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PROTOTYPE EXPERT SYSTEM FOR PERSONNEL SELECTION AND PROMOTION: A CASE STUDY OF FEDERAL CIVIL SERVICE COMMISSION OF ETHIOPIA

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN INFORMATION SCIENCE

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ABSTRACT

Human resources are the most important assets to an organisation and their effective management is the key to its success. Human Resource Management (HRM) facilitates the most effective use of employees to achieve organisational goals.

The rapid expansion in the use of computers has brought the growth in the applications of computer to the Human Resource (HR) area. Originally, the use of computers in this area was limited to such routine functions as producing pay checks, payroll reports, etc. Today, full fledged Human Resource Information Systems (HRIS) have been developed that support other activities beyond these routine functions.

The various type of systems that come under HRIS fall into three major categories: Decision Support Systems (DSS), Executive Information Systems (EIS), and Expert Systems (ES). Expert systems development in HR domains is helpful for solving unstructured HRM activities.

This study experiments with the development and application of ES in HRM, taking personnel selection for promotion in Federal Civil Service Commission of Ethiopia as a case and using existing resources and facilities at the School of Information Studies for Africa (SISA). As a result, a prototype expert system is developed using expert system shell - KnowledgePro, and rule based knowledge representation approach. The features and capability of the prototype system developed in this work is demonstrated and discussed.

The knowledge required for performing the task is extracted from: domain experts, written documents (on rules and regulations of promotion process), and analysis of actual cases processed.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Any organisation has an objective to meet and employees, as human resources of the organisation, play major role in meeting the objective. Accordingly, human resources are the most important assets to an organisation and their effective management is the key to its success.

Human Resource Management (HRM) facilitates the most effective use of employees to achieve organisational goals. HRM is concerned with helping an organisation achieve its future objectives by providing competent, well-motivated employees. It consists of numerous activities, including: recruitment, selection, placement, evaluation, compensation, and training and development of the employees of an organisation.

The rapid expansion in the use of computers has brought the growth in the computer applications to the HR areas. Originally, the use of computers in human resource areas was limited to such routine activities as (O'Brien 1993):

- producing pay checks and payroll reports,
- maintaining personnel records, and
- analysing the use of personnel in operations of the organisation.

Today, the use of computers in human resource management has gone well beyond these routine functions. They are used to develop full-fledged Human Resource Information Systems (HRIS) that support such other HRM activities as:

- recruitment, selection, and hiring,
- job placement,
- performance appraisals,
- employee benefits analysis,
- training and development, and
- health, safety, and security.

The major type of systems that come under HRIS fall into one of three categories:

- Decision Support Systems (DSS): those that provide HR managers with interactive information support during decision making,
- Executive Information Systems (EIS): those that provide HR managers with immediate and easy access to information about HR focusing on meeting the strategic information needs of top management, and
- Expert Systems (ES): those that primarily provide and support HR managers with computer-aided decision-making, planning and control by covering the three management levels: operational, tactical, and executive (top management).

Expert systems are usually helpful for solving unstructured HRM activities. It is the purpose of this work to experiment with the development and application of ES to support the personnel selection for promotion activity at the Federal Civil Service Commission of Ethiopia.

The Federal Civil Service Commission of Ethiopia (FCSC), formerly known by the name Central Personnel Agency (CPA), was established in 1962, with the responsibility for the recruitment, selection, appointment, placement, conduct and termination of employment of civil servants employed by government ministries, chartered government agencies and other public authorities which have independent juridical status.

The principal activities within FCSC, among others, include the review and approval of:

- recruitment actions;
- salary increments;
- promotions;
- position classifications;
- allowances; and
- transfers

relating to federal government offices.

Currently, there are 10 regional governments with their own civil service bureaus which have the same responsibility as FCSC for the civil servants in their respective regions. But, preparation of policies concerning the administration of civil servants and issuing detailed implementation directives are still the responsibility of FCSC. Regional government civil service bureaus conduct their duties according to these implementation directives and forward statistics of personnel activities concerning civil servants in their region to FCSC.

On the other hand, each ministry or organisation is mandated to deal with promotion cases for its employees up to a specified salary level. The FCSC monitors the promotions within the delegated authority levels of organisations and process others above that. High level promotions, above department head, are usually made by appointment from the government.

To fulfil its duties and responsibilities FCSC is organised into different functional units as shown in Figure 1.1. Among a number of distinct functions within FCSC the administration of employment of civil servants, including, the review and approval of recruitment actions, salary increments, promotions, transfers, and other staffing activities, are the responsibilities of the Staffing Department.

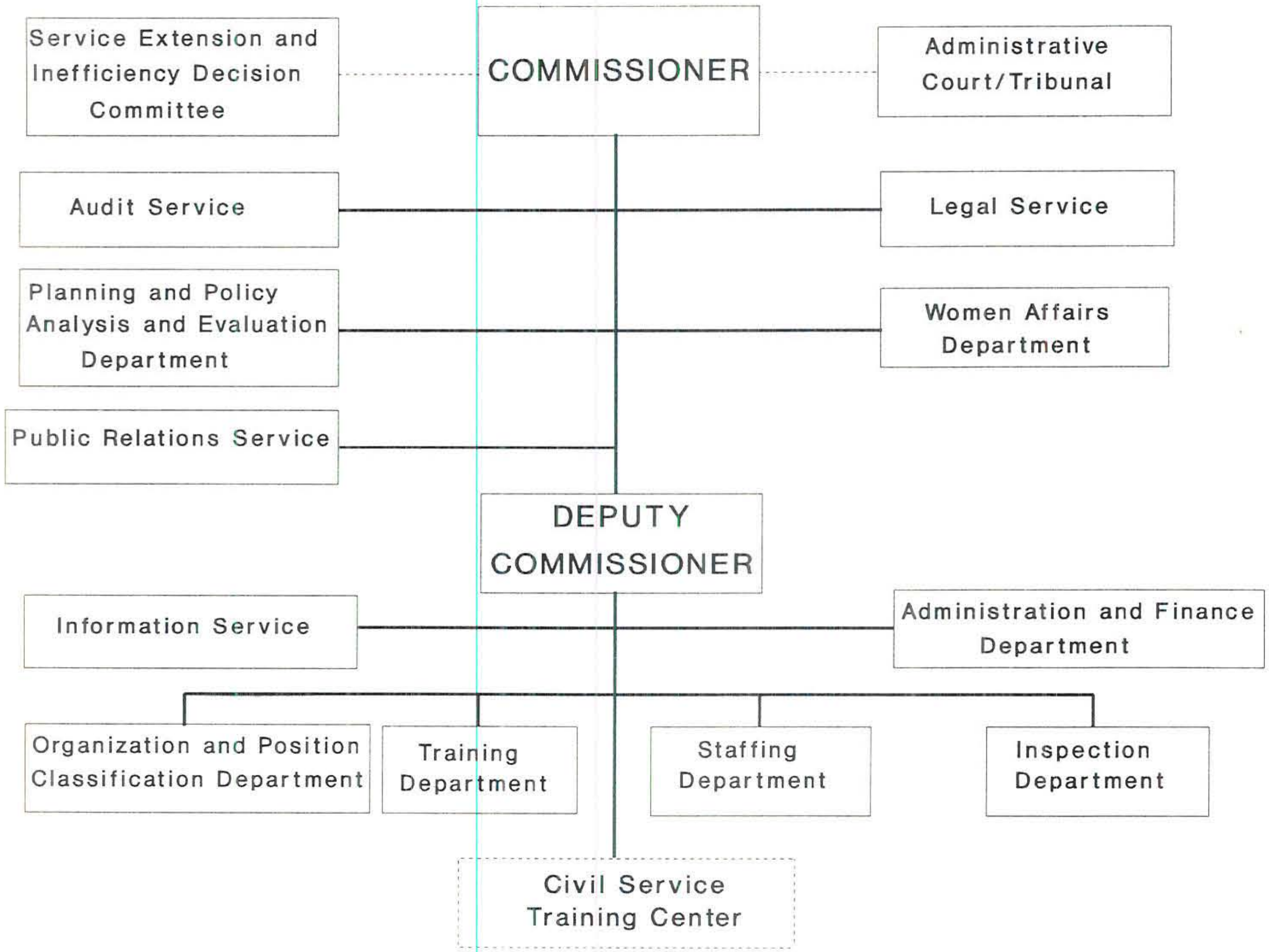

Figure 1.1 The organizational chart of FCSC

1.2 STATEMENT OF THE PROBLEM AND JUSTIFICATION

According to the guideline for promotion processing, the main criteria used for selecting employee for promotion are (the percentage in parenthesis indicate the weight given for each):

- level of education (45%),
- work experience and training (30%),
- efficiency report (20%), and
- record of disciplinary action (5%).

Once selection has been made on the bases of these criteria by the employer organisation, it will be sent to FCSC for approval. Unless delegation has been made or general consent has been given with regard to individual positions or careers, the ministry, chartered government agency or other public authority shall, upon completion of the in-house selection process, apply for the consent of the FCSC to the promotion (as per Public Service Regulations No. 1). There are some exceptions where ministries and organisations have a delegated authority for promotions up to a specified salary level to reduce the burden and work load at FCSC.

The process of effecting promotion at FCSC usually involves a detailed analysis of personnel records of the contending candidates to ensure that the best deserving candidate has been given the promotion by the organisations.

The following data (obtained from Staffing Department of FCSC) of 1985 Ethiopian fiscal year (1992/93) has been provided as an indication of the general picture on the volume of the promotion cases handled and the decision made at FCSC. During the year (1992/93) the Staffing Department processed a total of 17,133 promotion cases of which:

- 4904 were according to the regulation and thus approved;
- 7955 within delegated authority level were according to the regulation and thus accepted;
- 2272 were not according to the regulation and thus rejected; and
- 2002 needed additional information for decision and thus delayed in need of information.

There are 56,165 civil servants (Merit, December 1995), as of February 1995, in 106 bodies of the federal civil service (15 Ministries, 6 Commissions, 10 Authorities, 17 Agencies, 9 Institutes, and 49 other Government bodies).

According to the findings of a preliminary survey conducted at the start of this work, the process of approving selections made by employer organisations requires considerable expert time and resource. For processing a case, usually it takes more than a month on the average. Often employer organisation (and candidates) complain about the delay. The main cause of the delay is attributive to the fact that the experts dealing with this task occupy positions of higher responsibility in FCSC. They are assigned in different decision making committees at different managerial levels. Their time is extremely valuable and scarce.

It has also been observed that, due to lack of time, at times the experts tend to make decisions on the basis of examining selected factors, especially when faced with complicated cases. This usually leads to inconsistency.

It is strongly felt that such delays and inconsistency may be largely minimised by the use of expert systems which would assist with or carry out most of the tasks performed by the experts. That is, the use of expert systems in the selection process may be one potential solution to most of the difficulties being experienced at FCSC.

This and the following observations made from literature make the bases as well as justification for the current undertaking.

To achieve effective HRM in organisations with the aid of computers, involves the use of both non-ES and an ES approach (Byun & Suh, 1994). The non-ES approaches, that have been used in conventional personnel management, are primarily categorised as follows: interviews; use of versatile materials such as questionnaires; behavioural analysis; Management Science (MS)/ Operations Research (OR) approaches; decision theories; and statistical analysis. OR and statistical analysis are regarded as scientific approaches more or less on a par with behavioural analysis, even if they could not constitute an information system and don't support the overall HRM activities in the same way as an ES. Compared with traditional MS/OR techniques, ES in HRM not only support complex managerial decision-making effectively and efficiently but also provide competitive advantages in organisations. Generally, deciding between a non-ES and an ES approach, depend largely on: algorithms as appropriate for structured problems (that can be reduced to a predictable series of steps) versus heuristics as appropriate for unstructured problems (complex or full of uncertainties).

Heuristics are rules of thumb often used by human experts. They can be contrasted with algorithms, which represent procedures which, if remorselessly followed, will eventually produce a solution to a problem.

Structured problems involve situations where the procedures to follow when a decision is needed can be specified in advance. Unstructured problems involve decision situations where it is not possible or desirable to specify in advance most of the decision procedures to follow.

The conventional algorithmic programming approach is more convenient for:

- numeric kind of data rather than concepts or symbols, and
- structured problems rather than unstructured or semi-structured ones.

Expert system approach is more convenient for symbolic processing and in handling problems with unstructured or semi-structured nature. Semi-structured problems involve situations where some decision procedures can be pre-specified, but not enough to lead to a definite recommended decision. Moreover, expert system approach is considered due to its advantage of reasoning capability. It has the potential to reproduce human reasoning to an extent which is acceptable for supporting problem solving and decision making. Like a human expert, an expert system is able to explain the line of reasoning it uses for each problem it solves, thus separating expert system architecture from conventional algorithmic applications of computers. The explanation facility is generally made up of an identification of steps in the reasoning process and a justification of each step. A user can study the rationale on which the recommendation is based and is free to accept or reject it.

In general, managerial decisions are multidisciplinary, involving a large number of factors if managers are to make good decisions. Byrd (1992) and Edwards 1992, cited by Byun & Suh 1994, discusses the major benefits of ES in an organisation: improving productivity; helping personnel by making more consistent, timely and accurate decisions to improve competitiveness; and reduction in staff personnel by providing automated decision-making. ES allow HR managers to make better decisions and enforce consistent methods with their heuristic knowledge regarding unstructured or semi-structured problems. ES can free the expert for more interesting and challenging work, while freeing him or her from many of the familiar, routine tasks. ES, also, allow junior personnel to perform expert like tasks with accuracy, credibility and confidence.

There is a general agreement among workers in this area that (Byun & Suh, 1994), Human Resource Management Expert Systems (HRMES) can support HRM activities effectively if the following conditions apply: the task requires cognitive skill (i.e. depends on the HR manager's skill); the domain is well bounded (i.e. it is clearly understood and the objective is well defined); and data are available (i.e. personnel databases are always in existence without needing to develop additionally). Furthermore, among the activities within HRM, the most appropriate domains in which ES can be built successfully include planning, job analysis, recruitment, selection, performance evaluation, compensation, training, and labour management relations. Extejt & Lynn (1988), cited by Byun & Suh 1994, present three possible areas that are in particular potentially suited to ES applications: staffing; training and development; and control systems. Edwards (1992), cited by Byun & Suh 1994, presented the ES applications developed and used in Westinghouse Electric Corporation and American Express for employee selection, placement, performance appraisal, and training and development.

Selecting an appropriate domain is an important initial task in ES development. Sometimes finding HRMES success stories or case studies is helpful for domain selection (Byun & Suh 1994). Thus the systems in the success stories can be similar to our development system. However, there are few ES for HRM that support operational tasks. Most successful ES in the HR domain are not well-known and it is not easy to derive and summarize the overall results of the ES, unlike other areas such as medicine, education, and production. Moreover, most of the proposed applications of expert system in HRM are reported only on a conceptual level, and actual implementation of expert systems in this area remains largely undocumented (Tavana et al. 1994).

The intention of this study is to experiment with the application of expert systems in HRM taking personnel selection as a case. This study, in particular, attempts to design and develop a prototype expert system for personnel selection and promotion taking FCSC as a case.

The FCSC case is considered suitable for the following reasons:

- The task of personnel selection for promotion requires cognitive skill. In FCSC experts qualified in management and related fields are assigned to undertake the approval of promotion cases since it requires personnel management skill.
- The domain is well bounded, i.e., it is clearly understood and the objective is well defined.
- Data are available
- Promotion process needs more consistency, timeliness and accuracy in decisions.

1.3 OBJECTIVES

The general objective of the study is to experiment with the application of expert system for personnel selection taking personnel selection for promotion in Federal Civil Service Commission of Ethiopia as a case, and using existing resources and facilities at the School of Information Studies for Africa (SISA).

The specific objectives are:

- Explore the potential and limitations of expert system technology and approach for personnel selection

- Develop a prototype system using the KnowledgePro shell, that has the following specific features:
  - **A knowledge-base** which consists of facts on employee qualifications, job requirements, relations among jobs, etc. A knowledge-base also consists of rules that represents expert knowledge about personnel selection.
  - **An inference engine** which carries out the reasoning function for utilizing the knowledge-base in selecting personnel.
  - **A user interface** which allows users to supply information, receive advice on the selection of personnel, and explanation of how the selection is performed.

1.4 METHODOLOGY

Knowledge Acquisition

The knowledge required for performing the task is extracted from:

- domain specialists during periods of intensive discussions with them,
- written documents (on rules and regulations of promotion process), and
- analysis of actual cases processed.

Staffing Department Head, promotion and salary increment Team Leader, and two promotion and salary increment experts are used as domain experts. The Department Head and the Team Leader have 29 and 22 years of work experience respectively; and the two experts have 7 and 5 years of work experience in FCSC.

Prototyping

Prototyping approach is adopted for the development of the prototype expert system for the following reasons. Prototyping is a common approach in expert systems because of the nature of what is encoded: knowledge, and the independent nature of rules. With this approach a system prototype could be produced in a short period of time. The prototype is to be used for demonstration and discussion of the capabilities of the system. The prototyping approach is suitable to code the knowledge base in small groups (chunks) that can be tested before risking too much on an extensive detailed design process.

Using Shells

There are two alternatives to develop an ES: (1) using expert system shells, or (2) developing from scratch as a custom system. Developing an expert system from scratch requires using one or more programming languages such as Prolog and Lisp to develop the inference engine and user interface programs and build the knowledge base of facts and rules. Obviously, this is a much more difficult, time-consuming, and costly undertaking in view of the time and skill/expertise within which this work operates. Hence, expert system shell is used as a development tool in this study, since it is the easier way to develop an expert system. Expert system shell is easier because of its built in inferencing and user interface capabilities.

An expert system shell available at the School of Information Studies for Africa (SISA) is KnowledgePro. Hence, to develop the prototype expert system for personnel selection, KnowledgePro is used. KnowledgePro is a knowledge-based hypermedia shell enabling the development of intelligent and expert hypermedia systems. It allows the integration of hypermedia navigation facilities with rule-based programming.

1.5 SCOPE

As stated the purpose of this study is to design a prototype expert system that would serve as an aid in the process of selecting personnel for promotion per the rules and regulations of FCSC. It is recognized, however, that this task is extremely complex and that it is unlikely the worker will be able to develop a fully operational prototype in the current undertaking. To this end, in order to arrive at a realistic case, the worker has to limit the functionality and capability of the ideal system. The prototype system does not cover full representation of all the facts (such as, the relation among jobs, etc.) in building the knowledge base. However, most of the criteria in selecting personnel for promotion are represented in the knowledge base.

Also, as an academic exercise emphasis is more placed on the educational value of the work than its contribution to the operational environment. To this end more time and effort is devoted to the knowledge representation and programming aspect, when compared to the inferencing and testing.

1.6 ORGANIZATION OF THE THESIS

The thesis is organised into five chapters. Chapter one is a brief introduction of the study including its objectives and justifications. Chapter two deals with review of literature on expert systems in HRM. The approaches used in the development of expert systems including knowledge representation are discussed in Chapter three. Chapter four deals with the design and development of the prototype expert system. The final Chapter presents the discussions of results obtained in this work, as well as some concluding remarks derived from the results.

CHAPTER TWO

EXPERT SYSTEMS IN HUMAN RESOURCE MANAGEMENT

2.1 EXPERT SYSTEMS: OVERVIEW

Definition

Expert systems are one of a group of disciplines often labelled artificial intelligence (AI). AI aims to make computers capable of displaying behaviour that is considered intelligent when observed in humans.

Published literatures provide a number of definitions for expert systems.

Pederson (1989) defines expert systems as:

> **Expert systems are computer programs that give the appearance of human like reasoning for problems ordinarily requiring expertise.**

Parsaye & Chignell (1988) define expert systems from a functional point of view as:

> **An expert system (ES) is a program that relies on a body of knowledge to perform a somewhat difficult task usually performed only by a human expert. The principal power of an expert system is derived from the knowledge the system embodies rather than from search algorithms and specific**

reasoning methods. An expert system successfully deals with problems for which clear algorithmic solutions do not exist.

Both definitions reveal that an expert system is one which has a large set of factual and heuristic knowledge acquired from one or more human expert(s) in that field, and is able to achieve the same performance in problem-solving as those experts. ES is basically a set of computer programs and coded knowledge that interact in such a way that the system can reason and solve problems by emulating the logical process of the human mind. In order to achieve such a capability, it simulates the human reasoning process by applying specific knowledge and inferences. In addition, it is able to explain and justify its course of action, thus separating expert system architecture from the conventional algorithmic applications of computers.

An expert system can be seen as a piece of software that explicitly represents human knowledge about some specific domains. Such knowledge is not, for the most part, in the form of ad hoc rules, and beliefs. A particular characteristic of expert knowledge is that it can be inconsistent, in that it may imply two contradictory answers to a given problem. Experts have strategies for dealing with such situations that include priority or certainty factors, so that one might select "the most likely to be true" result and methods for seeking extra information that could resolve such a conflict. All of these notions have found their way into expert system technology. Unlike conventional systems, it is normally expected to be able to explain to a user, in some way, why it has come to a particular conclusion.

The computer programs written for ES differ from conventional programs in the way they are organised, the way they incorporate knowledge, the way the programs execute, and the impression created through interactions with users, for these systems are designed to simulate expert human performance and to present a human like facade to the user.

The distinguishing characteristics of ES programs are that they are qualitative rather than quantitative in nature and that they use heuristic rules and logical reasoning to solve problems that would normally require the knowledge and experience of an expert in a particular field.

The underlying principle of expert systems technology focuses on separating the representation of the domain knowledge from the logical mechanisms for processing and interpreting this knowledge. This allows knowledge relevant to a particular field to be easily updated, since such modifications only affect the knowledge base. Furthermore, since statements containing the knowledge are defined declaratively in the knowledge base, they do not be defined in any particular order; they are more easily accessible than if they were incorporated into a program. This has led to the proliferation of expert systems, each covering a specific domain of interest.

Since there appears to be no functional limitation to the ultimate use of expert systems, they will most likely find eventual use in almost every endeavour where symbolic reasoning with detailed professional knowledge is required. In the process there will be exposure and refinement of the heuristics of the various fields of expert system application. This addition to human knowledge will undoubtedly be the most important contribution of the knowledge based systems approach.

Expert Systems are developed through a process of knowledge engineering which starts from a knowledge base containing facts and a body of expertise (heuristics, or rules of thumb) about the use of those facts. The rules enable decisions to be made on the basis of factual information presented to the computer. These facts and rules are processed by what is termed the inference engine, which solves problems or makes predictions, and the results of this process are presented to the user in the user interface.

Structure

The structure of expert system parallels that of human expertise. The first part of human expertise is a long-term memory of facts, structures, and rules that represents expert knowledge about the domains of expertise. The analogous structure in an expert system is called the knowledge base. The second part of human expertise is a method of reasoning that can use experts' knowledge to solve problems. The part of an expert system that carries out the reasoning function is called the inference engine. To interact with users an expert system has a user interface that allows users to query the system, supply information, receive advice, etc. Figure 2.1 shows the structure of expert system.

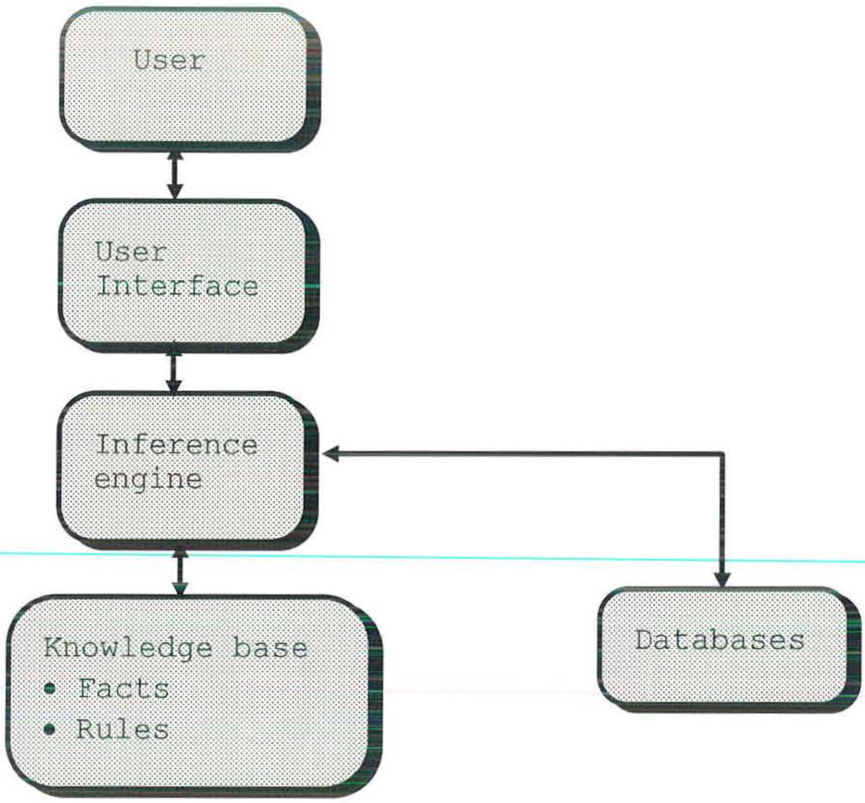

Figure 2.1 The structure of an expert system

Potential Benefits and Limitations

Expert system offer many benefits (Parsaye and Chignell, 1988; Zahedi, 1993). These benefits are what make the study of expert systems interesting and worthwhile. The benefit of an expert system is that it provides consistent, timely and uniform advice. It is thorough and methodical. Unlike the human expert, an expert system does not have lapses that causes it to overlook important factors, skip steps, or forget. It is not politically motivated, temperamental, or biased (unless the developer designs it to be so).

The use of expert system increases the consistency, quality, and speed of the decision making (or performing a given task). It also provide an aid to managerial effectiveness.

The potential benefits and limitations of HRMES allow ES builders to identify the probability of success for the system and to make considerations for its development. The benefits and limitations of HRMES are not so different from those of MES. Together with MES or business ES that can solve complex organisational problems, they give strategic advantages first or all to the organisation.

Byrd (1992), cited by Byun and Suh (1994), discusses the major benefits of ES in an organisation: improving productivity; helping personnel by making more consistent, timely and accurate decisions to improve competitiveness and market share; and a reduction in staff personnel by providing automated decision-making. Mery & curley (1989), cited by Byun and Suh (1994), summarized such ES benefits based on two classification dimensions (knowledge complexity and technology complexity) as improving personal and group decision-making, and increasing throughput, productivity and quality of product service. ES also allow junior personnel to perform expert-like tasks with accuracy, credibility and confidence.

The other benefit of HRMES is that they are useful in overcoming the judgement bias of traditional supervisor-only systems which require the supervisor to justify the principles.

There are some limitations of ES in HRM (Byun and Suh, 1994). First, HRMES need more than experience to make unstructured decisions in HRM. Second, an ES is usually confined to a very narrow domain because building and maintaining a large knowledge base is very difficult. Third, HRM applications involve behavioural variables; the heuristic knowledge that leads to good judgement on human behaviour is hard to define. Finally, in setting up the knowledge base, certain kinds of knowledge cannot easily be translated into IF...THEN rules.

The three-step that seeks to find sub-goals in order to meet an HRM objective is similar to inference mechanisms in the MES. That is, HR managers make the objective more specific by developing policies that are general guides to consistent decision-making, as well as rules specifically aimed at decision-making on how to do a particular activity. Here, policies allow HR managers to focus on decisions in which they already have the most experience and knowledge. For example, job satisfaction is an objective in a job placement ES. The principle of the right-person-in the right-place becomes a policy and aptitude tests or personality tests are used to make rules.

In practice, as well as dealing with the above complex procedures, HRMES builders are confronted with many additional problems, including handling and supporting multiple decision makers such as operating managers, HR managers and HR executives with different roles according to their managerial level; a set of conflicting policies and rules; and knowledge acquisition from multiple experts.

Compared with traditional MS/OR techniques, ES in HRM not only support complex managerial decision-making effectively and efficiently but also provide competitive advantages in organisations.

The introduction of an expert system that can offer comparable advice should have a very positive impact on the human expert. This allows the human expert to focus on the most challenging problems and to concentrate on new creative activities.

Current Trends

The early successful applications of expert systems were in mathematics, speech, and medicine. They were developed mainly for the purpose of demonstrating the feasibility and usefulness of expert systems.

Today, numerous companies are engaged in the development of expert systems. Schorr and Rapport (1989), cited by Zahedi (1993), report on some 27 interesting real-world applications of expert systems in areas such as aerospace, the military, banking and finance, manufacturing, retail, personnel management, biotechnology, emergency services, law, manufacturing assembly, manufacturing design, media, and music.

The current trend in expert system building is domain specific, i.e. there is one expert system for each problem domain. The increased involvement of computers in the decision-making process will inevitably lead to increased demand for expert systems.

In recent years, with the availability of an increasing number of expert system shells, applications of expert systems are being proposed to help improve management decision making in a variety of areas (Tavana et al. 1994). Potential benefits of these systems include: more consistent decisions, efficiency, operational cost savings, better utilization of human resources, and easier access to rare or dispersed knowledge.

2.2 APPLICATIONS IN HUMAN RESOURCE MANAGEMENT

The application of artificial intelligence techniques is playing a major role in reshaping traditional notions of what organisations are, how they are managed, and how decisions are made (Holsapple, 1989). This presents a major challenge and an important opportunity to today's managers and organisations. Though the transition will not be without pains, it will lead to tremendous increases in the productivity of managers and organisations. Those organisations in the forefront of applying AI methods to aid in management will have distinct competitive advantages over those that lag.

The essence of management is decision making, for the purpose of determining what course of action will be taken. Up-to-date knowledge about the environment in which a decision will be made is a necessary ingredient for good decision making. In addition, the decision maker must be able to analyse, evaluate, and reason with this knowledge in appropriate ways.

The integrated approach to expert systems for management can change the very nature of decision-making process, managerial practices, and an organisation itself.

Byun and Suh (1994) reported that expert system have been successfully applied to human resource domains. It is a subject covering issues that are versatile and open. The complexity of HRM problems and critical nature of the decisions to be made make HRM one of the most important application fields for expert systems. In HRM expert system the knowledge needed usually will be obtained from HRM experts who themselves may become users of the HRMES.

An expert system can produce a list of suitable candidates for promotion by using information from the database. If more information was required, it would ask the user to answer questions. It would also respond to users' questions about why particular candidates had been identified, by giving details of qualifications, performance appraisal results and so on.

The following table summarizes the crucial activities that could possibly be developed as an ES in organisations and their non-ES techniques that have been used in conventional personnel management (Byun & Suh 1994).

Table 2.1 Conventional methods for achieving HRM activities

Planning	Determination of future HR needs by taking cognizance of supply and demand	Situation analysis; forecasting and modelling (Markov chain, regression analysis); Delphi
Job analysis	Collection and recording of information concerning the purpose of a job, its duties, and condition	Use of chart; questionnaires, observation; interview; job incumbent diary
Recruitment	Process of identifying and attempting to attract job candidates who have abilities and attitudes needed to achieve organisational objectives	Job posting; advertisements; college recruitment; employment agencies; realistic job preview; computer databases
selection	Process of choosing which job candidates best suit organisational objectives	Interview; application blank; background; reference checks; performance simulations; personality test; physical examination
Performance evaluation	Determination of the extent to which an employee is performing the job effectively	Graphic rating scales; behaviourally anchored rating scale; forced choice; critical incident technique; checklist; ranking; paired comparison
Compensation	Every type of reward (financial or non-financial) that individuals receive in return for performing organisational tasks	Pay survey; job ranking; factor comparison; grading system; point system
Training	A planned effort to facilitate employee learning of job related behaviours in order to improve employee performance	Case method; role playing; in-basket technique; management game; behaviour modelling; on-the-job training; off-the-job training; transactional analysis; career planning
Labour management relation	Negotiation of a contract concerning pay, hours and other conditions of employment	Union and bargaining

The ES in these domains can assist operational, tactical and top management decisions. In the development of ES, several influencing factors and decision types must also be considered according to each HRM activity.

An expert system can also decide such problems as wage adjustment, education discipline and team assignments.

Recently, Tavana et al. (1994) describe the development and validation of an expert system for screening entry level candidates for employment in an accounting firm. The system is designed to assist a recruiter conducting campus interviews in deciding which candidates to call for a second interview at company premises. According to these workers, such expert systems have the potential for improving consistency and efficiency of the many human recruiters' decisions, and for minimizing personal biases or the use of unlawful criteria (e.g., race, gender, or age) in these decisions. The system developed by these workers is one of the few studies in which the development and validation of an expert system for a human resources decision is adequately documented. It clearly establishes the feasibility and usefulness of such an expert system.

Human resource management expert systems (HRMES) are decision support systems to aid HR managers who have to solve complex HRM problems.

HRMES has similar characteristics with management expert systems (MES) and business ES. Expert systems for management (ESM) which capture the specialized knowledge and experience of line managers and staff analysts are applied to problems in management decision making, leaving three problem types: the technology, the level of management and the type of decision problem. Decision problems deal with three categories: resource allocation, problem diagnosis, and scheduling and assignment of resources. MES are also defined as decision aiding systems for managers who have to solve complex problems in their own fields and as combinations of both decision support systems and knowledge-based systems.

In comparing HRMES with other MES or ESM dealing with accounting, marketing, finance, and research and development (R&D) management, HRMES are similar to accounting because there are externally mandated rules. They are also similar to R&D management because expertise is not as well recorded and understood.

In practice management problems require knowledge-based decision support systems. The role of managers in organisations is largely defined as working to make decisions and solve problems. What requires attention is setting goals, creating or recognizing suitable courses of alternatives, and evaluating and choosing among alternatives. Decision-making entails following a cognitive process: stimulus, perception, cognition, decision and response.

The problems of HRMES are similar to other MES when they concern technology, such as the design of knowledge bases, but are different when they concern management. The results or goals of the HRMES are decisions to be executed.

The principle plays a role in making the rules that constitute the knowledge bases. For example, in planning the employment of employees, requirements and existing inventory are optimally balanced based on the strategic concepts for the HR executive; in assigning or placing employees to jobs, employee qualifications are optimally matched to the job requirements; in on-the-job training, the ES identify employee strengths, skills, knowledge and development needs and make recommendations for target training and placement decisions.

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CHAPTER THREE

APPROACHES FOR EXPERT SYSTEM DEVELOPMENT

3.1 DEVELOPMENT APPROACH

Various methods and approaches have been suggested for the development of knowledge based systems. None, however, has a comprehensive view of the development process. Each method puts its emphasis on different aspects of the development process (Hilal & Soltan 1993).

Although, at present it seems that there is no universal methodology for expert system development (this is hardly surprising as there is none for information systems), two major approaches underly all methods for expert systems development: the **life cycle** and **prototyping** approaches.

The life cycle approach consists of the following six phases.

Phase 1: **Feasibility analysis**

In this phase, the domain in which the expert system is to operate and the task which will be performed by the expert system are studied and analysed by the expert system builder.

Phase 2: **Conceptual design**

In this phase, the conceptual structure of the system is defined, along with a specification that describes the way in which the expert system will carry out the task. A good conceptual design tells the knowledge engineer what to look for and can be used to decide which issues are important and which are not.

Phase 3: **Knowledge acquisition**

In this phase, the knowledge required for performing the task is acquired from a human expert, actual case histories, reference sources, etc. Since expert system rely heavily on the quality of the knowledge they posses, knowledge acquisition is a crucial part of the expert system construction process.

Phase 4: **Knowledge representation**

In this phase, the knowledge is formalized and represented within a symbolic program so that it is executable by the inference engine. Knowledge must be expressed in the knowledge representation method and the language of the expert system tools used for building the expert system.

Phase 5: **Validation**

In this phase, user's views, expert opinions, or operational criteria are used to determine whether the expert system (developed in Phases 1-4 above) has achieved an acceptable degree of success.

Phase 6: **Implementation and maintenance**

In this phase, the expert system is moved to an operating business or an industrial environment, and its structure and use are gradually modified through maintenance.

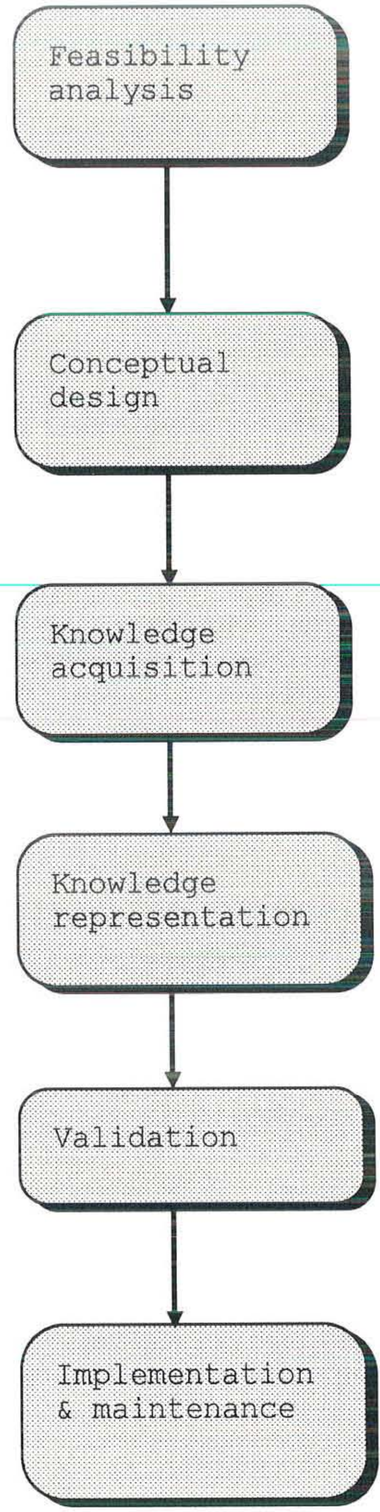

Figure 3.1 The expert system life cycle

The fundamental theme of the life cycle approach philosophy is that implementation should only take place after a thorough analysis of the problem, and that it should be possible to provide a complete and correct specification of the required system before technical design or implementation take place.

In the application of this to expert system, usually in practice, it is very difficult to obtain a detailed analysis of the problem when the expertise is hidden in the mind of the expert. At times experts themselves might not hold the actual expertise suitable to solve the problem - a fact difficult to determine in the early stages of the project. Hence, spending more time in analysing this hidden knowledge in order to specify it is considered costly activity as well as time consuming and risky - as it could turn out to be fruitless (when resulting in piles of useless paper work which can be meaningless to management). The design-before-you-begin approach that conventional software encourages is impractical when what is being designed is a representation of someone's knowledge, which itself may not be fully understood at the beginning. To this end, it is generally suggested that developers might be better off developing the system prototype (which does not require extensive analysis at the initial stage) which can be presented to management, and modified per their reactions.

A prototype is a system which has some of the essential elements of the final system, but not all. Prototyping is a common approach in expert systems because of the novelty and unstructured nature of problems that these systems solve. The development of a prototype is far cheaper than the full version, and the gradual expression of the prototype gives the managers who pay for the system more control over the cost and extent of the system. The point is, it is desirable to code the knowledge base in small groups of chunks that can be tested before risking too much on an extensive detailed design process. By showing the in progress prototype to the expert and getting feedback early, we quickly refine our understanding of the knowledge before investing too much.

Representing the knowledge elicited from the expert is another difficulty faced in the life cycle approach, especially when the experts themselves do not hold a particular representation in their minds. Thus, the knowledge engineer resorts to a representation which might not suit the problem or be difficult to visualise by the expert. This results in added complication of communication between the expert and the knowledge engineer, where as if immediate implementation was allowed (prototyping), the feedback from the expert would be more natural once the expert tries the system - a picture is worth a thousand words.

Producing a prototype of an expert system, however, does not mean the stages of system development identified in the life cycle approach are discarded. Rather, in prototyping an expert system, the developer goes through these stages in a quick and incomplete fashion, enhancing each stage in the next iteration of the prototype. By nature, prototype involves a number of iterations, through which the prototype is gradually altered and expanded to meet organisational needs.

In view of the foregoing considerations, in this study, the prototyping approach is used since it is the easiest, fastest and most effective way of checking the knowledge within the project constraints.

3.2 KNOWLEDGE REPRESENTATION APPROACH

3.2.1 General Context

The single most important part of any expert system is its knowledge base, that is, the set of heuristic rules (i.e., rules of thumb) that serve to determine the conclusion at which the expert system ultimately arrives. Knowledge representation refers to the form/format in which knowledge is to be stored in computers.

Some of the inspiration for developing knowledge representation methods has come from observing how humans in general cope with the problem of representing and organizing knowledge. The human mind, like other reasoning systems, faces the problem of storing knowledge in some type of memory, retrieving knowledge from that memory when it is needed, and acting on knowledge.

There are many ways of representing knowledge in expert systems. Three of the most popular are: Semantic Network, Frame, and Production System[1].

The earliest explicit attempts at knowledge representation in artificial intelligence (AI) reflected psychological models of human memory and drew on the analogy between knowledge and natural

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1 Other methods of knowledge representation include case-based knowledge gathered from cases of actual experience in an application area, predicate logic, fuzzy logic, and so on. For detailed discussion you are referred to Parsaye and Chignell (1988), and Ford (1991).

size of a knowledge base increases and, partly because it is easier to interface other methods of knowledge representation to an inference engine. However, ideas based on semantic networks still exist in some recent knowledge representation environments.

Frames are also used as a means of knowledge representation in the form of a hierarchy or network of frames. A frame is a collection of knowledge about an entity or other concept. Each frame is a complex package of slots, that is, data values describing the many characteristics or attributes of an entity, including its relationships to other entities (See Figure 3.3).

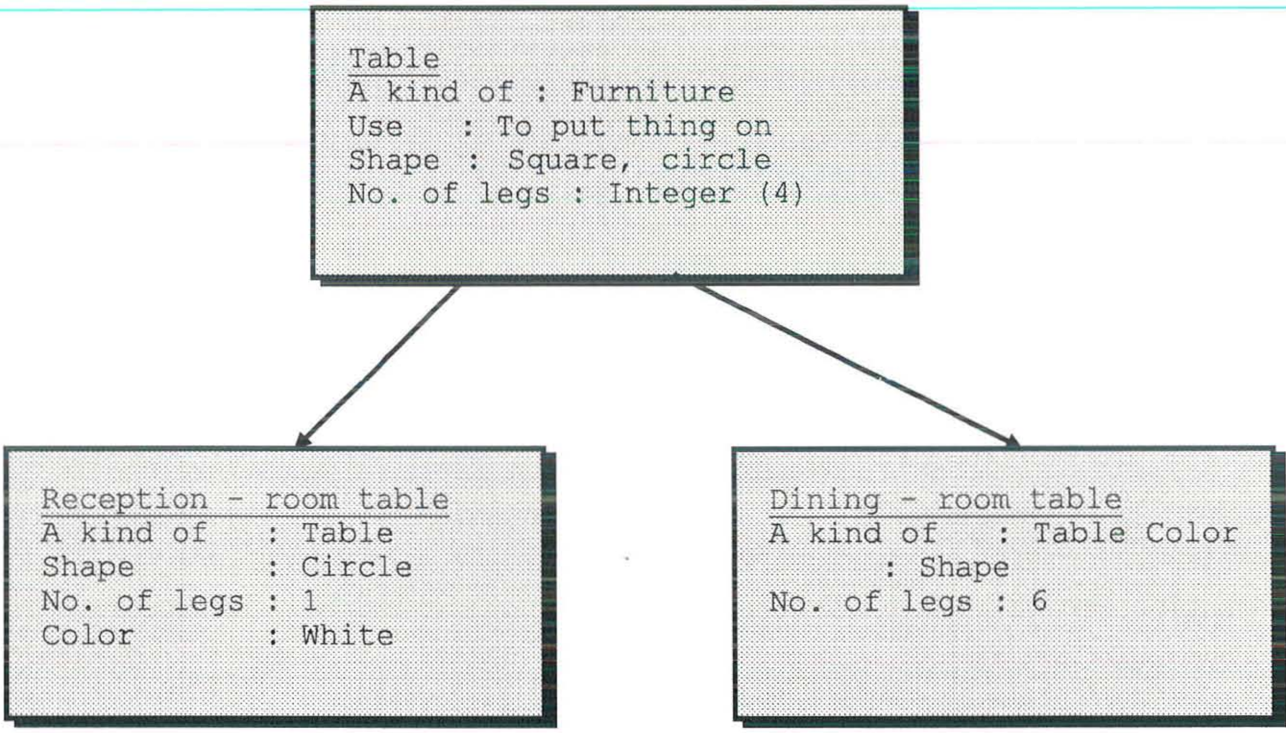


Figure 3.3 Frames

Another early approach to knowledge representation was based on production rules. In this approach knowledge is represented as a series of IF....THEN rules. In this study rule-based approach is used for knowledge representation for reasons of its popularity and widespread use, and thus discussed in detail in the next section.

3.2.2 Rule-based Approach

Rule-based production systems are one of the most widely used models of knowledge representation in AI, in particular expert systems. Rule-based expert systems represent knowledge in the form of rules and statements of fact (Parsaye and Chignell, 1988). The rule consists of a conditional part (IF...) being a prerequisite and a conclusive part (THEN...) identifying a fact or action - if the conditional part holds, the conclusive part results. Through the development of such rules, we attempt to represent the decision making process through which a human expert, or experts, solve certain types of problems. In this regard, a collection of rules is said to represent a knowledge base.

Rules - the basic building block of rule-based expert systems - seem a natural way to summarize much of what we know. They can be added, changed, and deleted with less impact on the workings of the program than with most conventional programs in which any change to the program's logic runs a high risk for entering "bugs" into the program.

While alternative modes of knowledge representation exist, and have their particular uses, advantages, and disadvantages, the rule-based approach is the one that is, far and away, the most commonly encountered - as well as the most widely implemented in actual practice - the most popular early expert system, MYCIN employ rule-based knowledge representation.

The modular, easy to read nature of declarative rules written with English-like syntax can make an expert system easier to read for non-programmers, and easier to maintain for the maintenance programmer.

CHAPTER FOUR

DESIGN AND DEVELOPMENT OF THE PROTOTYPE

4.1 KNOWLEDGE ACQUISITION

The knowledge acquisition, for the purpose of developing the prototype, is mainly done through discussions with experts in the Staffing Department, and supplemented with knowledge obtained from guideline for promotion processing.

In the acquisition process discussion were held with four domain experts. Their responsibility and qualifications are indicated below.

Table 4.1 Profile of domain experts

Position	Education	Experience
Head, Staffing department	B.A., Management	29 years
Team leader, promotion and salary increment	B.A., Management	22 years
Expert, promotion and salary increment	B.A., Political Science and international relations (minor public administration)	7 years
Expert, promotion and salary increment	B.A., Public administration	5 years

The selection of domain experts for acquisition interview and discussion is made on the basis of their experience and responsibility.

After conducting a discussion with these experts, an insight as to how the personnel selection problem is analysed and decomposed is gained. Next, the enhancement of the knowledge gathered is achieved by constructing a model to resolve decision problems on the basis of the additional knowledge captured from printed document, such as:

- guideline for promotion processing,
- International Standard Classifications of Occupations (ISCO),
- International Standard Classification of Education (ISCED), and
- Ethiopian Classification of Occupations (ECO).

As a result of the unstructured interviews, the experts way of identifying the relevant education and experience is observed. Education is divided into two in terms of their degree of relation to education required by the job for rating: relevant and not relevant. Experience is divided into three in terms of their degree of relation to the job for rating: direct, indirect, not related.

4.2 PROBLEM ANALYSIS

The first attempt made in the analysis of the problem is to document the existing promotion processing on the basis of the knowledge gathered. Figure 4.1 illustrates the principal action steps involved in the promotion processing.

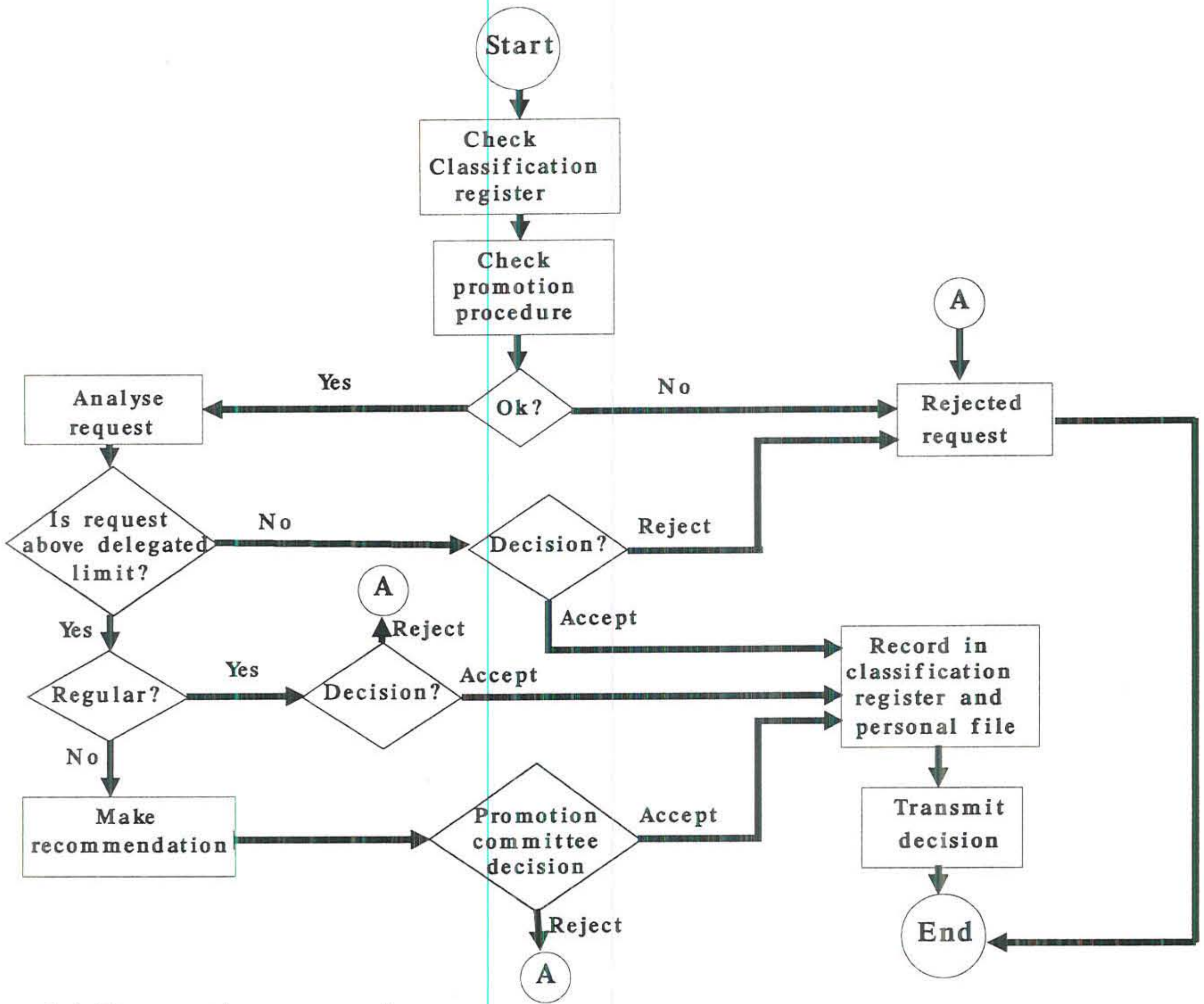


Figure 4.1 Promotion procedure

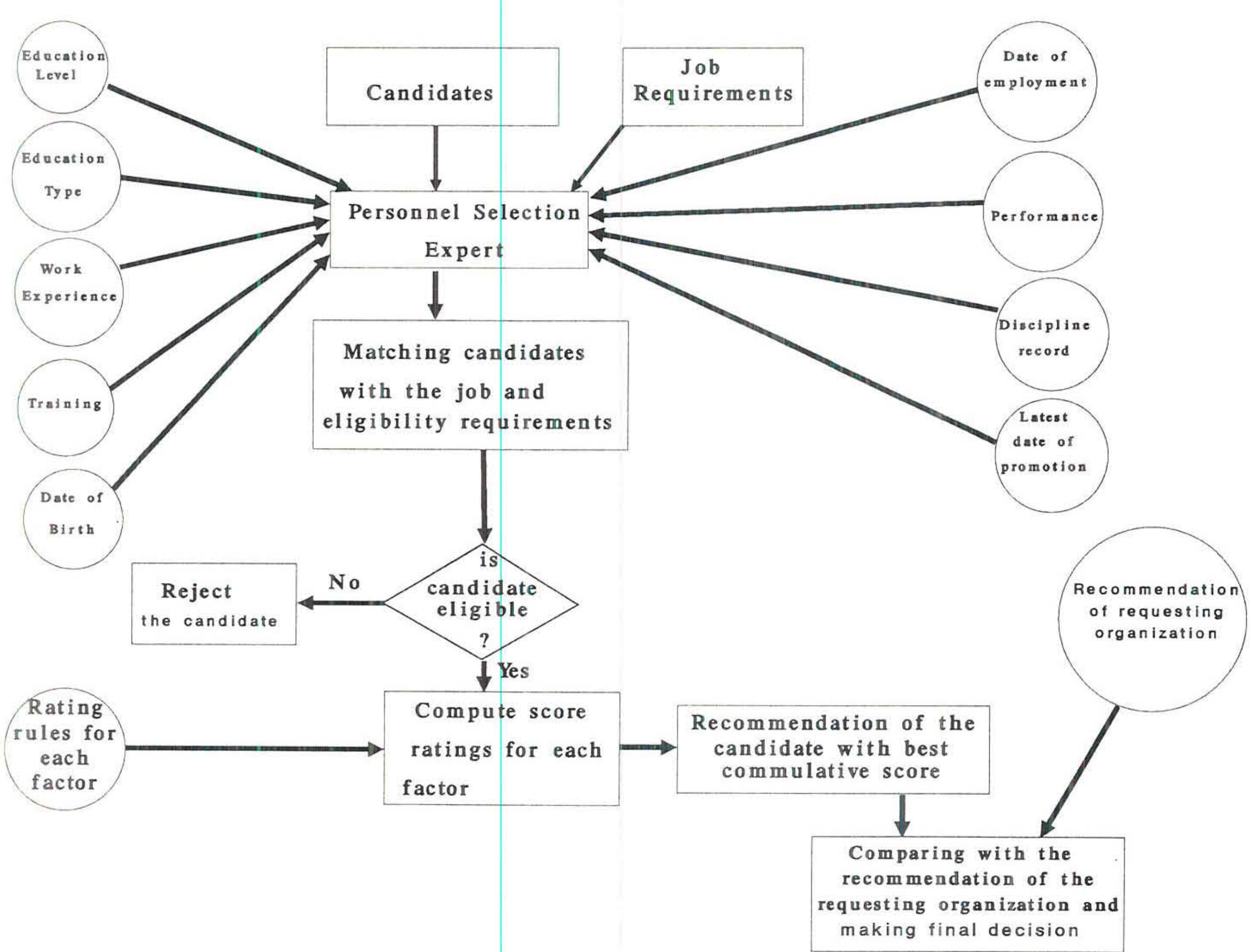


Figure 4.2 The analysis of promotion request

According to the guideline for promotion processing, to be registered as an eligible candidate, an employee should:

1) deserve the requirements for the vacant post;
2) be a permanent employee;
3) complete probation period for employment;
4) complete nine months after latest promotion;
5) have efficiency result greater than or equal to 3.45;
6) resume the previous post and salary in case of demotion or salary decrement with time limit;
7) be authorized by the head of the organisation to be a candidate in case of demotion or salary decrement with no time limit;
8) have not been hindered from salary increment; and
9) have left with more than three months for pension.

And to deserve the requirements for the post a candidate should have:

- adequate education level; and
- relevant education type and work experience.

Checking adequate education level, in turn, requires matching education level and year of experience of the candidate against the minimum requirements for the job. Minimum education level and year of experience as well as base salary for the job are determined by its grade according to position classification in the civil service.

There are six categories in the position classification for grading jobs (see Table 4.2).

Table 4.2 Position classifications

Classification	Grades
Professional & Scientific service (PS)	PS1 - PS9
Administrative service (AD)	AD1 - AD9
Sub-Professional service (SP)	SP1 - SP12
Clerical & Fiscal service (CF)	CF1 - CF12
Trades & Crafts service (TC)	TC1 - TC10
Custodial & Manual service (CM)	CM1 - CM5

The following are examples of minimum education level and year of experience requirements for job grades PS4 and PS3.

a) For job grade PS4, the minimum requirement is (base salary Birr 980)

- bachelor degree and 6 years work experience, or
- masters degree and 4 years work experience, or
- doctorate degree and 2 years work experience, or
- law/engineering bachelor degree and 4 years work experience, or
- law/engineering masters degree and 2 years work experience, or
- law/engineering doctorate;

b) For job grade PS3, the minimum requirement is (base salary Birr 835)

- bachelor degree and 4 years work experience, or

- masters degree and 2 years work experience, or
- doctorate degree, or
- law/engineering bachelor degree and 2 years work experience, or
- law/engineering masters degree.

As indicated in Figure 4.2, a lot of information is obtained from different sources for the analysis of promotion request. In matching education and experience of the candidate, first, education level and year of experience will be checked against minimum requirements of education level and year of experience for the job grade. Then relevancy of the education and experience of the candidate will be checked. That is, if education type and experience are related to the job, they are relevant, otherwise they are considered irrelevant.

Once the candidates records are analysed and checked against eligibility requirements, score rating will be determined. During these process such information as education type, education level, experience, training, performance evaluation, and discipline records will be obtained on each candidate from their personal records.

The weights for the factor considered in the selection process are:

- 45% for education;
- 30% for experience and training;
- 20% for performance; and
- 5% for discipline record.

While scores for education level and disciplinary record are allocated per the weights indicated in Table 4.3 and 4.4 respectively, the score for work experience will be allocated using the factor rate 0.74 for each year. Thus, to get score rate of the candidate experience (in relation with the job), his/her year of experience will be multiplied by either:

- 0.74 for experience having direct relation,
- one-half of 0.74 for experience having indirect relation, or
- one-fourth of 0.74 for experience having no relation.

The weight of 20% for performance is allocated for the points 3.45 to 5.00. Accordingly the performance result will be multiplied by 4 to get the score rate.

Table 4.3 The scores allocated for education

Education level	Score rate in relation to the job	
	relevant	not relevant
. . .		
bachelor	37	27
masters	41	29
doctorate	45	31

Table 4.4 The scores allocated for discipline record

Discipline action	Score rate
Demotion or hindrance from salary increment	0
Punishment above one month salary and not more than two months salary	1
Punishment of one month salary	2
Warning more than once	3
First time warning	4
No discipline record	5

The experts determine the best candidate on the basis of such ratings.

The education and experience factors are the ones difficult to rate and that require expert knowledge.

The rate for education is divided into two:

- relevant to the job; and
- not relevant to the job,

and requires relevant judgement. Education type is considered relevant if it is one of the required education types or if it is related to one of the required education types.

The rate for experience is divided into three:

- directly related to the job;
- indirectly related to the job; and
- not related to the job.

There is no standard for making decision on the relations of education type and experience to the job. Experts make these decisions by experience and analysing job descriptions.

In an effort to simplify (the difficulty of rating education & experience), it is assumed reasonable to classify occupations and educations based on International Classification of Occupations and International Standard Classifications of Education. In an attempt to form such categories occupations are structured in two levels: group and broad group. A group is made up of a number of individual occupations which are more related to each other (on the basis of the type of work performed) than to occupations outside the group. Table 4.5 shows a sample of the occupation category organised into groups and broad groups.

Table 4.5 Sample occupation category

Occupation	Group	Broad group
- Chemist, general - Organic chemist - Inorganic chemist - Analytical chemist - Biochemist - Other chemists	Chemists	Physical scientists
- Physicist, general - mechanics physicist - Heat physicist - Light physicist - Sound physicist - Electricity and magnetism physicist - Electronics physicist - Nuclear physicist - Other physicists	Physicists	
- Statistician, general - Mathematical statistician - Statistician, applied statistics - Demographer	Statisticians	Statisticians, mathematicians, systems analysts and related specialists
- Mathematician, pure mathematics - Mathematician, applied mathematics - Operations research analyst - Actuary	Mathematicians and actuaries	
- Systems analyst - Computer programmer	Systems analysts and computer programmers	

Educational background is structured in a group which is based upon a subject-matter content of the study. The following are samples of the education group:

- Biological science programmes
- Chemistry programmes

- Physics programmes
- Programmes in statistics
- Programmes in actuarial science
- Programmes in mathematics
- Programmes in computer science

These categories of occupation and education are used in the decision process as indicated in Figure 4.3 & 4.4 respectively.

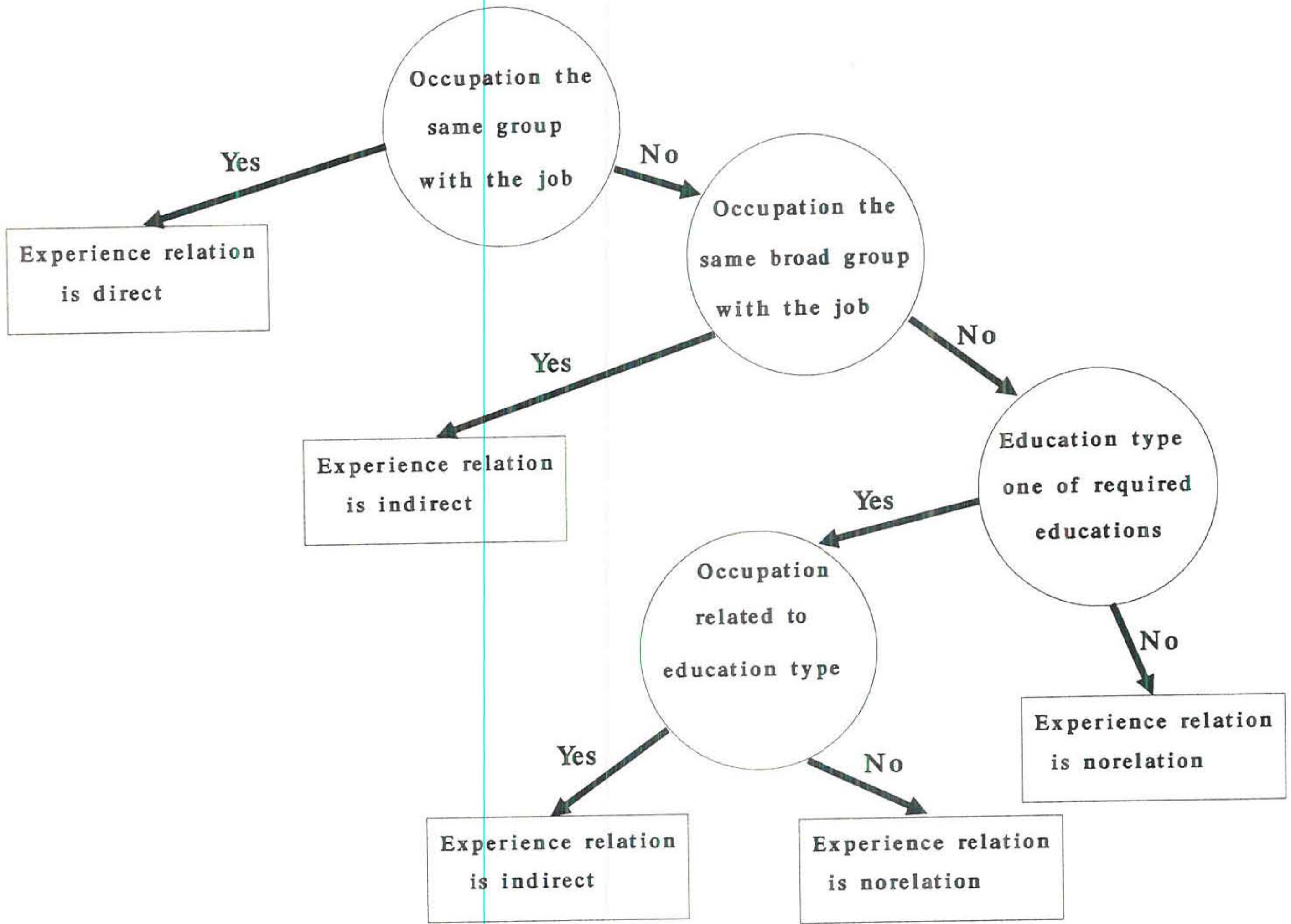


Figure 4.3 Decision tree for experience relation

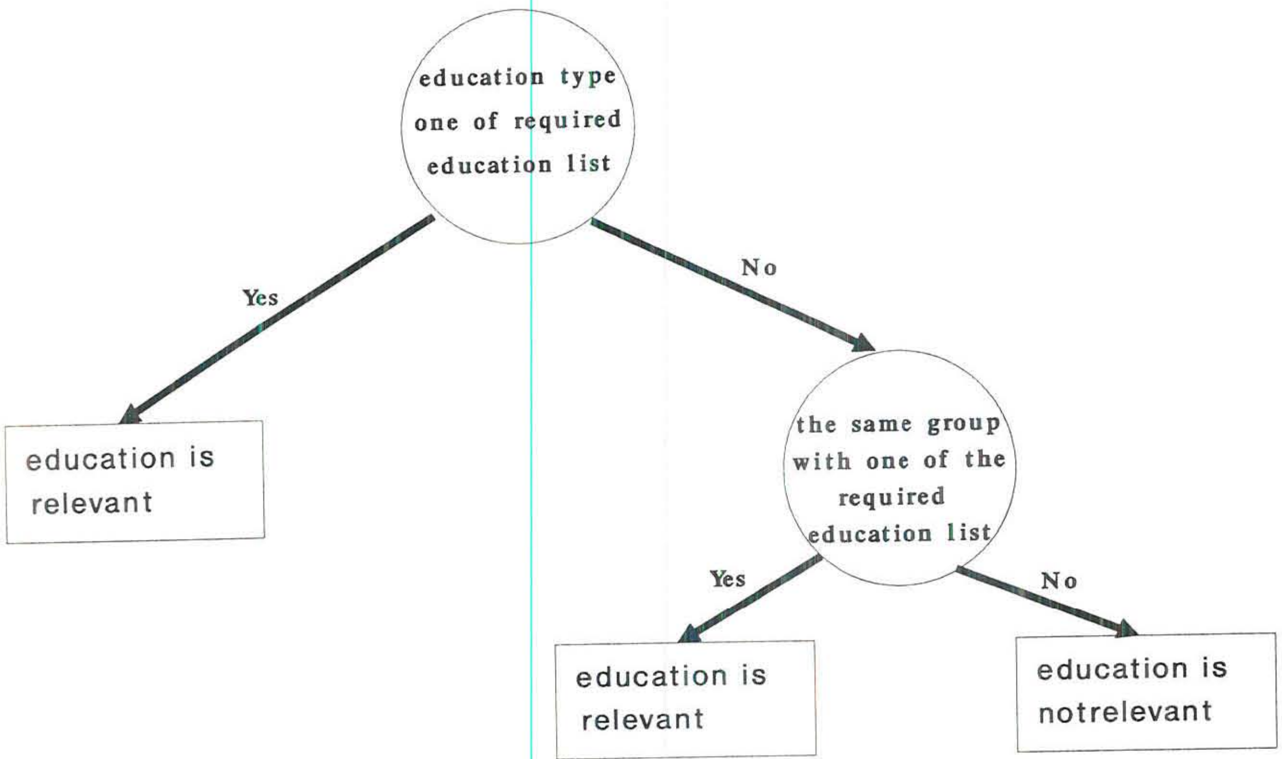


Figure 4.4 Decision tree for deciding education relevancy

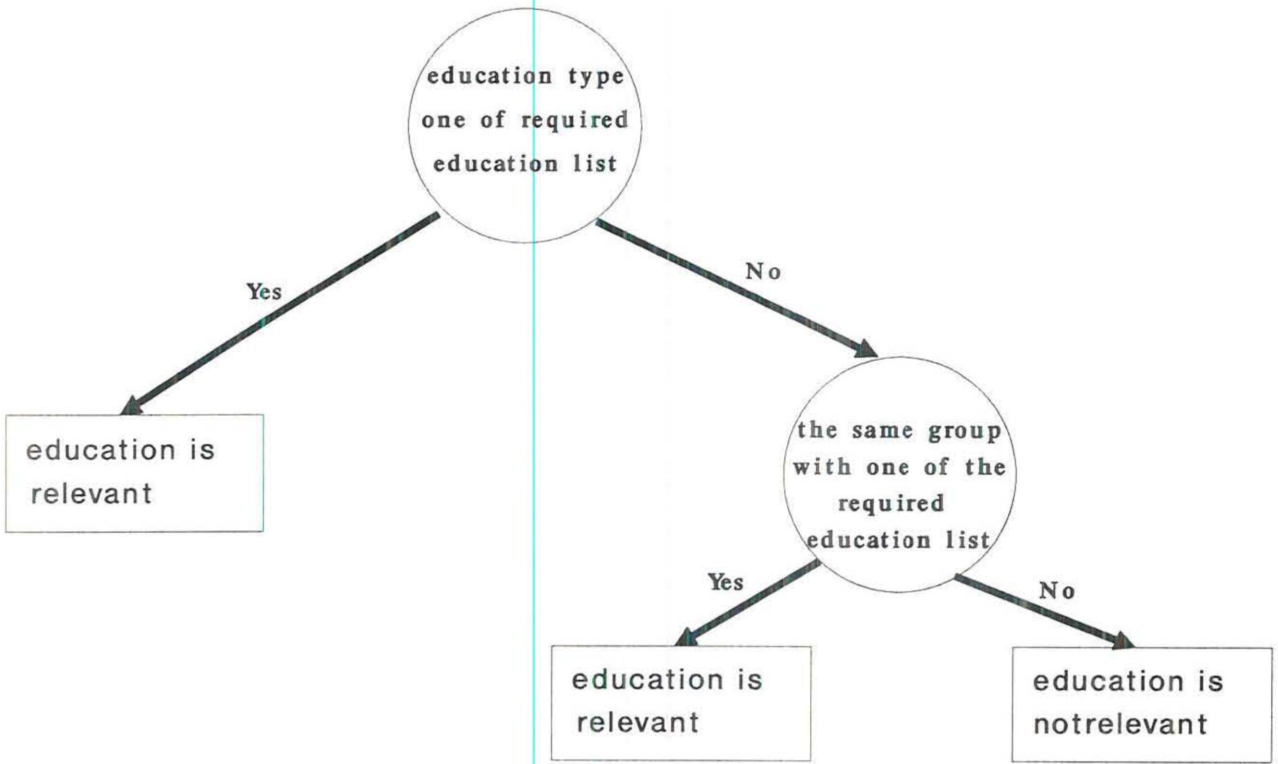


Figure 4.4 Decision tree for deciding education relevancy

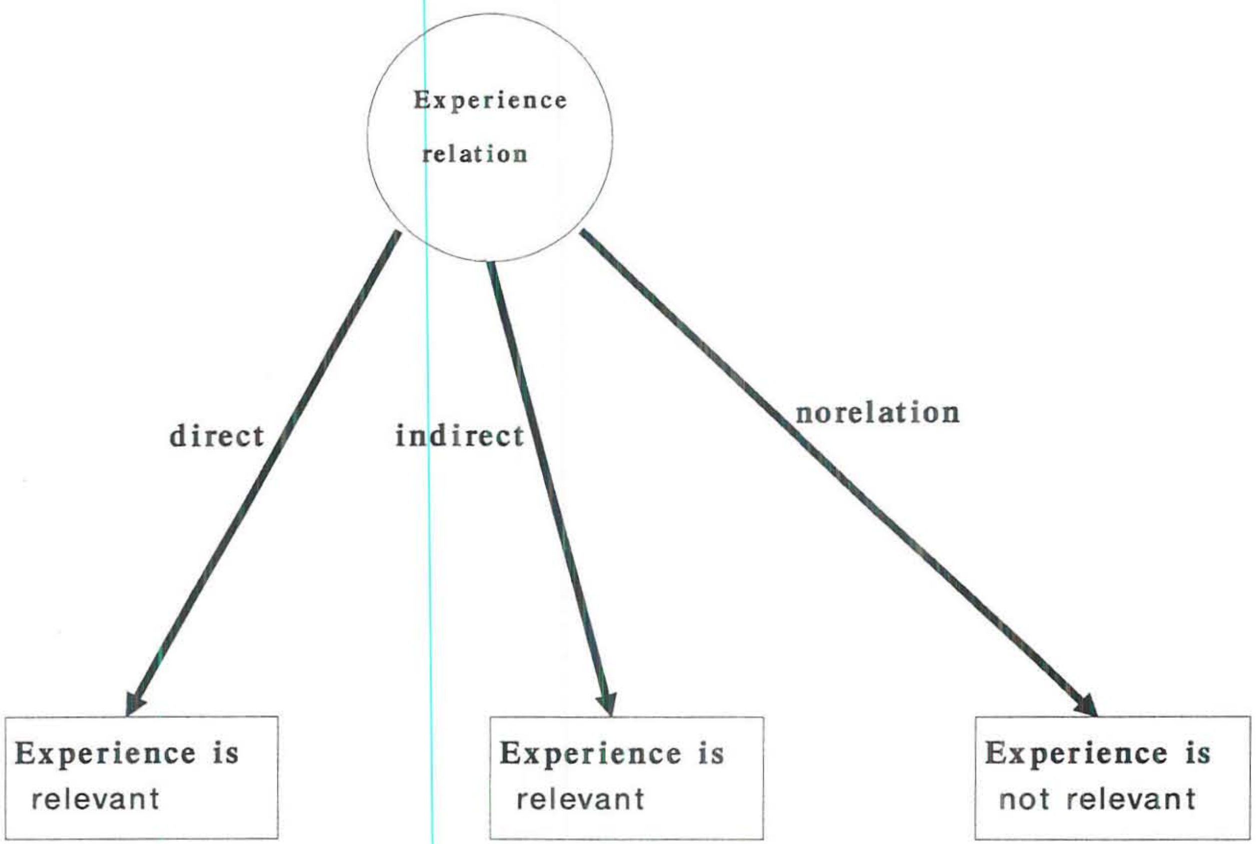


Figure 4.5 Decision tree for deciding experience relevancy

The experts primary compliant about the current process is that they are very busy and have no enough time for the promotion processing. Due to the workload decisions may not be taken on time and there is delay of decision on the approval of promotion request of employer organisations. They all believed that their time could be better utilized if routine tasks could be computerized.

Finally, the experts noted that, in selecting personnel for promotion, the criteria used are those indicated in the guideline for promotion processing, but the guideline have no any more information in deciding relevant education and experience. The experts believe that there must be some standards established on education relations and occupations that suit the purpose. In case of exact match there is no difficulty in deciding the relevance. In case of similar there is no clear cut for deciding those similarity with the job.

4.3 PROTOTYPING

A prototype expert system is designed on the basis of the knowledge gathered to help standardize the decision making process in the personnel selection process and in an attempt to alleviate the problems being experienced in the existing manual system.

4.3.1 System Overview

The prototype system developed is made to contain knowledge on:

- the requirements of the job,
- candidates records,
- rules for matching employee against the job,
- rules for factor ratings,
- occupation relationships, and
- education relationships.

The prototype system developed is made to operate by:

- taking into account the attributes that define rules for matching candidates against the job,
- interacting adequately with the user through a friendly interface,
- storing occupation relationships,
- storing education relationships,
- relating candidate records to job requirements, and
- recommend best candidate appropriate to the requirement of the job.

The general structure of prototype developed and its components are outlined in Figure 4.5 and 4.6 below respectively.

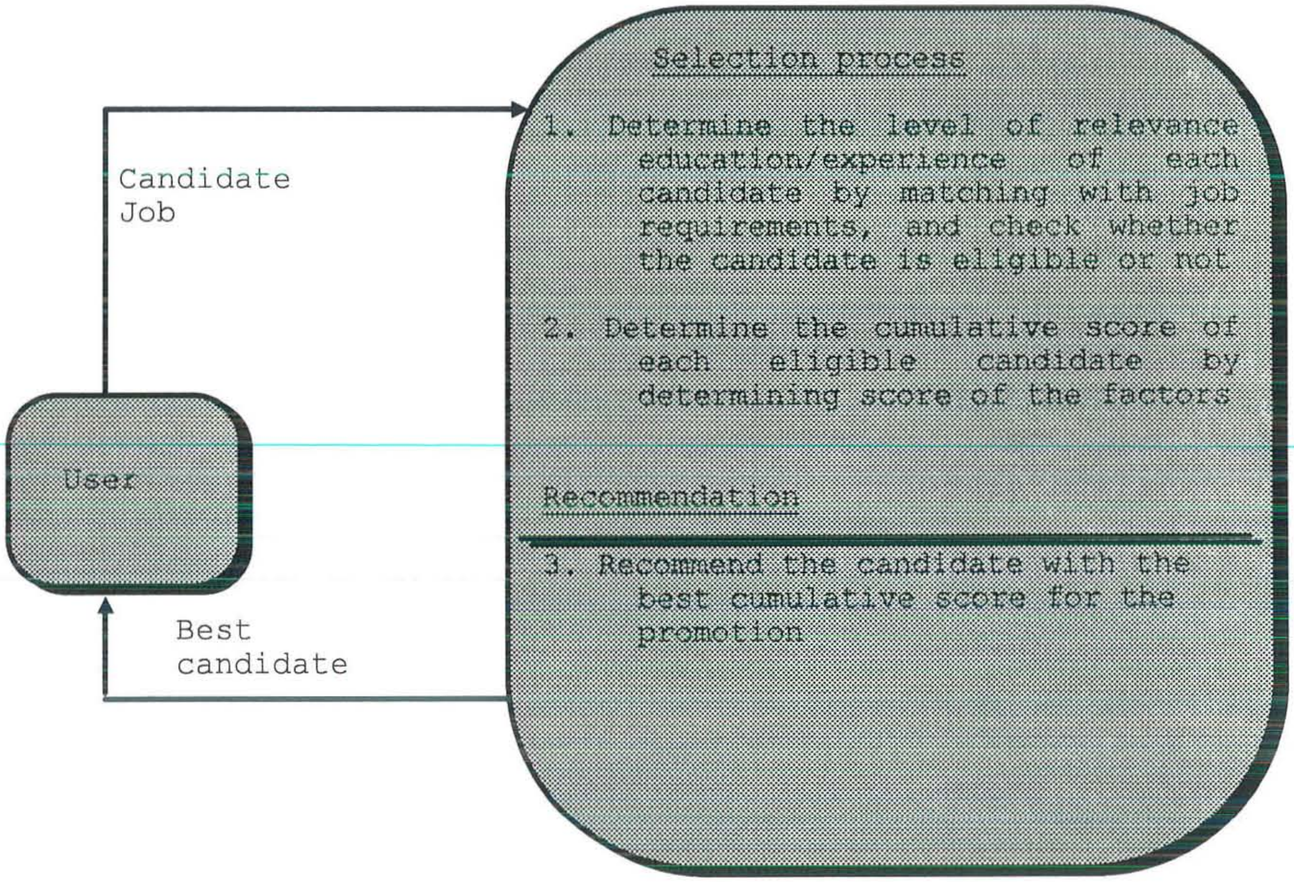


Figure 4.6 Overview of the prototype system

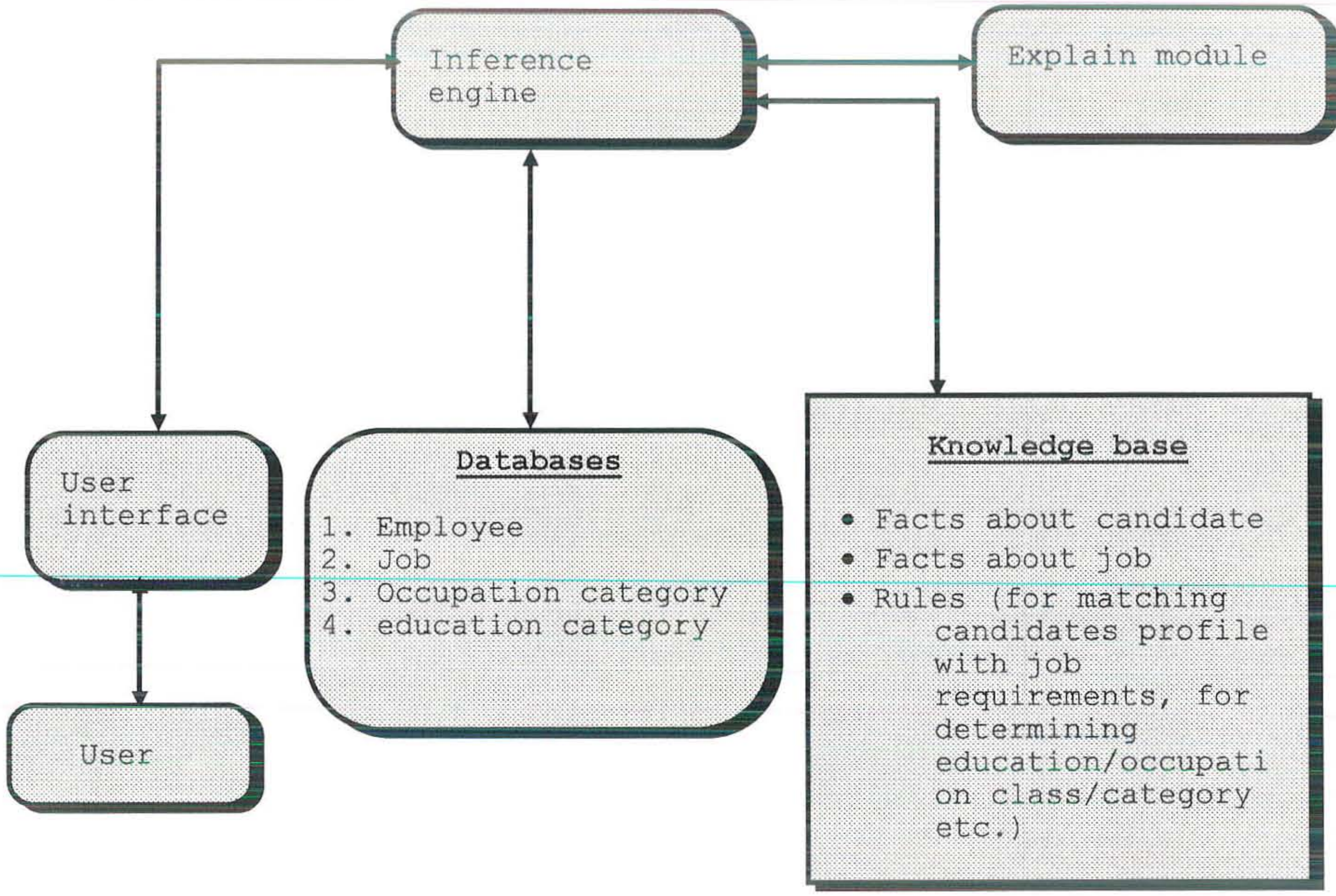


Figure 4.7 The components of the prototype expert system for personnel selection and promotion

Currently, the prototype system has about 50 rules plus databases. The database component is made up of the following databases created using dBase IV (Table 4.6).

Table 4.6 Record structure of databases

a) Job database

Job id.	Job title	Job grade	Salary	Occupation class

b) Req_ed database (Required educations)

Job id.	Education type	Education code

c) Employee database

Id. no	Name	Education type	Education level	Occupation	Occupation code	year of experience

d) O_class database (Occupation class/category)

Occupation code	Occupation	Occupation group	Occupation broad group

e) Ed_class database (Education group)

Education code	Education group

The explain module keeps track of the path/logic that the system is following to explain, upon the users request, the lines of reasoning, in processing the selection, used to reach the decisions.

The knowledge base component of the prototype system is discussed in detail in the following section.

4.3.2 Knowledge Base

The knowledge base of the prototype is organised into two parts: (a) knowledge base-1: a knowledge base to decide on the eligibility of candidates; and (b) knowledge base-2: a knowledge base for determining score ratings of candidates and recommend candidate with best score.

Knowledge base-1

This part of the knowledge base is consulted by the inference engine to decide whether a candidate is eligible or not.

The system interacts with the user:

- to identify the job and the candidates
- if the candidate has training related to the current job, and if yes, length of duration of training,
- the performance result of the candidate
- if there is any disciplinary action taken on the candidate in the past five years, if yes, the discipline action taken.

The system uses these facts and other facts from databases to determine the eligibility of a candidate.

The necessary attributes for the rules deciding on the eligibility are:

- education

- adequate education level
- experience
- performance result
- discipline action

Date of employment, latest date of promotion, and date of birth are not included in the prototype. It is assumed that the candidates:

- have completed six months probation period;
- have not been given promotion with in nine months more than once; and
- have left with more than three months for pension.

Table 4.7 Decision table for eligibility

Conditions					Action
AEL	P	DAL	E	EXP	Eligible
Yes	>= 3.45	NS	R	R	Yes
Yes	>= 3.45	NS	R	NR	No
Yes	>= 3.45	NS	NR	R	Yes
Yes	>= 3.45	NS	NR	NR	No
Yes	>= 3.45	S			No
Yes	< 3.45				No
No					No

Abbreviations:

E - education
AEL - adequate education level
Exp - experience
P - performance
DAL - discipline action level
R - relevant
NR - not relevant
S - serious
NS - not serious

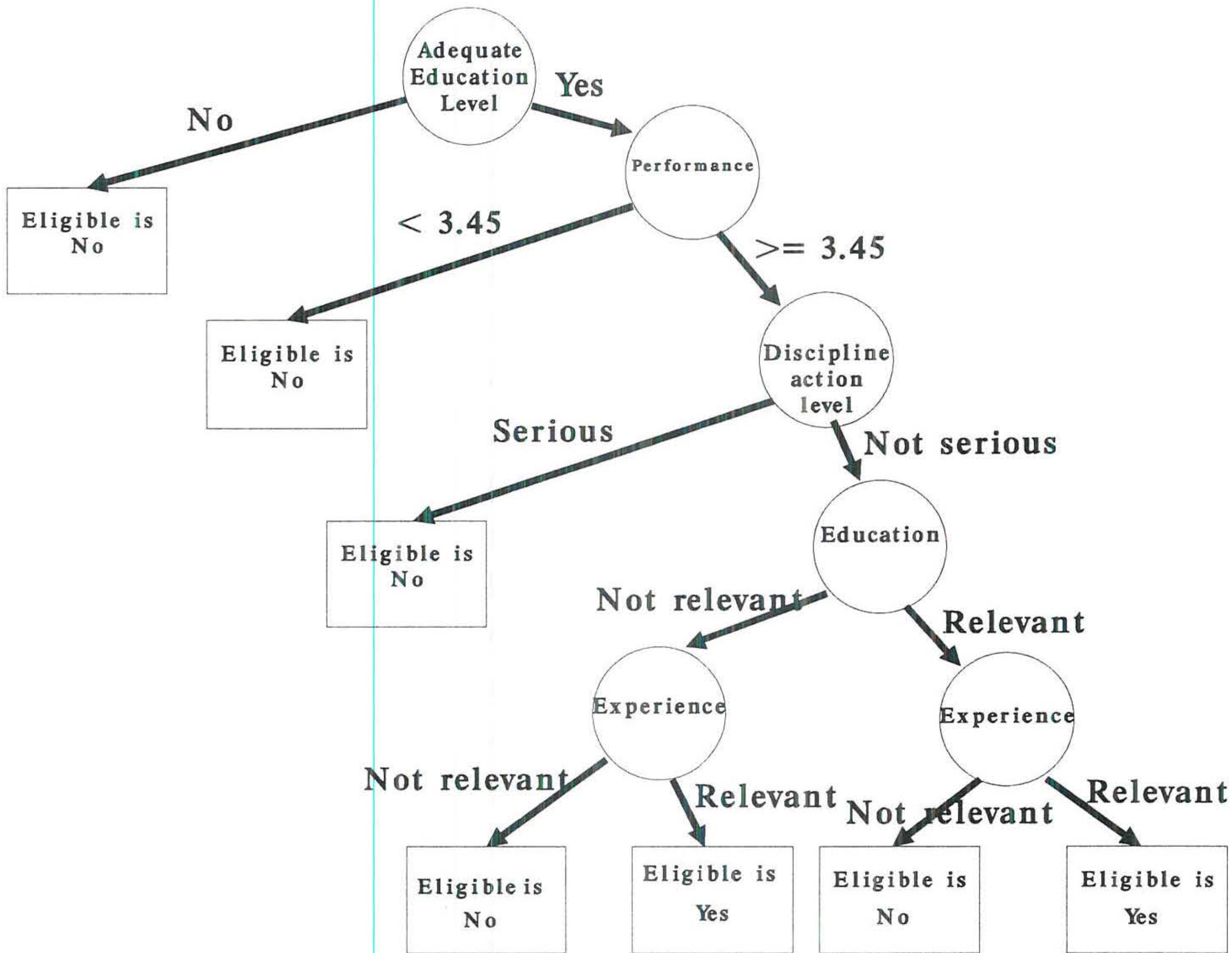


Figure 4.8 Decision tree for checking eligibility

The rule structure for checking eligibility is as follows:

If adequate education level is Yes
and performance result >= 3.45
and discipline action level is not serious
and education is relevant
and experience is relevant
then eligible is Yes

If adequate education level is Yes
and performance result >= 3.45
and discipline action level is not serious
and education is relevant
and experience is not relevant
then eligible is No

If adequate education level is Yes
and performance result >= 3.45
and discipline action level is not serious
and education is not relevant
and experience is relevant
then eligible is Yes

If adequate education level is Yes
and performance result >= 3.45
and discipline action level is not serious
and education is not relevant
and experience is not relevant
then eligible is No

If adequate education level is Yes
and performance result >= 3.45
and discipline action level is serious
then eligible is No

If adequate education level is Yes
and performance result < 3.45
then eligible is No

If adequate education level is No
then eligible is No

Using backward chaining the system searches the value of each of these attributes. For education, the system determines if it is relevant to the current job. Here for eligibility the education should be at least in the same broad group. Otherwise considered only if experience is relevant.

To decide on adequate education level the system checks job grade and minimum requirements in terms of education level and year of experience.

Table 4.8 Decision table for adequate education level (for professional science service grades)

Conditions				Action
Job grade	Candidate education level	Engineering or law	Year of experience (including training)	Adequate education level
PS1	bachelor	No		Yes
PS2	bachelor	Yes		Yes
PS2	bachelor	No	>= 2	Yes
PS2	bachelor	No	< 2	No
PS2	masters	No		Yes
PS3	bachelor	Yes	>= 2	Yes
PS3	bachelor	Yes	< 4	No
PS3	bachelor	No	>= 4	Yes
PS3	bachelor	No	< 4	No
PS3	masters	Yes		Yes
PS3	masters	No	>= 2	Yes
PS3	masters	No	< 2	No
PS3	doctorate	No		Yes
PS4	bachelor	Yes	>= 4	Yes
PS4	bachelor	Yes	< 4	No
PS4	bachelor	No	>= 6	Yes
PS4	bachelor	No	< 6	No
PS4	masters	Yes	>= 2	Yes
PS4	masters	Yes	< 2	No
PS4	masters	No	>= 4	Yes

PS4	masters	No	< 4	No
PS4	doctorate	Yes		Yes
PS4	doctorate	No	>= 2	Yes
PS4	doctorate	No	< 2	No
PS5	bachelor	Yes	>= 6	Yes
PS5	bachelor	Yes	< 6	No
PS5	bachelor	No	>= 8	Yes
PS5	bachelor	No	< 8	No
PS5	masters	Yes	>= 4	Yes
PS5	masters	Yes	< 4	No
PS5	masters	No	>= 6	Yes
PS5	masters	No	< 6	No
PS5	doctorate	Yes	>= 2	Yes
PS5	doctorate	Yes	< 2	No
PS5	doctorate	No	>= 4	Yes
PS5	doctorate	No	< 4	No
PS6	bachelor	Yes	>= 8	Yes
PS6	bachelor	No	< 8	No
PS6	bachelor	No	>= 10	Yes
PS6	bachelor	No	< 10	No
PS6	masters	Yes	>= 6	Yes
PS6	masters	Yes	< 6	No
PS6	masters	No	>= 8	Yes
PS6	masters	No	< 8	No
PS6	doctorate	Yes	>= 4	Yes
PS6	doctorate	Yes	< 4	No
PS6	doctorate	No	>= 6	Yes
PS6	doctorate	No	< 6	No
PS7	bachelor	Yes	>= 10	Yes
PS7	bachelor	Yes	< 10	No
PS7	bachelor	No	>= 12	Yes
PS7	bachelor	No	< 12	No
PS7	masters	Yes	>= 8	Yes
PS7	masters	Yes	< 8	No

PS7	masters	No	>= 10	Yes
PS7	masters	No	< 10	No
PS7	doctorate	Yes	>= 6	Yes
PS7	doctorate	Yes	< 6	No
PS7	doctorate	No	>= 8	Yes
PS7	doctorate	No	< 8	No
PS8	bachelor	Yes	>= 12	Yes
PS8	bachelor	Yes	< 12	No
PS8	bachelor	No	>= 14	Yes
PS8	bachelor	No	< 14	No
PS8	masters	Yes	>= 10	Yes
PS8	masters	Yes	< 10	No
PS8	masters	No	>= 12	Yes
PS8	masters	No	< 12	No
PS8	doctorate	Yes	>= 8	Yes
PS8	doctorate	Yes	< 8	No
PS8	doctorate	No	>= 10	Yes
PS8	doctorate	No	< 10	No
PS9	bachelor	Yes	>= 14	Yes
PS9	bachelor	Yes	< 14	No
PS9	bachelor	No	>= 16	Yes
PS9	bachelor	No	< 16	No
PS9	masters	Yes	>= 12	Yes
PS9	masters	Yes	< 12	No
PS9	masters	No	>= 14	Yes
PS9	masters	No	< 14	No
PS9	doctorate	Yes	>= 10	Yes
PS9	doctorate	Yes	< 10	No
PS9	doctorate	No	>= 12	Yes
PS9	doctorate	No	< 12	No

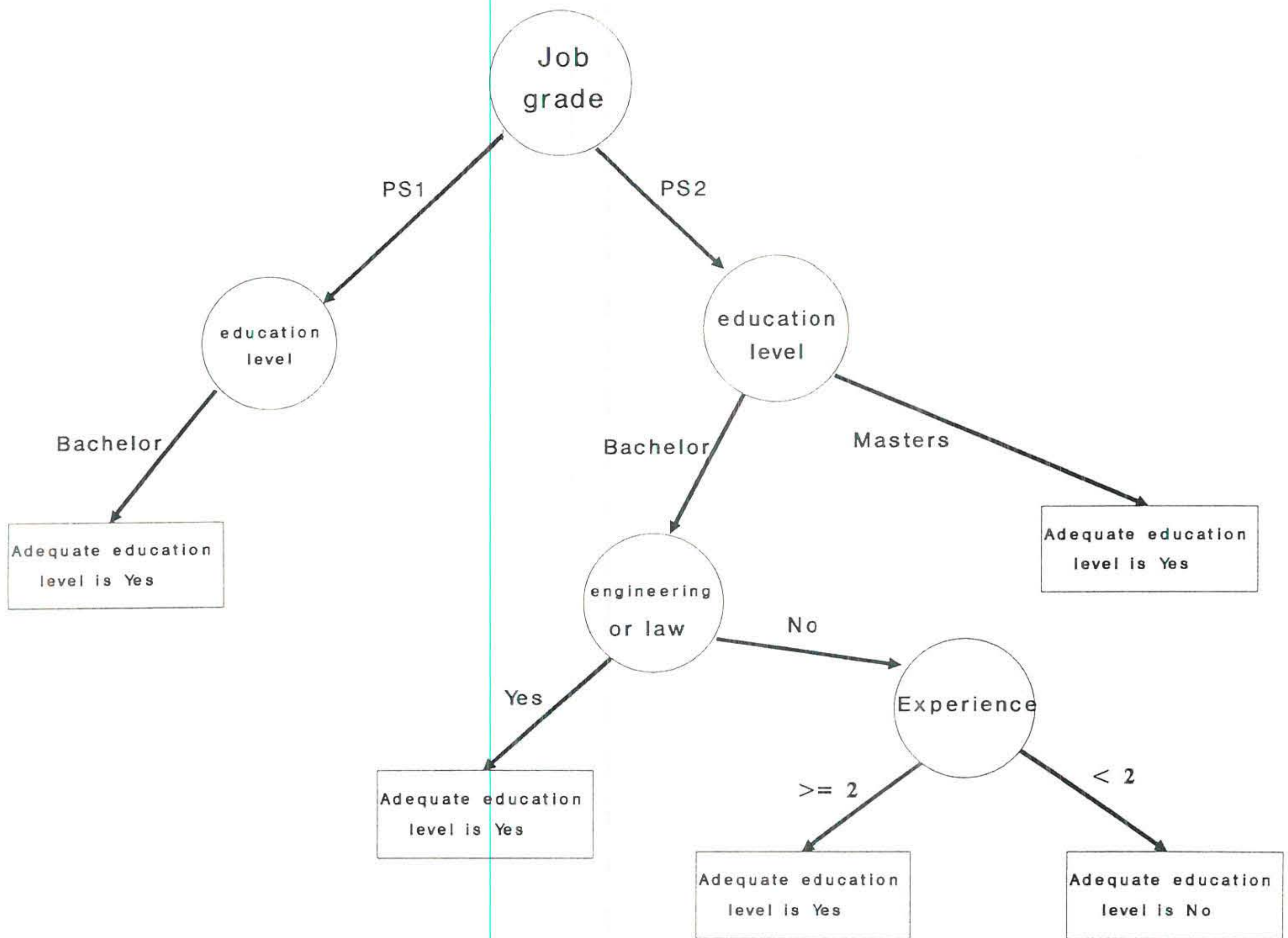


Figure 4.9a Decision tree for deciding adequate education I.

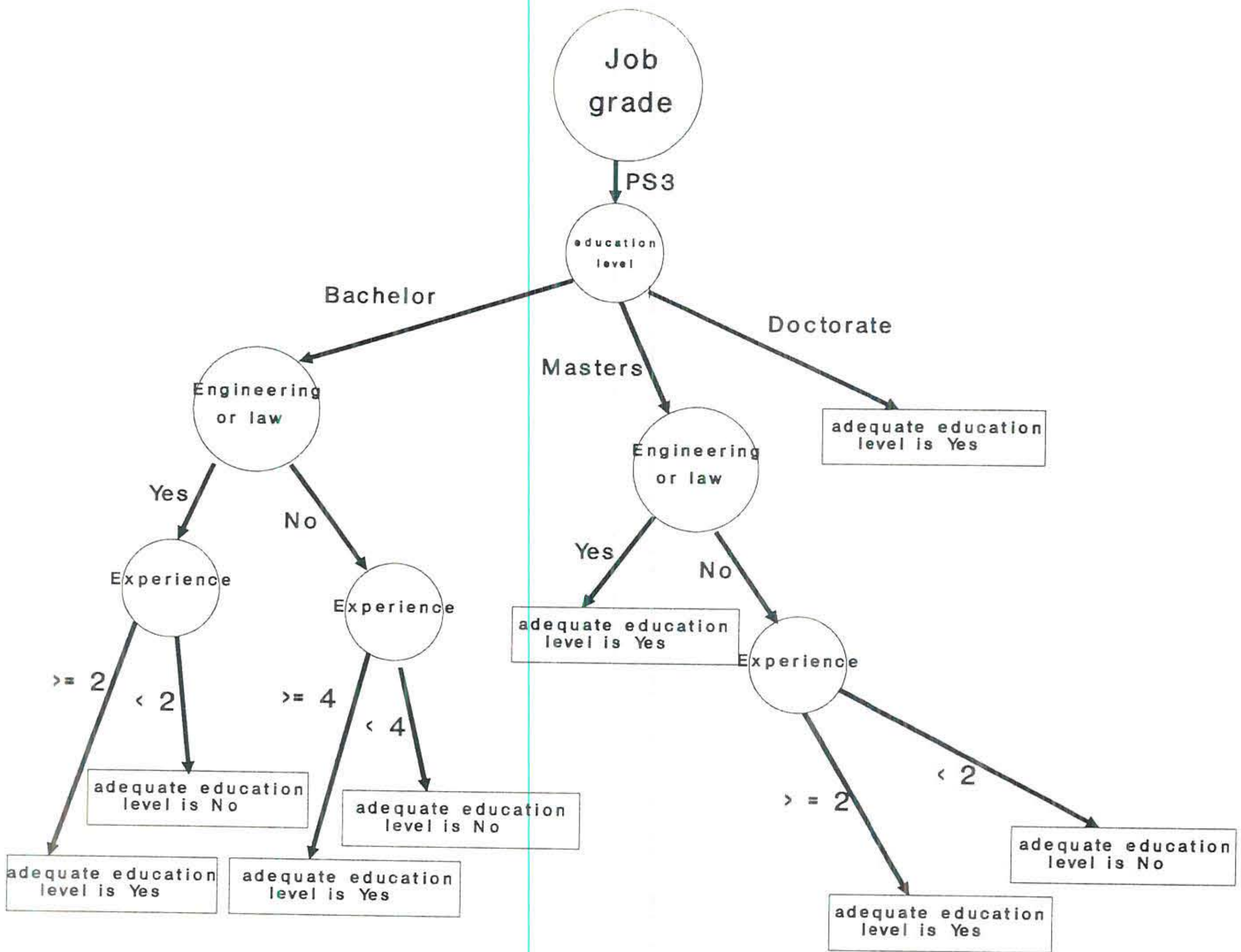


Figure 4.9b Decision tree for deciding adequate education l

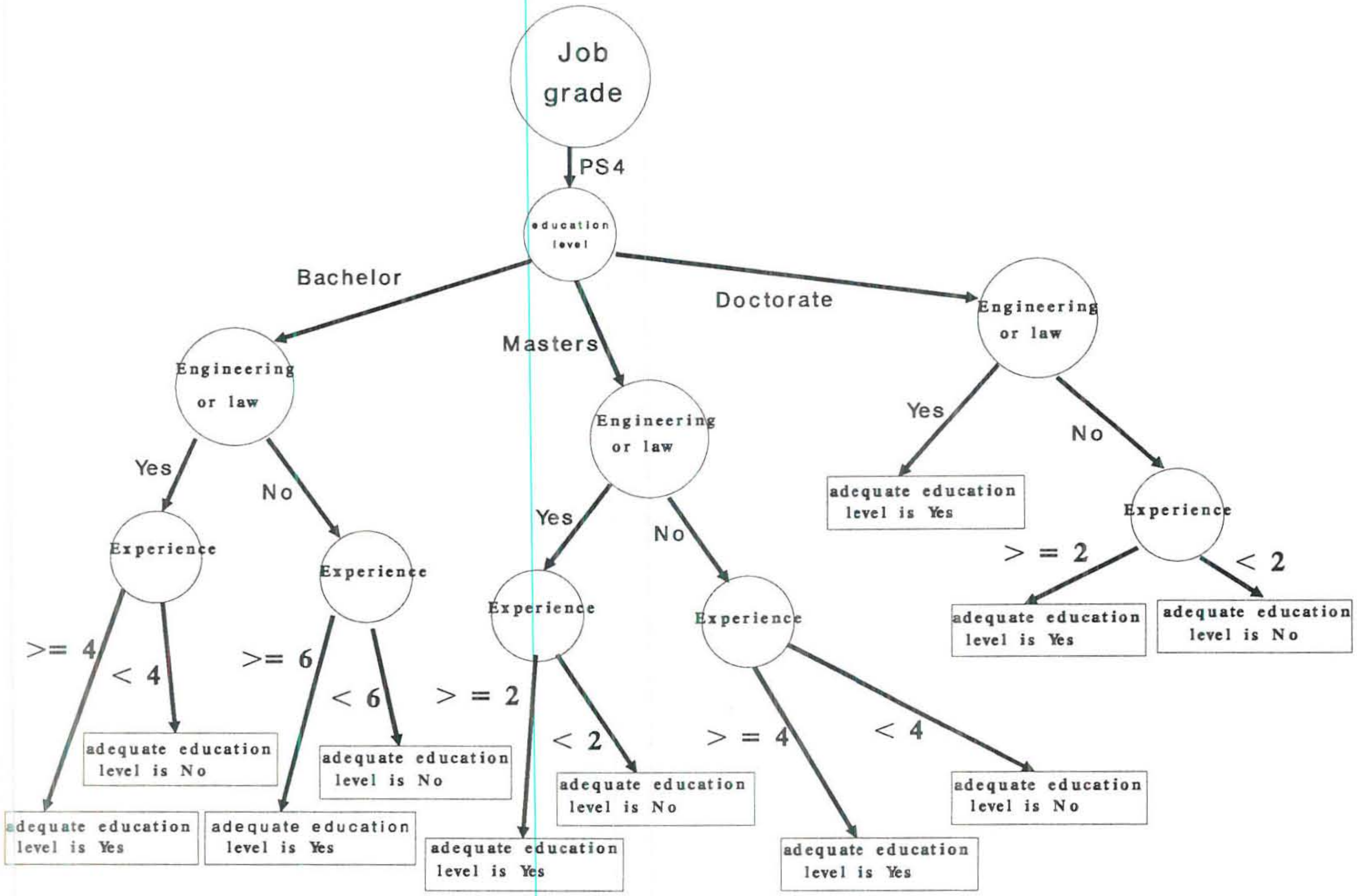


Figure 4.9c Decision tree for deciding adequate education l

The rule structure for adequate education level operates as follows:

if job grade is PS1
and education level is bachelor
then adequate education level is Yes

if job grade is PS2
and education level is bachelor
and engineering or law is Yes
then adequate education level is Yes

if job grade is PS2
and education level is bachelor
and engineering or law is No
and year of experience >= 2
then adequate education level is Yes

if job grade is PS2
and education level is bachelor
and engineering or law is No
and year of experience < 2
then adequate education level is No

if job grade is PS2
and education level is masters
then adequate education level is Yes

if job grade is PS5
and education level is bachelor
and engineering or law is Yes
and year of experience >= 6
then adequate education level is Yes

if job grade is PS5
and education level is bachelor
and engineering or law is Yes
and year of experience < 6
then adequate education level is No

if job grade is PS5
and education level is bachelor
and engineering or law is No
and year of experience >= 8
then adequate education level is Yes

if job grade is PS5
and education level is bachelor
and engineering or law is No
and year of experience < 8

then adequate education level is No

if job grade is PS5
and education level is masters
and engineering or law is Yes
and year of experience >= 4
then adequate education level is Yes

if job grade is PS5
and education level is masters
and engineering or law is Yes
and year of experience < 4
then adequate education level is No

if job grade is PS5
and education level is masters
and engineering or law is No
and year of experience >= 6
then adequate education level is Yes

if job grade is PS5
and education level is masters
and engineering or law is No
and year of experience < 6
then adequate education level is No

if job grade is PS5
and education level is doctorate
and engineering or law is Yes
and year of experience >= 2
then adequate education level is Yes

if job grade is PS5
and education level is doctorate
and engineering or law is Yes
and year of experience < 2
then adequate education level is No

if job grade is PS5
and education level is doctorate
and engineering or law is No
and year of experience >= 4
then adequate education level is Yes

if job grade is PS5
and education level is doctorate
and engineering or law is No
and year of experience < 4
then adequate education level is No

Knowledge base-2

Once the candidates are checked against eligibility requirements the system continue to determine the score ratings for the factors education, experience, performance, and discipline for those eligible candidates.

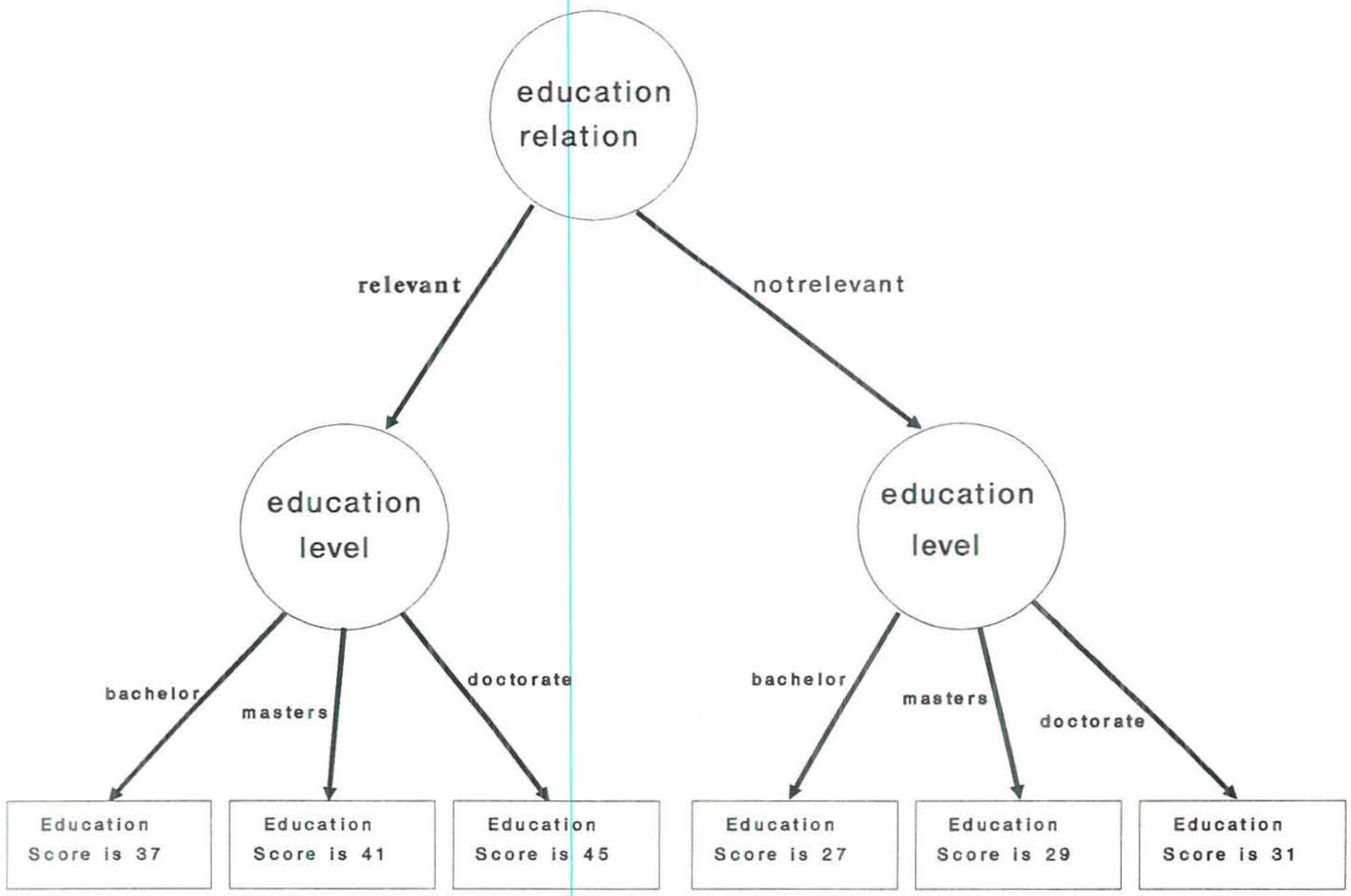


Figure 4.10 Decision tree for education score

To determine score rate for education, the system starts with the following rules:

if education is relevant
and education level is bachelor
then score rate is 37

if education is not relevant
and education level is bachelor
then education score rate is 27

if education is relevant
and education level is masters
then score rate is 41

if education is not relevant
and education level is masters
then education score rate is 29

if education is relevant
and education level is doctorate
then score rate is 45

if education is not relevant
and education level is doctorate
then education score rate is 31

To determine education relation the following rules are used

if education type of the candidate is one of education required by the job
then education is relevant

if education type of the candidate is in the same group with that required by the job
then education is relevant

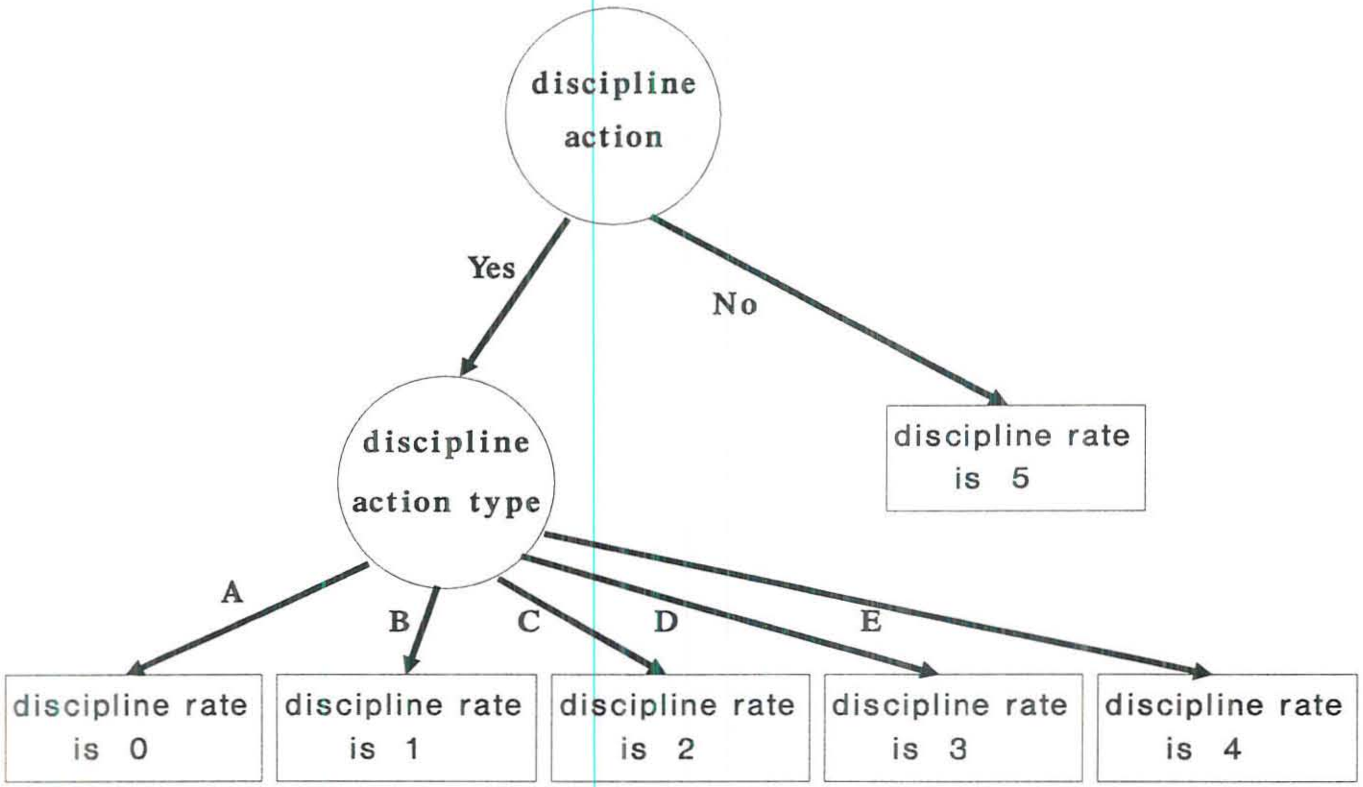
if education type of the candidate is not in the same group with that required by the job
then education is not relevant

To determine score rate for experience, the system starts with the following rules:

if experience relation is direct
then score rate is year of experience * 0.74

if experience relation is indirect
then score rate is year of experience * 0.37

if experience relation is norelation
then score rate is year of experience * 0.19



<u>Key</u>

A - Demotion or hindrance from salary increment

B - Punishment above one month salary and not more than two months salary

C - Punishment not more than one month salary

D - Warning more than once

E - First time warning

Figure 4.12 Decision tree to determine discipline rate

4.3.3 KnowledgePro: The Shell

The prototype expert system developed in this study is implemented using KnowledgePro Windows (KPWin). KPWin is a knowledge-based hypermedia shell enabling the development of intelligent and expert hypermedia systems. It is a development environment which allows to build complex Windows applications rapidly. It has also a database toolkit which adds database access capabilities to knowledgePro. The toolkit is used to create, read, write and maintain dBase compatible files. KPWin is much more than a rule based shell. The strength of the language lies in its flexibility and the power of its combined object oriented programming (OOP) and list processing capabilities (Bev and Bill, 1991).

KPWin was chosen, primarily, because it allows the development of rule based expert system easily and rapidly. It has built in backward searching facility, and forward searching capability. The 'HOW' and 'WHY' features used for reasoning, however, are not provided as built in KPWin shell. Due to the flexibility of OOP and list processing capability of KPWin these features could be programmed by adding an explanation of the rule to a building explanation list as rules are fired in KPWin. This could be used for displaying explanation of how the system arrived at a given conclusion. In this study this capability is programmed and found to be effective.

4.3.4 Operating Procedure

The flow charts in Figure 4.13 (a) and (b) present the main stages and procedures of the prototype expert system. Generally there are two stages: 'checking eligibility' and 'selection'

The system requests the user for information on the candidate and performs a search in its knowledge base and match against eligibility requirements and determine factor ratings.

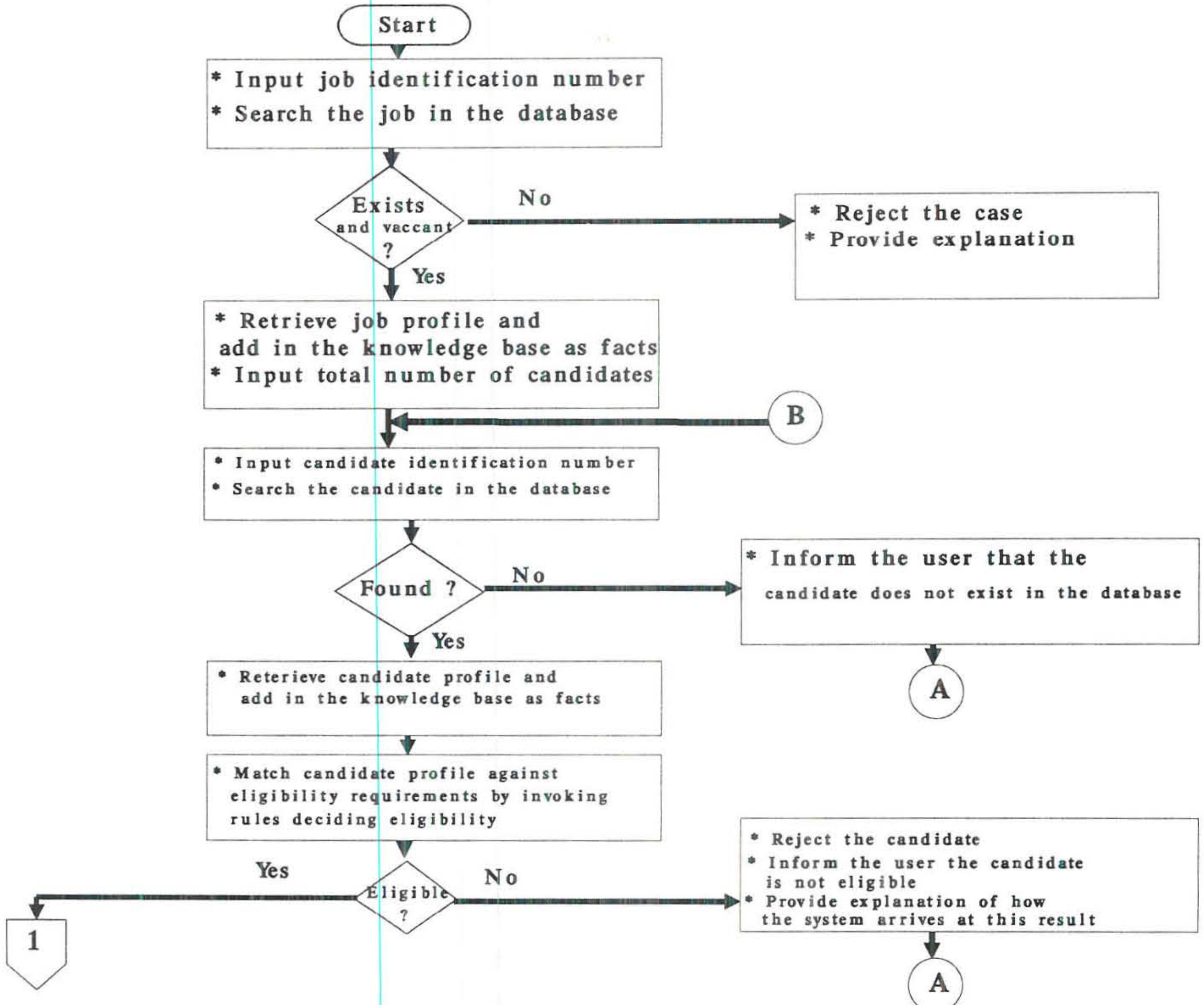


Figure 13a Main procedures for 'checking eligibilty' stage

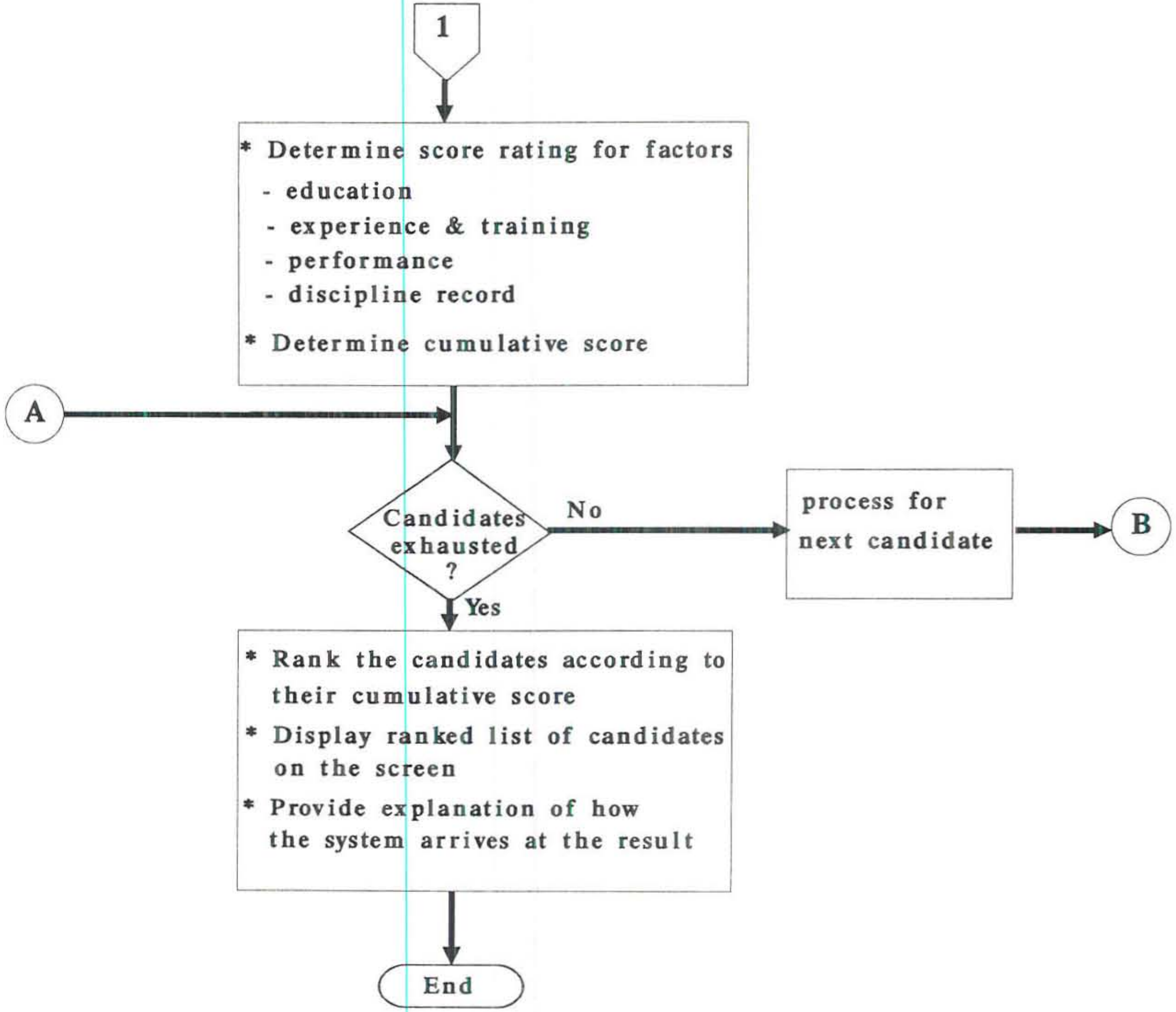
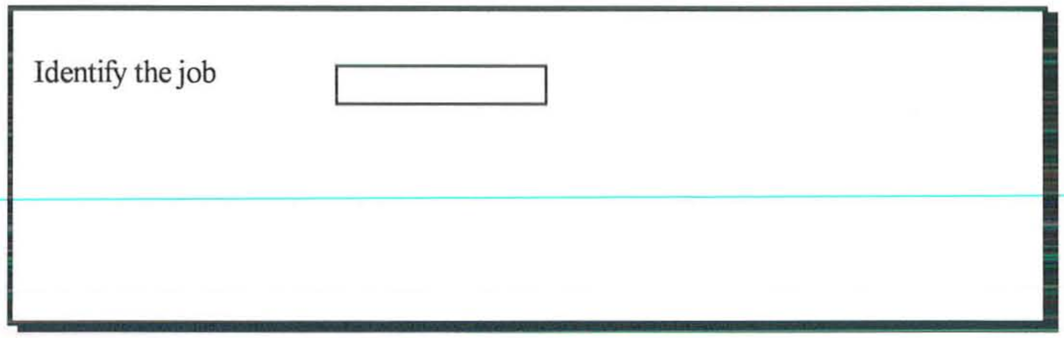
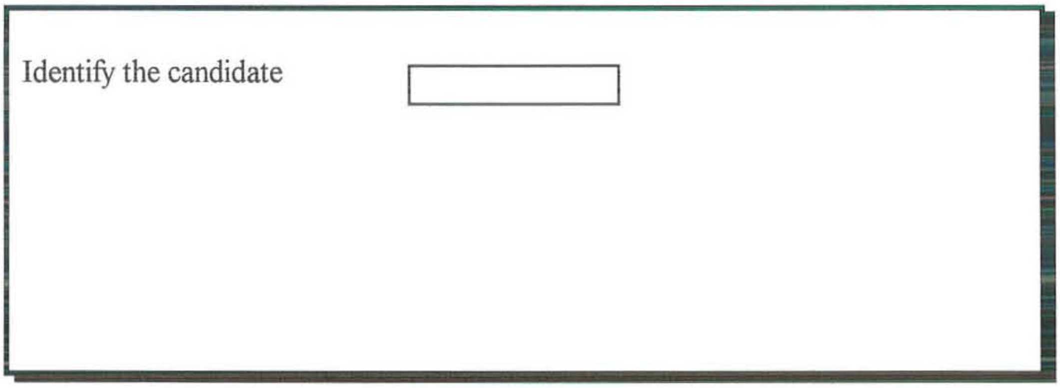


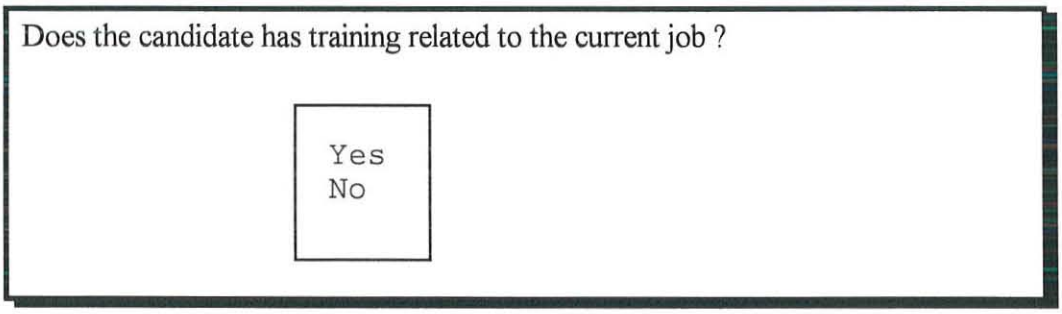
Figure 13b Main procedures for 'selection' stage

At the start up, the first screen display appears which consists of a logo and brief introduction to the system. This is followed by second screen that displays instructions for using the system. The next set of screens will ask the user to input information on the post and the candidate. The user interface interacts with the user through a series of questions concerning candidates as under.

After the second screen, the following screens will appear.







If Yes, what is the length of training in months ?

Enter the performance result of the candidate

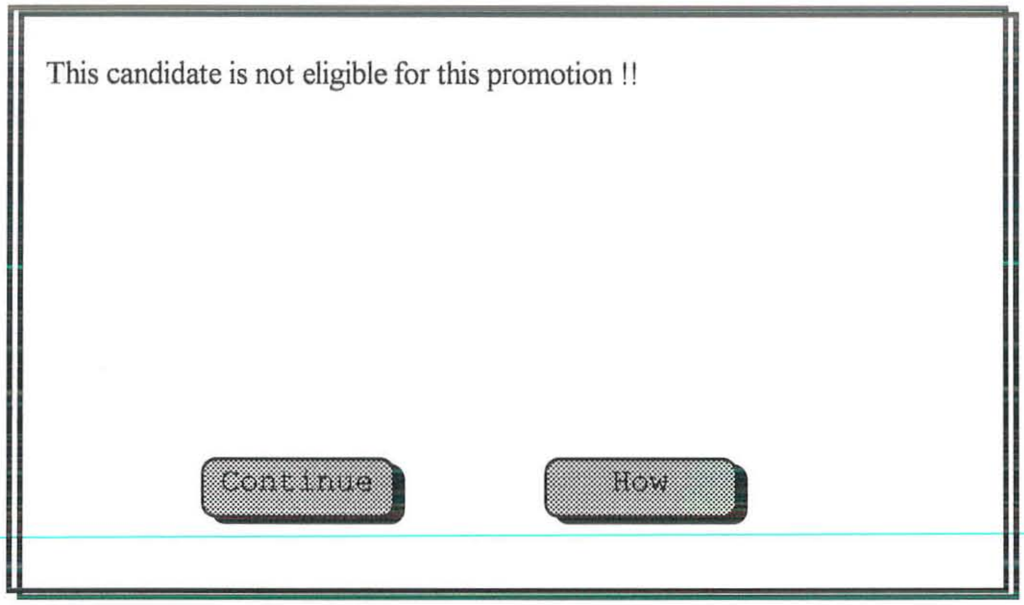
Is there any disciplinary action related to this candidate in the past five years ?

Yes
No

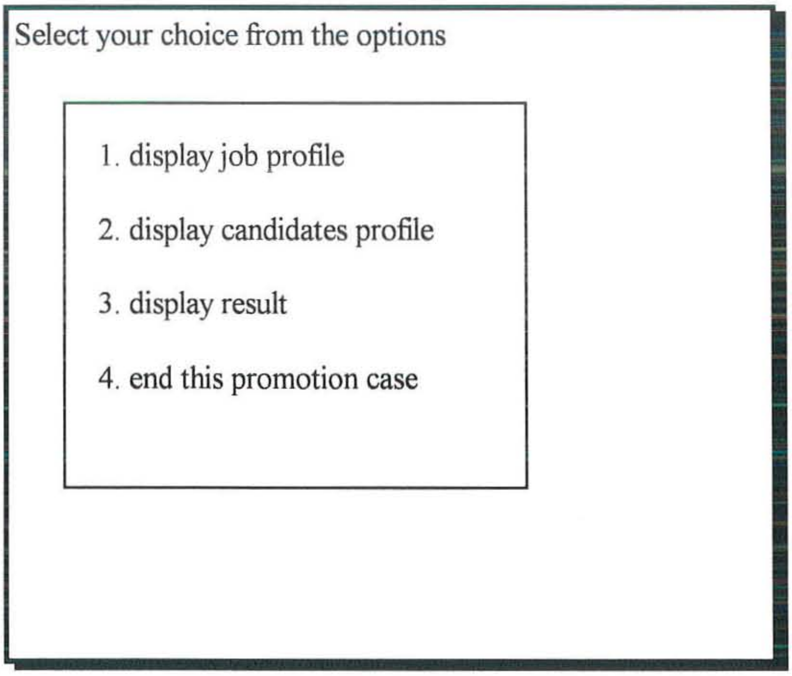
If Yes, what is the discipline actions taken ?

1. Demotion or hindrance from salary increment
2. Punishment above one month salary and not more than two months salary
3. Punishment of one month salary
4. Warning more than once
5. First time warning

If the candidate is not eligible, the system informs this to the user. If the user requests, the system will provide explanations on how it arrived at this result.

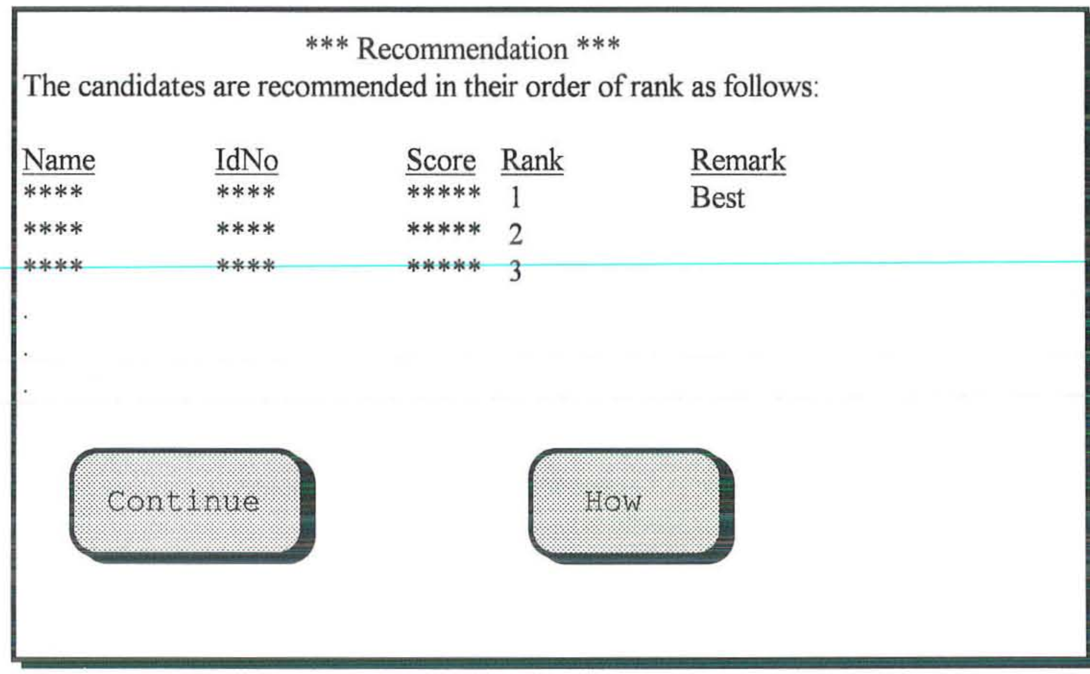


After completing the above questions for all candidates the following will appear on the screen.



If display job profile is selected, then the information about the job will be displayed. If display candidates profile is selected, then detail profile of each candidate will be displayed.

If display result is selected, the following will appear on the screen. If the user clicks on the button How, the system will provide how the results for each candidate is obtained.



4.3.5 Evaluation and Testing

The selection routine clearly shows that the process of selecting personnel for promotion can be formalized into a decision tree. In testing the prototype as part of the development process the following case which is not considered during the knowledge acquisition process were used (other cases are included in the ANNEX).

Sample case

Table 5.1 Job profile

Job Id:	112
Job Title:	Computer programmer
Grade :	PS4
Salary:	980
Job class:	Computer programmer
Req-education:	Computer science, Statistics, Mathematics

Minimum requirements:

- Bachelor degree and 6 years of work experience
- Masters degree and 4 years of work experience
- Doctorate degree and 2 years of work experience

Table 5.2 Candidates profile

Id. No.	Name	Education Type	Education Level	Occupation	Year of exp.	Performance	Discipline
31/82	Abebe K.	Mathematics	Bachelor	Computer programmer	6	4	No
39/82 *	Tezera Z.	Mathematics	Bachelor	Systems analyst	6	4.5	Yes
40/81	Alemu W.	Statistics	Bachelor	Statistician	7	4	No
50/80	Teklu G.	Accounting	Bachelor	Computer programmer	8	4	No

* The candidate has 6 months training related to the job; and disciplinary action taken is - warning more than once.

The candidates are checked against eligibility requirements and all are eligible. The candidate Teklu G. has experience related to the post, and therefore considered eligible even though his education is not one of the required educations.

After checking eligibility, the system determines score ratings and the following results are obtained.

Table 5.3 Candidates score

Id. No.	Name	Education score	Experience score	Performance score	Discipline score	Total score
31/82	Abebe K.	37	4.44	16.00	5	62.44
39/82	Tezera Z.	37	4.81	18.00	3	62.81
40/81	Alemu W.	37	2.59	16.00	5	60.59
50/80	Teklu G.	27	5.92	16.00	5	53.92

From the result above the candidate with best total score is recommended by the system (candidate Tezera Z. with total score of 62.81).

Since accounting is not one of the required educations, it is not relevant to the job and education score for the candidate Teklu G. is 27 (less than the others which have relevant education). But the candidate has work experience as a computer programmer; and thus his experience is directly related to the job. Hence, experience score is year of work experience multiplied by 0.74 (i.e., 0.74 x 8 = 5.92).

The candidate Alemu W. has experience as statistician and this is not in the same group with the job computer programmer; but it is in the same broad group. Hence, it is indirectly related to the job, and thus year of work experience is multiplied by one-half of 0.74 (i.e., (0.74)/2 x 7 = 2.59).

For the candidate Tezera Z. the score for factor discipline is 3 since the candidate has discipline record of - warning more than once - in the past five years. The others have no discipline record and thus assigned score of 5.

Performance result is multiplied by 4 to obtain score rate for the factor performance.

With this case, recommendation produced by the prototype system and that by the experts showed agreement.

Moreover, users (colleagues) that have no expert level knowledge were able to operate the system and process the selection for this selected case and those included in the ANNEX - a situation which if implemented in reality would very much free the experts to discharge their other assigned duties and responsibilities.

CHAPTER FIVE

DISCUSSIONS AND CONCLUSION

This study has demonstrated the usefulness of expert systems approach for the case of personnel selection for promotion in FCSC. The worker collect knowledge from human experts and printed documents, develop a decision model to enhance the knowledge base, and then incorporate that model into a computer system.

In spite of some limitations, developing the prototype expert system using KPWin was very convenient and quick. The difficulty faced is in the database accessing utility of KPWin. This is mainly due to the less familiarity the developer has with the software.

The developed prototype is capable of matching candidates qualifications with the requirements of the job to determine the eligibility and the score ratings of the candidates. The difficulty experienced in the promotion processing is in determining the relations of experience and education type of candidates to the job. Even though an attempt is made to simplify this, in the present work, using occupation relations and education relations by categorizing occupations and educations based on International Standard Classification of Occupations (ISCO), and International Standard Classification of Education (ISCED), this requires more research to determine these relations so that it is possible to decide on the score to be assigned to the experience and education of candidates.

Such expert system should be used as decision aid and the user should be responsible for the decision made. The system only advises the user on the decision to be made. Using the reasoning power of the expert system, the user may accept or override system recommendation.

Transparency is required and attainable via explanation modules of high-level concepts and familiar models which can tell what systems know, how systems use their knowledge, and why systems reason as they do. Explanation is needed because users cannot be expected to know or understand the entire system. Users want advice about the selection of personnel and take action based, partly, on that advice. Users are held responsible for the actions they recommend. Therefore, they must understand the rationale for system decisions. The 'HOW' shows the user how the system reached to the final recommendation. The program allows the expert (user) to understand and follow the inference logic of the program step by step. The user could override this logic and suggest other rules that should be used in order to achieve the desired conclusion.

It would be fair to state that the process of applying expert system techniques to HRM is yet at a very early stage. One of the major difficulties is the complex nature of the HRM problems which are not well understood or documented. In the current work, this study clearly establishes the feasibility and usefulness of using expert systems approach for the case under consideration. The worker believes that the study contributes important practical lessons in the area of knowledge representation and shell programming for those who may be involved in the development of expert systems in related areas. The work documented concrete and real examples of the implementation of production rules. What is more, as the prototype development was mainly considered as a research and training vehicle (more than an aid in the real selection process at this stage), a lot of time is spent in programming with KnowledgePro shell, at times to incorporate the modules lacking in the base system. This was, in fact, an exciting experience worth sharing.

Having said this however, several suggestions for improvements in the existing systems are immediately apparent, to develop the system for practical use.

Any expert system should be evaluated both by experts and end-users before it can be widely accepted. This is more true in this work as well because the system is based, partly, on knowledge acquired from four domain experts and partly from printed documents (such as guideline for promotion processing).

Developing the prototype to the point of practical use requires substantial testing and refinement utilizing real world decision constraints and data. This step will prove to be an on-going one in which the knowledge base and the decision criteria it contains will constantly be re-evaluated and adjusted.

For systems to have high performance, careful attention must be paid to the representation of knowledge, the methods of inference, and to performance validation. For systems to have utility, a large body of knowledge about a sizeable problem area is required, which requires careful attention to knowledge acquisition and knowledge base maintenance.

In short, for the prototype to attain full functionality further work is required to incorporate:

- improved knowledge acquisition (and learning) systems,
- better explanation functions,
- user friendly interfaces (with Amharic language support), and
- better inference procedures.

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ANNEX

1. Sample cases used in the development process of the prototype

Case 1

Job profile

Job Id: 371

Job Title: National Unesco Office Secretary

Grade : PS7

Salary: 1440

Job class: Other government executive officials

Req-education: Education science, Political science, International relations

Minimum requirements:

- Bachelor degree and 12 years of work experience
- Masters degree and 10 years of work experience
- Doctorate degree and 8 years of work experience

Candidates profile

Id. No.	Name	Education Type	Education Level	Occupation	Year of exp.	Performance	Discipline
40/58	Abebe T.	Education science	Bachelor	Education methods specialist	29	4.12	No
20/73	Almaz B.	International relations	Masters	Public relations specialist	15	4.55	No
15/64	Zewidie K.	Education science	Bachelor	Education methods specialist	24	4.27	No
60/59	Temtim M.	Political science	Bachelor	Public relations	28	4.55	No

				specialist			
25/58	Teka K.	Political science	Bachelor	Public relations specialist	29	4.38	No
25/62	Abebech Z.	Education science	Bachelor	Education methods specialist	22	4.66	No
30/73	Aberash T.	Education science	Bachelor	Education methods specialist	15	4.75	No
20/63	Temam M.	Education science	Bachelor	Education methods specialist	23	3.89	No
30/71	Mohamed S.	Education science	Bachelor	Education methods specialist	13	4.33	No

Candidates score

Id. No.	Name	Education score	Experience score	Performance score	Discipline score	Total score
40/58	Abebe T.	37	10.73	16.48	5	69.21
20/73	Almaz B.	41	5.55	18.20	5	69.75
15/64	Zewidie K.	37	8.88	17.08	5	67.96
60/59	Temtim M.	37	10.36	18.20	5	70.56
25/58	Teka K.	37	10.73	17.52	5	70.25
25/62	Abebech Z.	37	8.14	18.64	5	68.78
30/73	Aberash T.	37	5.55	19.00	5	66.55
20/63	Temam M.	37	8.51	15.56	5	66.07
30/71	Mohamed S.	37	4.81	17.32	5	64.13