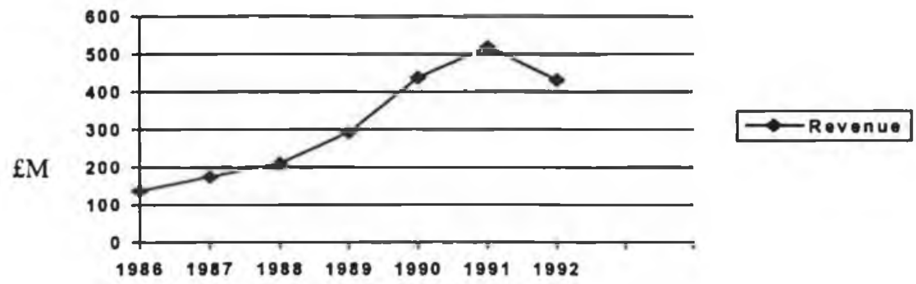

Figure 2.1 - Net Tourism Balance, 1986 - 1992[8].

Total expenditure by people travelling abroad in 1991 was IR£880 million which, for a population of 3.5 million, is very substantial. The comparison of receipts from inbound tourism was IR£1,213 million. As the latter figure represents earnings from the population of the whole world, it could be suggested that Ireland must earn a greater share of the world tourism market.

These attributes of the Irish tourism industry suggest that it is one of great importance and, as such, demands concerted efforts by both government and operators in producing a product which is worthy of marketing on a global scale. As well as government intervention, the hotel industry, as a major player, must fully develop and take advantage of all opportunities for increased effectiveness. This requires management who are highly skilled in the sale and operation of their product. In order for this to be possible, it is necessary for management to both understand how their property operates and how problems can arise.

2.3 - The Hospitality Industry.

The Hospitality industry, a sector of the service industry, consists of several different types of operations, providing both products and services to its clients or guests[9]. The core products include food, beverages, and accommodation; the service is the manner in which they are presented to the purchaser. The Industry includes hotels, motels, quick-service restaurants, fine-dining restaurants, resorts and clubs, to name just a few of the businesses involved. This research, however, will concentrate on the hotel sector.

2.3.1 - The Hotel Product.

The main activities found in the hotel industry relate to the provision and service of accommodation, food and beverages[10]. While some operators have extended their products to include leisure activities, retail outlets or outside catering, the elements above constitute the "core" products of the hotel organisation. An essential element of the business that must be outlined is the involvement of people. Although all products and services are sold to individuals, companies or government agencies, the hospitality product must be more people-oriented as they are present in the production process. A major element of the operation is therefore geared towards customer satisfaction and thus complicates the process as the customer is an integral part of this process[11].

Some have suggested that the management of a hotel is merely an extension of home management[12]: the provision of something to eat, drink and somewhere to sleep. However, on close examination any resemblance is deceptive. Hotels and restaurants are commercial enterprises that trade in the business environment, and like other businesses are subject to the complexities of economic and market forces. This involves competing for consumer spending, monitoring and improving the product, and keeping abreast of technological and managerial developments. This view clearly differentiates hotels from domestic management but the analogy may pin-point where some of the problems of quality and efficiency associated with the hotel industry arise. Consider the suggestion that anyone who can adequately run a home can run a hotel. Unfortunately this is not the case. Hotel managers must be trained in all aspects of management from finance to human resources, marketing to operations.

The need for "multi-skilling" in management is a result of the fact that an hotel, in its simplest form, covers three separate, yet inter-related, businesses. They are[13]:

1) *Room Letting activity* - The provision of rooms, originally for sleeping, but now also for banquets, meetings and conferences. This element represents a nearly pure, intangible service industry product. The letting of a bedroom is the sale or rental of space over a period of time. Their is no tangible product, nothing to bring away, simply a memory of the experience.

2) *Beverage service activity* - The provision of beverages, alcoholic and non-alcoholic, represents a service industry product that contains a retail function. Unlike room letting, the beverage product is somewhat more tangible, but it does contain an important service element which is intangible.

3) *Food service activity* - The provision of food represents a service industry product that contains a manufacturing or production function. This activity includes the purchase and conversion of raw materials into finished products.

The product is reasonably tangible but, again, also has a significant service component.

Traditionally these "core" products were essentially the same; more recently, however, hotel companies began to segment their products. This was, basically, a reaction to the needs of the customer. The perception of the experience will vary for different customers. Each customer will have different requirements and varying expectations of the products and therefore will be willing to pay different rates for the service[14]. For example, business or conference guests tend to spend a lot more time in their rooms and in the hotel than tourist guests. For this reason, their requirements differ. They may need a more spacious bedroom with a desk, a more varied menu in the restaurant and an amiable atmosphere in the bar. These varying requirements have led many large hotel companies to segment their hotel products, to provide different categories of hotel products for the different consumers. Later in this chapter it will be shown how the industry naturally segments by hotel grade, region, size, and so on and how this causes complexity in the supposedly simplistic hotel products.

2.3.2 - Product Characteristics.

As well as some of the factors mentioned above, the hotel product possesses certain other characteristics which differentiates it from other products[15]. As these characteristics cause complexity in the product from an operations and strategic level, it is important that they are understood before attempting to develop an effective diagnostic method.

Fixed capacity - Hotels have a stock of bedrooms which in the short-term is static; for example, unexpected periods of high demand cannot be easily met by producing extra bed-nights. A similar situation is found with restaurant and bar seating capacity or conference and banquet room capacity. In effect, these periods of high demand result in business being refused and a subsequent loss of revenue. Likewise, in periods of low demand, a hotel can reduce a portion of its labour costs, but a large proportion of other costs such as administration, energy, maintenance, rent, interest and depreciation are still present. This characteristic calls for effective *planning* and *control* skills in forecasting demand and *marketing* skills in maximising sales of the space available.

Perishability - Hotels experience absolute perishability in terms of room stock. An unsold room represents a loss in revenue that is irretrievable: a room for a particular night, now past, can never be sold. Similarly, unsold rooms cannot be held in stock for periods of higher demand. Raw and prepared food items are also perishable, though to a lesser extent than rooms. Again, this characteristic calls for the same skills mentioned above, *planning*, *control* and effective *marketing*.

Erratic demand - Hotels and restaurants often experience erratic demand; for example: busy dinner periods and quiet lunch periods, busy mid-week and quiet week-ends. Over a year, a hotel may attain high occupancies at peak holiday times while suffering from low take-up in the off season. Effective *pricing* and creative *marketing* may be used to maximise the sales effort.

Product range - Hotels and restaurants are characterised by their low volume and wide choice. In many cases restaurants offer three or four different product lists, in the form of menus per day. With a relatively wide range of choice within each menu, even large establishments experience a comparatively low sales volume per menu item. *Forecasting* demand and stringent *control* are generally used to combat this problem.

Real-time activity - Another characteristic in hotel and catering operations is the immediacy of the activities i.e. the customer, arriving for a room, meal or drink, requires the product immediately and cannot be expected to wait until a later date. This characteristic requires professionalism in *operations* from both staff and management. This is only possible through training and re-training of the *human resources* of the firm.

Labour intensity - The nature of hotel and restaurant service necessitates the activities to be carried out by human beings rather than machines. In recent years, automation and production methods have been applied in the industry. However, the rendering of services is an area in which machines have been unable to replace human beings to any appreciable extent. As a result of the labour intensity, hotels experience high labour costs; in Ireland, this is approximately 22% of revenue and, in the USA, the figure can be as high as 40%. A key element of remaining competitive is the tight control of these costs from effective planning and the use of various forms of work: full-time work, part-time work, contract work, and so on.

Location - The hotel and catering business is a market-centred activity and, as such, establishments generally need to be located where the products and services are consumed. Frequently they need to be located on prime sites which attract high purchase and operating costs, which in turn requires highly skilled *financial management*.

Production and consumption - In hotel and restaurants, production and consumption are often synonymous. Food is prepared on site and is usually consumed soon afterwards. The efficiency of staff in this process is an essential element of the overall hotel experience.

Capital intensity - Another feature of hotel and catering establishments relates to the amount of capital investment. Large sums are usually required, particularly in hotel projects, of which the greater proportion is tied up in property, the land and the buildings. The return on this investment is generally low, approximately three percent in Ireland, substantially lower than the return available from other businesses or a simple bank account. The maximisation of the return is therefore of great concern to investors and consequently management.

The result of these characteristics is that hospitality managers must be at least capable of effective and innovatory *marketing*; implementing effective *planning* and *control* procedures; optimising relative product *profitability*; *operating* the establishment in a smooth manner in times of pressure; and of effective *human resource management*, in order for the unit to perform effectively. These areas are therefore suggested as important candidates for analysis and diagnosis within a hotel unit. If these functions are being carried out effectively, as indicated by the operation's profitability and return on investment, a reasonable market share and a loyal and happy workforce, the company is in a good situation.

2.3.3 - The Irish Hotel Industry Structure.

As well as the product characteristics suggested above, hotel managers in Ireland also face an industry structure which requires extra skills in the functional areas of hotel operations. These areas also suggest factors to be considered in evaluating the effectiveness of an hotel company. Some significant factors that must be considered are:

Seasonality - 39% of the total bed-nights sold in 1992 were during the three months of July, August and September[16]. The proportion of sales during those peak months was one percent lower than in 1989. The April, May and June "shoulder months", on the other hand, attracted a slightly higher proportion of business. The share of annual sales falling into the off-peak months of January to March and October to December remained virtually unchanged. This aspect of the business cannot usually be affected by an individual operator. An industry or regional level marketing initiative is required.

Number - In 1992*, the last year of available data, there were 659 registered hotels in Ireland, offering about 22,000 bedrooms and 46,000 beds[17]. Although this number of hotel premises is remaining relatively stable, an increase in the number of rooms and beds exists, signifying expansion by individual operators. The expansion, geared towards the high season, results in even greater competition for the business available in the off-season. Competition of this type usually results in low pricing that erodes the already low profit margins. Effective pricing and marketing must be used in this situation.

This total number of hotels can be further categorised by Grade, the grade awarded to a premises signifying the level of quality and facilities available. Eight out of every ten hotels belong to the four highest grades, A*, A, B* and B. Grade B is the largest single category in terms of premises; grade A provides the most beds due to the larger average hotel size. Higher grades generally perform better than the lower ones. The lower grades, offering a lower standard, are restricted in the price they can charge and therefore must concentrate on cost containment to remain profitable. Therefore the grade in which the hotel unit is operating has a very large effect on the customers which can be targeted and the prices which can be charged.

Geographical positioning and size - The highest proportion of hotel beds is found in the South West region of the country, followed closely by Dublin, the poorest served region being the Midlands where hotels have the lowest average number of rooms. This small hotel size is also a feature of hotels located in the West region. Although the number of beds is the second highest in Dublin, the actual number of premises in this area is quite low. This shows that Dublin hotels tend to be much larger, having nearly double the average national number of beds. This same area has also been the region of greatest percentage increase in bed supply over the past five years. Operating in this area will obviously involve greater competition.

Capacity - In 1992, the total number of bed-nights available was 14.2 million, representing an increase of 5% since 1989. Again, the higher grade hotels are dominating capacity, A*, A and B* accounting for 88% of all the bed-nights available. In that year over 7 million bed-nights were sold, representing an increase in demand of over 13% on 1989 figures. This upturn in demand, however, was not uniform across all regions. While above average growth was experienced in the Midlands, Midwest, North West and West, demand actually fell in Dublin and the South East. While grade A hotels attracted the most business in 1992, it was the premier grade, A* which enjoyed the highest growth. The trends in demand for higher quality accommodation was also true of the B category, with sales growth in Grade B* exceeding performance of grade B.

Market performance - Hotel bed-night sales very much reflect the overall trends in tourism performance. The strong overall growth in the volume of British and mainland European visitors was reflected in the increase in hotel guest-night sales to these nationalities. The decline in the North American market was also reinforced. Accounting for 29% of bed-night sales in 1985, the North American market accounted for just 13% of sales in 1992. However, this was a direct result of the Gulf war, and as such, is not expected to continue. Britain, followed closely by mainland Europe, has usurped North America's former position as the most important overseas market in terms of absolute numbers of hotel bed-nights sold. Demand from the domestic market, which accounts for nearly half of all bed-nights sold, was very strong in 1991 and sales increased by 17%.

These industry statistics pin-point areas which cause hotel managers concern. For example, if they belong to a declining grade, should they invest and upgrade? If they upgrade, are they increasing competition in the area and instituting a price-war? Is the business available in the first place and are they managing effectively considering these industry characteristics? Will the hotel have to close in the off-peak season to cut costs? These questions describe the problem situations in which many Irish hoteliers find themselves.

2.4 - The Diagnostic Model.

As suggested from the previous sections, the "anatomy" of a business can be categorised under the following headings; marketing, finance, human resource management, control and operations. Each area must be considered with the others; this is due to relationship between the various systems (see figure 2.2). For example, human resources has a direct relationship with all operating departments within a hotel. Any dramatic changes in human resource policy will obviously affect all departments with a labour element.

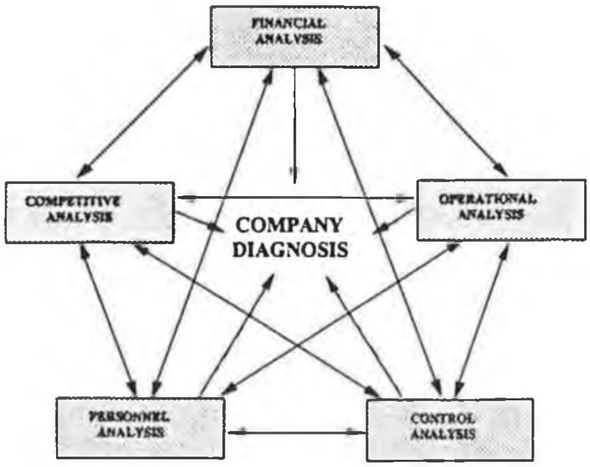

Figure 2.2 - The Hotel Diagnosis Model

In order to understand this model, it is necessary to describe what is meant by each of the functions.

2.4.1 - Marketing

Marketing is often mistakenly equated with selling, advertising or promotion. While these activities are important in the overall function, marketing is much more. Marketing is the integration of basic business functions such as sales, advertising, public relations, promotions, merchandising and pricing in order to produce the maximum profit[18]. Its most basic task is bringing buyers and sellers together. An extension of this process involves firstly identifying who the customers are in terms of location, economic status or lifestyle characteristics. More essentially, the marketing concept attempts to see the business of the hospitality operation through the eyes of the customer. It is essential that the hotel operator discovers what their customers need, how the property can deliver the appropriate services and planning strategies for competing against other properties attempting to attract the same customers. From this perspective it is obvious that activities other than selling and advertising become important and makes marketing critical to the success of the hotel unit.

As the industry expands, competition is becoming keener. Because today's guests expect more services, amenities and value, the industry is responding by becoming more specialised and sophisticated. As more and more companies equip themselves to surpass the competition and to meet these new customer demands, marketing will play an increasingly important role.

Until recently, many companies did not understand what the marketing concept involved. They have however, now been forced to take marketing measures, usually due to unfavourable circumstances, such as:

- Sales decline - When companies experience falling sales, they often react by looking for answers in the market-place. Many hotel companies in this situation have had to take a hard look at their products and how well they meet the needs of the customers.

- Slow growth - Slow growth gives companies the impetus to look for new markets. They recognise a need for marketing know-how if they are to successfully identify, evaluate and select new opportunities. Many hotel companies faced with slow growth in their traditional markets are diversifying or developing new products for different market segments.

- Changing buying patterns - Many industries are marked by rapidly changing consumer wants and needs. In the restaurant industry for example, concepts come and go. In fact, it could be suggested that the variety has actually stimulated a fickleness on the part of consumers - knowing that more is available, more is constantly demanded.

- Increasing competition - complacent companies may suddenly be attacked by powerful marketing strategies launched by their competitors. When this happens they are forced to learn sophisticated marketing techniques in order to meet the challenge.

- Increasing marketing expenditure - Companies may find their expenditures for advertising, sales promotion, marketing research and consumer service getting out of control. In these situations management may decide that it is time to adopt a strategic marketing planning process.

2.4.2 - Finance

Financial management can be argued to be one of the key roles for hotel managers. As already mentioned, the hotel industry is highly capital intensive with the majority of finance tied up in buildings and property. The return made on this investment is generally about 3%, considerably lower than could be returned from a simple savings account. For this reason, financial management obviously plays a major role in the hotel manager's duties. As the return on investment is so low, it must be achieved over the long term so as to produce satisfactory wealth. One of the main aims of management is to maintain a good financial posture that will allow a long-term level of profitability[19]. Any problems affecting liquidity, working capital, debt structure, or dividends, to name a few, may have disastrous affects on a company's financial viability.

2.4.3 - Human Resource Management

Probably no other area of management has undergone more dramatic changes in recent years than that of human resources[20]. These changes have been driven by powerful forces sweeping through society, business and government. One factor causing these changes has been the tremendous growth in the service sector. This increase has created an even greater demand among hospitality companies for skilled workers[21]. Not only must hospitality managers be able to recruit and hire competent employees, they must also be able to retain them despite strong competition from other employers inside or outside of the hospitality industry.

In order to meet these challenges, hospitality employers must realise the vital importance of managing human resources in the service environment. In the hospitality business, personnel are a key factor of success[22]. Almost every member of staff comes in contact with a guest. The marketing plan will have identified the company's customers and the company's marketing objectives. The business plan then outlines how to accomplish the marketing objectives in terms of finance, materials, timetables, measurement systems and so on. The human environment or organisational culture must support the marketing and business plans, or neither will work successfully.

The human resources strategy is a long term, systematic approach to the development and maintenance of all the elements that affect the organisational culture of a workplace, so that all the elements support one another and the goals of the company[23]. In the past, managers didn't think about improving operating effectiveness and profitability through direct involvement in the development of the human resources strategy. Today, effective managers know they need to master its development and integrate it with the marketing and business plans. Otherwise they won't be able to achieve the level of service demanded by guests or the profitability demanded by the company.

2.4.4 - Control

This is one of the most important functions of the very broad and complex systems loosely referred to as management. It is basically a series of co-ordinated activities that helps managers ensure that the actual results of the operation closely matches the planned results[24]. An effective control system is important because[25]:

- The manager must know how the operation is doing - whether and to what extent it is meeting its goals.
- Control procedures can determine whether delegated tasks are being carried out correctly.
- Through control procedures, managers can assess the effect of changes necessitated by the economy, market, and/or reactions to competition.
- Control procedures can identify problems early so that they can be resolved before they turn into bigger problems.
- Control procedures can determine where problems are occurring.
- Control procedures help identify mistakes and lead to actions to correct these mistakes.

The control process follows a series of basic steps. The process begins with the establishment of standards. Next, accurate information about the actual results achieved by the operation must be gathered. If actual results do not conform to the standards, corrective action must be taken. The action taken may be a change in operating procedures or a revision of the standards. By repeating the cycle, the effects of implementing any corrective action can be evaluated.

In the hotel business, food, beverage, quality, labour and sales income have the highest priority for control. Over the past decade, many models and procedures have been developed so as to minimise the risk in these areas. Some of them will have been utilised in the industry to some degree of success. However, the systems, although in existence, may not be adequate. Managers should consider whether the systems are performing at a sufficient level. If they are not, this denotes a problem within the control function. For example:

- Do the systems and standards set reflect the level of service quality that is being offered?
- Is the data being collected correctly and effectively?
- To what extent is computerisation used in the process?
- How broad and deep is the control effort?

2.4.5 - Operations

Having considered the previous sections, it can be argued that ensuring the success of a hotel unit, the manager is not interested in marketing, finance, control and personnel as disciplines in their own right. The manager is interested in using these techniques to achieve the results required. Management are concerned with using techniques in an integrated way to apply to the problems facing the unit and the organisation.

The last category within the diagnostic model concerns analysing the operations of the hotel unit, i.e. how the techniques are being used in the overall effectiveness of the business. The results that a manager is concerned with must be derived from the three major components of the hotel operation[26].

- The customers
- The workforce
- The assets

The operational level of the diagnostics is concerned with the amount of fit between these three components. In practise, many management problems are derived from a lack of fit. It is now possible to identify "key result areas" or that are derived from managing the three components so far identified[27]. A key result area can be defined as an area of activity that must be successfully managed in order to ensure the continued existence and the ultimate success of the operation. Thus the key result area derived from the customer is ensuring customer satisfaction; the key result area derived from the workforce is maintaining employee performance; and that from considering the assets is protecting them from threat. (see figure 2.3)

Figure 2.3 - Three component model of operations management

But the manager does not manage these components in isolation from each other. They interact and overlap. Where each component interacts with one of the other two, a new key result area is evident (See figure 2.4). The interaction of the workforce and the customer highlights the key result area of managing customer service. The workforce/assets interface is concerned with maximising productivity. And the interaction between the customer and the assets focuses the manager's attention on maximising income and profit contribution. Finally, the combined interaction of all three components focuses on the key result area of managing quality.

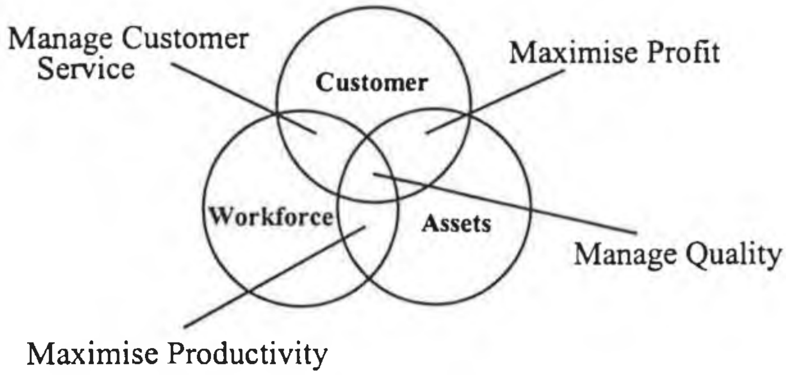

Figure 2.4 - Integrated model of operations management

The extent of fit required will vary for different sectors of the industry, and of the same sector at different times when facing different market conditions. The focus of attention or relative priority of each of the key result areas will vary across sectors, and over time within sectors.

The operational diagnosis will be geared towards identifying what are the key result areas for a particular business at that particular time and ensuring that the best possible fit is being exercised.

2.5 - Early Warning Signals

As few people can truly be experts in all of the required areas mentioned above, much research has been carried out recently in developing useful frameworks for analysis and practical tools for crafting strategies towards the effective management of a hotel unit. An original direction of this research was to develop a comprehensive list of the critical success and failure factors for the hospitality industry. These are factors that exist within the business that can help determine whether or not the business in question will succeed or fail. For example, low cash flow, a high staff turnover value, decreasing market share, below average profit margins or a combination of these, would be serious failure factors in any business and the opposite would be examples of factors of success.

Although it would be helpful to have a general list of the critical success / failure factors for the hospitality industry, such a list is difficult to generate as every property is different, as it is managed by different people, visited by different customers and operates in a different external environment. It was determined to be beyond the limits of this research to consider in depth all the material presented on all functional areas of the hospitality industry. Instead, for the purposes of demonstrating the suitability of expert systems to the task the identification of what may be the most crucial internal factors and appropriate methods of analysing them were investigated.

There are three basic categories of early warning signals which may be analysed[28]. Early warning signals constitute the symptoms a company may exhibit if in a problem situation.

The first is a *mathematical analysis* approach used to "Red-Flag" potential problems. Commonly referred to as financial statement analysis, this method provides more valuable information from financial statements than could be received from reviewing the absolute numbers reported in the documents. A combination of ratios can be used to efficiently and effectively communicate more information about the well being of the business and where corrective action is required. The detection of company operating and financial difficulties is a subject which is amenable to analysis in this manner. As early as 1935, Smith and Winakor[29], Merwin[30] and Hickman[31] concluded that failing firms exhibit significantly different ratio measurements than continuing ones. The most significant use of ratio analysis carried out by Beaver[32] in 1967 found that a number of indicators could discriminate between matched samples of failed and non-failed companies for as long as five years prior to failure.

The second category of signal - *adverse trend signals* - is a more subjective method and less precise mathematically. These cover a variety of functions, but are principally market-oriented, i.e. the company is viewed by the managers through the eyes of the customer. There is no absolute good or bad values for these measures, since they can vary from industry to industry and region to region. It is the relative trend of these factors and their comparison to industry numbers that is significant. The first tip-off on the overall company is when growth in sales is not translated into profits. Declining margins are the first key, and can be evaluated using the profit margin ratio. The second key is price incompatibility in the market, with loss of market share. When both are apparent, that would suggest a company that is in trouble. In Bibeault's survey of executive opinions, declining margins came out as the strongest adverse trend signal[33]. Other early warning signals that came up in that survey were: declining market share, rapidly increasing debt, rapid turnover of staff and management and a decline in the rate of reinvestment in the company.

A problem with such quantitative approaches is that they are based on published information that in turn is dependent on the proper statement of financial results by management. Another major handicap of mathematical approaches is that they depend on relatively old information. For these reasons, it is obvious that other early warning signs are needed.

The third category of signals is even more subjective and a great deal more behavioural. These signals centre on *observation and communication* within an organisation. The only gauge in this situation is the feel of the people and the business involved. Questions which might be asked are: Is motivation high?; what is the quality of the service?; how clean are the premises?; what sort of atmosphere exists? All of these questions could be answered in a different way, depending on who is being asked and their ability to detach themselves from the business. Considering this, an analyst must be present in the company or at least formulate a way to ask such subjective questions in a way that will produce the most accurate result.

According to Bibeault, these subjective warning signals are as likely to exist in a relatively successful company, but in a company close to failure, few might be apparent. These arguments may be applied to all the non-financial symptoms discussed here, however they still can have some confirmatory value in predicting failure. Considering this, it is evident that no one method will suffice. An accurate analysis for diagnostic means, must combine all the methods and their inter-relationships.

2.6 - Internal Causes of Concern.

> *It is never sensible to push any analogy too far, but the collapse of a company is in some ways similar to the sinking of a ship. If the ship is in good condition and the captain is competent, it is almost impossible for it to be sunk by a wave or a succession of waves. Even if there is a storm, the competent captain will have heard the forecast and taken whatever measures are needed. Only a freak storm for which quite inadequate notice has been given, will sink the ship.* **John Argenti.**

Having considered the early warning signals and the symptoms of problems, it is necessary to also consider the problems which exist. The reason why companies of any sort find themselves in crisis situation or distress is a large topic. Therefore, it is essential for research of this type to develop a suitable classification of the factors which cause decline. Many authors suggest that it is possible to trace virtually all the reasons for declining performance back to "bad management", either poor decisions or inaction[34]. Even where outside factors are the cause, management should have forecast and planned against them. Although sheer bad luck can be a cause of collapse, generally this accounts for very few failing companies. Management's responsibilities include getting the company into a posture, both from a marketing and financial point of view, where it can resist normal business hazards and other more serious external challenges. In real analytical terms, this approach, however, is useless, as it merely places blame rather than pin-pointing causes.

When looking deeper at the situation, the most significant problem of this research is encountered. In the process of diagnosing a company, two seemingly related elements must be separated. The analyst must be clear what are the true causal agents and what are merely the effects of a problem or a symptom. For example, an hotel is experiencing intense price competition. Is the price competition the cause of decline or is the cause the inferior cost position relative to competitors? If the latter is the cause, is it due to lack of market share or poor financial policy? If financial policy, what caused adoption of the policy? Again poor management appears to be the true cause. What was originally viewed as the cause, is now shown to be a symptom of a deeper problem. However in this process the full chain of causal agents can be identified, instead of skipping the "middle men". It must be noted that in practice, instead of one cause, it is usually a combination of interrelated causal factors.

Argenti[35], Schendel *et al*[36] and Slatter[37] have suggested similar categories of causal factors which lead to company failure. Although the majority of work centred on manufacturing and retailing, Slatter did analyse some service industry companies. The categories, though an incomplete list, establish the principle factors which suggest a company is in or approaching a decline i.e. critical failure factors. They are (with some examples):

- *Lack of financial control.*

  Poorly designed management accounting system.

  Management accounting information poorly used.

- *Inadequate management.*

  In 1980 94% of all failures were identified with the lack of experience of unbalanced experience (50%) or incompetence[38].

  Elements of poor management are further recognised by one-man rule; combined chairman and chief-executive; ineffective boards of directors; management neglect of core business; or lack of management depth.

- *Competition.*

  Product competition.

  Price competition.

- *High cost structure.*

  Operating inefficiencies.

  Low labour productivity.

  Poor planning.

- *Changes in market demand.*

  Cyclical market decline.

  Changing pattern of demand.

- *Operational marketing problems.*

  Ineffective and wasted advertising.

  Lack of market research.

  Weak new product development.

- *Big projects.*

  Underestimating capital requirements.

  - Poor cost estimates.
  - Poor project control.

- *Acquisitions.*

  Acquisition of a "loser".

  Paying too much.

- *Financial policy.*
  A high debt to equity ratio.
  Conservative financial policy.
    No reinvestment.
    High liquidity and low gearing.
    Inappropriate financing sources.

Although suggested by many, this categorisation is actually given some credibility by Slatter. In his study, he found that twice as many of these causal factors of decline existed in crisis situations than in non-crisis situations. The most prominent causes of decline found were poor management and lack of financial control. Most likely, a crisis situation would occur in a firm weakened by inefficient management with little control. When subjected to adverse movement in demand, price competition or a big project, the firm will quickly sink into insolvency.

Symptoms of decline, although easier to detect, may not always be differentiated from causes. The symptoms give analysts some idea of where to start looking for problems. Financial indicators, discussed previously, are the most commonly used symptoms. However, non-financial, and sometimes non-quantifiable indicators are important. Some of these symptoms are[39]:

- Change of auditor, possibly to one less well known.
- Delay in publishing accounts.
- Top management fear.
- Rapid management turnover.
- Declining market share.
- Lack of planning or strategic thinking.
- Poor upkeep of the premises.
- Management unavailable.
- High staff turnover.
- Decrease in levels of stock.
- Decrease in levels of service quality.

This list is also incomplete, and management who want to be aware of symptoms must constantly scan the internal environment for problems. No single symptom will indicate that the business is in trouble. A combination of adverse symptoms is required.

2.7 - Causes of Distress in the Hotel Industry.

Within the hotel industry, the most common symptom of distress is the lack of ability to generate sufficient cash flow to satisfy operational costs, debt service and an appropriate return on the investment[40]. The possible reasons for this may be a big project, decreased sales due to increased competition or many other factors. Although management's recent emphasis on cost containment has improved the operational efficiencies of many hotels, the increasing capital costs have tended to consume the additional available pounds. Many of the factors that have contributed to this situation are outside the control of the hotel manager as they are imposed by governmental or economic elements. Changes in tax laws, changes in funding, the Gulf war and its effect on tourism as well as the world wide recession, all have had an impact on the hotel business. Some of these may have been unforeseen or constitute just bad luck.

The result of these factors can be a drop in revenue, which in some marginal properties may cause an irreversible decline. Other hotel businesses, although not permanently damaged, share some or all of the following characteristics, indicative of a distress situation[41]:

- The property has become obsolete because of age or location.
- The property faces unexpected (local or regional) market conditions.
- The property cannot achieve planned market share because of the emergence of unexpected competition.
- Mismanagement has reduced the property's revenues or has increased expenses.
- The property is over-financed: that is, it is carrying a debt that is larger than it reasonably could be expected to pay off from the proceeds of the sale of the business.
- The property cannot afford or is unable to attract professional personnel. The quality of the product drops and sales continue to decrease.

When any industry is faced with such difficulties, alternatives strategies must be implemented. Instead of planning for growth, managers must now plan for survival. Some of the operator's alternatives in this situation are to sell the property, if it can be sold for enough money to pay off the debt and taxes; to re-position the property in the market, if the re-positioning promises to generate sufficient revenues to pay the mortgage and operating costs; to work with the major lender on a program to relieve the situation; or to correct the faults and "turn-around" the business.

All of these alternatives require a major redirection of the business. The author argues that a sufficient knowledge of the product and its operation, the industry and its structure, the causes of problems, and an effective analysis and diagnostic model will avoid a decline situation. In this way it is possible to ensure that the situation is constantly redirected in minor ways, to prevent major changes from having to be made. This requires monitoring the business carefully, using all appropriate models and techniques, to identify those elements which may cause failure in the future. Once the correct cause has been diagnosed, measures, either immediate or long-term, can be taken to eradicate the problem.

2.8 - Action Research

In the hope that a company will never find itself in a distress situation, management must adopt a method for analysing and diagnosing their business situation and use it to monitor their progress, as suggested in Chapter One. Considering the amount of data available to the hotel manager, how can the search be limited to a few areas with confidence that they are the "right" ones? An assumption that has been made by Weisbord must be considered[42]. The assumption is that generally what you look for determines what you find, and the inverse is also true, that what you find is based primarily on what you are looking for. In the case of company diagnosis for factors which are limiting success or causing decline, some categories will be more important than others. As diagnosis concerns the identification of problems which may cause distress to a company, it is these problems which will focus the search effort of this project.

The ideal is to find a method that allows the symptoms and causes discussed previously, and the analytical methods to be represented in a comprehensive and effective manner. *Action research* is one name for a form of systematic problem identification and solution in which the identifiers and solvers are the same person, as in internal company diagnosis by management. The term implies "learning from your own situation, as you modify and seek to improve it"[43]. The process involves:

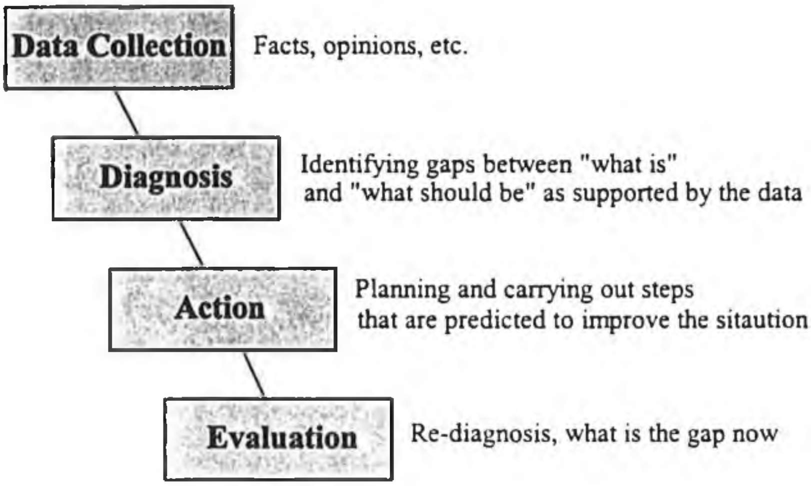

Figure 2.5 - Action Research Model

From this sequential list, it is with the first two elements that the author is most concerned, the data collection (analysis) and the diagnosis. In most organisations, the problem is not the absence of data. The author has already discussed three types of data which may be used for the purpose of analysis and diagnosis: early warning signals such as financial statement analysis, adverse trend analysis such as applicable to the marketing function, and behavioural signals such as the condition of the premises, the staff attitude and so on. The problem is deciding what data warrants attention and in what order, and whether executives are aware of the relationship between data which may exist. The developmental challenge is to provide hotel managers with a diagnostic tool which will enable managers to develop a coherent view of the business and to focus on the data relevant to the organisations future survival.

2.9 - Summary

This chapter has identified the importance of tourism and more specifically the hotel industry to the national economy. In order for the industry to remain competitive and profitable, it is necessary that hotel managers understand how to operate and sell their product. To be able to do this, managers must be aware of the problems that exist is order to avoid them causing distress for the business.

The product itself, is complex. This is due to the overall product being a combination of other products, the difficulties involved in service as opposed to manufacturing industry, and an industry structure highly fragmented by size, location, and grade. Due to the complexity, hotel managers are required to be highly flexible in the jobs, to the point where they must be experts in all areas of the business: marketing, finance, personnel, operations and control.

As a high level of such inter-disciplinary skill is hard to achieve, this project proposes to develop a system which will support hotel managers in the diagnosis of the hotel unit.

In order for such a system to be developed, it is necessary to structure the hotel unit in a way that would simplify the structuring of the problems. From the product characteristics and the industry structure, the hotel unit was divided into five 'systems'. Finance, marketing, control, personnel and operations were selected as the most appropriate categorisation for the purposes of this research.

Considering this model, it is necessary to identify both the problems that can occur in each of the areas, as well as the causes of those problems and the symptoms which would suggest a problem is in existence. Early warning signals, including both quantitative and qualitative ones, were recognised as appropriate symptoms of a company in distress. These signals were broken into three categories:

Financial statement analysis: Profitability, liquidity, operational, activity and investment ratios can be used to develop a picture of how the hotel is operating from a financial point of view.

Adverse trend signals: Decline in sales, decline in profits, weakening market share, and price incompatibility are examples of signals particularly relevant to the marketing function.

Behavioural signals: This category is concerned with the more qualitative information available about a hotel which would suggest a problem. Motivation of staff, cleanliness of the premises, management presence, and the atmosphere of the hotel are examples of such signals.

This signals will constitute some of the information that will be required by the diagnostic system when carrying out an analysis of the hotel unit. This information will then be compared against the prominent problems which may occur. In order to identify these problems, the causes of concern in businesses in general and the hotel industry were analysed. Problems such as the lack of financial control, inadequate management, competition and financial policy were identified as examples of such problems.

The objective of the following chapters, therefore, is to identify a further, more comprehensive list of problems. These in turn must be related to each other within a particular functional area, and related to problems which exist in other functional areas. This knowledge will then be developed into a computerised tool to support the hotel manager in this problem identification process.

References

1 Oxford English Dictionary, 2nd. Ed., Clarendon Press, UK., 1989.

2 Halloway, C.J., **"The business of tourism."** 4th. Ed., Pitman Publishing, UK, 1994.

3 Central Statistics Office, **"Report of the tourism task force to the minister for tourism, transport and communications."** , October, 1992.

4 Cert, **"Manpower survey of the hotel, catering and tourism industry in Ireland."** Vol. 1., 1993.

5 Op. Cit. (4)

6 Op. Cit. (3)

7 Source - Central Statistics Office.

8 Bord Failte, **"Hotel Profile."** 1991

9 Buttle, F., **"Hotel and food service marketing."** Cassell, UK., 1993.

10 Medlik, S., **"The business of hotels."** Heinemann Professional Publishing, UK., 1984.

11 Op. Cit. (9)

12 Lundberg, D.E., **"The hotel and restaurant business."** Van Nostrand Reinhold, New York, 1989.

13 Op. Cit. (9)

14 Abbey, J.R., **"Hospitality Management Library - Sales."** Educational Institute of the American Hotel and Motel Association, USA, 1989.

15 Op. Cit. (9)

16 Simpson Xavier, **"Irish hotel industry review."** 1993.

* 1992 is the last year in which published data is available.

17 Op Cit (8)

18 Kotler, P., and G. Armstrong, **"Principles of marketing."** 6th. ed., Prentice-Hall International Editions, USA, 1994.

19 Schmidgall, R.S., **"Hospitality management library - finance."** Educational Institute of the American Hotel and Motel Association, USA, 1990.

20 Wheelhouse, D., **"Hospitality management library - human resources."** Educational Institute of the American Hotel and Motel Association, USA, 1990.

21 Ibid.

22 Gregor, K.R., **"A view from the helm."** The Cornell Hotel and Restaurant Administration Quarterly, October, 1991.

23 Wheelhouse, D., **"Hospitality management library - human resources."** Educational Institute of the American Hotel and Motel Association, USA, 1990.

24 Ninemeier, J.D., "**Hospitality management library - Control.**" Educational Institure of the American Hotel and Motel Association, USA, 1986.

25 Ibid.

26 Jones, P., "**Food service operations.**" Cassell, London, 1988.

27 Ibid.

28 Bibeault, D.B., "**Corporate Turnaround - how managers turn losers into winners.**" McGraw Hill Book Company, 1992.

29 Smith, R., and A. Winakor, "**Changes in financial structure of unsuccessful corporations.**" University of Illinois, Bureau of Business Research, 1935.

30 Merwin, C., "**Financing small corporations.**" National Bureau of Economic Research, New York, 1935.

31 Hickman, W.B., "**Corporate band quality and investor experience.**" Princeton University Press, USA, 1958.

32 Argenti, J., "**Corporate collapses: the causes and symptoms.**" McGraw Hill, USA, 1976.

33 Op. Cit. (26)

34 Ibid

35 Op. Cit. (32)

36 Schendel, D., et. al., "**Corporate turnaround strategies: a study of corporate decline and recovery.**" Journal of General Management, 1976.

37 Slatter, S., "**Corporate recovery - a guide to turnaround management.**" Penguin Books, UK., 1984.

38 Op. Cit. (32)

39 Ibid.

40 Flannery, M.J., and J.J. Flannery, "**Causes of hotel industry distress.**" Real Estate Review, Vol. 20,3, Fall, 1990, pp. 35-39.

41 Berg. Peggy, "**Exploring solutions in hotel workouts.**" Real Estate Review, Summer, 1992, pp. 33-41.

42 Weisbord, R.M., "**Organisational diagnosis: six places to look for trouble, with or without a theory.**" Group and Organisation Studies, Vol 1,4, December, 1976, pp. 430-447.

43 Ibid.

Chapter Three.

Technology Evaluation

3.1 - Introduction.

Chapters One and Two have identified the importance of developing a computerised system capable of supporting the hotel manager in effectively scanning the internal environment for problems. This scanning is the basis of the diagnostic decision, i.e. the analysis and interpretation of data which may establish the existence of problems. This research concentrates on scanning five selected areas of the hospitality business: Finance; Personnel, Operations; Sales/Marketing and Control.

In order to develop such a computerised system, it is vital that an appropriate tool is selected. A wide variety of tools are available including: Management Information Systems (MIS), Decision Support Systems (DSS), Executive information Systems (EIS) and tools within the Artificial Intelligence arena.

This chapter examines the capabilities of each of these technologies and establishes how they are presently being used. Based on their capabilities and functionality, the most appropriate technology is selected as the development tool for the proposed system. Of prime importance for this selection are the capabilities to use imperfect data, employ heuristics, allow for both quantitative and qualitative information and use knowledge in addition to data, as a human solving the problem would.

3.2 - Information

Since the 1950s, management in companies have realised the importance of information in the decision-making process. Unfortunately, the "information revolution" as it was termed, has been slow to come to fruition[1]. Several reasons for this are apparent:

- Computer hardware was too expensive for use in areas where information did not have a very high value.
- Software was unavailable or too expensive to merit the high development costs.
- A concerted effort to develop an information "orientation" within companies was not adopted.

Today, however, more time and interest is being afforded to information technology in the hope that investment in these areas will provide a sustainable competitive advantage associated with growth and even mere survival.

Prior to discussing the technologies available to managers in their quest for information, it is necessary to describe what is meant by the term "information". This is appropriate as the characteristics of information must be considered in the development of any information system. Although often seen as synonymous, data and information are quite different. Data are the raw material from which information is actually derived. Information on the other hand, is the product which results from the thoughtful analysis, manipulation and presentation of data in a form that will enhance the decision-making process[2]. A table of numbers found in a balance sheet could be described as data. By performing ratio analysis or by simply graphing the data in a meaningful manner, trends and patterns are shown, and the data is converted into information.

Information is generally described in terms of accuracy, verifiability, completeness, relevance and timeliness[3]. These characteristics are important in that they have significance for systems development.

- Accuracy: Accuracy refers to the degree to which information is free from error.

- Verifiability: In order to provide accuracy, verifiability is the degree to which the information can be proven correct. Unverifiable information may be used in decision-making but usually with caution and skepticism.

- Completeness: This refers to the degree to which the information is free from omissions. The information may be completely accurate and verifiable, but useless if it does not tell the complete story.

- Timeliness: Up-to-date information may be of significant value to the manager. The same information in six weeks or even six months will have considerably less value.

- Relevance: The appropriateness of the information as input for a particular decision. "Information overload" is becoming increasingly regular in decision-making situations. This occurs when the volume of information available is so great that it is difficult to distinguish relevant information from that which is not.

It has been suggested that an effective information system must contain all of the above characteristics[4]. For example, it can be suggested that in order for a system to be capable of making a "correct" diagnosis of a hotel unit, it is essential that the data and information provided are up-to-date, relevant and correct. However, the idea that completeness, accuracy and verifiability of information are also essential in a system is open to argument. The very nature of the company diagnosis problem is entirely subjective. As a result, the system capable of replicating the process must be able to deal with incomplete data and with perceptions rather than absolute facts, possibly even incorrect or unsuited to verification. This point will be crucial to the selection of an appropriate technology.

3.3 - Computers and Information Processing.

> *The new source of power is not money in the hands of the few, but information in the hands of the many.* ***John Naisbitt.***

Technology is a term which has become synonymous with computers. Although not strictly accurate, an actual definition being "the science of the industrial arts"[5], modern technology advances have become possible through the use of powerful micro processors, the basic elements of computers. Although utilised for many other purposes, computers are seen regularly providing information whether for commercial or domestic purposes. The area of computers and information processing deals directly with this computer-assisted flow and provision of information.

From the literature reviewed, the scope of computing seemingly includes everything from word-processing through management information systems to industrial robots[6]. Computers are the base technology which enables us to tap the information resource, the value of which is becoming more important in times of high competition[7]. Computers have been recognised as a valuable business tool for over three decades. In this short time computers have proven to be incredibly effective processors of data, and have more recently won praise for their ability to produce meaningful information. It could be argued that computers have always produced information, but generally only a select few people had access to a limited amount[8].

Today, through increased utilisation of computers, information is being made available and readily accessible to those who need it, whether at the operational or executive levels. Although the information requirements may be different, the same computer system can supply information which is relevant to each end-user. The end-user is anyone who provides input to the system or uses the outputs. For example, a hotel front-office system supplies operational information to the receptionist regarding arrivals, guest accounts, and departure lists. The same system could provide tactical information to the marketing executives regarding performance from different market segments. Higher executives can receive strategic information concerning returns on investment, asset utilisation and so on. Computers still process data, but their increased potential to produce meaningful information has resulted in MIS having increased importance in companies.

Two major contributors in the emergence of computerisation are[9]:

1) The improved power / price ratio of computers, which makes it more economically feasible to make the power of computers accessible to more people.
2) The availability of user-oriented software. A wide variety of software packages are available to assist the end-user in obtaining needed information without the intervention of an MIS professional.

In addition, companies have become more aware of the competitive advantage that can be achieved through creative use of information technology. As Naisbitt suggests, information is now one of the most important resources available to management[10]. It is no longer a case of being able to afford the technology; more importantly, can management afford not to make use of this resource?

3.4 - Information and Competitive Advantage.

According to Jong, technology is an area which has no obvious return on investment and the benefits are therefore hard to establish. For this reason, and prior to the development of any information system, it is necessary to question why a company would be interested in such large scale investment in such an area, where no direct return is apparent[11]. Until recently, this question may have been difficult to answer by industry leaders. However, through adverse conditions, inflicted by a more competitive market, managers have been forced to understand the reason.

Modern commercial life not only requires but insists that management in every area of business are challenged to become more competitive and, thereby, more profitable[12]. In the past, management has approached this task by focusing its efforts to enhance competitiveness on the resources of people, materials, and money. These efforts have proven successful, but are alone insufficient for a company to remain competitive in a world market. In an all-out effort to gain a competitive advantage, managers are looking to the information resource.

It has been suggested by numerous authors that information is a strategic weapon that, if used creatively, can provide a company with a clear competitive advantage[13]. This could be argued to adequately justify any investment in this area. However, until recently, although this technology was available, many companies insisted on exhausting every other avenue for improving profitability before turning to information systems[14]. An example of this attitudinal problem is demonstrated by a comment made by Ralph Sprague, Professor of Decision Sciences at the University of Hawaii. In 1990, Sprague gave a one-day conference on marketing decision support systems to 12 top executives. At the close of the day one executive asked for examples of companies who were already using this technology. Sprague replied, "If I could, it would be too late for you." Although a simple statement, it makes a powerful point. Basically, it does not help to be second. Each company must be creative in its use of computers and information technology. With the availability of both powerful computers and appropriate technologies, it can be argued that companies not fulfilling their information requirements are being hampered purely by what can be termed as "Information Myopia", the inability to visualise innovative uses of the technology and available information.

Companies with an information oriented approach are gaining competitive advantage by making information an integral part of the corporate strategic planning process. For decades, research and development, finance, and marketing have been the dominant areas of consideration in corporate strategic planning. Today, the situation is different. Profitability is being increased by using information technology to: increase sales; increase productivity and reduce costs; improve customer service; and manage resources better. See figure 3.1[15].

Figure 3.1 - Ways to use Information systems to enhance profitability

A combination of these four functions can affect an organisation in three ways:

Improve efficiency:	Increasing the efficiency of a task. Completing more work with the same or fewer resources.

Improve effectiveness:	Doing the right things. Using resources to produce desirable and high-quality results.
Improve competitiveness:	Selecting and implementing strategies that change the way an organisation competes. Improving performance in comparison to competitors using chosen criteria (e.g. market share and industry ranking).

These areas constitute the core benefits available from the use of technology, if the technology is used correctly. In order to actually achieve these benefits, it is vital that the systems are as effective as possible. This goal is realised through selecting the most appropriate tool for whatever the task.

3.5 - Information Systems

Some of the technologies available to achieve competitive advantage include:

- Transaction Processing Systems (TPS);
- Management Information Systems (MIS);
- Decision Support Systems (DSS) and
- Expert Systems (ES).

These technologies support planning, problem-solving and decision-making activities at varying levels. This categorisation of technologies is based on their orientation toward data, information, a suggestion or a decision and the complexity of the problem to which they can be applied.

In reviewing the literature available on these systems, it is apparent that a clear and concise definition of each is unavailable. Possibly, such definition is inappropriate. It is possible that strictly defining the technologies may cloud professionals' perceptions of the uses of the systems which may inhibit lateral thinking[16]. Surveys have shown that the definitions tend to vary according to the user's perceptions of the functionality and uses of each system. With this in mind, the author has chosen to discuss and evaluate the appropriateness of the technologies based on their application to the problem area, specifically to the model of decision-making discussed in chapter one. The appropriate technologies will be discussed and applied to the level of support they offer to the modified model of the decision-making process.

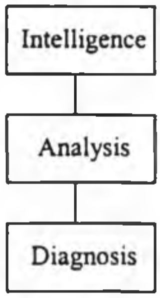

Figure 3.2 - Decision-making model

3.5.1 - Transaction Processing Systems.

The most basic form of information system is a Transaction Processing System (TPS). These systems substitute computer processing for manual record keeping procedures. They are primarily data oriented and their most important feature is that they are capable of handling well structured and routine processes[17]. Such processes are generally repeated many times during the course of the day and are clearly understood, to the extent that clearly specified routines can be formulated. These systems have many advantages. They can handle tedious and boring work which when carried out by humans is susceptible to inaccuracy[18]. Secondly, the electronic speed of operation of such a system is much faster than its manual equivalent. Lastly, a computerised system can be relied upon to store and accurately recall large quantities of fact and also can force users to follow procedures by ensuring that they complete all necessary steps in a transaction[19]. Examples of such transactions are the taking of reservation details, posting to guest accounts, checking guests in and out of an hotel.

Although offering many advantages, it can be argued that few of these benefits apply to the decision maker directly. They are simply oriented toward the collection and storage of data. Little processing of information is carried out and few reports are available with the exception of summary reports. The aim of Transaction Processing System is obviously the processing of high volumes of data, not providing support for decision-making. Therefore this technology is of little use to this research area.

3.5.2 - Management Information Systems.

The term "Management information systems" (MIS), although a specific area in its own right, is commonly used in the business environment as a generic reference to all technologies, procedures, systems (manual or computerised), and people associated with computers and information processing[20].

As stated the definitions are vague. MIS has been called a method, a function, an approach, a process, an organisation, a system and a subsystem. Even executives, or MIS professionals offer little assistance. They will each offer a different explanation as to their idea of MIS. In this section the author is more concerned with MIS as a specific category of system. MIS has been defined as:

> The entire set of systems and activities required to manage, process, and use information as a resource in the organisation. Ralph Sprague Jr.[21].

> A MIS is a business system that provides past, present, and projected information about a company and its environment. David M. Kroenke and Kathleen A. Nolan[22].

> MIS is the subsystem of an organisation's information system relevant to managerial decisions for control and strategic planning. A. Ziya Aktas[23].

These and many other definitions are offered to give a feel for what authors and practitioners perceive a management information system to be. Davis suggests a more comprehensive definition[24]:

> A management information system (MIS) is defined as a formal system (manual or computer based), intended to retrieve, extract and integrate data from various sources. They provide accurate, reliable and valid information, whenever such information is needed, to aid in the operation, management and decision-making by providing past, present and future oriented information about internal operations and external intelligence.

Although MIS are not synonymous with TPS, an important relationship exists between them. Much of the data needed to support managerial decision-making activities originate from business transactions[25]. However, captured data from the TPS must be selectively processed before it produces meaningful information. Although TPS add speed accuracy and reliability to a procedure, they do not improve the effectiveness. MIS, on the other hand, can be argued to change the effectiveness of the system by allowing previously impossible manual analysis to be carried out simply[26].

In the continuum or range of problems discussed in chapter one, structured through semi-structured to unstructured problems were identified. MIS have been most successful in providing information for routine, structured and semi-structured decisions and problems[27]. Structured and some semi-structured decisions, especially of the operational and managerial control type, have been supported by computers since the

1960s. Such problems which are encountered fairly repeatedly. Therefore, it is possible to abstract and analyse them into computerised solutions. Such systems have been used for capital budgeting, allocation of resources, planning and inventory control. For each of these problems a prescribed solution can be developed through the use of mathematical formulae.

The use of computers allows the solution for the problem to be found in a quick and efficient manner. MIS assist in the managerial process by providing timely, accurate and relevant information on which controls and future planning can be based. While structured and semi-structured problems can be solved with the aid of a host of such systems, the less structured ones can not[28]. Although MIS provide information on which managers can base decisions, little further support is offered. Applied to the whole process of decision-making, MIS is really only capable of supporting the intelligence phase. Through the reporting function, MIS can provide information to assist in the problem-finding activity by comparing expectations with current or projected performance.

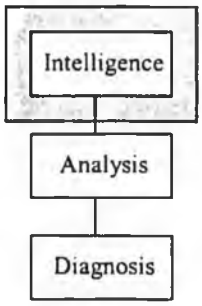

Figure 3.3 - MIS and decision-making

3.5.3 - Decision Support Systems.

On many occasions, decision makers can rely on their experience to make quality decisions or they may need to look no further than the information that is readily available from the integrated corporate MIS[29]. However, decision makers, especially at the tactical and strategic levels, are often confronted with complex decisions that are beyond their human capabilities to properly synthesise the factors involved. These types of decisions are assisted by using Decision Support Systems. A Decision Support System (DSS) is an information system that assists in decision-making and tends to be used in planning, analysing alternatives and in trial-and-error searches for alternatives[30]. As opposed to simply providing ever increasing amounts of information, DSS support the process of decision-making. Managers, particularly at higher levels of decision-making, require more than information. They require additional capabilities which assist them in rapidly evaluating future conditions and decisions. These are provided by the modeling facilities of the DSS, the information from the MIS being modeled to provide an effective method of analysis.

The concepts involved in DSS were first articulated in the early 1970s by Scott-Morton under the term "management decision systems". He defined such systems as "interactive computer-based systems, which help decision makers utilise data and models to solve unstructured problems[31]. Another classical definition of DSS, provided by Keen and Scott-Morton[32] states:

> Decision support systems couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with semi-structured problems.

These definitions indicate four major characteristics of DSS[33].

1. DSS incorporate both data and models.
2. They are designed to assist managers in their decision processes in semi-structured (or unstructured) tasks.
3. They support, rather than replace managerial judgement.
4. The objective of DSS is to improve the effectiveness of the decisions, not the efficiency with which decisions are being made.

Although people have been making decisions for thousands of years without the use of technology, DSS have become more important. DSS are needed because it has been suggested by psychologists that human minds cannot handle the complexities that decision-making entails. The mind can only focus on approximately eight facts at a time and its ability to calculate probabilities, especially two or more probabilities together, which is essential for decision-making, is low[34]. Furthermore, people allow emotions - especially fear - to get in the way, leading to decision avoidance, over reaction or hyper-vigilance[35]. In these situations, there is a tendency to make decisions without taking all the relevant information into consideration, particularly where the time scale is too short for the above work to be carried out satisfactorily. As well as information, top-level managers require additional capabilities which assist them in rapidly evaluating future conditions and decisions. These are provided by modelling facilities of the DSS.

Applied to the decision-making process, DSS is capable of supporting two of the three areas:

Intelligence: A DSS can readily access information made available from either TPS or MIS.

Analysis: A DSS, through its modeling capabilities, can analyse data very fast. Therefore the scanning carried out during this phase is considerably quicker. This phase involves the generation of alternative courses of action, decisions about the criteria for choice and their relative importance, and forecasting the future consequences of using various alternatives. Several of these activities could use models provided by DSS (e.g., forecasting).

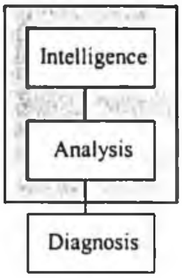

Figure 3.4 - DSS and decision-making

Some argue that a DSS can also support the diagnosis phase. However, as this phase requires the integration of qualitative information, heuristics and incomplete data, DSS are inappropriate.

3.5.4 - Artificial Intelligence.

This type of support to decision-making seemed to be the pinnacle of computerising the decision-making and problem-solving process. Forgionne argued that as judgement and experience also play a part in management decision-making, it was not possible, or even desirable to automate the entire evaluation process[36]. However, at the beginning of the 1980s, a technology, previously limited to academic institutes, had begun to appear in commercial applications. The General Purpose Problem Solver (GPS), later to become Expert Systems, offered the promise of "intelligent systems" which could incorporate judgement and experience into their analysis[37]. These systems were specific areas of the larger field of Artificial Intelligence (AI).

Many definitions have been proposed for AI. One suggested by Patrick Winston, director of the Massachusetts Institute of Technology, Artificial Intelligence laboratory, states[38]:

> *"Artificial Intelligence is the search for methods that will make computers far more intelligent (or at least act as if they were more intelligent) and therefore more useful."*

AI can be broken down into seven main research areas as shown in figure 3.5.

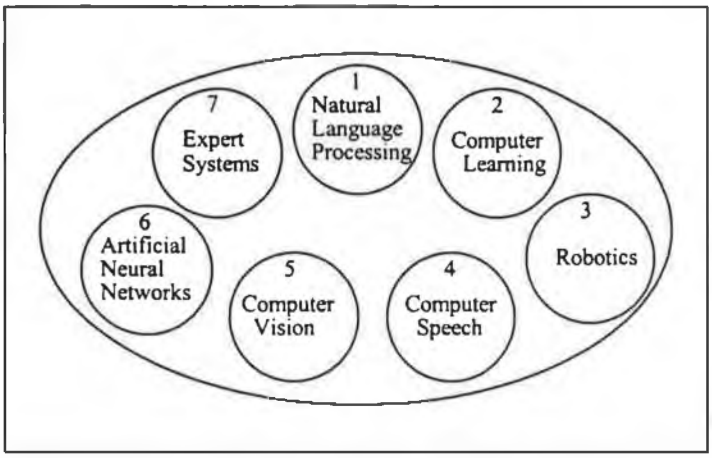

Figure 3.5 - The seven major areas of Artificial intelligence research

3.5.5 - Expert Systems

From these seven areas, two are most appropriate for the task of developing support tools for management tasks: artificial neural networks and expert systems. As the term suggests, artificial neural networks are an attempt to develop a system which would replicate the way in which a human brain stores knowledge and processes it to produce solutions for any given problem by means of pattern recognition.[39] Systems are developed by providing test data which is analysed for patterns. Neural networks are particularly useful when dealing with data that is noisy, ambiguous, distorted or has a lot of variation. For these reasons, neural networks seem most appropriate to the task of developing a diagnostic support tool for the hospitality business as the data available generally follows the characteristics described above. However, a significant objective of this project is to develop a system from a hotel managers perspective. In the authors opinion, neural networks are sufficiently complex to be beyond the capabilities of anyone other than a computer professional fully conversant in the area of artificial intelligence. System generators for this type of technology do not presently exist.

Expert systems however, use a knowledge representation scheme more natural and easier to understand (discussed further in the next chapter) and in addition, exist in shell form where the knowledge simply needs to be elicited and entered. For these reasons they are most appropriate to this project and therefore will be the focus of this dissertation.

When an organisation has a complex problem or decision to make, it often turns to experts for advice. These experts have specific knowledge and experience in the problem area. They are aware of the alternatives, the chances of success, and the costs the company may incur. The more unstructured the situation, the more expensive the advice[40].

Before discussing Expert Systems, it is first necessary to discuss Experts. According to Turban, human experts specialise in relatively narrow problem-solving areas or tasks[41]. Typically, human experts possess the following characteristics:

- They solve problems quickly and fairly accurately.
- They explain what they do.
- They are capable of judging the reliability of their own conclusions.
- They know when they are "stumped".
- They communicate smoothly to other experts.

They can also learn from experience, change their points of view to suit a problem, transfer knowledge from one domain to another, and reason on many levels. Finally they use tools, such as rules of thumb, mathematical models and detailed situations. A computer system attempting to mimic an expert must also contain some if not all of these characteristics.

Expert systems theoretically offer such promises. They are computerised advisory programs that attempt to imitate or substitute the reasoning process and knowledge of experts in solving specific types of problems. MIS and DSS can produce reams of paper, perform billions of calculations and assist management in their tasks, but at the end of the day, they know no more than at the beginning. ES offer an application of AI more suited to the area of management. Researchers offer two fundamental capabilities of ES: 1) the ability to emulate human reasoning, 2) the ability to learn. The state of the technology today supports some emulation of human reasoning. However the rudimentary ability to learn has not yet been achieved.

According to Jackson[42], several characteristics of Expert Systems differentiate them from conventional programs. They are:

- The Expert System simulates human reasoning about a problem domain, rather than simulating the domain itself. This distinguishes expert systems from more familiar programs that involve mathematical modeling.

- It performs reasoning over representations of human knowledge in addition to doing numerical calculations or data retrieval. The knowledge in the program is normally expressed in some special-purpose language and kept separate from the code that performs the reasoning.

- It solves the problem by heuristic or approximate methods which unlike algorithmic solutions are not guaranteed to succeed. Such methods are approximate in the sense that they do not require perfect data and the solutions derived by the systems may be proposed with varying degrees of certainty.

Regarding the characteristics of DSS previously mentioned, it has been suggested that an ES is merely a finely tuned Decision Support System. This is because the same capabilities apparently apply to both systems. The feeling among many practitioners is that there is no real difference between ES and other DSS, and that as a consequence the criteria already available to determine appropriate applications of DSS will suffice for ES[43]. However, as suggested by the above points, ES provide capabilities which overcome the functional problems of DSS, will therefore effect their potential applications. They are[44]:

1. ES have the capability to replace, rather than merely support, managers in the decision-making process. However, this is rarely recommended because it is impossible to completely program a computer to react in the same way as humans.
2. ES can theoretically improve both the efficiency and the effectiveness of decision-making.
3. ES is oriented toward a decision rather than simply providing information.

Of the technologies under discussion, these functionality's allow Expert Systems to be the most comprehensive in their support of the decision-making process. This technology can be utilised in all three areas of the procedure.

Intelligence: ES can render advice regarding the nature of the problem, its classification, its seriousness, and consequently can determine the quantity and quality of information required to produce the alternative solutions. ES can advise on the suitability of the solution approach and on the likelihood of successfully solving the problem. This capability can be utilised during the intelligence phase.

Analysis: Generation of alternatives for complex problems requires expertise that could be provided by a human or an Expert System. Knowledge about technology, availability of resources, market conditions and more could be contained in the knowledge base of the system. This knowledge is essential for the development of alternative solutions to the problems and for the prediction of decision consequences. In addition, while DSS incorporate forecasting methods, an ES can assist with more qualitative methods of forecasting as well as with the expertise required in applying quantitative forecasting methods.

Diagnosis: An ES can be used to assess the desirability of certain solutions as well as recommend appropriate solutions. With the incorporation of probability factors, the likelihood of success can be evaluated and the actual choice made by the manager can be made with increased confidence.

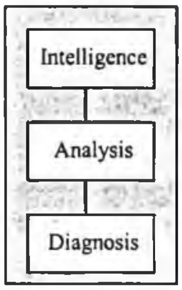

Figure 3.6 - ES and decision-making

3.6 - Summary.

This Chapter assessed a variety of technologies for the task of developing a hotel diagnosis software package. From Chapters One and Two, the problem has been analysed to be one which is unstructured in nature and complex in the number of factors and variables to be considered. MIS, while being capable of providing the information required to solve complex problems, are not suited to problem-solving where there is no clear structure. DSS, on the other hand, are capable of both working with complexity and, theoretically, a lack of structure. However, as was discussed in the last section, ES seem to the most appropriate technology for a hospitality unit diagnostic system. They too can solve complex and unstructured problems. In addition ES are most appropriate for: solving problems in a logical manner; emulating human thought processes; using rules of thumb as opposed to pure facts. They are based on expertise and where there may be no correct answer; rather, they can produce several answers with probabilities of their correctness.

References

1 Peppard, J., **"I.T. strategy for business."** Pitman Publishing, UK., 1993.

2 Long, L., **"Management information systems."** Prentice Hall International Editions, USA, 1989.

3 Op. Cit. (2)

4 Kogan, J.A., **"Information for motivation - a key to executive information systems that translate strategy into results for management."** Conference on Decision Support Systems, The Institute of management science, April 1986, pp. 6-13.

5 Oxford English Dictionary. 2nd. Ed., Clarendon Press, UK., 1989.

6 Op. Cit. (2)

7 Gamble, P.P., **"Small computers and hospitality management."** Hutchinson, UK, 1984.

8 Op. Cit (2)

9 Ibid.

10 Naisbitt, J., In Long, L., **"Management information systems."** Prentice Hall International Editions, USA, 1989.

11 Jong, H., Personal communication, February, 1994.

12 Op. Cit (2)

13 Senn, J.A., **"The Myths of Strategic systems."** Information Systems Management, Summer, 1992, pp. 7-12.

14 Op. Cit. (1)

15 Op. Cit. (2)

16 Kroenke, D., **"Management Information Systems."** McGraw Hill, Singapore, 1989.

17 **Bullers**, W.I., and R.A. Reid, **"Management systems: four options, one solution."** Journal of Information systems management, Spring, 1987, pp. 54-62.

18 Gamble, P.R., and M. Kipps, **"The conception and development of a micr-computer based catering information system."** The International Journal of Hospitality Management, Vol. 2,3, 1983, pp. 141-147.

19 Kasavana M., **"The anatomy of a Hotel computer system."** Hotels and restaurants international, Vol. 17, 7, December 1983, pp. 57-61.

20 Op Cit (2)

21 Sprague, R.H., **"Framework for the development of decision support systems."** MIS Quarterly, Vol. 4, 4, June 1980, pp. 1-26.

[22] Kroenke, D.M., and K.A. Nolan, **"Business computer systems."** 3rd. Ed., Mitchell, USA, 1987.

[23] Aktas, A.Z., **"Structural analysis and design of information systems."** Prentice Hall, USA, 1987.

[24] Davis, G.B., **"Management information systems, conceptual foundations, structure and development."**, 2nd. Ed. Mcgraw Hill, 1985.

[25] Keen, P.G.W. and M. Scott-Morton, **"Decision Support systems - an organisational perspective."** Addison Wesley Publications company, USA 1978.

[26] Gamble, P.R., **"Small computers and hospitality management."** Hutchinson, UK, 1984.

[27] Op. Cit (16)

[28] Ibid.

[29] Op. Cit (2)

[30] Op. Cit (23)

[31] Scott-Morton, M.S., **"Management decision systems: computer based support for decision making."** Division of Research, Harvard University, USA, 1971.

[32] Keen, P.G.W., and M.S. Scott-Morton, **"Decision support systems, an organisation perspective."** Addison Wesley, USA, 1978.

[33] Turban, E., **"Decision support and expert systems."** Maxwell MacMillan International Editions, Singapore, 1990.

[34] Etzioni, A., **"Humble Decision Making"** , Harvard Business Review, July - August 1989.

[35] Ibid.

[36] Forgionne G.A., **"Building effective Decision Support Systems."** Business. Jan-Mar 1988, p19-30.

[37] Op. Cit (32)

[38] Winston, P.H., **"Artificial Intelligence."** Addison Wesley, USA,

[39] Ibid.

[40] Op. Cit. (32)

[41] Ibid.

[42] Jackson, P., **"Introduction to expert systems."** 2nd. Ed., Addison Wesley, 1990.

[43] Connell, N.A.D., and P.L. Powell, **"A comparison of the potential applications of expert systems."** Journal of the Operational Research Society, Vol. 41,5, 1990, pp. 431-439.

[44] Forduce, K., and Norden, P., and Sullivan, G., "**Artificial intelligence and the management science practitioner: one definition of knowledge-based expert systems.**" Interfaces, 19, September-October, 1989, pp. 66-70.

Chapter Four.

An Overview of Expert Systems

4.1 - Introduction.

At present, the field of Expert Systems are an important part of the Artificial Intelligence arena. This is possibly because ES appear to be the most commercially viable of the technologies[1]. Experts, where they exist, are becoming increasingly difficult to maintain on a company "payroll" due to their high salaries and external demand. A system which can replace at least some of these experts has clear financial benefits[2].

This chapter offers an overview of this specific technology. Expert Systems are described, including how they were developed and how they are structured. These issues establish how expert systems offer benefits over conventional software applications, in the context of the development of the system under discussion.

Many of the benefits are due to the knowledge orientation of expert systems as opposed to the data orientation of conventional systems. This chapter details how this knowledge orientation is managed through the use of representation, control and uncertainty methods and collected through knowledge acquisition techniques.

Early expert systems and their characteristics are described. Although these systems are primarily scientific in orientation, more recent expert systems applied to business are discussed. Considering the varying applications, appropriate methods for classifying these applications are established. This categorisation offers some refinement relevant to the task of this research.

The final section of this chapter details the approaches which may be utilised in the development of expert systems.

4.2 - Expert Systems

An Expert System (ES) generally implies a computer software system that solves or assists in problem solving, using knowledge of a particular subject area or domain[3]. These systems can be used in two ways, either to completely fulfil a function that normally requires human expertise, or to play the role of assistant to a human decision maker. The decision makers may be experts in their own right, in which case the program may justify its existence by improving each decision maker's productivity. Alternatively, the human collaborator may be someone who is capable of attaining expert levels of performance given the technical assistance from the program[4].

Many authors believe this technology to be the most commercially viable of the Artificial Intelligence arena. Possibly this is due to the fact that experts are not born; they are created through years of experience and training. Because they are rare and in great demand, they generally carry a high price tag. Due to the high price, only the largest corporations can afford the luxury of maintaining experts on their "payroll". External demands and competitive salaries make experts hard to retain and when they leave a company they take their knowledge with them, leaving what can be termed as an "information void"[5]. In order to counter these problems, companies have recently turned to technology and more specifically to expert systems for help.

As previously stated, expert systems are a branch of that class of software named Artificial Intelligence (AI). Early AI research established the components and functions which would constitute expert systems as used today. The more important of these are[6]:

- A search process, which would be effective and efficient in its goal of problem solving.
- An ability to store domain specific knowledge to guide the search process.
- An effective method of representing the knowledge which would assist the systems ability in solving problems in a manner similar to human experts.
- A reasoning capability, allowing the system to use the stored knowledge logically.

These points established both the structure of expert systems and the methods which would be utilised in the representation of and reasoning with knowledge. Prior to discussing the latter two points, it is important to clearly define how an Expert System works. This will be done by describing the structure of the modern expert system.

4.3 - Structure of an Expert System

The main components of an expert system are the knowledge base, inference engine and the consultation or user interface (See Fig 4.3).

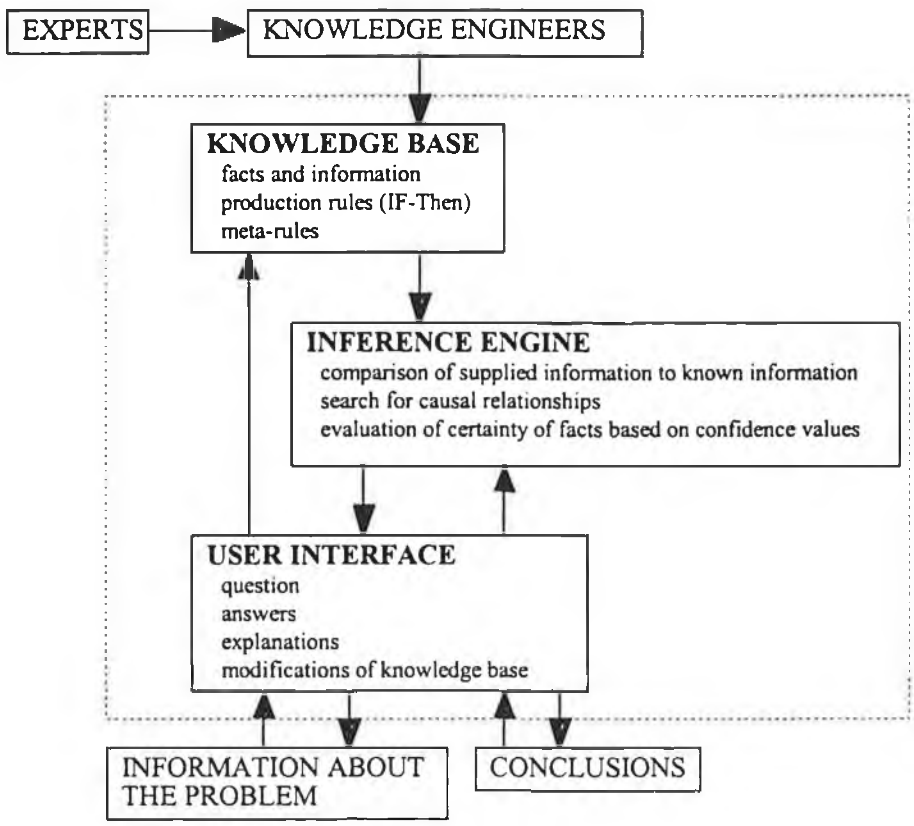

Figure 4.1 - Structure of an Expert System

1) The *knowledge base* contains all known facts and information necessary to understand, formulate and solve a problem. It contains two basic elements:

a. Facts such as the problem situation and theory of the problem area, for example the theory relating to how a hotel is "correctly" managed; and
b. Special heuristics, or rules, which direct the use of knowledge to solve problems in a particular domain.

The heuristics represent the informal judgmental knowledge of an application area. Knowledge, not mere facts, is the primary material of expert systems. The information in the knowledge base is incorporated into a computer program by a process called knowledge engineering.

2) The "brain" of the ES is the *inference engine*, also known as the control structure or the rule interpreter (in rule-based ES). This component is essentially a computer program that provides a methodology for reasoning about information in the knowledge base, and for formulating conclusions. This component makes decisions about how to use the system's knowledge by developing the agenda that organises and controls the steps taken to solve current problems. The major elements of the inference engine are[7]:

- An interpreter, which executes the chosen agenda items by applying the corresponding knowledge base rules.
- A scheduler, which maintains control over the agenda. It estimates the effects of applying inference rules in the light of item priorities or other criteria on the agenda.
- A consistency enforcer, which attempts to maintain a consistent representation of the emerging solution.

3) The *user interface* facilitates the exchange of information between the user and the inference engine. It also allows the user to maintain, modify and update the knowledge base as necessary. The communication can best be carried out in a natural language and in some cases is supplemented by menus and graphics. The easier to use and friendlier the user interface, the more likely the system is to be used[8].

Other components include an explanation sub-system to explain to the user how the system reached any conclusions proposed and a knowledge acquisition sub-system to help the developer add knowledge to the knowledge base. Special interfaces may also exist to allow the system access to databases, spreadsheets, and industry specific software.

These components allow computers to help people analyse and solve problems which can often be stated only in verbal terms. They capture and distribute human expertise in making judgements under various conditions. Due to their structure, expert systems extend the power of the computer beyond the traditional application areas of third generation programming languages, beyond mathematical and statistical applications which perform complex calculations and beyond database applications which use computer capabilities to store and distribute information[9]. The most fundamental difference between expert systems and conventional computer programs is that "expert systems manipulate knowledge while conventional programs manipulate data"[10]. For a further comparison see table 4.1.[11]

Conventional Systems	Expert Systems
• Knowledge and processing are combined in one sequential program	• Knowledge base is clearly separated from the processing (inference) mechanism
• Do not usually explain why input data are needed or how conclusions are drawn	• Explanation is part of most ES
• Changes in the data are tedious	• Changes in rules are easy to accomplish
• The system only operates when it is completed	• The system can operate with only a few rules as the first prototype
• Execution is done on a step by step (algorithmic basis)	• Execution is done using heuristics and logic
• Need complete information to operate	• Can operate with incomplete or uncertain information
• Representation and use of data	• Representation and use of knowledge
• Efficiency is a major goal	• Effectiveness is a major goal
• Easily deals with quantitative data	• Easily deals with qualitative data
• Captures, magnifies, and distributes access to numerical data (TPS) or to information (MIS, DSS)	• Captures, magnifies, and distributes access to judgement.

Table 4.1 - Comparison of Conventional Systems and Expert Systems.

The effect of these differences can be summarised by the characteristics the Expert Systems possess.

The system performs reasoning over representations of human knowledge, in addition to doing numerical calculations or data retrieval, familiar to Management Information Systems or Decision Support Systems. As a result, Expert Systems have the ability to simulate human reasoning about a problem domain rather than simulating the domain itself. The objective is to perform the relevant tasks as well as or better than the expert.

The system solves problems by heuristic or approximate methods which, unlike algorithmic solutions, are not guaranteed to succeed. Such methods are approximate in that they do not require perfect data and the solutions derived by the system may be proposed with varying degrees of certainty[12].

4.4 - Expert System Concepts.

The last section has described the structure of an Expert System and the differences between Expert Systems and conventional systems. As previously stated, the structure and advantages of Expert Systems are due to the research into Artificial Intelligence. This research established important issues regarding the development of intelligent or seemingly intelligent systems. Of significant importance are the methods of representing and controlling the knowledge. Subsequently, methods for acquiring this knowledge and incorporating uncertainty were established.

4.4.1 - Knowledge Representation.

Acquired knowledge needs to be organised in the computer so that it can be accessed and used whenever it is needed. Specific domain knowledge, acquired through a process called knowledge acquisition (discussed in a later section), is stored in the knowledge base. In the field of expert systems, knowledge representation implies some systematic way of codifying this knowledge. A representation has been defined as:

> a set of syntactic and semantic conventions that make it possible to describe things[13]

In artificial intelligence, 'things' normally mean the state of some problem domain, such as the objects in that domain, their properties and any relationships that hold between them. The syntax of a representation specifies a set of rules for combining symbols to form expressions in the representation language. It should be possible to tell whether or not an expression is well formed; that is, whether or not it could have been generated by the rules.

The semantics of a representation specifies how expressions so constructed could be interpreted; that is, how meaning can be defined from form. The specification is usually done by assigning meanings to individual symbols, and then inducing an assignment to the more complex expressions.

A variety of knowledge representation schemes have been developed over the years. Much of this research has grown from the area of artificial intelligence and the goal of simulating the manner in which the human brain holds and reasons with its knowledge. The schemes share two common characteristics. First, they can all be programmed with existing computer languages and stored in memory. Secondly, they are designed so that the facts and other knowledge contained within them can be used in reasoning.

The knowledge representation schemes have generally been categorised as declarative or procedural. A declarative scheme is one used to represent facts and assertions. A procedural scheme deals with actions or procedures. Declarative knowledge representation methods include semantic networks, frames, and rules. Procedural knowledge representation schemes include procedures or subroutines and, again, rules[14]. The most common knowledge representation scheme found is the production or rule-based representation. However, in order to evaluate the scheme, it is necessary to review the prominent schemes available. Turban establishes semantic networks, frames and production rules as the most common schemes[15].

(i) Semantic Networks

Networks are a natural and efficient way to organise knowledge. They are composed of nodes and links. Nodes describe facts like physical objects, concepts or situations, whereas links (arcs) define the relevant relationships between the facts. Each node may point to a sub-node that represents more detailed levels. Semantic nets are an easy to understand means of representing non-rule knowledge. However, they pose difficulties when searching for specific objects. For this reason, semantic nets are more popular in other AI applications, such as natural language processing than in ES.

(ii) Frames

A frame is a data structure that includes all the knowledge about a particular object. This knowledge is organised in a special hierarchical structure that permits a diagnosis of knowledge independence. The hierarchy permits inheritance of characteristics, each frame usually inheriting the characteristics of all related frames of higher levels. Frames are basically an application of object-oriented programming for AI and Expert Systems. Each frame describes one object. There are some similarities with semantic nets and it is believed that frames reflect the way in which humans think.

A frame representation is based on the theory that previous situational experiences create certain expectations about objects and events associated with new situations. Frames provide frameworks within which new information can be interpreted.

(iii) Production Rules

Production rules were developed by Newell and Simon for their model of human cognition[16]. These schemes have become the most popular in the development of AI and Expert System applications. Within such a system there are three main components: the rules or productions; the working memory; and the recognition-action cycle[17]. The basic idea of these systems is that knowledge is presented as rules, called productions, in the form of condition-action pairs. The rules consist of IF statements (the evidence) and a THEN statement (the hypothesis) . For example:

"If the traffic light is red, then stop the car at the junction"

If the evidence is satisfied by the facts, the rule is 'Fired' and the action specified is inferred. The *condition* is the model which judges if a rule can be utilised in a particular situation. The *action* is the next part of the problem solving process, where another If...Then... statement is used. The rules can have various formats for representing knowledge, allowing greater flexibility for knowledge engineering.

IF Precondition P **THEN** Conclusion C	**IF** Revenue is decreasing **THEN** A problem exists within marketing
IF Situation S **THEN** Action A	**IF** Poor motivation in staff **THEN** Review remuneration
IF Condition C1 **AND** C2 hold **THEN** Condition C holds	**IF** Market is growing **AND** Sales are static **THEN** Market share is declining

Table 4.2 - Examples of IF-THEN rules.

IF-THEN rules also have the following characteristics which make them useful for developing Expert Systems[18].

1) Modularity	Each rules defines a small, relatively independent, piece of knowledge.
2) Modifiability	As a consequence of modularity, rules can be changed relatively easily and independently of other rules in the knowledge base.
3) Incrementability	New rules can be added to the knowledge base relatively independently of other rules.

The working memory (the current state of the world) contains sets of facts which are compared against the condition part of the rule to "fire" off appropriate actions. These actions will change the contents of the working memory, as actions change the current state of the world.

The recognition cycle is the process that occurs in a "rule-base" run. There are some facts in the working memory which are matched with rules in the rule base. When a pattern with a particular rule is achieved, then the action of the rule is enabled. When there are conflicts of rules (when two or more rules contain for example, the same conditions but different actions), then a conflict resolver decides which rule is enabled. A conflict-resolver can be a very simple command, such as "Enable the rules in order", or it can be a more complicated heuristic or rule of thumb. When the rule is enabled, the actions change facts in the working memory ready for the next recognition cycle.

Using the IF-THEN rule structure within a rule-based system, knowledge on a specific subject can be captured and applied to solving relevant problems. The utility of the production rule representation comes from the fact that the conditions for which each rule is applicable are made explicit and, in theory, the interactions between rules are minimised. In addition, they involve simple syntax and are flexible and easy to understand.

A preliminary investigation of these three methods of knowledge representation identified semantic nets and frames as complex structures requiring a in-depth knowledge of program coding in the area of Artificial Intelligence[19]. Production rules however represent data in a more natural form that is easily understood, allow the Expert System to be readily changed and added to and as a result are commonly used in many Expert System shells. This scheme would therefore be most appropriate for this project as the author is attempting to develop a system as would be developed by a hotel manager rather than a computer professional.

4.4.2 - Control Methods.

As well as being a neat formalism for representing expert knowledge in a computer, production rules also represent a model of actual human behaviour[20]. In addition, this method is popular as it makes reasoning with the knowledge relatively simple[21]. The way that an expert system reasons with the knowledge or chooses which rules to use and when to use them can dramatically effect the performance of the system as a whole. This process is controlled by the second element of the expert system, the inference engine. There are two approaches for controlling inference in a rule-based Expert System: forward chaining (data-driven) or backward chaining (goal-driven)[22].

(i) Forward Chaining.

In the forward chaining approach, the system starts with available information as it is made available and then tries to draw conclusions. The computer analyses the problem, looking for the facts that match the IF portion of its IF-Then rules held in the knowledge base. By matching the available data with the conditions of the rules, each rule is tested until the program works its way to a conclusion. For example, an expert system may be developed to monitor a hotel's energy management. This expert system could constantly interpret information available, such as temperature, lighting and cooking device utilisation. Based on the available data, the system could offer solutions to management to minimise the energy costs. The system is data driven in that the available data is used to provide an appropriate solution.

(ii) Backward Chaining.

Backward chaining start with an expectation of what is to happen (hypothesis), then seek evidence that supports (or contradicts) the expectation. Often this entails formulating and testing intermediate hypotheses. The program starts with a goal to be verified as either true or false. It then looks for a rule that has that goal in its conclusion. It then checks the premise of that rule in an attempt to satisfy the rule. It checks the assertion base first. If the search there fails, the ES will look for another rule whose conclusion is the same as that of the premise of the first rule. An attempt is then made to satisfy the second rule. This process continues until all the possibilities have been checked or until the first rule is satisfied. For example the hypothesis may be that a problem exists within the personnel area. The system will attempt to prove this hypothesis by checking the conditions that suggest the problem, e.g., staff turnover is high or quality of service is poor. If the conditions are unavailable, a second rule may be checked. The second hypothesis may be that staff turnover is high, the condition being that high is any value greater than ten percent. If the second rule is verified this will trigger the first rule to be inferred, i.e., there is a problem within the personnel area.

The method utilised generally depends on the task of the application[23]. Applied to this research area, an expert performing a diagnosis of a hotel unit is both data and goal driven. Firstly, they are data driven in that a certain amount of data is collected (e.g. financial and sales data) to establish the direction of the problem search. Secondly, considering the direction of the search, the goal driven approach evaluates several problems against the situation conditions. In order to replicate this process within an expert system it is necessary that such a system employ both methods.

4.4.3 - Uncertainty.

An integral feature of any Expert System is the manner in which it deals with uncertainty with respect to the evidence and hypothesis of the IF statement, both at the time the expert system is built and at the time the expert system is being used. There are many different sources of uncertainty in problem solving, but most of them can be attributed to either imperfect domain knowledge or imperfect case data[24].

For these reasons, an Expert System must be able to apply inexact methods. Although there is a broad agreement amongst Expert System practitioners that inexact methods are required, there is little agreement concerning what form these methods should take[25]. One of the earliest methods employed was probability theory based upon Bayesian approach. This approach requires that the expert provides prior probabilities to all hypotheses as well as a pair of conditional probabilities for all pieces of evidence (the conditions). This method, however had limited appeal because of the practical difficulties of assessing the prior and conditional probabilities inherent in the theorem. In addition, strong arguments against the Bayesian approach have been concerned with the possible absence of independence between pieces of evidence on the one hand and between hypotheses on the other hand[26]. To help overcome these shortcomings, other methods have been adopted using subjective probabilities based purely upon experience, while others have resorted to non-probabilistic methods.

An alternative approach has been devised by Shortliffe and Buchanan[27]. This approach adopts estimates provided by experts which reflect the tendency of a piece of evidence to prove or disprove a given hypothesis. These estimates which measure the increase in either belief or disbelief in some hypothesis as a result of observing the existence of some piece of evidence are called certainty factors. In general, certainty factors are acquired from an expert who is asked to weight his belief in the parameter of each THEN statement reflecting the degree of certainty he affixes to that conclusion. As opposed to the conditional probabilities, these weights are *judgmental* measures that reflect the level of belief.

The Bayesian approach can be argued to be inappropriate for this task. The method, although developed to counteract uncertainty, must be applied in a precise manner. Each conclusion and condition must be appointed a probability score used to calculate the probability of the solution being correct. As the knowledge is totally subjective, a precise method of applying these scores to hospitality diagnosis is obviously difficult.

The second approach, certainty factors, seems more appropriate. These scores reflect the judgmental measures of the expert in the belief of a conclusion being correct. As the scores are purely judgmental, no level of precision is required.

4.5 - Knowledge Acquisition

All of the above sections, although separate, are dependant on what could be argued to be the most important activity of expert system development, knowledge acquisition.

This is the activity of gathering knowledge for essentially knowledge intensive applications such as the Expert System under discussion. Knowledge acquisition is often considered as a difficult problem and a bottle neck in development of Expert Systems[28]. As a result of these difficulties, many techniques have been developed to increase the effectiveness and efficiency of the process. The knowledge acquisition approaches differ from traditional analytical methods by emphasising elicitation of knowledge from experts in relevant fields[29]. The experts in this project are the practitioners, educators and researchers within the hospitality industry.

4.5.1 - The Human Element.

Experts make up one side of the human element of the knowledge acquisition process, the second element being the knowledge engineer. An expert is a person who generally knows what to do based on mature and practised understanding[30]. Typically, a human expert is capable of a combination of behaviours involving the following activities[31]:

1. Recognising and formulating the problem.
2. Solving the problem fairly quickly.
3. Explaining the solution.
4. Learning from experience.
5. Breaking rules.
6. Determining relevance.
7. "Degrading gracefully".

Experts can take a problem stated in some arbitrary manner and convert it to a form that lends itself to a rapid and effective solution. Problem solving ability is necessary, but not sufficient by itself. Experts should be able to explain the results, learn new things about the domain, restructure knowledge whenever needed, break rules when necessary and determine whether their expertise is relevant[32]. The term "degrading gracefully" is used to describe the effect of getting close to the boundaries of an expert's knowledge. When this occurs, experts generally become less proficient at solving problems.

Experts are so named because they possess expertise in a specific domain. Expertise is the extensive, task-specific knowledge acquired from training, reading and experience. Expertise includes the following types of knowledge[33]:

- Facts about the problem area - a current ratio of higher than two-to-one denotes an excess in working capital.

- Theories about the problem area - the majority of problems in hotels are generally due to poor quality and poor marketing.
- Hard-and-fast rules and procedures regarding the general problem area - if a marketing problem is apparent, systematically examine orientation, communications, use of marketing information and sales team activity.
- Rules (Heuristics) of what to do in a given problem situation - if a decrease in revenue is less than two percent, monitor but do not evaluate.

These types of knowledge enable experts to make better and faster decisions than non-experts in solving complex problems. It can be argued that much of an experts knowledge is gained through education, reading of textbooks on the domain area and industry journals. Considering this, it is logical to assume that much of the required knowledge regarding the hospitality industry and its problems should be available through the same source. This approach will be further discussed in chapter six.

Expert systems, in order to simulate the problem solving behaviour of a human expert, must therefore be able to exhibit all of the previously mentioned characteristics of an expert using the various types of knowledge. The state-of-the-art to date has primarily been concerned with the second, third and fourth of the activities, these capabilities being made possible through the general research into knowledge representation and control, and knowledge acquisition.

The person responsible for these tasks, i.e. knowledge representation, acquisition and control, is the knowledge engineer. In order to carry out the task properly, the knowledge engineer must: be adept in interviewing and other knowledge elicitation techniques; be able to recognise important knowledge; and be experienced in the representation of the relevant knowledge in the expert system, as well as the development of the structure and user interface. For most systems, the knowledge acquisition stage plays a key role in determining the quality of the resulting system. Knowledge acquisition usually involves eliciting, analysing and interpreting the knowledge human experts use in solving a particular problem, and then transforming this knowledge into a proper representation[34].

4.5.2 - The Knowledge Acquisition Activity.

In order to do this, the knowledge engineer generally interviews one or more domain experts and enters these experts' knowledge into the knowledge base. This process can be costly since it requires long sessions engaging both knowledge engineers and valuable experts. As well as the cost, the level of commitment offered by the domain expert seriously affects the success of the developed system. A third problem which exists within the process concerns the bias exhibited by both engineer and expert[35]. The process allows for knowledge to be filtered through the knowledge engineers and subsequently may not reflect the actual thought process. Two possible events occur. Firstly, some developers emphasise the experts, insisting that what the experts express should go unchanged into the knowledge base. This seems the most appropriate approach; however, the knowledge engineer must exert some control in order to avoid the inclusion of irrelevant knowledge for the application. The second school of thought suggests that the knowledge engineer should be responsible for everything that is used in the program (i.e., other sources of knowledge can be used if required and balanced against the experts). The problem here arises when the knowledge engineer (or non-domain expert) has too much control and misses some of the subtleties of the problem solving procedure.

4.5.3 - Knowledge Acquisition Techniques.

In order to gather the required knowledge, prior to modelling and representation, several techniques have been developed[36]. From a broad perspective, these techniques can be divided into four main headings: interviews; observation; protocol analyses; and structuring techniques.

Interviewing is generally the most popular knowledge acquisition technique in the practical development of expert systems. Methods for structuring these interviews have further advanced the process, with the knowledge engineer (KE) varying the level of control he takes in the interviewing process. Two such methods are the tutorial interview and the teach-back interview. In the former example, the knowledge engineer selects topics of discussion, and the latter method involves the expert explaining a procedure to the KE, who then teaches it back to the expert. Another approach involves asking experts how they would solve hypothetical problems.

Observation involves observing an expert solving a problem. This method may avoid the biases introduced by interviewing; however, the set of available cases to observe may be limited and might not be representative.

Protocol Analysis extracts knowledge from some record (or protocol) of events. A record of events may be a video tape of an expert solving a particular problem while thinking aloud. The typed protocol of this tape is then analysed to elicit the required problem-solving related knowledge.

Structuring techniques elicit expertise through letting experts structure some material, for example, domain concepts, in certain ways and analysing the results. For example, card sorting is a technique where the expert is asked to group a set of cards, each labelled with a concept, according to criteria of his or her choice.

4.5.4 - Knowledge Acquisition (KA) Problems.

Those techniques mentioned have allowed knowledge to be elicited from experts with some degree of success. However, they are prone to the same problems. Some of the more widely reported problems of the activity are[37]:

Knowledge is hard to articulate. Experts find it difficult to explain their knowledge and the factors which they consider when solving problems. This fact also hinders knowledge engineers in that they find it difficult to understand enough to make use of the knowledge.

Eliciting the way an expert thinks of the domain and the domain knowledge is problematic. Modelling the expert's reasoning strategy and the knowledge needed to support it is difficult.

There is typically a representational mismatch among the way experts express themselves, the way knowledge engineers think of the experts' knowledge, and the knowledge representation used in a computer system.

In summary, these obstacles pin-point the substantial downfall in knowledge acquisition and the impending development of the expert system. The human factor is obviously of great importance to the success of any expert system development, and subsequently poses most of the difficulties.

4.5.5 - Rule Induction.

Rule induction is a different approach to the provision of rules for expert system development, concentrating on the manipulation of knowledge using a scientific method as opposed to subjective qualitative methods of knowledge elicitation[38]. To overcome the problems of expert based knowledge acquisition, a number of researchers have suggested this alternative approach which takes advantage of inductive inference mechanisms to induce decision rules from data. The goal of a rule induction algorithm is to construct a set of rules from the data to interpret the data and facilitate decision making when a new case is encountered[39]. The knowledge engineers collect the relevant data from previous decisions, identify key attributes (variables) with the help of domain experts, and then use an induction program to construct a set of rules for decision making. Compared to the traditional approach, inductive knowledge acquisition generates more consistent rules and the knowledge engineering process depends less heavily on domain experts[40].

The successful use of such an induction system depends to a great extent on the task under development. An example of an application where this technique has been successfully utilised is loan approval analysis. By entering the variable values for many loan applications with the result of each application, such as approved or not approved, the induction system determines the rules structure. Generally the three major components of the induction systems are[41]:

1. A hypothesis generator that determines proper relationship between dependent and independent attributes.
2. A probability calculator that determines the probability associated with each rule.
3. A rule scheduler that determines how candidate rules should be organised to form a structure.

In the example given, this method can be highly rewarding. With the use of such a system, a knowledge engineer can construct knowledge by collecting previous cases solved by the experts, identifying attributes that may have effects on the decision (experts can provide valuable advice in these two stages) and executing a rule induction program[42]. For those cases where rules are a good representation of the experts' knowledge, the tedious process of interview and protocol analysis can be reduced to a minimum level. The Expert System can be easily developed, success depending only on the number of available cases to be examined. The only development left is the production of a customised user interface to facilitate the communications between the system and the end user.

Although a powerful method for acquiring knowledge, obviously the task of the application under development determines its potential use. In the case under discussion, i.e. the development of a diagnostic tool for a hospitality unit, the method is inappropriate. There is not the availability of cases where clear dependent attributes can be identified. It is unlikely that research could develop enough cases where certain variables produce a particular result, and furthermore, there is no limitation on the number of results or variables that could be perceived as important by different managers within the industry.

4.5.6 - Knowledge Acquisition Approach.

Considering these approaches to knowledge acquisition, it should be noted that a major objective of this research is to evaluate to ability of a hotel manager to produce a sufficiently effective Expert System for hotel company diagnosis. Therefore, the approach to development differs from traditional Expert System development. In this project the author, a qualified and experienced hotel manager with a proficiency in computer applications, acts as both domain expert and knowledge engineer. As a result of this, few of the above KA problems exist. There is no confusion in the presentation and representation of knowledge and knowledge does not necessarily have to be articulated in such concise terms.

4.6 - Expert System Applications.

Considering the theory of structure and expert system concepts, the following section details how the technology has been applied to specific tasks. Firstly, early expert systems will be discussed as these projects determined the manner in which modern expert systems were developed. It should be noted that the majority of early Expert Systems were developed for areas concerned with the sciences. This section will also demonstrate how the technology has been more recently applied to management applications, both in general and in the hospitality industry.

4.6.1 - Early Expert Systems

Considering the theory of Expert Systems discussed, the author will now describe how specific early Expert Systems were developed, leading to modern expert systems.

(i) General Problem Solver

The first "intelligent" computer system was developed by Newell and Simon in 1972[43]. The General Purpose Problem Solver (GPS) was a procedure to work out the steps required to change an initial situation into a desired goal state and was the predecessor to the modern ES. For each problem, GPS is given a set of "operators" that change the world in various ways, a statement of what "preconditions" each operator needs to be true before it can be applied, and a list of "post-conditions" that will be true after the operator has been used. In ES terms, these form a rule base. Although an important research area, GPS did not fulfil its inventors' dreams, but these programs did produce important side benefits. Some of the techniques could be applied to more special purpose programs.

(ii) DENDRAL

This shift to special purpose programs occurred in the mid-1960s with the development of DENDRAL by E. Feigenbaum, at Stanford University[44]. This system development recognised that the problem solving mechanism demonstrated by GPS was only a small part of the complete intelligent system. As well as a method for solving problems, the knowledge of the domain was crucial as was the manner in which the human expert would solve the same problem manually. The task of DENDRAL was to determine the molecular structure of an organic compound. This process, combined with a knowledge base relating to the interpretation of data obtained from a laboratory device known as a mass spectrometer, produced a system which is now used to support hundreds of international users everyday. However, DENDRAL did have some weak points. The system uses a weak search method, called "Generate and Test", to traverse the space of alternative molecular structures. In this method, the system generates a possible solution and then tests the solution against conditions for success. If the generated solution is adequate the method has succeeded, if not it generates a second possible solution. This continues until a solution is found. This approach resulted in two problems[45]. Firstly, the method on its own generally requires large computational power. In order to assist the process, the system takes advice from the human expert into account as it generates candidates for testing. Secondly, the system uses an algorithm to systematically enumerate all possible molecular structures, knowledge being represented as a procedural code. It has no advanced feature for controlling inference and as a result control over the program's iteration through the candidates remains in the hands of the user. The result of these points is that the user must have a sufficiently high level of expertise in the domain area.

Considering the flaws of the system, the construction of DENDRAL, which was one of the two first Expert Systems ever developed, was an important stepping stone between the GPS and more functional Expert Systems. The development led to the following findings:

- General Problem Solvers are too weak to be used as the basis for building high performance ES.
- Human problem solvers are good only if they operate in a very narrow domain.
- Expert Systems need to be constantly updated for new information. Such updating can be done efficiently with rule-based representation.
- The complexity of problems requires a considerable amount of knowledge about the problem domain.

(iii) MYCIN

MYCIN, another Expert System developed for the scientific community, was an important development project to the overall areas of ES[46]. This system, began development in 1972, seven years after the DENDRAL project, as a collaboration of the medical and artificial intelligence communities at Stanford. The aim of the system was to assist a physician, who generally should not be an expert in the field of antibiotics with the treatment of blood infections. Although MYCIN has been revised and extended since its original development, the basic system comprised of five main components[47].

1. a *knowledge base*, which contains factual and judgmental knowledge about the domain;
2. a *dynamic patient database* containing information about a particular patient;
3. a *consultation program*, which ask questions, draws conclusions and gives advice about a particular case based on the patient data and the static knowledge;
4. an *explanation program*, which answers questions and justifies this advice, using static knowledge and a trace of the programs execution;
5. a *knowledge acquisition program* for adding new rules and changing existing ones.

The most significant difference between DENDRAL and MYCIN was the more advanced control structure utilised in the latter. MYCIN's control structure involved a method of sub-goaling[48]. The structure contains a top-level goal rule which defines the whole task of the consultation system. Paraphrased, that rule states:

IF	1)	there is an organism which requires therapy, **and**
	2)	consideration has been given to any other organisms requiring therapy
THEN		compile a list of possible therapies, and determine the best on in the list.

The consultation is then essentially a search through a tree of goals. The top-goal at the root of the tree is the action part of the goal rule; that is the recommendation of a drug therapy. Sub-goals further down the tree include determining the organism involved and seeing if it is significant. Many of these sub-goals have sub-goals of their own. The information required to satisfy the goals can be obtained either directly from the user, or via some chain of inference based on symptoms and laboratory data provided by the user.

In tests, MYCIN's performance was shown to compare favourably with that of experts. However, although accurate in diagnosis, the main problem of the system lay in the fact that the knowledge base was incomplete. It did not cover anywhere near the full spectrum of infectious diseases. Although not achieving the commercial value of DENDRAL, never being used in hospitals for the above reason, MYCIN development was an important research vehicle in the area. The system introduced several features which have become hallmarks of expert systems[49].

- *The knowledge representation is rule based.* The knowledge base consisted of about 500 "IF-THEN" inference rules.
- *Probabilistic Rules.* Many of the rules include a chance option that allows the system make plausible conclusions from uncertain evidence. The chance figures in the rules are expressed as certainty factors.
- *Backward chaining method.* The program executes an exhaustive backward chaining search for a diagnosis, augmented by a numerical heuristic function. In its output, it rank orders competing hypotheses
- *Explanation.* MYCIN can explain its reasoning. The user can interrogate it in various ways by enquiring why the ES asked a particular question or how it reached an intermediate or final conclusion. Because each rule is a semi-independent package of knowledge, the user can easily trace the rules that led to a certain question or conclusion.
- *User friendly system.* MYCIN is very easy to use. The required training is minimal. The entire dialogue is conducted in English.

The examples of two of the first Expert Systems developed, notably represent very scientific and academic fields. This may be due to the fact that ESs at that time were primarily in areas of research, confined to academic institutions. However in the 1980s, Expert Systems began to appear in commercial organisations. Information systems professionals had begun to realise the power and potential advantages of utilising such technology.

4.6.2 - Expert Systems Applied to Management.

It was previously noted that pre-1980 expert systems were notably applied to scientific fields. The most obvious reason for this was that scientific knowledge, by its nature, is easier to engineer into rule-based knowledge bases. However, since the 1980's, more expert systems have been developed for various management tasks. An example of such applied systems are:

(i) Marketing

Expert systems were developed for the marketing area, generally in companies with a recurrent marketing problem. Some of the broad areas tackled include: 1) value enhancement, 2) resource utilisation, 3) re-packaging and co-marketing company expertise, 4) broadening service distribution, 5) creating smarter services, and 7) training. Each of these areas is notably selected for tasks in which the system will not replace the marketing manager but merely assist in the numerous decision making situations which they face.

COMSTRAT is an expert system developed for strategic marketing[50]. The systems aim is to help marketing managers to analyse the position of their company relative to their competitors in a particular business or product area and then suggesting ways in which the position might be improved.

Brand Manager's Assistant (BMA) is a knowledge based approach to the brand management function[51]. Brand management generally involve four steps: 1) analysis, 2) planning, 3) execution and 4) control (APEC). The BMA has been designed to augment rather than replace an existing marketing management information system (MMIS) where the MMIS traditionally computerises the process of viewing data and all other aspects of marketing management are left to the manager. The BMA provides a new architecture for supporting three of the key aspects of marketing decision making: analysis, planning and control. It contains data viewers for extracting and viewing data, analysers for analysing data, and designers for designing marketing events and programs, as well as monitors for monitoring events and programs.

(ii) Finance

One of the most active areas in the take-up of expert systems has been the financial services sector[52]. Expert systems in this field cover such subjects as auditing, personal and corporate taxes, personnel financial planning, and company analysis. The main advantage to finance professionals is that they allow accountants to focus on the professional parts of their jobs instead of being distracted by the routine, repetitive tasks[53]. One of the considerable benefits of the technology to finance was that the programs are especially effective in responding to questions that have more than one answer or that are difficult to frame because of their complexity.

Examples of expert systems in the domain include a product by Knowledge Products (Europe) Ltd. This company analyser assesses risk in a company using ratios and trend analysis and provides advice on what to do in any difficult situations[54].

A second similar system developed by Headway Systems Ltd. is a business review tool, which is for use by the owner manager of a small or medium sized company to carry out a position audit, helping to identify areas for change and the immediate action tools. The system is targeted at companies that need to take a number of short term actions before developing growth potential[55].

(iii) Human Resources

Information technology in the last few years has made its way into the offices of human resource professionals. Computers are being used to improve HR administrative, operational and planning decisions[56]. The three primary competitive objectives considered for technological assistance are i) cost leadership, ii) quality and customer satisfaction and iii) innovation[57]. The technologies applied to these objectives are transaction processing and tracking systems, decision support systems and Expert systems.

PRAXIS is an expert system to help determine the strengths and weaknesses of employees and design customised employee development programs based on this analysis[58].

COMPUCOACH coaches managers on effective approaches to use in communicating with peers, supervisors, and subordinates. The program also suggests ways to build management skills and to gain their superiors' favourable attention. "People Manager 1", from People Sciences, is a comprehensive program that helps managers make performance assignments, prepare performance appraisals, identify the skills needed for a particular job and formulate training and development plans.

4.6.3 - Expert Systems in the Hospitality Industry

An example of an ES system developed for use in the hospitality industry is the rooms control system developed by Balsam Grand Resort and Eloquent Systems corporation of Manchester, New Hampshire[59]. The system was designed to improve customer service by matching guests' room needs with the available rooms and compiling guest history information. The aim was to improve the sales of the resort and to improve marketing strategies. The sixteen years of guest history written into the program has enabled the employees to customise the service encounter based on the system's knowledge of the guest and consequently enhance the quality of service. The system also ensures that the management policies, such as selling the least desirable rooms first, are carried out consistently.

Sales Manager is another ES tool designed as a negotiating tool for hotel sales representatives[60]. The program is based on an analysis of the contribution margin of total revenue generated by a group's stay at a hotel. The total profits from room charges and food and beverage sales are analysed and compared with profits that the hotel should expect to make from a group for the dates in question, based on past history and current reservations. *Sales manager* offers a number of advantages to the hotel. It enables the sales department to book business based on consistent criteria, it provides the sales person with negotiating strategies, and it looks at the potential business in terms of what it will do for the whole hotel, not just for one department.

4.7 - The Generic Categories of Expert Systems

The above sections should demonstrate that Expert Systems can be applied to many different tasks. This may possibly be to the extent that potential developers might feel Expert Systems apply to every task. As this is not the case, classification schemes have been the topic of some research. One such classification is offered by Hayes-Roth *et al*[61]. This classification, although receiving much criticism, has not been improved upon and therefore is the most appropriate available. They are:

Category	Problem Addressed
Interpretation	Inferring situation descriptions from observations.
	Example: Chemical structure elucidation.
Prediction	Inferring likely consequences of given situations.
	Examples: Weather and financial forecasting.
Diagnosis	Inferring system malfunctions for observations.
	Examples: Medical, mechanical and electronic domains.
Planning	Developing plans to achieve goals.
	Example: Route planning.
Monitoring	Comparing observations to plan vulnerabilities, flagging exceptions.
	Example: Monitoring of nuclear power stations.
Debugging	Prescribing remedies for malfunctions.
	Example: Aids to computer programmers.
Repair	Executing a plan to administer a prescribed remedy.
	Example: Computer network administration.
Instruction	Diagnosing, debugging and correcting student performance.
	Example: Training of management students.
Control	Interpreting, predicting, repairing and monitoring system behaviour.
	Example: Battle management.

Table 4.3 - Hayes-Roth Categorisation of Expert Systems.

An alternative analysis based on the generic operations of the system, was proposed by Clancey in 1985[62]. Clancey's argument toward the Hayes-Roth *et al.* classification is based on overlaps between debugging, repair, monitoring and instruction systems. This argument is also supported by Reichgelt and van Harmelen (1986).

Clancey, in his categorisation, asks what kind of operation such a program can perform with respect to a real-world (mechanical, electrical or biological) system, as opposed to categorising programs directly in terms of the kind of problem they are set out to solve. A system in this case means a complex arrangement of interacting objects, existing in some environment and engaged in some process, involving the exchange of energy and information with that environment. Clancey distinguishes therefore, between *synthetic* operations that *construct* a system and *analytic* operations that *interpret* a system. These concepts can be viewed as a hierarchical analysis of the kinds of operation that a program can be called upon to perform. Applied to this research, the synthetic or construct classification has little significance as the system under discussion is not concerned with the construction of any system. However, the interpret classification is important, in that it helps to further specify the actions required in a diagnostic system.

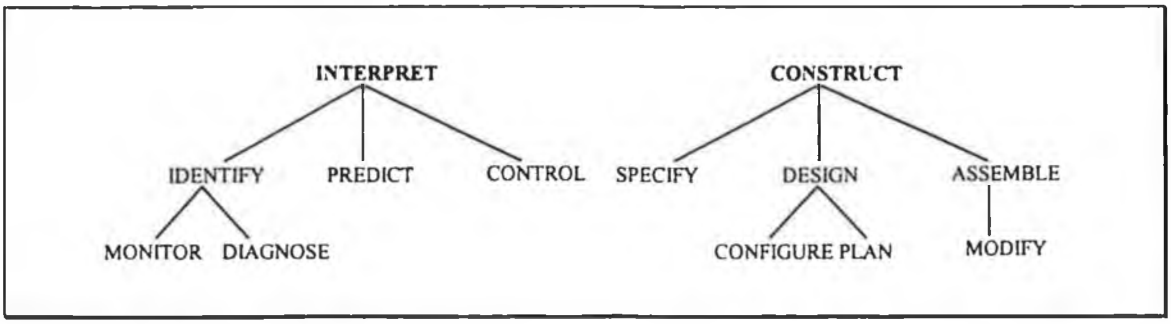

Figure 4.2 - Generic operations for analysing (left) and synthesising (right) a system

Looking at figure 4.5, it can be seen how the different kinds of INTERPRET operations relate to the notion of a system. Given input-output pairs, the IDENTIFY operation tells us what kind of system we are dealing with. Given a known system, PREDICT tells us what outputs to expect for a class of given inputs. CONTROL takes a known system and determines inputs which achieve a desired output. Thus the three specialisations of INTERPRET cover all the possibilities in which one member of the set {*input, output, system*} is an unknown quantity. IDENTIFY can be further specialised for faulty systems. The MONITOR operation detects discrepant behaviour and DIAGNOSE explains it.

This classification has specific implications for this research project. The process of selecting the most appropriate problem solving method is facilitated by the clear identification of the task. In this situation the task was originally identified as the diagnosis of a hospitality unit for senior level management. Considering Clancey's classification, the author can more specifically describe the task as the interpretation of the hotel system using an identification task and its various tasks of monitoring and diagnosis, where *monitoring* analyses the hotel for problems and *diagnosis* explains exactly what is wrong.

4.8 - Expert System Development tools

Although each classification of expert system can be developed using any of the following methods, it is important that the most appropriate method is selected from the point of the developer. The options available to a systems developer include non-symbolic programming language such as C and Pascal, symbolic processing languages or development tools. The former, although having been used in the past, are not suitable for developing expert systems since they make the development of inferencing mechanisms difficult and have no built in structures for handling knowledge representation. If unsuitable, why were they used at all? Several reasons are suggested by Turban[63]. Firstly, no other language may be available for the hardware on which the system is to run. Secondly, conventional languages offer the developer more control on the memory utilisation of the program, unavailable in AI languages. Thirdly, the interface between expert systems and databases, or DSS can be much easier if the ES is written in a conventional language. Finally, non AI languages suffer from a disadvantage in that they manipulate effectively only a small range of ES data types such as numbers and logical values.

Therefore the expert system developer is left with a choice of 1) using a symbolic language or 2) using an expert system building tool, known as an expert system shell.

The AI or symbolic manipulation language provides an effective way to present AI type objects such as rules and explanations. Two major languages in this category are Prolog and Lisp. Using these languages, the programming and debugging procedures can frequently be done much faster than with the procedural languages.

4.8.1 - Lisp.

Lisp (List Processor) is one of the oldest general purpose languages still in active use. Developed in 1958 by J. McCarthy at MIT, Lisp's applications include artificial intelligence, robotics, natural language processing and educational programming[64]. The language is oriented toward symbolic computation; the programmer is able to assign values to terms like "Financial" and "Liquidity". The Lisp program can conveniently manipulate such symbols and their relationships. Lisp programs also have the ability to modify themselves. This means that a computer can be programmed to "learn" from past experiences. This feature gives the Lisp programmer the power to develop software far beyond the limitations of other general purpose languages.

4.8.2 - PROLOG

PROLOG (Programming in LOGIC) is the most popular AI language utilised in Japan and Europe[65]. The basic idea is to express statements in logic as statements in programming language, and the method of proving a theorem using these statements could be thought of as a way of executing those statements. Consider the following rule, "All hospitality companies will generate supernormal profits" and "Hilton is a hospitality company" and the theorem "Hilton will generate supernormal profits", could be expressed formally in PROLOG as:

PROLOG	**Meaning**
supernormal_profit (X):- hospitality_company(X)	(X is supernormal profits if X is a hospitality company)
hospitality_company (hilton)	(Hilton is a hospitality company)
?-supernormal_profits (hilton)	(Has Hilton supernormal profits)

PROLOG can then be run to try to prove the theorem given the two statements. In this case, it will come to the conclusion that the theorem is true.

PROLOG's basis in logic provides its distinctive feature. Because a PROLOG program is a series of statements in logic, it can be understood declaratively; that is, it can be understood quite separately from considerations of how it will be executed. Traditional languages can be understood only procedurally by considering what happens when the program is executed on a computer.

4.8.3 - Expert System Shells

The third tool available is "skeleton expert systems" which are more commonly known as expert system shells. Harmon defines these shells as[66]:

> "Software packages which include a programming language and support features designed to simplify the effort involved in building an expert system. These support features usually include an inference engine, user interface facilities, and optional productivity tools like a knowledge base editor, debugging aids and testing facilities".

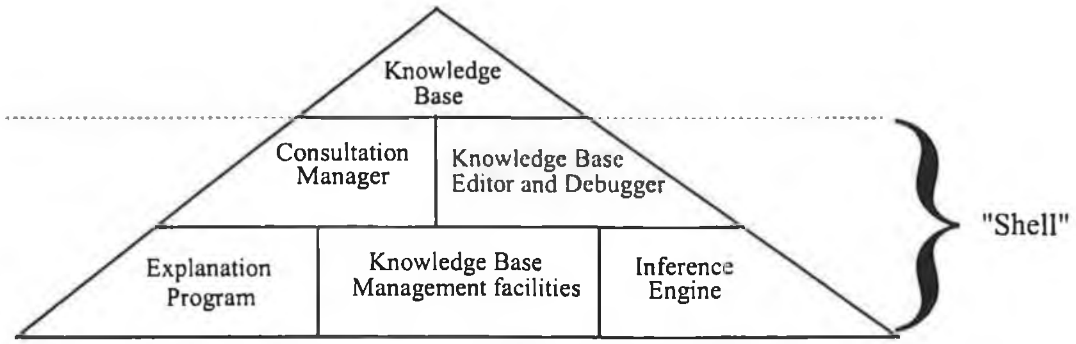

Figure 4.3 - Expert System Shell components.

Rather than building an expert system from scratch, it is often possible to borrow intensively from a previously built specific ES. This structure makes possible the replacement of the original knowledge base by a new knowledge base for a different task, obviously simplifying construction. One of the first shells developed, known as EMYCIN, is a shell of the previously discussed MYCIN expert system (EMYCIN standing for Empty or Essential MYCIN). As the name suggests, EMYCIN was simply MYCIN minus its domain specific medical knowledge. The shell was originally used to help expert system developers build and debug performance programs. Although one of the first shells, EMYCIN was responsible for establishing several features which have since become widespread in expert system shells. They are[67]:

- An abbreviated rule language, which is neither Lisp nor the subset of English used by MYCIN. This notation is easier to read than Lisp and more concise than the English subset.
- An indexing scheme for rules, which also organises them into groups, based on the parameters that they reference.
- A backward-chaining control structure like MYCIN which unfolds an AND/OR tree, the leaves of which are data which can be requested of the user.
- An interface between the final consultation program and the end-user, which handled all communications between the program and the user.
- An interface between the system designer and the evolving consultation program, providing tools for displaying, editing and partitioning rules, editing knowledge held in the tables, and running rule sets on sets of problems.

Most shells can be classified as *rule-based* or as *hybrid.*

Rule-based are the oldest and the simplest shells, many of which originated from EMYCIN. Simple rule-based tools represent knowledge in the form of rules and use backward chaining to process the rules. Structured rule-based tools differ from the simple type in that they allow the developer divide rules in hierarchically arranged sets.

Hybrid tools are shells lacking the narrow focus typical of large, structured rule based tools[68]. They use frames, objects, semantic networks and a rich variety of inheritance techniques in a programming environment which allows for the structure and relationships typical of more complex expert knowledge. As a result, system design becomes generally much more flexible. However the price to pay for this flexibility is high. Hybrid tools are considerably more expensive. In addition, the developer must be proficient in both knowledge engineering and Lisp programming to use a hybrid tool.

These problems contradict one of the basic requirements of an expert system shell, in that they are developed for use by non-computer specialists, with no knowledge of programming.

A comparison between symbolic languages and expert system shells is similar to a comparison between third generation programming languages and fourth generation languages. Languages have the functionality to be more flexible than shells, but on the other hand are more time-consuming in their use. Only well trained developers are able to build knowledge systems from scratch using symbolic languages like Lisp or PROLOG.

In order to develop, "in-house", a symbolic language based hospitality company diagnostic program would require experienced Lisp or PROLOG programmers. If these people were not available in the company, they must be recruited and trained or expensive systems analysts must be hired. Expert system shells, on the other hand, have been developed so that business managers may be capable of producing Expert Systems relatively easily. No formal computer training is required, many of the systems are easy enough to master. The manager come Expert System developer is in control of the development and as the system is tool based, modifications can be easily made as required.

The use of expert system shells can considerably reduce the design and implementation time of an expert system. A major advantage of the shell is that the inference engine is built in, thereby saving the time in building one.

In the past, only very expensive mainframe based ES could tackle complex problems, but now cheaper powerful PC-based shells have become available. Expert system shells have become common, with commercially produced shells available for all types of computers. It is important that the developer selects the most appropriate shell as it will impact the whole development process. This selection and evaluation of expert system shells will be discussed further in chapters five and six.

However, it is important to note that a shell can only be used when the intended application matches the shell's capabilities. Choosing the right domain problem is essential as it can affect the best programming language, knowledge representation schema and inference engine to be used.

4.9 - Summary.

Although chapter three established that Expert Systems were most appropriate for the development of the diagnostic system discussed, many options are available to an Expert System developer which must be considered. These options relate to the manner in which knowledge is acquired, represented and controlled within the knowledge-base. In addition it is also necessary to evaluate the methods of employing uncertainty, where it is required.

Production rules were selected as the most appropriate format for this research. This is primarily due to the fact that other formats are highly complex in nature and as a result, are rarely found in the types of tools available to non-programmers. In conjunction with an ease of use, they readily facilitate the required control mechanisms found in expert systems. Relating to this research, it was established that the developed system would require both a goal and data driven control mechanism. In addition, certainty factors were established as the most appropriate method of representing uncertainty.

Considering the approaches to classifying Expert System applications, this chapter has used these approaches to further specify the required task of the system under discussion. As opposed to purely being a diagnostic system, Clancey's classification established that diagnosis is a sub-system of the overall interpretation system. As a result, this particular system is now described in terms of an interpretation system, utilising the monitoring and diagnostic tasks.

Allowing for the issues mentioned above, Expert System shells were selected as the most appropriate development approach. This was due to the fact that they were easier to use than programming languages and offered the representation, control and uncertainty factors required.

The following two chapters discuss how a specific tool was applied to the development of the Expert System-Based Analysis and Diagnostic Software.

References

1 Barrett, M.L., and A.C Beerel, **"Expert Systems in Business."** Ellis Horward, 1990.

2 Loofbourrow, T.H., **"The payoff of expert systems."** Best's Review ((Prop/Casualty), Vol. 92, May 1991, pp. 56-67.

3 Stockdale, A., and M. Wood, **"Building a small expert system for a routine task: a case study."** Management Decision, Vol. 30,3, 1992, pp. 46-49.

4 Turban, E., **"Decison support and expert systems."** Maxwell Macmillan International Editions, Singapore, 1990.

5 Bowen, J.J., and D.N. Clinton, **"Expert systems; advisor on a disk."** Cornell Hotel and Restaurant Administration Quarterly, November 1988, pp. 62-67.

6 Jackson, P., **"Introduction to expert systems."** 2nd. Ed., Addison Wesley, UK, 1990.

7 Op. Cit. (4)

8 Duchessi, P., and R.M. O'Keefe, **"Contrasting successful and unsuccessful expert systems."** European Journal of Operational Research, Vol. 61, 1992, pp. 122-134.

9 Turban, E., and P. Watkins, **"Integrating expert systems and decision support systems."** MIS Quarterly, Vol. 10, 1986, pp. 121-136.

10 Waterman, Donald A., **"A guide to expert systems."** Addison Wesley Publishing Company, Inc., USA, 1986.

11 Op. Cit. (4)

12 McCool, A.C., **"Some considerations in developing expert systems for the hospitality industry."** International Journal of Hospitality Management, Vol. 6,4, 1987, pp. 191-198.

13 Winston P.H., **"Artificial Intelligence."** Addison-Wesley, USA.

14 Op. Cit. (6)

15 Op. Cit. (4)

16 Newell, A., and H.A. Simon, **"Human problem solving."** Prentice Hall, 1972, USA.

17 Harmon, P. and D. King, **"Expert systems."** Wiley and sons, UK., 1985.

18 Bratko, I., **"Prolog programming for artificial intelligence."** 2nd. ed., Addison Wesley, 1990, USA,

19 Ibid.

20 Op. Cit. (16)

21 Op. Cit. (4)

22 Ibid.

23 Long, L., **"Management information systems."** Prentice-Hall International Editions, NJ, USA, 1989.

24 Op. Cit. (6)

25 Magill, W.G.W., and S.A. Leedy, **"Uncertainty techniques in expert system software."** Decision Support Systems, Vol. 7, 1991, pp. 55-65.

26 Ibid.

27 Buchanan, B.G., and E.H. Shortliffe, **"Rule-based expert systems."** Addison Wesley, USA, 1984.

28 Feignbaum,E.A., and P. McCormack, **"The Fifth Generation."** Michael Joseph, Ltd., London, 1984.

29 Eriksson, H., **"A survey of knowledge acquisition techniques and tools and their relationship to software engineering."** Journal of Systems Software, Vol. 19, 1992, pp.97-107.

30 Op. Cit. (4)

31 Ibid.

32 Ibid.

33 Ibid.

34 Op. Cit. (22)

35 Chandler, J.C. and T.P. Liang, **"Developing expert systems for business applications."** Merrill Publishing Company, USA, 1990.

36 Op. Cit. (28)

37 Kidd, A.L. , **"Knowledge acquisition for expert systems."** Plenum Press, New York, 1987.

38 Messier, W.F., and J. V. Hansen, **"Inducing rules for expert system development: an example using default and bankruptcy data."** Management Science, Vol. 32,12, December 1988, pp. 1403-1415.

39 Ibid.

40 Liang, T.P., **"A composite appraoch to inducing knowledge for expert system design."** Management Science, Vol. 38,1, January, 1992, pp. 1-17.

41 Ibid.

42 Crystal Rule-Induction Manual, Intelligent Environments, UK. 1993.

43 Newell, A., and H.A. Simon, **"Human problem solving"** Prentice-Hall, USA, 1973.

44 Lindsay, R., et. al. **"Dendral."** McGraw Hill, New York, 1980.

45 Op. Cit. (6)

46 Buchanan, B.G. and E.H. Shortliffe, **"Rule-based expert systems."** Addison Wesley, USA, 1984.

47 Op. Cit. (6)

48 Ibid.

49 Ibid.

50 Moutinho, L., and B. Curry, and F. Davies, **"The comstrat model: development of an expert system in strategic marketing."** Journal of General management, Vol. 19,1, Autumn 1993, pp.32-47.

[51] McCann, J.M., W.G. Lahti and J.Hill, **"The brand manager's assistant: a knowledge-based system approach to brand management."** International Journal of Research in Marketing, Vol. 8,1, April 1991, pp. 51-73.

[52] Bolton, L., **"The expert in your toolkit."** Accountancy, Vol. 111, May 1993, pp. 70-71.

[53] Phillips, M.E., and C.E. Brown, **"Need an expert? ask a computer."** Journal of Accountancy, Vol. 172, November 1991, pp. 91-93.

[54] Bolton, L., **"The expert in your toolkit."** Accountancy, Vol. 111, May 1993, pp. 70-71.

[55] Op.Cit. (53)

[56] O'Connell, S.E., **"Using the computer to manage costs in tough times."** HR Magazine, Vol. 35,12, December 1990, pp. 27-31.

[57] Broderick, R., and J.W. Boudreau, **"Human resource management, information technology, and the competitive edge."** Academy of Management Executive, Vol. 6,2, May 1992, pp. 7-17.

[58] O'Connell, S.E., **"Expert systems provide new access to knowledge."** HR Magazine, Vol. 35,9, September 1990, pp. 30-32.

[59] Bowen, J.T., and D.N. Clinton, **"Expert systems: advisor on a disk."** Cornell Hotel and Restaurant Administration Quarterly, November 1988, pp.62-65.

[60] Ibid.

[61] Hayes-Roth, B., *et al*, **"Building expert systems."** Addison Wesley, USA, 1983.

[62] Clancey, W.J., **"Heuristic classification."** Artificial Intelligence, Vol. 27, pp. 289-350.

[63] Op. Cit. (4)

[64] Winston, P.H., and B.K. Horn, **"Lisp."** 2nd. ed., Addison Wesley, USA, 1985.

[65] Clocksin, W.F., and C.S. Mellish, **"Programming in prolog."** Springer, USA, 1981.

[66] Harmon, P., **"Expert Systems tools and applications."** Wiley, USA, 1988.

[67] Op. Cit. (4)

[68] Op. Cit. (65)

Chapter Five.

Expert System Analysis

5.1 - Introduction

Most of the early Expert Systems developed, such as the previously mentioned Mycin and Dendral, took many person-years to construct and cost many millions of dollars[1]. Today, however, this situation has changed, primarily for two reasons. First, powerful development tools are now available which do not require special purpose computing hardware and highly trained personnel. Instead common place personal computers (PCs) can be used by non-computer specialists to produce effective Expert Systems. Second, it is now apparent that less complex and powerful ES are also valuable in almost all industries, from manufacturing through to service[2].

Irrespective of the task to which the ES is being applied, the development process generally follows the same format (see figure 5.1)[3], the procedure covering the selection of the problem through prototyping to evaluation and testing. For the purpose of the research, the process will be discussed in two separate chapters. This chapter describes the first four stages of the development process of the Expert System Based Analysis and Diagnostic System, Chapter Six deals with the remaining phases. The elements under consideration here are the selection of the problem (phases one and two), selection of the expertise (phase two), the conceptual design and feasibility (phase three) and the selection of the software and hardware (phase four). In addition to these areas, the related area of system maintenance will also be discussed. This area, although not necessarily an element of development, considers how the system will be maintained in the future to ensure the validity of the systems knowledge.

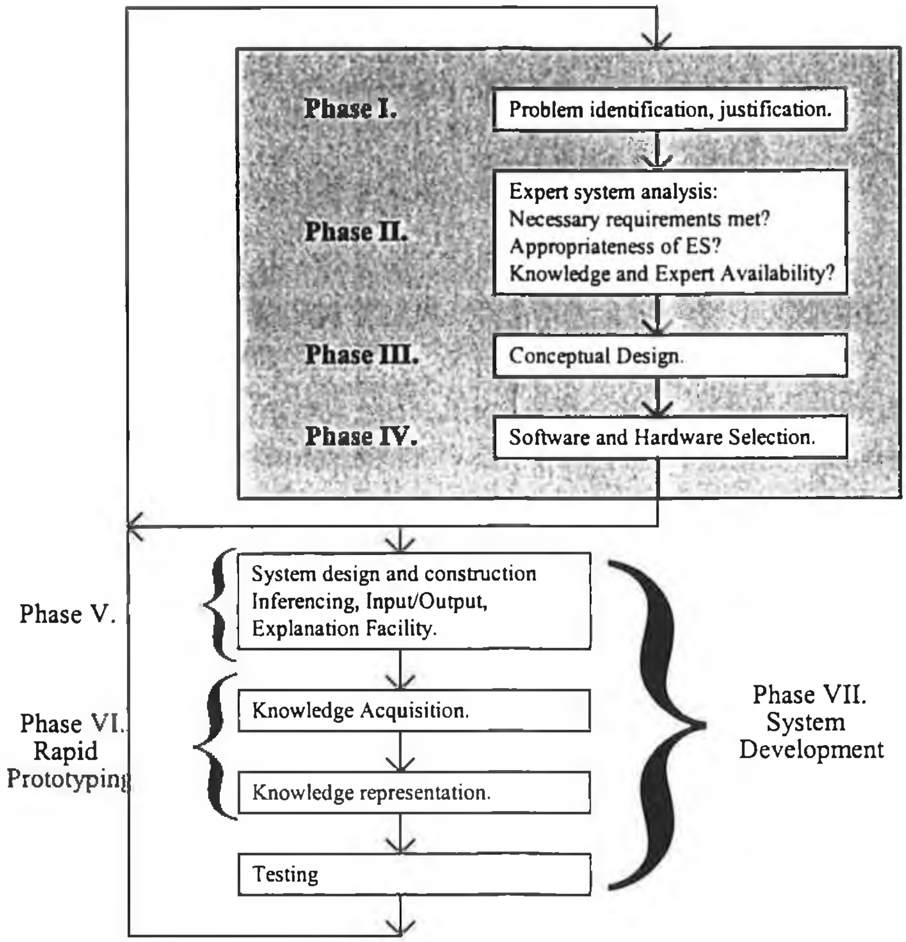

Figure 5.1 - Expert System Development Process

5.2 - Phase one - Problem Identification.

An essential element of the Expert system development process is to ensure that the problem or domain area has been correctly identified. Chapter one investigated the area of problem-solving and decision-making. It was established that although much research has been carried out in this area, the present approaches to problem-solving and decision-making are limited in their functionality. The utilisation of a formal problem-solving process generally assumes the manager is aware of a problem or is sure that the correct problem has been identified. This may not always be the case. The author therefore argues that a formal system of problem identification is required.

In conjunction with this observation, chapter one also established that, although often seen as synonymous, problem-solving and decision-making are in fact separate processes. Decision-making is merely an element of the problem-solving process, the number of decisions being made depending on the complexity of the problem in hand. The specific decision under consideration in this project is the identification of problems within a hotel unit. The ability to offer comprehensive support to this single decision is argued to increase the effectiveness of the overall problem-solving process. The other important element of the problem-solving process concerns the design of possible solutions. As this process is essentially creative, the ability of computers to support it is limited.

In order to avoid confusion when defining the research problem, it is necessary to establish the terminology that will be used. The *research problem* is the development of a system which will support the manager is carrying out an analysis and diagnosis of a hotel unit prior to utilising a formal problem-solving process. The analysis and diagnosis element is primarily concerned with systematically scanning information, using domain knowledge, to establish the likelihood of a functional problem (i.e. one which will cause distress for the unit if not tackled) existing within the unit.

Essentially, the project is comprised of the development of a system which assists managers in identifying problems by supporting their decisions using the knowledge of domain experts contained in the Expert System. Chapter two established that problem identification was difficult, due to the inter-disciplinary skills of hotel managers, with most having responsibilities in the areas of: finance, marketing, operational, control and personnel. This categorisation was further established as important by an examination of the product characteristics, the industry structure, and the major causes of distress in business generally and specifically hospitality. For this reason, the research problem is concerned with the functional problems that exist most prominently within the five areas identified.

It is important to note at this point that many Expert Systems have been developed to provide support to tasks which are generally carried out by human experts. This research development, however, is substantially different for one essential reason. The process of analysis and diagnosis, as described above, does not occur at present within the hospitality industry in any formal manner. The process is generally carried out intuitively and often subconsciously, to varying levels of success. As opposed to simply automating an existing process, this research is concerned with the development of a new process in a computerised environment.

5.2.1 - Justification.

The second element of phase one is the justification of the application of the technology to the task. As previously stated, the availability of powerful, low cost personal computers, in conjunction with the development of useful expert system shells, has increased the awareness and utilisation of the technology. However, the cost of development of any application can still be high in terms of domain expert time and knowledge-engineer time. Therefore, a mere interest in the new technology is insufficient to justify its utilisation.

A more appropriate analysis of justification might consider the potential of having practical, expert knowledge, such as that under discussion, encapsulated in a form which is transferable to those who are not experts[4]. As stated in chapter two, the Irish hotel industry has various problems and is comprised of units too small to warrant the employment of full-time business analysts. Therefore, the justification of an analysis and diagnostic system, readily available to all, should be a simple process, the specific incentives being:

The system should improve the performance of non-experts by providing a tool which is available to those who require quick and ready reference to experts. Although many hotel managers have operated properties in the past with some success, the business environment has substantially changed. Increased competition, quickly changing economic pressures such as inflation and the availability of labour and financial pressures have reduced hotel units to problem manufacturing machines requiring many daily decisions. The ability to gain support from a system which is 'knowledgeable' on the prominent problems which exist will potentially increase performance of both managers and properties.

The system should provide training of a consistently high quality with the capability of being disseminated throughout the organisation. Both in industry and education, the ability to learn how to visualise problems and their causes is an essential process. The proposed system, although having the capability to support the overall analysis and diagnostic process, should provide a more fundamental use. Disregarding the level of time spent in the development it is unlikely that all possible problems and combination of inter-related symptoms and causes will be elicited to provide a fully comprehensive system. However, the process of using such an interactive system should provide the user, either industry manager or college student, with a thought-provoking experience that may 'trigger' the recognition of a problem not contained in the system. Continual use will train the user to readily associate problems with their inherent causes and symptoms.

The system should provide a standardised approach to solving the diagnostic problem. It is unlikely that any individual manager will have the total required knowledge to carry out a comprehensive diagnosis. The representation of the knowledge of all management within a company into such a system offers each individual manager access to knowledge they may not possess themselves and subsequently provides a more comprehensive system. In addition, the ability for a corporate office to ensure each hotel is carrying out a diagnosis in the same manner offers benefits. The use of such a system which has been developed to their specifications with their knowledge provides the assurance that the results gained from a diagnosis are accurate and standardised.

The system should automate the application of expert judgement to a large mass of data. The analysis and diagnosis process suggested requires the availability of a considerably large mass of data, including financial accounts and ratios, operating data and management observations. Manually, this amount of data and information is difficult to deal with due to "information overload" and the inability of humans to reason with too many pieces of data. The expert system, however, does not suffer from these problems. In fact it can be argued that the more information and data available to such a system, the more the validity of any findings will be increased.

The system should assist managers with a relatively routine task so that they have more time to devote to the specialised, more demanding tasks which only they can handle. Many problems encountered in the hotel business occur so frequently that it is impossible and impractical to represent them within a support system. By being assisted in the diagnostic process, a manager can devote more time to these problems, in the knowledge that he or she is aware of and tackling the more important ones.

Considering the above points, it would seem that an Expert System for hotel diagnosis purposes would be justified in its development.

5.3 - Phase two - Necessary Requirements for Expert System Development.

On establishing the domain problem, chapter three examined the problem in the context of the available technologies. Management Information Systems, Decision Support Systems and areas of Artificial Intelligence were examined. As the domain problem was established as being relatively ill-structured, complex in the number of factors and variables and essentially knowledge rather than data based, Expert System technology was selected as the most appropriate for the task.

However, Waterman[5] suggests that a formal method for validating the selected task to Expert System technology should be utilised. The costs of expert system development are high and therefore it is important to establish that the task is being correctly matched to the right technology. Although a study of this type would have greater implications for a commercial development, it is necessary for this research to confirm the findings of chapter three, i.e. that the technology selection is appropriate. Waterman's proposal suggests a study should be composed of three parts: *necessary requirements, justification, and appropriateness.*

The requirements for ES development, listed by Waterman, concern the domain problem and the availability of knowledge on solving that problem. All of the following requirements are necessary to make ES development possible. They are:

The task does not require common sense.
Common sense, in this context, means an approach where no rational or logical description can be given for how a problem is solved. Although managers perceive that common sense is essential in their decision-making role, it can be argued that the process is not dependent on it. The identification of functional problems does not require common sense. Instead, a logical process can be employed to move from problem to problem, analysing each for its existence within the hotel unit.

The task requires only cognitive, not physical, skills.
The form of analysis and diagnosis under discussion is primarily based on the collection and processing of information, followed by interpretation and recognition of patterns. For example, a business analyst may collect data from financial accounts and further information from management and staff. Analytical skills may be used to calculate useful ratios and then judgement and intuition is used to recognise patterns prior to making a decision regarding the diagnosis. This process is entirely cognitive, with no element of physical skills involved.

At least one genuine expert, who is willing to co-operate, exists.
As discussed in chapter four, the ability to create a comprehensive expert system depends on the availability of domain experts who are willing to participate in the development of the system. However, it was also stated that gaining such a commitment for a research project is difficult. It was found that sufficient knowledge could be gained on the domain from literature analysis and supported by the personal knowledge of the author who, as stated, is a qualified hotel manager. In this situation, the author will act as both domain expert and expert system expert or knowledge engineer.

The experts involved can articulate their methods of problem-solving.
Again, for the reasons stated above, the articulation of knowledge and problem-solving procedures is minimised in importance. As the human element is primarily limited in

this project to one person, the author, knowledge acquisition is simplified. This approach is sufficient for prototyping purposes, however, in the commercial development of a similar system, several experts should be used.

The experts involved must agree on the knowledge and the approach to solving the problem.

When more than one expert is involved in the system development and knowledge acquisition phases, it is important that there is considerable agreement on the knowledge contained in the system. This is essential for both structured development and the verification of the validity of the system. When the development is concerned with the knowledge of one expert, this problem does not exist. However, in this case the literature analysis for knowledge acquisition will both supplement and support the personal knowledge of the author.

The task is not too difficult.

The process of analysing and diagnosing businesses in general and hospitality units specifically has been carried out for some time. However, the process to date has depended to a large extent on subconscious and intuitive methods, managers basing decisions on 'gut feelings' and carrying out very limited analysis. The task therefore is simply the identification of prominent problems and the elicitation and representation of the 'symptoms' of those problems in a semi-structured manner.

From the above list, the necessary requirements are present for this task. Other requirements have also been suggested by Waterman. However, these are stated as being less important. Some of these requirements are:

- The domain must be well bounded and narrow.
- Data and test cases must be available.
- The vocabulary has no more than a couple of hundred concepts.

These points have been raised by many writers on Expert System technology and are generally based on the findings of researchers in the area. An absence of one or more of these requirements may deter a commercial project. However, from a research point of view, these findings should not deter the application of the technology to tasks which do not seem to fit. The area or task under discussion can be argued to be broad in scope, lacking any previous cases or data and have to a large vocabulary of concepts and therefore may be unsuitable for ES development. Considering this, however, the author argues that the application must be prototyped to really evaluate if it is possible.

5.3.1 - Appropriateness of Expert Systems.

As well as setting the requirements for ES development, Waterman[6] also suggests points which must be considered when evaluating the appropriateness of ES to the task. They are:

The nature of the problem. As opposed to facts being available, the subject under discussion is composed primarily of heuristics, each educator, practitioner and author in the area having different viewpoints as to what can go wrong in the industry. As regards the decomposition of the task, the process of development itself forced the task to be broken into individual components. This aspect of development is discussed in the following chapter.

The complexity of the task. The task should neither be too easy nor too difficult for a human expert. The process of hotel unit analysis and diagnosis, as proposed, is a combination of pattern matching and reasoning with a large number of variables. This process could be carried out manually by an expert but with, perhaps, some difficulty. As previously stated, the numbers of variables involved is immense, and therefore difficult to reason with. The use of a computerised knowledge based system would enhance the process both in terms of speed and increasing the number of variables that could be examined.

The scope of the problem. The task problem should be of manageable size and it should also have some practical value. As stated previously, the task under discussion is both broad and deep and, as such, is rarely recommended for Expert System development. However, the issue as to what constitutes a manageable size is rather subjective. The author argues that manageable size depends on the amount and structure of the knowledge available. For example, a large task may be simplistic if the knowledge available is plentiful and structured in a manner which is readily amenable to representation. On the other hand, a smaller task, while seeming easy, may be complicated by the little knowledge available which has no obvious structure or relationships. The author argues that a prototype must be developed prior to making any claims as to whether the task is manageable.

Considering this analysis, the author concludes that the task under discussion is an appropriate one for an expert system application. The following chapter describes how such a basic analysis described by Waterman is insufficient for evaluating the appropriateness of Expert Systems to a task. Although shown to be appropriate, the actual development of the Expert System-Based Analysis and Diagnosis Software was hampered by many problems, not addressed by the Waterman's evaluation.

5.3.2 - Expert Selection and Availability.

Although successful hotel managers are plentiful, the process of formal diagnosis as defined in this project is a new concept judging by the lack of available knowledge in literature. Therefore, in the author's opinion, many hotel managers would have difficulty in providing the required knowledge. As managers are unaware of the process it would obviously be difficult for them to verbalise how they would tackle the task. As the knowledge acquisition process is highly involved, requiring hundred of hours of interviews, the commitment could not be expected from people who would gain little from the research findings. Secondly, much of the knowledge required may pin-point weak areas in particular hotel companies. This knowledge is obviously highly confidential and unlikely to be provided, therefore the knowledge acquired could not be viewed as the fully representational of knowledge available on the subject.

Primarily for this reason, the author played the role of both knowledge engineer and domain expert when developing the prototype system. This combination of roles is particularly important to the research, as a primary objective is to evaluate the ability of a hotel manager to produce an effective expert system using the readily available tools. Although not fully effective for a commercial system, the author, using his knowledge of both the hospitality industry and computerised support tools, can sufficiently provide the knowledge required to develop a prototype system for research purposes.

This approach however does prompt some confusion in the objective of the application. Firstly, if the expert is the knowledge engineer, why does the system need development at all? Secondly, does the domain expert have sufficient expertise in the required area in conjunction with an adequately high level of expert system development knowledge. Considering the first point, expert systems are widely suggested as tools to assist in the problem-solving process. The computerisation of the more basic elements of the process can free up valuable time for the expert to solve more complex problems lacking any structure and therefore beyond the bounds of computerised assistance. This system when adequately developed, matching the expectations of the expert, is then available for distribution to other managers with similar decisions to make within the organisation.

Concerning the level of expertise which the domain expert has available, other sources of knowledge are available, which will assist in the development. In conjunction with his personal knowledge, the author also utilised the knowledge available in literature and from relevant educators in the area of hotel management. In the latter category, lecturers in finance, human resource management, marketing, economics and operations were called on for both their general viewpoints, expertise, and for refinement of ideas sourced from the literature search.

The main difficulty, in this approach to knowledge acquisition, concerns the immense number of journals, and books which contain information relevant to the project. Practically every book in a library, from child care through to hospitality financial management, may contain individual pieces of knowledge that are applicable to such a broad area as hospitality unit diagnosis. It is obviously therefore essential that the literature search is confined to a more specific approach. Therefore the knowledge requirements for the prototype model were established by the problematic areas under development, as detailed in Chapter Three. Texts on hospitality financial control, marketing, operations, personnel and control were selected to provide the basis of the systems knowledge.

Therefore, considering the sources of knowledge and the particular problems associated with each, textbook analysis in conjunction with the domain specific knowledge of the author has been selected as the method of knowledge acquisition used. Any shortcomings of the available knowledge from the textbooks can be overlooked at this prototyping stage of development.

The literature search produced the majority of knowledge for the project. The literature search was used for two important purposes. They were: first, to identify and develop the requirements of the task; second, to acquire the knowledge for the solution of that task. The specifics of the knowledge acquired and its impact on development are discussed in the following chapter on system development.

5.4 - Phase three - Conceptual Design

Prior to prototyping, the conceptual design of the expert system was established. The design was based on the outputs required from the system. They were:

- *A ranked list of the problems which a hotel unit is exhibiting.* This list should be the result of a detailed examination by the system, showing only the lowest possible level or real problems. The issue of problem 'levels' is important as, although a problem may be identified, it is possible that it is purely a symptom of a lower level problem. Correction of such a problem is analogous to a doctor curing the symptoms of a patient's disease and not the disease itself.

- *The most appropriate solution to that problem.* In the case of several possible solutions being available, they too should be ranked in their order of appropriateness. (This area caused significant problems in effectively representing a comprehensive list of solutions. Therefore, it is not available in the prototyped system; however, an alternative approach is detailed in Chapter Six.)

- *The system must be capable of explaining to the user why that problem was selected and ranked in its particular place.* The explanation facility must be available on both the problem identification and solution recommendation facilities. This explanation capability should show any relationships the problem has with any of the data given to the system by the user.

- *The above outputs should be available in both a 'soft' form as on screen and in a 'hard' form or printout.* The latter output could be used as the basis for inter-departmental discussions.

5.5 - Phase four - Hardware Selection.

Considering the identification of an appropriate task which is conceptually feasible, it is necessary to select both the hardware and software which will be utilised for development. In this case the hardware was selected prior to evaluating the available software. Although generally it is more important to select software first, in this case the system had to be developed so that it could be integrated into an already developed hotel computer environment.

Traditionally, artificial intelligence and expert systems required specific hardware[7]. Today, however, many powerful tools are available for standard hardware and more specifically for personal computers. As this system is being developed for the hospitality industry by a hotel manager, it is necessary to select a development platform that will facilitate both development and implementation. As most computerised hotels use standard PCs, perhaps operating on a network, this format seemed most appropriate.

This research started in October 1992, at which time Intel processors were most common. It was therefore decided to use an 80386 processor on a PC with four megabytes of RAM and a one hundred megabyte hard disk.

5.5.1 - Software Requirements.

As previously stated, the software which is to be used for development is an expert system shell and, considering the hardware selection, must be PC-based. The primary reason for the selection of this approach to development is that the author is a non-computer scientist and therefore requires the utilisation of a developmental tool. The expert system shells commercially available are varied in many ways; these include: cost, inferencing methods, knowledge representation and interface capabilities. Due to this, prior to selection of a system, the requirements of an expert system shell for the particular task must be examined. The requirements were examined under the categories of knowledge base, the inference engine and interfaces.

(i) Knowledge Base Requirements.

a) The shell should utilise the knowledge representation method of IF-THEN production rules discussed in chapter five. This method is required as it reflects the reasoning skills used by human experts and is generally the easiest method for representation.

b) The knowledge base should be easily modifiable. This is required for both changing existing rules and adding new ones. The modifiability is required due to both the changing environment of the hospitality industry and the probability that knowledge will be made available after development.

c) The shell should be capable of employing a method of measuring uncertainty, such as Bayesian probability or certainty factors as discussed in chapter five. This is required due to the subjectivity of both the knowledge utilised in the knowledge base and the knowledge provided by the user.

(ii) - Inference method requirements.

a) For hospitality unit diagnosis, it is necessary that both a forward-driven and a backward-driven inference method is available. This is required as a manual process would consist of both a data collection phase (data driven) and a problem examination phase (goal driven). In order for the expert system to replicate this, both methods of inferencing are required.

b) In order to satisfy the required outputs, the system must be able to produce an explanation of its findings. This function would allow the user to examine the findings of the system, subsequently both validating the findings and providing the medium for the 'thought-provoking' process promised by system utilisation.

(iii) - Interface requirements.

a) The expert system must have the ability to interface with several different systems. This functionality would allow information to be sourced from the component systems already present in many hotels, such as front-office and back-office systems, stock control and payroll.

b) Interfaces should also be available for the expert system to utilise file formats of other development tools such as spreadsheets and database management systems. This would enable greater development flexibility, the author being able to match the component tasks within the expert system with the most appropriate tool.

(iv) - Expert System Shell selection.

Previous research had selected "Crystal 4", an Expert System Shell developed by Intelligent Environments, as an appropriate tool for the development of a strategic marketing expert system for the hospitality industry[8]. This research evaluated: "Super Expert", "Experience" for both DOS and Windows and "Crystal". The research found "Crystal" to be easy to use, flexible for development, and most importantly, highly stable. In addition, "Crystal" had been established as the Expert System Shell that would be utilised co-operatively with other projects between this and other academic institutions.

Evaluation of this tool showed that it contained the above requirements. It should be noted that although ES shells are sold as expert system development tools, the task in hand should solely dictate the shell utilised. Due to their design and capabilities, some types of ES shells are suited to particular domains. For this reason, the same shell may not be sufficient for different expert system applications. However, in this case, the previously used shell seemed appropriate, and was therefore selected. In addition, using the same shell as the previously developed expert system would facilitate the integration of the two systems, an important objective in the on-going research carried out in DIT Cathal Brugha St..

5.6 - Future Systems Maintenance.

An essential element to developing any information system must consider how the system will be maintained. For example, Property Management Systems include features which allows guest history and guest folios to be purged from the database, Accounting systems allow the user to remove previous years forecast and budget information and Computer Aided Manufacturing equipment allows for designs and processes to be changed. Expert systems must also allow for a form a maintenance, although in a different manner.

An essential element of an expert system is the knowledge base, the facts and information necessary to understand, formulate and solve a problem. It can reasonably be expected, that throughout the life of the system, those rules may become invalid, require some modification or may become inappropriate in some areas which they exist within the knowledge base. When this happens, it is necessary to change the knowledge base to ensure the validity of its conclusions. Unlike the databases described above, this form of maintenance cannot be built into a simple procedure. These changes must be performed on an ad-hoc basis and therefore it is necessary to get "inside" the system, make the required changes, ensuring that the remaining rules within the knowledge base are not adversely affected by the changes.

Generally this type of systems maintenance can occur when the systems developer remains within the company and involved with the system. Where this is not the case, difficulties arise. Has the development of the system been meticulously documented? Is there someone else in the company capable of making changes without damaging the system? Even if the skilled person exists, do they have the required security access to the system to make the required changes? These questions must be considered where any commercially utilised system is being developed.

5.7 - Summary.

Considering the Expert system development process described by Turban and the requirements for Expert System development established by Waterman, this project has been shown to be appropriate for Expert System development. The task is clearly defined as a diagnostic support tool for the hospitality industry, which has been justified in its potential benefits. All of the necessary requirements have been met and the technology seems appropriate to the task.

Considering actual development, the author will act as both knowledge engineer and domain expert. The conceptual system has been established and the Expert System Shell has been selected. This chapter has covered some of the analysis required prior to developing an Expert System. The following chapter will describe the process of development working from the conceptual design through to the finished prototype using an iterative prototyping process. It could be argued that it is this process which will truly evaluate the appropriateness of applying the technology to the task of hotel company diagnosis.

References

1 Turban, E., **"Decision support and expert systems."** Maxwell Macmillan International Editions, Singapore, 1990.

2 Ibid.

3 Ibid.

4 Prerau, D.S., **"Selection of an appropriate domain for an expert system."** AI Magazine, Vol. 6,2, 1985, pp. 26-30.

5 Waterman, D., **"A guide to Expert Systems."** Addison-Wesley, USA , 1986.

6 Ibid.

7 Op. Cit. (1)

8 Sunderland, E. **"Expert Systems and Strategic Marketing."** Thesis in Preparation, DIT Cathal Brugha St.

Chapter Six.

System Development.

6.1 - Introduction.

This chapter describes the development of the Expert System-Based Analysis and Diagnostic software package, using the Expert System Shell "Crystal". The shell is firstly described, and then follows a description of the prototyping process. This description follows a primarily chronological approach.

6.2 - Crystal.

Before discussing the development of the Expert System-Based Analysis and Diagnosis Program (ESAD), it is first necessary to describe the manner in which the development tool is utilised. "Crystal 4" is a structured expert system shell, structured in that the knowledge is grouped in a strict hierarchical manner in the form of production rules.

Crystal uses a “depth first” mechanism. It goes through the rule conditions in exactly the order in which they appear, stopping as soon as one of the conditions fails. This ensures that, if each rule is proven true, the system will logically flow through every possible branch of the knowledge base. If a rule fails, the system will stop at that point.

Diagram 6.1 shows the logical flow. The flow must check all the levels associated with the first rule of level 1. If rule B, of level 2 succeeds, the flow continues to level 3. If rule C succeeds, the flow reverts to level 2 and continues to the next line i.e. rule D. If at any point, a rule cannot be proved true, the flow will stop.

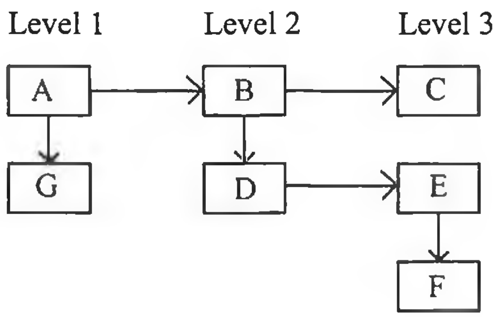

Figure 6.1 - Logical flow path

The production rules within this structure differ slightly from the examples of rules given in chapter four. The general production rule, described as an ‘IF-Then’ rule, consists of a condition (the "IF" portion) and an action (the "THEN" portion). This rule can either fail or succeed depending on the conditions involved. In real terms this means that IF the condition is satisfied THEN carry out the action. For example, IF “The marketing function is Deficient” THEN “Further analyse the marketing function for causes". Crystal, however, operates the IF-Then rule differently. As opposed to starting with the IF portion, Crystal requires the action or the THEN portion first. A Crystal rule conclusion is made up of a sentence, consisting of up to 50 characters without any required syntax. From the above example, this rule in Crystal looks like:

Further analyse the marketing function for problem causes
IF The marketing function is deficient

This rule can be expanded in Crystal by adding "AND" or "OR" conditional statements in the condition portion. A condition is a piece of information Crystal will use to attempt to evaluate a rule as being true. The conditions are always checked in the order that they appear. This has the effect of being easily able to expand the condition for the action. For example, in the rule below, the action will only be carried out if all of the conditions are true.

Further analyse the marketing function for problem causes.
IF The company is not market oriented
AND The company has a poor product strategy
AND The company has a poor pricing strategy
AND The company advertising media is poorly selected

Similarly, a rule can be altered by including "ORs" in place of "ANDs", where only some conditions may have to be true for the rule to succeed and subsequently carry out the action. The ORs are also used where there are several ways of proving a rule. These are used when, in order to prove a rule, the developer offers alternatives. An OR alternative will be checked if any of the previous conditions fail. Again the alternatives are checked as they appear. An alternative will never be looked at unless a previous condition has failed in some way. There is no need to prove a rule in two or more different ways.

Further analyse the marketing function for problem causes.
IF The company is not market oriented
AND The company has a poor product strategy

OR Sales are decreasing
AND Industry growth in increasing

This rule can be proven true in either of two ways, i.e. the system will further analyse the marketing function if either the company is not market oriented and the company has a poor product strategy, or, sales are decreasing and industry growth is increasing, inferring that a problem must exist in the marketing function.

Any condition itself can be subject to a whole series of conditions of its own. The hierarchical structure is used to expand any one of the condition's elements. So, in the above example, this rule cannot be satisfied until a sufficient number of the conditions has been proven true. In order to evaluate the market orientation, the system might contain a rule starting with:

The company is not marketing oriented
IF There are no senior management in the marketing area
AND There is no use of market information

OR The company is strictly sales oriented.

Again, each condition is individually evaluated in an attempt to prove this rule true and subsequently prove the previous rule true. Crystal will totally prove or disprove each condition it encounters before moving on to the next rule, however many levels that involves.

Although allowing for easy representation of knowledge, this structured format does complicate the development process. Other expert system shells simply require the entering of the knowledge in an unstructured format to the extent that related knowledge does not have to stored together. In 'run-time' the expert system will automatically develop the decision tree required for the problem. This simplifies the knowledge acquisition and representation process.

However, Crystal does offer particular features which aid the novice developer. These include commands, rule-dictionaries, variable-dictionaries and function-dictionaries, a screen painter, and keyboard macros.

1) Commands. Commands are used in Crystal to carry out special tasks for the developer. For example they can be used to:

- Display information to the user.
- Accept input from the user.
- Print information for the user.
- Assign and test variables.
- Restart the system.
- Give explanations to the user.
- Transfer data between "Crystal" and outside systems.

These commands offer the developer methods of creating faster, more efficient systems. This is enabled by creating easy to use systems, using complex techniques for manipulating knowledge and data. The commands are used by "Crystal" in exactly the same way as conditions. Most commands succeed; that is, they do their job and do not affect the logical flow of the system. For example:

Further analyse the marketing function for problem causes
IF The company is not market oriented
AND The company has a poor product strategy
AND The company has a poor pricing strategy
AND The company advertising media is poorly selected

OR Display Form

In the above example, Crystal has been unable to prove the previous conditions true, therefore the alternative command is given. This command will display a form which may tell the user that 'The marketing function does not need to be further analysed'. By offering this alternative, the rule can now succeed in that an alternative, i.e. the command to display the form, has succeeded. This will allow the system's logical flow to return to the previous level and go to the next line.

2) The rule-, variable- and function-dictionaries readily display those elements which are present in the system. This feature allows the developer to easily 'cut and paste' within the expert system under development. This ensures that rules or variables can be placed in different parts of the system, where required, without being concerned with ensuring the syntax of each entry is the same.

3) The screen painter is a feature of Crystal which allows input, output and menu fields to be added to forms. This enables information to be gathered in ways other than yes/no answers from the user. The screen painter also provides all the facilities required to design screens for the application.

4) Keyboard macros enable the developer to record sequences of keystrokes so that they can be played back without having to be re-keyed. Instead a single key stroke is used to replay the macro.

6.3 - System Development.

As opposed to discussing system development under specific headings (for example: knowledge acquisition, representation, and structuring) it is discussed primarily in chronological order. Structure is provided in the development process by two approaches used to develop the system, firstly, a data driven orientation, and secondly, a goal driven orientation. In this way, each change in development can be readily associated with its causes.

6.3.1 - Data-Driven Approach.

The development process began by attempting to develop a system which would constantly monitor the hotel unit, under the five functional areas, and alert management of any problems which were occurring or were likely to occur in the future. Although the faults may not be serious, it was established in Chapter Two, that a full diagnostic system should be able to inform of even small deviations from the norm. Although each identified problem may not require action, this approach is essential to ensure that small problems are not allowed to escalate into bigger, more serious problems.

In order to be able to do this, a system must have a large amount of data and information available to it. The research, at this point, concentrated on finding this data and information. Operations and finance were two areas which had many analytical techniques developed especially in the hotel industry for the processing of such information. Ratio Analysis, Market Segment Profitability Analysis and Variance

Analysis were selected as techniques for inclusion in a prototype model. Briefly, these techniques offered a structure for collecting particular data, processing it in a specific manner and providing information which can be used by management in their decision-making and problem-solving processes. If these techniques could be incorporated into an expert system, it was envisaged that data could be entered either by management or automatically through interfaces with other existing hotel systems such as front-office. Analysis would be carried out including calculating ratios, performing the substitution of the variance analysis and performing the marketing segmentation analysis. Although knowledge would be required for the collection and analysis of the data, the principal knowledge represented in the expert system would be concerned with the evaluation of the results of the various models.

This knowledge, represented in rule form, would evaluate the data provided by the user or outside systems. Based on this data, the system would advise the user of problems, ensuring that the 'true' problem was identified as opposed to simply a symptom of a deeper, more serious problem.

The development of this system involved two prime areas of concentration:

1) To investigate how the model analysis could be best carried out within the system.
2) How and what knowledge was to be acquired for the interpretation of information.

To simplify development, the system was originally intended to be comprised of separate knowledge bases, one for each of the five functional areas selected earlier: finance, marketing, operations, economic and human resources (see figure 6.2).

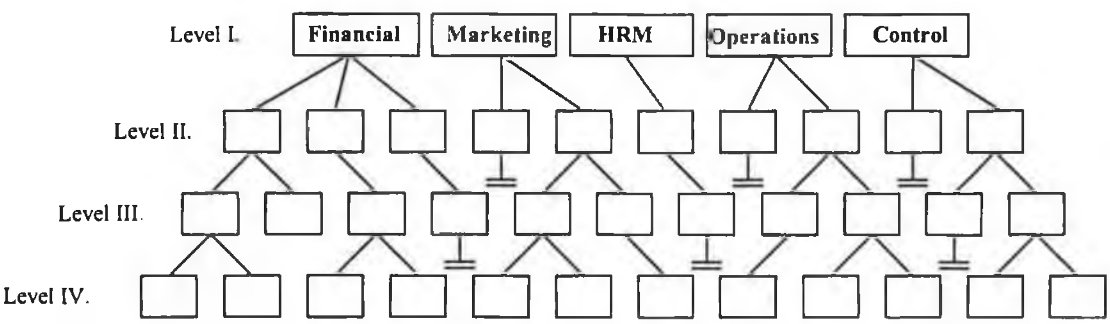

Figure 6.2 - System Layout.

Each knowledge base would have the functionality to collect its own relevant data, perform the analysis and carry out the diagnosis. Analysis would be carried out in level one and the diagnosis in the following levels. The levels below level one of the knowledge base would be responsible for the true diagnostics, varying numbers of levels being required depending on the complexity of the problems. These areas would contain the knowledge required to analyse the available information and draw conclusions as to the existing or future problems the hotel unit was facing. At this stage, it was uncertain as to what this knowledge would be or where it would be sourced. However, as these levels depended on the availability of information from the analytical techniques, the incorporation of these techniques were tackled first.

It was this area, the analysis function, which caused many of the primary problems of the development. Although "Crystal" had the capability to perform quantitative analysis, using both variables and arrays, this method seemed slow and tedious to both develop and use at run-time. For example, to perform a simple calculation for an "acid-test" ratio would require four variables. The calculation was:

acid_test := (current_assets - stock)/current-Liabilities

This formula had to be entered each time the calculation was required. Several calculations of the same ratio may be required depending on the number of years for which data is available. This approach put a considerable strain on the available memory. As "Crystal" offered an interface to the spreadsheet *Lotus 1-2-3*, it was decided that the quantitative analysis would be carried out using this application. The spreadsheet would be able to carry out the above calculation quicker and would be more efficient for development. In addition, it would reduce the memory requirements of the Expert System.

The Lotus interface allows the developer to both import and export information to and from a Lotus spreadsheet file. As ratio analysis, variance analysis and market segment profitability analysis (MSPA) are primarily quantitative techniques for the provision of information, the spreadsheet application seemed most appropriate for this task.

The first use of the spreadsheet interface was an attempt to computerise the general financial ratio analysis carried out by many managers. This process involves the collection of final accounts such as profit and loss accounts and balance sheets. This data is then manipulated using mathematical formulae to provide more meaningful information. The ratios are generally categorised under four headings: profitability and operating ratios; debt and gearing ratios; liquidity ratios and stockholder investment ratios. Each category is of primary interest in the different elements concerned with the running of a business, such as owners, managers, investors or lenders. For a more complete list of ratios, see Appendix B.

It was decided to develop the financial analysis module to collect the required data, export it for processing and import the results of the ratio analysis. These results would then be analysed by the knowledge base. As the information was being processed in this way, it was attempted to increase functionality by applying forecasting techniques to the accounts data, increasing the information base available to the expert system for analysis.

As the system was to be developed for use in many different hotel units, it was necessary to develop the data analysis models in a form that was amenable to different accounting practices. An investigation of various final account layouts, through a literature review, established the most commonly used variables and subsequently established the data that would be available for manipulation. The selected format was found to be the most common final accounts layout for analysis purposes (See figure 6.3 and 6.4).

Income Statement	yr. 1	yr. 2	yr. 3
TURNOVER			
Apartments			
Food			
Drink			
Other			
TOTAL TURNOVER	0	0	0
GROSS PROFIT			
Apartments			
Food			
Drink			
Other			
TOTAL GROSS PROFIT	0	0	0
OVERHEADS			
Salaries & Wages			
Repairs & Renewals			
Insurance			
Rates			
Light & Heat			
Advertising			
Laundry & Cleaning			
Telephone			
Postage & Stationary			
Other Overheads			
TOTAL OVERHEADS	0	0	0
PROFIT BEFORE INTEREST AND DEPRECIATION	0	0	0
Financial expenses			
CASH OPERATING PROFIT/(LOSS)	0	0	0
Depreciation			
NET OPERATING PROFIT/(LOSS)	0	0	0
Other Income			
Other Expenses			
PROFIT/(LOSS) BEFORE TAXATION	0	0	0

Figure 6.3 - Hotel Analysis Income Statement.

Balance Sheet	Yr. 1	Yr. 2	Yr. 3
FIXED ASSETS			
Depreciation			
CURRENT ASSETS			
Stock			
Debtors			
Cash			
Prepayments			
Other			
TOTAL	0	0	0
CURRENT LIABILITIES			
Bank overdraft			
Creditors			
Accruals			
Other			
TOTAL	0	0	0
WORKING CAPITAL	0	0	0
NET ASSETS	**0**	**0**	**0**
FINANCED BY			
Equity Shares			
Retained Earnings			
P&L Account			
Long Term Debt			
	0	0	0
	Guest Information		
Total No of Days Open			
Total No of Rooms			
Total No of Rooms Sold			
Total No of Guests			

Figure 6.4 - Hotel Analysis Balance Sheet.

Based on this format, a spreadsheet model was developed for ratio analysis. This comprised of a data entry section, an analysis block containing the necessary formulae and an output block to display the results of the analysis and make them easily available to the Expert System. The latter section was used to allow the use of "Crystal" arrays which are lists of variables with up to three dimensions. Although Crystal could load single cells from a spreadsheet, a more effective approach was to load an entire block of data into the Expert System through an array. A two-dimensional array was used containing the ratios for actual results, deviations from budgeted figures, previous years' data and a number of years' forecasted figures. As approximately twenty ratios were involved, by seven categories (three years' actual results, two years' deviations and two years' forecast), this resulted in a data block of one hundred and forty cells. In conjunction with this ratio analysis, other quantifiable information was to be processed in the same manner. Simpson Xavier Irish Hotel Industry Reviews were used as a source of industry comparison statistics. These statistics were also generally standardised in their format and are primarily concerned with the hotel's operation. Figure 6.5 shows an example of the information available, in this case only operational statistics for two years and the yearly deviations are shown. The inclusion of more years and the financial ratios would considerably increase the size of the data block.

Profit BT per Avail Room	9.3	-7.60909	16.90909	-23.0076
Profit BT % of Total Sales	0.2325	0	0.2325	-0.16667
GOP as % of Total Revenue	0.5	0	0.5	-0.16667
Avg. Annual Room Occupancy	0.821918	-0.04981	0.871731	-0.04151
Avg. No Guests per Room	1.333333	0.047619	1.285714	0.035714
Avg. Daily Room Rate	0.033333	-0.02381	0.057143	-0.01786
Avg. Rate per Guest Night	0.025	-0.01944	0.044444	-0.01556
% Comp of Sales (Rooms)	0.25	0	0.25	0
% Comp of Sales (Food)	0.25	0	0.25	0
% Comp of Sales (Drink)	0.25	0	0.25	0
% Comp of Sales (Other)	0.25	0	0.25	0
Cost of Sales % (Food)	0.5	0	0.5	-0.16667
Cost of Sales % (Drink)	0.5	0	0.5	-0.16667
Rev per Guest Night (Rooms)	0.025	-0.01944	0.044444	-0.01556
Rev per Guest Night (Food)	0.025	-0.01944	0.044444	-0.01556
Rev per Guest Night (Drink)	0.025	-0.01944	0.044444	-0.01556
Rev per Guest Night (Other)	0.025	-0.01944	0.044444	-0.01556

Figure 6.5 - Example of Information from Data Block.

As this information was readily available for industry comparison, it was decided to include the results in a separate spreadsheet file. If the same statistics as available from the hotel review were calculated for the unit in question, more information would be available for analysis by the expert system. The report details the statistics by both region and grade and comparisons can be made with the unit data on both areas. Again, as this form of analysis was quantitative, the spreadsheet model was most appropriate for the task. However this dramatically increased the size of the data block (several hundred cells) to be imported. Crystal defaulted the amount of memory available to such an array to one hundred cells. Any increase in the size forced the available memory for the arrays to be increased, substantially decreasing the memory available for running the expert system diagnosis application.

However, in order to attempt to prototype the system, it was necessary to select an appropriate spreadsheet application. Although the interface was for a "Lotus" file, most spreadsheet applications could export a file in the same format. The selection was to be based on the functionality of the application. Spreadsheets looked at included Microsoft's *Excel* and Borland's *Quattro Pro for Windows*. Although they were powerful applications, offering many advanced functions, it was decided to maintain a DOS based development as Crystal is DOS based. For this reason, Supercalc by Computer Associates was used. This approach was selected to ensure that both spreadsheet and Expert System applications would have a similar look when being used. Although the spreadsheet model was primarily for use by the expert system, it could be examined by the user.

The first system was developed with a primary expert system shell for collecting the raw data, the spreadsheet model for executing the analysis techniques and a secondary expert system for the analysis of the data and the diagnostics (see figure 6.6). On collecting the data from the user, including operational data and accounting data, the data was exported to the spreadsheet model. The analysis was then carried out and the results imported.

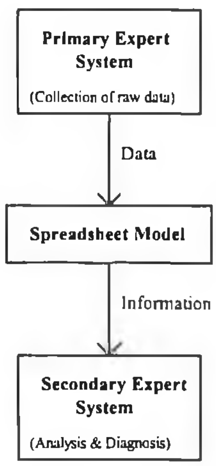

Figure 6.6 - Data Driven ESAD System

In order to carry out calculations, it was necessary that the spreadsheet application physically opened the spreadsheet model. In an attempt to integrate this into the expert system, the system was altered to execute the Supercalc application. A function available allowed Crystal to execute external DOS programs. However two problems occurred. Firstly, the user would then have to open the file to force recalculation and immediately quit the application to return to the expert system. This would mean that the user would have to have an appropriate spreadsheet application and be familiar with its operation. Secondly, although the function was available, insufficient memory was available to run the DOS program from inside the expert system.

In order to tackle these problems, a third software application was utilised. Baler is a tool allowing the development of stand-alone applications from *"Lotus 1-2-3"* or compatible spreadsheet applications. Using the Supercalc file, Baler was utilised to customise this file into an executable program which included a menu driven system. This program was both easier to use and required substantially less memory for execution. In addition the file could be made tamper proof, safe-guarding against any unintentional changes to the file format. This was essential to ensure that the data block imported into the expert system corresponded to the data that was expected.

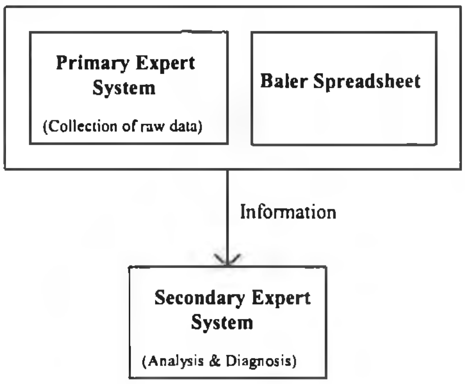

Figure 6.7 - Integrated Spreadsheet System

However, again this approach did not succeed. "Crystal" was unable to run the spreadsheet application due to insufficient memory. This displays a major limitation of the "Crystal" Expert System Shell, although functions are available, they are difficult to use when developing a system.

The last attempt to carry out the required analysis was to use variables within the expert system. The system was altered to allow the user to manually enter the required data. In order to offer the best possible level of information to the expert system, it was envisaged that several years' data would have to be entered. However, as varying companies would have been in business for a different number of years', a set number was impossible to evaluate. It was decided to give the user the option of entering two to five years' data. Variables were then set up to carry out the ratio and comparative analysis. However as previously stated, this analysis was comprised of several hundred results, possibly requiring thousands of variables. Shortly into the development it was discovered that the expert system was becoming increasingly slower and the amount of memory available was decreasing substantially. As the true knowledge base i.e. that for analysis of the data and the diagnosis, had not been included, it was obvious that this approach was not going to succeed. Failure in this approach was due entirely to the limitations of the Expert System Shell, "Crystal".

6.3.2 - Knowledge Acquisition.

At this stage, it was decided to temporarily ignore the logistics of the analytical technique computerisation and concentrate on the knowledge that would be required for the analysis of the results and the performing of the diagnosis. Essentially the true knowledge base was to be developed.

The literature analysis was used to search for any rules which could be applied to the information e.g. the ratio analysis results, the MSPA results and the variance analysis results. Although these are commonly used techniques, the level of the required knowledge was both limited in its availability and more importantly unavailable in a manner which was amenable to knowledge representation. For example, what observations could be made about a hotel with a liquidity ratio of 1:1, an average room rate of £45, a rooms department contributing only 20% of the sales mix and an annual staff turnover of 150%. Although many hotel managers could comment on each of the above issues, establishing a single observation from these, or any other combination of elements was impossible to find in either the literature search or knowledge acquisition using academic staff. This is due to the fact that knowledge regarding the inter-dependence of such elements is essentially unavailable.

This lack of knowledge may be a result of the fact that each element is actually independent of others, or on the other hand, maybe such relationships have never been considered in the past. The author suggests that it is the latter. It seems likely, that some combination of such elements should be capable of identifying a problem in much the same way as a human doctor uses symptoms to diagnose a illness. Although this knowledge was found to be unavailable and unachievable in an appropriate time-scale for a project of this nature and scope, recommendations for an approach to its collection are made at the end of this dissertation.

6.3.3 - Goal-Driven Approach.

However, considering the lack of available knowledge, it was attempted to produce a structure of a system which could be used when more knowledge was available. Knowledge for prototyping would be supplied by the author, a qualified hotel manager, representing his opinion on hotel management. In an attempt to overcome the problems to date, it was decided to limit the data which would be used in the analysis. At the same time it was decided that the orientation of the system was incorrect to satisfy the demands of the task. Initially the task was established as the development of a system which could diagnose problems in the hotel industry. Examining the term *"diagnosis"*, the Oxford English dictionary describes it as "the identification of a disease by careful investigation of its symptoms and history", the term being applied to the medical profession. Considering this and the previous attempts at the system development, it could safely be assumed that a doctor carrying out a diagnosis does not spend the first thirty minutes of the consultation collecting a myriad of information before thinking about possible diseases. In fact, a doctor is more likely to ask for some key pieces of information that will suggest a particular line of reasoning to follow. In the medical profession, examples of such pieces of information include temperature, aches, and any sickness. Based on the answers to these questions, the doctor is in a position to select a number of possible causes, and using both pattern matching and logical skills, determine the diagnosis. The knowledge base of the doctor could be described as an extensive list of diseases and illnesses, and their symptoms and causes. As opposed to being *data-driven*, doctors are *goal-driven* in their approach, in that their goal is to match a disease in their knowledge base with the symptoms presented.

It was then felt that the system should operate in the same fashion. The knowledge base should be comprised of the possible problems which may exist, and they would be evaluated against the symptoms the hotel is exhibiting through a reasoning process as opposed to evaluation against a database of information. The effect of this change in orientation would mean less information being supplied at the beginning, making the utilisation of the system less tedious, and decreasing the memory requirements of the system.

As opposed to utilising a modular system, it was also decided to develop the system in one piece. This was now possible due to the decreased memory requirements. This option would help develop a more effective system. In a modular system, information required by more than one system would have to be entered more than once or exported from system to system. In addition, the inferencing capability of the expert system would be diminished due to the fact that the knowledge and information was fragmented into different systems.

6.3.4 - Control

As the content of the system was generally selected, it was necessary to decide on a structure. How was the system going to operate and how would the inferencing take place to carry out the pattern matching? The development of this system involved an investigation into three separate methods of inferencing.

Three approaches were tested in the prototypes:

1) The first attempt involved a process whereby the system would ask various questions in a decision tree structure. The questions would change from general to more specific as the consultation was carried out. Depending on the answer to a particular question, different branches of the tree would be traversed. When the tree has been traversed to the bottom of a branch, a conclusion could be made. Profitability was selected as the key area of analysis for the prototype system. This area was selected as a decrease in profitability can be symptomatic of other areas which are failing[1]. Selecting this area enabled a clear structure to be identified for logically following a decision tree through to possible causes of problems. For example, if it is considered that profitability has been established as deteriorating, the element of profit (revenue versus costs) can be analysed systematically to diagnose where the problem is occurring. Each level suggests an area which must be further analysed until the path can go no further and therefore the real problem has been identified.

The original enquiry process asked the user for an answer to each of the questions in figures 6.8 and 6.9. This allowed the system to proceed along a logical path where further questions were asked until the end of a path was reached.

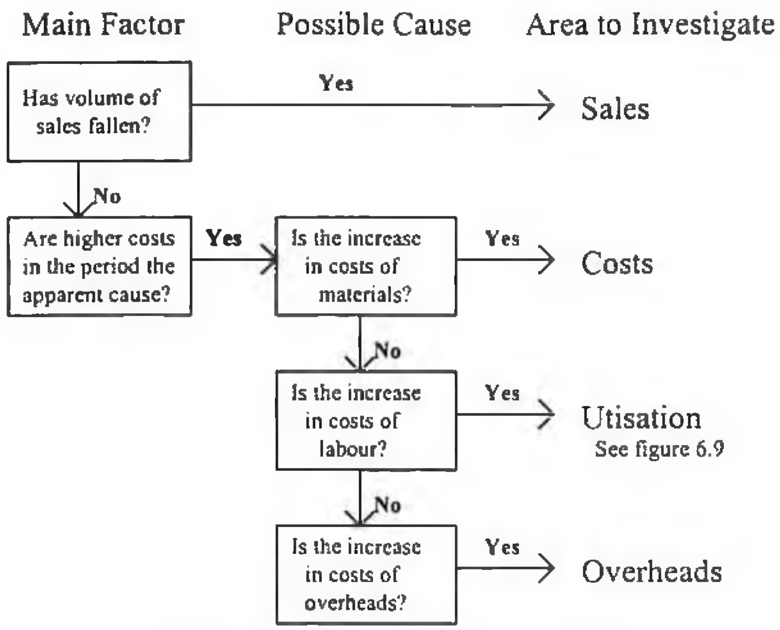

Figure 6.8 - Analysis of fall in profitability

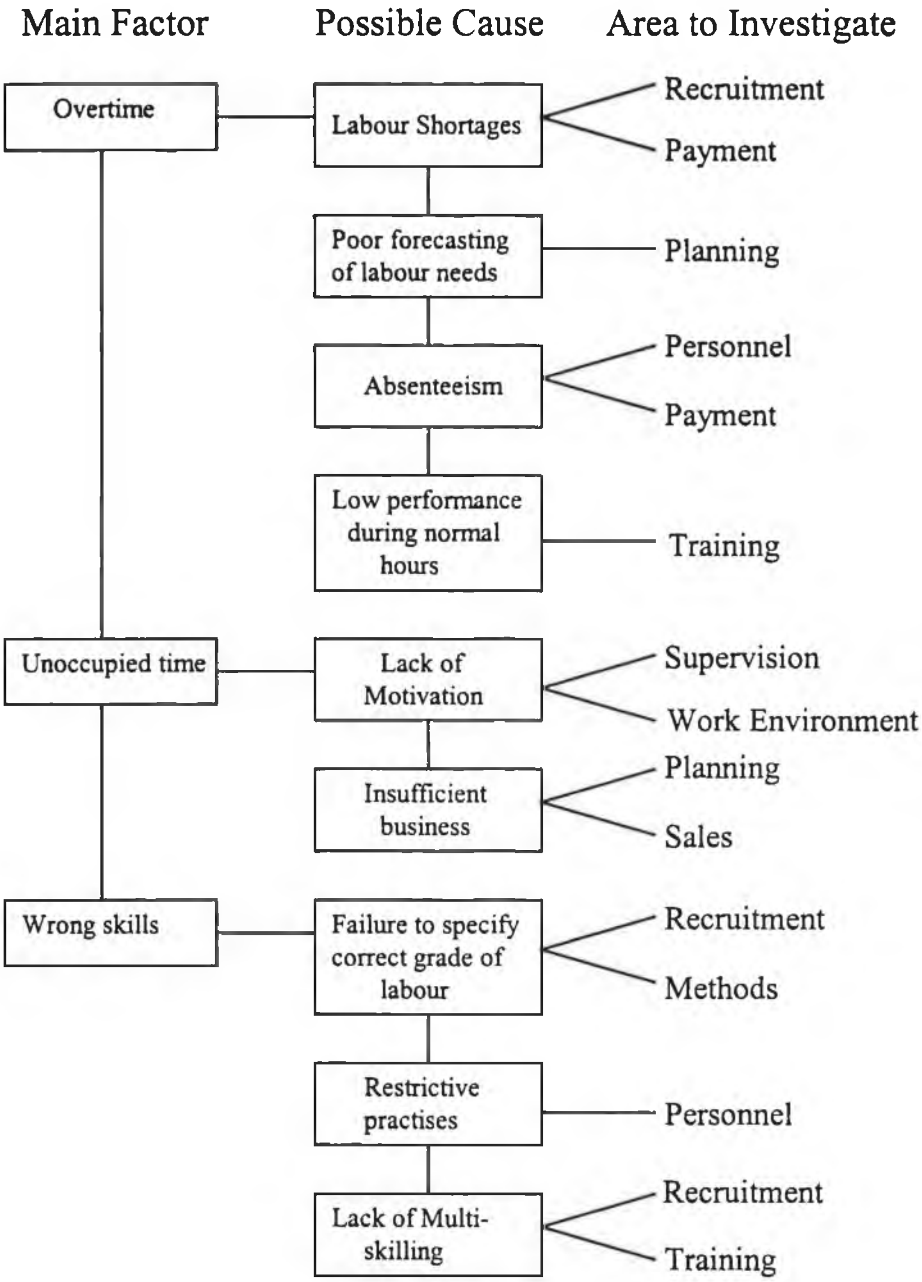

Figure 6.9- Analysis of factors affecting the efficiency of labour utilisation

This path format however led to a very substantial limitation. Once a path was selected, the other elements of the decision tree were disregarded; for example, if overtime was blamed for the increase in labour costs, unoccupied time and wrong skills were ignored (see figure 6.10). This is clearly unsatisfactory. Unlike medical or even machine diagnostics, where generally the identification of one problem is the goal, business diagnostics must be broader. This is due to the fact that usually a failing company will be experiencing problems in many different areas. This approach is therefore only applicable where strict rules are concerned and there is only one or no result. This is basically a data driven approach i.e. the data is driving the logical flow through the decision tree.

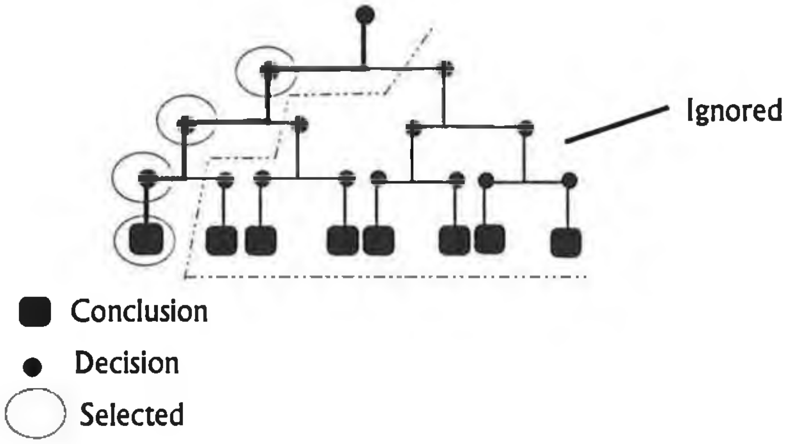

Figure 6.10 - Limitation in control method

2) A solution to this problem of question structure was to combine a selection system with the diagnosis system. A selection structure allows for a sequence of alternatives, each of which consists of a rule containing conditions that determine whether it should be selected. To allow a multiple item selection structure, each alternative is examined and scored depending the answers of the user. The questions asked by the system would be similar to those represented in diagrams 6.8 and 6.9.

This is a goal-driven approach. All the causal agents and problems to be evaluated are established. Each possible problem is evaluated in turn to see if it applies to the particular situation e.g. poor training, poor retraining, poor quality control, poor stock control etc. Each intersection in the decision tree asks the relevant question. However, the answer to these questions will not purely determine the direction of the decision tree. If a question results in a particular answer that can be judged to be a conclusion, that problem will be selected. If the answer does not suggest a conclusion, the branch is further traversed. The most important feature is that, disregarding the answer or conclusion, the system will continue to traverse the other paths of the tree ensuring that all possible problems are investigated. This can easily be accomplished by including a command that will force a rule to succeed and therefore continue through the tree.

The order of the questions in this approach is most important. If the most significant problems are asked first, problems are established in order of importance. In the following diagram, if "NO" is the answer to the training policy question, this is established as a problem. All other questions are irrelevant as without a training policy, retraining is inconsequential. If "YES" to training policy, retraining is questioned. A "NO" to this establishes retraining as the problem and not the actual training policy. This process continues to the end of the tree where the problem of the lowest level is established or to where a conclusion can be made. It is important to note that the system is not entirely aimed at the identification of the causal problem. Equally important is the interaction between the system and the user, helping in identifying the pattern in which problems are associated.

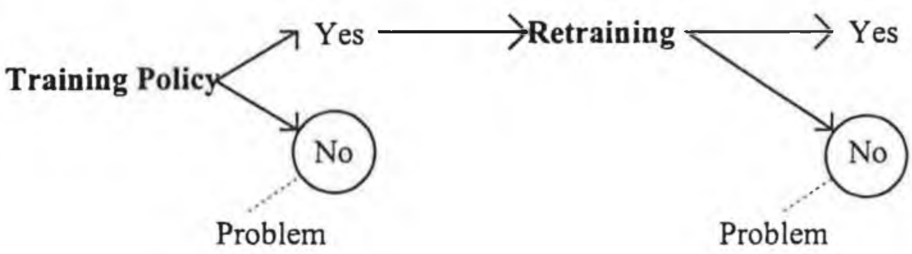

Figure 6.11- Structured Problem Identification Approach

All questions are structured in this sequential manner. The sequence is selected from available textbook information and the point of view of the author and available experts. A more scientific approach would have to involve knowledge acquisition from many hotel industry experts. (In most Expert systems of this type where the ideas are purely subjective, the knowledge of fifty or more experts has often been used).

This approach ensures that although all possible problems are evaluated, only relevant questions are asked. The system is effective, structured and more efficient. Questions already asked do not have to asked again if required later, simply tested for their value.

3) The third approach, is similar to the second approach. The same evaluation of all the possible problems is carried out; however, all the questions are asked prior to evaluation. In this way the expert system has a database of information against which to evaluate. The user is basically excluded in the analysis and diagnostic process. This approach, although as effective in structure, removes the user from the decision tree and therefore removes the thought provoking interaction with the system where relationship are shown. It also involves the tedious chore of entering a large amount of data at the beginning of the session.

6.3.5 - Revised Development.

It seemed possible at this stage that the prototype system would resemble a structured checklist i.e. a checklist where the user only sees the required areas. This can be argued to be a valid situation, as a diagnosis involves going through a checklist even if subconsciously.

Considering this structure however, a previously encountered problem was again faced. If the system was to analyse every possible problem which may affect a hotel unit, the consultation process would be long and tedious. In a busy unit, this issues could be responsible for a rejection of the system. It was necessary that the system could quickly identify problematic areas.

Again this system depended on the availability of certain pieces of information. These were required so the system could 'draw a picture' of the hotel unit, in a similar way to a doctor asking the most important questions. However, unlike a human patient, a hotel unit is unable to voluntarily offer key pieces of information as to what is the actual problem. For this reason, the selection of the initial block of information was crucial. This feature would ensure that the expert system could select areas from the hotel which warranted most attention, and subsequently could be evaluated in some depth.

It was decided that this initial block would contain data on five categories: marketing, operational, human resources, financial, and control. Each category was comprised of several pieces of information relating to that area (See table 6.1). Different to the previous attempt, the amount of data was limited. The objective was to select individual pieces of information for their potential value. Those selected again reflect the opinion of the domain expert i.e. the author.

Marketing	Company Orientation
	Operational areas where sales are increasing
	Operational areas where sales are decreasing
	Any change in market share
	Prices in comparison to competition
	Target markets
Operations	Condition of the premises
	Facilities offered
	Customer satisfaction
	Strategic planning by management
	Grade of the premises
Human Resources	Staff turnover
	Management turnover
	Staff productivity
	Employee morale
Financial	Return on investment
	Fixed asset utilisation
	Liquidity
	Capital structure
	Cash flow
Control	Profit margins
	Inventory control
	Cost control
	Use of information systems
	Use of computer systems

Table 6.1 - Primary analysis areas.

These questions are asked at the beginning of the consultation with the system. The pieces of data selected, although covered in many textbooks, are only a few of the hundreds available. However, the author, acting as domain expert, selected those that would offer the best overall picture of the hotel situation and would be appropriate to most hotels. The important feature of these questions is that they are qualitative in nature. As business analysts use quantitative information as well, it was necessary that this feature was included. For this purpose the "Lotus" interface was utilised, although in a limited capacity. A stand-alone management information system was developed using Microsoft Excel. This application was selected for its superior functionality over the previously selected Supercalc. In addition, as the two systems were to be independent, a common DOS platform was unnecessary. This system although independent, was developed with the expert system in mind. Its function being to collect a limited amount of key information and perform an operational analysis (see figures 6.12 and 6.13). The system can be used to immediately view the results; however, more importantly, the system outputs the results in a "Lotus" format file for use by the expert system.

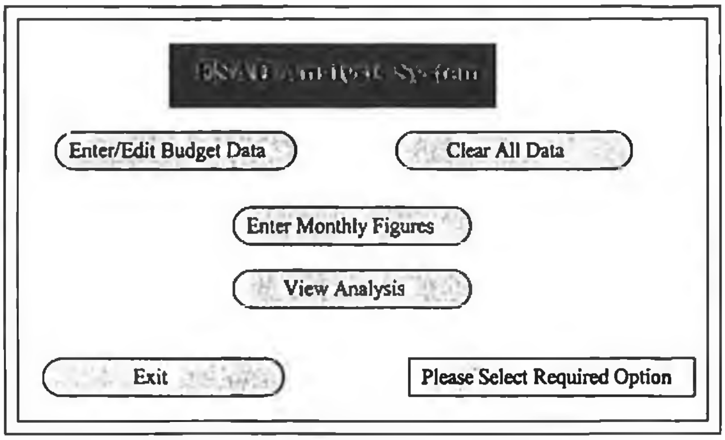

Figure 6.12 - MIS Main Menu.

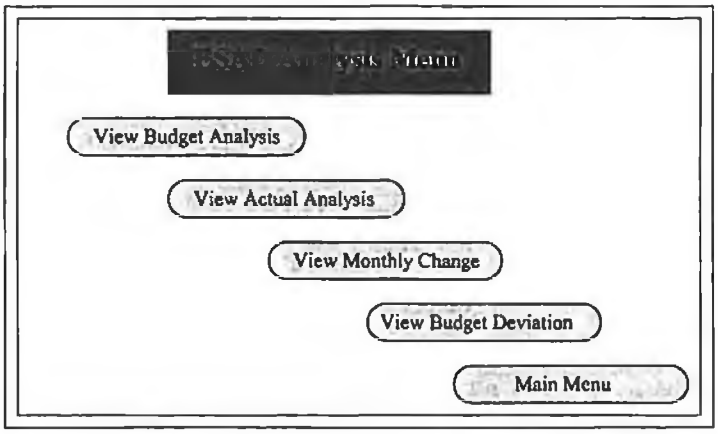

Figure 6.13 - MIS Analysis Menu

Similarly to the previous problems associated with this interface, memory for importing was limited. The new data block, although limited, was still over four hundred cells and therefore too much for the expert system to handle. These cells were made up of the statistics under three separate categories: actual figures, budget deviations and monthly changes (See figure 6.14 as an example). The thirty statistics were then available for the twelve months of the year.

	Ratio	January	February
Actual	Food Inventory Turnover	333.33%	666.67%
Actual	Bev Inventory Turnover	187.50%	233.33%
Actual	Food Cost Percentage	66.67%	62.50%
Actual	Bev Cost Percentage	93.75%	50.00%
Actual	Profit Margin	9.89%	8.63%
Actual	Occupancy Level	81.33%	94.67%
Actual	Occupancy Per Room	160.66%	169.01%
Actual	Average Room Rate	£73.77	£88.73
Actual	Rooms to Total Sales	49.45%	45.32%
Actual	Labour Cost Percentage	19.78%	14.39%
Bud Dev	Food Inventory Turnover	33.33%	288.89%
Bud Dev	Bev Inventory Turnover	20.83%	64.10%
Bud Dev	Food Cost Percentage	29.17%	24.7[illegible]
Bud Dev	Bev Cost Percentage	43.75%	
Bud Dev	Profit Margin	0.80%	
Bud Dev	Occupancy Level	1.3[illegible]	
Bud Dev	Occupancy Per Room		
Bud Dev	Average Room Rate		
Bud Dev	Rooms to Total Sale[illegible]		
Bud Dev	Labour Cost Pe[illegible]		
Mth Chg	Food In[illegible]		
Mth Chg	B[illegible]		
Mth Ch[illegible]			
M[illegible]			

Figure 6.14 - Example MIS Export Data Block.

In order to reduce the size of this data block, it was decided to import the required data only. In effect, this meant that only two months' data would be imported for any consultation i.e. the present month and the previous month. . This reduced the data block to sixty cells. However, in a commercial system, this would reduce the accuracy of the system and would affect the long term diagnosis function. It would therefore be essential that a more effective approach to memory management would be utilised in a larger system.

Using this quantifiable information in conjunction with the qualitative information, the system was developed to isolate the areas which were most apparently deficient. Using the selective mechanism, each area was evaluated against the relevant pieces of information. For example, the following rule states that the marketing function has been evaluated if competition in the area is evaluated, substitute competition is evaluated, distribution channels used are evaluated and an appropriate score is calculated.

Marketing Function Evaluated
IF Competition in the area evaluated
AND Substitute competition evaluated
AND Distribution channels used evaluated
AND Score assigned

Each answer provided to the system by the user is assigned a score based on rules within the knowledge base. Two approaches to assigning this score were attempted. The first approach used a sliding scale for the user to select the most appropriate point in relation to the question. For example, see figure 6.15.

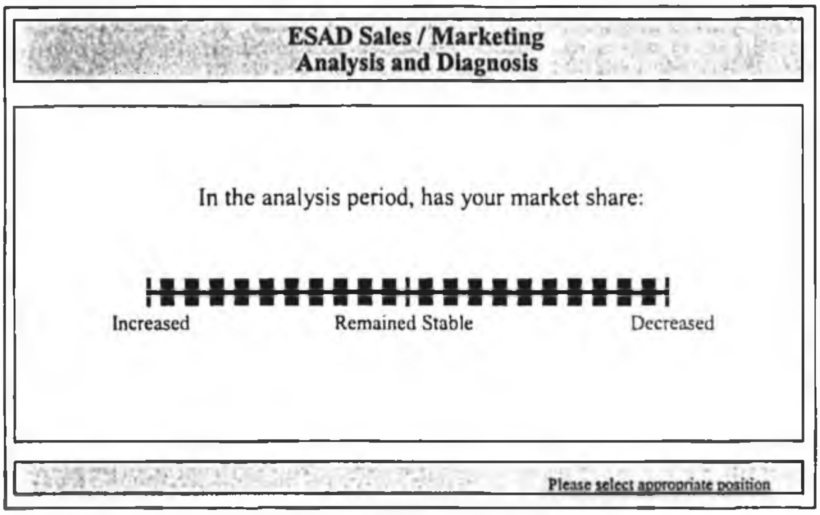

Figure 6.15 - Sliding Scale Data Collection Method

The user would be allowed to slide the scale and select the point which most reflected his opinion about a change in market share. This technique allowed for a more precise reflection of the user's opinion as opposed to simply asking for either increased, decreased or stable. Each point in the scale was represented in "Crystal" using input values, each being numbered from left to right, 0, 1, 2, 3 etc. Numbers between 0 and 10 represented increased competition to stable, and number from 11 to 20 represented stable to decreased competition.

Crystal would then use the returned value as a symbol standing for the company's position in regard to local competition. When evaluating the marketing function, the value returned from this input variable, and others, would be used to calculate the final score for the marketing function. A good answer, i.e. greater than 10 in this example, would be deducted from the score, a bad answer, i.e. less than 10, would be added to the score. The higher the returned area score, the more problems apparent within that area, and subsequently greater analysis would be required.

Although easy to set-up within the expert system, it was found that the sliding scale did not readily facilitate knowledge elicitation for two reasons. Firstly, it was difficult to precisely assign a score to a returned value. For example, would highly increased competition merit the same score as highly decreased competition? For the purposes of company diagnostics, the former situation might require a higher score, signifying a serious threat to the business. Secondly, it was likely that a similar opinion about two different questions would receive a different answer by simply selecting a point on either side of the point previously used. For example slightly increased might be assigned an eight in one question and a nine or seven in the next. This inaccuracy might invalidate the results of the consultation.

In order to overcome this problem, the sliding scale was replaced with a simpler, more definite answering technique. In this technique, the user was prompted with a selection of answers. For example, see figure 6.16.

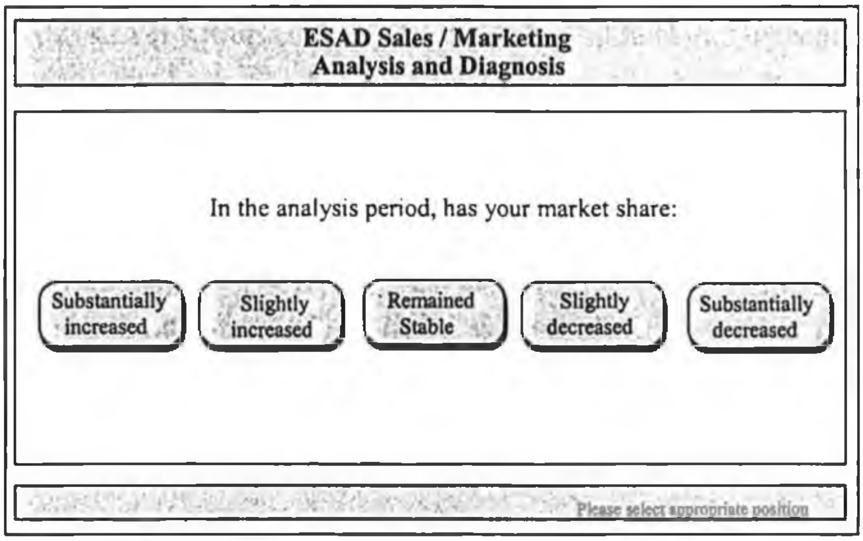

Figure 6.16 - Prompted Answer Data Collection Method

Although this approach did not counter the problem of assigning precise values to an opinion, it was selected as appropriate for the development of the prototype model. This method was found to provide sufficient information for the expert system to make an evaluation of the areas.

In a similar manner, the data from the management information system was evaluated. Each information item used for an area was assigned a value depending on its impact on the evaluation. For example, the degree of deviation between the actual occupancy percentage and the budgeted occupancy level was quantified and included in the overall area score.

The system was developed to carry out a similar evaluation for each of the five functional areas. As described this process was used to 'draw a picture' of the unit and advice the user as to areas which were most in need of investigation. Using the scoring method described above, each area is ranked and presented to the user, the higher the score reported the more an investigation was required. This module established the top-level of the diagnostic process.

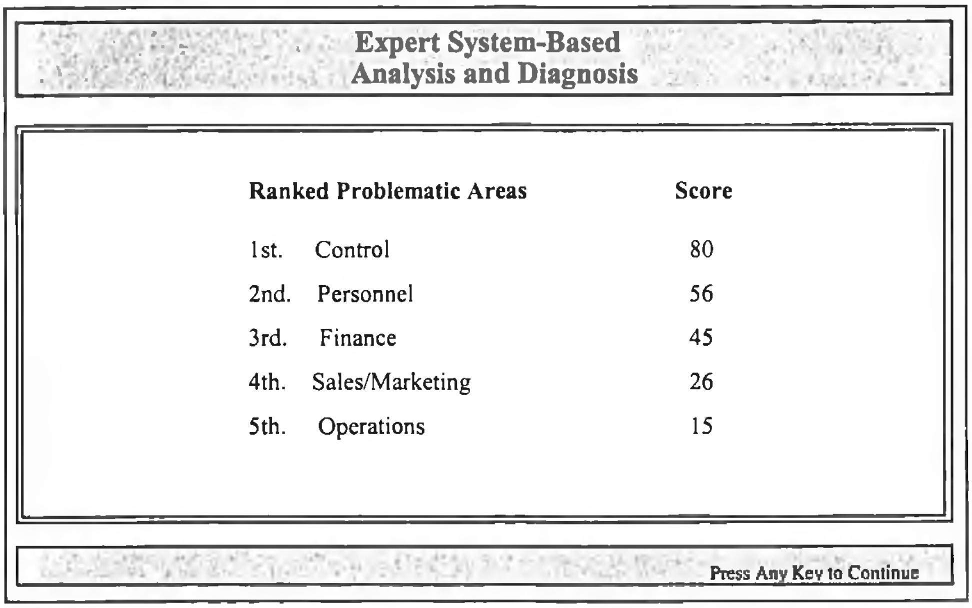

Figure 6.17 - Problematic Area Evaluation Output

This process of area evaluation is followed by an in-depth investigation of the problems in each of the specific areas. Again, due to memory management problems associated with the "Crystal" expert System Shell, these area specific diagnostic elements required development as separate modules. The primary evaluation is carried out in a top level module, using information provided by the user and the MIS. Each functional area has its own specific module which draws information from the top level module and the other four secondary level modules.

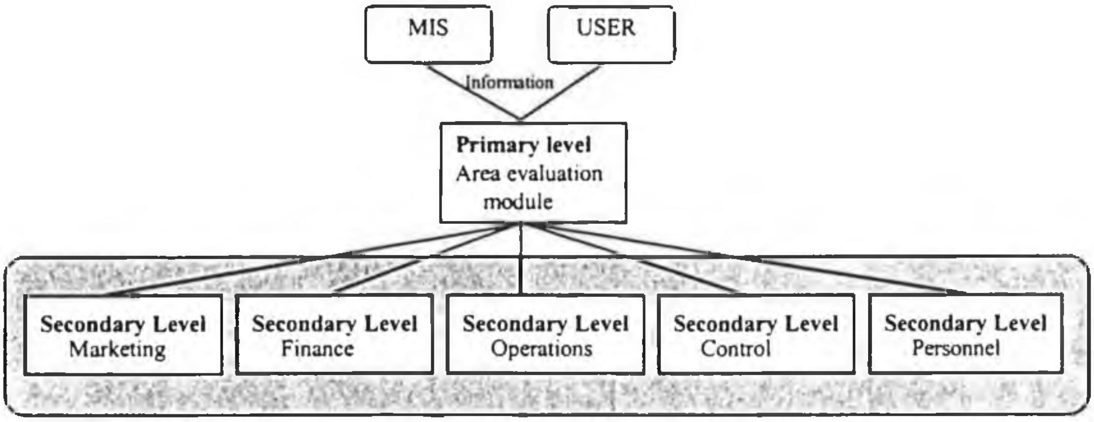

Figure 6.18 - Revised ESAD Prototype Model.

An essential element of this knowledge in the secondary level modules was concerned with the relationship of problems between disciplines. For example, is a decrease in restaurant sales a problem within the food and beverage department or a symptom of poor training and subsequently a human resources management problem? The structure of the hotel unit is such that operational departments such as accommodation and food and beverage, who actually produce the product, are simply serviced by departments such as marketing and human resources. For this reason the identification of problems under specific categories was almost impossible. The attempts to elicit this knowledge was again subject to the 'Information Overload' effect, i.e. too much information under consideration. Although it would be favourable for the system to evaluate as much information as possible, the knowledge regarding what information is important and what information is irrelevant was unavailable. This is essentially a knowledge acquisition problem and not a problem related to Expert Systems. For this reason, the knowledge was attempted to be acquired purely in terms of the diagnostic areas under discussion (financing, marketing, operations etc.). Relevant experts (see below) and textbooks were analysed in an attempt to pin-point the problems which constantly occur and the symptoms and solutions to those problems.

Expert interviews were carried out initially with academic staff within the related areas. This approach proved unsuccessful in the acquisition of the required knowledge. Although being able to identify problems which may occur, few experts were capable of formally describing the symptoms of these problems or the relationships which may exist. This research, although limiting, did substantiate the need for a system such as the one under discussion. Although each expert was capable of identifying problems, they each had difficulty in applying and verbally describing a process for analysing these problems in any great detail.

However, these interviews did establish some of the prime areas of consideration within each of the functional areas. Some of the problems identified related to:

Marketing	Control	Operations	Finance	Human Resources Management
Company Orientation	Cost Control	Maintenance	Capital Structuring	Labour Market
Marketing Information	Menu Engineering	Quality Standards	Cost Control	Labour Costs
Product Strategies	Labour Costs	Energy Management	Liquidity/ Cash flow	Recruitment
Pricing Strategies	Theft of Sales Income	Security	Cash Management	Training
Field Sales and Distribution	Deviations from Budgets	Systems Utilisation	Return On Investment	Staff/Management Turnover
Marketing Communications	Purchasing Control		Levels of Sales	Motivation

Table 6.2 - Problematic areas.

Using the above areas, a literature analysis was implemented. The objective was to further analyse these areas and develop a more comprehensive list of problems for use in the Expert System. Further analysis concentrated on identifying individual problems within each of the areas. This was necessary to enable the system to clearly define what the problem was. A system which merely advised the user of a problem within his pricing strategies, would be somewhat ineffective in achieving the overall objective of carrying out a detailed diagnosis. It was necessary to identify each of the smaller, yet related problems associated with these areas for inclusion in the system. As well as the smaller problems, it was also essential that the symptoms of these problems could be sourced. These symptoms would be an essential element of the system, constituting the rule base against which a company could be diagnosed.

This approach to knowledge acquisition again proved impossible given the knowledge acquisition method necessary, i.e. personal knowledge of the author and literature searches. The knowledge necessary for this form of diagnosis is essentially unavailable. As stated, the search concentrated on textbooks from the specific areas, finance, marketing, human resources, etc., as well as general textbooks on general management and hospitality management. Although each textbook is utilised in the education of future managers, few, if any approached the topic of problem identification and solution selection. A single textbook was sourced which provided sufficient knowledge about the marketing function. This textbook presented the knowledge in a form which was readily adaptable to knowledge engineering, offering a structured manner for the diagnosis of the relevant area. The marketing function was broken down into the six required areas. Each area was subsequently divided into the most important issues which must be considered. For example, pricing strategy is divided into the key factors of: pricing objectives; price setting; and price changes and discounts. Each of these functions is subsequently divided into areas of important consideration.

This knowledge allowed the extension of the expert system to the four level structure, shown in figure 6.19 (this model is superseded by the top level previously described). The levels are used to break a problem into its constituent problems. The knowledge concentrated on the areas previously identified, i.e. orientation, information, product strategy, pricing strategy, field sales and distribution and marketing communications constituting level one. Each of these large areas was further analysed in its individual constituent elements, levels two and three. However, as opposed to diagnosing for problems in existence, an alternative approach was utilised. Each area was evaluated to ensure that it was *clear* of any problems. The objective of the system, or goal, is to ensure the overall area, and consequently the individual components, operate in accordance with the rules in the knowledge base. The method used to achieve this is similar to that in the MYCIN system. Sub-goaling establishes the overall goal, and then sub-goals are used to prove or disprove the main goal. For example:

The Marketing Function is OK

IF	Orientation is OK
AND	Information usage is OK
AND	Product Strategy is OK
AND	Pricing Strategy is OK
AND	Field Sales and Distribution is OK
AND	Marketing Communications is OK

Sub-goaling, or expanding a condition such as information usage, establishes whether the rule can be proven true. This approach is particularly appropriate in this system. As opposed to searching for a single problem, the system must evaluate all possible problems. This approach ensures that every tree is traversed to its end point.

For example, orientation was broken down into the marketing concept as the driving force of the company, the objectives of the company and the use of appropriate marketing planning. These areas were assigned to level two of the diagnostic model, level three contains more detailed analysis of each of the areas in level two.

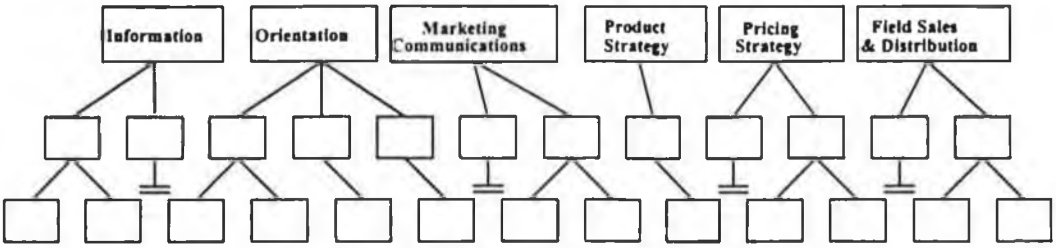

Figure 6.19 - Marketing Function Expanded

Representation of this knowledge, however, was altered from the original plan. As opposed to symptoms of the problems being analysed, each area was broken into key areas of importance. As an example, the user is asked about the use of marketing information (see figure 6.20). The user can then choose to answer the question "yes" or "no", or further evaluate the question.

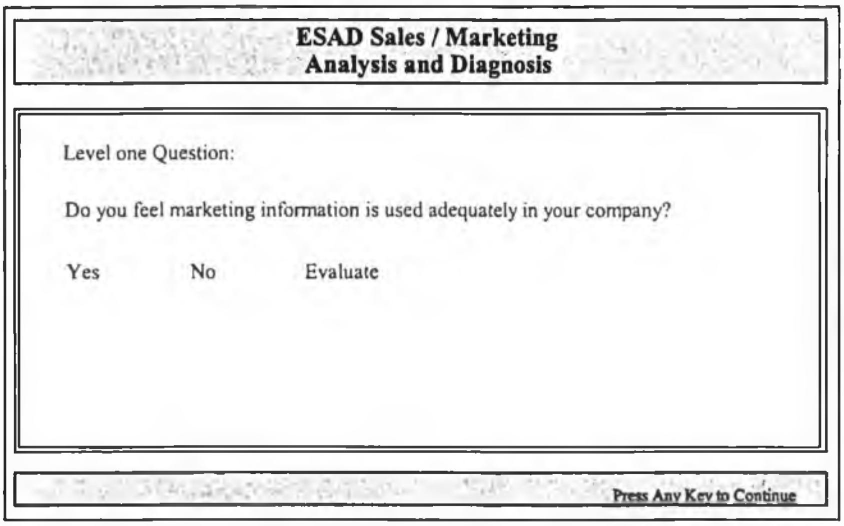

Figure 6.20 - Level One Information Question

As an example, if the level one area on "information" is identified, then further evaluation concentrates on the level two problems associated with that level one area i.e. information. The user is asked about the information used in the company i.e. how it studies the market, searches for opportunities to enhance the sales mix and uses market information (see figure 6.21). Again the user will answer "yes" or "no" to the questions or choose further evaluation going to the level three questions (see figure 6.22).

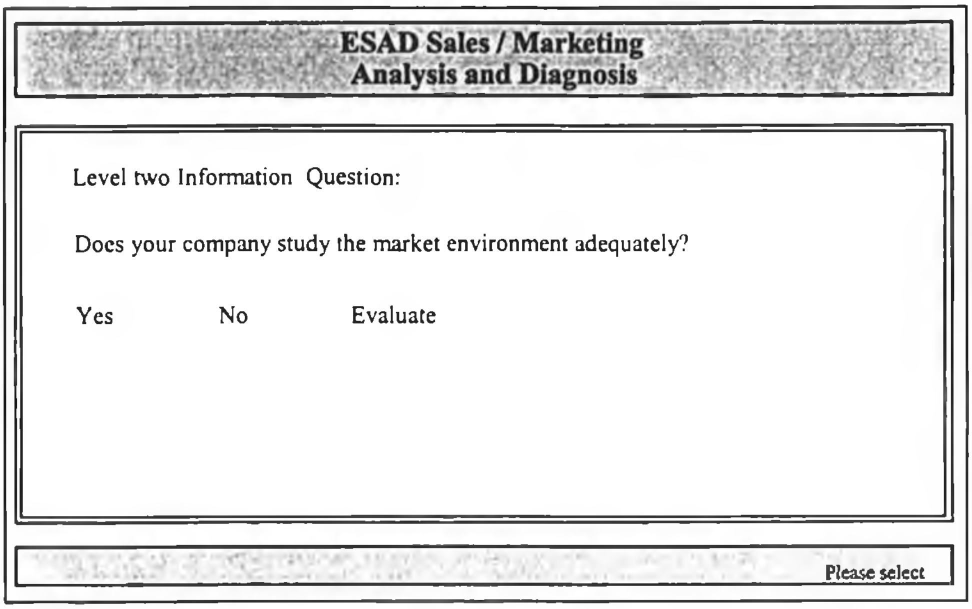

Figure 6.21 - Level two Information Question

This level (level three), as opposed to asking questions, presents the user with three statements on a particular area. For example, level three of the marketing information i.e. the study of the market environment, requires information about market structure, market attitudes and market trends. For example see figure 6.22.

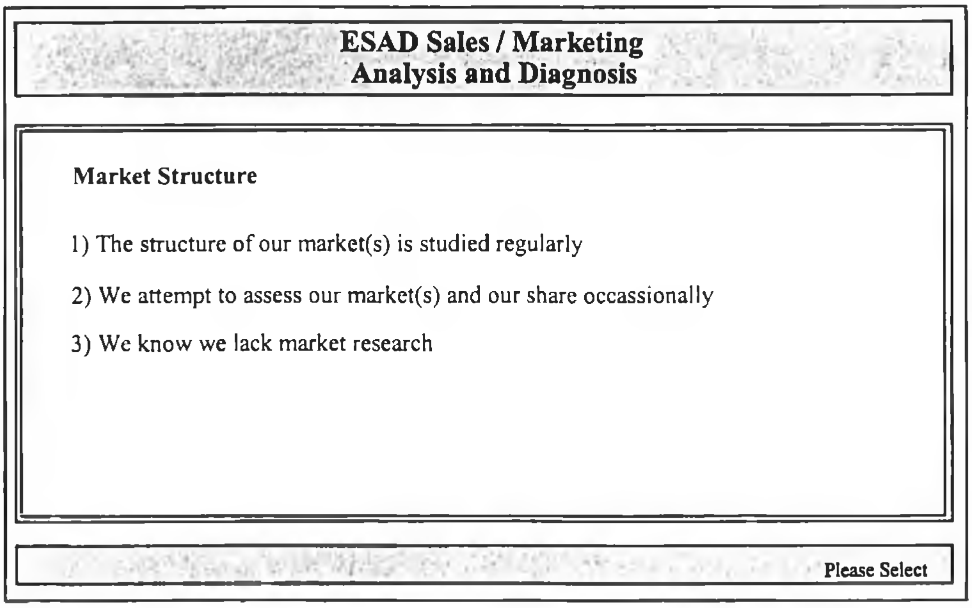

Figure 6.22 - Level three - Marketing information

The user selects from this list the statement which most applies to his company's situation. The answer to this question helps in determining the "answers" to the previous levels. This is carried out within the expert system by again assigning scores to the answers given at various levels. Looking at diagram 6.23 which represents one single route down the decision tree, each statement at level three will be assigned a particular score ranging from 0 to one hundred (the worse the answer, the higher the score). At this level, each question is asked, therefore making three scores available to level three, the marketing concept.

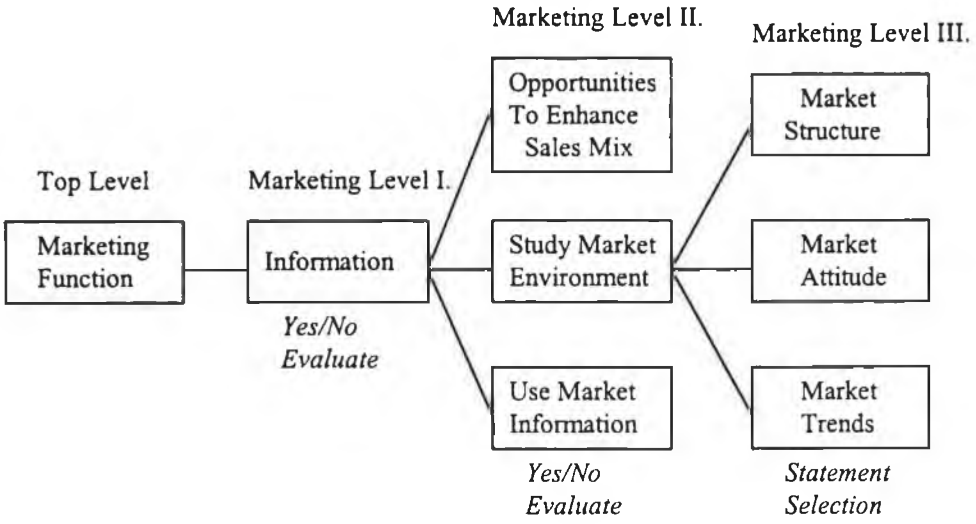

Figure 6.23 - Logical Flow Path, Marketing Function

For example, if market structure scores 15, market attitude scores 0, and market trends scores 45, study of the environment will be assigned a score of 20, the average of its related level three questions.

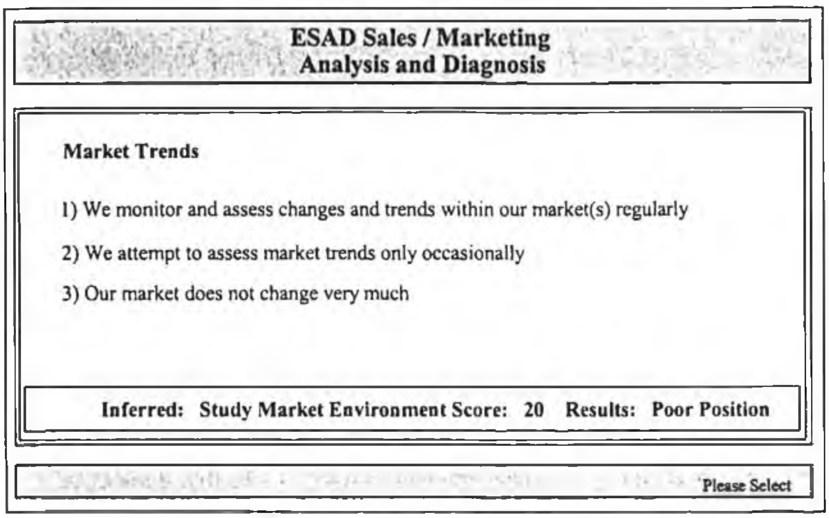

Figure 6.24 - Inferred Result Output

Similarly, the level one problem will be assigned a score as a result of its related level two problems. If at any point, either level I or II, the user does not choose to evaluate, the expert system will apply the appropriate score. For example, "is marketing information used adequately?" A "yes" answer will achieve a good score, a "no" answer achieving a bad score. At the end of the analysis, the user is allowed to see the scores that were obtained from any problem identified. The system will present all problems over a certain threshold score (10 in the prototype system).

ESAD Sales / Marketing Analysis and Diagnosis

First Level Problems Within The Marketing Function

1st.	Marketing Communication	56
2nd.	Orientation	50
3rd.	Pricing Strategy	25
4th.	Information	20
5th.	Product Strategy	17
6th.	Field Sales and Distribution	11

Press Any Key to Continue

Figure 6.25 - Marketing Function Diagnosis Output, Level One

The user is also allowed to question the system for a level breakdown of each problem i.e. what scores in level two made up the scores for level one, and what scores in level three made up the scores in level two (see figure 6.26 and 6.27). In this way, the user is made aware of all the problems which may exist within a function, also ensuring that they are aware of the problems which constitute the causal agents of larger problems.

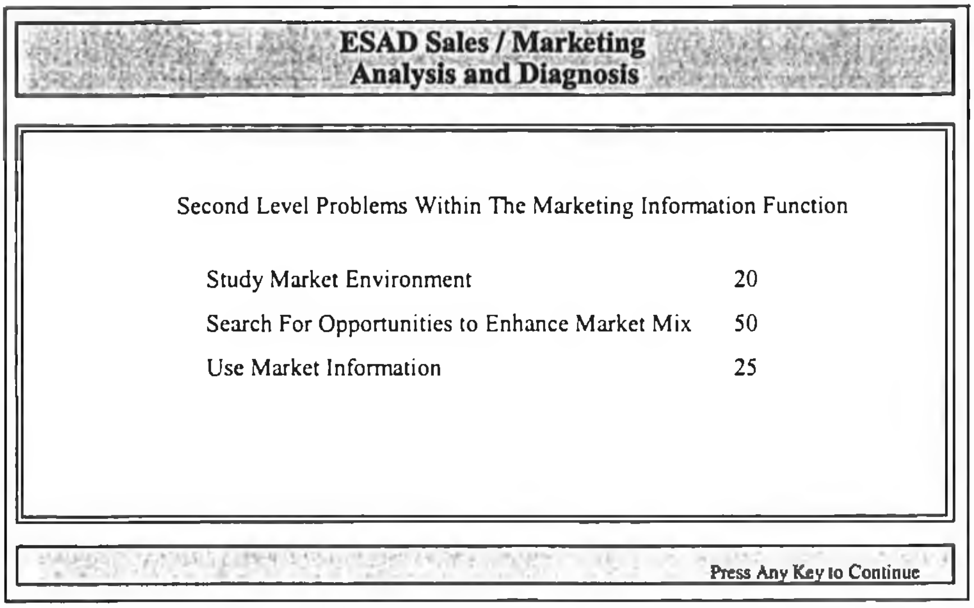

Figure 6.26 - Level Two Diagnosis Output

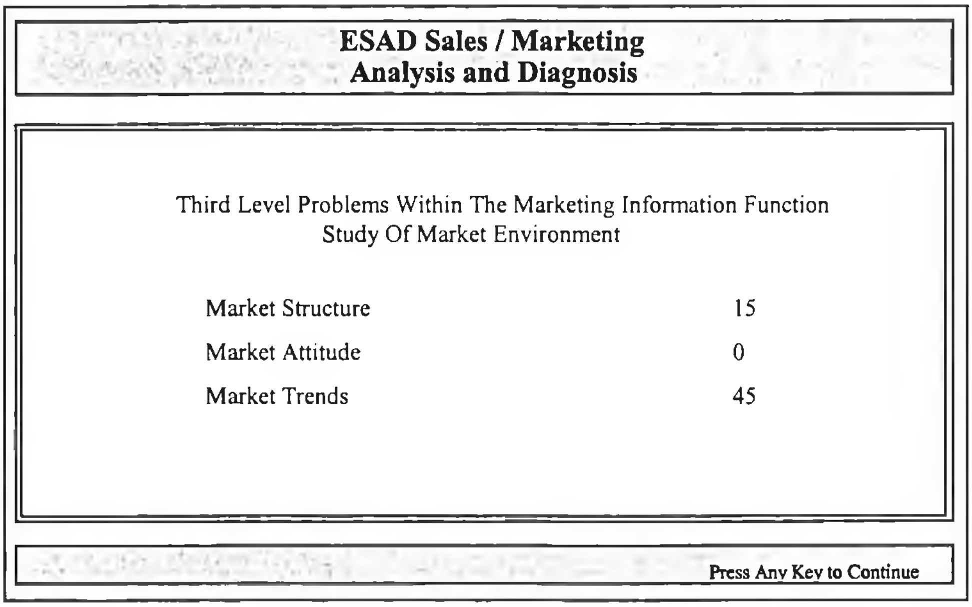

Figure 6.27 - Level Three Diagnosis Output

A similar diagnostic approach is available for each of the six functional areas within the marketing function. As stated, the level of knowledge available for the development of this system was so limited that only the top level for all areas and all of the marketing module were developed. However, the structure shows the application of the technology to the task. The prototype displays both breadth and depth in an area which is difficult to define. Assuming the availability of the required knowledge, the system could be fully developed, using an identical structure to the one utilised in the marketing module.

6.4 - Evaluation.

An integral element of the development process of Expert System calls for the evaluation of the performance of the developed prototype. The objective of the evaluation is to determine whether the developed system matches in effectiveness the conceptual system.

According to Sharma and Conrath[2], many techniques are available for the evaluation of expert systems and should be used, the broadest technique being post-implementation evaluation. This generic technique is defined by Sharma and Conrath[3] as an assessment of quality of the system after its development and the implementation of a working model. The objective of evaluation is suggested by Kumar[4] to verify that the system met requirements, provide feedback for the development team, justify the adoption or termination of the project, clarify and set priorities for modifications to the system and transfer responsibility for the system from the developers to the users. For the purpose of this research, analysis of the first four objectives would be highly beneficial. However, in this situation, comprehensive evaluation is difficult. This is due primarily to the fact that the system's knowledge base primarily reflects the expertise of the author. Although sufficient for demonstrating the appropriateness of the technology to the task, the system would not be accurate enough to effectively demonstrate to industry practitioners.

Instead of field testing, a basic lab evaluation will be used. This is carried out in two elements. Firstly, the system is evaluated against the objectives as set out in the conceptual system. Secondly, evaluation is carried out against the issues discussed under the justification of the development in Chapter Five.

6.4.1 - Conceptual System Evaluation.

This finished prototype offers the majority of features described in Chapter Five, under the section "conceptual system", with the exception of a solution facility (see appendix F. for a sample run of the system).

1. A ranked list of problems.
2. A ranked list of solutions.
3. An explanation facility.
4. "Hard" and "soft" outputs.

The ranked list of problems required is available as the result of a detailed examination of the hotel unit. Although the originally planned process of evaluating problems against symptoms is not utilised throughout the system, the top level effectively uses this approach while the lower modules utilise an alternative yet sufficiently effective approach. Each level of problems is presented to the user, the process making the user aware of problems and the relationships which exist between these problems within the functional areas.

The conceptual design established that solutions should be available for the diagnosed problems. The major problems of the research existed in not only identifying a comprehensive list of prominent problems but also sourcing the thousands of possible solutions which may exist with each problem; as a result this function is not available in real terms. However, the system evaluates the hotel unit to a sufficiently deep level that problems identified should propose a relatively obvious solution. For example, in the above case, a marketing problem has been diagnosed as a problem within the marketing information function. The examination of this function diagnosed that the problem is essentially due to a poor study of market trends (score 45). An obvious solution to this is to implement a more effective approach to how the company studies the market environment. A more precise solution or how this is actually done depends on the creative skills of the relevant managers. This creativity is a process beyond the bounds of the state of the art technology available at present.

The explanation facility is offered by the break-down function of the diagnostic system. The user can easily see how the various level scores were calculated and what areas require further consideration.

The outputs are available as hard copies in a similar fashion to the form presented on screen.

6.4.2 - System Justification Evaluation.

Justification was established for the system under the following requirements. The system should:

1. *Improve the performance of non-experts.*

   The system, as developed, should improve the performance of non-experts. As stated, the hospitality business is complex and requires management to be inter-disciplinary in their skills. As expertise is difficult to achieve in a diverse number of areas, this system when completed should assist managers in diagnosing areas of the business in which they are not experts. The prototype confirms this in so far as it is possible.

2. *Provide training of a consistently high quality.*
A potential use of this system is in the area of education of hotel managers. If developed fully, the diagnostic system produces a structured approach to the area of problem identification, prior to implementing a formal problem-solving process. This approach will help users to recognise the relationship between related problems in a single functional area and to recognise the relationship between problems in separate yet related functional areas. In addition, the system should make user aware of the fact that problems can actually be symptoms of deeper level deficiencies.

3. *Provide a standardised approach to solving the problem.*
The system, if utilised within a hotel corporation, offers a standardised approach to problem identification. Although the required knowledge concerning the evaluation of the information and data may differ, the structure of the system will remain the same. This allows companies to ensure that managers are supported in their problem-solving activities and that results obtained from the system relate directly to the objectives of the company, as established in the system development.

4. *Automate the application of expert judgement to a large mass of data.*
The developed prototype does not automate the application of expert judgement to a large mass of data. This is primarily due to the lack of knowledge available for evaluation and the immense quantity of data which could be analysed. However, if developed using the recommendations suggested in the following chapter, sufficient knowledge could be acquired to perform this function. In addition, the development of interfaces to presently utilised hotel system could provide a large amount of data which could easily be evaluated given the acquisition of the required knowledge.

5. *Assist managers with a relatively routine task.*
As opposed to assisting the manager with a relatively routine task, this system offers a computerised approach to a task which is presently not carried out by management in any formal manner. Instead of freeing manager's time for more complex activities, this system offers management the assurance that problems

under consideration have been correctly identified. This would ensure that management resources are not wasted on tackling the wrong problem.

References

[1] ACCA Manual 3.2 , **"Financial Management."** Bpp Publishing Ltd., UK. 1990.

[2] Sharma, R.S. and D.W Conrath, **"Evaluating Expert Systems: a review of applicable approaches".** Artificial Intelligence Review, part 7, 1993, pp. 77-91.

[3] Op. Cit. (2)

[4] Kumar, K., " Post Implementation Evaluation of Computer-Based Information Systems: Current Practises". Communications of the ACM, 33(2), pp. 203-212.

Summary, Conclusions and Recommendations.

Summary and Conclusions.

Problem solving is an important element of a manager's work and as such, occupies a significant amount of their time. However, as described in chapter one, the commonly utilised process is somewhat flawed, resulting in what may be ineffective problem solving. This is suggested due to the following reasons:

Formal problem solving is generally reserved for complex problems. This suggests that minor problems are sometimes ignored until they escalate into major problems. Dealing with the minor problem earlier on would result in fewer serious problems, save both money and management time and result in a more efficient operation.

Even where formal problem solving methods are employed for every problem, the process is not always strictly adhered to. The rational problem solving process requires the problem solver to diagnose the causes of the problem so that they may formulate alternative solutions. However, when attempting to define a problem, symptoms tend to be more apparent than causes and as such have been tackled as the root of the problem. In addition, biases, as a result of experience and responsibilities, cause different managers to view the same problem in a different manner and subsequently formulate different strategies. Where this occurs simultaneously in an operation it is unlikely that the problem will be solved effectively. Instead, each solution will be run in a hierarchical order until the problem is eventually solved.

It may also be suggested that the rational problem solving process is made ineffective by the order in which it is processed. Diagnosis, the identification of the cause, is carried out after the problem has been identified. The author argues that this should be an element of the overall process of problem definition. This would ensure that the 'true' problem is identified in contrast to the previous approach where the process may simply be evaluating a symptom of a deeper, more serious problem.

To overcome these limitations and thereby increase the effectiveness of a manager's problem-solving skills, the author suggests that a formal method of diagnosis be employed iteratively prior to the formal problem-solving process. As such, an adaptation of Simon's model of decision-making is used as an appropriate model of the requirements for the task. In the modified model, the investigative element of the process is substituted with formal diagnosis element. This is an iterative process of collecting the required intelligence, analysing the information and subsequently diagnosing problems when and if they exist. In this situation, the remaining element of the problem solving process are only utilised after a problem has been correctly and clearly identified.

The management, using such an approach, would then be in a position to initiate the formal and time-consuming process of problem-solving, satisfied that the correct problem has been identified. It can also be suggested that ongoing diagnosis of an operation, where no problems are immediately apparent, would ensure that managers are kept aware of problems materialising. As a result, problems would not require solving as they could simply be avoided.

Considering the flaws as described above, the following question may be posed. How have managers been effectively solving problems in the past? The answer is that the better managers have more experience and as such can rely on a qualitative approach to problem solving. This research identifies quantitative analysis as an important additional element of the problem solving process. The manager who is knowledgeable in quantitative decision-making procedures is in a much better position to compare and evaluate the qualitative and quantitative sources of recommendations and ultimately to combine the two sources in order to make the best possible decision. This skill however cannot increase with time, it can only be learned by studying the assumptions and methods of management science.

The process of diagnosis, if carried out continuously, is time-consuming and complex as the number of factors which require consideration is immense. The author proposes that the process could be made more effective through computerisation as computers can carry out complex analysis more quickly than humans and use an almost unlimited number of variables in the reasoning process. The proposed system would manage the iterative collection, analysis and diagnosis using both quantitative and qualitative analysis methods.

As opposed to developing a generic system for general diagnosis, the hospitality industry is chosen as an appropriate case for this research. Hospitality, an element of the tourism industry, displays certain characteristics that would benefit from the implementation of the proposed system. They are:

- Tourism and the hospitality industries provide significant benefits to the Irish economy in terms of national revenue and employment. An increased efficiency and reduction in major problems, can only affect the economy positively.

- The hotel product in itself displays characteristics that cause inherent management problems. In an industry that relies on the highest level of customer service, effectively solving problems may not always be sufficient. Instead, avoiding problems will ensure better customer satisfaction and subsequently sustained business success.
- The hotel industry, although largely dispersed geographically, is small in size. The large majority of hotels have less than 100 bedrooms and are typically family owned. In many cases, the management of such hotels, although experienced, do not possess a formal hotel management education and as such do not possess the knowledge on formal problem solving.

In the continuum of problem categories hospitality unit diagnosis may be classified as ill-structured. However, in order to be computerised the diagnostic process must be given some structure.

The structure is comprised of the collection of important problems, causes and symptoms within an "anatomical" arrangement of a hotel. The "anatomy" of the unit was developed as a collection of functions or sub-systems, namely: Finance; Sales and Marketing; Operations; Control; and Human Resources Management. These functions were identified from an investigation of the hotel product characteristics and industry structure. The model was subsequently developed to contain these functions, and, more importantly, to consider the relationship which existed between each of the functions. This inter-disciplinary relationship is important and it reflects the true inter-disciplinary skills possessed by Irish hotel managers. This model further established the need for an appropriate support tool for the diagnostic process, as hotel managers cannot be expert or professionally competent in all functional areas of management.

Having identified the importance of developing a computerised system capable of supporting hotel managers in the problem definition phase of problem solving, it was necessary to evaluate all appropriate technologies and select the most appropriate for the task.

The technology selection was based on the level of support that could have been achieved for the diagnosis process. Transaction Processing Systems (TPS), Management Information Systems (MIS), Decision Support System (DSS) and Expert Systems (ES) were evaluated based on their potential support for each of the stages of the diagnostic process. In addition, the evaluation considered the characteristics of the human decision-making process. Both a rational-analytical and an intuitive-emotional approach to problem-solving are required, as a combination offers a higher chance of making quality decisions. As decisions may be relatively ill-structured, decision makers must allow for an insecure informational base, consider uncertainty and risk, employ both quantitative and qualitative analysis techniques and utilise heuristics to increase the efficiency of the process. A system required to replicate the human decision-making process must be capable of employing such methods.

The arena of Artificial Intelligence (AI), and more specifically, Expert Systems, offered the most comprehensive support covering all three of the required phases. The "intelligence" phase is supported by Expert Systems in that they can provide advice regarding the nature of the problem, its classification, its seriousness and, consequently, can determine the quantity of information required to produce alternative solutions. Analysis and the generation of alternative solutions for complex problems requires expertise which can be represented in an expert system. Finally, Expert Systems can support the actual diagnosis by reasoning with the available information based on the knowledge contained in its knowledge base.

Expert Systems are also capable of utilising both quantitative and qualitative information, employing uncertainty techniques and heuristics to counteract an insecure informational base and to represent the intuitive knowledge of the human expert

Using expert systems, or specifically expert systems shells, the research focused on the collection and representation of knowledge into a prototype system for hospitality unit diagnosis. Using primarily literature review and industry expert's input, knowledge was collected to build a knowledge base on the domain of hospitality unit diagnosis. However, the level of knowledge available was found to be insufficient. This was due mainly to two reasons; the quantity and quality of knowledge represented in text books and the ability to translate an industry expert's knowledge on hotel management into rules.

The literature review found an immense number of applicable textbooks and industry journals. In order to focus the literature search, textbooks from the five functional areas of the hotel unit were selected and evaluated for available knowledge which could be utilised in hotel unit diagnostics. This approach proved unsuccessful for three reasons.

1. Each textbook offered considerably different viewpoints on the operation of a hotel unit. although this gave a greater level of knowledge, it was impossible to evaluate which opinions were more correct.

2. No textbooks were found which detailed the problems that could arise in the functional areas of the hotel business.
3. The knowledge which was available generally took a form which was unsuitable for knowledge representation within an expert system.

Considering industry expert input, two difficulties were encountered. Firstly, as opposed to simply computerising a manual process, the research involved developing a primarily subconscious process into a more formal approach. As a result, few industry experts would be capable of explicitly explaining their reasoning processes. Secondly, the knowledge acquisition is lengthy and involved. Hotel executives would be required to commit a substantial amount of time and also provide highly confidential information. This level of commitment was too difficult to obtain from practitioners.

However, in order to test the appropriateness of the technology, the author, acting as both expert and knowledge engineer, developed a knowledge base that would analyse and identify some of the more common problems that exist in hospitality units. This approach was favourable in that it overcame many of the obstacles associated with the traditional knowledge acquisition problem such as the difficulties in articulating knowledge, modeling an expert's reasoning strategy and the representational mismatch between the way experts express themselves and the way a knowledge engineer understands and represents an expert's knowledge. By performing both roles, there is no confusion in the presentation and representation of knowledge.

The prototype system developed is comprised of an independent Management Information System, which carries out the quantitative analysis required by the diagnostic Expert System. This was developed using a spreadsheet application because, although some level of analysis was available within the Expert System shell, it caused the system to be both slow in run-time and tedious to use. The application of a more appropriate tool (i.e. a spreadsheets) to the task increased the effectiveness of the entire system. The MIS processed data which were readily available to hotel managers and which were selected for their usefulness in providing information. The data were processed using appropriate operational ratios, selected for their usefulness in the process of performing a diagnosis of the business. Although much more information could have been processed, this would involve the user in a constantly lengthy process of data input. In order to simplify the process, the information with the most relevance to the process was selected.

In the developed prototype, the MIS supplies information to a top-level expert system. This quantitative information, and other qualitative information supplied by the user, is evaluated by the Expert System by examining the functional areas of the business and producing scores to establish the level of problems within each area. Each area with a significant problem is evaluated by the appropriate sub-system for a more comprehensive diagnosis. This modular approach is limited in its effectiveness in that inter-functional information is unavailable, i.e. marketing information is unavailable to the financial module and vice versa. However, this approach was necessary because of the memory management problems associated with "Crystal". It was found that a knowledge base of approximately four hundred rules was the maximum size which could be run using a conventionally configured PC.

For a hotel manager, expert system shells are effective development tools for the purpose under research; however, "Crystal", the specific shell used in this research limits the effectiveness of the finished system by poorly managing memory and forcing the problem to be highly structured. Further limitations in the system were caused by the fact that the essential knowledge regarding hospitality company diagnosis is presently unavailable in a form suitable for incorporation into an Expert System. As many managers perform well in their jobs on a daily basis, it can be assumed that the knowledge is stored somewhere. However, the collection of this knowledge would require a considerable commitment from industry practitioners in terms of time.

Literature has suggested that Expert Systems are only appropriate for problems in narrow domains. This project shows that a broad problem, such as hospitality unit diagnosis, can be tackled using Expert Systems. The major drawback to the prototyped system is not the logistics of developing the system, but the availability of comprehensive knowledge about the domain. Because of this the author suggests that proving the appropriateness of the technology to the task is insufficient. Chapter five showed that Expert Systems could be applied to hospitality unit diagnosis but did not establish the problems regarding knowledge acquisition. Therefore it can be argued that it is also important to analyse the amount and structure of available knowledge as well as the theory regarding the application of Expert Systems to a particular task.

Recommendations.

This research has established areas which are suitable for further research:

An extensive research initiative is required to elicit the knowledge that was unavailable for this research and, using it, develop a full diagnostic system. Recommendations for this further research can be made under the following headings: commitment, knowledge acquisition and development tool selection.

Commitment.

To gain the commitment of several leading hotel executives is essential to the area of research. This commitment would be major, as considerable time would be required for the lengthy process of establishing what problems exist and their relationship to other problems. A proposed approach to gaining this commitment may be to involve a large hotel group. In this way both the researcher and the hotel company would benefit from the project.

Knowledge Acquisition.

Knowledge acquisition from the domain experts can be elicited in either of two ways. First, a structured approach to acquiring knowledge from the relevant expert should be developed. This should start by identifying a comprehensive list of problems which exist in hotels and consequently establishing the relationship which exist between the problems. Case studies could be used to facilitate the knowledge acquisition from industry experts. This approach would help the knowledge engineer discover the issues important to hotel managers and how the managers logically evaluate a given situation.

A second approach is Rule Induction. Rule induction could be used in areas where variables are related. For instance, this approach could be used to evaluate the relationship between elements such as staff turnover, percentage increase/decrease in rooms revenue with a fixed variable such as net profit. Several analysis periods could be evaluated to produce the rules which link the entities. In addition, a comprehensive set of examples could be analysed to facilitate the development of the system. Using this approach, it would be necessary to experiment with several hundred pieces of data to establish the rules regarding a problem within the hotel. Through different experiments, enough observations could be established to develop a comprehensive system.

Development Tool.

The third recommendation concerns the selection of an expert system shell for further development. Although the use of "Crystal" allowed a relatively easy development, its structured orientation forced the knowledge to be structured. As the problem is ill-structured, it is recommended that a non-structured expert system shell be employed. This would facilitate both the acquisition and representation of the knowledge. Instead, the inferencing capability of the shell would develop a structure as required.

In addition, it is recommended that a development tool with considerable memory management functionality be selected. This would facilitate the development of a large and effective system where more knowledge and data could be manipulated.

Interfaces should be developed for the complete system. Such interfaces could be utilised to automatically monitor the present hotel systems for data with which the Expert System could work. This approach would free the manager from the tedious chore of entering large amounts of data. The manager would only be required when a problem was identified which requires further evaluation.

Bibliography

Abbey, J.R., "**Hospitality Management Library - Sales.**" Educational Institure of the American Hotel and Motel Association, USA, 1989.

ACCA Manual 3.2 , "**Financial Management.**" Bpp Publishing Ltd., UK. 1990.

Adair, J., "**Management decision making.**" Gower Publishing, UK, 1985.

Aktas, A.Z., "**Structural analysis and design of information systems.**" Prentice Hall, USA, 1987.

Ancher, S.A., "**The structure of management decision theory.**" Academy of Management Journal, No. 4, December 1964, pp. 269-287.

Anthony, R., "**Planning and control systems: a framework for analysis.**" Harvard Business School, USA, 1965.

Argenti, J., "**Corporate collapses: the causes and symptoms.**" McGraw Hill, USA, 1976.

Barrett, M.L., and A.C Beerel, "**Expert Systems in Business.**" Ellis Horward, 1990.

Berg. Peggy, "**Exploring solutions in hotel workouts.**" Real Estate Review, Summer, 1992, pp. 33-41.

Bibeault, D.B., "**Corporate turnaround - How managers turn losers into winners.**" McGraw Hill Book Company. 1992. USA.

Bolton, L., "**The expert in your toolkit.**" Accountancy, Vol. 111, May 1993, pp. 70-71.

Bord Failte, "**Hotel Profile.**" 1991

Bowen, J.J., and D.N. Clinton, "**Expert systems; advisor on a disk.**" Cornell Hotel and Restaurant Administration Quarterly, November 1988, pp. 62-67.

Bratko, I., "**Prolog programming for artificial intelligence.**" 2nd. ed., Addison Wesley, 1990, USA, Bridges, F. J., K. W. Olm , and J. A. Barnhill, "**Management decisions and organisational policy.** "Allwyn and Bacon, Boston, 1971.

Broderick, R., and J.W. Boudreau, "**Human resource management, information technology, and the competitive edge.**" Academy of Management Executive, Vol. 6,2, May 1992, pp. 7-17.

Bronner, R., "**Decision-making in complex situations - results of German empirical studies.**" Management International Review, Vol. 33, 1993, pp. 7-25.

Buchanan, B.G., and E.H. Shortliffe, "**Rule-based expert systems.**" Addison Wesley, USA, 1984.

Bullers, W.I., and R.A. Reid, "**Management systems: four options, one solution.**" Journal of Information systems management, Spring, 1987, pp. 54-62.

Buttle, F., "**Hotel and food service marketing.**" Cassell, UK., 1993.

Central Statistics Office, "**Report of the tourism task force to the minister for tourism, transport and communications.**" , October, 1992.

Cert, "**Manpower survey of the hotel, catering and tourism industry in Ireland.**" Vol. 1., 1993.

Chandler, J.C. and T.P. Liang, "**Developing expert systems for business applications.**" Merrill Publishing Company, USA, 1990.

Clancey, W.J., "**Heuristic classification.**" Artificial Intelligence, Vol. 27, pp. 289-350.

Clocksin, W.F., and C.S. Mellish, "**Programming in prolog.**" Springer, USA, 1981.

Cohen, M. D., J. G. March and J. P. Olsen, "**A garbage can model of organisational choice.**" Administrative Science quarterly, Vol. 17, USA, 1972, pp. 1-25.

Connell, N.A.D., and P.L. Powell, "**A comparison of the potential applications of expert systems.**" Journal of the Operational Research Society, Vol. 41,5, 1990, pp. 431-439.

Crystal Rule-Induction Manual, Intelligent Environments, UK. 1993.

Davis, G.B., "**Management information systems, conceptual foundations, structure and development.**", 2nd. Ed. Mcgraw Hill, 1985.

Duchessi, P., and R.M. O'Keefe, "**Contrasting successful and unsuccessful expert systems.**" European Journal of Operational Research, Vol. 61, 1992, pp. 122-134.

Eriksson, H., "**A survey of knowledge acquisition techniques and tools and their relationship to software engineering.**" Journal of Systems Software, Vol. 19, 1992, pp.97-107.

Etzioni, A., "**Humble Decision Making**" , Harvard Business Review, July - August 1989.

Experience, by Expert Edge.

Feignbaum,E.A., and P. McCormack, "**The Fifth Generation.**" Michael Joseph, Ltd., London, 1984.

Flannery, M.J., and J.J. Flannery, "**Causes of hotel industry distress.**" Real Estate Review, Vol. 20,3, Fall, 1990, pp. 35-39.

Forduce, K., and Norden, P., and Sullivan, G., "**Artificial intelligence and the management science practitioner: one definition of knowledge-based expert systems.**" Interfaces, 19, September-October, 1989, pp. 66-70.

Forgionne G.A., "**Building effective Decision Support Systems.**" Business. Jan-Mar 1988, p19-30.

Gamble, P.P., "**Small computers and hospitality management.**" Hutchinson, UK, 1984.

Gamble, P.R., and M. Kipps, "**The conception and development of a micr-computer based catering information system.**" The International Journal of Hospitality Management, Vol. 2,3, 1983, pp. 141-147.

Gardner, J.W. , **"How to prevent organisational dry rot"**. Harper's Magazine, October 1965, p. 24.

Goss, D., **"Principles of Human Resource Management."** Routledge, London, 1994.

Gregor, K.R., **"A view from the helm."** The Cornell Hotel and Restaurant Administration Quarterly, October, 1991.

Halloway, C.J., **"The business of tourism."** 4th. Ed., Pitman Publishing, UK, 1994.

Harmon, P. and D. King, **"Expert systems."** Wiley and sons, UK., 1985.

Harmon, P., **"Expert Systems tools and applications."** Wiley, USA, 1988.

Harris, P., and P. Hazzard, **"Managerial accounting in the hotel and catering industry."** Northwood Publications, 1987.

Hayes-Roth, B., *et al*, **"Building expert systems."** Addison Wesley, USA, 1983.

Hickman, W.B., **"Corporate band quality and investor experience."** Princeton University Press, USA, 1958.

Hickson, D.J., *et al*, **"Top decisions - strategic decision-making in organisations."** Basil Blackwell Ltd., England, 1986.

Hickson, D.J. *et al*, **"Decision and organisation - processes of strategic decision-making and their explanations."** Public Adinistration, Vol. 67, Winter, 1989, pp. 373-389.

Jackson, P., **"Introduction to expert systems."** 2nd. Ed., Addison Wesley, 1990.

Jauch, L.R., and W.F. Glueck, **"Business policy and strategic management."** 5th. Ed., McGraw Hill, Singapore, 1988.

Jones, R.E., L.W. Jacobs, W. van't Spyker, **"Strategic decision processes in international firms."** Management International Review, Vol. 32, 1992, pp. 219-236.

Jones, P., **"Food service operations."** Cassell, London, 1988.

Jong, H., Personal communication, February, 1994.

Kasavana M., **"The anatomy of a Hotel computer system."** Hotels and restaurants international, Vol. 17, 7, December 1983, pp. 57-61.

Keen, P.G.W. and M. Scott-Morton, **"Decision Support systems - an organisational perspective."** Addison Wesley Publications company, USA 1978.

Kidd, A.L. , **"Knowledge acquisition for expert systems."** Plenum Press, New York, 1987.

Knight, F.H., **"Risk, uncertainty and profit."** Harper and Brothers, New York, 1920.

Kogan, J.A., **"Information for motivation - a key to executive information systems that translate strategy into results for management."** Conference on Decision Support Systems, The Institute of management science, April 1986, pp. 6-13.

Koontz, Z.H., and H. Weinrich, **"Management"**, 9th. Ed., McGraw Hill International Editions, Singapore, 1988.

Kotler, P., and G. Armstrong, **"Principles of marketing."** 6th. ed., Prentice-Hall International Editions, USA, 1994.

Kotler, P. **"Marketing Management."** 7th. Ed. Prentice Hall, USA, 1991.

Kroenke, D., **"Management Information Systems."** McGraw Hill, Singapore, 1989.

Kroenke, D.M., and K.A. Nolan, **"Business computer systems."** 3rd. Ed., Mitchell, USA, 1987.

Liang, T.P., **"A composite appraoch to inducing knowledge for expert system design."** Management Science, Vol. 38,1, January, 1992, pp. 1-17.

Lindsay, R., et. al. **"Dendral."** McGraw Hill, New York, 1980.

Long, L., **"Management information systems."** Prentice Hall International Editions, USA, 1989.

Loofbourrow, T.H., **"The payoff of expert systems."** Best's Review ((Prop/Casualty), Vol. 92, May 1991, pp. 56-67.

Lundberg, D.E., **"The hotel and restaurant business."** Van Nostrand Reinhold, New York, 1989.

Magill, W.G.W., and S.A. Leedy, **"Uncertainty techniques in expert system software."** Decision Support Systems, Vol. 7, 1991, pp. 55-65.

Manley, P., **"Technology and Hospitality."** Presentation to the Hospitality Information Technology Association Conference, Dallas, June, 1994.

McCann, J.M., W.G. Lahti and J.Hill, **"The brand manager's assistant: a knowledge-based system approach to brand management."** International Journal of Research in Marketing, Vol. 8,1, April 1991, pp. 51-73.

McCarthy, J.E. and W.D. Perreault Jr., **"Basic Marketing."** $10^{th.}$ Ed. Irwin, USA, 1990.

McCool, A.C., **"Some considerations in developing expert systems for the hospitality industry."** International Journal of Hospitality Management, Vol. 6,4, 1987, pp. 191-198.

Medlik, S., **"The business of hotels."** Heinemann Professional Publishing, UK., 1984.

Merwin, C., **"Financing small corporations."** National Bureau of Economic Research, New York, 1935.

Messier, W.F., and J. V. Hansen, **"Inducing rules for expert system development: an example using default and bankruptcy data."** Management Science, Vol. 32,12, December 1988, pp. 1403-1415.

Mintzberg, H., **"Planning on the left-side and managing on the right."** Harvard Business Review, Vol. 55, July-August 1976, pp 49-58.

Moutinho, L., and B. Curry, and F. Davies, **"The comstrat model: development of an expert system in strategic marketing."** Journal of General management, Vol. 19,1, Autumn 1993, pp.32-47.

Murray, M., **"Decisions: a comparative critique."** Pitman, USA, 1986.

Naisbitt, J., In Long, L., **"Management information systems."** Prentice Hall International Editions, USA, 1989.

Newell, A., and H.A. Simon, **"Human prblem-solving."** Prentice-Hall, USA, 1972.

Ninemeier, J.D., **"Hospitality management library - Control."** Educational Institute of the American Hotel and Motel Association, USA, 1986.

O'Connell, S.E., **"Using the computer to manage costs in tough times."** HR Magazine, Vol. 35,12, December 1990, pp. 27-31.

Owen, D.E., **"Delivering on the promise of management information systems."** IMC Journal, September / October 1987. pp.

Oxford English Dictionary. 2nd. Ed., Clarendon Press, UK., 1989.

Pearse, J.A., and R.B. Robinson, **"Management."** McGraw Hill International Editions, Singapore, 1989.

Peppard, J., **"I.T. strategy for business."** Pitman Publishing, UK., 1993.

Phillips, M.E., and C.E. Brown, **"Need an expert? ask a computer."** Journal of Accountancy, Vol. 172, November 1991, pp. 91-93.

Prerau, D.S., **"Selection of an appropriate domain for an expert system."** AI Magazine, Vol. 6,2, 1985, pp. 26-30.

Riley, M., and S. Jauncey, **"Examining structure in decision making in hotels."** International Journal of Contempory Hospitality Management, Vol. 2,3, pp. 11-15.

Samuels, J.M., F.M. Wilkes and R.E. Brayshaw, **"Management of compny finance."** 5th. Ed., Chapman and Hall, UK., 1990.

Schendel, D., et. al., **"Corporate turnaround strategies: a study of corporate decline and recovery."** Journal of General Management, 1976.

Schmidgall, R.S., **"Hospitality management library - finance."** Educational Institure of the American Hotel and Motel Association, USA, 1990.

Scott-Morton, M.S., **"Management decision systems: computer based support for decision making."** Division of Research, Harvard University, USA, 1971.

Senn, J.A., **"The Myths of Strategic systems."** Information Systems Management, Summer, 1992, pp. 7-12.

Sharma, R.S. & D.W. Conrath, **“Evaluating expert systems: a review of applicable approaches.”** Artificial Intelligence Review, Part 7, 1993, pp. 77-91.

Simon, H.A., **"Administrative behaviour."** Free Press, New York, 1957.

Simon, H.A., **"The new science of management decision."** Harper and Brothers, New York, 1960.

Simon, H.A. , **"Model of man: Social and rational."** Wiley, New York, 1957.

Simpson Xavier, **"Irish hotel industry review."** 1993.

Slatter, S., **"Corporate recovery - a guide to turnaround management."** Penguin Books, UK., 1984.

Smith, R., and A. Winakor, **"Changes in financial structure of unsuccessful corporations."** University of Illinois, Bureau of Business Research, 1935.

Sprague, R.H., **"Framework for the development of decision support systems."** MIS Quarterly, Vol. 4, 4, June 1980, pp. 1-26.

Stockdale, A., and M. Wood, **"Building a small expert system for a routine task: a case study."** Management Decision, Vol. 30,3, 1992, pp. 46-49.

Stoner, J.A., and R.E, Freeman, **"Management."** 4th. Ed., Prentice Hall International Editions. NJ. USA., 1989.

Storey, J., **"New perspectives on human resource management."** Routledge, London, 1989.

Sunderland, E. **"Expert Systems and Strategic Marketing."** Thesis in Preparation, DIT Cathal Brugha St.

Tomkins, C., **"Corporate resource allocation, financial, strategic and organisational perspectives."** Basil Blackwell, 1991.

Torrington, D. and L. Hall, **"Personnel Management."** 2nd. Ed., Prentice Hall, New York, 1991.

Trenkle, T., **"Organisation der vorstandsentscheiding."** Lang, Frankfurt, 1983.

Turban, E., **"Decison support and expert systems."** Maxwell Macmillan International Editions, Singapore, 1990.

Turban, E., and P. Watkins, **"Integrating expert systems and decision support systems."** MIS Quarterly, Vol. 10, 1986, pp. 121-136.

Tversky, A., and D. Kahneman, **"Judgement under uncertainty: heuristics and biases."** Science 18, 1974, pp. 1124-1131.

Tversky, A., and D. Kahneman, **"Availability: A heuristic for judging frequency and probability."** Cognitive Psychology. Vol. 5, 1973, pp. 207-232.

Van Horne, J.C., **"Financial management and policy."** 9th. Ed., Prentice Hall International Editions, USA, 1992.

Waterman, Donald A., **"A guide to expert systems."** Addison Wesley Publishing Company, Inc., USA, 1986.

Weisbord, R.M., **"Organisational diagnosis: six places to look for trouble, with or without a theory."** Group and Organisation Studies, Vol 1,4, December, 1976, pp. 430-447.

Wheelhouse, D., "**Hospitality management library - human resources.**" Educational Institure of the American Hotel and Motel Association, USA, 1990.

Winston, P.H., "**Artificial Intelligence.**" Addison Wesley, USA,

Winston, P.H., and B.K. Horn, "**Lisp.**" 2nd. ed., Addison Wesley, USA, 1985.