ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

FACULTY OF INFORMATICS

DEPARTMENT OF INFORMATION SCIENCE

AN EXPERT-BASED SYSTEM FOR SOCIAL SECURITY STATUS DETERMINATION IN ETHIOPIA: THE CASE OF ETHIOPIAN SOCIAL SECURITY AUTHORITY (ESSA)

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BY
Ermias Wondie EMIRU

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AN EXPERT BASED SYSTEM FOR SOCIAL SECURITY STATUS DETERMINATION: THE CASE OF ETHIOPIAN SOCIAL SECURITY AUTHORITY

BY
ERMIAS WONDIE

Name and Signature of Members of the Examining Board

Dr. B. L. Desai, Chairman, Examining Board _____

Prof. B. R. Krishna Rao, Advisor _____

Dr. S. K. Sarma, Examiner _____

_____	_____	_____
Chairman, Faculty	Signature	Date
_____	_____	_____
Chairman, Graduate Council	Signature	Date

Table of Contents

Page

Content

List of Figures i

List of Tables ii

List of Appendices iii

Acknowledgment iv

Abstract v

Chapter One

Introduction

1.1. Background to the Study 1

1.1.1. Social Security: an overview 1

1.2. Statement of the Problem and Justification 6

1.2.1. Decision-Making Process at ESSA 6

1.2.2. Drawbacks of the Existing Working Procedure 8

1.3. Methods 11

1.4. Scope and Limitation of the study 12

1.5. Thesis organization 13

1.6. Research Contribution 13

Chapter Two

Existing Systems Analysis

2.1. Background 15

2.2. Social Security Programs at ESSA 15

2.3. Claim Handling Strategies 16

Chapter Three

Knowledge-Based System and Application in Social Security Administration

3.1. Introduction 18

3.2. Expert Systems: Definition 18

3.3. Expert Systems: Evolutions 18

3.4. Building Blocks of Expert Systems 21

3.4.1. Knowledge Base 21

3.4.2. Inference Engine 22

3.4.3. Explanation Facility 23

3.4.4. User Interface 23

3.5. Expert System Characteristics 23

3.6. Advantages and Disadvantages of Expert System 24

3.6.1. Advantages of Expert System 24

3.6.2. Disadvantages of Rule-Based Expert Systems 25

3.7. Application of Expert Systems 25

3.7.1. Introduction 25

3.7.2. Expert system Applications in Insurance 26

Chapter Four

Knowledge-Based Systems Development

4.1. Introduction 28

4.2. The knowledge System Building Cycles 28

4.2.1. Analysis 29

4.2.2. Design 29

4.2.3. Build a Prototype 29

4.2.4. Test the Prototype 30

4.3. Knowledge System Reasoning Strategies 30

4.3.1. Inference Strategies 30

4.3.2. Control Mechanisms 31

4.4. Knowledge Representation 31
4.4.1. Semantic Networks 32
4.4.2. Rule-Based Expert System 33
4.4.3. Frames 33
4.5. Requirements for Expert System Development 34
4.6. Inference Engines and Inference Mechanisms 35

Chapter Five

Knowledge Acquisition and Modeling

5.1. Introduction 37
5.2. Acquisition of Knowledge from an Expert 37
5.2.1 Conceptual Modeling 40
5.2.1.1. Retirement Age Pension 40
5.2.1.2. Invalidity Pension 43
5.2.1.3. Incapacity (Employment Injury) pension 44
5.3. Social security program Amount Determination 46
5.4. Social Security Determination Process at ESSA. 48
5.5. Analysis of the Problem 52

Chapter Six

Knowledge Representation

6.1. Introduction 56
6.1.1. Knowledge Base 56
6.2. The Explanation Facility 60
6.3. Operation of the System 62

Chapter Seven

Application of Knowledge

7.1. System Interaction with the User: Interfaces 63
7.2. Testing and Evaluation 70
7.3. Knowledge Base Maintenance 73

7.4. Discussions 73

Chapter Eight

Conclusions and Recommendations

8.1. Conclusions 75

8.2 Recommendations 76

References 78

Appendices 80

List of Figures

Figure No. **Title of Figure** **Pages**

Figure 3.1. The Architecture of an Expert System..... 22
Figure 5.1. Decision Tree for Retirement and Survivors Pension 42
Figure 5.2. Decision Tree for Invalidity Pension..... 44
Figure 5.3. Decision Tree for Incapacity Pension 46
Figure 6.1. Code to calculates retirement age pension.....59
Figure 6.2. Code to calculates incapacity pension.....59
Figure 6.3. Code to calculates invalidity gratuity.....60
Figure 7.1. Main window of ExpSSD.....63
Figure 7.2. Window including instructions.....64
Figure 7.3. Help window with hypertext list of help contents.....65
Figure 7.4. Example of the window containing the first question.....66
Figure 7.5. Example of the window containing the second question.....67
Figure 7.6. Example of the window containing the third question.....68
Figure 7.7. Recommendation (result) window.....69

List of Tables

Table No. **Title of Tables** **Pages**

Table 5.1. Experts profile..... 39
Table 5.2. Requirements for Retirement and Survivors Pension.....41
Table 5.3. Decision Table for Invalidity Pension..... 43
Table 5. 4. Decision Table for Incapacity Pension 45
Table 5.5. Percentage share of the customers & their families.....47
Table 5.6. Detailed procedures for determination of social security..... 51

List of Appendices

Appendix No.	Title of Appendix	Page
I	Sample Rules from the Knowledge Base.....	..81
II	Sample cases used during testing along with the output of **ExpSSD**.....	88
III.	Knowledge Pro shell as development tools.....	90
IV.	Organizational Structure of Ethiopian Social Security Authority.....	92

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ABSTRACT

The objective of most *social security scheme* is to provide access to means of earning. Pension systems ease the retired, injured, incapacitated workers from the burden of labor when these workers productivity has fallen to a low level. *Work injury* schemes are the oldest and most widespread form of social security that are playing an increasingly important role in rehabilitating workers who fall victim.

Similarly *sickness benefits* contribute to the recovery of sick workers by adjusting or removing the financial pressure on them to some extent while they are ill. *Child benefits* are other set of schemes that help to ensure the families with children have enough income to provide proper nutrition and a healthy living environment for their children.

Social security programs in Ethiopia provide social security services in the form of *pension*. The major services focus on *pension schem*es such as, *retirement age pension, invalidity pension, incapacity pension, and survivors' pension.*

However, in a country like Ethiopia, where the fertility rate is optimal, and the number of civil servants working in public institutions is increasing alarmingly, the need for developing and strengthening social security programs are vital. Customers should be educated about the social security category status that they belongs to, and also get informed about the amount of one time or life long payments they deserve.

In an attempt to address such problems, the present study, specifically, explores the potential of applying *Expert Systems Technology* in determining social security status of the civil servants, considering the *Ethiopian Social Security System* as a case study. A prototype **Exp**ert system on **S**ocial **S**ecurity **D**etermination, (***ExpSSD***), is developed by exploring the existing expert know-how and existing procedures in decision making in the area of social security as source of knowledge.

Modeling the knowledge acquired has been made using hierarchical structure that represents concepts and parameters involved in social security determination. Based on the model and using production rules, the knowledge has been represented. Using an expert system shell, know as, **Knowledge Pro Gold**, the rules were materialized to the prototype system. *Back ward reasoning* is used in inferring the rules and extracting results.

The prototype system (ExpSSD) was validated and verified using some cases and proved correct when matched with the decisions made earlier by human experts. The experts participated in the testing of the system has also suggested that, the scope of the rules has to be broaden encapsulating largely the civil laws of the country.

CHAPTER ONE

Introduction

1.1. Background to the Study

1.1.1. Social Security: an overview

The concept of *social security* is very broad area and has several classifications. According to the International Labor Organization (1989), social security can be defined as the protection which society provides for its members, through a series of public measures, against the economic and social distress that otherwise would be caused by the stoppage or substantial reduction of earnings resulting from sickness, maternity, employment injury, underemployment, invalidity, old age and death; the provision of medical care; and the provision of subsidies for families with children.

It has been suggested by various commentators that social security contributes to economic growth by raising labor productivity and enhancing social stability. Various types of social security programs are particularly relevant to labor productivity (ILO, 2001) in terms of:

- **Health-care** systems help to maintain workers in good health and to cure those who become sick. Poor health is a major cause of low productivity in many developing countries where workers do not have access to adequate health care.

- **Pension systems** ease the departure of the older workers from the labor force, thereby helping to avoid the problem of workers remaining in employment when their productivity has fallen to a low level.

- **Cash sickness benefit** contributes to the recovery of sick workers by removing the financial pressure to carry on working when ill.

- **Maternity insurance** is of particular importance for the reproduction of a healthy workforce, as well as for the maintenance of the health of working mothers.

- **Work injury schemes**, which is the oldest and most widely spread form of social security-are playing an increasingly important role in preventing work-related accidents and sickness and in rehabilitating workers who fall victim to these.

- **Unemployment benefit** provides unemployed workers with the breathing space they need in order to find suitable work which makes full use of their talents and potential.

- **Child benefits** (and other cash benefits provided when the breadwinner is unable to work) help to ensure that families with children have enough income to provide proper nutrition and a healthy living environment for their children.

There are nine types of social security programs identified by the International Labor Organization in 1952. These are *Old Age Pension, Invalidity Pension, Survivors Pension, Employment Injury, Health-care, Cash sickness benefit, Maternity insurance, Unemployment benefit, and Child benefits* (Mouton, 1973). The programs are being implemented in different countries as required depending on the social, economical, and political situations.

In Ethiopia, among the nine types of social security programs, four are implemented and being under operation. These are the *Old Age Pension, Invalidity Pension, Survivors Pension, and Employment Injury*. Each of the programs is designed to serve different purposes and execute the scheme differently. If we look at the *Old Age pension scheme*, it entails under most schemes as the minimum age at which the pension may be claimed ("pensionable age"). But the pensionable age varies from one scheme to another, and the very difference indicates that the concept of "old age" is not simple (ILO, 1967). For example, in the case of Ethiopia, a public servant is required to reach sixty (60) to be classified under Retirement Age or Old Age scheme. Where as in other countries the retirement age limit could be less than or greater than this.

Unlike the old age pension scheme, *Invalidity pension scheme* is nearly always linked to sickness. It could be described as an incurable, but stabilized, sickness involving permanent incapacity for work, and having therefore economic consequences for the insured person similar to those of advanced old age. The 1967 ILO's Convention on "*Invalidity, Old-age, Survivors, and Employment Injury Benefits*", defines invalidity as 'incapacity to engage in any gainful activity, to an extent prescribed, which incapacity is likely to be permanent or persists after the termination of a prescribed period of temporary or initial incapacity'.

In Ethiopia, a public servant who has completed at least ten (10) years of service and is retired because he does not fulfill the medical condition of service shall receive invalidity for life. However, this is not the only criteria that can make the individual eligible for the invalidity status. Other factors which will be discussed later in this study are also considered.

Social security benefits are also transferable to a member of a family, such as wife, husbands, and children following the death of a breadwinner. Such social security scheme is known as *Survivors social security scheme*. Such scheme has been dealt in detail by the convention of ILO and incorporates or addresses the following major categories of beneficiaries:

1. Survivor's benefits should be paid (a) to the widow of an insured man; (b) for the children, stepchildren, adopted children and, subject to their previous registration as dependents, illegitimate children of an insured man or of an insured women who supported the children; and (c) under conditions to be defined by national laws, to an unmarried women with whom the deceased cohabited.

2. Widow's benefits should be paid to a widow who has in her care a child for whom child's benefit is payable or who, at her husband's death or later, is an invalid or has attained the minimum age at which old age benefits may be claimed; a widow who does not fulfill one of these conditions should be paid widow's benefit for a minimum period of several months, and thereafter if she is unemployed until suitable employment can be offered to her after training if necessary.

3. Child's benefit should be paid for a child who is under the school, leaving age, or who is under the age of 18 and is continuing his general or vocational education.

The other type of social security program implemented in Ethiopia is the *Employment Injury Benefits*. Protection against employment injury is the oldest branch of social security, and is found today in almost every country in the world. According to the 1989 publication of ILO, which describes about different social security programs, an employment injury scheme is explained as a means of providing special medical and sickness benefits, and special invalidity and survivors' benefits, in contingencies which represent only a small fraction of the total number of cases of sickness, invalidity and death.

Employment injury benefits are carried out in Ethiopia considering several routine steps, such as verification of whether the injury is self inflicted or not and other legal factors that can prove or disprove his/her eligibility. Thus, requiring significant amount of time for the member as well as the responsible body passing a decision.

In each of the social security programs described above, however, an individual is required to meet eligibility requirements set for the program or plan. Eligibility requirements are those conditions an employee must meet in order to become participant in the plan. Specific eligibility requirements vary somewhat among plans, but they are generally composed of one or more of the following broad types of requirements (ILO, 1989): (1) minimum age; (2) minimum period of service; (3) maximum age; (4) minimum earnings; and (5) specified employment classifications.

Generally, the scope of coverage of the social security schemes in Ethiopia includes three categories of employees working in a fully or partially owned government organizations, who have Ethiopian nationality by birth or acquisition.

(1) The Civilian government employees. This category includes:

- Government offices and agents, who are to any degree repositories of the power or authority of the state, and whose salaries are paid by the Ministry of Finance from the National Budget;

- Employees of all autonomous organizations and public agencies;

(2) The Military

(3) Employees in the government owned undertakings

Employees, who on the date of transfer on undertaking, were permanent employees of the undertaking or are thereafter employed in any nationalized undertaking. The scheme does not cover only the public servant but also his/her;

- Wife/husbands
- Children (under 18 years of age)
- Parents (fully or partially supported by the member)

Each member of the Ethiopian social security program pays monthly contribution to the Civil Service Fund. The amount of the contribution payable to the Civil Service Fund, based on the salary of the Public Servant is:

1) by the employer six percent (6%)
2) by the public servant four percent (4%)

Each Employer deducts the contribution due upon each public servant's salary and pays the amount, together with the contribution due from the office as an employer, into the fund monthly. The entire operations of the organization currently are based on manual system, which is time taking and costly. Moreover, inconsistencies in decision making have been resulting as a result of absence of an integrated and consolidated knowledge base system.

By developing the Expert System, it is believed that, the Ethiopian social security authority could strengthen the capability to manage complex cases related to social security and improve timeliness and responsiveness of customer service.

1.2. Statement of the Problem and Justification

1.2.1. Decision-Making Process at ESSA

The Ethiopian social security scheme is a contributory, earnings and service related, social insurance program whose objectives are to give protection against loss of income to a member of the scheme and his Survivors'. The contingencies covered in the scheme are Old Age, Invalidity, Employment injury and death (Survivors') benefits.

A public servant, covered under the Ethiopian public servant's social security scheme, is entitled to different amounts of benefits depending on conditions such as attainment of the retirement age, non-fulfillment of medical conditions for service, voluntary resignation after completing a retired minimum years of service, and in time of death of a member, his survivors are entitled to pension.

The current working procedure of the organization shows that, facilitating the registration of permanent public servants by the employing organizations, as the initial task. Accordingly, permanent employees, covered under the scheme, are required to complete a registration form (Reg. Form/1). After the registration forms are filled, the employing organization would send them to the Ethiopian Social Security Authority (ESSA). The registration form contains several essential information such as:

- Name and address of employing organization
- Full name of the employee
- Occupation
- Sex
- Address, date and place of birth
- Educational status
- Previous service
- Family status and descriptions

Upon receiving the employee's first registration form, the registration and entitlement section at the ESSA checks the form and gives a registration number. A file would be opened for each

registered employee after making sure that the registration form contains refined information and finally get documented.

The organization maintains manual system in retrieving information. For example, in order to retrieve information from the documented files, the authority uses an alpha-numeric filling system so that files can be located either alphabetically or numerically.

In case of any contingencies (injury, death etc) happening to a member, the employing organization would send a completed form (Form-28) to the authority, which describes personal history of the individual (name, name of employer organization, address etc) and the current status. On the basis of which the verification procedure begins. The verification procedure involves checking of the consistency of the current evidences at Form-28 with Form-1 that has been documented during the registration period.

Once this verification process is completed, experts get involved to determine the type of social security program an individual deserves. The experts use heuristic knowledge as well as refer to the existing rules and regulations for each type of social security programs before arriving at decision.

For instance, if the expert's decision goes to *Invalidity pension*, determination of actual *Invalidity Pension and Gratuity* is required. To do so, experts in the area are required to give analysis on the following points.

- Amount of Invalidity Pension
- Invalidity Gratuity
- Amount of Invalidity gratuity

Similarly, if the experts decide that the social security to be provided to the individual is *Employment Injury,* the experts' advice in this regard is also required to explain the following points:

- Extent of Incapacity Schedule
- Admissibility of Proof
- Notification of Accident
- Assessment of Employment Injury
- Incapacity Pension
- Amount of Incapacity Pension
- Incapacity gratuity
- Amount of Incapacity gratuity

On the other hand, if the case of the individual is classified as *Survivors Pension,* determination of *Survivors Pension and Gratuity* is required by the experts. To carry out this task, experts' explanation is mainly required on the following survivors' feature.

- Widow or Widower's Pension
- Orphan's Pension
- Parent's Pension
- Survivors' Pension
- Limit of Survivors' Pension

1.2.2. Drawbacks of the Existing Working Procedure

The organization maintains huge number of records of thousands of public servants in its day to day activity. Everyday, several different cases related to social security are given decision manually. Thus, the organization is engaged in deployment of large number of experts to look after each public servants case and pass decision according to the type of the social security programs. However, decisions are not often facilitated at the shortest time possible. Experts are also involved in some other activities such as in committee's, spend significant amount of time in meetings etc. Thus, in many of the cases, passing decision for a particular case becomes time taking. However, the social security cases of several thousands of public servants require the right decision at the right time. Similarly, complaints as a result of dissatisfaction by the decision passed are also requiring reconsideration. This is usually happening due to decision making

inconsistencies as there is no formal procedure to be followed uniformly by all experts. Thus, demanding large number of experts and as a result the cost implication is eroding the organization.

According to Gory & Scote Morton, as cited by Kalay and Chen (1991), most of the present decisions made in an organization are semi-structured. It equally holds true for the decision made in the social security and pension type determination.

In general, the expert's knowledge is scare, poorly distributed in an organization, often distributed among many people, and unavailable with any degree of reliability.

In summary, the organization is currently suffering from the following major problems:

- Extended customers complaint as a result of service dissatisfaction
- Demand for large number of experts
- Handling huge amount of unstructured data
- Large amount of running and capital cost
- Mismatch of rules and actions
- Taking long time to pass decisions

In order to alleviate such problems and increase the performance of the organization, introducing computer technology based working environment is believed to bring significant change. Particularly expert system technologies are considered an appropriate choice for a number of reasons. Expert systems are knowledge based systems (Cornelius, 2000) which contain "expert domain knowledge" that is elicited from human experts and used to emulate the experts' reasoning within narrow areas of the domain. Expert systems are typically used to support "knowledge workers" in performing their functional tasks.

Some of the more common reasons and justifications (Wiig, 1990) given by several long-time users of expert systems are:

- Strengthen the capability to manage complex:
    - Operations, where many factors and systems interact at the same time;
    - Decision-making, where large amounts of information have to be taken into account

- Improve timeliness and responsiveness of customers service
- Increase quality of services and products
- Enjoy direct economic benefits such as:
    - Reduce costs and losses through savings on staff resources, reduction in repetition, personnel, inventories, etc.;
    - Increased profit margins through increase in revenues

- Provide high-knowledge-content services with less-trained people.
- Preserve and accumulate knowledge from departing or promoted personnel.
- Foster co-operation between line and staff functions.

On the other hand, in order to develop an expert system, the following conditions should be fulfilled (Ardis, 1988).

- At least there should be an acknowledged expert in the area, the document verification and validation section, in the case of (ESSA).
- Sources of the expert's expertise are judgments and experience; it is rule based.
- The expert is able and willing to explain knowledge in a systematic way that others can understand.
- Problem is well bounded.
- The problem area has a real consensus.

Thus, the research has clearly defined objectives to be addressed in order to solve problems that are inhibiting ESSA to run the day-to-day activity smoothly. ***The general objective of the research is to develop a prototype expert system for public servants social security status***

Determination. There are ***specific objectives*** pinpointed, which are essential and critical mechanisms to achieve the overall objective. These are,

- Study the existing system, identify its problems and information requirements and structure the information;
- Acquire required domain knowledge and skill from experts in the area and construct the knowledge base;
- Investigate different methodologies and approaches available;
- Investigate the methods of knowledge acquisition, knowledge representation and inference mechanism;
- Explore the potential of expert system technology in the public servants social security program operation;
- To develop a prototype and demonstrate the suggested solutions.

In order to achieve the objective of the research, application of tools and methods are necessary. The methods and tools are discussed in the next section.

1.3. Methods

To successfully achieve the objectives of the study, the following methods have been employed.

Literature Review

For the purpose of identifying and studying expert system tools and techniques and problem areas of the social security system, articles in journals, books, related thesis and other related sources in hard copies and soft copies have been reviewed.

Acquisition of the expert's knowledge

During the acquisition of required knowledge from the expert, the following procedures have been used.

1. Conducting in-depth interviews with the expert
2. Observation of the experts in action, solving real problems
3. Different types of available data, knowledge, manuals and procedures used to solve problems at the organization have also been explored.

Prototyping

Prototyping approach has been adopted for the development of expert systems. This approach is justified because, prototyping is a common approach in expert systems and suitable to code knowledge base that can be tested before risking too much.

Development Tools

The expert system is developed using the commercial shell, known as KnowledgePro version 3.0. The software is implemented because; it is suitable for rule-based expert systems and because it is the only available expert system software at the faculty.

Thus, in light of the importance of the social security program decision making, the aim of this research is therefore, to develop a prototype of rule-based expert system technology and minimize the growing complexity of the problem and enhance the decision-making process by considering Ethiopian Social Security Authority as a case.

1.4. Scope and Limitation of the study

The Ethiopian Social security Authority is responsible for administration of social security cases of *public servants*, *military/police personnel*, and *semi-government owned organizations*. Decisions are required on daily basis for each category. The researcher believes that developing

and designing expert system technology for the entire categories enhances the efficiency of the organization. However, due to the huge decision making operation being conducted incline to the public servant cases and the limited time left to conduct this research, the focus of this research is developing and designing prototype expert system for public servants category. The expert system development doesn't include the military and police forces.

1.5. Thesis organization

The rest of this thesis is organized as follows. Chapter two simply describes in general the *structure of existing system, the Ethiopian Social Security Authority (ESSA). Knowledge-Based systems and application in social security administration* has been discussed in chapter three. Chapter four is devoted to the discussion of *the development approaches of expert system.* In this chapter, expert system development stages, knowledge acquisition, representation, inference engines and inference mechanisms, and expert system development tools are discussed. Chapter five is concerned with *acquisition of knowledge.* That is, identification of expert groups, conceptualization of the knowledge acquired, procedure of existing manual based social security determination etc are dealt with.

In chapter six, *knowledge representation* is covered. It focuses on the prototyping of the knowledge acquired during knowledge acquisition. The last two chapters, chapter seven and eight, discuss the *knowledge application* and *conclusion and recommendation* respectively.

1.6. Research Contribution

In this study an attempt was made to use rule-based expert systems as a changing agent in enhancing the decision making capability of the Ethiopian Social Security Authority, where thousands of public servants social security cases are handled. The study could also contribute in formulating new social security policies and widen the scope of its applicability nation wide by utilizing the performance capability of the expert system.

Moreover, the research can be used as input for other researches on the domain, that is, specifically work on related areas. The work may also shed light on the applicability of expert system for other activities of the social security authority.

CHAPTER TWO
Existing System Analysis

2.1. Background

The Ethiopian Social Security Authority was established in 1958 by the name of Ministry of Pension under the proclamation number of 20/1958. Working until 1996, the name was changed to Ethiopian Social Security Authority (ESSA) under the proclamation number 38/1996 (FDRE, 2003).

The Ethiopian Social Security Authority is accountable to council of Ministers and administered by the management board. The organization is providing services at the federal and regional levels of the country. The head office in Addis Ababa is responsible for the overall administration of the organization. The organizational structure of ESSA indicated at Appendix IV, shows the overall and current structure of the organization. Moreover, eleven regional and seventeen Zonal branch office are organized under the Authority.

ESSA currently owns about 150 staff working at different section.

2.2. Social Security Programs at ESSA

The Ethiopian social security scheme is a contributory, earnings and service related, social insurance program whose objectives are to give protection against loss of income to a member of the scheme and his Survivors'. The contingencies covered in the scheme are Old Age, Invalidity, Employment injury and death (Survivors') benefits. The old age pension system helps the customer to support the rest of his life after retirement. The invalidity pension is meant for assisting public servants, in case they get sick. Whereas the employment injury pension is provided for employees who encounter accident or injury while on duty. Unlike other pension programs, the survivors' pension is concerned with supporting families of employees when the breadwinner deceased.

A public servant, covered under the Ethiopian public servant's social security scheme, is entitled to different amounts of benefits depending on conditions such as attainment of the retirement age, non-fulfillment of medical conditions for service, voluntary resignation after completing a retired minimum years of service, and in time of death of a member, his survivors are entitled to pension.

2.3. Claim Handling Strategies

The current working procedure of the organization shows that, facilitating the registration of permanent public servants by the employing organizations, as the initial task. Accordingly, permanent employees, covered under the scheme, are required to complete a registration form (Form-1). After the registration forms are filled, the employing organization would send them to the Ethiopian Social Security Authority (ESSA). The registration form contains several essential information such as:

- Name and address of employing organization
- Full name of the employee
- Occupation
- Sex
- Address, date and place of birth
- Educational status
- Previous service
- Family status and descriptions

Upon receiving the employee's first registration form, the registration and entitlement section at the ESSA checks the form and gives a registration number. A file would be opened for each registered employee after making sure that the registration form contains refined information and finally get documented.

The organization maintains manual system in retrieving information. For example, in order to retrieve information from the documented files, the authority uses an alpha-numeric filling system so that files can be located either alphabetically or numerically.

To process a particular social security application, several sections get involved before passing the decision. The major sections involved in the decision making are the Document Verification Section, the Benefits Entitlement Section and the Legal Division. The processed application should get approved by higher level managers such as the Deputy Manager of ESSA, before announcement is made to the customer.

CHAPTER THREE

Knowledge-Based System and Application in Social Security Administration

3.1. Introduction

Understanding the notion of expert systems requires conceptualizing its theory, definitions, and other explanations. The science of expert systems has several dimensions to be looked at, although, this chapter deals with the application of expert systems in social security administration, other issues such as evolution of expert systems, its components, characteristics etc have been reviewed.

3.2. Expert Systems: Definition

Expert systems are computer programs that capture the expertise of human experts who are knowledgeable in a particular application domain (Clyde W, 1996). Expert systems are appropriate in a situation as such human experts are in very short supply; they are expensive and difficult to get (Hindin, 1986).

3.3. Expert Systems: Evolutions

Human decision making process is much more facilitated when assisted by technology. Many authors agree that the use of technology, such as expert systems for decision making is appropriate, particularly in a situation where getting the real human expert has proved to be a problem. Thus, as alternative, the expert system scheme is to represent an expert's knowledge in a form that a computer can use. As stated by (James P., 1991), a computerized model of the expert's reasoning and problem-solving abilities then uses that knowledge to solve problems in humanlike fashion.

However, early day decision making processes have not only been assisted by expert systems technology. Statisticians, for instance had been developing mathematical techniques (Boden, 1996), for a decade or more before the appearance of expert systems, for medical diagnosis, educational assessment, personnel selection, staff allocation and many other problems. Early decision making systems using mathematical techniques were using numerical symbols, whereas, expert systems relied upon qualitative, or "symbolic," methods. This creates a boarder line between expert based decision makings and earlier time decision makings using mathematical techniques.

Pioneer programs in expert system such as, MYCIN program, which is one of the first recognized expert systems, could be mentioned as the first generation of expert systems. The intention of MYCIN is to help people without specialist knowledge of a field makes decisions as though they were experts in medical field. MYCIN was intended to help physicians make diagnosis and treatment decisions in the area of bacterial infections (Martin, J. and Oxman, 1988).

Similarly, the R1 system, which is also categorized under the first decade of expert systems generation, can be worth mentioning. R1 was designed to help computer engineers configure computer systems to meet customer's requirements. That is, it is designed to assist people without specialist knowledge in the field (Boden, 1996).

Second generation of expert system was characterized by the transition from decision making to expertise. That is, major capabilities such as, task-oriented analysis of knowledge and reasoning with uncertainty were recognized.

Explaining the features peculiar to the second generation of expert systems, Boden states that:

> *'A growing interest in understanding the nature of some tasks such as monitoring events, planning and scheduling actions, and designing artifacts or processes, and the construction of software capable of carrying them out. Task organization and the formalization of knowledge, which is important to build complex behaviors from elementary components, are a major feature of recent expert systems research. However, first generation of expert systems was widely criticized for certain technical inadequacies.'*

Current expert systems are the result of industrial experience. However, as stated by Revi (1992), the earliest expert systems were small-scale and emerged from academic cognitive science labs, not from the software industry. Consequently, the first two generations of systems were not much influence by industrial experience.

Lack of underlying engineering discipline is found to be the limitations of first-and second-generation technologies. The third generation of expert system was characterized by the systematic engineering of knowledge. In general, the third generation can be characterized by the following features:

- Introduction of advanced development methodologies that are appropriate for expert systems and techniques for establishing the consistency and adequacy of knowledge bases.
- Developing Formal Theories of Knowledge to overcome problems associated with commonsense knowledge and commonsense reasoning techniques, such as:

    1. Commonsense inferences tend to use a great variety of partial and incomplete knowledge, and representations for partial knowledge whose knowledge meaning is left at all open to intuitive understanding are very liable to be ambiguous or unclear in important respects (Boden, 1996); and

    2. The very familiarity of commonsense concepts and their close connection to basic natural language forms renders them liable to ambiguity.

Hindin (1986) states that such kinds of concerns encourage many researchers to advocate a more rigorous, formal approach to the representation of knowledge. They are particularly concerned with providing systematic notations that permit us to capture ontological concepts in such a way that the properties of the concepts are expressed mathematically and hence their properties-what they can and cannot express in principle-can be properly analyzed. A particular natural class of tools for this kind of formalization is the class of systems called mathematical logics.

3.4. Building Blocks of Expert Systems

An expert system has four main architectural components, the knowledge base, the inference engine, the knowledge acquisition module, and the user interface for input/output as shown in Figure 3.1 (Chadwick, 1986). Description of each component is presented in the following section.

3.4.1. Knowledge Base

The knowledge base contains the domain specific knowledge that is used for problem solving in the domain. Or Knowledge base in some symbolic manner representing knowledge of facts and general information, as well as heuristics such as judgments, institutions, and experience, about a particular narrow problem area.

According to (Blaise, 1983), expert system designers aim to represent an expert's understanding of a subject rather than an abstract quantitative formalization of it. The meanings of concepts of a specialist field or "domain" can be approximated in a form that computers can use by means of appropriate formal languages. For example, an important component of a knowledge base is often a body of facts that represents the way in which concepts are related to each other.

Since the power of a knowledge-based system is in its knowledge, a major concern of knowledge systems is the representation of that knowledge. Knowledge can be represented and stored in the knowledge base with a format suitable for computer manipulation. One of the most commonly used ways to represent knowledge is as rules (in the form of IF-THEN). (Chadwick, 1986).

On the other hand, there seems to be similarity between Knowledge Bases and Databases. Hindin describes that Knowledge bases and traditional databases are designed to store information, however, there are differences between the two components such as;

- By type of information they can store
- The type of interrelationships between data they can handle (that indicate either application-specific or commonsense knowledge).

- In what kind of training is needed for the person who updates the stored information.

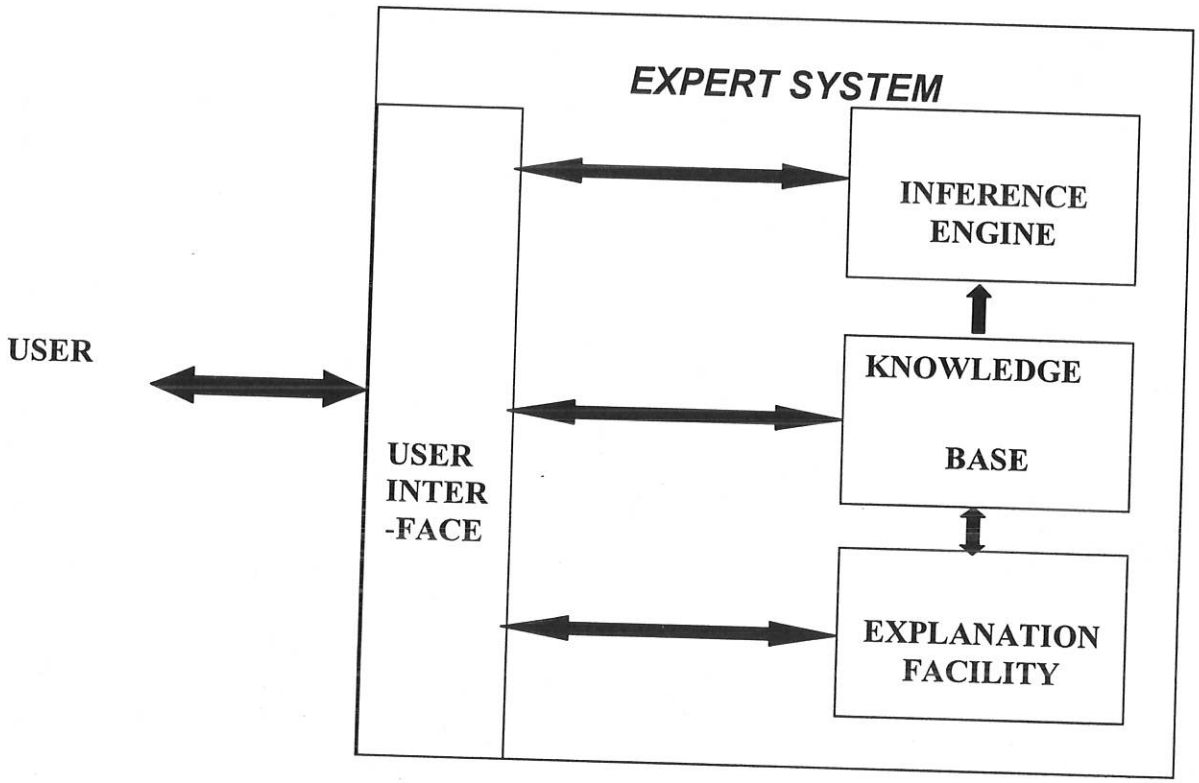


Figure 3.1. The Architecture of an Expert System

3.4.2. Inference Engine

The inference engine is based on **inference rules** and **search strategy** and contains **algorithms**. Algorithms are used to manipulate the knowledge stored in the knowledge base in order to solve problems. Inference mechanism-interprets the knowledge in the knowledge base of rules and facts and performs logical deduction and certain knowledge base modifications. Expert systems also contain control mechanism, which organize and control the strategies taken to apply the inference process.

3.4.3. Explanation Facility

The explanation subsystem allows the program to explain its reasoning to the user. These explanations include justifications for the system's conclusions, explanations of why the system needs a particular piece of data, and, in some experimental systems, tutorial explanations or deeper theoretical justifications of the program's action.

3.4.4. User Interface

The interface for input/output is used for the expert system to interact with the user, the environment and other systems such as databases, and spreadsheets.

3.5. Expert System Characteristics

Expert systems respond or reason in the way that human expert does to solve problem in a particular domain. The usefulness of the system is measured by the accuracy rate of meeting the target. To this end, there are several characteristics (Hindin, 1986) that experts must exhibit to be useful and are discussed in the next section.

- In order to add more knowledge and to improve on the model of the expert developed, expert systems must have the capability to update their knowledge easily.

- To be able to cope with real-world problems, expert systems must have flexible problem-solving strategies, just as do human experts. This feature is necessary because each problem to be solved, as well as the information available to solve it, may be slightly different each time.

- Expert system need to exhibit high performance in terms of their ability to solve their assigned problems correctly. Just as human beings, who have difficulty getting the right answer are not considered experts, expert systems that blunder when dealing with the basic problems they were designed to solve are not considered expert systems.

- Expert systems need to have the capability to explain what they have done and why, in the same way that human experts explain their actions.

3.6. Advantages and Disadvantages of Expert System

It is an obvious fact that expert systems are useful for human beings. This is justified from the view point of the services they are providing. To explain this, let us look at some of the advantages and disadvantages that an expert system possesses.

3.6.1. Advantages of Expert System

- **Permanence**: Expert systems do not forget, but human experts may
- **Reproducibility**: Many copies of an expert system can be made, but training new human experts is time-consuming and expensive.
- **Efficiency**: expert systems can increase throughput and decrease personnel costs. Although expert systems are expensive to build and maintain, they are inexpensive to operate. Development and maintenance costs can be spread over many users. The overall cost can be quite reasonable when compared to expensive and scarce human experts.
- **Consistency**: With expert systems similar transactions are handled in the same way. The system will make comparable recommendations for like situations.
- **Documentation**: an expert system can provide permanent documentation of the decision process.
- **Completeness**: an expert system can review all the transactions, a human expert can only review a sample.
- **Consistency of decision making:** decisions can not be carried out inconsistently, as it happens in a human being decision making process, due to changes in decision makers, level of understanding of the case etc.

3.6.2. Disadvantages of Rule-Based Expert Systems

Common sense: in addition to a great deal of technical knowledge, human experts have common sense. It is not yet known how to give expert systems common sense.

Creativity: human experts can respond creatively to unusual situations, expert systems cannot.

Learning: human experts automatically adapt to changing environments; expert systems must be explicitly updated. Case-based reasoning and neural networks are methods that can incorporate learning.

Sensory Experience: Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input.

Degradation: Expert systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise.

3.7. Application of Expert Systems

3.7.1. Introduction

Knowledge based systems may play several business roles depending upon the application opportunity. The business role that a KBS performs is a function of a particular situation, but to a very large extent it is also a function of the concepts that the managers of the functional area and designers of the system built into it. Business advantages obtained through KBS applications are to:

- Improve internal operating practices and conditions, and thereby achieve such benefits as higher quality, reduce operating costs, or the creation of better work environments which, in turn, reduce personnel turnover.

- Increase competitiveness through having greater knowledge available to create better products more quickly and at less cost, or more complex products, than competitors are able to do.

- Provide services and products with knowledge content or components that make those products or services more valuable to customers.

A great many types of expert system applications are currently in use. In insurance industry, industry specific applications such as underwriting, Reinsurance placement advisor, Claims settlement, insurance program, and design advisor have been developed and implemented to serve the purposes that are designed for.

KBS applications often are implemented to provide strategic benefits such as increased customer service, improved product quality and better personnel utilization. Benefits from KBS applications are usually broader than those from conventional systems that automate clerical or transaction functions. Many KBSs automate parts of human intellectual functions to aid knowledge workers in performing their tasks. As a result, they tend to have a more far-reaching impact on an organization's operation those conventional systems. Justification of KBS applications therefore requires identification of broader, indirect benefits with indications of how officials of the firm expect tat implicit and intermediate benefits will translate into end-value benefits.

3.7.2. Expert system Applications in Insurance

The use of expert systems for several different areas of application have been proved effective in terms of increasing productivity through saving time and cost, disseminating scarce knowledge to areas where an expert is not available. Application of expert systems in areas such as accounting systems, chemical plants, medical diagnosing etc have proved effective by improving decision making capabilities.

Similarly, different insurance companies have been developing and implementing expert systems in order to respond for the challenge they are facing in maintaining profitability. A life insurance company, Hibernian in Ireland for example, decided to re-engineer their existing Life Underwriting Process (BPR, 2001).

Their main objectives were to reduce the cost of underwriting, to speed up the underwriting process and provide customers with a better service, and to target key distribution channels such as large brokerages with a unique 24 hour decision service. A decision was taken to implement an Expert Underwriting System as part of the New Business System, with the objective of automating the processing of 50% of life insurance proposals.

Hibernian then investigated a different solution based on a PC-based knowledge development and maintenance tool from XpertRule Software in the UK. A main attraction of XpertRule was its ability to convert knowledge captured on the PC into source code. This allowed underwriting rules to be generated programs, which could be embedded seamlessly into the mainstream New Business System. A further advantage of XpertRule was the graphical knowledge representation and structuring which speeded up the development and maintenance of knowledge.

On the other hand, a life insurance companies in Japan (2003), which offers a wide range of insurance and pension products had developed Life Insurance Plan Selection expert system. The purpose of the expert system was to ensure that all the insurance sales staff had the expertise and the latest knowledge required to provide the best advice and service to the customers, which is found to be difficult for the company as a result of the increasing number of products.

To overcome this problem, Meiji has used XpertRule to develop the Life Insurance Plan Selection Expert system. The system can select the most suitable product, along with a reason for the choice; from Meiji's range of 37 individual oriented products.

The knowledge base developed contained 47 decision tasks. The rules for selecting each plan were developed as a separate task. The system was structured so that when the details of a customer are entered, the system assesses the suitability of all the plans and report on the best five.

CHAPTER FOUR
Knowledge-Based Systems Development

4.1. Introduction

To develop a system, it requires acquiring necessary knowledge that can enable the developed to achieve the desired goal. The knowledge gathered has to be represented in using the right knowledge representation techniques. The represented knowledge has to be stored and retrieved using queries or applying some reasoning mechanism of artificial intelligence. However, to retrieve or use the knowledge for applications that require intelligence capability, the system has to first get developed in a proper way. To this end, the system development should base up on formal system development life cycles. Expert systems like any other systems have developmental stages. In this chapter, therefore, issues like developmental stages of expert system, knowledge acquisition, representation, inference engines and inference mechanisms are discussed.

4.2. The knowledge System Building Cycles

In building knowledge based systems applications there are different activities involved. The major activities are to capture knowledge, preserve knowledge, structure knowledge, and expand or enhance knowledge, and distribute knowledge (Eveline, 1988).

As described by Hindin (1986), developing expert systems in general follow four steps, which are applicable to microcomputer or large-scale AI tools. The developmental steps are classified to *analyze the problem*, *design the system, build a prototype,* and incrementally *test the prototype.* These steps are equivalent to the classical engineering phases of software development: plan, design, edit, and compile, and test. Only the details are changed.

4.2.1. Analysis

Explaining the analysis stage of building an expert system, Hindin describes it as the stage for the knowledge engineer, contractor, or user to choose a problem. That is, the knowledge engineer determines whether the problem is suitable for AI solution. Moreover, at this stage, the knowledge engineer should figure out what type of expertise will be needed and who can effectively provide it and gathers the knowledge for the program.

4.2.2. Design

The knowledge gathered during the analysis phase has to be organized for proper utilization. The knowledge engineer organizes the knowledge in a way that best corresponds to the expert's organization in working with it, and creates a skeleton structure for the knowledge system. A typical skeleton structure is hierarchical and each hierarchical structure would further subdivided until finally a sufficient level of detail is reached that supposes the goal to be achieved.

4.2.3. Build a Prototype

Two types of tasks are performed during the next stage of building the prototype. In one task, the knowledge system designers fill in the detailed application information for each step of the hierarchy. Depending on the system and its knowledge representation methods, the details include diagnostic or other application rules, characteristics of physical structures, acceptable values that end users can enter, and other information necessary for the internal workings of the system. This information is written in whatever language is provided by the tool. Knowledge of these details allows the expert system to progress down the hierarchy by the reasoning strategies employed by the tool (forward chaining, backward chaining, or a combination) until it has concluded a specific diagnosis identified at the bottom of the hierarchy.

The second type of information entered during the building-the–prototype phase is control information. This is contained in rules that control an actual end-user consultation by controlling

the order in which both hypothesis and different lines of reasoning should be pursued and letting the system know when the problem has been solved.

4.2.4. Test the Prototype

In the test-the program step, the system designer challenges the knowledge system with several sample problems that it is supposed to be able to solve. The problems are identified by the expert.

If execution of any of the test cases produces erroneous results, it is necessary to go back to the expert. The expert can generally tell why the program produced the erroneous result and recommends what the knowledge system should know or do so as not to repeat the same mistake. This new knowledge is encoded in the form of new rules and added to the system, which is tested again wit more sample test cases. This process is iteratively conducted until the system consistently provides accurate answers.

4.3. Knowledge System Reasoning Strategies

4.3.1. Inference Strategies

A knowledge system's advice and recommendations are produced by the system's inference strategies, which operate on the knowledge encoded in the knowledge base. Inference strategies in the rule-based knowledge systems can be goal driven (a method called backward chaining) or data driven called forward chaining), or a combination of these.

Backward-chaining inference strategies start off with a known goal and try to use the expert program's rules to get to that goal. In contrast to backward-chaining procedures, which plan the rules to use to reach an identified goal, knowledge systems that use a forward-chaining paradigm react to externally or internally simulated conditions or data. Some particular data or condition may cause certain rules to be invoked. The reaction, directed by the rules that happen to be invoked by the current data or conditions, may change the knowledge base or the knowledge system's environment.

The new data in the changed knowledge base or environment may cause other rules to be invoked and other changes in the knowledge base and environment. The object of a forward-chaining stem is to trigger these reactions until it produces a situation that satisfies a particular goal.

4.3.2. Control Mechanisms

Knowledge systems of any size generally also have a control mechanism. The control mechanism controls the search and prevents the knowledge system from wasting its time exhaustively through irrelevant rules at random.

Both rules and strategies are inherent in a knowledge system's control mechanism. The rules known as meta-rules, are also about rules and how best to apply them, rather than about subject application knowledge. Most commonly, they are used to direct the order in which both hypotheses and different lines of reasoning should be pursued. Meta-rules such as these facilitate knowledge system performance because knowledge systems view problem solving as a search through a space of possible solutions. Therefore, if there is a large space of possible solutions to a problem, meta-rules help narrow the search space.

4.4. Knowledge Representation

Overview

There are several methods used to represent knowledge in a knowledge base, such as semantic networks, frames, and rules. The representation of knowledge so that a computer understands it is one of the major problems in building a knowledge-based system.

Knowledge representation techniques such as Semantic Networks are also used to represent knowledge particularly for linguistic and other concepts. In expert systems and AI, however, techniques for knowledge representation have been developed much further. The introduction of rules is one obvious extension. Another is the introduction of "frame-based" and "object-oriented" representations. These provide way of structuring large collections of interrelated facts

and rules. They also capture an important set of intuitions about what we can infer in specific situations from general knowledge of the world.

In an object-oriented representation concepts are organized into hierarchies; objects that are higher in the structure normally represent "classes" or "generalizations" of concepts of levels below them. In this section, knowledge representational techniques, mainly, Semantic Networks, Rule-based, and Frames are discussed.

4.4.1. Semantic Networks

In contrast to database mechanisms that represent relatively straightforward relationships, knowledge bases contain a system of "predicate functions" and" symbolic data structures" which have meaning , or "semantics," built in. A function is a kind of procedure that is performed on certain input values, called arguments, and produces or is associated with a set of admissible values.

Besides predicates, the other type of item in a knowledge base is a symbolic data structure. A symbolic data structure is a structure that is used to represent symbolic knowledge and that can also be stored in a computer's memory. Other knowledge representation structures called a semantic network.

A semantic network is a node-and-arc graphical notation that represents objects (or actions or events) and contains built-in real-world meaning about the objects. The nodes represent the objects. They could also represent actions or events. The arcs between the nodes represent predicates or attributes that indicate relationships between the objects (or actions or events) shown in the nodes.

4.4.2. Rule-Based Expert System

A knowledge system is called as an expert system because this system solves problems by the knowledge of experts. The basic unit of knowledge in these expert systems is the rule, defining 'so-called rule-based expert system'. A rule is a conditional test-action pair, for example, if condition is true, then action.

There are several approaches using knowledge in solving problems of various domains. These are rule-based expert systems, model-based reasoning (MBR), and case-based reasoning (CBR) (Choi, 1995).

According to Kowalski (1996), the basic rule-based programming approach is to decompose a computation in to a set of elementary transformations. Each elementary transformation attempts to much its input against a set of temples. If the temples is chosen, and the action associated with the rule is effected. If no temples much, the program halts.

The rule-based approach has often been chosen for programming expert systems, because the pattern-action model resembles human decision processes. Programming with rules should narrow the semantic gap between the way a problem is conceived and its representation in a computer program (Kowalski, 1996).

The rationale for using rule-based systems are also explained from several dimensions. For instance, Rauch-Hindin (1986) stated as follows the reasons why rule-based systems are used:

First, rules can be easily understood by programmers or experts because the control structure is relatively simple as an if-then format. Second, rules can encapsulate an important part of knowledge in that rules can model a complex problem. Also, knowledge can be saved by rules. Third, the control structure of a rule seems to mimic some human problem-solving strategies, and hence rules saved in an expert system can be used for solving human problems. Fourth, rules are independent of each other. Even though some parts of the rules are deleted or incorrect, these mistakes will not affect all rules or functions. Some mistakes of other programming languages that can be used to describe an if-then structure may affect the entire function. Fifth, rules can be

placed in any order in a program. Last, natural languages can be used for questions on the user interface, and hence it is very convenient for non-experts to use rule-based expert system for solving problems.

4.4.3. Frames

Another symbolic knowledge representation structure used to represent knowledge in knowledge bases is known as "frames." Like databases, frames store information. However, database stores information about its data in what are called "fields." A field is the memory area that contains each item in a record. For example, an employee record might contain an employ's number, name, job, date of hire, salary, and department number. The area of memory allocated to employee number is one field; employee name, job, date of hire, salary, and department number are the other five fields in the employee record. The record is actually the collective group of fields for a single employee.

Instead of memory areas called fields, which a database uses to hold information about its data, frames are data structures that contain variable-sized memory areas called *slots*. The slots may contain standard attributes, such as are found in databases. But *slots* may also contain other types of information, such as hypotheses, that relate to the expert program's function. In addition, slots can contain rules about application area situations and actions to take under certain conditions. They can contain subprograms, or "pointers," that point to and link the slots of one frame to other frames. Finally, individual slots in one frame may also be independent frames, with their own complete sets of slots of attributes, hypotheses, rules, and processes. This slot-to-other-frame link creates a hierarchy of relationships not found in databases.

4.5. Requirements for Expert System Development

To build knowledge-based system for any problem domain, certain prerequisites concerning the human beings involved and problem characteristics must be met. These are:

- There must be at least one person who performs the task well enough to be classified as an expert in the task. The experts must be able to articulate their knowledge and explain how to apply that knowledge to a particular task. It is possible to bring the knowledge of several human experts to bear on a problem. Dealing with more than one expert, however, can cause inconsistencies in the knowledge extracted for computer use because different experts often arrive at the same or equivalent answer by what seems to be very different means.

- Prerequisite conditions that apply to the problem, rather than the human expert, require that the application area be well bounded. In other words, the problem limits that the knowledge system can handle should be well defined because most knowledge systems today do not deal well with problems at the limits of their knowledge.

- The chunks of knowledge encoded within the program must be relatively well defined so that when solving a problem the knowledge system can select from its various alternative pieces of knowledge. Finally, the problem chosen for a knowledge system application should be solvable by human beings within a period of three minutes to three weeks.

4.6. Inference Engines and Inference Mechanisms

Knowledge base systems are AI-based reasoning systems that include explicit knowledge about some domain. In most cases, the knowledge is held as a separate "knowledge base", distinct from the computer programs, much as text in a word processor is kept separate from the program that are used to manipulate, display and print the text. The domain knowledge in the knowledge base is represented in well-defined ways to facilitate the use of formal, AI reasoning strategies to draw inferences about particular situations under analysis.

The expert's knowledge is contained in what is aptly called a knowledge base. An inference mechanism also does what its name implies. It makes inferences based on its interpretation of the representation of the expert's knowledge. These expert systems (or knowledge-based systems),

which incorporate these experts' reasoning a problem-solving models, augment the experts' capabilities and are similar to having a consultant on call.

It is important to realize, that while expert systems can reason from knowledge in a limited domain and can approach (in some cases, even exceed) human performance, they cannot provide solutions for problems that human beings do not know how to solve. Instead, expert systems contain, in encoded form, the existing knowledge of experts and use that encoded knowledge to reason like a human being. Therein lies the power of expert systems—in that knowledge, not in clever programming. (J.D., 1984).

To reason like a human being, expert systems rely not only on factual knowledge as do conventional programs, but also on uncertain knowledge and observations based on experience and intuition (collectively called heuristics). The facts and heuristics are extracted from experts in a specialized subject area. They can then couple with methods of analyzing, manipulating, and applying the encoded knowledge so that the program can make inferences and explain its actions. (Amar, 1988).

Expert systems differ from computer programs because their reasoning is not straightforward. Their tasks have no practical algorithmic solutions, and they must often make conclusions based on incomplete, judgmental, speculative, uncertain, or fuzzy information.

Typically, to build an expert system, the developer chooses a form to represent the expert's knowledge. The developer and the expert work together to encode some of the expert's basic knowledge and reasoning techniques in that form.

CHAPTER FIVE

Knowledge Acquisition and Modeling

5.1. Introduction

Expert systems applications are suitable for tasks about which people are more knowledgeable and perform a lot better if they have had years of experience. Usually the number of such people is relatively small. As a result, their knowledge is scare, poorly distributed in an organization, often distributed among many people, and unavailable with any degree of reliability. The scarce, poorly distributed, and unavailability results in a knowledge bottleneck for an organization (Hindin).

(Christer, 1991) suggests that, application of suitable expert systems in an organization demands the necessity for analyzing the flow of information in the organization. That is, understanding clearly the existing system and identifying the actual problems can help to design the right solutions, which ultimately alleviate the knowledge bottlenecks in the organization.

In this chapter, the knowledge required in social security status and amount determination are collected, organized and presented. That means, in order to identify the information requirements of the social security system, the existing system was analyzed and the findings are presented.

5.2. Acquisition of Knowledge from an Expert

As a real expert working in a particular area uses his/her own knowledge and experience to solve a particular problem, an expert system or knowledge system acts like a real expert. This is because it has embedded in it the factual and experiential (heuristic) knowledge of a real expert. However, when it comes to the expert system, it is obvious that, acquiring that knowledge out of the real expert and put it into a form that can be used by a computer is a difficult job.

This is because, for one thing, it requires an expert who is both cooperative and articulate. For another, it requires a person who knows something about computers and the expert's application area in order to interview the expert and convert the knowledge acquired from the interviews in to a computer-usable form.

In this framework, the knowledge acquisition task which has been conducted at ESSA (Ethiopian Social Security Authority) was mainly to address the following components:

- To understand the social security determination process.
- To gather data about the criteria required for social security eligibility.
- To clearly understand the social security program types.
- To know the amount of social security payable to customers, mainly the pension amount and the gratuity amount determination to a customer as well as to his families.

In this regard, questioners were prepared, interviews were held, and conduct observations on the job were made to gather the required knowledge for the knowledge engineering task. The right experts on the domain area were identified based on the job requirements of the experts assigned at different positions. The profile of the domain experts is identified earlier to determine the right experts in the domain area. This is done to acquire the appropriate information that can ultimately meet the knowledge engineer's goal. The profile is summarized in Table 5.1.

Educational level	Experience	Position
BLL in law	5 years	**Expert**, *Pensioners document verification (eligibility determination) section*,
BLL in law	3 years	Legal Analysis
B.A in Language	7 years	Public relations offices
B.A in Accounting	13 years	Finance head
B.A in Accounting	6 years	**Expert**, *Fund contribution section*
B.A in Accounting	12 years	Auditor

Table 5.1. Experts profile

The knowledge acquisition task was not limited to only the experts indicated above, but substantial amount of additional knowledge has been gained from existing and world wide social security standards, manuals, procedures, pamphlets.

From the knowledge gathered, it is identified that, there are four types of social security program types implemented currently at ESSA. These are,

- Retirement age pension
- Invalidity pension
- Survivor's pension
- Employment injury pension (Employment injury means-employment accident and occupational disease)

Eligibility criteria to classify the pensioner in one of the social security program types has also been gathered and structured. Each of the programs has got their own peculiar criteria distinguishing one program type from the other. The criteria for each social security programs have been shown at different tables in this chapter. The eligibility criteria for the programs are identified from the experts description. Modeling the knowledge gathered conceptually, would structure the specification of the data and knowledge required for application.

5.2.1 Conceptual Modeling

Basically, conceptual modeling is a central activity in knowledge base system construction. A knowledge model provides an implementation-independent specification of knowledge in any application domain. The conceptual modeling for the social security programs have been illustrated and discussed in the next section.

5.2.1.1. Retirement Age Pension

Retirement age pension is type of pension a public servant secures or claims when his/her age reaches 60 together with some years of service in a public organization. The detail specifications of knowledge that qualify a public servant for a retirement and survivor's pension have been indicated in Table 5.2. Moreover, the decision tree with the intent of showing the concepts used by the expert as decision making strategy, have been illustrated in Figure 5.1.

Condition			Action
Experience	**Retirement Reason**	**Family Condition**	**Eligibility Status**
>=10 years	Retirement Age (60)	Y/N	Retirement Pension
>=10 years	Death	yes	Survivors pension
>=10 years	Resignation	Y/N	Retirement Pension- *Up on attainment of Retirement Age*
>=10 years	Resignation	Y/N	Retirement Pension- *Up on attainment of Retirement Age*
>=10 years	Death	yes	Survivors pension
>=10 years	Retirement Age	Y/N	Retirement Pension
>=10 years	Death	yes	Survivors pension
Less than 10 years	Retirement Age	Y/N	Retirement Gratuity

Table 5.2. Requirements for Retirement and Survivors Pension

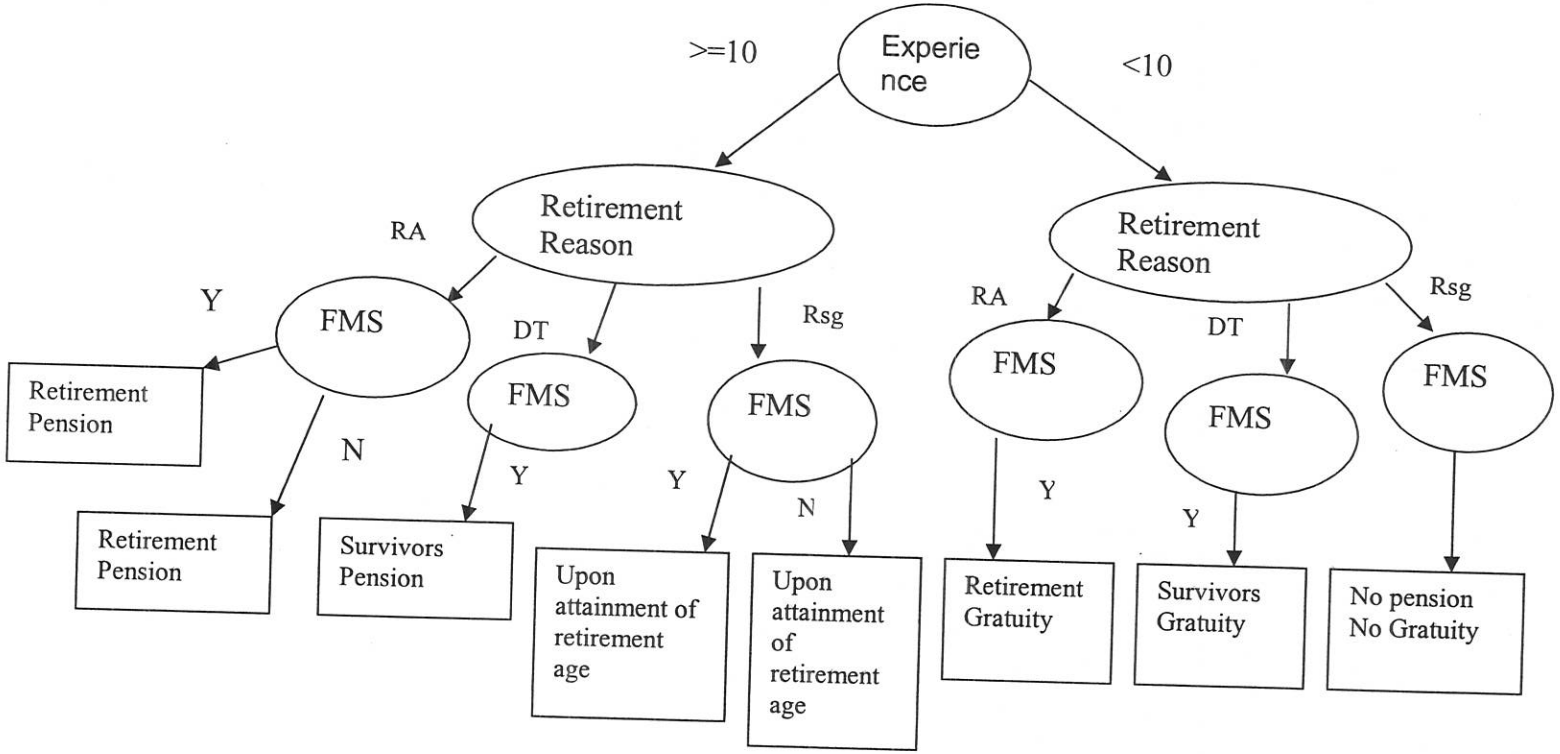


Figure 5.1. Decision Tree for Retirement and Survivors Pension

KEY: - **DT**---Death - **FMS**—Family Status -**Rsg**---Resignation -**RA**—Retirement Age

5.2.1.2. Invalidity Pension

The invalidity pension entails the illness an individual is facing while in duty in a public service organization. Though, the requirements for invalidity pension are indicated in Table 5.3 invalidity pension can be expressed in general as a public servant who has completed at least ten (10) years of service and is retired because he does not fulfill the medical condition of service, shall receive invalidity pension for life. Figure 5.2 also illustrates the invalidity pension hierarchical tree.

Condition			**Action**
Experience	**Reason for Retirement**	**Family Condition**	**Eligibility Status**
>=10 years	Health failure	Yes/No	Invalidity Pension
>=10 years	Death	yes	Survivors pension
>=10 years	Health failure	Yes/No	Invalidity Pension
>=10 years	Death	yes	Survivors Pension
Less than 10 years	Health failure	Yes/No	Invalidity Gratuity
Less than 10 years	Death	yes	Widow/Widower/children gratuity

Table 5.3. Decision Table for Invalidity Pension

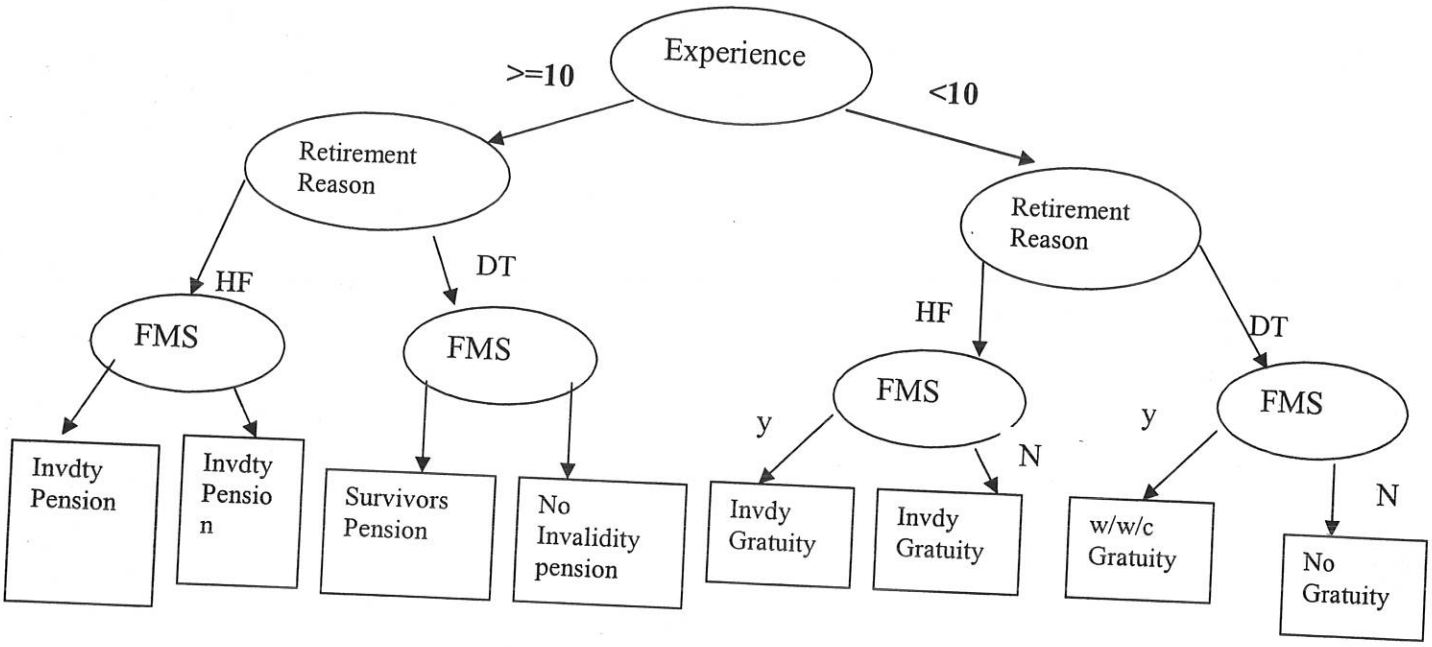


Figure 5.2. Decision Tree for Invalidity Pension

KEY:

- **HF**---Health Failure
- **DT**--Death
- **w/w/c**—Widow/widower/child
- **FMS**—Family Status

5.2.1.3. Incapacity (Employment Injury) Pension

Employment injury is an *employment accident* and *occupational disease*. Employment accident means any organic injury or functional disorder suddenly sustained by a public servant during or in connection with the performance of his work. To decide up on

whether an individual can secure employment injury or not after the accident or injury has happened, conditions such as *injury recovery level* and the *capacity to work* are very important. The general specifications (detail knowledge) required for determination of employment injury pension are gathered, structured, and presented in Table 5.4. Besides, the hierarchical tree representation is also illustrated in Figure 5.3.

The extent of employment injury sustained by a public servant shall be assessed by authorized medical board. The medical board shall assess the extent of employment injury based on the directives to be issued by the Ethiopian Social security Authority (ESSA). Thus, incapacity pension for life or incapacity gratuity shall be paid as the case may be, for injure sustained from employment A public servant who sustains employment injury of not less than ten percent (10%) and separates from work due to absolute incapacitation shall receive an incapacity pension for life.

Condition		**Action**	
Injury Recovery Level	**Capacity to work**	**Family Condition**	**Eligibility Status**
>=10 percent	Absolute incapacitation	yes	Incapacity Pension
>=10 percent	Absolute incapacitation	no	Incapacity Pension
>=10 percent	Death	yes	Survivors Pension
>=10 percent	Able to work	yes	Incapacity Gratuity
>=10 percent	Able to work	no	Incapacity Gratuity
<10 percent	Able to work	yes	No Incapacity Gratuity

Table 5.4. Decision Table for Incapacity Pension

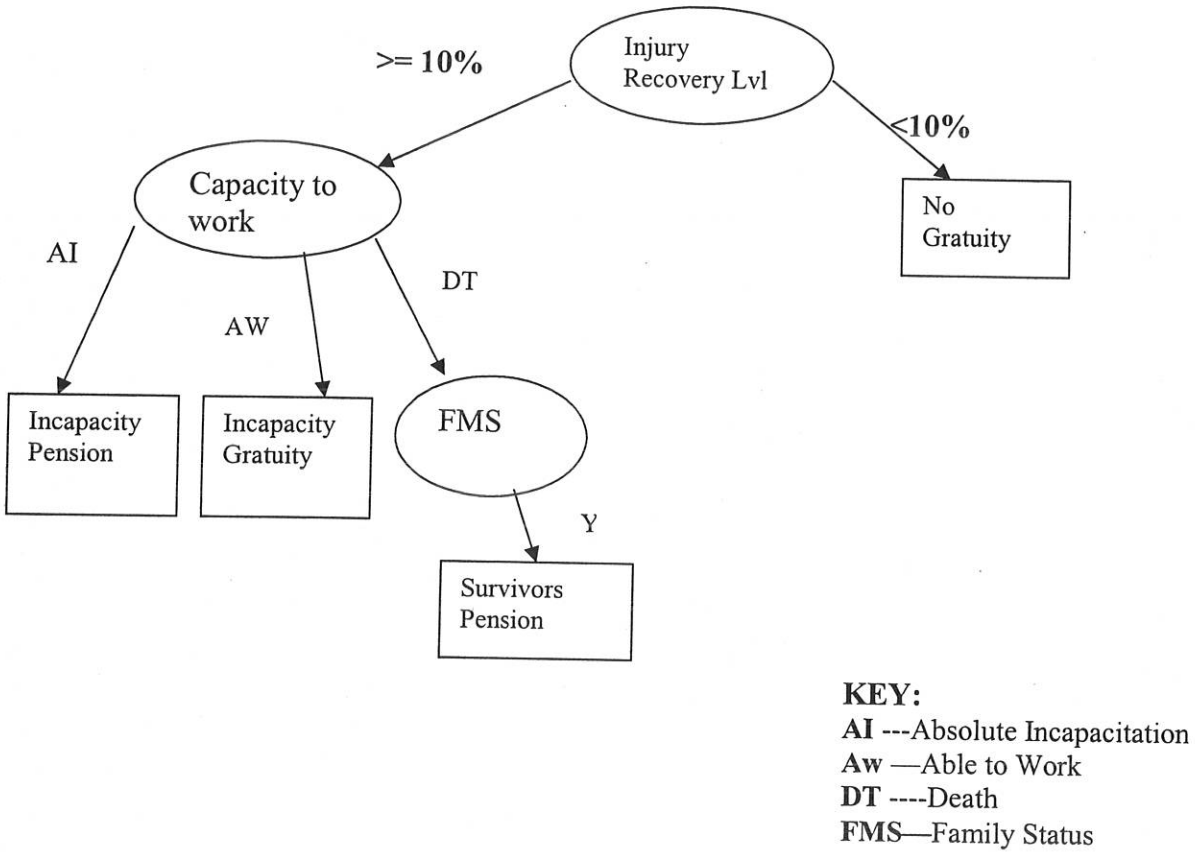


Figure 5.3. Decision Tree for Incapacity Pension

5.3. Social Security Program Amount Determination

A public servant, to whom pension is decided or determined, the equivalent amount of money will also be allocated for one time payment in the form of gratuity, or monthly payment for life. The amount of money varies from one social security program to another. For example, if a public servant secures eligibility for or categorized as

retirement pension, the amount of percentage allowed for him/her will be 30% of average salary of last 36 months. Similarly, for other pension programs, there is a specific amount of percentage calculated based up on their salary. Table 5.5 in the next section summarizes the specific percentage of social security programs offered to the customers and their families in the form of pension or gratuity.

Program Type	**Amount**
Retirement Pension	30% of average salary of last 36 months.
Retirement Gratuity	Salary preceding retirement * No of service years the customer provided
Invalidity Pension	30% of average salary of last 36 months
Invalidity Gratuity	Salary preceding retirement * No of service years.
Incapacity Pension	45% of basic salary
Incapacity Gratuity	45% of basic salary * 5 years * % of the injury level.
Widows/Widowers Pension	50% of the pension
Orphan's Pension	20% of the pension to each child
Parent's Pension	15% of the deceased pension
Widows/Widowers Gratuity	50% of the gratuity
Orphan's gratuity	20% of each of their gratuity

Table 5.5. Percentage share of the customers & their families.

5.4. Social Security Determination Process at ESSA

Determination of public servants social security status and determination of the right pension amount and pension gratuity is performed based up on several procedures. At each procedure or step, different expertise is used for decision making. In this section, description of the social security determination procedures has been dealt with.

- **Registration and Verification of Public Servants**

When an employee for the first time gets employed, the employer organization sends Form-1 to ESSA, which contains the public servants profile. Then, registration of Public Servants is conducted by the Ethiopian Social Security Authority (ESSA) to have active list of public servants working in a public organizations.

The *registration section* of ESSA registers the employee based on the data indicated in Form-1. Moreover, this section conducts verification to make sure that the employee had not been registered before. If verification process found the stated customer indicated at Form-1, it will be concluded that the employee had been registered before; the right measures will be taken, such as correcting errors, updating the file, or replacing the previous file. After completing the registration process, the personal data contained in Form-1 will be classified alphabetically for later retrieval.

- **Determination of Social Security**

When an employee requests the employer organization for social security due to some reasons, such as resignation, sickness or due to any other reasons, the employer organization fills Form-28 and sends the form to ESSA together with any necessary documents that testify the customer's work experience, current family situation, etc which are already documented in the employer's organization. Moreover, the form also contains detail information about an employee such as name, address data of employment etc. The *registration section* at ESSA verifies the received documents together with form-

28 and make sure whether it is complete or not. Before this process take place, of course, Form-28 is checked against Form-1, to make sure that the customer has been registered in active civil servants file. If found and identical, then registration of the data contained in Form-28 will be conducted.

During the registration time, file number is also given to the registered customers, and the form will be transferred to the *Document verification* section together with any documents about the employee. The document verification section conducts expert analysis to determine the eligibility of the employee for social security benefits. The *legal division* of ESSA will also give analysis about the customer's evidences attached with Form-28. For example, if the customer has been in jail and quit his/her job for some years, the legal division investigates the case and give decision about the cause of the disciplinary action passed on the customer being considered for social security program. The legal division raises questions such as, "For how long the individual has been in jail?", "Does the individual's case has been settled after released or still the case is active?.

These and other very detailed investigations are conducted to trace, gather, and determine the exact service years of the individual. The investigation is also very important to make sure that, whether the individual has been blocked by the court not to secure any social security benefits for some time due to the course of procedures followed by the court.
The eligibility requirements that have been discussed under section 5.3 such as, experience of the customer in serving public servants, the family situation, the health situation etc are checked given expert analysis. If found eligible, the file is transferred to the *fund contribution* section to check whether the employee has been contributed the required contribution during his service years. Public servants are contributing 4% of their salary during the entire service years.

If contribution verification is verified, then the file will be transferred to the *amount determination section.* The role of this section is determining the actual amount the

pensioner has to get based up on the social security category determined. The process of computing of the amount is explained in the next section.

- **Determination of amount and preparation of pension identification Book**

Following the document verification or fund contribution, the customer's file will be taken to *finance section*. The finance section will investigate the status of the employee's social security program type decided earlier during document verification time, determine the amount referring pension amount determination procedures, fill out Form-29 and Form-33 which will be containing decided pension amounts and necessary information, and transfer the forms together with the required documents to the required head to approve the amount indicated in the forms.

After approving the forms, the head will send the forms to the *Auditors*. The role of auditors here will be:

- Checking the completeness of the required documents for pension
- Investigate the appropriateness of the decision given in Form-29 & Form-33
- Approve the aforementioned pension amount by signature

Performing the above activities, the auditors will send the file of the employee to the head of *Pension fund approval division*. The head analyzes the documents received and give his/her decision. That is, approving, requesting for more explanation or rejecting.

Finally, completing all decision cycles, the file of the customer will be directed to perform two activities:

- Registration of final decision given
- Preparation of Pension Identification Book *(this will serve the pensioner to collect pension payments every month)*

Based on the above social security determination processes, a decision is made to a public servant. However, the overall decision making process follows several other

detailed steps such as, receiving the customer's personal data from the employing organization, preparing pension determination form etc. The detailed and routine steps and processes are summarized in Table 5.6 next.

Step 1	Receiving the required information from employers
	Registering the information received
	Verification of the information
	Transferring eligible cases for social security determination
Step 2	Prepare pension determination form
	Determining social security type
	Approving of social security type by first level Auditors
	Approving the social security type by the responsible head
	Performing statistical registration
	Prepare pension identification Book
Step 3	Receiving the determined social security type for payment preparation
	Approve miscellaneous payment orders by second level Auditor
	Approve payment orders by the responsible head
	Issuing pension identification Book and other documents to pensioner
	Transferring the final pensioner file for documentation
Step 4	Receiving the final pensioner file and conduct registration
	Marking as a registered file
	Sending the registered file to Archive section
Step 5	Verification of the registration of the file
	Filing and keeping the file in appropriate location

Table 5.6. Detailed procedures for determination of social security

5.5. Analysis of the Problem

The purpose of Social Security in Ethiopia is to provide means of earning for public servants, military and police force and their families. The social security service provided is mainly classified into two main schemes. These are the pension scheme and gratuity scheme. Securing one of the social security schemes depends upon the pensioners' situation. For example, if the pensioner claims retirement after attainment of age (60) sixty (retirement age) and more than ten (10) years of service, retirement pension is provided. On the other hand, if the social security claimer's age reached sixty (60) and provided less than ten (10) years of service, retirement gratuity would be provided.

Similarly, social security claimer can be provided other types of social security programs such as invalidity pension (gratuity), survivor's pension (gratuity), and employment injury pension (gratuity) depending up on the current situation an individual has come up with. The requirement an individual is required to fulfill to belong to one of the social security programs varies from one program to another.

When an individual for the first time get employment in a public organization, the employer organization sends a letter together with social security registration form (Form- 1), which holds data about the individual to Ethiopian Social Security Authority declaring that the aforementioned public servant is employed in the sender's organization. The Registration and Verification section of ESSA verifies the document and register the individual permanently by opening a file. When the individual come up with social security claims, the same organization or the current organization where the individual is working sends another form known as Form-28, which holds data about the individual's experience, the name of organization he has been working, his family situation, etc. ESSA after receiving the form verifies the completeness of the form by checking whether the required information is completed correctly or not. This is verified using the additional information or testimonies sent from the employer organization together with Form-28.

A number of professionals working at different sections verify the document received before arriving at any decision to make sure that to what extent the documents meet the social security programs requirements, which are describing about the eligibility requirements for any type of social security program.

Processing an individual's claim for social security programs, by average take more than a month. This is due to the time required for verification of each and every document. If something in the individual's document is not clear or found to be something that requires further clarification, ESSA hold the decision for Social security until the required information is fulfilled. Further clarifications may be required from the employer organization or from the individual himself.
The other reason identified for the slow decision making of the organization is the fact that unavailability of professionals responsible for decision making. From the analysis of the existing system, it is found to be possible to understand that, the experts are also busy working in another duty such as working in committees.

On the other hand, decision makings of an individual's case delays because, the individual's case are directed to several unnecessary sections for verification, which might not be necessary or that could have been verified at the first document verification section. This causes redundancy as well as inconsistency.

Absence of computer systems to support social security status determination processes is the other factor identified that is causing for the significant poor performance of the organization. Pensioners files are registered manually, and assigned identification number manually and permanently filed using alphanumeric filing system. Thus, when an individual's file is retrieved, it takes significant amount of time. Similarly, filing an individual's file to the right place is also tedious and sometimes it gets to be filled in the wrong position and causes retrieval worst. Active Public servants record or pensioners' record is thus handled in a traditional manual filing and retrieval system.

For example, during knowledge gathering process, it is possible to understand that, there were incidents that pensioners file have been misplaced and customers were forced to wait for sometime until the file is found. Moreover, professionals working in different sections are often resigning from their job and as a result delay in decision making happens. When a new staff is recruited and assumes the position, the precision and speed that has been maintained have not been demonstrated until the new staff gets well acquainted with the working procedure and style of decision making. For instance, in order to determine the amount of pension or gratuity for a particular social security type, a responsible individual working in the finance section must understand the calculations and computing necessary for the determination of monthly pension or determination of exact gratuity for survivors such as children, wife or other relatives.

The analysis made in the Ethiopian Social Security Authority's existing system shows that, there are multiple problems with the existing manual based working systems. In a nutshell, we can describe the problems as follows:

- Significant amount of time is required to pass decision for a particular case.
- Responsible experts assigned for a particular task are also busy in running some other activity of the organization.
- Verification of an individual's testimonies and passing decision for a particular social security case requires approval of a number of section heads. Such extended steps could have been cut down. As a result process redundancy occurs, which has an overall effect on the pensioners' time and on organization's resources?
- It is found that, there is no computerization at ESSA to handle civil servants and pensioners record. Thus, information retrieval and storage tasks are not facilitated as required.
- During times such as staff resignation, customers' cases are suspended until a substitute is found.
- When a substitute is ready for the job, decisions get inconsistent, as results of lack of experience and awareness to the usual procedures followed for solving a problem.

- Complaints are raised due to inconsistent decisions.
- In many cases, determination of a particular type of social security program for a public servant requires screening of several documents, which are evidences for the smooth determination of pension.

To sum up, the problems identified through the analysis of the existing system entails the urgency of implementing a computerized working system. Thus most of the problems, though not all, can be tackled and the organization can maximize its efficiency through reduced cost and time, if appropriate technology is used. In this regard, application of expert systems technology is the most appropriate remedies for handling such unstructured decision making processes.

From the view point of the suitability of application of expert systems, the findings pinpointed in this study, justify that application of expert systems technology is the right choice to address the information requirements of the existing social security status determination.

CHAPTER SIX
Knowledge Representation

6.1. Introduction

In chapter five, experts for knowledge acquisition in the domain area were identified; the required knowledge has been gathered and modeled. Based up on the analysis of the existing system and the knowledge gathered, problems of the existing system were identified clearly. The knowledge model has been developed using the top-down approach of hierarchical structure. Designing of the knowledge base has been developed based on these models.

In this chapter, techniques for knowledge representation in the designing and building of the prototype for the development of the intended expert system have been discussed. Since the knowledge is organized in a way that best corresponds to the experts organization in working with it, the end result of the representation of the knowledge will also address the expert's method. To address this, rules have been represented using rule based system in the form of IF-THEN.

6.1.1. Knowledge Base

The collection of knowledge in the domain area is known as the knowledge base. The knowledge base component of the system is organized into two parts. The first represents the ***social security category determination*** of the customer *(retirement age pension or gratuity, invalidity pension or gratuity, employment injury pension or gratuity, and survivors' pension or gratuity)*. The second component is meant for ***calculation of the customer's pension amount***.

The expert system in this research, therefore, performs four types of social security program determination tasks and computes the pension or gratuity amount payable to the customer based up on the social security program determined. For instance, as soon as,

the system determines type of social security program for a customer, the expert system prompts the user whether he/she needs to compute the amount of money payable to the customer.

To execute the two components of the expert system described above, rules have been developed in the form of IF-THEN, structured and tested. The knowledge representation performed in the study has also been shown using sample rules, which are developed using Knowledge Pro Gold expert system shell. The samples are shown in the next section:

Sample rules for Retirement age Pension determination:

Topic Program.

Set_number_of_values (program, 1).

If ?'experience' is '>=10 years'
And?'retirement' reason is 'retirement age'
And?'family' condition is yes
Then program is 'retirement pension'

If ?'experience' is '>=10 years'
And?'retirement' reason is 'retirement age'
And?'family' condition is no
Then program is 'retirement pension'

Sample rules for Survivors Pension determination:

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Widow/Widower survivors pension. The share of the pension will be--50% of the pension goes to the widow/widower and 20% of the pension amount goes to the children'.

Sample rules for Incapacity Pension determination:

If ?'injury recovery level' is '>=10%'
and ?'experience' is '<10 years'
and ?'retirement reason' is 'Injury'
and ?'capacity to work' is 'absolute incapacitation'
then program is 'incapacity pension'.

Sample rules for Invalidity Pension determination:

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'health failure'
and ?'family' is yes
then program is 'invalidity pension. The amount is 30% of average salary of last 36 months'.

After determination of the social security category program, computation of the amount payable to the customer performed. The expert system does about six types of calculations to determine different categories of payments. Sample codes that calculate pension amounts for *retirement age pension, incapacity pension* and *gratuity* are shown below. The program accepts input from user and computes an output. The output is net amount payable to customer.

Sample computational codes to calculate retirement pension amount.

```
Topic Amountretagepen.

ask('#e Monthly salary amount of year 1#s', x).
ask('#e Monthly salary amount of year 2#s', y).
ask('#e Monthly salary amount of year 3#s', z).
w = 12.
year1Total = ?x * ?w.
year2Total = ?y * ?w.
year3Total = ?z * ?w.
GrandTotal = ?year1Total + ?year2Total + ?year3Total.
AvgSal = ?GrandTotal div 36.
p = 0.3.
retageamount = ?AvgSal * ?p.
text ('#e #fblue The Monthly Net Pension amount( Salary) will be
#s',?retageamount,
'#nTo determine social security for another customer, click the button').
 end.
button (continue,mmmm, 20,8).
wait ().
close_window (?mmmm).
 end.
```

Figure 6.1. Code to calculates retirement age pension.

Sample computational codes to calculate incapacity pension amount.

```
Topic Amountincpen.

ask('#e What is the basic salary amount?', J).
Bsalary = ?J.
Q = 0.45.
incpenamount = ?Bsalary * ?Q.

text ('#e #fblue The Monthly Net Pension amount( Salary) will be
#s',?incpenamount,
'#nTo determine social security for another customer, click the button').
 end.
```

Figure 6.2. Code to calculates incapacity pension.

Sample computational codes to calculate invalidity gratuity pension amount.

```
Topic Amountinvgra.

Ask('#e Enter the amount of salary preceding  retirement#s', LastSalary).
Ask ('#e How many of years of service does the pensioner provided?#s', x).

Sal = ?LastSalary.
Yr = ?x.

invGranuity = ?Sal * ? Yr.

text ('#e #fblue The retirement gratuity amount will be #s',?invGranuity,

'#nTo determine social security for another customer, click the button').
 end.
```

Figure 6.3. Code to calculates invalidity gratuity.

6.2. The Explanation Facility

The expert system in the study includes the HOW feature. The HOW and WHY features are commonly referred to as the characteristics of an expert based systems. This is because, when ever necessary there must be explanation describing about the procedures followed by the system and conclusions forwarded.

The HOW feature in the expert system, provides user with detailed description of how a particular social security program decision has been reached at. When a user clicks a button labeled as **"Explanation"**, the reasons how the system reached at such recommendation or decision can be displayed in another window providing the user detailed explanation. For example, if the expert system concludes that the customer belongs to '**A *Social Security Category of invalidity pension***; the user can click the explanation button and get detailed information as shown below:

EXPLANATION:

Incapacity pension for life shall be paid as the case may be, for injury sustained from employment. A public servant who sustains employment injury of not less than ten (10%) and separates from work due to absolute incapacitation shall receive an incapacity pension for life.

Similarly, the amount appropriate for the incapacity pension would be computed and the result of the computation, that is, the monthly amount of money (pension salary) calculated and informed to the user might require explanation. The user follows the same procedure and clicks the Explanation button located at the end of the calculation result displayed. For example, the customer can find the following type of explanation:

EXPLANATION:

A public servant who sustains from employment injury shall receive an incapacity pension for life amounting to forty five (45%) of his basic monthly salary which he was receiving the month prior to the occurrence of the injury.

Explanations provided by the system as indicated above, would convince the customer and avoid the complaints that might have come out of dissatisfaction by the decisions made.

6.3. Operation of the System

When a request for social security comes, the organization first receives the application from the customer. Since the rules are already organized in the knowledge base, the user is expected to launch the program. The system then asks the user to answer series of questions, which in this case has to be answered referring the customer's profile.

The system uses the facts entered by the user to determine category of the social security of the customer.

Using backward chaining technique, the system searches for the value of each of the attributes used by each social security program type and conclude a result.

CHAPTER SEVEN

Application of Knowledge

7.1. System Interaction with the User: Interfaces

The system interacts with the user through interfaces to capture the required information before arriving at decision. The user interface is the interface used between the system and the user. When the system starts, it displays the main window screen indicated at Figure7.1 prompting the system initiation. The window contains a welcome message and three other buttons, namely, the **Continue** button that takes the user to the next window shown at Figure 7.2.

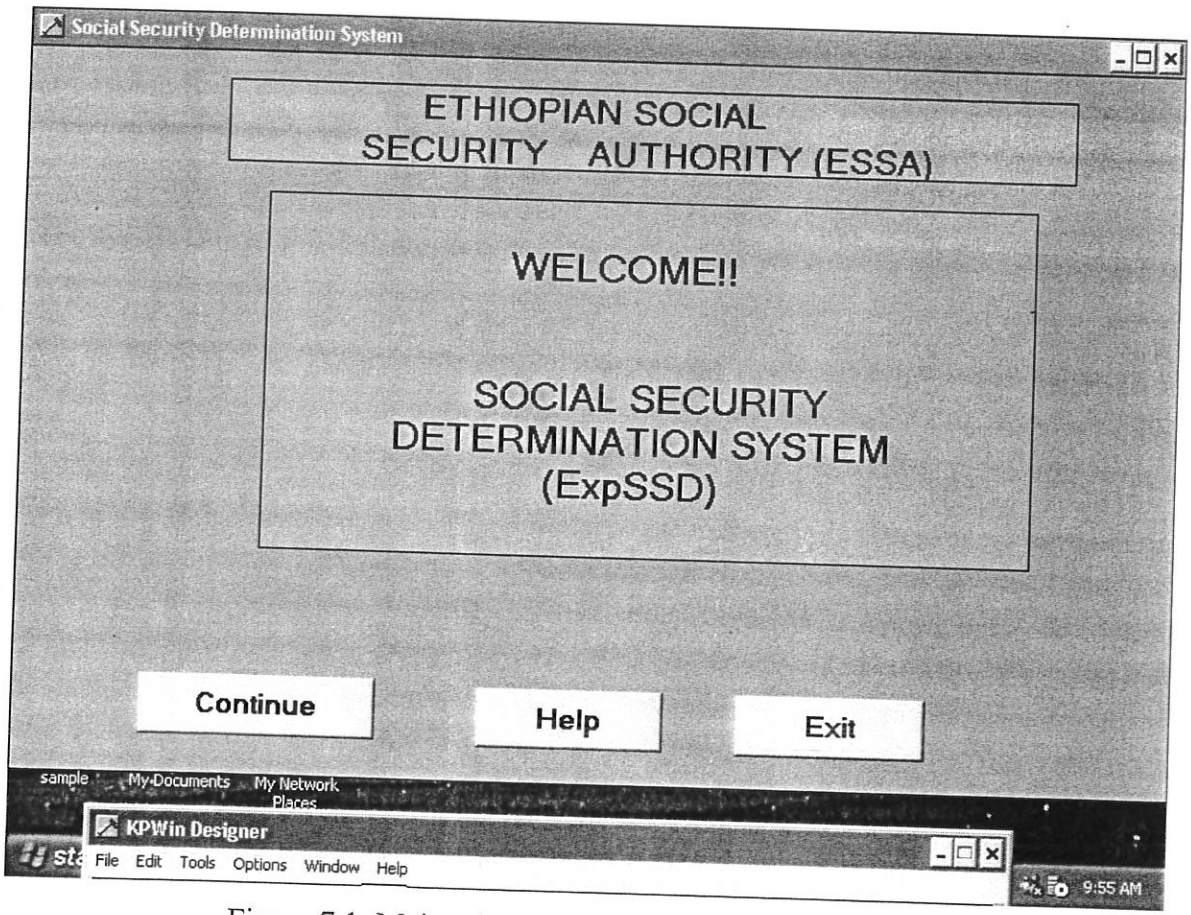


Figure 7.1. Main window of ExpSSD.

The window contains instructions that should be read by users before continuing to the next action.

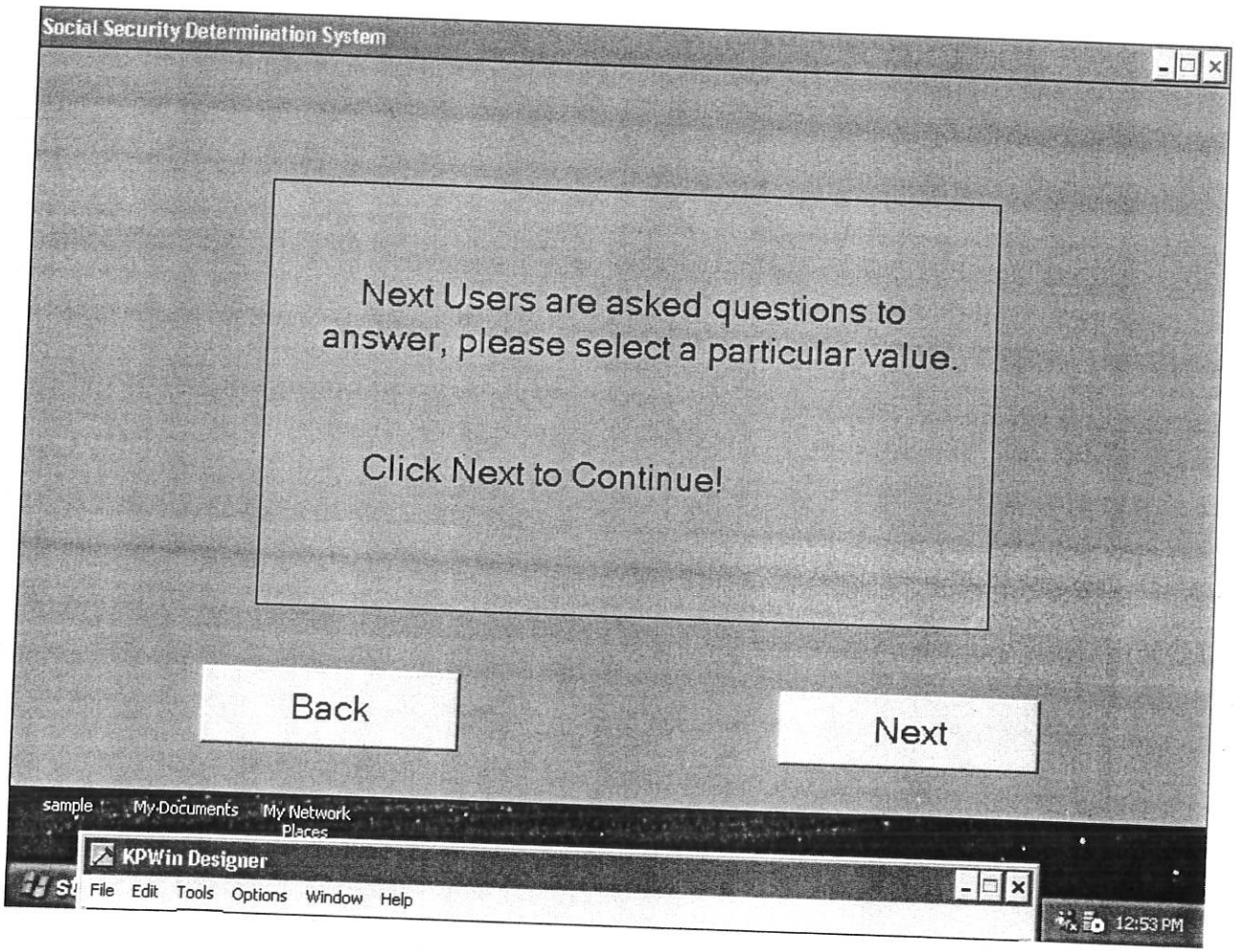


Figure 7.2. Window including instructions

The **Help** button is the other type of button included in the main window. Clicking Help button links the user to a window with a list of hypertext help contents as shown in Figure 7.3. Then the user can click any of his the topics to access technical information as well as information about ExpSSD.

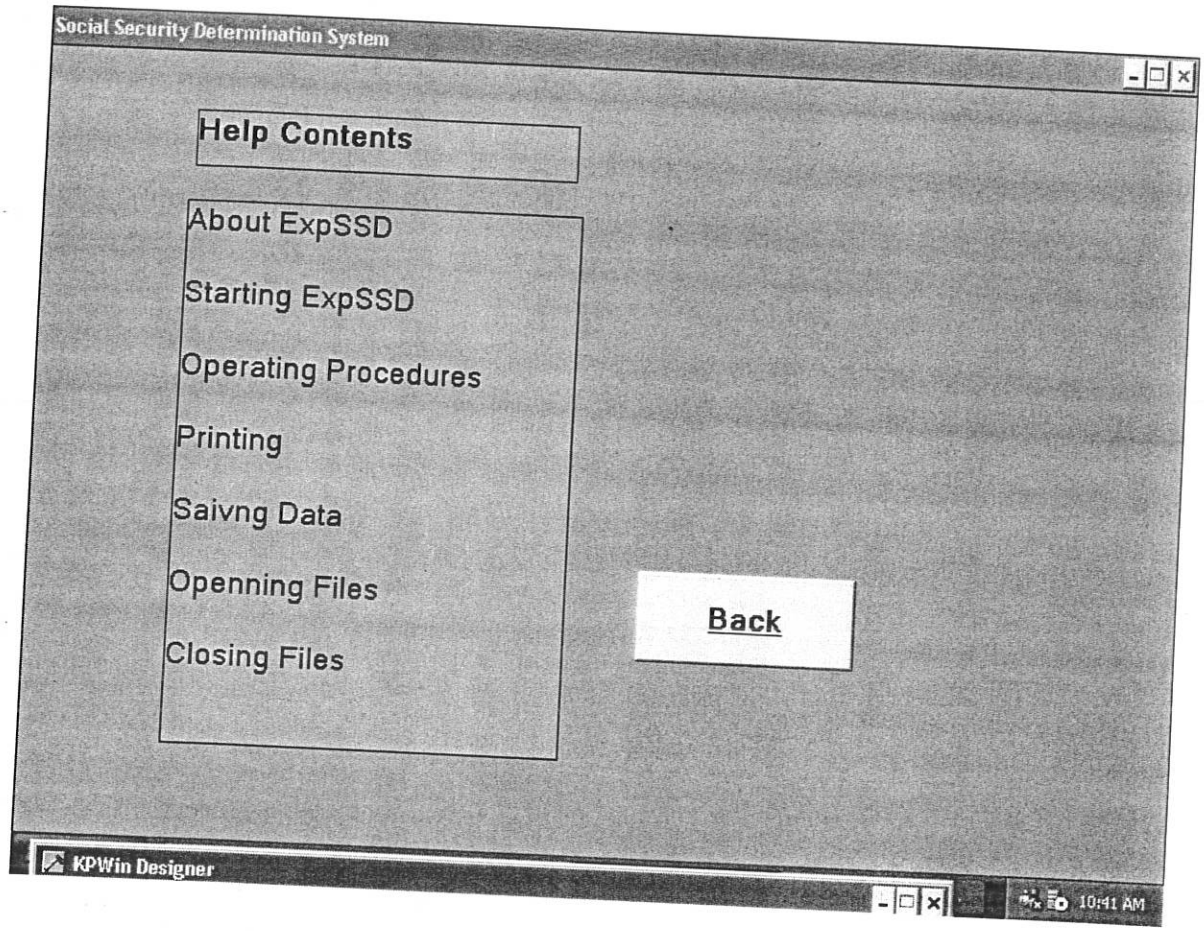


Figure 7.3. Help window with hypertext list of help contents

After reading particular information accessed through the link, in case the user needs to get back to the main Help window, the **Back** button drives to the intended location. The **Exit** button is the other button available at the main window of the system, pressing Exit, completely closes the KPWin application.

Pressing the **Next** button at Figure 7.2 displays series of windows prompting the user to answer several questions. The questions to be asked are organized into different categories suitable for describing the current situation that the customer is in. For instance, a social security case that recommends the customer as *'a retirement pension'* poses three different types of questions and displays the questions as shown in the following figures.

As indicated in Figure 7.4, the first window with questions about the *work experience* of the customer contains values of which the user is expected to double click for the system.

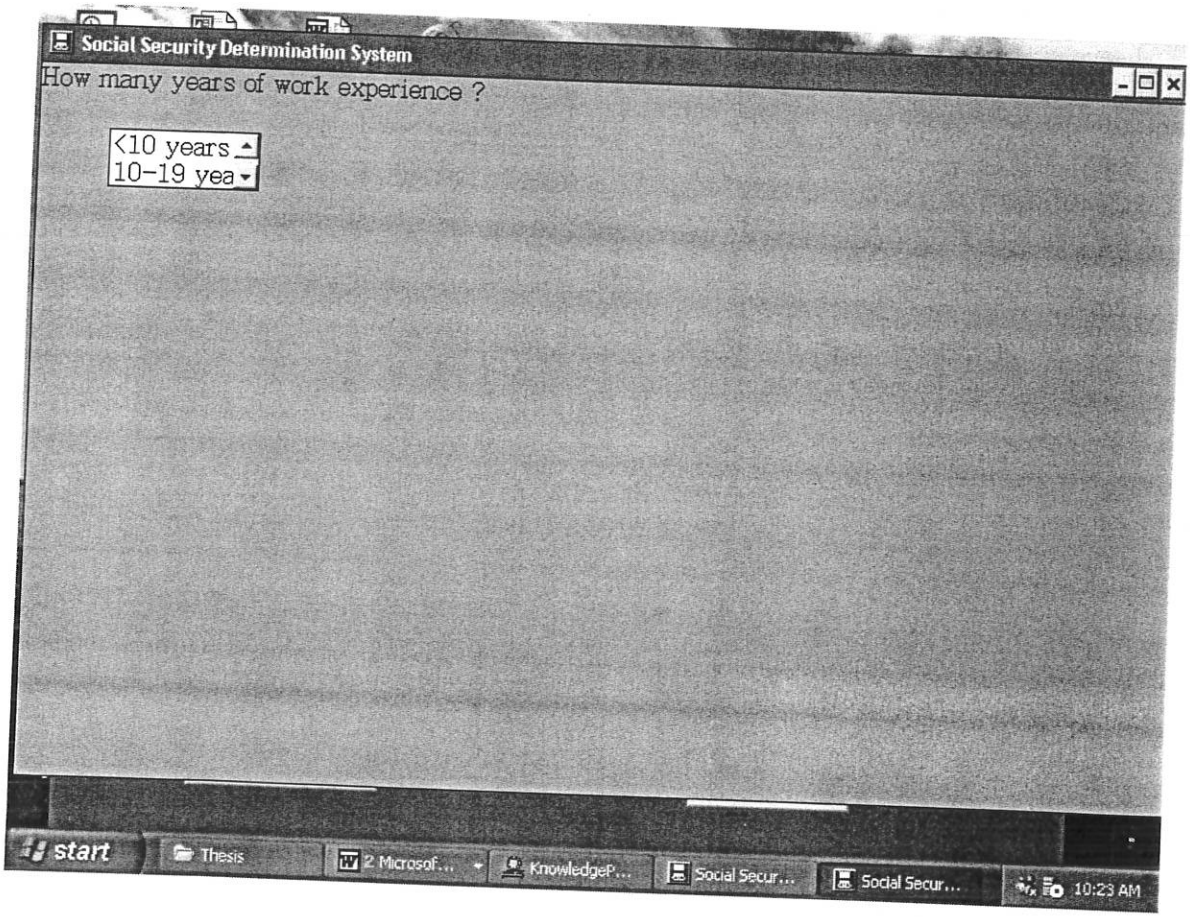


Figure 7.4. Example of the window containing the first question.

Similarly, the second window shown at Figure 7.5, asks question and displays a value about the likely *'retirement reasons'* of the customer.

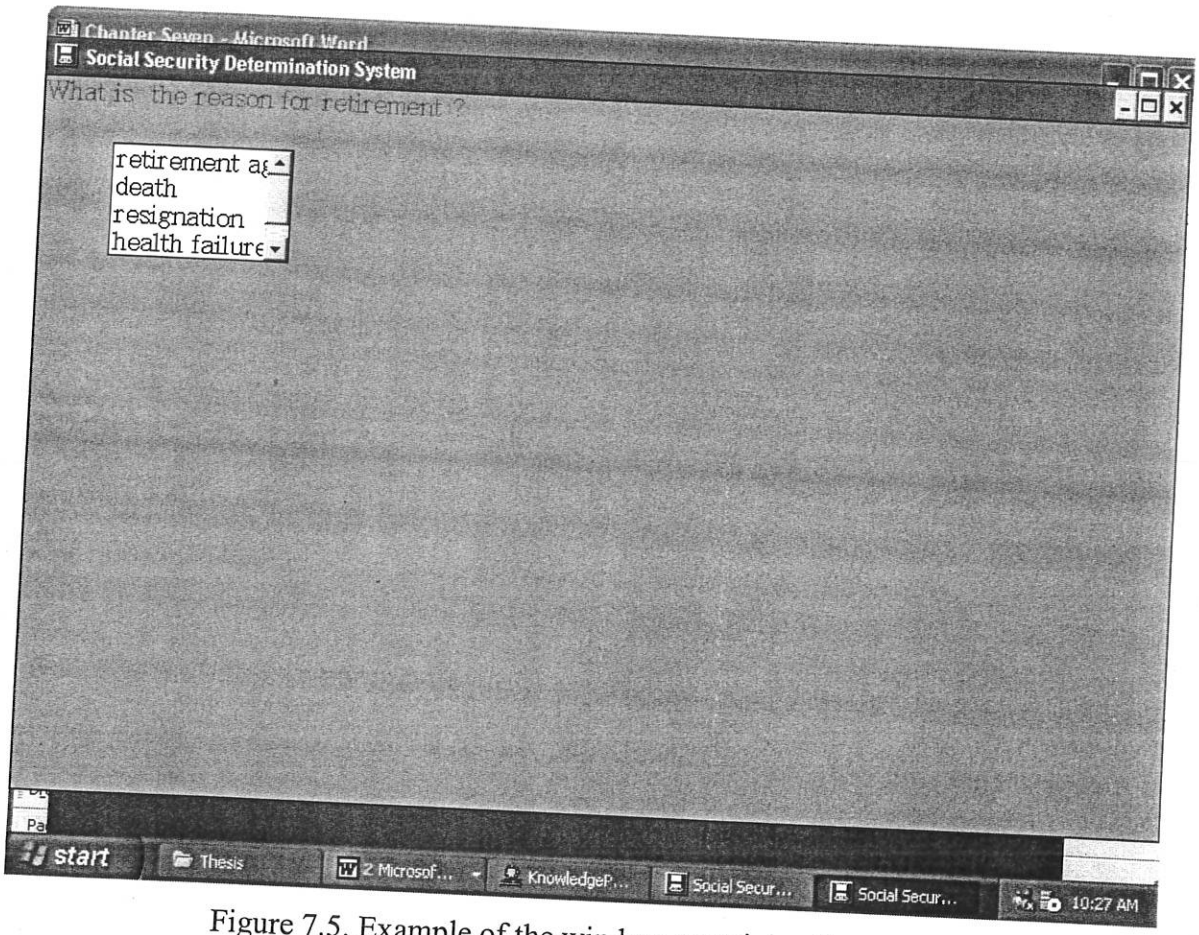


Figure 7.5. Example of the window containing the second question.

The window with question asking about the existing *'family situation'* of the customer is the third window shown at Figure 7.6.

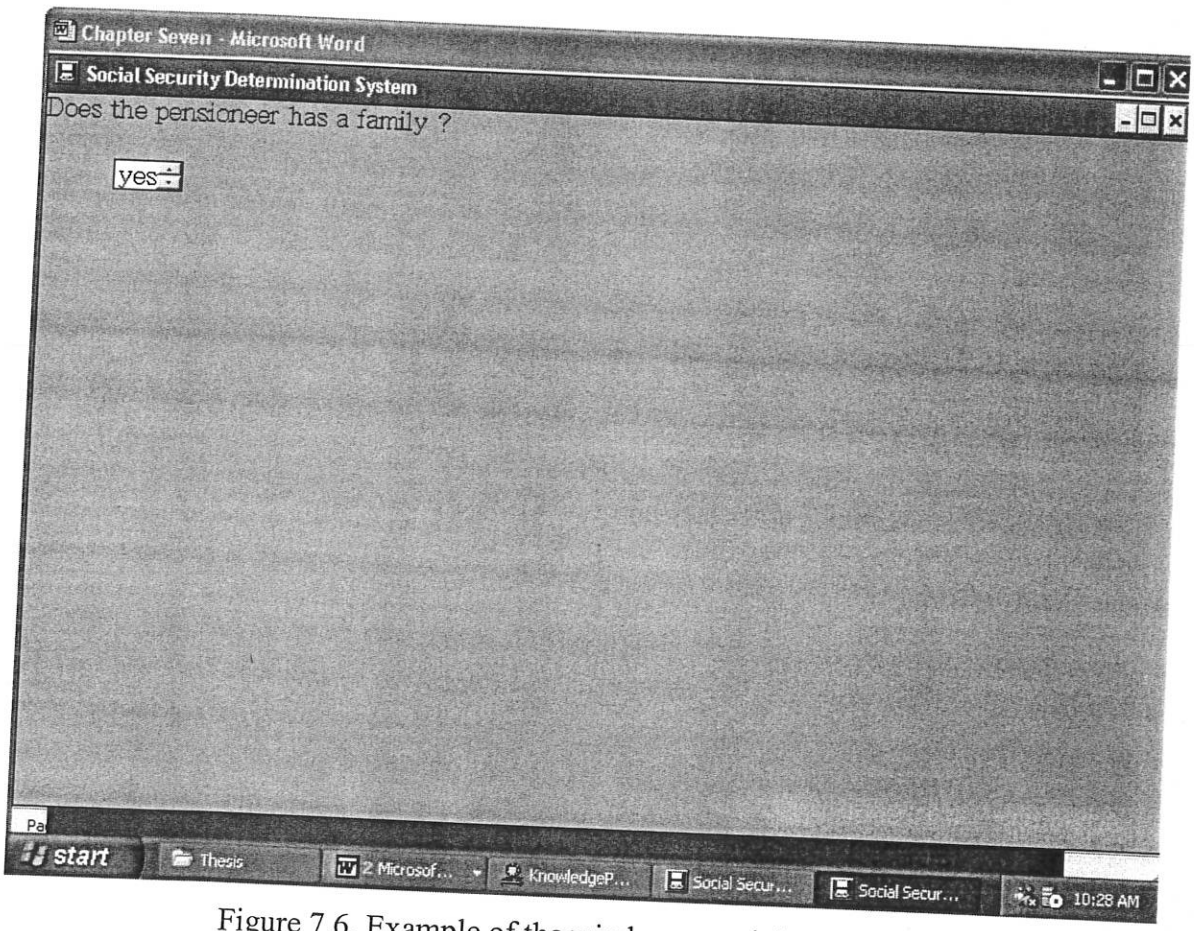


Figure 7.6. Example of the window containing the third question.

The system after inputting the required information, finally displays a window showing the recommended social security program in a new window. Figure 7.7 shows the window that the Knowledge Pro, expert system shell generates as a recommendation for the customer.

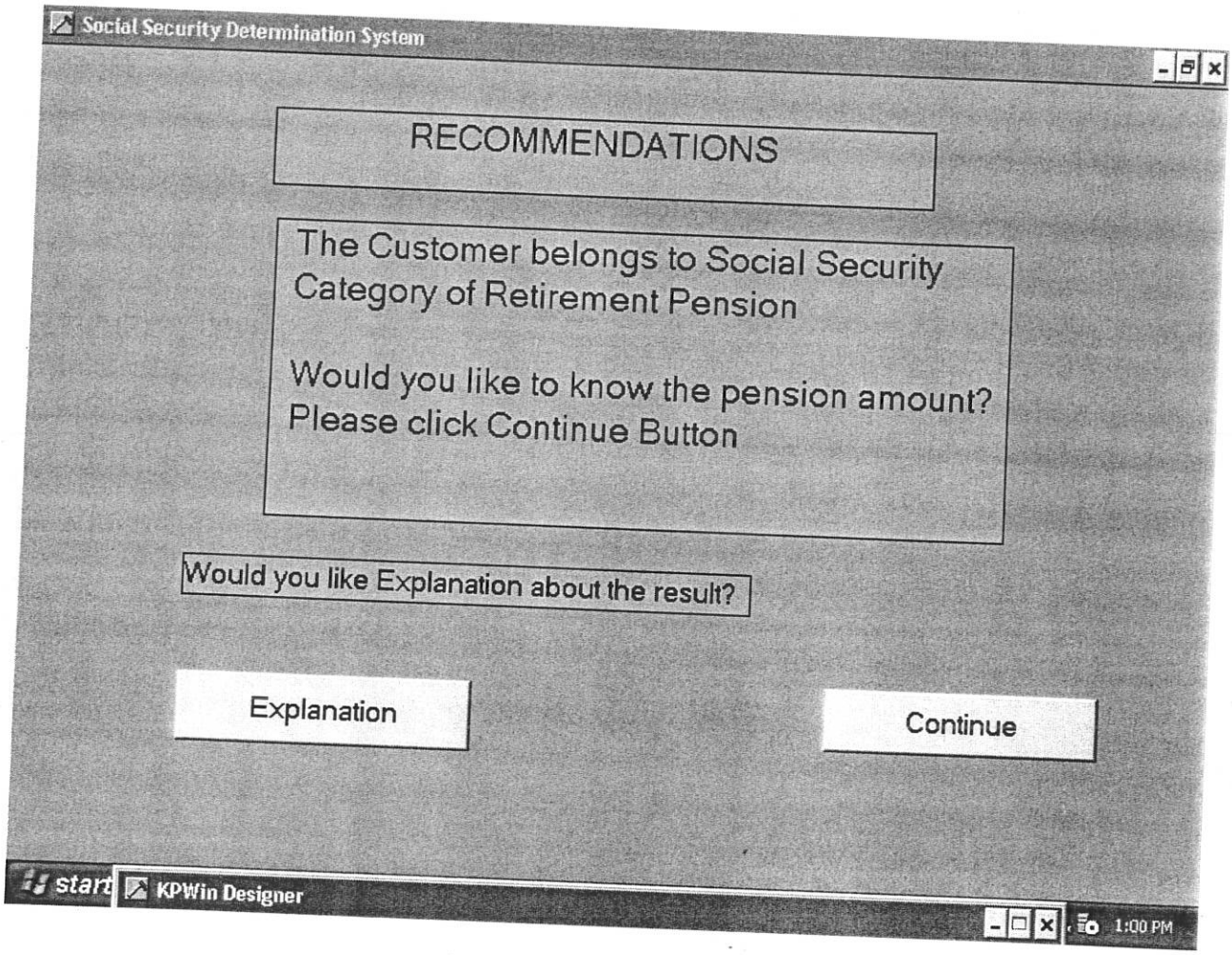


Figure 7.7. Recommendation (result) window

At the bottom of the window there are two buttons, the **Continue** and **Explanation** buttons. The Continue button responds to question asked *'Would you like to calculate the pension amount?'*, if the user presses the Continue button, the system takes the user to the retirement pension amount calculation window. Then the user is asked to enter the last three years salary of the pensioner and press enter.

Pressing Enter displays a computed result of the monthly pension amount of the customer. The system, accepting the last three years salary of the customer, does compute average and announce the net monthly pension amount.

Finally, the system asks the user whether there is a need for determination of social security for another customer or not. If there is a need, the user can click the Continue button and start inputting values for another customer.

7.2. Testing and Evaluation

The performance and correctness of operations *(validity)* of expert systems generally have to be evaluated subjectively. A common method is to make the system handle a set of real test cases which have been dealt with by domain experts. *The system's responses* can then be compared with the responses by the experts, and the appropriateness of differences can be judged. Apart from testing the overall behavior and performance of the system, several subsystems need to be tested in isolation. The most important of these are the tests of the *rules for consistency*, the *completeness of the data*, and the *correctness of the knowledge base* on a detailed level.

Test of the rules for consistency has been carried out by checking the knowledge base for availability of redundant rules, and then the required corrections were made. The completeness of the data refers to the well organization of structures that lead the system to arrive at the right conclusions for all valid input cases.

Validation and verification of the knowledge and automated reasoning of the expert system must be performed to ascertain that whether the system is operating according to the desired functioning. In this regard, different cases of customers for whom social security programs have been determined have been identified from each program. The cases were randomly picked from the case file cabinet. Experts in the domain area were involved as they are to play major role players in making professional judgments. Two different social security cases are presented here in for discussion.

CASE 1:

'Mr. Belhu Derbew has been working in the Ethio-Djibuti rail way corporation since March 1, 1970 in the capacity of assistant Mechanic. While he was on duty, that is, maintaining the motor of the rail in the Garage, an accident has occurred to him. He was hit by loose parts of the motor component and fell on the ground and as a result his Spinal cord broke. The accident had happened on 26 January, 1987 at 2:00pm.

Since the accident has happened, Mr. Belhu was hospitalized any way at Tikur Anbessa hospital. However, on April 20, 1987, the medical board of the hospital decided that the injury recovery level was 40% on his Spinal Cord.'

The data indicated in the case were summarized to fit for the expert system as follows:

Experience: >=10 years
Retirement reason: injury
Injury recovery level: >=10%
Capacity to work: Absolutely incapacitated

CASE 2:

'Mr. Taddesse Belay was employed in the ministry of finance in November 3, 1950. Working until March 30, 1967, he resigned from the ministry of finance. Then, he joined the ministry of health in January 1, 1969 and served the ministry until February 30, 1987.'

Now, Mr Taddesse has requested the employer organization for social security. However, Mr Taddesse, from 1967 to 1969, terminated from job. The reason for termination was

uncovered from his personal files, and it was due to disciplinary measures taken. However, after putting his case to court, the court proved that he was not guilty. For this he submitted evidence from the court.

Since, he was not guilty, ESSA considered the job termination period (from 1967 to 1969) in the process of determination of his social security.

The data indicated in the case were summarized to fit for the expert system as follows:
Experience: >=10 years
Retirement Reason: Resignation
Family: yes

Having as an input the values for each category of the cases, the system resulted with determination of social security of ***'Incapacity Pension'*** for the first case and ***'Retirement Pension'*** for the second one. The results were evaluated successfully for its correctness. The results were compared against the case that was decided and proved identical. Moreover, the experts in the area followed the steps how the system followed in arriving at the decision and suggested that, the customer has also to get some compensation from his organization in addition to the social security benefits. However, consensus has been reached at describing the scope of ExpSSD. That is, since the ExpSSD is meant for determination of social security only at ESSA, the system shouldn't be expected to do some other organizations job.

Having determined the social security program for the customer, the calculation of the amount payable has also been performed and showed accuracy.

From the view point of the reviewers, the result of the evaluation indicates that, the expert system can also be applied in determination of issues related to compensation or payments in industries and any other organizations. The feedback, from users and experts is however, promising though, further research to fully develop the system is essential.

7.3. KNOWLEDGE BASE MAINTENANCE

The major task performed in maintaining the system focuses on the knowledge base. The knowledge base needs to be updated, expanded, corrected and changed in line with changes in knowledge or in the decision environment. Decision environments change as do new system and procedures, new organizational goals and new operational practices are put into effect. Knowledge bases and reasoning embedded in the expert system thus have to be updated and maintained.

In the case of Ethiopian social security decision making process, new social security standards, regulations, public servant reforms act as change agents in updating, expanding, and changing the knowledge base. To this end, the domain knowledge base should be maintained by representatives from the domain expert community or development team or the information systems department.

7.4. Discussions

The idea, diversity, and understanding of the purpose of social security in Ethiopia is at its infant stage. As a result, well organized procedures, working standards, and highly skilled experts have not been available to the required level. As a matter of fact, the developer has been facing some problems through out the journey of developing the prototype system. This section is therefore, dedicated to discuss some of the obstacles and the way how it was resolved.

Extraction of rules for building the knowledge base, as has been mentioned in the chapter dealt with acquisition of knowledge, required a great deal of endeavor in the sense that, managing and structuring the knowledge gathered in the form that suits for the prototype expert system. Understanding the technical jargons, categorizing related components, assigning the right values used as an input for the system, and structuring variables and

user interfaces that accept input to perform several layers of the calculation of pensioners amount and gratuity have been a tedious task.

Discussions, consultations, and error corrections with the responsible experts in the domain area have also been a challenge. Referring the social security cases already determined and reading several books, and other related materials have been critically necessitated in dealing with the problem. Though matching the accuracy of the system's decision with the real-world decision making results were also a daunting task, it was resolved by constructing and adding rules repeatedly to the knowledge base.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1. CONCLUSIONS

Social security scheme unlike insurance companies in Ethiopia is owned by government. The social security programs include the retirement age pension, incapacity pension, invalidity pension, and survivor's pension. Ethiopia, with a total civil servants number of more than 300 thousand, requires multi-faceted social security programs. This helps to provide means of earning to employee in case of employee demise or incapacitated due to accident/injury/health problems.

Administering huge number of social security claims by ESSA related to civil servants and their families necessitates the implementation of an integrated and well structured social security administration scheme. The existing manual system have demonstrated several problems such as extended delay in decision making, absence of clearly defined working procedures, shortage of experts in analyzing claims, and passing proper decision in terms of categorizing the claimer in to one of the pension programs for computing the right amount of monthly pension payment (salary) or gratuity.

The study is conducted in an effort to explore applicability of Knowledge Based System in determining the status of social security category of a customer can belong to and compute the required amount based on the decision made on the status. As the basic requirement of the study, knowledge has been acquired from the experts in this area, procedures, and other related materials were referred. The knowledge gathered is structured in a model using decision tree. Based on the model, rules are used to represent the knowledge in accordance with the model developed.

Building the knowledge base and executing the prototype (ExpSSD) was done on expert system shell-Knowledge Pro Gold. Since KPWin uses, backward chaining technique, to interpret the knowledge encoded in its rules and to yield a conclusion or recommendation, a suitable prototype is developed. The system and the user will communicate through the graphical interface windows, which will link the user to work with the system, so as to answer series of questions and reach at a conclusion. The windows are designed with appropriate buttons, using which users can move backward, forward, provide help, and explanation, and to exit the system.

Validation and verification of the system was also carried out using different decided cases and are reviewed by the experts in this area and found satisfactory.

Finally, application of expert systems in social security determination in Ethiopia is a new idea and there seems to be lack of awareness about it, the study is believed to pave ways and serve as a spring board for igniting the zeal of using it in different sectors of the country.

8.2 RECOMMENDATIONS

The ExpSSD, developed in this study is a prototype knowledge base system. Further recommendations have to be made to conduct related works, hence expand the scope of its functionality and develop a new system in functionally related domain such as insurances and personnel recruitment and promotion. In this regard the following recommendations are made:

- A strategy should be designed to integrate the KBS with the civil servants administration commission system in the country. The integration assists for the smooth exchange of information about a civil servant can be facilitated. As a result information about a particular employee can be shared whenever required using the common standard interface between the ESSA and the civil servants administration commission.

- The KBS should be further enriched through clearly stating social security regulations and standards. This can be done working in a collaborative manner by including domains from the federal higher court, ESSA, and civil service commission and others.

- Due attention should be exerted to maintain the accuracy of the system (setting exact certainty factors). This is achieved through setting verification and validation standards. Therefore, accuracy can be maintained on the decisions made by the system and avoids phenomenon that lead for complaining by the customer.

- Since Knowledge Based Systems operate with cases represented in the knowledge base and/or not able to learn from experience, neural networks can be used to resolve the problem. This is because; neural networks can process incomplete and imprecise data.

- A database system should be designed, so that the KBS can fetch data as desired. The database system stores the required data retrieve and helps to update data. By integrating database system with the KBS, the registration, verification and accessing the user through the pension number could be facilitated. Moreover, the series of questions asked by the system to capture values can significantly be reduced.

- Before implementation or expansion of the scope the system, cost-benefit analysis should be done to justify the cons and pros of the Knowledge Based System.

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APPENDIX I

Sample Rules from the Knowledge Base

Topic Status.
set_number_of_values (Status, 1).

If ?'experience' is '>=10 years'
and ?'retirement reason' is 'retirement age'
and ?'family' is yes
then program is 'Retirement Age Pension'.

If ?'experience' is '>=10 years'
and ?'retirement reason' is 'resignation'
and ?'family' is no
then program is ' Retirement Age pension. This will be effective upon attainment of retirement age (that is-- 60) '.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'retirement age'
and ?'family' is yes
then program is 'Retirement Gratuity'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'retirement age'
and ?'family' is yes
then program is 'Retirement Gratuity'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'retirement age'
and ?'family' is no
then program is 'Retirement Gratuity'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Widow/Widower survivors pension.
The share of the pension will be--50% of the pension
goes to the widow/widower, 20% of the pension
amount goes to the children and 15% will be given to parents'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Widow/Widower survivors pension. The share of the pension
will be--50% of the pension goes to the widow/widower and 20% of the pension
amount goes to the children'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Orphans and parents survivors pension. The share of the pension
will be--20% of the pension amount goes to each children and 15% will be given to
parents'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Orphans and parents survivors pension. The share of the pension

will be--20% of the pension amount goes to each children'.

If ?'experience' is '10-19 years'

and ?'retirement reason' is 'death'

and ?'family' is yes

then program is 'parents survivors pension. The share of the pension will be--15% of the pension goes to the parents'.

If ?'experience' is '>= 20 years'

and ?'retirement reason' is 'death'

and ?'family' is yes

then program is 'Widow/Widower survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be--50% of the pension goes to the widow/widower and 20% of the pension amount goes to the children and 15% will be given to parents'.

If ?'experience' is '>= 20 years'

and ?'retirement reason' is 'death'

and ?'family' is yes

then program is 'Widow/Widower survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be--50% of the pension goes to the widow/widower and 20% of the pension amount goes to the children'.

If ?'experience' is '>= 20 years'

and ?'retirement reason' is 'death'

and ?'family' is yes

then program is 'Orphans survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be-- 20% of the pension amount goes to the children and 15% will be given to parents'.

If ?'experience' is '>= 20 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Orphans survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be-- 20% of the pension amount goes to the children'.

If ?'experience' is '>= 20 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Widow/Widower survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be--50% of the pension goes to the widow/widower and 15% will be given to parents'.

If ?'experience' is '>= 20 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'Widow/Widower survivors pension. This will be effective up on attainment of retirement age (that is--60). The share of the pension will be--50% of the pension goes to the widow/widower'.

If ?'experience' is '>=20 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'parents survivors pension. The share of the pension will be--15% of the pension goes to the parents'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'widow and children Gratuity.'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'children survivors Gratuity. The share will be
20% to each children'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'death'
and ?'family' is yes
then program is 'widow/widower Gratuity and 50% of the share will be
given to widow/widower'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'health failure'
and ?'family' is yes
then program is 'invalidity pension. The amount is 30% of average salary of last 36 months'.

If ?'experience' is '10-19 years'
and ?'retirement reason' is 'health failure'
and ?'family' is no
then program is 'invalidity pension. The amount is 30% of average salary of last 36 months'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'health failure'
and ?'family' is yes
then program is 'invalidity gratuity. The amount is equal to salary preceding retirement times years of service'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'health failure'
and ?'family' is no
then program is 'invalidity gratuity'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'health failure'
and ?'family' is yes
then program is 'wife or widow or child gratuity'.

If ?'experience' is '<10 years'
and ?'retirement reason' is 'health failure'
and ?'family' is yes
then program is 'no gratuity'.

If ?'injury recovery level' is '>=10%'
and ?'experience' is '<10 years'
and ?'retirement reason' is 'Injury'
and ?'capacity to work' is 'absolute incapacitation'
then program is 'incapacity pension'.

If ?'injury recovery level' is '>=10%'
and ?'experience' is '<10 years'
and ?'retirement reason' is 'Injury'

and ?'capacity to work' is 'able to work'
then program is 'incapacity gratuity'.

If ?'injury recovery level' is '>=10%'
and ?'experience' is '<10 years'
and ?'retirement reason' is 'Injury'
and ?'capacity to work' is 'death'
and family is yes
then program is 'survivors pension'.

APPENDIX II

Sample cases used during testing along with the output of ExpSSD

'Mr. Belhu Derbew has been working in the Ethio-Djibuti rail way corporation since March 1, 1970 in the capacity of assistant Mechanic. While he was on duty, that is, maintaining the motor of the rail in the Garage, an accident has occurred to him. He was hit by loose parts of the motor component and fell on the ground and as a result his Spinal cord broke. The accident had happened on 26 January, 1987 at 2:00pm.

Since the accident has happened, Mr. Belhu was hospitalized any way at Tikur Anbessa hospital. However, on April 20, 1987, the medical board of the hospital decided that the injury recovery level was 40% on his Spinal Cord.'

The data indicated in the case were summarized to fit for the expert system as follows:

Experience: > 10 years

Injury recovery level: >=10%

Retirement reason: injury

Capacity to work: Absolutely incapacitated

When the above values are given to the system it recommends the following type of social security program:

The Customer belongs to a social security Category of **"Incapacity Pension".**

CASE 2:

'Mr. Taddesse Belay was employed in the ministry of finance in November 3, 1950. Working until March 30, 1967, he resigned from the ministry of finance. Then, he joined the ministry of health in January 1, 1969 and served the ministry until February 30, 1987.'

The data indicated in the case were summarized to fit for the expert system as follows:

Experience: > 10 years

Retirement Reason: Resignation

Family: yes

When the above values are given to the system it recommends the following type of social security program:

The Customer belong to a social security Category of **"Retirement Pension"**

CASE 3:

Mr. Siraj Jafar has been working in the ministry of education since February 1, 1970. He was working in the capacity of security guard during his service years. While on duty, he encountered serious sickness. However, after attending some medical treatments he died on December 12, 1984. From his personal files, it was learnt that, the late Siraji Jafar was survived by his wife and two children.

The data indicated in the case were summarized to fit for the expert system as follows:

Experience: > 10 years

Retirement reason: Death

Family: yes

When the above values are given to the system it recommends the following type of social security program:

KP lists processing functions such as topics defined in an application, built in functions, and access to windows application provides easy building of programs interface. The topic a very flexible and powerful new paradigm up on which the whole KP language is used. Topics can be commands, lists, rules, and hypertext nodes, objects or functions. It has true object-oriented features like the ability to inherit properties from other topics.

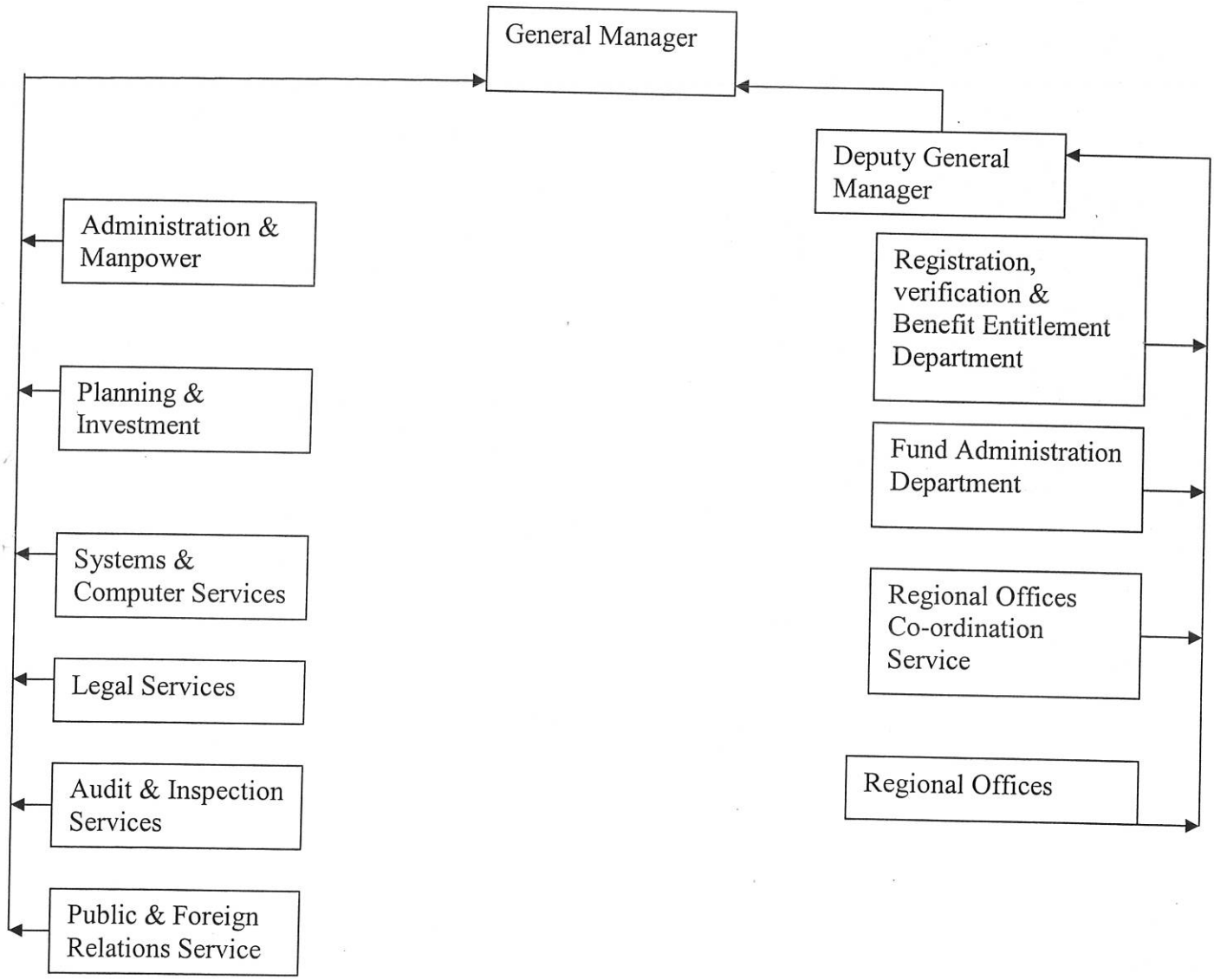
KP includes design tools, which can be used for screen design very easily. This design tools can generate code to be used in the KPwin environment with or without modification. Or it can be compiled into executable file and can be accessed via the external access feature of the tool. The features are useful in designing of the user interface and the prototypes easily.

KP has several features for the user and the system to communicate. These object oriented features enabled to reuse the interface objects such as windows, manuals, buttons, and checklist, list boxes, radio buttons and edit windows; and graphic objects, such as bitmaps, icons, and cursor palettes. Hypertext and hyper-regions are also provided for manipulations of texts. In the prototype, the interface objects such as windows, buttons, list boxes, edit windows and icons were used in the design of the user interface. These objects were used to collect data from the users and display the results and explanations.

KP programs can be transmitted into C++ code and compiled to create an executable file, runtime version, which can be used in any platform without KPwin.

Appendix IV

Organizational Structure of Ethiopian Social Security Authority (ESSA)



DECLARATION

The thesis is my original work and has not been presented for a degree in any other University.

ERMIAS WONDIE
June, 2005

This thesis has been submitted for examination with my approval as advisor

DR. B.R.K.Rao

June, 2005

