DESIGN OF MIPFI: AN ADVISORY EXPERT SYSTEM FOR MEASUREMENT AND IMPROVEMENT OF PRODUCTIVITY OF FOODSERVICE INDUSTRIES

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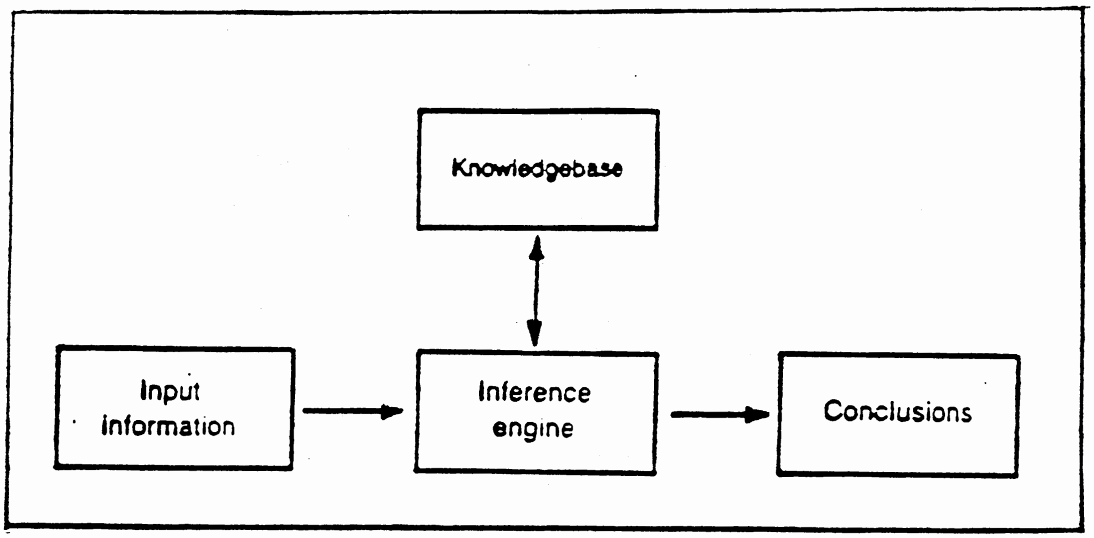
CHAPTER I

INTRODUCTION

The development of expert systems is concerned with the application of computers to the solution of problems that normally require the use of human expertise. Prof. E. Feigenbaum of Stanford University, a pioneer in the field of Artificial Intelligence (AI) defines an expert system as: an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution.

The knowledge in an expert system is derived from people who are considered to be experts in their field. The process of building an expert system is often called Knowledge Engineering (KE) and is considered to be applied AI. In an expert system, the rules (or heuristics) that are used for solving problems in a particular domain are stored in a knowledge-base. Knowledge-base of an expert system is the result of interaction between the expert system builder, called the knowledge engineer, and one or more knowledge sources (e.g., books, case studies, personal experiences etc.) The problems are stated to the system in terms of certain facts that are known about a particular situation.

The system then attempts to draw a conclusion from the facts using the knowledge-base. The general structure of an expert system is shown in Figure 1.



Source: Townsend, C., Feucht, D. Designing and Programming Personal expert systems. TAB books Inc., Blue Ridge Summit, PA (1986).

Figure 1. The Knowledge System

Heuristics are the rules of judgement that are used to make decisions from known facts. The majority of expert systems being used commercially are rule-based systems [42]. Examples include the MYCIN [36], DENDRAL [3], PROSPECTOR [13], etc. All of these use hundreds of rules and are designed to operate on mini computer or mainframe computer systems. The development time for each of these has been approximately 10 man-years [42].

Statement of Problem

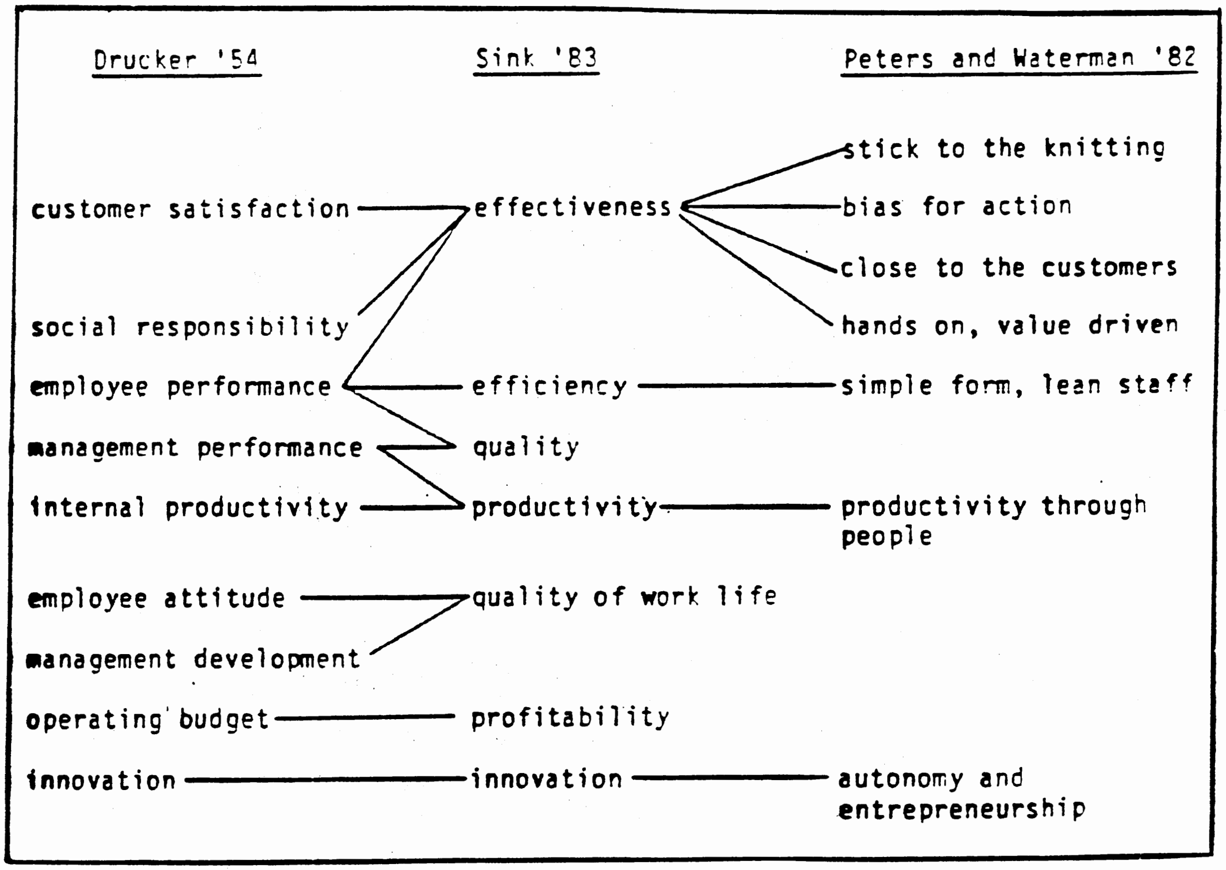
In this thesis an advisory expert system for Measurement and Improvement of Productivity of Foodservice Industries (MIPFI) is designed for foodservice industries. The expert system will be used both to evaluate the organizational productivity performance and also to advice on the improvement of productivity of foodservice industries. Management personnel i.e. director of dietary department, director of foodservice, or cafeteria manager whomever is in charge of productivity control of foodservice industries, will be able to measure performance or determine when productivity improvement needs to occur, by using this expert system.

Domain Background

In 1973, Leon Skan [40] found only 10 firms that had initiated companywide performance improvement efforts. In 1984, well over half of the nations 1000 largest companies had improvement efforts underway and the number was still growing. With current economic state of a rapidly growing service industry it has become very much necessary to monitor performance and to produce quality products and services [33]. In light of the increasing cost and increasing competition from expanding markets, improved performance and productivity becomes an absolute condition of survival for such industries. The pressure is mounting to develop better ways to manage and measure productivity [33]. Although performance evaluation systems and productivity measurement (evaluation) systems are available for manufacturing companies, similar systems do not exist for the foodservice industry even though productivity research has been conducted in this industry. An expert system is developed in this thesis which measures the productivity along with the other well established performance measures (Figure 2), and provides advice on the productivity improvement.

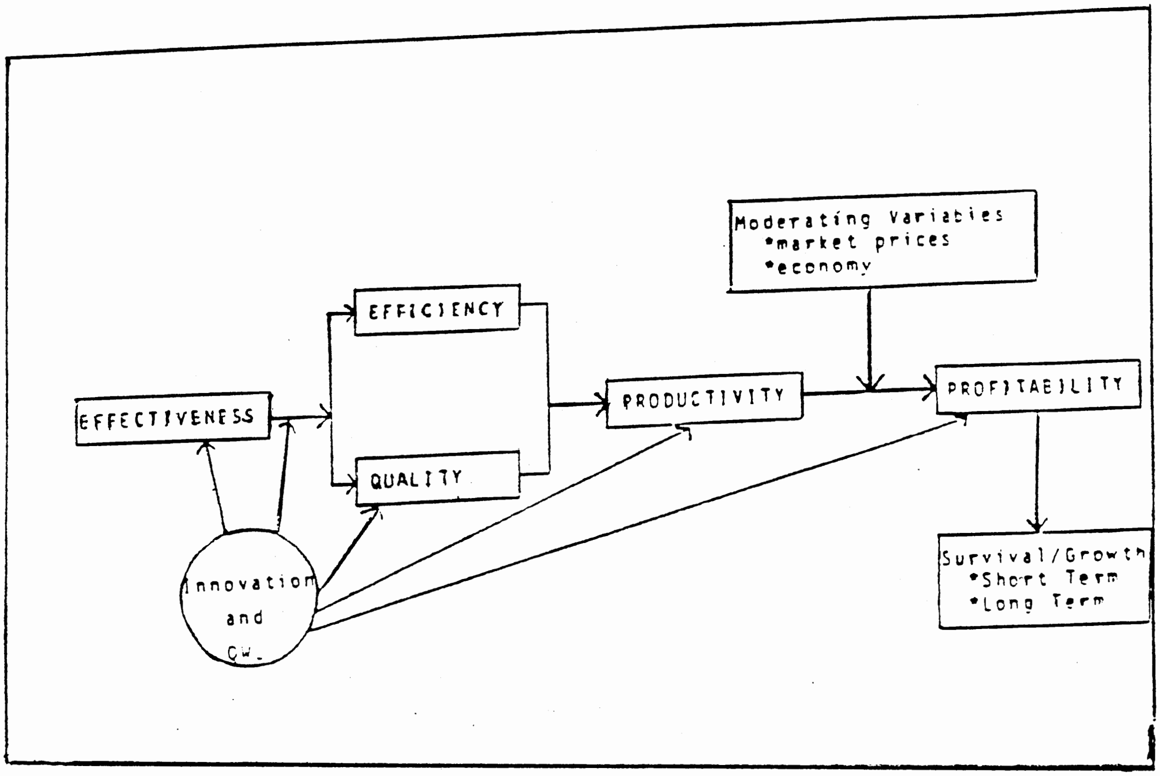
According to Sink [38], productivity is only one of seven measures of organizational performance, the other six include: effectiveness, efficiency, quality, quality of worklife, profitability, and innovation. Drucker [12] lists the organizational performances as: customer satisfaction, social responsibility, employee performance, management performance, internal productivity, employee attitude, management development, operating budget, and innovation. Peters and Waterman [30] classified organizational measures as: stick to knitting, have a bias for action, stay close to the customers, hands on-value driven approach, simple form and lean staff, productivity through people, and autonomy-entrepreneurship. The relationship between all the three conceptualizations is shown in Figure 2.

The performance measures used for this expert system are those mentioned by Sink [38], i.e., effectiveness, efficiency, quality, quality of worklife, productivity, profitability and innovation. All these seven measures are interrelated. Figure 3 illustrates the causal relationship between all these seven criteria.



Source: Sink, D. S. Productivity management: planning, measurement and evaluation, control and improvement. New York, John Wiley and Sons (1985).

Figure 2. Relationship Between Three Conceptualizations of Organizational Systems Performance Criteria.



Source: Sink, D. S. Performance and productivity measurement: the art of creative scoreboards. Productivity management, 5(1), 4-7 (1986).

Figure 3. Causal Relationship Between the Seven Basic Performance Criteria.

The expert system developed in this thesis collects information from the user (a foodservice management personnel who actually uses the expert system to get the advice). The expert system will provide the user with the existing productivity situation in his/her department and will also advice the user on productivity improvement, if needed.

An Overview of Expert Systems

Definition

Expert systems has been defined by a host of researchers in the area of AI. A few notable and relevant definitions are :

"An expert system is a computer program designed to replicate some aspect of the decision making of one or more experts, and to be used by atleast one non-expert [20]."

"Expert systems are computer based decision support aids that embody reasoning knowledge about a particular discipline [27]."

"Expert systems are computer programs that emulate the behavior of an expert in a specified domain of knowledge [44]."

"An expert system is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution [41]."

The knowledge of an expert system consists of facts and heuristics. The facts constitute a body of information that is widely shared, publicly available, and generally agreed upon by experts in a field. The heuristics are mostly private, little discussed rules of good judgement that characterize expert-level decision making in the field. The working of an expert system is primarily a function of the size and quality of the knowledge base that it possesses.

Some of the areas where expert systems are applied are presented below:

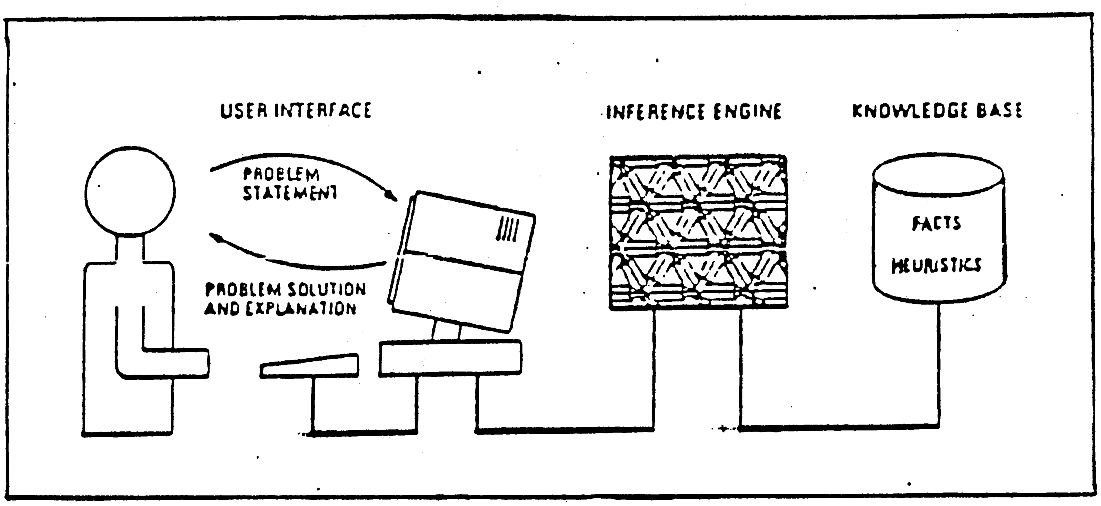
- diagnosis
- monitoring computer aided instruction
- data analysis and interpretation
- signal interpretation
- knowledge acquisition
- engineering
- defense

An expert system consists of four parts (Figure 4):

1. A knowledge base (or knowledge source) of domain facts and heuristics associated with the problem. Many expert systems are rule based; they consist of the formalized theoretical and empirical relationships and the rules of thumb, or heuristics, that the expert system uses to make a decision.
2. An inference engine (or control structure) for utilizing the knowledge base in the solution of the problem.
3. A working memory --"global data base"--for keeping track of the problem status, the input data for the particular problem, and the relevant history of what has been done. Sometimes this is infused with the inference engine.

4. User interface is an important component of any expert system where one must be able to describe the problem to the expert system, and the system must be able to respond with its recommendations. Also the user may wish to ask the system to explain its reasoning behind a certain response.

All the above mentioned expert system components are utilized in the development of MIPFI. The knowledge-base is developed through the process of knowledge acquisition from different knowledge sources.



Source: Harvey, J. J. Expert systems: present and Future. COMPUTERS and PEOPLE (1987, January).

Figure 4. Main Expert System Components

A human "domain expert" usually collaborates to help develop the knowledge base. AI researcher Michie [43] observes that [ideally] there are three different user modes for an expert system in contrast to the single mode (getting answers to problems) characteristic of the more familiar types of computing: (1) getting answers to problems --user as client; (2) improving or increasing the system's knowledge --user as tutor; (3) harvesting the knowledge base for human use --user as pupil. Users of an expert system in mode (2) are known as "domain specialists."

Knowledge Representation Methods

When the domain knowledge is stored as production rules, the knowledge base is often referred to as the "rulebase", and the inference engine as the "rule interpreter."

In an expert system there is a clear separation of general knowledge about the problem (the rules forming a knowledge-base) and methods for applying the general knowledge to the problem (the rule interpreter). In a conventional computer program, knowledge pertinent to the problem and methods for utilizing the knowledge are all intermixed, making it difficult to change the program. In an expert system the program itself is only an interpreter (or general reasoning mechanism) and [ideally] the system can be changed by simply adding or subtracting rules in the knowledge-base.

Other than production rules, other knowledge representation methods include: inclusion hierarchies, mathematical logics, frames, scripts, semantic networks, constraints, and relational databases [41]. Production rules method is appropriate when knowledge is action-oriented. For the expert system developed in this thesis the knowledge is gathered in rule form. Paul Siegel [37] mentions rule system as one of the simplest way to present knowledge. He also mentions that rule method is popular because it is:

1. Simple: It is easy to express, to understand, and to work with.
2. Modular: Each rule expresses a separate thought and it may be changed or modified without affecting other rules.
3. Of appropriate size: Relations in semantic networks seem to be too detailed. Frames seem to be too broad. Rules are or could be made the correct size.
4. Procedural as well as descriptive: Rules may be descriptive and also may refer to procedure as well.

Reasoning

Machine reasoning is the path the computer follows as it traces rules through a knowledge base [37]. It is also referred to as control strategies. When the inference engine or the machine starts with the facts, and then works forward to find a conclusion that is supported by facts, it is called forward reasoning (or forward chaining). When the inference engine or the machine works backward from conclusions, or goals, to facts, the process is called backward reasoning (or backward chaining).

Another form of reasoning is inductive reasoning, or the process of generalizing from examples. The expert system developed in this thesis utilizes all the above said reasoning methods.

Computer Hardware for Expert Systems

In the early days of artificial intelligence research, most programming was time-shared on big computers such as the DEC-KL-10, with memory-intensive compilers for the AI languages such as LISP. In the mid-1970s, researchers at MIT developed a design for a dedicated machine to process LISP directly. A similar symbolic processor was developed at the Xerox Palo Alto Research Center. Since an extensive programming environment is not required to run expert systems after they have been built, a new breed of computers called delivery machines began to enter the marketplace in 1984. These computers have a much lower cost than the LISP machines which remain to be used for program development.

The personal computer is also becoming a popular tool for AI programming. They are primarily used for small-scale problems and training. The expert system developed in this thesis works on an IBM PC. Knowledge systems almost invariably require large amounts of computer memory and fast processors. Most of the computer memory is used to store the knowledge-base and the heuristics that are used to reach the conclusions. The actual program is quite small. A personal computer with 640 K bytes of memory might be limited to a few hundred rules [42]. This limits personal knowledge systems to very small domains, developing prototypes for larger systems, and teaching knowledge system concepts.

Some possible applications for a knowledge system on a personal computer are:

- Calculating postage and the best way to mail packages based on the weight and destination.
- Analyzing alternative phone services for the service with the lowest cost for a particular application.
- Automotive repair diagnosis.
- Analyzing customer computer needs and configuring small computer systems.
- Local weather forecasting.
- Security systems.
- Solar heating systems.
- Analyzing trip reports for corporate deductions.
- Analyzing personal investment strategies.

The limitations of personal computer knowledge-based systems are imposed by the memory size and processor speed. The expert system developed in this thesis requires a minimum of 512K of memory on an IBM PC. Advantages and limitations of this expert system are mentioned in chapter VI.

Organization of Study

Chapter II contains the background and review of the literature for this thesis. Chapter III describes the Knowledge Acquisition method used to develop the knowledge base required for this expert system. The features of the expert system development tool used for this expert system are mentioned in chapter IV. The detailed description of different stages involved in the design of this expert system is given in chapter V. Future work that can be done to expand this expert system is explained in brief in chapter VI.

CHAPTER II

LITERATURE REVIEW

Expert systems have been built to solve many different types of problems in different application areas such as medicine [36], chemistry [25], manufacturing [16], electronics engineering [17], law [29], geology [13], military science [14], computer systems [28] etc. Expert systems work has been done by major groups such as universities, research organizations, and businesses. The research work in the field of expert systems grew from an interchange of ideas between Stanford University (SU) and Carnegie-Mellon University (CMU) [44]. Expert system work in chemistry started with DENDRAL [25] at Stanford University in the mid 1960's for determining the topological structure of organic compounds. XCON [28], built by Digital Equipment Corporation and Carnegie-Mellon University in the late 1970's, is one of the first and most successful expert system in computer systems. Expert system work in medicine began with MYCIN [36], one of the earliest and best known expert systems developed at Stanford University in mid 1970's. It helps a physician diagnose and treat infectious blood disease and also used for research and medical teaching.

Knowledge Acquisition Review

Knowledge Acquisition has been considered as the major bottleneck in the development of knowledge based systems [20]. Knowledge acquisition is a major limitation on the widespread use of expert systems since it is a skilled, time consuming, painstaking, and complicated task. In the next section, a review of knowledge acquisition methods, used by different researchers for developing expert systems in the past is provided.

Handcrafting and induction are two principal techniques used to acquire an expert's knowledge as described by Harvey [19]. Harvey [19] describes handcrafting as a technique in which the rules are defined directly on the basis of interviews between the knowledge engineer and the experts to identify the domain knowledge. Harvey [19] also defines induction as a technique in which computer based tools induce rules from examples supplied by domain experts. The examples could be amended and the induction repeated. This knowledge acquisition technique uses automated systems that learn either through interaction with an expert (e.g. TEIRESIAS [11]) or inducing rules from the examples (e.g. META-DENDRAL [3]). In this technique, an expert is only needed to provide the sample problems. The expert is not required to verbalize his knowledge but instead, the expert demonstrates it. The interview is best suited for initially setting up the knowledge base. Once some of the major concepts, facts and rules are known, experiments can be designed to interrelate pieces of knowledge or strategies used to solve the problem.

Software systems that generate prototypical knowledge-based systems have also been developed. The system interviews experts and creates knowledge bases for several expert system shells. The description of AQUINAS, an expanded version of the Expertise Transfer System (ETS), is given by Boose and Bradshaw [6]. ETS is an expert system developed by Boeing Computer Services. It interviews experts to uncover key aspects of their problem solving knowledge.

Cooke [10] describes two alternatives to knowledge engineer-domain expert interaction as ways of extracting the knowledge. One method is the use of controlled experimentation to investigate expert knowledge. Sorting or categorization of problems used in the physics experiments and reconstruction of situations such as in chess are some examples of this method. Another type of method that Cooke [10] describes is less controlled but also less direct than the interview technique. It consists of collection of protocols in which the experts are asked to think aloud while solving a problem.

Friedland [15] describes the methods of acquiring and representing procedural knowledge. Friedland [15] uses the MOLGEN [4] project at Stanford university. He also uses examples taken directly from the knowledge-bases of various domain experts, specifically, those of Professor Laurence Kedes, Professor Douglas Brutlag, and Dr. Rene' Bach all of Stanford university, and Professor John Sninsky of Albert Einstein college of Medicine. In the MOLGEN project emphasis was on the domain experts themselves to build the knowledge-bases. The project experienced a few drawbacks in allowing the experts themselves to describe their domain in a knowledge-base. This has been the experience of the MYCIN [36] project, and the PROSPECTOR [13] project. Thus, the computer scientist serves a useful function by providing a logical organization to the domain experts' rules.

Robert Hoffman [22] shares his ideas about research methods that he found worthwhile as he worked with expert interpreters on a project involving expert planners of airlift operations. Hoffman [22] has pointed out some very good ideas that should be useful to knowledge engineers and others who might be interested in developing an expert system. Hoffman [22] divides the methods for extracting expert knowledge into different categories. One obvious category involves observing the performance of the expert at the kinds of tasks with which the expert is familiar. A second category is the method of interviewing the expert. Another method involves studying the experts' performance on the cases that the expert does not encounter too often; those can be said as 'tough cases'.

David Prerau [31] describes over 30 points on knowledge acquisition that were found to be important during the development of Central Office Maintenance Printout Analysis and Suggestion System (COMPASS). COMPASS is a multiparadigm expert system developed by GTE laboratories for telephone switching-system maintenance [17]. COMPASS accepts maintenance printouts from telephone company central office switching equipment and suggests maintenance actions to be performed. Prerau [31] describes the knowledge acquisition considerations in selecting an expert and an appropriate domain for the expert system. Eligible experts were interviewed to select a potential expert for the COMPASS. The COMPASS development project proceeded through a selection stage, in which the application domain and system development tool were chosen, and a development stage, in which an experimental version of the system was produced, demonstrated and evaluated.

Cooke [10] talks about the modelling of human expertise in expert systems. Cooke's research work involves the study of cognitive science as applied to the expert systems. Transfer of expertise from the human expert to the artificial expert also involves the study of human behavior. The knowledge engineer may question the expert or do a protocol analysis in which the expert is observed as he solves a problem while verbalizing his thought processes. Cooke [10] describes the interview method and protocol method as the most common ways that knowledge is acquired from the domain expert. The knowledge that is extracted from the expert can be domain independent and/or domain specific. According to Cooke [10], domain specific knowledge is obviously necessary for any expert system, for it comprises the major and most noticeable difference between experts and nonexperts. Extracting domain independent knowledge leads to the discovery of commonly used heuristics, general strategies for organizing information, and efficient learning techniques. Also, as an adequate model of an expert system necessitates an adequate model of a human, it is desirable to investigate domain independent characteristics of expertise, as well as domain specific knowledge [10].

Barr and Feigenbaum [5] classify knowledge acquisition systems as those that use an interactive transfer of expertise (e.g. TEIRESIAS) or those that use automatic theory formation (e.g. Meta-DENDRAL). TEIRESIAS is an example of a learning program that adds knowledge to, and modifies its knowledge base by interacting with a human expert. This system was designed as an automated knowledge acquisition system to be attached to MYCIN.

Hayes-Roth and McDermott [27] describe a knowledge acquisition method in which an algorithm is used to infer rules from structural descriptions of pairs of examples. Howard Hill [21] describe a methodology for building expert systems in which he mentions the strategy of "divide and conquer" for knowledge acquisition. In this strategy, the problems are decomposed into separate subproblems, and the solution of the complete problem is obtained by combining the solutions to the subproblems.

Chandrasekaran and Bylander [8] discuss the interaction problem which has serious implications for the method of knowledge acquisition. The interaction problem as defined by them is this:

> Representing knowledge for the purpose of solving some problem is strongly affected by the nature of the problem and by the inference strategy to be applied to the knowledge (P. 232).

As described by Kornell [24] there are two different kinds of thought of interest to Knowledge Engineers in knowledge acquisition. One of them is formal thought which is exemplified by logic and mathematics, and the other one is narrative thought which is exemplified by analogies.

Allen, Boarnet, Culbert and Savely [1] mentions that obtaining knowledge and implementing it, in an expert system is the slowest and most difficult part of the development process. They mentioned about some current tools, including micro-computer based software such as Rule Master, INSIGHT, and NEXPERT, that allow users to create example decision tables, with the system then automatically constructing a decision tree based on the examples. They also mentioned that although automated knowledge acquisition aids are a desirable feature, for a general purpose tool they must be provided in a framework that does not restrict the tool's flexibility.

Hoffman R. R. [23] describes five methods in extracting the knowledge of experts.

1. Structured interviews, in which the expert comments upon a corpus of facts derived by the knowledge engineer from published documents;
2. Familiar tasks, in which the knowledge engineer observes and analyses the expert's activity during typical tasks (e.g., the forecasting of weather events in an operational environment);
3. Limited information tasks in which the expert is given only a subset of the information normally available (e.g., only satellite data);
4. Constrained-processing tasks, in which the expert is provided with all the needed data, but must perform the task under a constraint (e.g., severely limited time);
5. 'Tough-case' analysis, in which experts 'think aloud' as they analyze a particularly difficult case. (what is 'tough' is determined by the expert).

Chapter Summary

In this chapter different approaches to knowledge acquisition are discussed. From the experiences of different authors mentioned here, it can be summarized that the process of knowledge acquisition was one of the most important issue in the process of developing an expert system. It was also observed that the method of knowledge acquisition by interviewing the domain expert is widely used by many knowledge engineers. Harvey [19] uses automated system of knowledge acquisition. The expert system developed in this thesis does not use any kind of automated system for knowledge acquisition. Instead, the author interviewed the expert personally to collect the knowledge. The detailed description of the process of knowledge acquisition used by the author to develop MIPFI is given in Chapter V.

CHAPTER III

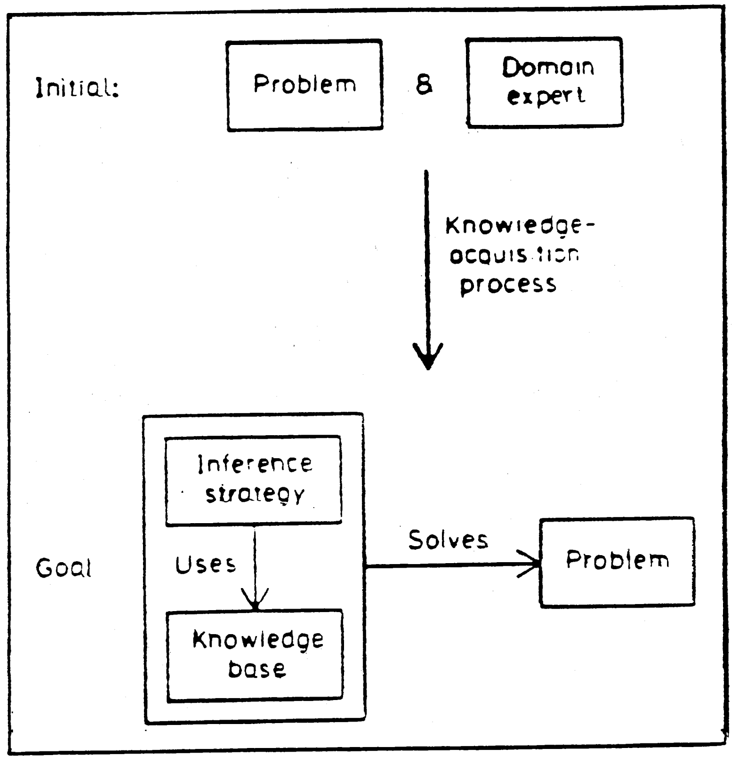
KNOWLEDGE ACQUISITION

Introduction

Knowledge Acquisition includes the general task of knowledge engineering, the organization/transfer of domain expertise from a knowledge source to a computer program (Figure 5). Knowledge-base of an expert system may originate from many sources, such as textbooks, reports, databases, case studies, empirical data and personal experience. The expertise to be elucidated is a collection of specialized facts, procedures and judgmental rules about the narrow domain area rather than general knowledge about the domain or commonsense knowledge about the world. The dominant source of knowledge for this expert system is the domain expert. The work done by the OSU College of Home Economics researchers since the last 6 years also provided a useful knowledge source.

Knowledge Acquisition Technique used for MIPFI

As described in the previous chapter, knowledge acquisition is recognized by experts as one of the issues with expert systems because it has turned out to be difficult and time consuming. The knowledge acquisition



Source: Townsend, C., Feucht, D. Designing and Programming Personal expert systems. TAB books Inc., Blue Ridge, PA (1986).

Figure 5. Knowledge Acquisition

technique used for this expert system consists of direct interaction between the knowledge engineer (author) and the domain expert. Author's first step was to become familiar with the problem and the domain. This included locating sources and expertise (books, journal articles, theses, and people) and learning from them as much as possible about the problem. The author selected Dr. Lea L. Ebro as the domain expert, who agreed to collaborate in the building of the system.

The basic cycle used for this design as an effective method of Knowledge Acquisition was:

1. Elicit knowledge from the expert,
2. Follow through with the expert on the solution of several example problems. Record the processes in detail.
3. Document and implement the knowledge.
4. Use the cyclic method of adding the knowledge, then modifying and adding again.
5. Use modular design, working towards creating limited but accurate modules.

The expert was asked to define the domain reasoning in terms of general information regarding the problem solution and IF-THEN rules. The knowledge-base developed for this expert system was in the form of IF-THEN rules. Expert was explained the ways the knowledge was going to be documented. It helped the expert interpret the knowledge base being built and provided a foundation for the expert to eventually participate in the development of the expert system.

The author met the expert on an average of once a week for approximately four months to ask questions relating to the domain problem. During these meetings with the expert, attempts were made by the author to understand concepts that are important and relevant to the problem. The expert was asked to explain and justify reasoning used to deal with specific type of subproblem. In addition to noting the terms that the expert used (Appendix C) in a well defined technical manner, other organizational mechanisms were also noted that the expert used. Some of the organizational mechanisms are listed in Figure 6 below. This identification of terms used in a technical way and the description of any additional organizational mechanisms constituted the structural expertise about the domain.

<u>Organizational Mechanisms:</u>

1. Inventory control methods - LIFO, FIFO, Averaging.
2. Training in productivity measures.
3. Control of employee absenteeism, and tardiness.
4. Maintenance of different types of records such as purchase records, inventory records, labor records, and production records.

Figure 6. Examples of Organizational Mechanisms

Other points that were noted about the kind of knowledge collected from the expert were the basic strategies the expert used when performing the task. Some of these were:

- what facts does the expert try to establish first? (e.g. for the measurement of Effectiveness the first information to be collected was whether the organization sets specific goals for their foodservice operation.)
- Does the expert make initial guesses about anything based on tentative information? and how does the expert then determine which questions to use to refine the guess? (e.g. If the organization is evaluating the goals then where does the evaluation report go? (to the President, Vice President, Director, Asst. Director, Manager, Asst. Manager, or to the files. Are there any actions taken on the reports? Are the reports compared? Is the organization able to meet the goals? etc.)

Figure 7 shows a sample of questions asked by the expert to collect the information from the user. Further details are provided in the sample consultation in APPENDIX A.

Do you set specific goals for your foodservice operation?

(YES/NO)

[If NO, then expert's advice to set goals for the future that may help in assessing the effectiveness of the foodservice operation.]

Figure 7. Example Questions to Assess Effectiveness

Are the goals evaluated monthly, quarterly, or annually, OR are the evaluation reports received monthly, quarterly, or annually?

(YES/NO)

[If NO, then expert's advice to maintain the goal evaluation reports, which may further help for future reference.]
Where does the evaluation report go? (does it go to one of the key management personnel or just go to the Files?)

(YES/NO)

[If NO, then expert's advice to send the reports to the key management personnel, and to make sure that the actions are taken basis the evaluation.]
Are there any actions taken?

(YES/NO)

[If NO, then expert's advice to take periodic actions, involve upper level management personnel, and try to meet the goals.]

Figure 7. (Continued)

Chapter Summary

In conclusion, the whole process of knowledge acquisition consisted of basic steps, as mentioned earlier, and each step had other internal steps which are discussed in detail in Chapter V. The process was lengthy as there were seven different criteria for measuring the organizational systems performance of a foodservice industry. Each criterion was in itself an individual module for the entire knowledge acquisition process.

CHAPTER IV

EXPERT SYSTEM DEVELOPMENT TOOL

Introduction

The tool used to develop this expert system is 1st-CLASS version 3.5. 1st-CLASS is an expert system development tool for the IBM PC/XT/AT and all compatible computers [18].

1st-CLASS combines both, example-based and rule-based method to develop a knowledge-base. 1st-CLASS creates compact, fast-running knowledge-base from 'examples' that show how an expert makes a decision. 1st-CLASS then converts all the examples supplied by the knowledge engineer into a concise rule that forms the basis for a knowledge-base. The procedure followed by the author to develop a knowledge-base using 1st-CLASS is explained in details in chapter V.

Schindler [34] describes 1st-CLASS as a good example of an induction system. Some salient features of 1st-CLASS are described below.

Features of 1st-CLASS as Expert System Development Tool

1st-CLASS is generally recognized to be the easiest to use expert system tool available today [18]. Some of the features are:

1. A spreadsheet (tabular) format for entering data makes organizing the data easy.
2. A logical set of screens for building the expert system: name the knowledge-base; define the terms; give some examples; choose a solution method; inspect the resulting rule; and use the advisor.
3. The data can be transferred into 1st-CLASS from spreadsheets or other programs. The advisor text can come from a word processor. The text versions of the knowledge-bases can be send to the printers or files for documentation or reports.
4. On-line help guides the user, if the user forgets the command.
5. 1st-CLASS is fast! Both in development and later in running the advisors.

To build a large expert system using 1st-CLASS, the problem can be structured using these methods.

1. FORWARD CHAINING - build a knowledge-base that figures out the area in which to search for a solution; then chain forward to one of several knowledge-bases which work on these areas.
2. BACKWARD CHAINING - build a knowledge-base first which asks very high level questions to the user. Then extend the expert system by chaining backward so that these general questions are answered by a detailed knowledge-

base working on one topic.

3. EXTERNAL PROGRAM INTERFACE - user can write an external program (e.g. to read the data base, or hardware instrumentation) in any language and use this program to answer one or more questions.
4. EMBEDDED LOGIC ENGINE - a master program can be written that calls on 1st-CLASS to solve the problem, or several expert systems can be tied together, communicate through a file interface or even a batch file.

1st-CLASS is a small program, so it can be used along with other programs without running out of memory.

TABLE I

1st-CLASS SPECIFICATIONS

Program type:	Expert system generator.
Methods used:	Inductive classification, Database search, and/or Direct rule construction and editing.
Hardware required:	IBM PC or compatible; 256K memory min., 512K recommended; one floppy disk drive.
Operating system:	MS-DOS or PC-DOS 2.0 or higher.
Size of the module:	Up to 32 factors, 32 results, and 255 examples.
Chained modules:	No limit except on-line disk capacity.
Expert advisor:	Auto-generated or user-created advisor screens.

TABLE I (Continued)

Advisor editor:	Full screen editor, supports color/attributes.
Rule generation:	Four algorithms can be used: - optimized decision tree construction; - ordered, allows to choose the processing order; - matching, for pattern matching applications; - direct building/editing of rules.
Weights:	Can be assigned to each example; several statistical indexes can be calculated from them and displayed.
Report generation:	Can build a report on disk automatically, either a full session report or a customized report.
Shell capability:	Full DOS shell included.
File access:	can process data from disk files.
External programs:	Can be written in any language, and can pass data to and from 1st-CLASS.
Logic engine:	1st-CLASS can be called from other programs and can return an answer to them.

Source: Hapgood, W. 1st-CLASS Instruction Manual. Programs in motion Inc. (1987).

In conclusion, 1st-CLASS is an expert system development program intended for the businessperson, engineer, or analyst who wants to either analyze data to find the cause and effect relationship behind it, or who wants to build an expert system to allow non-expert personnel to use an expert's knowledge. 1st-CLASS can chain together an unlimited number of solved knowledge-bases to allow the user to build a very large system [18]. It is possible to use any other program to carry out special tasks, such as create a custom display or operate hardware.

1st-CLASS has a limitation on number of factors that can be entered for each knowledge-base. Further more, the absence of Hyper-text facility in 1st-CLASS restricted the author in developing and displaying certain user friendly screens.

CHAPTER V

DESIGN AND DEVELOPMENT OF MIPFI

Introduction to Design Steps

One of the major problems in the design of any expert system is that of converting the knowledge and problem-solving techniques of the expert to a knowledge-base that can be used effectively to solve problems in the domain of expertise [42]. This is especially true in the development of MIPFI. Generally most of the effort required to build an expert system is in gathering and organizing this knowledge. A considerable amount of time is consumed in the iterative process of knowledge engineering. As mentioned earlier, Knowledge engineering is the codification of a specific domain of knowledge into a computer program that can solve problems in that domain.

The problem to be solved is decomposed into separate subproblems, and the solution to the complete problem is obtained by combining the solutions of the subproblems. Diagnosis, advisory, and troubleshooting problems usually can be decomposed using this technique. The advisory expert system developed in this thesis uses the afore mentioned technique. Figure 8 shows a sample of problem and subproblems used to assess the Efficiency.

Goals:	To measure the Efficiency
Subgoals:	1. To collect information on labor records,
	2. To collect information on materials records,
	3. To collect information on capital records,
	4. To collect information on energy utilization records.

Figure 8. Sample Goal (problem) and Subgoals (subproblems)

The atomic subproblems represent the lowest level of problems that an expert system is designed to solve. The development process of this expert system consisted of number of stages, which is described in detail later in this chapter. This process is usually termed as Knowledge Engineering.

Knowledge Engineering

The Knowledge engineering task for this expert system involved the cooperation of the domain expert (Dr. Lea L. Ebro) working with the program designer or knowledge engineer (author) to codify and make explicit the rules that the expert uses to solve real problems. The information gathered from the expert was represented by the author in the form of IF-THEN rules. The expertise of the system increased when the rules were refined on discussions with the expert. Knowledge engineering usually has a synergistic effect. The knowledge possessed by the human experts is often unstructured and not explicitly expressed to be useful in a computer program.

Major goals in knowledge engineering included the construction of knowledge-bases that are modular in nature, so that additions and changes can be made to one module without affecting the workings of other modules. The main modules consisted of knowledge-bases for Effectiveness (EFT.KBM), Efficiency (BEFY.KBM), Quality (QLTY.KBM), Quality of Worklife (QWL.KBM), Profitability (PFT.KBM), Innovation (INOV.KBM), and Productivity (FOOD.KBM) measurement of foodservice industry. Other additional knowledge-bases were also developed, the listing of which is given in Table II on the following page.

Getting started on a new knowledge engineering project is a difficult and challenging task. One of the reasons is that methodologies for developing expert systems by extracting, representing, and manipulating an expert's knowledge are not fully developed. A step-by-step explanation of the development process used to prototyping this expert system without inducing conceptual bottlenecks into this process is mentioned in the next section.

TABLE II

LIST OF KNOWLEDGE-BASES DEVELOPED FOR MIPFI

FILE	TYPE
FOOD	KBM
INOV	KBM
MLHP	KBM
MLHPE	KBM
MLHPE1	KBM
MLHPG	KBM
MLHPG1	KBM
MLHPL	KBM
MLHW	KBM
MLHWE	KBM
MLHWE1	KBM
MLHWG	KBM
MLHWG1	KBM
MLHWL	KBM
MLHWL_NT	KBM
MLHWL_OT	KBM
MTFC	KBM
MTFCE	KBM
MTFCE1	KBM
MTFCG	KBM
MTFCG1	KBM
MTFCL	KBM
MTFCL2B	KBM
NO_OT	KBM
OVERTIME	KBM
QLTY	KBM
QWL	KBM
BEFY	KBM
BEFY1	KBM
BEFY2	KBM
BEFYC	KBM
BEFYE	KBM
BEFYM	KBM
EFT	KBM
EFT2	KBM
FIRST	KBM
PFT	KBM
START	KBM

Stages of Development

The development proceeded through a selection stage. The application domain and system development tool was chosen during the selection stage, and an experimental version of the system was produced.

Selection of Problem Domain

The problem domain selected for this expert system is the Department of Food Nutrition and Institution Administration (FNIA), College of Home Economics (CHE), Oklahoma State University (OSU), Oklahoma.

Selection of the Domain Expert

After deciding the domain for this expert system, it was necessary to find out who the experts are and what problems they solve. Selecting an expert is a crucial decision for the success of an expert system, and also is an important element in knowledge acquisition process. The expert selected for the problem domain is Dr. Lea L. Ebro, Professor and Interim Head department of FNIA, OSU, Oklahoma. The domain or area expert selected is an articulate, knowledgeable person with a reputation for producing good solutions to problems in the field of foodservice industries. The selection was based on convenience rather than on an objective methodology.

The next development stages constitute the actual process of knowledge acquisition, where the domain expert and the knowledge engineer (author) worked in close interaction. All the five steps mentioned in Chapter III as a basic cycle for knowledge acquisition were incorporated in the following stages. For each knowledge-base developed (TABLE II), the author used all the basic cycle steps repeatedly in order to complete the knowledge-base.

Define the Problem(goals)

After the problem domain and expert were selected from the department of FNIA, the next step was to define the problem (goals) for the system. The author familiarized himself with the background knowledge on the problem domain. The author first collected the information from reference books and previous research work done in the field of foodservice industries. The research work was done by the graduate students of the College of Home Economics, OSU, for last 6 years [26,32,33,35]. Then the author had to arrange for a series of meetings with the expert to define the goals. The following goals were then defined for this expert system:

1. Does the foodservice organization measure effectiveness of the organization (do they set specific goals for the foodservice operation and see if the goals are accomplished)?
2. Does the organization follow food quality standards?
3. Does the organization measure Quality of worklife of

their employees in the organization?

4. Does the organization measure efficiency?
5. Does the organization measure profitability?
6. What does the organization do to innovate their employees?
7. Does the organization use productivity ratios to measure the productivity of the organization?
8. What actions are taken in case of increase or decrease in productivity?

Define the Subgoals

Once the system goals were defined, the next step was to describe subgoals. The basic strategy here was to break the problem into two or more smaller problems, and then try to solve the smaller problems.

This step required a series of interviews with the domain expert. At the end of this step, the problem was decomposed into atomic subproblems.

Identify the Causes for Subproblems

The next step was to identify the causes for each subproblem. The causes were collected during a series of interviews with the expert and from other sources of knowledge, as explained earlier.

Collecting Knowledge in the form of Advice

The data for the advice was collected from the expert and from the knowledge already collected from the previous meetings with the expert. A sample of questions used to collect data from the user for Efficiency module is shown in Figure 9.

Define the Knowledge into 1st-CLASS Shell Parameters

All the knowledge which was collected from the expert and research material was to be entered in 1st-CLASS. So, the next step was to convert the knowledge in the form of 1st-CLASS shell parameters which are called as \`factors', \`values', and \`results' (Figure 10). The factors determine the questions that the system asks the user (the person who actually uses the expert system to get advice). Each factor has several values, which are the choices the user selects from. Results are the possible recommendations that the system can make.

Highlights of MIPFI

Total number of knowledge-bases = 38

Total number of rules = 196

The four methods used to build rules for this expert system are:

1. Optimize: This method is used to eliminate factors (questions) that don't affect the result and puts remaining factors into the sequence that asked the fewest questions. This method saves the user time by

$$\text{Efficiency} = \frac{\text{resources expected to be consumed}}{\text{resources actually consumed}}$$

1. Labor record: Do you keep records of labor utilized for a specific period of time?
   (YES/NO)
   If YES : Use the information to measure the efficiency
   If NO : Collect the information:
   a. labor hours paid, and
   b. labor hours worked
   Use this information to measure the efficiency.

2. Materials record: Do you keep records of materials (food and supplies used to prepare food) utilized for a specific period of time?
   (YES/NO)
   If YES : Use the information to measure the efficiency
   If NO : Expert's advice to maintain materials record to measure the efficiency in the future.

3. Capital record: Do you keep records of capital designated for your foodservice organization?
   (YES/NO)
   If YES : Use the information to measure the efficiency
   If NO : Expert's advice to maintain the information about capital designated, and use that information to measure the efficiency.

4. Energy record: Do you keep records of energy consumed by your organization for a specific period of time?
   (YES/NO)
   If YES : Use the information to measure the efficiency
   If NO : Expert's advice to collect the information about the amount of energy consumed by the organization, and use that information to measure the efficiency.

5. Do you compare all the above mentioned resources used with resource utilization targets?
   If NO : Expert's advice to compare them and use effective methods to control the expenditure.
   If YES : Use the information to measure the efficiency and expert's suggested methods to control the expenditure.

Figure 9. Sample Questions to Assess Efficiency

```
new_Factor,  new_Value,  edit_Text,  Change,  Activate,  Move,  Delete
      Files   Definitions   Examples   Methods   Rule   Advisor
[F1=Help]        6  Factors in EFT2                  [F9=Files] [F10=Examples]

   often       goto        actions       compare       meet_goals   RESULT
   yes         yes         yes           yes           yes          no_goto
   no          no          no            no            no           no_actions
                                                                    no_compare
                                                                    no_goals
                                                                    no_often
                                                                    all_yes

                                        Complete the definitions, then
                                        press F10 to give some examples.

                                        For more help, press F1.
```

Figure 10. Sample Screen to Show the Factors, Values and Results

running faster and asking fewer questions.

2. Left-right: This method is used when all the questions listed in a particular knowledge-base have to be asked in the sequence prescribed by the author.
3. Customize: This method is used when the author wanted to build rules that were not satisfactorily be build by any of the other methods; or when the knowledge-base was to be constructed for certain customized data (rather than a set of examples.)
4. Match: This method is used by the author in the knowledge-base START.KBM. Because this knowledge-base has a large number of factors and values, it was too complicated to properly construct an exhaustive set of examples. The use of match method eliminated this problem.

External Programs: The author developed external programs in Advanced BASIC language to generate customized and user friendly screens, and to ask questions to the user. These programs are also used to get the user's response back from the external programs to 1st-CLASS.

Help Facilities: Reference or help windows are provided for the user of this expert system to understand a consultation session. The function keys (F1, F2,...,F8) are programmed to display windows that are different at each point in the advisor. Text files "PTXT", "FOODTXT", "HELPW" are used for help information which are called every time active function keys are pressed. It builds a window on the screen and displays a message or answer for the user's question. Online HELP menu is also available for the user. Facilities are also provided to display the rule screen to the user.

Automatic Report Generation: The consultation session of the user is automatically collected in a file called "START.RPT". The user can look at the file by typing the command "type START.RPT" at the DOS prompt after running the advisor.

Chapter Summary

The entire process of development of MIPFI was a total interaction between the knowledge expert and the author. The author realized that the selection of expert was a major and important decision which made the development process possible. The author also realized that the use of commercially available automated systems for knowledge acquisition may be helpful in reducing the development time and development steps of this expert system.

CHAPTER VI

SUMMARY AND FUTURE WORK

Summary

In this thesis, an advisory expert system is developed for industrial application. This expert system has capability to measure the productivity of foodservice industries. The knowledge acquisition for this expert system is through a series of interview sessions with the domain expert. Dr. Lea L. Ebro served as the domain expert to contribute her expertise in developing this expert system. 1st-CLASS is used as the expert system development tool. The knowledge-base is collected in the form of IF-THEN rules. Foodservices at hospitals, schools, colleges and restaurants are the major areas where this kind of expert system will be used.

As a knowledge engineer for this expert system, the author experienced that the process of knowledge acquisition was the most difficult and time consuming in developing this expert system. Approximately 75% of the total time used in developing this expert system was consumed in collecting and documenting the knowledge. Over and above the domain expert, the author used journal articles, text books, research papers on productivity and knowledge acquisition, and research theses completed by FNIA students at OSU from the year 1982 to 1986, to develop the background in productivity measurement in foodservice industry, and to ask questions from the domain expert for knowledge acquisition.

The object was to build an expert system using the general knowledge of the researchers as well as what they have learned about the subject being investigated. By developing this system it was possible to put together, analyze and refine the information collected, from different foodservice industries like schools, colleges, hospitals etc., by the graduate students of OSU. Also, since the domain expert herself was the guide for research work done in the field of Productivity measurement of foodservice industries by students of College of Home Economics at OSU, it was possible to put together her experiences in this field in the form of this expert system.

Over and above the measurement of Productivity, the author has also developed other knowledge-bases to help the user understand the factors involved in measuring other criterion to assess the overall organizational system performance. These criteria are effectiveness, efficiency, quality of food, quality of worklife, profitability, and innovation.

Future Work

This system can gradually be improved and extended over time. The number of rules for each and every knowledge-base developed for this expert system can be redefined and expanded. Proper selection of domain experts in the field of foodservice industry may be useful in expanding the rulebase. As the knowledge-base of the system expands, additional ways to solve a particular problem will expand as well. Modification of the program used to develop this system for use on Personal Computers with large memories can result in higher working speed of the expert system. Forming a group of knowledge engineers with atleast one person in the group who is more knowledgeable in the field of foodservice industries should definitely result in a more knowledge-rich expert system.

The system developed here is generalized for applications for foodservices in hospitals, schools, colleges, etc. It can be made more specific or specialized for a particular application area, e.g. hospitals or restaurants. In that case, the knowledge-base can have specific set of questions concentrating on the problem involved in hospitals or restaurants. Methods used for collecting information will correspondingly be more specific.

The steps to modify the knowledge-base of MIPFI can be explained as follows:

1. Load file "1stclass.exe" from the disk-1.
2. When the knowledge-base directory is displayed, press G to get the file whose knowledge-base is to be modified. If a new file is to be added, then press N to open a new

file.

3. Add the Factors, Values, and Results to that particular file. Provide examples on the Examples screen. Generate rules using thr Rule building screen.
4. Save this modified (or new) knowledge-base.
5. Run the program.

It is recommended by the author, who developed this program, to read the 1st-CLASS manual before an attempt is made to expand the knowledge-base of MIPFI. For information regarding the availability of the software, please contact at the following address:

Department of Computing and Information Sciences
Oklahoma State University
Stillwater, OK 74078

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APPENDIXES

APPENDIX A

SAMPLE CONSULTATION OF MIPFI

[F1=Help] 1st-CLASS Advisor for start [F9=Rule] [Esc=Stop]

Welcome to M I P F I

An advisory Expert System for

Measurement and Improvement of PRODUCTIVITY of

Foodservice Industries

Press ↵ to begin

****

Organizational Systems Performance:

Organizations have control systems for behaviors, costs, prices, information, decisions, financial performance, production, inventory, quality, etc. Organizations also have control systems that can be classified with respect to the type of 'Organizational System' performance they are attempting to control or manage. ('Organizational System' can be interpreted as a system comprising a variety of resources.)

In general there are at least seven distinct, although not necessarily mutually exclusive, measures of 'Organizational System' performance.

Reference: Sink D. S. Productivity management: planning, measurement and evaluation, control and improvement. New York, John Wiley and Sons (1985).

Performance measures are :

(1) Effectiveness
(2) Efficiency
(3) Quality
(4) Quality of work life
(5) Profitability
(6) Innovation
(7) Productivity

PRESS ANY KEY TO CONTINUE

****
Seven Criteria for Measuring Organizational Performance
of a Foodservice Industry

The following figure displays the criteria suggested by Drucker, P. F, (1954), Sink, D. S. (1986), Peters, T. J., and Waterman, R. H.,Jr., (1982).
****

PRESS ANY KEY TO CONTINUE

DRUCKER 1954	SINK 1986	PETERS and WATERMAN 1982
customer satisfaction social responsibility employee performance	-> effectiveness	<-stick to the knitting bias for action close to the customers hands on, value driven
employee performance	-> efficiency	<-simple form, lean staff
employee performance management performance	-> quality	
management performance internal productivity	-> productivity	<-productivity through people
employee attitude management development	-> quality of worklife	
operating budget	-> profitability	
innovation	-> innovation	<-autonomy and entrepreneurship

PRESS ANY KEY TO CONTINUE

****
The following figure displays the causal relationship
between the seven performance criteria suggested by
Sink. It indicates the mutual inter-relationship
and dependency of each criteria.
****

PRESS ANY KEY TO CONTINUE

```
                                                Moderating Variables
                                                  * market prices
                                                  * economy
                  |--> Efficiency --|                   |
                  |                 |                   |
                  |                 |                   v
Effectiveness  -->|                 |-->Productivity  ----->Profitability
   ^              |                 |         ^                ^   |
   |              |                 |         |                |   |
   |              |--> Quality -----|         |                |   |
   |                      ^                   |                |   |
   |                      |                   | ----------------   |
   |                      |                   | |                  v
     Innovation  and  Quality  of  Worklife               Survival/Growth
                                                             * short term
                                                             * long term
```

Figure:Causal relationship between the seven basic performance criteria
Reference:Sink. D. S. PRODUCTIVITY MANAGEMENT (1986).

PRESS ANY KEY TO CONTINUE

E F F E C T I V E N E S S

[F1=Help]   1st-CLASS Advisor for A:EFT   [F9=Rule] [Esc=Stop]

E F F E C T I V E N E S S

Effectiveness is defined as the degree of achievement of objectives.

Effectiveness is measured by comparing what was intended to accomplish against what is actually accomplished. Effectiveness is therefore an output or accomplishment issue. It is a measure of an organizational system's performance which focusses on the output side of the system. Effectiveness indexes can be developed that reveal the level of accomplishment in one period compared to that in another.

Example: Goal: To cut labor hours by 20% in the next year.

Achievement: Labor records show that goal has been reached.

Press ↵ to begin

E F F E C T I V E N E S S

[F1=Help]   1st-CLASS Advisor for A:EFT   [F9=Rule] [Esc=Stop]

Do you set specific goals for your foodservice operation ?

(To know WHY Press <F2>)

yes
no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Are the goals evaluated monthly, quarterly or annually?

(To know WHY Press <F2>)

yes no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Where does the evaluation report go ? (Does it go to one or more of the following?)

- President
- Vice President
- Director
- Assistant Director
- Manager
- Assistant Manager
- Files

(To know WHY Press <F2>)

yes no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Are there any actions taken ?

(Actions are suggested by the key management personnel basis the evaluation reports. It can either be in the form of new actions, or revised actions.)

yes no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Do you compare the reports month to month, quarter to quarter, or year to year ?

(To know WHY Press <F2>)

yes no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Are you able to meet the goals ?

(Comparison of the evaluation reports periodically, can help in knowing the level of accomplishment of goals.)

yes
no

[F1=Help] 1st-CLASS Advisor for EFT2 [F9=Rule] [Esc=Stop]

Press F5 to see the rule (How the conclusion is reached?)

If you are able to meet the goals then share the information with the upper level management, and it is advisable to revise the goals periodically for the future periods.

↵ to continue

E F F I C I E N C Y

[F1=Help] 1st-CLASS Advisor for BEFY [F9=Rule] [Esc=Stop]

Definition: Efficiency is defined as the ratio

resources expected to be consumed
----
resources actually consumed

Efficiency is the comparison between resources expected to consume in accomplishing specific goals, objectives and activities and resources actually consumed. Budgets, standards, estimates, forecasts, projections, rules of thumb, intuition, etc. are utilized to develop quantitative expressions for resources expected to be consumed. Accounting systems, records, estimates etc. are utilized to develop quantitative expressions for resources actually consumed.

Example:

$ budgeted for food (1987)

$ actually spent on food (1987)

PgDn to continue

E F F I C I E N C Y

[F1=Help] 1st-CLASS Advisor for BEFY [F9=Rule] [Esc=Stop]
PgUp

The efficiency measurement of a foodservice industry includes the measurement of resources that are "expected to be consumed", and measurement of resources that are "actually consumed."

The resources to be considered are:

1. Labor
2. Materials (include food & supplies)
3. Capital and
4. Energy

Press ↵ to begin

E F F I C I E N C Y

[F1=Help] 1st-CLASS Advisor for BEFY [F9=Rule] [Esc=Stop]

Do you keep record of the amount of labor used for a specific period of time e.g. weekly, monthly, quarterly, annually etc.?

(The record may include the number of LABOR HOURS PAID, number of LABOR HOURS WORKED and may be some other labor related information.

LABOR HOURS WORKED does not take into account the sick leaves, vacation leaves, etc. which are not 'productive' for the organization.)

yes
no

E F F I C I E N C Y

[F1=Help] 1st-CLASS Advisor for BEFY [F9=Rule] [Esc=Stop]

The following information is considered necessary for the labor records:

1. Labor hours paid : useful for measuring Profitability.

2. Labor hours worked : useful for measuring Productivity.

If you are collecting only one of the above information or if you are not collecting the information at all then it is recommended that both of them be recorded for measuring the efficiency, profitability and productivity of your foodservice organization.

It is also advisable to collect and keep the above information separately to track them periodically.

┘ to continue

```
[F1=Help]           1st-CLASS Advisor for BEFYM            [F9=Rule] [Esc=Stop]

   Materials record
   ----------------

   Materials record includes the cost of raw materials and also the

   supplies (consumables and non-consumables) used for food preparation.

 Press ┘ to begin
```

```
[F1=Help]           1st-CLASS Advisor for BEFYM            [F9=Rule] [Esc=Stop]

   Do you keep records of the amount of materials (include food and
   supplies) used for a specific period of time e.g. weekly, monthly,
   quarterly, or annually etc.?

 (To know WHY  Press <F2>)

 yes
 no
```

[F1=Help] 1st-CLASS Advisor for BEFYM [F9=Rule] [Esc=Stop]

Inventory records and purchase records may be very helpful in getting the information regarding the materials used in food preparation. If the information is not available, it is advisable to meet the key management personnel who keeps track of such information.

It is also advisable to see if there is any way to minimize the material cost to improve the efficiency of the foodservice organization.

┘ to continue

[F1=Help] 1st-CLASS Advisor for BEFYE [F9=Rule] [Esc=Stop]

Energy Record:

The sources of energy may be electricity, gas, steam, etc. The units of all such energy used for a particular department is stored as energy consumption records. The amount of energy actually consumed and the amount of energy expected to be consumed together give the efficiency measure for the foodservice organization.

Press ↵ to begin

[F1=Help] 1st-CLASS Advisor for BEFYE [F9=Rule] [Esc=Stop]

Do you keep records of the amount of energy consumed by your organization for a specific period of time (e.g. weekly, monthly, quarterly, annually etc.)?

yes
no

[F1=Help] 1st-CLASS Advisor for BEFYE [F9=Rule] [Esc=Stop]

Following points be noted:

Who tracks the energy consumption in your organization?

Is there any way you can find out your department's share of the total energy consumption in your organization?

Is there any way you can minimize the energy consumption for your department?

(Sources of energy may be: gas. electricity, steam etc. used for the food production units (e.g. microwave ovens, conventional ovens etc.) used for your department.)

↵ to continue

[F1=Help] 1st-CLASS Advisor for BEFYC [F9=Rule] [Esc=Stop]

Do you keep records of the amount of capital designated (current capital and projected capital) for your foodservice organization ?

(To know WHY Press <F2>)

yes
no

[F1=Help] 1st-CLASS Advisor for BEFYC [F9=Rule] [Esc=Stop]

If the information about the capital is not available then it is advisable to obtain the information from the upper management or the key management personnel. The information is helpful to measure the efficiency and other performance criteria of your foodservice organization.

↵ to continue

```
[F1=Help]           1st-CLASS Advisor for BEFY1           [F9=Rule] [Esc=Stop]

Do you compare resources used with resource utilization targets ?


(To know WHY Press <F2>)

+----------------------------------------------------------------------------+
|yes                                                                         |
|no                                                                          |
+----------------------------------------------------------------------------+
```

```
[F1=Help]           1st-CLASS Advisor for BEFY2           [F9=Rule] [Esc=Stop]

  After you compare the resources used with the resource utilization target

  do your expenditure exceed budget ?

   (e.g. food budget for 1988 fall was $20,000.00 and the expenditure on
    food is $24,000.00)
+----------------------------------------------------------------------------+
|yes                                                                         |
|no                                                                          |
+----------------------------------------------------------------------------+
```

[F1=Help] 1st-CLASS Advisor for BEFY2 [F9=Rule] [Esc=Stop]

If your expenditure exceeds the budget. you might be using some measure to eliminate/minimize that problem. Do the measure you are currently implementing working for you?

(e.g. price increases, budget increase for next period, etc.)

yes
no

[F1=Help] 1st-CLASS Advisor for BEFY2 [F9=Rule] [Esc=Stop]

If the method you use to control your expenditure does not work for you.

the following methods are suggested :

- Investigate and evaluate the causes and. minimize the expenditure
- Negotiate with the administration for higher budget
- Request additional funds with justification from the management
- Increase the meal prices (price recovery)

Press F5 to see the rule used (How the conclusion is reached?)

┘ to continue

Q U A L I T Y

[F1=Help]   1st-CLASS Advisor for B:QLTY   [F9=Rule] [Esc=Stop]

Definition : Quality is defined as the degree to which the system conforms to specifications, or at the consumer level, fitness for use.

Example : Meeting health department regulations.

Press ┘ to begin

Q U A L I T Y

[F1=Help]   1st-CLASS Advisor for B:QLTY   [F9=Rule] [Esc=Stop]

Do you have Quality standards which are specific to your operation?

yes no

Q U A L I T Y

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

Who developed these standards? Is one or more of the following management personnel involved in developing these standards for your foodservice organization?

- Manager
- Assistant Manager
- Director
- Assistant Director
- Dietitian
- Production Manager
- foodservice management company or
- some other management personnel

(To know WHY press <F2>)

yes
no

Q U A L I T Y

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

Do you use one or more of the following to control quality of food in your operation ?

1. Temperature check of food in steamtable
2. Periodic survey of customers as to quality of foodservice
3. Regular (unannounced) sanitation inspections
4. Taste testing/can cutting of new food items by management
5. Written standards for quality of food
6. Written standards for quality of service
7. Manager personally inspecting all food deliveries
8. Manager personally tasting all cooked foods for quality
9. Purchasing specifications
10. Detailed instructions to employees
11. Menus and charts, production schedules
12. Use of fresh food, if available and economical

yes
no

QUALITY

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

Are quality standards discussed with employees at any time beyond

their initial training ?

(To know WHY press <F2>)

yes no

QUALITY

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

Is one or more of the following personnel in charge of quality control

in your operation ?

- Manager
- Assistant Manager
- Production Manager
- Foodservice Contract Company
- Director
- Assistant Director
- Dietitian or
- some other management personnel

yes no

Q U A L I T Y

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

Do one or more of the following organizations govern quality standards in your operation ?

1. State Health codes
2. County Health codes
3. City Health codes
4. Contract Company standards

yes
no

Q U A L I T Y

[F1=Help] 1st-CLASS Advisor for B:QLTY [F9=Rule] [Esc=Stop]

It is advisable to arrange for meetings with the key management personnel to continuously revise the quality standards for better performance of the organization.

┘ to continue

Quality of Worklife

[F1=Help] 1st-CLASS Advisor for B:QWL [F9=Rule] [Esc=Stop]

Definition : Quality of worklife is defined as work with meaning, or the degree to which work provides an opportunity for an individual to meet a variety of personal needs, to survive with security, to interact with others, to feel useful, to be recognized for achievement and to have an opportunity to improve one's skill and knowledge.

Quality of worklife represents the tendency of an individual to act in a certain way when confronted with a given set of stimuli from his work environment. People's psychological reactions to working in an organization are a factor affecting performance.

Example : Job satisfaction, Pay satisfaction, Promotion, Job challenge,... etc.

Press ↵ to begin

Quality of Worklife

[F1=Help] 1st-CLASS Advisor for B:QWL [F9=Rule] [Esc=Stop]

Do you measure Quality of Worklife in your operation ?

Following are some of the measures of Quality of worklife:

1. employee participation in decision making,
2. job security,
3. safety,
4. opportunity for employees to satisfy personal or intrinsic needs,
5. personal development,
6. promotion,
7. integration of people and technology,
8. quality of work group,
9. job challenge,
10. efficiency of operation.

yes
no

Quality of Worklife

[F1=Help] 1st-CLASS Advisor for B:QWL [F9=Rule] [Esc=Stop]

Do you perform any of the following in your organization ?

1. Use written job satisfaction questionnaires
2. Encourage employees to make suggestions, participate and cooperate with management on new projects, problem solving , goal setting, etc.
3. Monitor turnover, absenteeism, and tardiness
4. Make the job more interesting by redesigning, job enrichment, task identification, etc.
5. Provide promotion opportunities
6. Provide supplies, materials, and assistance to employees as needed.

yes
no

Quality of Worklife

[F1=Help] 1st-CLASS Advisor for B:QWL [F9=Rule] [Esc=Stop]

Do you link performance to rewards ?

(To know WHY press <F2>)

yes
no

```
                    Quality of Worklife
                    -------------------
[F1=Help]          1st-CLASS Advisor for B:QWL          [F9=Rule] [Esc=Stop]

  Do you use one or more of the following as employee rewards ?

    1. Raises based upon performance appraisals
    2. Commendation letters
    3. Verbal recognition
    4. Merit pay for management staff
    5. Performance amards (non-monetary)
    6. Performance awards (monitary)
    7. Plaque and certificate or other forms of recognition
    8. Recognition in newsletter, newspaper
    9. Bonuses (time.pay)
   10. Scheduling preferences

 yes
 no
```

```
                    Quality of Worklife
                    -------------------
[F1=Help]          1st-CLASS Advisor for B:QWL          [F9=Rule] [Esc=Stop]

Do you use one or more of the following forms of Participative management ?

    1. Suggestion system
           (accept suggestions from the employees, implement worthwhile
           suggestions, and give rewards to the employees)
    2. Quality circles
           (a group of employees, typically drawn from the same department,
           who meet regularly to identify, analyze, and solve work-related
           problems)
    3. Incentive system
           (a plan which ties day-to-day earnings or periodic bonuses
           directly and automatically to relatively objective indices of
           individual, group, or sometimes organizational performance.)

 yes
 no
```

Quality of Worklife

[F1=Help] 1st-CLASS Advisor for B:QWL [F9=Rule] [Esc=Stop]

For future improvement in the productivity and profitability of your organization, it is advisable to analyze and evaluate the effects of the reward systems you are using. Furthermore, if you find that the incentives provided to the employees are effective i.e. there is an improvement in productivity and profitability, then the organization may want to add or improve the existing award system, to keep up with the future trends regarding the incentive systems.

↲ to continue

P R O F I T A B I L I T Y

[F1=Help] 1st-CLASS Advisor for PFT [F9=Rule] [Esc=Stop]

Definition:

Profitability is defined as the earned return on investment (owner equity) or the return on all things a business owns, or the relationship of revenue to costs.

Press ┘ to begin

P R O F I T A B I L I T Y

[F1=Help] 1st-CLASS Advisor for PFT [F9=Rule] [Esc=Stop]

Is your organization profit-oriented ?

(for more information PRESS <F2>)

yes
no

P R O F I T A B I L I T Y

[F1=Help] 1st-CLASS Advisor for PFT [F9=Rule] [Esc=Stop]

Do you happen to exceed the budget in your foodservice operation when measuring the profitability ?

yes
no

P R O F I T A B I L I T Y

[F1=Help] 1st-CLASS Advisor for PFT [F9=Rule] [Esc=Stop]

Press F4 to see the RULE (in the form displayed by 1stCLASS).
Then Press <CR> to continue.

Following are some of the methods that might be useful for your foodservice operation when you exceed the budget. and you want to control the expenditure:

Investigate the causes and readjust the budget.
Increase meal price.
Increase volume of Sales.
Audit purchasing systems: food specification, receiving procedures, volume buying, etc.
Tighten control on overtime, etc.
Tighten inventory controls.
Use less expensive materials.
Narrow choice offerings of food items.

Press F5 if you want to see the rule used to reach the conclusion

↵ to continue

I N N O V A T I O N

[F1=Help] 1st-CLASS Advisor for B:INOV [F9=Rule] [Esc=Stop]

Definition:

Innovation is defined as a deliberate, novel, specific change aimed at accomplishing the goals of the system more effectively.

Innovation may be seen in technological and procedural areas. Technological advances in the foodservice industry in recent years include the blast freezer, the microwave oven, conveyorized broilers, energy saving ventilation systems, and circular dish machines and tray liners. Procedural advances may involve a new marketing technique, a change in work flow involved in food processing, or a new incentive system.

Press ↵ to begin

I N N O V A T I O N

[F1=Help] 1st-CLASS Advisor for B:INOV [F9=Rule] [Esc=Stop]

Do you use one or more of the following to promote innovation in your organization?

1. Brainstorming sessions
2. Active suggestion system
3. Employee participation at meetings
4. Reward employee input
5. Incentive systems
6. Employee training seminars

yes
no

I N N O V A T I O N

[F1=Help] 1st-CLASS Advisor for B:INOV [F9=Rule] [Esc=Stop]

You are on the right track, but do you also use one or more of the following to promote innovation?

Computer (may be a word processor)
New menus and recipes
New equipment (cooking, catering, etc.)
New kitchen, new services, etc.
Participative management method/quality circles
New benefits plan
New cleaning agents
Robot arm
Sending employees to attend professional meeting, or training, or food and equipment shows, etc.

yes
no

I N N O V A T I O N

[F1=Help] 1st-CLASS Advisor for B:INOV [F9=Rule] [Esc=Stop]

It is advisable to add one or more of the following to have a better effect on promoting innovation in your organization.

1. Computer (may be a word processor)
2. New menus and recipes
3. New equipment (cooking, catering etc.)
4. New kitchen, new services, etc.
5. Participative management method/quality circles
6. New benefits plan
7. New cleaning agents.
8. Robot arm
9. Sending employees to attend professional meetings, or training, or food and equipment shows, etc.

┘ to continue

****

As mentioned earlier the seven Organizational Performance measures used for this software are:

Effectiveness, Efficiency, Quality, Quality of Worklife, Profitability, Innovation, and Productivity.

Now we are going to illustrate how one can measure the Productivity of a foodservice organization.

****

Press any key to continue

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
   P R O D U C T I V I T Y
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
Definition     Productivity is defined as the ratio of quantities
               of outputs to quantities of inputs.


Examples       OUTPUTS --> # of meals served, # of meals prepared, etc.

               INPUTS  --> total labor hours worked, total labor hours paid,
                           total food cost, etc.
```

Press any key to continue

P R O D U C T I V I T Y
....

[F1=Help]   1st-CLASS Advisor for B:FOOD   [F9=Rule] [Esc=Stop]

Do you use one or more of the following to control outputs of your organization ?

1. Keep production records for cafeteria and/or catering
2. Check production records at least quarterly to see that production is appropriate for demand
3. Have a system for utilizing leftover bulk foods
4. Meals served daily
5. Follow amounts prepared versus amounts served
6. Dollar sales daily
7. Profit and loss statement
8. Computerized cash register
9. Daily operation control sheets
10. Sales last year versus sales this year
11. Customer count daily

(Use up or down arrow to select the answer and press return)

yes no

P R O D U C T I V I T Y
....

[F1=Help]   1st-CLASS Advisor for B:FOOD   [F9=Rule] [Esc=Stop]

Do you use one or more of the following to control inputs to your foodservice organization?

1. Detailed specifications when purchasing equipments and supplies
2. Check (and appropriately adjust if necessary) labor usage at least quarterly
3. "Comparison shop" for food and supplies
4. Take advantage of seasonal food buys
5. Use of standardized recipes
6. Evaluate kitchen energy costs at least quarterly
7. Monitor energy usage of specific pieces of equipment
8. Routinely conduct physical inventory of storeroom
9. Monitor breakage and pilferage of supplies
10. Peridically review and revise job descriptions in order to prevent duplication of tasks
11. Routinely follow food costs

(Use up or down arrow to select the answer and press RETURN)

yes no

P R O D U C T I V I T Y

[F1=Help] 1st-CLASS Advisor for B:FOOD [F9=Rule] [Esc=Stop]

Do you develop ratios/formulas by which to measure productivity ?

From the research done on productivity measurement, the three most commonly used formulas, for productivity measurement of foodservice industries like hospitals, schools, colleges, etc. are as follows:

1. Meals served / Total food cost
2. Meals served / Labor hours paid
3. Meals served / Labor hours worked
(detailed description on each of the above ratios will be presented to you later in this exercise)

These formulas can be used one at a time or in combination. Here is an exercise/example on how productivity is measured in foodservice industries. Select the formula you would like to use to measure the productivity in your foodservice industry. Select one formula at a time for this exercise.

If you are not using any ratios for your industry, then you can begin collecting information on inputs and outputs in to ratios and track them over time. (Compare them month to month, quarter to quarter, etc.)

PgDn to continue

P R O D U C T I V I T Y

[F1=Help] 1st-CLASS Advisor for B:FOOD [F9=Rule] [Esc=Stop]

Select the formula (Productivity Ratio) you want to use in your FOODSERVICE INDUSTRY to measure the PRODUCTIVITY for different TIME PERIODS.

If You have questions regarding

(a)FORMULA (PRESS key F2)

(b)TIME PERIOD (PRESS key F3)

Total number of meals served / Total food cost (FOR MEALS SERVED)
Total number of meals served / Total labor hours paid (FOR MEALS SERVED)
Total # of meals served / Total # of labor hrs. worked (FOR MEALS SERVED)

```
              PRODUCTIVITY MEASUREMENT OF FOODSERVICE INDUSTRIES
              ..................................................
[F1=Help]       1st-CLASS Advisor for B:MTFC          [F9=Rule] [Esc=Stop]

   FORMULA SELECTED :      MEALS SERVED / TOTAL FOOD COST
    (by the user)          ..............................

   Following numeric figures will be needed to assess the productivity
   performance for the two TIME PERIODS you want to compare.

       1. Total number of meals served in time period 1.
       2. Total food cost for number of meals served in time period 1.
       3. Total number of meals served in time period 2.
       4. Total food cost for number of meals served in time period 2.

   If you have any questions regarding Food cost   (Press Key F2)

   If you have any questions regarding TIME PERIOD (PRESS key F3)

Press ┘ to begin
```

```
Data For TIME PERIOD 1 :
------------------------

A. What is the total # of Meals served (enter numeric figure)? 100

B. What is the total food cost (in Dollars) for Meals served
                                    (enter numeric figure)? 300

Data For TIME PERIOD 2 :
------------------------

C. What is the total # of Meals served (enter numeric figure)? 123

D. What is the total food cost (in Dollars) for Meals served
                                    (enter numeric figure)? 400
```

```
******************************************************************************
*       From the figures you just entered it shows that the productivity     *
*       ratio has Lower value for TIME PERIOD 2 (as shown below).            *
******************************************************************************

          TIME PERIOD 1                        TIME PERIOD 2
         ---------------                      ---------------
      meals/total food cost                meals/total food cost
      = 100 / 300                          = 123 / 400
      = .3333334                           = .3075

                         T H A N K Y O U

                     PRESS ANY KEY TO CONTINUE
```

PRODUCTIVITY MEASUREMENT OF FOODSERVICE INDUSTRIES

[F1=Help] 1st-CLASS Advisor for B:MTFC [F9=Rule] [Esc=Stop]

The productivity has gone down for the TIME PERIOD 2.

(To know why ? Press <F2>)

Food cost per meal served in TIME PERIOD 2 has increased compared to TIME PERIOD 1.

! to continue

ADVISE TO IMPROVE THE PRODUCTIVITY

[F1=Help] 1st-CLASS Advisor for B:MTFCL2B [F9=Rule] [Esc=Stop]

Let us now find out the reasons for Lower productivity in TIME PERIOD 2.

Higher food cost is the major source for Lower Productivity.
(Press <F2> to know why)

Press ┘ to begin

```
                  ADVISE TO IMPROVE THE PRODUCTIVITY
                  ..................................
[F1=Help]         1st-CLASS Advisor for B:MTFCL2B        [F9=Rule] [Esc=Stop]

    Do you perform Inventory control in your organization?

    Why Inventory control? (Press key F3)

 yes
 no
```

```
                  ADVISE TO IMPROVE THE PRODUCTIVITY
                  ..................................
[F1=Help]         1st-CLASS Advisor for B:MTFCL2B        [F9=Rule] [Esc=Stop]

Which inventory method did you use?

     (Why? Press <F2>)

 Last In First Out(LIFO)
 First In First Out (FIFO)
 AVERAGING
 None of the above
```

ADVISE TO IMPROVE THE PRODUCTIVITY

[F1=Help] 1st-CLASS Advisor for B:MTFCL2B [F9=Rule] [Esc=Stop]

It is recommended you try either FIFO system or Averaging system, which ever gives the minimum food cost.

You may want to do one or more of the following:

Use Seasonal food.
Change menu items.
Buy in volume to get food at cheaper cost,
Employ methods to minimize waste in food preparation,
Monitor Pilferage,
Change Purveyors.

┘ to continue

ADVISE TO IMPROVE THE PRODUCTIVITY

[F1=Help] 1st-CLASS Advisor for start [F9=Rule] [Esc=Stop]

T H E E N D

T H A N K -- Y O U

[N=New session] [R=Replay this session] [Q=Quit]

APPENDIX B

TERMS USED FOR EXPERT SYSTEMS

ARTIFICIAL INTELLIGENCE (AI) - a subfield of computer science concerned with the concepts and methods of Knowledge representation and problem solving.

BACKWARD CHAINING - an inference engine control strategy in which inferences are made by starting with a conclusion and working backward in an attempt to find the facts to support the conclusion.

DOMAIN - a definable extent of knowledge about a subject matter. Computer science is a broad domain, while cognitive modeling would be a much narrower domain.

EXPERTISE - Heuristics and knowledge possessed by some humans in a particular domain. Expertise is gained by amassing large amounts of knowledge in a domain and organizing it into appropriate hierarchical chunks so that it can be applied to the solution of problems in the domain.

FACT - A statement or premise that is true. A fact can consist of an attribute and an associated value.

FORWARD CHAINING - An inference engine control strategy in which inferences are made by applying facts to rules, resulting in conclusions that are supported by the facts.

HEURISTIC - Informal knowledge used to improve the efficiency of search in a given problem space.

IF-THEN RULE - A statement of relationship between premises and a conclusion, also called a production.

INFERENCE - A reasoning process in which new facts are derived from known facts.

INFERENCE ENGINE - That part of a production system that derives new facts from known facts in the knowledge-base.

KNOWLEDGE - A collection of facts, relationships, and heuristics which can be used to solve problems.

KNOWLEDGE-BASE - That portion of a knowledge system that consists of facts and rules. In a production system it consists of the rulebase and working memory.

KNOWLEDGE ENGINEER - An individual skilled in assessing problems and building knowledge systems.

KNOWLEDGE REPRESENTATION - The method that is used to encode facts and relationships in a knowledge-base.

KNOWLEDGE SYSTEMS - A class of computer programs that use knowledge and inference procedures to solve problems.

LISP - A programming environment that is used to solve problems involving symbolic relationships.

REASONING - The application of inference rules to facts.

RULEBASE - That part of a knowledge-base that is used to store the productions or rules; the static part of the knowledge-base in a production system.

SHELL - A tool that can be used to develop a complete knowledge system; consists of inference engine, a working memory, and optional auxiliary components such as a knowledge acquisition subsystem or explanatory interface.

TOOL - Any device (hardware or software) that can be used to improve the efficiency of the knowledge system design.

WORKING MEMORY - The storage used for the facts in a production type of knowledge system that have been ascertained as true or not true during a particular consultation; also called a database.

APPENDIX C

TERMS USED FOR PRODUCTIVITY

FOODSERVICE SYSTEM - The methodology used to prepare, assemble and deliver food to the consumer.

PERFORMANCE - Is equal to the outcomes of the combined functions of the following criteria: effectiveness, efficiency, quality, quality of worklife, profitability, innovation an productivity (Sink, 1985).

PRODUCTIVITY MEASUREMENT - the selection of physical, temporal, and/or perceptual measures for both input and output variables and the development of a ratio of output measure(s) to input measure(s) (Sink, 1985).

PROFITABILITY - Various financial measures relating total revenues to total costs; budgetability measures are used to assess adherence to a planned budget (Sink, 1985).

APPENDIX D

SAMPLE SCREENS

RULES AND RULES STATISTICS

```
Edit_rule,  Mark!examples,   Print_rule,  Statistics_on/off          line:  5
         Files   Definitions   Examples   Methods   Rule   Advisor
[F1=Help]      .File = b:OVERTIME                       [F9=Methods] [F10=Advisor]
---- start of rule ----
New_menu??
├yes:Lab_AB??
│    ├yes:Difclt_fd??
│    │    ├yes:Customer??
│    │    │    ├yes:──────────────────────────mylydycyhy
│    │    │    └no:New_Hire??
│    │    │        ├yes:──────────────────────mylydycnhy
│    │    │        └no:───────────────────────mylydycnhn
│    │    └no:Customer??
│    │        ├yes:New_Hire??
│    │        │    ├yes:──────────────────────mylydncyhy
│    │        │    └no:───────────────────────mylydncyhn
│    │        └no:New_Hire??
│    │            ├yes:───────────────────────mylydncnhy
│    │            └no:────────────────────────mylydncnhn
│    └no:─────────────────────────────────────mylydycyhy
└no:Lab_AB??
    ├yes:─────────────────────────────────────mylydycyhy
Active  examples:    32   Result's  examples:    2   Examples: 1,8
Result frequency: 0.75   Result probability: 0.06   Relative probability: 1.00
Total weight:    32.00   Result weight:      2.00   Average weight:        1.00
```

METHODS USED TO BUILD RULES

```
Optimize,  Left-right,  Customize,  Match,  ICO,  ?,  Test,  Save,  Advisor
         Files   Definitions   Examples   Methods   Rule   Advisor
[F1=Help]        File = trial                      [F9=Examples] [F10=Rule]


    Select a method to build the rule:

       O = Optimize the rule

       L = Use the factors in order, Left-to-right

       M = Match the advisor responses against the examples

       C = Customize the rule with the rule editor


    Factors:     2     Active Factors:     1     Factors in rule:   0
    Examples:    0     Active Examples:    0     ? as response:    no
    Results:     1     Lines in Rule:      0     Inference CutOff:  1

    Report generation: off
```

EXAMPLES USED TO BUILD RULES

Examples for Knowledge Base b:OVERTIME 1:48 am 1/01/1980

	MEMO	New_menu	Lab_AB	Difclt_fd	Customer	New_Hire	RESULT	weight
1:	_	yes	yes	yes	yes	yes	mylydycyhy	1.00
2:	_	yes	yes	no	no	yes	mylydncnhy	1.00
3:	_	yes	yes	yes	no	no	mylydycnhn	1.00
4:	_	yes	yes	no	yes	no	mylydncyhn	1.00
5:	_	yes	yes	no	no	no	mylydncnhn	1.00
6:	_	yes	yes	no	yes	yes	mylydncyhy	1.00
7:	_	yes	yes	yes	no	yes	mylydycnhy	1.00
8:	_	yes	yes	yes	yes	no	mylydycyhy	1.00
9:	_	no	yes	yes	yes	yes	mylydycyhy	1.00
10:	_	no	yes	no	no	yes	mylydycyhy	1.00
11:	_	no	yes	yes	no	no	mylydycyhy	1.00
12:	_	no	yes	no	yes	no	mylydycyhy	1.00
13:	_	no	yes	no	no	no	mylydycyhy	1.00
14:	_	no	yes	no	yes	yes	mylydycyhy	1.00
15:	_	no	yes	yes	no	yes	mylydycyhy	1.00
16:	_	no	yes	yes	yes	no	mylydycyhy	1.00
17:	_	yes	no	yes	yes	yes	mylydycyhy	1.00
18:	_	yes	no	no	no	yes	mylydycyhy	1.00
19:	_	yes	no	yes	no	no	mylydycyhy	1.00
20:	_	yes	no	no	yes	no	mylydycyhy	1.00
21:	_	yes	no	no	no	no	mylydycyhy	1.00
22:	_	yes	no	no	yes	yes	mylydycyhy	1.00
23:	_	yes	no	yes	no	yes	mylydycyhy	1.00
24:	_	yes	no	yes	yes	no	mylydycyhy	1.00
25:	_	no	no	yes	yes	yes	mylydycyhy	1.00
26:	_	no	no	no	no	yes	mylydycyhy	1.00
27:	_	no	no	yes	no	no	mylydycyhy	1.00
28:	_	no	no	no	yes	no	mylydycyhy	1.00
29:	_	no	no	no	no	no	mnlndncnhn	1.00
30:	_	no	no	no	yes	yes	mylydycnhy	1.00
31:	_	no	no	yes	no	yes	mylydycyhy	1.00
32:	_	no	no	yes	yes	no	mylydycyhy	1.00

FORWARD CHAINING AND BACKWARD CHAINING

```
new_Factor,  new_Value,  edit_Text,  Change,  Activate,  Move,  Delete
        Files   Definitions   Examples   Methods   Rule   Advisor
[F1=Help]        2  Factors in b:MTFC                [F9=Files] [F10=Examples]
       (inactive)
       MEMO          @Ratio_MTFC RESULT_MTFC
                     LARGER_THAN #b:mtfcl2b
                     LESS_THAN   #b:mtfcg
                     EQUAL_TO    #b:mtfce
```

```
Complete the definitions, then
press F10 to give some examples.

For more help, press F1.
```

PRODUCTIVITY MEASUREMENT OF FOODSERVICE INDUSTRIES

```
Edit_rule,  Mark|examples,   Print_rule,  Statistics_on/off          line:  2
        Files   Definitions   Examples   Methods   Rule   Advisor
[F1=Help]       File = b:MTFC                      [F9=Methods] [F10=Advisor]
---- start of rule ----
@Ratio_MTFC??
├LARGER_THAN:────────────────────────────────────#b:mtfcg
├LESS_THAN:──────────────────────────────────────#b:mtfcl2b
└EQUAL_TO:───────────────────────────────────────#b:mtfce
---- end of rule ----
```

```
Active  examples:     3   Result's  examples:    1   Examples: 1
Result frequency: 0.33   Result probability: 0.33   Relative probability: 1.00
Total weight:     3.00   Result weight:      1.00   Average weight:       1.00
```

APPENDIX E

SAMPLE PROGRAM

```
470 CLS: COLOR 1,7,4 : LOCATE 6,1 : COLOR 7,1
480 PRINT "**********************************************************************
**********
490 PRINT "*        From the figures you just entered it shows that the producti
vity     *
500 PRINT "*        ratio has higher value for TIME PERIOD 2 (as shown below).
         *
510 PRINT "**********************************************************************
**********
520 GOTO 400
530 CLS: COLOR 1,7,4 : LOCATE 6,1 :COLOR 7,1
540 PRINT "**********************************************************************
**********
550 PRINT "*       From the figures you just entered it shows that the productiv
ity      *
560 PRINT "*       ratio is Equal for TIME PERIOD 1 & TIME PERIOD 2 (as shown be
low).    *
570 PRINT "**********************************************************************
**********
580 GOTO 400
590 DEF SEG = &H40
600 BOFFSET = PEEK(&HF0) + 256 * PEEK(&HF1)
610 BSEGMENT = PEEK(&HF2) + 256 * PEEK(&HF3)
620 DEF SEG = BSEGMENT
630 FOR I = 1 TO LEN(VAR$)
640 POKE BOFFSET+I, ASC(MID$(VAR$,I,1))
650 NEXT I
660 POKE BOFFSET, LEN(VAR$)
670 COLOR  4,2: LOCATE 20,30
680 PRINT "T H A N K Y O U"
690 COLOR 14,0 : LOCATE 23,26
700 PRINT "PRESS ANY KEY TO CONTINUE"
710 A$ = INKEY$
720 IF A$ = "" THEN 710
730 CLS:COLOR 1,7,4
740 SYSTEM
```

```
10 REM file bmtfc
20  CLS: KEY OFF: COLOR 1,7,4
30  CLS: COLOR 1,7,4: LOCATE 3,1
40 COLOR 14,0 : PRINT "Data For TIME PERIOD 1 :"
50 COLOR 14,0 : PRINT "------------------------"
60 LOCATE 6,1
70 REM To get variable for MTFC.KBM
80 COLOR 14,9
90 INPUT "A. What is the total # of Meals served (enter numeric figure)";MS1
100 PRINT
110 COLOR 14,9
120 PRINT "B. What is the total food cost (in Dollars) for Meals served   "
130 COLOR 14,9
140 INPUT "                                        (enter numeric figure)";TFC1
150 PRINT
160 PRINT
170 COLOR 14,0 : PRINT "Data For TIME PERIOD 2 :"
180 COLOR 14,0 : PRINT "------------------------"
190 PRINT
200 COLOR 14,9
210 INPUT "C. What is the total # of Meals served (enter numeric figure)";MS2
220 PRINT
230 COLOR 14,9
240 PRINT "D. What is the total food cost (in Dollars) for Meals served   "
250 COLOR 14,9
260 INPUT "                                        (enter numeric figure)";TFC2
270 R1 = MS1/TFC1
280 R2 = MS2/TFC2
290 IF R2 < R1 THEN VAR$ = "LESS_THAN"
300 IF R2 > R1 THEN VAR$ = "LARGER_THAN"
310 IF R2 = R1 THEN VAR$ = "EQUAL_TO"
320 IF R2 < R1 THEN GOTO 350
330 IF R2 > R1 THEN GOTO 470
340 IF R2 = R1 THEN GOTO 530
350 CLS: COLOR 1,7,4 : LOCATE 6,1 : COLOR 7,1
360 PRINT "*********************************************************************
**********
370 PRINT "*       From the figures you just entered it shows that the productiv
ity      *
380 PRINT "*       ratio has Lower value for TIME PERIOD 2 (as shown below).
       *
390 PRINT "*********************************************************************
**********
400 LOCATE 12,10
410 PRINT "    TIME PERIOD 1                           TIME PERIOD 2 "
420 LOCATE 13,10:PRINT "   ---------------                        ---------------"

430 LOCATE 14,10:PRINT "meals/total food cost                   meals/total food co
st
440 LOCATE 15,10:PRINT "=";MS1;"/";TFC1:LOCATE 15,47:PRINT "=";MS2;"/";TFC2
450 LOCATE 16,10:PRINT "=";R1 :LOCATE 16,47:PRINT "=";R2
460 GOTO 590
```

APPENDIX F

LIST OF EXTERNAL PROGRAMS AND TEXT FILES

1. FOOD.BAT
2. FOODT2.BAS
3. PFT.RUL
4. PFTTXT
5. PTXT
6. FOODTXT
7. FOODT2.BAS
8. BMTFCE.BAS
9. BMTFCG.BAS
10. QLY1.BAS
11. BEFT1.BAS
12. EFY1.BAS
13. BQWL.BAS
14. BINOV.BAS
15. PPQWL.BAS
16. PROD.BAS
17. BMTFC.BAS
18. BMLHP.BAS
19. BMLHW.BAS
20. BMLHW1.BAS
21. FOODT.BAS
22. BMLHPTR.BAS
23. BMTFCG.BAS
24. BBYE.BAS
25. BMTFCE.BAS
26. BMLHPG.BAS
27. TITLE.BAS

VITA 2

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