ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

SCHOOL OF INFORMATION STUDIES FOR AFRICA

A PROTOTYPE EXPERT REFERENCE ADVISORY SYSTEM FOR ETHIOPIAN STUDIES

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

BY

AZENE ZENEBE

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DEDICATION

TO MY MOTHER AND MY FATHER

ABSTRACT

Reference services exist to maximise access to information contained in information centres/libraries. Yet human experts have not achieved this goal as they desired. But the development of the expert system technology the possibilities, have become promising.

Demonstration of how the expert system technology could be used in enhancing the reference services for the domain, Ethiopian Studies, in general and for Ethiopian History in particular is the main theme of this thesis.

For this purpose a prototype expert reference advisory system was developed following the prototyping approach using the KnowledgePro Windows version 2.0 shell. The interview, protocol analysis and observation methods for acquiring knowledge from the reference librarians; production rules for representing the acquired knowledge; backward chaining for inferencing mechanism; and graphics and hypertext technology for designing the user interface were employed.

In addition to facts about a user's inquiry to be input to the system by the user, the system has an interface with the database program from where facts about the possible sources are retrieved during the system's inferencing. The system provides the user with possible sources of information or advice as well as an explanation how it reaches to its conclusion and why it asks the user to input some facts.

Even though, production rules are not suitable for representing individual users model, overall they are found to be fitting for modelling the knowledge of the reference experts in the domain. Besides the interfaces features, for both user and other systems, are found to be quite satisfactory.

It sounds to be feasible to develop a working system based on this prototype that could be used both by the end-user and the reference librarians who are interested in the domain. Moreover, the models, tools and approaches that are used in this study could be used for other related domains.

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CHAPTER 1

INTRODUCTION

1.1 Background Information

At its most fundamental reference form services may be defined as answering questions. Reference Service is a function which utilises published resource materials, databases, contacts with government agencies, institutions, researcher projects and individual sources of expertise to provide a wide spectrum of information/knowledge. It also involves in giving instructions in the choice and use of information sources. With the emergence of information centres the concept reference services and information services are being used interchangeably.

According to Katz (1982), reference services are categorised functionally into direct and indirect. The direct category includes:

a. " Reference or information service which is the personal assistance provided to users in pursuit of information. This service may range from answering an apparently simple query to supplying information based on bibliographical search....."

b. " Formal and informal instruction in the use of the library or information centre and its resources."

The indirect services reflect user access to wide range of informational sources through co-operation with other library or information centres, i.e., referral services.

Reference services are one of the library functions that accept a user inquiry for information and provides an answer or indicate where or how an answer may be found. It involves the following continuous process:

- Accepting a user inquiry
- Interview/negotiate with the user to clearly define the user inquiry, i.e., need analysis
- Develop a search strategy
- Conduct a search
- Provide answer/output of the search
- Accept feedback from the user and repeat the above steps if necessary

Reference inquiries can be broadly divided into data retrieval and document retrieval. Most of these types of inquiries could be answered by a well-trained person with a bachelor's degree (Katz 1982) and have been handled by human experts/reference librarians manually for several years. However, with the emergence of modern information technology several programs have been developed to teach reference through simulation of the reference interview; to offer low-level assistance to users when skilled staff are not available; and to capture and model the decision-making steps involved in negotiating a question and selecting appropriate sources to

answer it. But they lacked the flexibility, speed, ease of development and modification, and portability required of a reference program intended to used in an actual library setting. On the other hand, the advent of the recent technology - expert systems - has promised to overcome some of these limitations.

As Grogan(1991) describes expert system embodies within a computer "the knowledge and decision making skills of a human expert in a particular 'domain' - a specific field - so that the system can offer intelligent advice or take an intelligent decision about a problem posed to it." He also states that an expert system should compromises three components: an interface module to elicit details of the problem from the user; a knowledge base in the form of a set of heuristics or rules that an expert would normally follow; and inference engine which is a sort of software program that specifies how to apply these rules to the data gathered from the enquirer in order to arrive at a solution. Besides it is desirable to have an explanation capability.

Many writers (Ford 1991; Morris 1991; and Rauch-Hindin 1988, etc.) indicated that expert systems are making a significant impact on commercial, industrial, academic and government organisations for various applications. Some of the reasons are:

- the gradual evolution from data -- through -- information to knowledge processing and management;
- the rapid development in the expert system technology;
- the potential of expert systems to be cost- effective; and

- the potential of integrating expert systems with database, multimedia and hypertext/hypermedia technologies.

Fully programmed systems can offer sophisticated natural language interfaces and embed detailed knowledge about sources and users. However, through the use of expert systems shells, prototype programs can be developed relatively quickly and modified easily (Roysdon and White, 1989). Current application programs vary widely, ranging from recommending sources on a specific topic to simply acquainting users with the general layout of the library.

Normally, an expert system deals with a particular area, which is referred as domain knowledge. In reference services the domain knowledge can be various fields of studies or disciplines such as chemistry, agriculture, breeding, history and others. A reference expert system is concerned with capturing and making use of knowledge about where information may be found and how it can be accessed and used, for a given domain area. It does not contain within itself the answers, any more than a reference librarian's memory does. The expertise it seeks to embody is that of finding answers(Grogan 1991).

Likewise, Ethiopian Studies can be considered as a knowledge domain for which reference advisory expert systems can be developed. Ethiopian Studies are studies relating to Ethiopia which covers subjects such as Ethiopian history, culture, sociology, anthropology, languages, literature, etc. (Tadesse, 1990).

We have a number of interesting attempts to automate specific parts of the reference process, such as discovering something about the enquirer's background, translating the inquiry into a search statement for on-line searching, or selecting appropriate databases or reference books to consult (Grogan 1991). As a result, in the area of expert systems, several prototypes and few actual systems for reference services have been developed for different domain knowledge/areas such as in agriculture, chemistry, humanities, and medicine (Ford 1991; Morris 1991). Still work is continuing in different research centres as the technology is in the experimental stage with tremendous scope for researchers in reference services and other LIS (Morris 1991).

1.2 Statement of the Problem and Justification

Reference services/Information services involve (Grogan 1991):

- questioning users during an interview session;
- understanding users' request;
- finding the possible sources;
- considering the feedback from users; and
- if the sources/answers are not satisfactory, the processes are repeated until users are satisfied or failed.

These services are one of the LIS that require experts who have enough knowledge about the totality of possible sources of information (documents, objects, people, and institutions); knowledge of searching information in a specific situation and area; identification of users' needs; and other additional characteristics such as imagination, persistence, curiosity, humility and love of services (Grogan 1979). Thus a reference expert is expected to be knowledgeable enough to suggest alternative, relevant and accurate information sources for end-users.

Reference services are gateways for users of a library by providing proper guidance and help on where to find information, which materials to use and how to use. This in turn prompts the effective and proper use of available information sources. The overall standard and accuracy of reference services are low even though there has been a considerable improvement since the services developed in the late 19th century (Morris 1991).

Because either users are (still) not aware of the existence of the reference experts, or are reluctant to make use of the reference experts, or because the reference services have not coped with the demand (Brooks 1985). Studies have shown that information systems are frequently under-utilised. Chang and Zahir(1992) explained the main reason to be the lack of knowledge of how to locate and make use of appropriate sources of information. This makes end-users often spend more time to locate, or unable to use properly, or consult inappropriate sources especially when the number of possible reference sources are large and located in different areas. And also, often users come to an information specialist for assistance, but they are unable to specify their information need explicitly.

Reference service, among others, has the following features:

- It requires knowledge of available information sources both documentary and non-documentary, user-information seeking behaviour, information storage and retrieval, and skills to relate users needs with available sources of information;
- In a specific field/area reference questions could be categorised and handled accordingly. For instance, as directional enquiries, data enquiries (fact finding), material finding enquiries and research enquiries. Hence, the knowledge of a reference expert can be articulated;
- The methods of answering reference questions are not always identical for all questions but varies from question to question as well as the purpose for which the information is needed. Thus, the problems are not structured and are not suitable to be solved using traditional programming methods directly;

- In developing countries expert reference librarians are scarce and are overworked by different administrative tasks; and
- Reference work as a field of study has shown , relatively, a stable nature and hence the acquired knowledge can be used for an equally relative long period of time thereby allowing for a minimum frequency of updating the knowledge base.

- These features of a reference service justify the following Waterman's (1985), cited by Hunt and et al. 1991, criteria that should be appraised before proceeding with an expert system development for a specific domain area.

i) Development of an expert system is possible when :

- Task does not require common sense alone;
- Task requires only cognitive skills;
- Experts can articulate their methods;
- Genuine experts exist;
- Experts agree on solutions;
- Task is not too difficult ; and
- Task is not poorly understood.

ii) Development of an expert system is appropriate when :

- Task requires symbol (than numbers) manipulation;
- Task requires heuristic (than algorithmic) solutions;

- Task is not too easy;
- Task has practical value ; and
- Task is of manageable size.

iii) Development of an expert system is justified when at least either one of the following conditions is true:

- Task solution has a high pay off;
- Human expertise is being lost;
- Human expertise is scarce;
- Expertise is needed in many locations ; or
- Expertise is needed in hostile environment.

Like users in other fields of studies, users(students, researchers) in the field of Ethiopian Studies have encountered the problems stated above besides the existing shortage of experienced and skilful reference experts in the subject. In general, information service in an area study is difficult due to the spread of information in a wide variety of sources (Seetharama 1990). Information provision in the field of Ethiopian Studies is also challenging as it involves assisting them in finding information, data and materials of relevance and interest in the work of specialists from different disciplines and fields of specialisation such as social anthropology, history, linguistics, literature, sociology and journalism (Abebe 1990). Even, it becomes challenging for reference experts to find the necessary data/ information in the large number of information generated on

different subjects due to the prevailing rapid growth in the fields of specialisation and the exponential growth in the world's information (Katz 1982).

One possible solution to the problems is to hire more experienced reference librarians, and to make every user library literate. This requires sufficient amount of funds and time to have enough expert reference librarian and to make every users library literate which is not feasible as far as other alternative solution is available.

Previously, reference services were not widely considered as an area where computers could be used. This was due to the unstructured nature of the task: the task does not rely on a precise series of steps to be taken each time to search for information or to answer inquiries. This made the conventional software approach, to be inappropriate. However, with the development of expert systems technology, the use of expert systems has shown the possibility of automated reference advisory services that help users select information sources or information responsive to their interests (Smite 1987).

To have an automated reference advisory services some of the possible options are: i) the in-house development of the system from the scratch using a programming language, i.e., the custom option; ii) purchasing of an existing expert system development tool, called a shell, for developing an expert system for a specific domain, i.e., the semi-custom option; or iii) buy a developed (complete or prototype) expert system for a specific domain of interest, i.e., the off-the-shelf option.

Unlike other generalised areas of study such as Mathematics, Physics and Chemistry, where an expert reference advisory system experimented in any information centre/library can be used as it is or with a little modification, experimentation of an expert reference advisory system for Ethiopian Studies calls for an in-house attempt either using a programming language or using one of the expert system development tools. This is because Ethiopian Studies deal with various specialised fields, information sources and users, and the system to be designed will have to incorporate their features.

Expert systems have been suggested to be useful for Africa where there is scarce experts in various professions. Similar situations are prevailing in the information profession. Thus in this study an attempt is made to experiment the application potential that the emerging expert systems technology has for the reference services in the area of Ethiopian Studies using an expert system shell, i.e., the semi-custom option. And an attempt is made to seek answers/explanations for the following questions:

1. Are expert systems helpful for reference services?
2. What are the factors that have to be considered in designing an expert system ?
3. How does one go about the task of designing an expert system in general and for reference services in particular? This involves answering the following interrelated questions:
   a) How can one take into account the attributes that define user needs?

b) How can one have an adequate human-computer interface?

c) How can one store the characteristics of individual information sources and information in terms of content, and access methods?

d) How can one relate information sources to user needs?

e) How can one suggest one or more information sources appropriate to potential users and the way through which the information sources can be accessed and used?

The selection of Ethiopian Studies as a domain knowledge is based on the nature of the subject which is highly interdisciplinary, and has various sources of information which are special and scattered in different information centres. This in turn highly calls for a reference advisory service for their various categories of users.

The selection of IES (Institution of Ethiopian Studies) library and the Museum section as a case area for the study is mainly based on the following reasons:

1. Among a few libraries and information centres in Ethiopia specialising in the provision of information to users in the field of Ethiopian Studies, the IES library is the one with the largest collection and users (Abebe 1993).
2. As a user and staff of the Addis Ababa university libraries, it was observed that: i) users spend much of their time in finding an appropriate information and sources of information to solve their problems; ii) there is a lack of knowledge on the importance of reference materials

and information in starting any research and/or to solve problems, and when and how to use them.

3. The library is mostly engaged in rendering reference services as a primary service as indicated in the studies conducted by Abebe (1993).
4. There are very few experienced and professional librarians in the library.

1.3 Objective

1.3.1 General Objective

The general objective of this study is to design and develop a prototype expert reference advisory system for Ethiopian Studies for demonstrating how the ES technology could be used to solve the problems of the reference service in the domain..

1.3.2 Specific Objectives

The specific objectives of the study are to:

1. Investigate the potential of applying expert systems to the library and information services in general and reference services in particular.
2. Investigate the different development methodologies and approaches available.
3. Investigate the methods of knowledge acquisition, knowledge representation and inference mechanism.
4. Investigate the methods of user modelling, and entering and accepting instructions and information from users (user interface) suitable for the application to be designed.
5. Elicit the knowledge, that is used for answering inquiries and other related activities, from the experienced reference librarians and other experts in the field as well as from other documentary sources by using the different knowledge acquisition methods. And organise, model and represent the acquired knowledge.

6. Examine the users' information inquiries as the basis for the design of the user interface in the expert system.
7. Explore the different software tools available for creating an expert system.
8. Design the general framework of the system and develop a prototype.
9. Explore the implementation requirements and constraints of the developed prototype system as well as the possible application to other areas.

1.4 Scope and Limitation

Due to the limited time available, in this study an attempt is made to develop a prototype expert reference advisory system for some of the current major focal areas of studies, covered by the IES -- Ethiopian history. Moreover the developed prototype system is not tested and evaluated outside the laboratory . Finally the use of appropriate development tools is limited to the resources and facilities available at the School of Information Studies for Africa (SISA).

1.5 Significance of the Study

If the prototype is demonstrated to users and tested for its validity and reliability, then a working system could be developed from the prototype system which can be used in information centres/libraries (IES and other similar libraries) working with the field of Ethiopian Studies. Therefore, the expert system could be used both by library/information professionals and end-

users who are working in the area of Ethiopian Studies. They are expected to benefit from this project because

- the reference librarian would be free from routine and ordinary inquiries so that they can utilise their professional skills in more difficult and challenging problems - such as bibliographic compilation, provision of current awareness services, and selective dissemination of information;
- end-users can make use of the system as many times as they want and at any convenient time without being a bothering to the reference librarian. This is because expert systems do not suffer from bad days, job frustration, fatigue; and are always available. Experts' knowledge is also stored and preserved. This, in turn, results in an increase in the extent of use of existing information by saving the time of the users and improving the service;
- more than one user can make use of the expert system either through the provision of a networked system or by replicating and deploying them at a number of sites;
- one of the distinguishing features of expert systems, that is, explanation/reasoning capability, could be used as an instructional tool to train librarian in reference work as well as to acquaint users with basic knowledge of locating and using information;
- the experience gained in this project could be used to develop other similar systems; and
- it creates an awareness among the information professionals on how the expert system technology can be utilised to enhance their professional role from information to knowledge management.

1.6 Methodology

1.6.1 Methods and Tools for Knowledge Elicitation

The methods adopted to collect the required data and knowledge for this study include the following:

I. Literature review is made: (a) for reviewing background sources, to understand about the Ethiopian Studies and the reference services; (b) to elicit knowledge for the creation of the system using guides to reference sources, directories, handbooks, manuals, encyclopaedias, glossaries indexes, dictionaries and other materials.

II. Interview, protocol analysis and observation of the actual activities at the selected library are used to collect/elicit knowledge from experienced professional in the reference services and in Ethiopian Studies.

1.6.2 Method of Developing the Prototype Expert System

An expert system development methodology with the prototyping approach is used to develop the expert reference advisory system. During the knowledge acquisition and organisation stage or logical design stage top-down or deductive method with the various knowledge collection tools; and pseudo code for documenting the acquired knowledge is used. The expert system software KnowledgePro Windows version 2.0 (KPWin), which is available at SISA's(School of Information Studies for Africa) computer laboratory, is used for coding the knowledge base, the inference mechanism and the user and system interface.

Due to the prescription nature of the domain knowledge of the reference services, the production rules method of knowledge representation is used for representing the knowledge. And also the backward chaining is employed for the inferencing process.

1.7 Organisation of the Thesis

The thesis is organised in six chapters.

The first chapter deals with background information, statement of the problem and justification, objectives, scope and limitations of the study, significance of the study and methodology to be used in the study. Chapter 2 is a general description of the domain area. It also describes the focal fields in the area, the general user group and their general information needs, the major information sources and the reference service in the area.

Chapter 3 reviews previous work in the expert systems for LIS including its current and future trends. The general structure of expert systems and the different methodologies, approaches and tools for the analysis, design and development of expert systems are discussed in this chapter.

Chapter 4 deals with the logical and physical design of the expert reference advisory system. The coding of the designed system, its documentation, demonstration and discussion, limitations, implementation requirements and constraints along with its possible applications to other areas are dealt in chapter 5.

Conclusion and recommendations are presented in Chapter 6. It is followed by bibliographic references and appendices.

CHAPTER 2

ETHIOPIAN STUDIES AND THE REFERENCE SERVICES

2.0 *Introduction*

In this chapter the domain of the study is described. Also the case area of the study is presented in terms of its users, the collection it holds and reference services it provides.

2.1 *Ethiopian Studies and its Focal Fields*

"Ethiopian Studies" is an area study. It deals with studies relating to Ethiopia, about its living and non-living things. The term "area" connotes people or groups with a culture, social, political, legal and geographical identity. For instance, the subjects 'science in Ethiopia', 'History of Ethiopia', and 'Archaeology in Ethiopia' are normally researched into and contributed to by scientists in various specialised subjects (Abebe 1993).

Ethiopian studies covers almost everything relating to Ethiopia such as science and technology, geology and natural resources, the useful arts and fine arts, language and literature, religion, philosophy, ethics, and education and human resources development (Chepkwony et al. 1992, cited in Abebe 1993). However, there are a number of major fields of study. For instance, Ethiopian history, culture, ethnology, anthropology, sociology, languages, literature, folklore of Ethiopia and related disciplines are the major focal areas of study conducted by Institute of

Ethiopian Studies (IES) which is the main institute in the country dealing with Ethiopian Studies (Tadesse 1990).

From the discussion held with the Director of the IES, among the focal fields described above by Tadesse(1990), currently Ethiopian History, Ethiopian Social Anthropology and Ethiopian Linguistics are the three major areas covered by researchers from both within and outside the country.

2.2 *User Groups and Their Information Needs*

Both from the study conducted by Abebe (1993) and the interview made with the librarians of the IES library, the major information user groups are found to be graduate students, university staff, fourth year students, junior students (below fourth year) and external researchers (both from abroad and within the country but outside the university community) ranked first, second, third, fourth and fifth respectively. Moreover, by the field of their specialisation, majority of the users are those who are conducting research in Ethiopian history (56.25% of the users), social anthropology and linguistics (15.63% of the users for each). Journalism, literature and sociology are the other fields of specialisation of the users. Also the information needs of the users vary from fact or data to documents to be referred to. Most of them refer to the reserved books, periodicals and reference materials in that order.

2.3 *Major Sources of Information*

Information sources can be categorised as primary, secondary, or tertiary. Primary sources are the original materials which have not been filtered through interpretation, condensation, or, often, even evaluation by a secondary party. These include journal articles, monographs, reports, patent, dissertation, or reprint of an article. Secondary sources are information about primary or original information. These include indexes, abstracts, databases and bibliographies. Tertiary sources consist of information which is a distillation and collection of primary and secondary sources. They include almost all source types of reference, such as encyclopaedias, reviews, biographical sources, fact books, almanacs, guide books and directories of experts and institutions (Katz 1982).

These sources are being used to render reference services in libraries/information centres. From functional point of view, reference sources may be categorised as control-access-directional type or source type. The former comprises bibliographies of reference sources, catalogues, indexes and abstracts and mainly used as a controlled access devices in the course of information and directional seeking. The latter comprises encyclopaedia, fact sources (yearbooks, almanacs, handbooks, manuals and directories), dictionaries, biographical sources and geographical sources and are mainly used to obtain the answers. Katz(1982) also indicated that this categorisation is not always so distinct in a real situation.

Among the possible reference sources, guides to reference material are the most useful ones and are being used as the basic guides for reference librarian to identify both the general and specific reference sources. Like the general guides, specific guides, which are limited to a broad or even a narrow field, give an overview of the subject, but they mainly cover the core of highly specialised publication such as list of textbooks, journals, newspapers, societies, libraries/information centres, subject experts, recordings, films - in fact, just about anything which is applicable to an understanding of research and reference in the field (Katz 1982).

The notable sources of information in the area of Ethiopian Studies are the Addis Ababa University, Institute of Ethiopian Studies (IES) library, the Ethiopian Collections Department of the Main university library, the National Library of Ethiopia, the Institute of Development Research Documentation Centre, the Institute of Agricultural Research (IAR) library, the International Livestock Research Institute(ILRI) library, the United Nations Economic Commission for Africa (UNECA) library and the National Science and Technology Documentation and Information Centre (NSTDIC) (Abebe 1993).

Among these, the IES library including the IES museum section is the one with the largest information sources and users. It has a comprehensive collection of materials (published and unpublished, bibliographic and non-bibliographic) (Abebe 1993). The main holding of the IES library in January 1996 is as summarised below:

- 104,000 volumes of books;
- 3,000 bounds and 500 current periodicals;

- 29,000 pieces of Manuscripts and Archives of which 16,000 rolls of microfilms, 500 framed and over 10,000 unframed photographs, and 25 albums;
- 10,000 museum objects; and
- 500 maps.

The library holding covers information resources in all languages as long as they deal with the geographic area. Almost 60% are in English, 20% in Amharic and 20% are in other - French, Spanish, Russian and others. Some of the other main information centres that are visited by the users when they failed to get information in the IES library are: Ethiopian Collections Department of the main University library, the National Library, the British Council library, Institute of Development Research Documentation Centre, and Central Statistical Authority (CSA) (Abebe 1993). Besides several experts/specialist within and outside the university exist to make contact for information.

2.4. The Reference Services

As mentioned in Chapter one, a reference work is a continuous process. The reason is that in expressing an information want an inquirer can only state the kind of conceptual elements and/or relations that he perceives as likely query for filling the knowledge structure (Vickery A. and et al. 1987). This process is described using the flow chart in Figure 2.1.

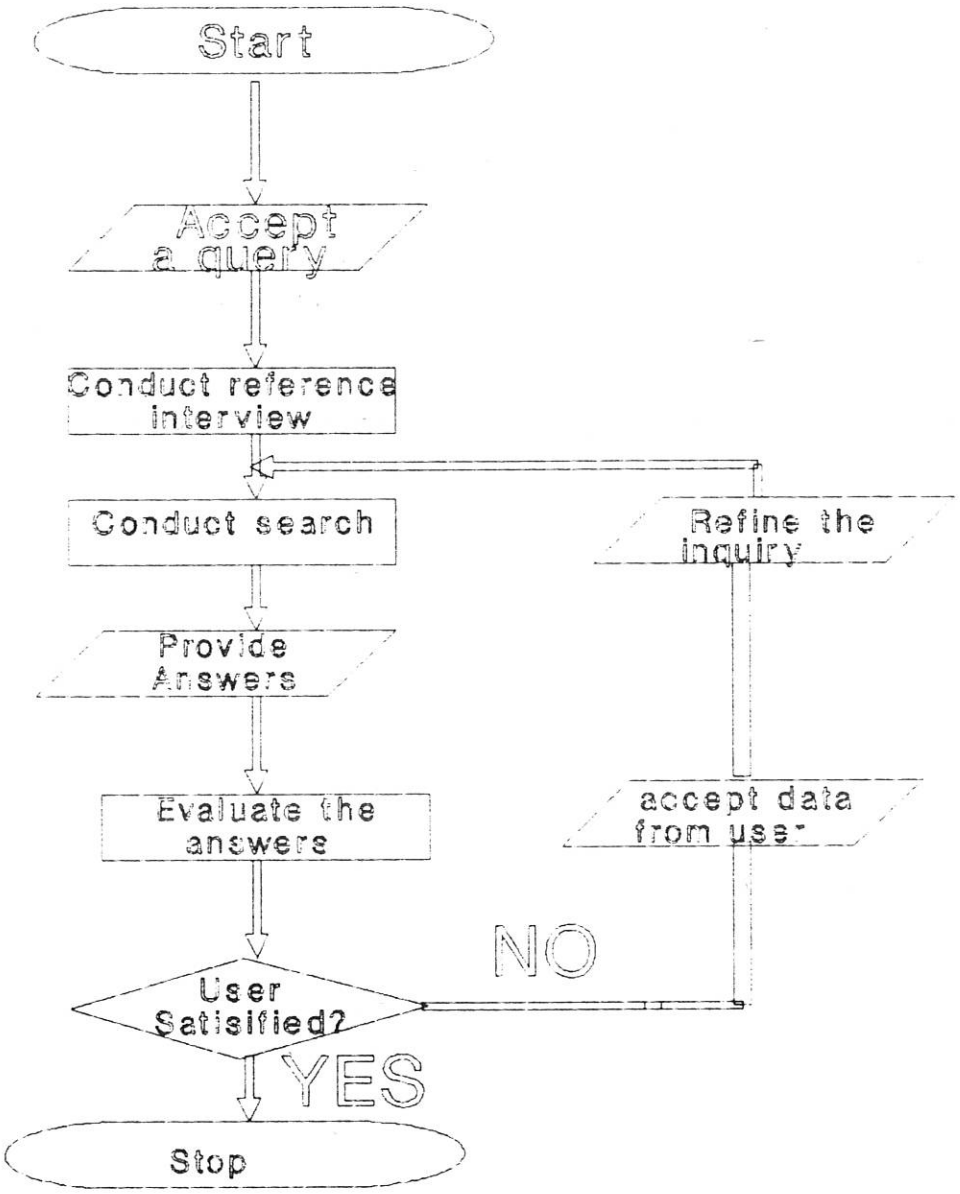

Figure 2.1: A Reference Process

Moreover, there are two basic modes of reference process: the systematic mode and the heuristic mode. In the former case, the interview is a reasonably complete phase before the search, and the reference librarian systematically covers all potentially relevant topics to provide a basis for decisions during the later search without the user. In the latter case, the interview is integrated more completely into the search phase. This mode combines personal interaction with trial look up into sources, feedback from a user, subsequent discussion with the user, additional search, etc. until an acceptable or no solution is reached, and usually results in a more successful result (Vickery A. and et al. 19s87).

From the discussion held with the reference librarian, based on the nature of the reference questions both of the above two modes are being used to answer reference questions at the IES library. Usually the systematic mode is being used to answer general questions/inquiries, and the heuristic mode to answer specific inquiries where the exact sources are unknown by the inquirer.

Abebe(1993) identified reference service to be the major (ranked as the first) service rendered by the IES library to users. The kinds of reference inquiries that are handled cover variety types with the majority being fact-finding, referral, material-finding and administrative and directional inquiries. Most of these inquiries have been handled by reference librarians with diploma degree in library Science and several years of experiences in the work. When they fail to answer inquiries, there are two senior librarians who help users.

Almost all of the various categories of reference inquiries/questions, that are given by different authors (Katz, 1982; Grogan 1991; etc.), are handled at IES library. That is,

I. Administrative and directional inquiries that include where things are and how things are done in the library;

II. Author/title inquiries where the user is seeking a particular work;

III. Fact-finding inquiries also known as quick-reference or ready-reference inquiries;

IV. Material-finding inquiries also called subject or search inquiries; and

V. Referral inquiries.

The reference librarians stated that users comes to get every thing about Ethiopia from the IES library. Some of the inquiries, as described by the librarians, are:

i) What do you have on Ethiopian History, Economy, Tourist sites, etc.?;

ii) Whom shall I consult to do research in Ethiopian Studies?;

iii) Who are resourceful persons on Ethiopian History, Anthropology, Population, Agriculture, etc.?;

iv) What indexes, bibliographies, abstract and other reference sources do you have on Ethiopian Studies?; and

v) What general information do you have on Ethiopian Art, Religions, Languages, etc.?

When inquiries come to the reference desk, to match to possible sources of answers or answers, they are categorised in different groups. First by the subjects they cover like Ethiopian History, Linguistics, and so on. Then, depending upon the users aim an inquiry in a subject could be again categorised into narrower domain of the subject like an inquiry about Ancient, Medieval or Modern Ethiopia for top category Historical Era. This categorisation of inquiries are described in detailed in Chapter Four.

In addition to personal experience of the librarians and general reference tools, some of the special tools that are used to identify and access the different information and expertise in the area of Ethiopian Studies are:

a) Ethiopian publications (a bibliography) and list of Ethiopian Periodical Publications in Ethiopia for identifying and accessing documented information;

b) A complete catalogue of museums objects, a catalogue of pottery, a catalogue of processional crosses, a museum manual and a museum guide for accessing museum objects;

c) List of experts within and outside the university;

d) Classification Schedules based on the Dewey decimal system which are adopted for the Ethiopian Collection.

e) Different bibliographies and indexes compiled by scholars and librarians.

f) Special tools like fact sheets.

In order to filter out and understand the actual information need of an inquirer, the reference expert, during a reference negotiation, looks for: subject definitions; objective and motivation; personal characteristics of an inquirer; relationship of inquiry to the way the information is organised; and anticipated or acceptable answers by an enquirer (Vickery A. and et al. 1987). This in turn helps in the ultimate provision of accurate information.

CHAPTER 3

EXPERT SYSTEMS IN LIBRARIES AND INFORMATION ACTIVITIES

3.0 Introduction

In this chapter expert systems and its main components are described along with a brief history. Literature review on issues such as methodologies for expert systems development, user modelling and user interface design, and expert systems development tools are also described. Finally the current trends of expert systems for LIS in general and reference services in particular are described.

3.1 Expert Systems: Definition and Structure

Various definitions are given to an expert system by different authors. For this study an expert system could be defined as a computer program which embodies knowledge about a specific problem domain, and manage to solve problems from the domain using its knowledge with a degree of expertise that is comparable to that of a human expert.

Mainly expert system consist of (Zahedi 1993):

(i) a knowledge base which embodies the part of the domain knowledge that should be included in an expert system. It consists of facts, relationships and heuristic relevant to the particular domain;

(ii) an inference engine which processes and combines facts and rules related to a particular problem or a question with the knowledge from the knowledge base in order to come up with answers or recommendations; and

(iii) the user-interface which provides communication with the user both in accepting input and providing output.

In addition to these main components, an expert system could have:

(iv) explanation capability that shows the line of reasoning leading to conclusion, and explaining to the user why a particular fact is needed;

(v) interface to other systems such as database management systems and spreadsheet; and

(vi) knowledge maintenance module to update the knowledge base.

These components interact each other to perform a task. These components and their interactions are indicated in the following structural diagram of an expert system.

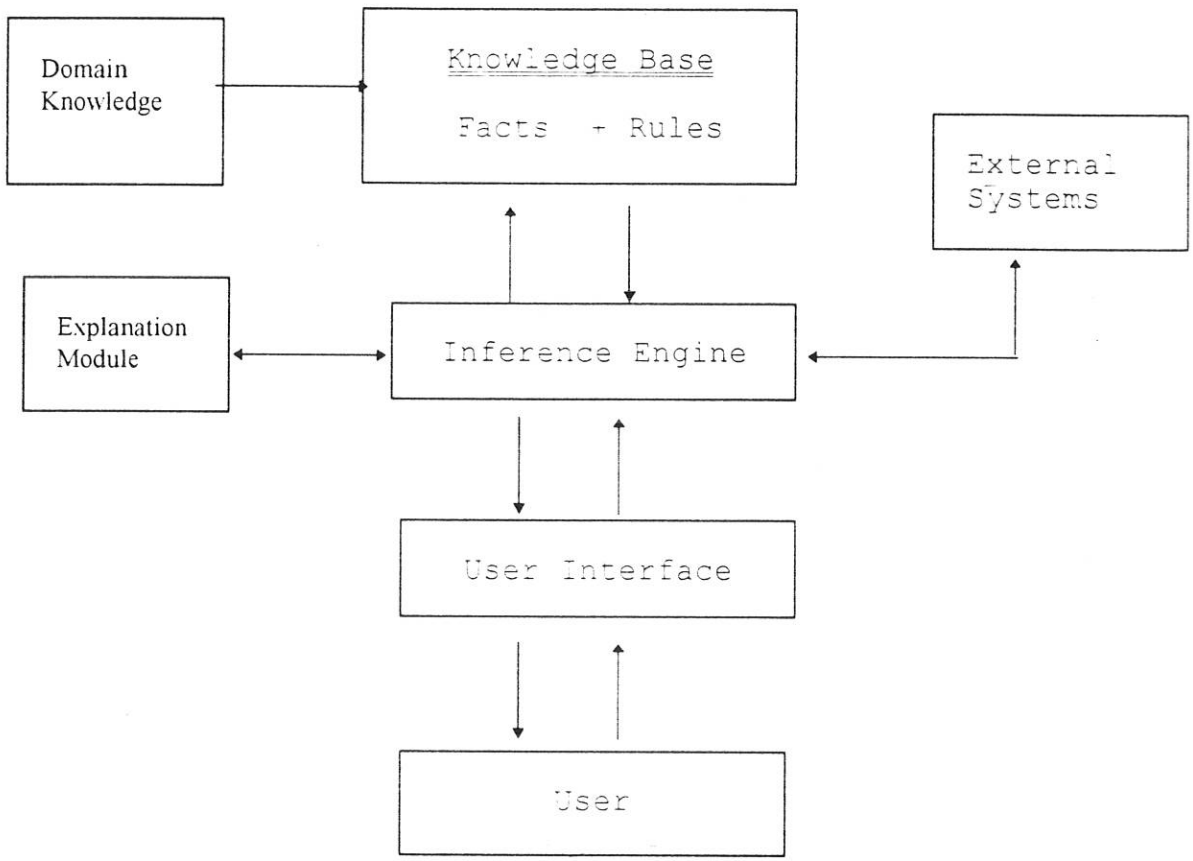

Figure 3.1: Basic Structure of an Expert System

As any computer-based system, expert systems use software for -- coding the knowledge base, user interface and systems interface, and a hardware as a platform to run the software which are considered in the next sections.

3.2 *Historical Development of Expert Systems*

Earlier artificial intelligence (AI) was focused on developing general methods and software for computer processing. A classical example of this research was the GPS (General Problem Solver). The second half of the 1960's witnessed the emergence of the practical side of AI - expert systems which were the result of the following four inter-related factors.

Firstly, the approach by research switched from general to specific or specialist knowledge - the facts and heuristic that are specific to particular problems or domains. As a result of this change, embryonic expert systems such as DENDRAL for determining the chemical structures of molecules; PROSPECTOR for mineral explorations; and MYCIN for medical diagnosis were designed. In 1978, McDermott started developing R1 (later XCON), which is the first commercially successful expert system, for aiding in computer configuration at Digital Equipment Corporation (Zahedi 1993).

Secondly, the announcement of the Fifth Generation computer Project in 1981 by the Japanese speeded up researches in expert systems and their applications. This in turn brought other parties on the race, mainly the United Kingdom and the US.

Thirdly, the gradual evolution that took place at conceptual and operational levels, from data - through information - to knowledge processing and management (Gibb 1986).

Fourthly, the industrial, commercial, educational and other organisations have awaken to the potential of expert systems. In fact, currently expert systems are one of AI research area which is

quite advanced and has moved out of research laboratory and into real world and is beginning to realise its potential in industrial and commercial applications (Smith 1990).

As the libraries and information services were becoming more computerised, the expert systems technology passed slowly in to the services in late 1980's and progress were made in the area of information retrieval (IR), cataloguing, reference work, indexing and classification, abstracting, thesaurus construction and training (Ford 1990; Morris 1991).

3.3 Development Methodology and Approaches

A methodology guides one what to do next, how to do it; and when to do it. It also provides reasons and assumptions for its process. Various methodologies and approaches have been suggested for the development of expert systems but there is no universal methodology as there is none for information systems (Hilal and Soltan 1993). Except the unique aspect of knowledge elicitation and representation that have necessitated a whole new area of software engineering called knowledge engineering, other aspects of expert systems development are similar to any information system (ZAHEDI 1993).

Unstructured and structured methodologies could be used in expert systems development. In the former the theme is to approach the problem arbitrarily and develop the system bit by bit. Whereas in the structured methodology the problem is undertaken in structured ways, and mostly either the principle of top-down or bottom-up design is used.

Hilal and Soltan (1993) stated that at present the life cycle (non-prototyping) and the prototyping are the two approaches available for expert systems development. No matter which of the two approaches are used, the expert system goes through the following development stages (Zahedi 1993):

(i) System Analysis stage that includes problem identification, domain analysis and modularization, goal identification, communication and expert identification;

(ii) System Design stage that includes knowledge acquisition as logical design; and software selection, hardware selection, user interface design and physical design of knowledge base;

(iii) Coding stage that includes coding the knowledge base and coding the user and system interfaces;

(iv) Testing stage that includes debugging, verification, validation and field tests;

(v) Implementation stage that includes user training, documentation and field support;

(vi) Post-Implementation stage that includes collecting field reports and statistics, learning new knowledge and discarding obsolete knowledge.

These stages are both applicable in both of the above approaches, but differently. This difference and others are described in the following sections.

3.3.1 Life - Cycle

In the life cycle approach the system developer goes through the different expert systems development successively to arrive at the implementation stage and produce the finished product. The strategy is to spend more time specifying and analysing the problem and to postpone all implementations till the detailed study or a complete and correct specification of the required system is ready.

This approach provides an orderly framework for the development of an expert system which reduces the probability of major errors and pitfalls. However, many authors (Zahedi 1993; Rauch-Hindin 1988; and Hilal and Soltan 1993) indicated that this approach is not suitable for an unstructured and new problems in general and in expert systems development in particular. The reason is that it is very difficult to achieve detailed specifications when the expertise is hidden in the mind of the expert. As Hilal and Soltan (1993) stated that spending more time in analysing the hidden knowledge in order to specify it is time consuming, costly and could turnout to be fruitless when resulting in piles of useless paper work. Instead, it is better off developing the system prototype without extensive analysis. That is by prototyping approach.

3.3.2 Prototyping

Prototyping is an increasingly popular approach in software development for small systems and for new area. In this approach, a scaled-down version, or prototype, is produced in a short time. Early during the developing cycle (and before any requirement document has been agreed

upon), a prototype version of the system is delivered to the sponsors and users so that they can see the system's capabilities and limitations, and give their suggestion before embarking to the development of a working/final system by allocating resources . Moreover, a prototype need not to meet user's requirements in non-critical areas such as completeness or response time, and exhibits limited functional capabilities, low reliability, and inefficient performance (Grogono 1991; Fairley 1985).

Prototyping is a common approach in expert systems because of the novelty and unstructured nature of problems that these systems are trying to solve (Zahedi 1993; Fairley 1985). Like the life-cycle approach, it follows the six stages of system development stated in section 3.3. However, in prototyping the developer goes through those stages in a quick and incomplete fashion, enhancing each stage in the next iteration of the prototype. Unlike the life-cycle approach, it takes a short time and hence not costly for the development of a prototype expert system; it allows developers to test and explore their ideas; and it serves as an invaluable focus for feedback from the experts in the application areas and from the users which is vital for the improvement of the knowledge base and the usability of the system (Drenth and Morris, 1992).

In this study a top-down methodology is used as the domain can be broken down into smaller parts. Moreover, a prototyping approach is employed because:

I. The problem area is new to the developer and hence need a great lengths of time in order to reveal the complete knowledge; and

II. It is the appropriate approach to demonstrate the different components and features of the expert reference advisory system by exploring the technology. And hence to check the prospect of developing an expert reference advisory system for the domain area.

3.4 *Knowledge Elicitation and Representation Methods*

Mostly development of expert systems in general, and knowledge acquisition in particular, requires the involvement of more than one person - a knowledge engineer, domain experts, users, computer programmers, systems analysts and AI specialist (Zahedi 1993). However, sometimes more than one roles are taken by same persons (Poulter and Morris 1994). Prior to the actual knowledge acquisition started, the essential tasks are: selection of experts(s) who has (have) the recognised expertise and experience in the particular domain knowledge; and identification of other sources of knowledge including printed sources and observation of the actual process. They all provide input to the knowledge base. In most cases domain experts are the main sources of knowledge, but they are found to be unable to articulate clearly the nature of their expertise (Poulter and Morris 1994). Moreover, in case of multi-expert knowledge elicitation, issues like organising the experts and the whole process, and solving conflicting views and opinions about various pieces of knowledge require decisions.

In order to elicit knowledge by helping experts in articulating their knowledge, there are knowledge acquisition methods that can be used by a knowledge engineer. Basically top-down (or deductive) methods and bottom-up (or inductive) methods are the two knowledge

acquisition methodology. In top-down methods, the knowledge engineer organises the acquisition sessions for discovering general concepts, rules, and objects, and then gradually goes into the details of each concept, rule, or object. They comprise questioning (Interviews and Questionnaire) methods where the expert is interviewed and/or asked to fill out a questionnaire; object-oriented methods where the expert is asked to discover objects in the domain and explain how the objects are manipulated; quantitative methods for helping the expert elicit relations among the objects, and determine the degree of uncertainty; and invent methods where the expert is allowed a more active part in the process either as a teacher to the knowledge engineer, as a partner in systematic innovation in which the expert and the knowledge engineer try to identify contradictory knowledge and discover solution methods for removing it, or as the knowledge engineer (Zahedi 1993).

In bottom-up methods the knowledge engineer focuses the expert's attention on specific cases, in order to help the expert abstract the decision for resolving a specific case to a more generalised rule or concept. Under this category, example-based methods, protocol analysis and observation of the expert's decision-making process are included (Zahedi 1993). In example-base methods the knowledge engineer and the expert work on a number of representative cases or examples in the domain. In protocol analysis and observation, the knowledge engineer seeks to ascertain the set of actions and responses that the human expert uses. Their difference is in the protocol analysis, the expert needs to talk through what one is doing, which is not the case in observation.

In this study knowledge is elicited from reference staff. The interview method, both unstructured at the beginning and structured later, supplemented with observation and protocol analysis methods are used to elicit knowledge from the reference staff at IES library. Besides published literature and reference tools in the domain are used to elicit additional knowledge. Because, in reference services published materials include an extensive body of knowledge used as sources of information by LIS professionals. For instance, documentary reference tools such as guides, bibliographies, indexes and encyclopaedia have been used to answer reference queries.

Once the knowledge is elicited and documented (say using pseudo-code) the next task is to represent the knowledge for use in a knowledge base. For this purpose there are various methods of knowledge-representation. The major ones are: rules, predicates, frames, semantic networks and objects. The first two are logic-based methods and the rest are object-based methods.

Rules, also called production rules, are the easiest to understand and use, and hence popular methods of knowledge representation. They consist of conditions and conclusions where each condition is an IF statement and each conclusion is a THEN statement of a known fact or condition. However, rules lack variation and are unstructured. Their format is not adequate to represent many types of knowledge such as association among objects and relationships or casual knowledge. In addition, as the number of rules grows, it becomes difficult to manage and modify. Despite these limitations, rules are still widely used to develop expert systems (Rauch-Hindin 1988; Zahedi 1993).

Semantic networks as knowledge representation method has a simple and graphic structure in the form of a network. The nodes of the network represent concepts or objects and the relationships between these concepts are expressed by arcs joining them. This method is suitable for the representation of associations between attributes and hence useful for modelling complex systems, such as language structure. Unlike rules, semantic nets tend to be difficult and costly to develop. Moreover the methods does not distinguish between the class of an object and a particular object. These and other limitations resulted in the coming of scripts and frames as knowledge representation methods (Zahedi 1993).

A frame which is a data structure that contains 'slot,' attributes of the entity represented by a kind of template as a whole, was developed. Frames represent a structure of knowledge in a much more organised and manageable manner. It is also possible to construct a hierarchy - a complete frame within a slot of another frame - so that frames lower in the hierarchy inherit features of those frames higher in the hierarchy. Hence, it is adequate to represent casual-relation knowledge. However, constructing an expert system with knowledge represented in frames is more complicated, costly and time-consuming as the frame method does not have a language of its own (Zahedi 1993). This in turn resulted in the new method called object representation.

A combination of two or more of those different knowledge representation methods has been used in order to gain the power each of them does have. But this also increases the complexity of system design and maintenance.

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In spite of the limitations of rules, in this study the knowledge is represented as facts and rules for the following reasons:

- Rules represent a particular natural mode of knowledge representation and hence it is simple to construct and validate the knowledge base;
- Knowledge represented in rules can relatively be easily updated, i.e., modified, deleted and inserted;
- Rules are suitable to represent the knowledge of the domain of the study except the knowledge about the users; and
- The time constraint and the lack of experience by the developer to use other methods such as frame and object-oriented representation.

3.5 Inference Strategies

One of the main components of an expert system is the inference engine which infers and reasons on the knowledge base to come up with a proposed solution or set of alternative solutions. The approach used by this component is heuristic search for solution which is the distinct features of expert systems and is found to give answers as good enough as human experts. For this task the two well-known and fundamental methods of inference strategies or search sequence are backward chaining and forward chaining.

Backward changing inference strategies starts from a goal, i.e., the conclusion in a rule, and then try to apply on the knowledge base to get that goal, i.e., it goes back to the condition(s) of the

rule. It is goal driven, and preferred when a problem has many premises and a few conclusion. Whereas in forward chaining, the inferencing starts from a condition and tries to match it from facts obtained from a fact base or a user. If the match succeeds, then the conclusion part is proved and hence the goal is achieved. It is data driven, and preferred when a problem has a few premises and many conclusions. It is also possible to combine these two methods of inferencing in order to gain the strength each has.

Because the domain of this study has many premises and a few conclusion, the backward chaining is preferred and used which is usually found as the default inferencing strategies of most of the prototyping tools. Also it makes users free from entering all the facts to questions that can often appear aimless to the users.

3.6 *End-User Modelling and Interfaces*

A computer-based system is designed for people (users) to accomplish a certain task. Hence the system should be simple and easy to be used by the intended users. This requires thorough consideration of the characteristics and needs of the users during the designing of the system, and then inclusion to the system. This can be achieved by establishing an appropriate user-model and by developing an appropriate end-user interface. These issues are very important for expert systems as they are trying to provide advice or answers for various applications on which decisions are to be taken; and also as the systems are designed for non-experienced users in the domain and computer usage.

A user-model contains knowledge about users of a system. Elain Rich (1986) suggested the following three main dimensions by which user models could be classified: Canonical (model of a single user) Vs models of individual users; explicit models constructed by the user Vs implicit models constructed by the system; and model of long-term more general information Vs models of short-term highly specific information.

Depending upon the nature of users and the function of a system, an appropriate approach could be made toward user modelling. Canonical models and individual models are useful for homogenous user group and heterogeneous user groups, respectively. On the other dimension, explicit models are not appropriate for systems with naive potential users. Instead, implicit models are more appropriate to them. Moreover, long-term models are suitable for having accurate model of some essentially permanent characteristics such as: data/fact about users, user's level of expertise with computer systems in general, his expertise with this system in particular, and his familiarity with the system's underlying task domain. And short-term models are important in modelling specific and dynamic characteristics such as preference for type of advice and a level of tolerance of system's time (Rich 1988).

Users modelling is still one of the difficult area in developing an expert system for library and information services. In an academic information centre and in a very narrow domain usually users are homogenous, and have more or less similar and more general information needs.

Thus, toward user modelling of an expert system for reference services in narrow domain like Ethiopian History, canonical, implicit and long-term models could be selected from the three main dimensions. However, they lack the dynamic nature of information needs and lack some accuracy.

Highly interrelated issue to user modelling in an expert system is the user interface. It links the user and the system, i.e., it is a means by which a user enters input to the system, obtains output from the system and explanation of the system's actions or answers. The user-friendliness of this link is very important for the utilisation of an expert system.

User interface is a technology with a rapid technological advance. The main products are menus, forms, graphic, symbols and icon, voice, hypertext and natural language (Zahedi 1993). The first three are relatively common in most software products. Symbols and icons are the recent phenomena with great significance for an expert system that involves objects.

A natural language interface accepts a user's input in the user's natural language and is able to translate into system commands. This technology is still in its early stage and so far, the systems which have been produced with natural language user interface are capable of only recognising a restricted vocabulary concerned with a particular problem domain (Smith 1990). The other new and attractive user interface technology is hypertext. Even though this technology for user interface is in the early stage, there are expert system shells such as KnowledgePro and

LEVEL 5 OBJECT which enable developer to develop expert systems with an integrated hypertext user interface.

Using latest user interface technology, doesn't guarantee a user-friendly interface for a system. Because designing of an appropriate user interface requires the identification of the user needs and the type of the system users (the user-model), and then their incorporation to it within the resource constraints.

The other interface component of an expert system is systems interface. It allows the expert system to hook and communicate to external systems such as popular database, spreadsheet and graphic systems.

In this study the WIMP and hypertext facilities are used in designing the user interface of the system. Besides, the expert system is interfaced with a database system to access facts about the different information sources that could answer users' inquiries.

3.7 Development Tools

The development tools available for expert systems are : AI programming languages, conventional programming languages and expert system shells.

AI programming languages such as LISP (LISt Processing) and Prolog (PROgramming in LOGic) are the early and most popular ones. They provide fully unconstrained development environment, i.e., they have the capability to manipulate arbitrarily complex data structures, and more importantly they have an external representation for these structures. However, they lack run-time and use. Hence they are not as suitable for prototyping as shells. On the other hand any conventional languages such as Pascal C, C++ and BASIC can be used to program expert systems. They provide run-time efficiency, and also have better interfaces to external application systems such as databases and graphics systems. But they lack a built-in inference mechanism and hence require code or algorithm to be written to access the data structures.

Expert system shells (like ADVISOR-2, CRYSTAL, 1st CLASS, KnowledgePro, and Level 5 Object) are expert systems stripped of their domain knowledge (Ford 1991). Available shells vary from simple ones with rules and facts constituting the knowledge base to more sophisticated ones with frames and inheritance constituting the knowledge base. Unlike the programming languages, they permit the relatively quick and easy building of a new system, and hence are suitable for prototyping.

Shells have been relatively constrained and inflexible compared to programming languages. But current shells such as KnowledgePro and Level 5 Object have built-in procedural languages and interfaces to external programming languages and application systems. For these and other reasons, which are elaborated in Chapter 4, in this study the shell, KnowledgePro is used for prototyping the expert reference advisory system.

3.8 *Expert Systems for Library and Information Services*

Ford (1990) suggested that expert systems can be developed for professional tasks in both traditional and non-traditional library and information services and management tasks. These tasks include: indexing, abstracting, thesaurus construction, cataloguing and classification. Boolean text retrieval, non-Boolean text retrieval including reference services, automatic content analysis and knowledge representation, relational database access and management, intelligent documents, training, database selection, and database analysis.

Poulter and Morris (1994) reviewed the expert systems for LIS over the year 1989 to 1993 by conducting on-line searches and general search from the known information science databases within DIALOG. Out of 195 papers obtained, they reviewed the development, features, and functions of 139 expert system projects in the LIS domain. These systems covered various subdoamins such as on-line information retrieval (28%), reference work (32%); indexing, cataloguing, or classification (12%); library management application (7%); abstraction (1%); and others (20%). Moreover, by function the systems were for advisors only (69%), for tutor only (3%), for both advisor and tutor (9%), and for other purposes (19%). This review entails :

I. Some particular LIS domains have received relatively little attention (e.g. abstracting) and others are hardly represented at all (e.g. acquisition). In contrary, some have received great attention (e.g. reference work and on-line IR); and

II. Majority of expert systems for LIS are advisory.

As of 1994, a number of expert systems for LIS are expected to be developed in the various part of the world. Due to the non-existence of the latest releases (after the year 1993) of the LISA (Library and Information Science abstract) database, the work after 1993 are not reviewed.

As explained by Morris (1991), during the development of most of expert systems for reference services the lack of explicit rules of reference, the lack of detailed models of the reference process, the lack of knowledge about user models, and the difficulty of deciding exactly what knowledge should be contained within an expert system are the major problems faced by the designer. Still these problems are not yet resolved, and hence researchers are trying to solve them. Nevertheless, many works have been attempted.

For reference services, several expert systems have been developed. These include early prototype system such as REFSEARCH (Meredith, 1971), REFLES (Bivins and Palmer, 1980), REFLINK (Bivins and Eriksson, 1982), the Reference and Information Station (Starks and et al. 1972), On-line Reference System, ORS (Chisman and Treat, 1984), and the Information Function, IF (Diskin and Michaleak, 1985).

Some of the more important expert systems that are developed in the late 80s' for the LIS are: PLEXUS (Vickery and Brooks, 1987) which is the most ambitious, and a demonstration prototype expert referral system and has a natural language type interface. It refers users to publications, organisations, databases, and experts, in the field of horticulture (Morris, 1991); Answerman (Waters 1986) which is a small microcomputer-based expert system to point users to wide variety of agricultural-related reference books and corresponding page numbers for easy access to answers; AquaRef (Hanfman 1989) which is a working system for providing references to sources of information, and answers and advice in response to commonly asked questions in the field of aquaculture; The Information Machine (Fadell and Myers, 1989) which is a menu-driven computer presentation that could also refer users to appropriate reference books or periodical indexes; The Technical Writing Assistant (Butkovitch and et al 1989) which matches the user's request against a database of information sources; and Material Librarian (Carande 1989) which is an expert reference advisory systems for material science.

Some of the more recently developed (early 90s') expert systems for the LIS include: Patent Information Assistant (Ardis 1990) which is a menu-driven expert system assisting users in processing patent information enquiries; ChemRef (Sarangapani 1990) a guide to reference sources in Chemistry; Expert Reference Advisor for Opera (ORFEO) which is a system designed to recommend specific sources in answer to questions about opera (Gerber 1992); Plant-Expert Advisor (Mason 1990) which is an expert system to guide the user to the best plant for a site, and it is integrated with an interactive hypermedia format; and The New Zealand Reference

Advisory (NZRef) which is an expert system to assist library assistants answer reference questions about New Zealand, by recommending appropriate reference sources (Smith 1992).

Due to a high level of experimentation required to acquire the demanded knowledge of an expert system, the approach adopted in developing most of the above expert systems for LIS has been prototyping. Besides unstructured development methodology, which "is a result of the immaturity of this field and the corresponding uncertainty of researchers in understanding how to deal with the broad base of the LIS profession" has been used (Poulter and Morris, 1994).

Regarding the knowledge sources and acquisition methods, expert systems in LIS developed so far have used: reviewing printed sources; interviewing experts in the domain; personal experience in the domain; observation; protocol analysis; and/or multidimensional sorting in their order of usage frequency (Poulter and Morris 1994). Moreover, depending upon the situation, one method is selected as the primary one and supplemented by others. This is the case in most expert reference advisory systems. ORFEO and ChemRef are examples which have used knowledge acquisition to printed sources (like Bibliographies, Monographs, etc.) for knowledge about reference information supplemented with interviewing to experienced reference librarians.

In relation to the knowledge representation methods, so far the expert systems for LIS have used:

- Production rules alone as in Answerman, Aquaref, NZRef and ORFEO;

- Frames alone as in Parrott's (1989) REFSIM, and
- Semantic Nets alone as in GRANT, developed by Paul Cohen and Rick Kjelsen, which uses a semantic network representing research funding agencies, research topics and research studies.
- Predicate Calculus as in CODER (FOX 1987) which is a multilayered system for document retrieval.
- Hybrid of production rules, frames, and/or semantic nets as in PLEXUS and REFSIM.

Among those methods of knowledge representation production rule is widely used and is found to be easy for representing and amendment of knowledge (Ford 1991; Morris 1991; ZAHEDI 1993). Moreover rules are frequently used with the other representation methods to select and activate them.

So far the development tools that have been used for developing expert systems for LIS in general and for reference services in particular are: AI programming languages (mainly PROLOG and LISP); Expert System Shells (mainly 1st-CLASS, KnowledgePro, Crystal, LEVEL-5, EXSYS and VP-Expert); and Procedural programming languages (mainly BASIC, PASCAL, C and C++). Among these tools, PC-based Shells are the most widely used to develop prototype expert systems. The reasons are: they save development time; they are easy to use as they rule out the need for original programming of the inference control mechanism; they offer good 'Help' facilities for developer; they have good user interface development facility; and they are comparatively low in cost. However, several developers later chose a programming

Evaluation of the systems developed so far indicates: a better result than statistical-based information retrieval system, for instance, by comparing PLEXUS and INSTRUCT; and users are satisfied with their performance and the answers they provide, for instance, in ChemRef 96% of the evaluators were satisfied with the knowledge ChemRef embodied, and for the same system the answers to a set of questions were compared with that of domain experts and found to be statistically significant (Poulter and Morris, 1994).

In conclusion, the expert systems that have been developed are largely experimental in nature, and lack integration with other systems. However, the technological advance ___the increasing power of the PC and the increase in the productivity and simplicity of the software on the one hand; and the consistent and continued research for solving the problems in the domain area -- user modelling, detailed modelling of the reference process, and lack of standards on the other hand are the driving forces for the current researches. These and other trends in expert systems technology are described in the following paragraphs.

Most of the expert systems that have been reviewed above and discussed in different literature are for stand alone system. However, currently the trend is towards the integration of expert systems with other application systems, mainly with database, spreadsheet, graphics, multimedia, hypertext, word processing, statistical and data communication systems. This is because expert systems, as systems, need to communicate with other systems for various reasons such as for obtaining data, advanced computations, and quality graphics output.

CHAPTER 4

ANALYSIS AND DESIGN OF THE PROTOTYPE SYSTEM

4.0 Introduction

Three experts, two from IES library and one from the museum section, served as domain experts in the course of knowledge acquisition. They were selected by the respective heads of the sections based on their experience in handling inquires in the field of Ethiopian Studies. Besides, the IES library librarian was consulted. Their profiles are indicated below.

Qualification	Work Experience
1. Diploma in Library Science and currently 4th year evening degree program student in library and information science.	More than 8 years experience in reference services at IES Library.
2. Degree in library and information science.	More than three years of experience at IES, as head of the public service of IES library.
3. Diploma in Archive	More than five years experience at IES museum section
4. Masters degree in library science	More than 10 years of experience at IES being a chief librarian

In the knowledge acquisition process, to build the domain experts' model, it was looked for :

a) The different inquiries the domain experts accept from the users, and the way they analyse them;

b) The different information sources they use;

c) The advice that the domain experts provide; and

d) The way or the model followed by the domain experts to match (a) and (b).

In this chapter, these issues are analysed and designed for prototyping of the reference advisory. However, it is not claimed to be exhaustive by any means. And for this purpose interviewing (mostly discussion), protocol analysis and observation were employed.

4.1 Domain Analysis and Goal Identification

The purpose of the reference advisory system is to provide advice and guide a user in the course of his/her information search. In the simplest way, this could be indicated in the following diagram.

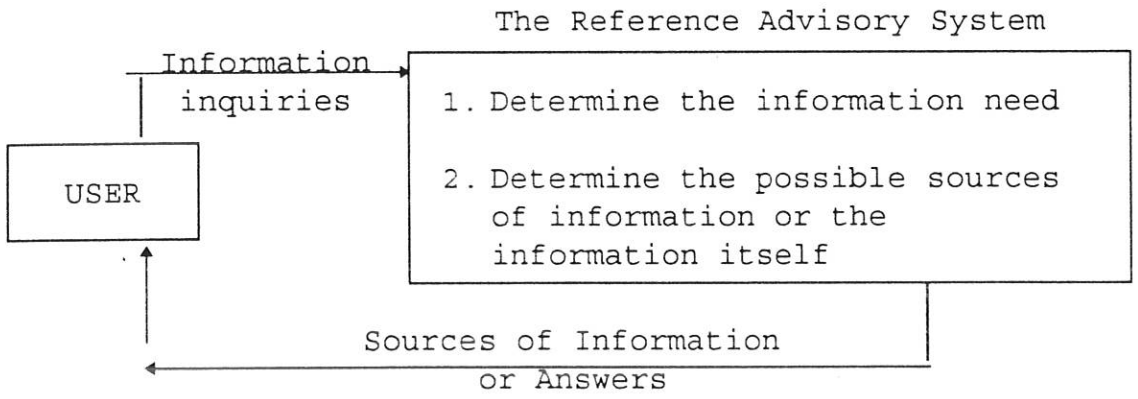


Figure 4.1: The General Structure of the Reference Advisory System

The main objects or entities of the system and their attributes are summarised below:

Object	Attributes for Decision
User	Educational level, Experience in the domain, Experience in Computer usage, Address
Information Source	Type, description for the inquiries it might answer or the information available from the source
Inquiry	Topic/Subject, description of the information required in terms of the wanted and the given categories (as explained below)

The above objects and their attributes are essential for the decision making process of the reference librarian in providing advice to users. And the objects are related as indicated in the following logical structure.

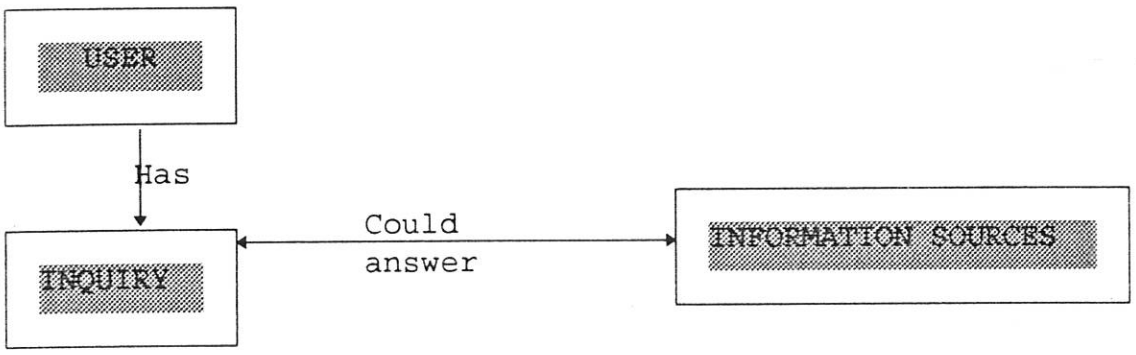


Figure 4.2: Logical interaction between the objects

The structure shows that a user could have one or more inquiries and an inquiry could by answered by one or more information sources and vice versa. The attributes of the objects and their relationships are useful for the identification and organisation of the different knowledge employed in the process of advising users for information sources.

Any computer program, whether conventional or expert system, needs some organisation. For the expert reference advisory program in Ethiopian Studies, the approach used is to analyse and organise the inquiries likely to be asked by users and the corresponding topics they refer to, but not the data/information/knowledge of Ethiopian Studies as a discipline because of the diversity of the subject. Moreover the reference librarians are also using this approach in answering inquiries. Thus, first the inquiries are analysed by the topic or subject they cover, and then by the information wanted and given in inquiries of users.

A reference inquiry in the focal field of Ethiopian Studies could be categorised as follows, as level zero:

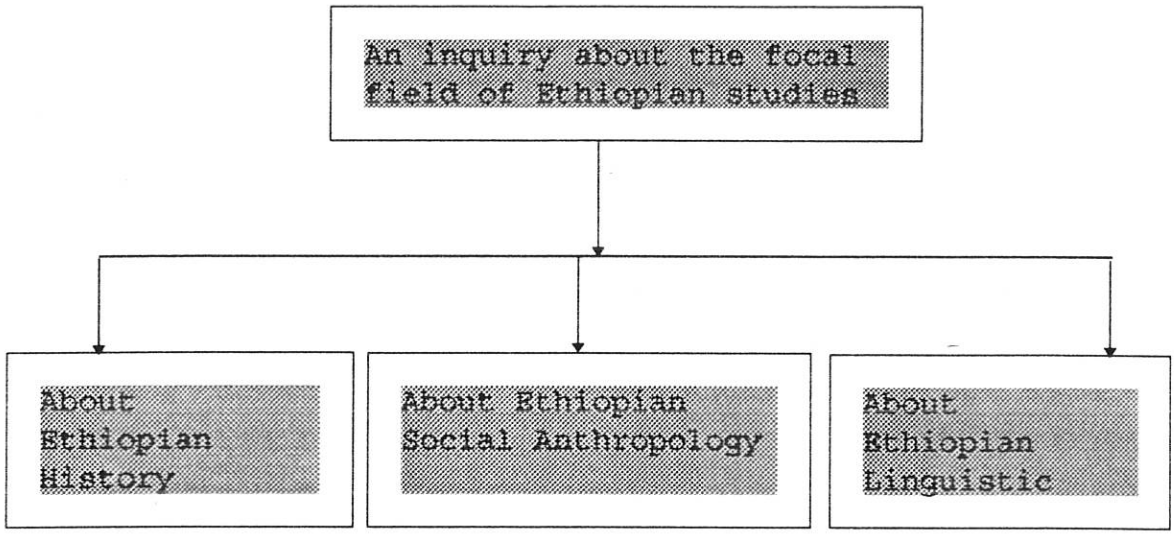


Figure 4.3: Level Zero: Top-level category of an inquiry by subject/topic

From these three main sub categories, due to the time constraint, only the first sub category, Ethiopian History, is considered in the development of the prototype. Ethiopian History is selected because it is the first ranked focal field of study with the largest number and varieties of inquires handled by the reference librarians at IES library.

Afterwards a detailed analysis is made for inquiries about Ethiopian History.

In questions of a historical nature the user usually wants to pin point some historical fact or facts which involves places, people, things, or time. Other questions of a broader nature involve reasons for disputes between two countries, the part some ruler played in the development of a country, etc. (Peck, 1976).

From the discussions made with the reference librarians at IES (the domain experts) users who need information on the field of Ethiopian history come with various inquires ranging from general to specific. And these different inquires are looked at by them under the following different categories of topics which are summarised at different levels using the following tree structures.

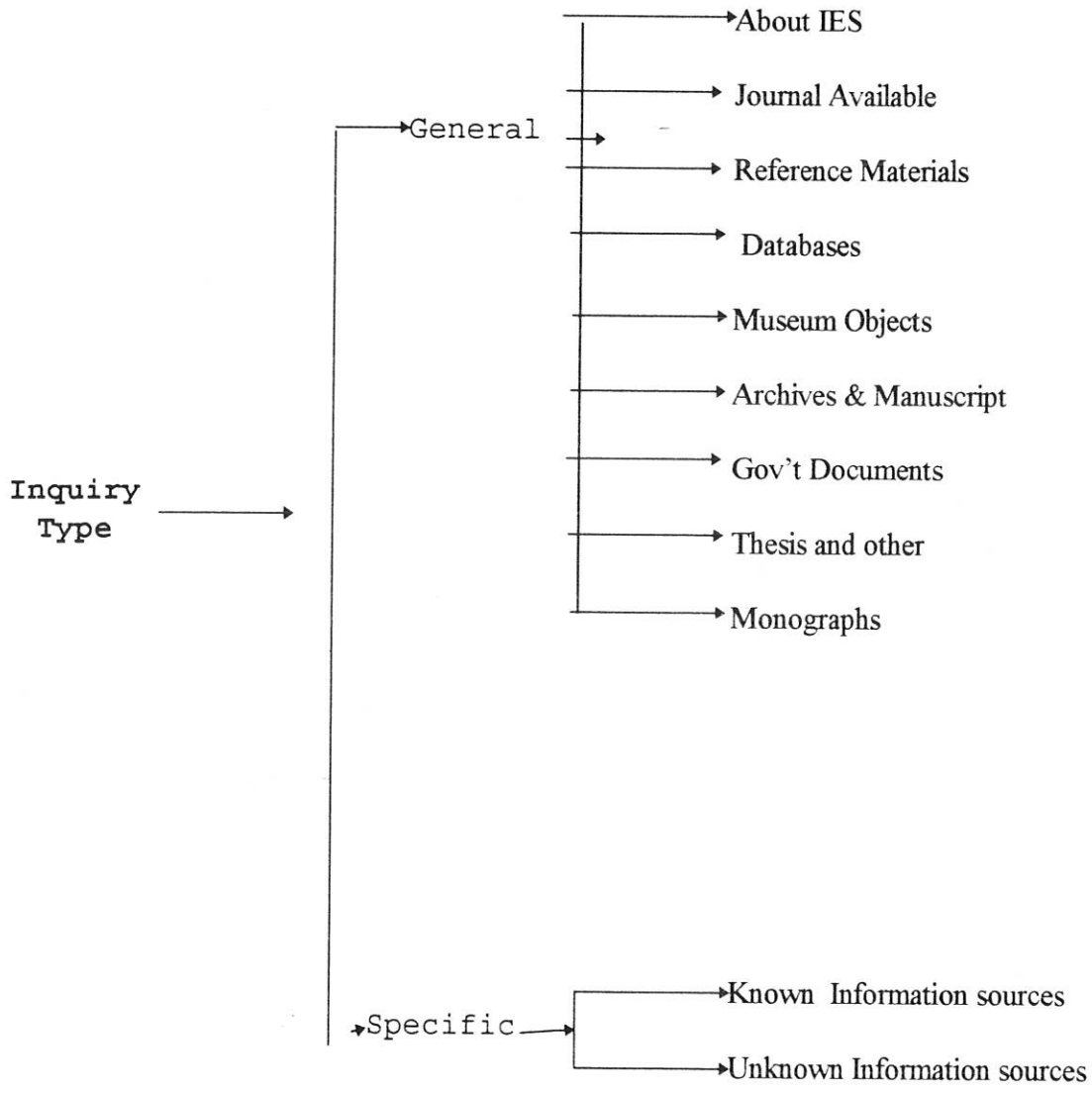


Figure 4.4: Level One: Inquiry classification in Ethiopian History

Broadly, an inquiry can be either general or specific. 'General inquiries' are for a general and broad information needs about the available major information sources in the fields of Ethiopian history, such as the different journals, indexes, databases, card catalogues, encyclopaedias, Geographical sources and other general information sources and tools that might answer his/her inquiry on the field of Ethiopian history.

Where as 'specific inquires' are for specific and narrow information needs about the specific and narrowed topic within the field of Ethiopian history such as history of modern Ethiopia and history of ancient Ethiopia, either for information sources known or unknown by the requester. 'Factual inquiries' are inquiries for information sources that can give answers' such as date of a historical event, locations or addresses of historical places, experts, institutions and other information centres involved in the field of Ethiopian history.

The different specific inquiries for which the user does not know the exact information sources could be organised in different categories; topics within the broad subject Ethiopian history are shown below, as level two.

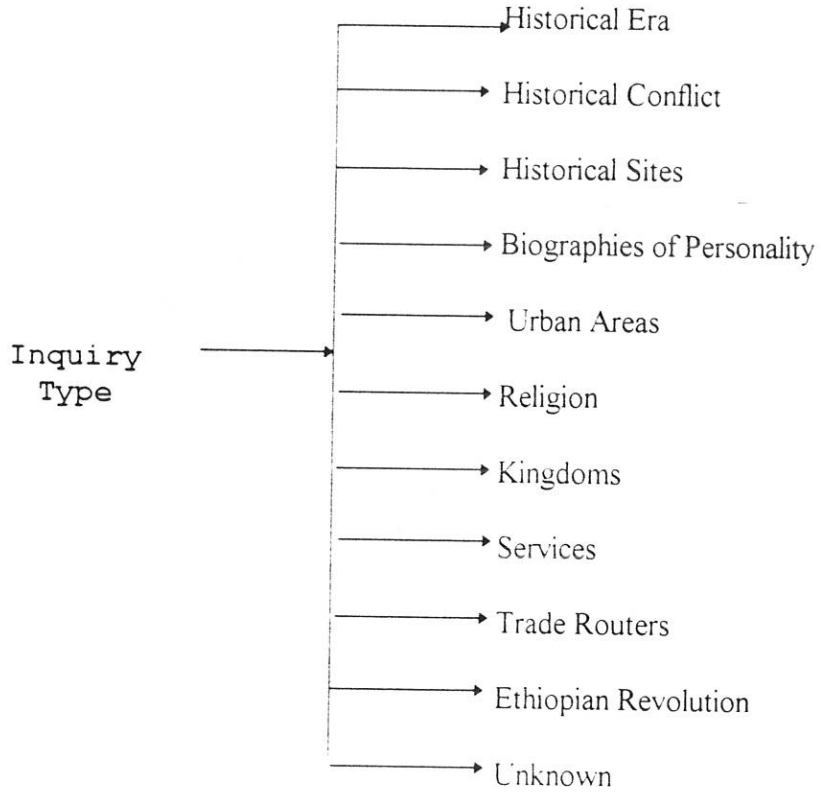
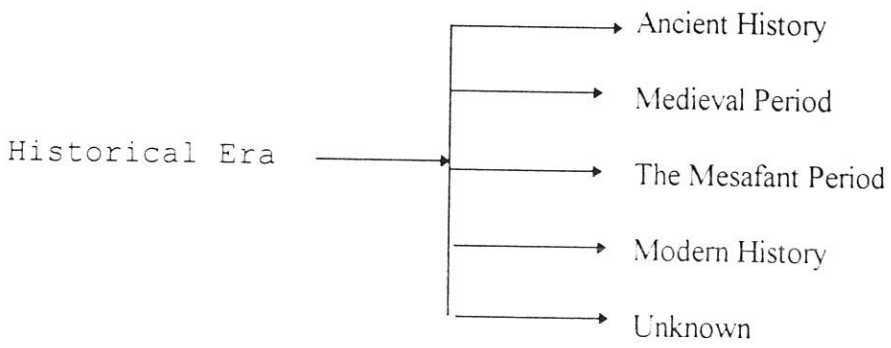
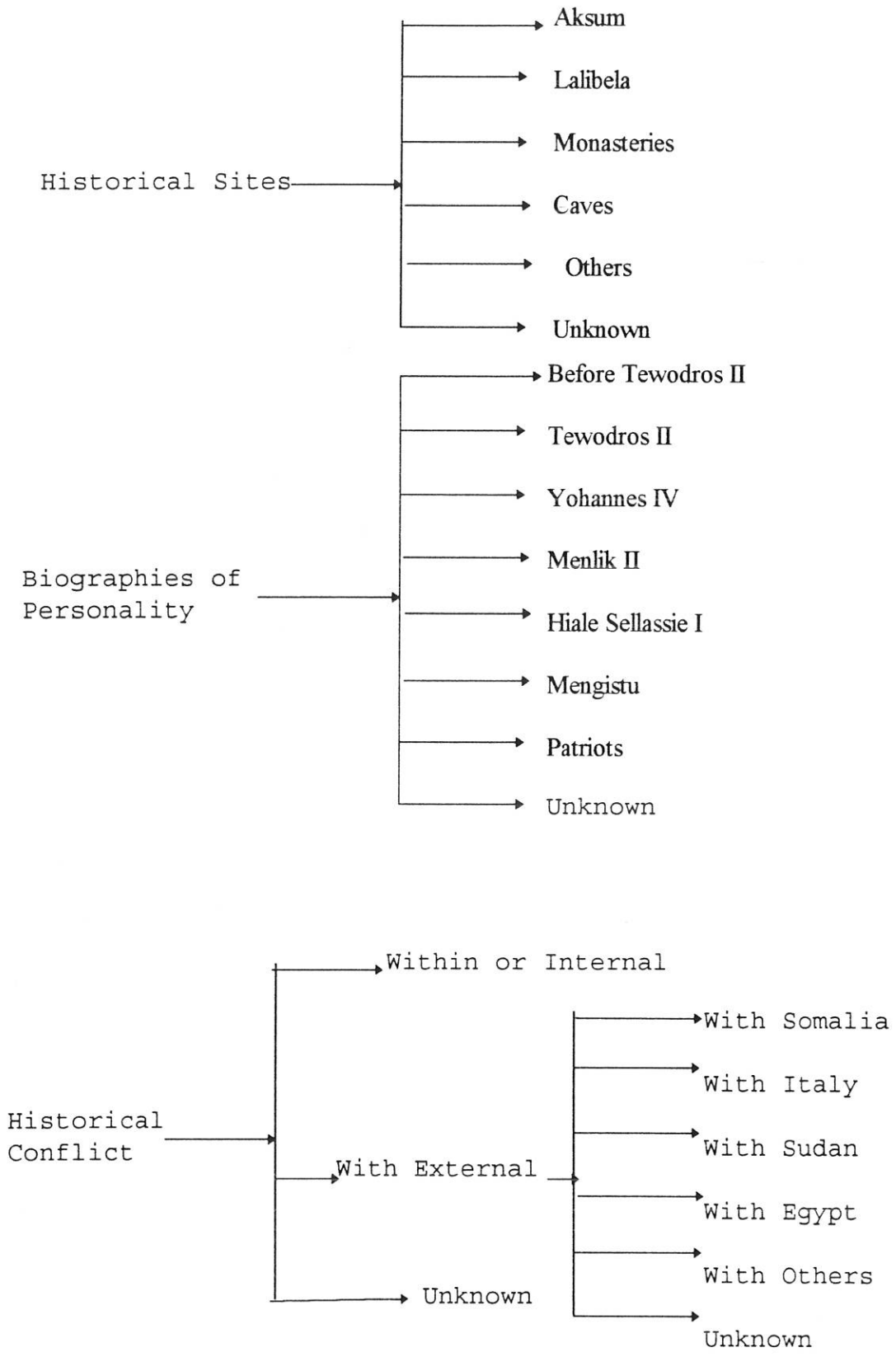


Figure 4.5: Level Two: Broad Categories of inquiry with unknown sources of information.

These categories/topics could be categorised into more detailed inquiries for sub categories/sub topics as indicated below, as level three.




Historical Sites
Aksum
Lalibela
Monasteries
Caves
Others
Unknown
Biographies of Personality
Before Tewodros II
Tewodros II
Yohannes IV
Menlik II
Hiale Sellassie I
Mengistu
Patriots
Unknown
Historical Conflict
Within or Internal
With External
Unknown
With Somalia
With Italy
With Sudan
With Egypt
With Others
Unknown

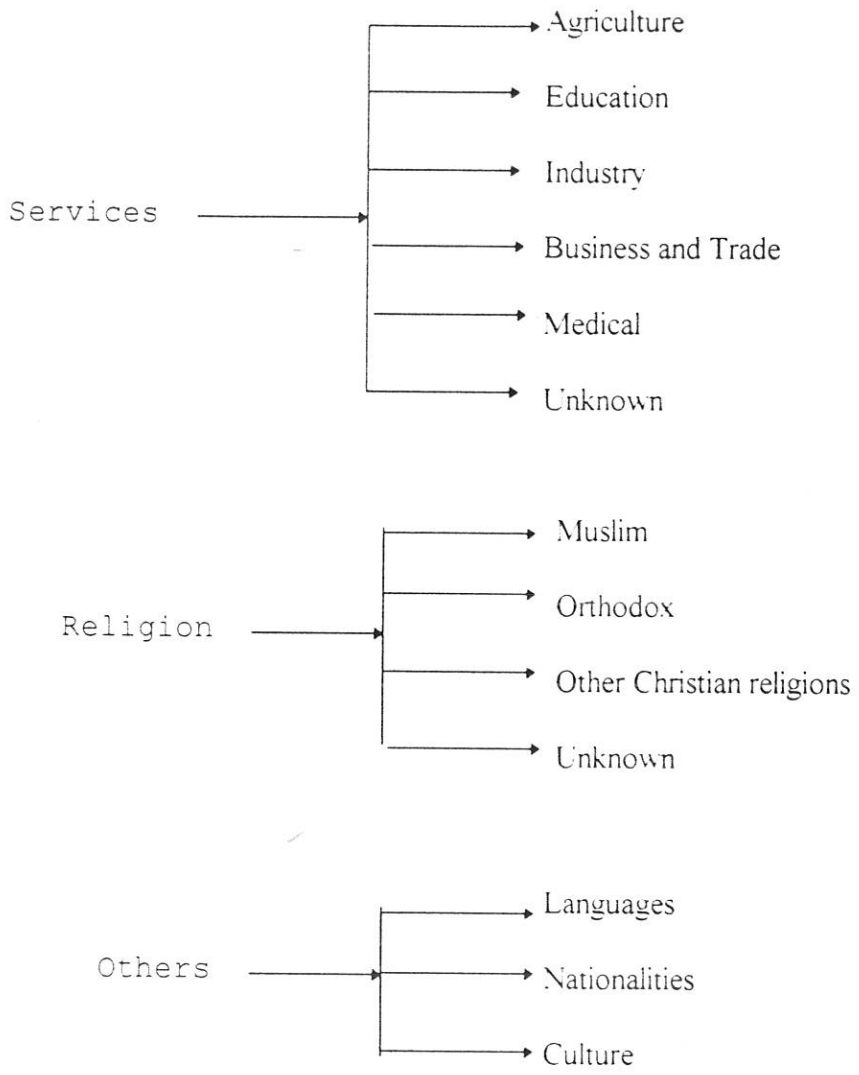


Figure 4.6. Level Three: Detailed categories of inquiries by topics

In the above categories 'unknown' is used to mean the inquiry is not complete at that level. The above categories help provision of information sources in very specific topic such as on modern Ethiopia, on Aksum and so on, in addition to the general ones.

An inquiry at any point in the above hierarchy could be modelled using the Given-Wanted model. In the Given-Wanted model of Gerald Jahoda and Judith Scheek Braunagel (1980), an

inquiry could be characterised as having two components : a given part and a wanted part; where the given part is what the requester knows and the wanted part is what the requester wants to find out. In this model, there are six categories of given part: abbreviation, specific organisation, specific person, specific place, term or subject, specific publication; and there are thirteen categories of wanted part: date, illustration, measurement, counting, organisation, person, address or general location, bibliography, document location, citation verification, definition, recommendation, and general information. The approach of this model is that once the combination of categories is chosen, a general selection of types of sources which might answer the inquiries could be given.

In this study the idea and categories of Jahoda and Braunagel are taken as a start and adapted to suit the domain Ethiopian History. An inquiry in Ethiopian history, either at general or specific level, could have the following wanted categories or descriptors:

a) Date. In general any date (like publication date), and in particular for specific historical date or time period wanted. For instance, when was the battle of Adwa started? In this case the given part is the place 'Adwa' and, the possible sources of answers could be Encyclopaedia, Geographical sources, Monographs and Persons;
b) Illustration for a historical picture, map, museum object, subject or term, etc.;
c) Organisation such as company, government agency, academic institution, etc.;
d) Person who has had historical significance like Tewodros II, Yohannes IV, etc.;
e) Location like Aksum, Lalibela, etc;

f) Publication on Ethiopian history including bibliography, document location and verification or completion of bibliographic data;

g) Textual information on Ethiopia history including definition of terms or concepts, recommendation for appraisal or review of publication, archives and manuscripts and general or background information; and

h) Numeric information including statistical data but not date.

For these wanted categories the possible given categories for Ethiopian history could be:

a) Organisation's/institution's name including historical organisation, publisher in the domain, etc;

b) Person's name including historical person, publisher in the domain;

c) Subject or term in the domain;

d) Specific publication in the domain; and

e) Location or address.

These given and wanted categories help in identifying the possible sources that likely answer the inquiries. These are summarised in the following tables.

Table 1: Summary of Sources, Wanted and Given Categories

Information sources for Ethiopian History	Wanted categories or descriptors for Ethiopian History	Given categories or descriptors for Ethiopian History
Bibliographies/ Indexes/ Abstracts	Bibliography, Document location, Background information	A specific publication, Term or subject, authors
Guides to literature	Bibliography, Document verification, Background information	Term or subject, specific publication
Handbooks/ Manuals	Illustrations, Definitions, Background information	Term or subject
Encyclopaedias	Date, Illustration, Organisation, person, address or location, definition, Background information	Organisation, person, place/ location and term or subject
Dictionaries	Illustration, Organisation, definition	Person, Place, Term or Subject
Biographical Sources	Date, Illustration, Organisation, Address or location, Background information	Person
Geographical Sources: Atlas, Maps,gazetteers and Guide books	Date, illustration, person, address or location, Background information	Place, Terms or Subjects
Directories/ Chronicles/ Register	Date, Organisation, Person, Location Address	Organisation, Place, Events
Card catalogue/ Union list	Bibliography, Document location, Document Verification	Organisation, Person, Place, Term or subject
Special Monographs/ Travel Books/ documentation	Date, Illustration, Organisation, Person, Address or location, Definition, Background information	Organisation, Person, Place, Term or subject
Primary Publications	Illustrative, Bibliography, Background information	Organization, Person, Term or Subject
Yearbook/ Almanacs	Date, Illustration, Numeric information	Organisation, Place, Term or Subject
Databases (Bibliographic)	Bibliography, Document verification, Background information	Organisation, Person, Place, Term or Subject

The table indicates a general selection of the types of sources which might answer an inquiry for a combination of a valid given and a wanted descriptors. For instance, if an inquirer wants an illustration then the possible valid given descriptors are organisation, person, location or term or subject. Consequently, for each valid combination of a wanted and a given descriptor, there are appropriate possible sources. For instance, if wanted is illustration and given is organisation then Encyclopaedia, monographs and primary publications are the most likely sources. The same pattern is prevailing for other cases. The following table summarised the valid combination between the given and wanted information part of inquiries.

Table 2: Valid combination between the given and the wanted parts

Wanted information	Given information
Illustration	Organisation, Person, Location or address
Date	Organisation, Person, Address or location, specific publication
Organisation	Organisation, Person, Location or address, Term or subject, Specific publication
Person	Organisation, Person, Address or location, Term or subject, specific publication
Address or Location	Organisation, Person, Address or Location, Term or subject, Specific publication
Bibliography	Term or subject, Specific publication, Address or location, person, organisation
Document Location	Organisation, Specific publication
Document Verification	Organisation, Person, Term or subject, Specific publication
Definition	Term or subjects
General/Background information	Specific publication, Term or subject, Person, organisation
Numeric Information/ Statistical data	Organisation, Person, Address or location, Specific publication

The goal of the reference advisory system is to provide a user with possible alternative information sources for obtaining the information they are looking for. The prototype reference expert advisory system has the goal to provide reference to possible sources of information (as indicated in the decision table below) in the field of Ethiopian History. Depending on the given and wanted part of the inquiries, the possible advice could be summarised in the following table.

Table 3: Decision table for possible sources based on a given and a wanted descriptor

Wanted	Given	Possible sources
Illustration	Organisation	Encyclopaedia, Monograph, Primary Publication
	Person	Biographical source, Encyclopaedia, Monograph, Yearbook, Almanac
	Location or Address	Encyclopaedia, Geographical source, Monograph
Date	Organisation	Encyclopaedia, Directory, Monograph
	Person	Biographical source, Encyclopaedia
	Location or address	Encyclopaedia, Geographical Source, Monograph
	Specific publication	Card Catalogue, Union list, Index, Bibliography, Abstract
Organisation	Address or Location, or Organisation, or Term or subject	Directory
	Person	Biographical source, Encyclopaedia, Monograph
	Specific publication	Card catalog/union list, Index, bibliography, abstract
Person	Organisation	Encyclopaedia, Directory, Monograph
	Person	Biographical sources, Encyclopaedia, Monograph
	Address or location	Encyclopaedia, Geographical source
	Term or subject	Encyclopaedia, Yearbook, almanac
	specific publication	Card catalogue; union list, index, bibliography, abstract
Address or Location	Organisation	Encyclopaedia, Directory, Guide to literature, Handbook/ manual
	Person	Biographical sources, Encyclopaedia, Monograph

Table 3 (Contd.)

	Address or Location	Encyclopaedia, Geographical source
	Specific publication	Index, Bibliography, Abstract
Bibliography	Term or subject	Card catalogue; Guide to the literature; Index; Bibliography Abstract
	Specific publication	
	Address or location	Card catalog; Index; Bibliography; Abstract
	Person	Biographical source; Card catalogue; Index; Bibliography; Abstract
	Organisation	Card catalog; Index; Bibliography; Abstract
Document Location	Organisation	Card catalog
	Specific publication	
Document Verification	Organisation	Card catalog; Index; Bibliography; Abstract
	Person	
	Term or subject	
	Specific publication	Card catalog; Index; Bibliography; Abstract; Primary publication
General/Backgr oud information	Specific publication	Card catalog; Index; Bibliography; Abstract; Primary publication
	Term or subject	Encyclopaedia; Handbook/manual; Monograph
	Person	

Table 3(Contd.)

	organisation	Encyclopaedia; Handbook; Monograph; Primary publication; Directory
Definition	Term or subject	Dictionary; Encyclopaedia
Numeric Information	Organisation	Encyclopaedia; Monograph;Primary publication; Directory
	Person	Encyclopaedia; Biographical Source; Monograph; Yearbook
	Address or location	Encyclopaedia; Geographical Source; Primary publication
	Specific publication	Index; Bibliography; Abstract

The above possible sources could be either in paper or electronic media. The table also indicates some sources are applicable only for some combination of the categories. Therefore, for a valid combination of a given and a wanted category of an inquiry the appropriate sources of information in the field of history in general, and in Ethiopian history in particular, would be recommended for a given topic in the domain described in the hierarchical categories of inquiries.

Therefore, by combining the two approaches (the topic/subject, and the given-wanted model) used in analysing the inquiries in the domain the following hierarchy could be set as basis for the prototype reference advisory system to be developed.

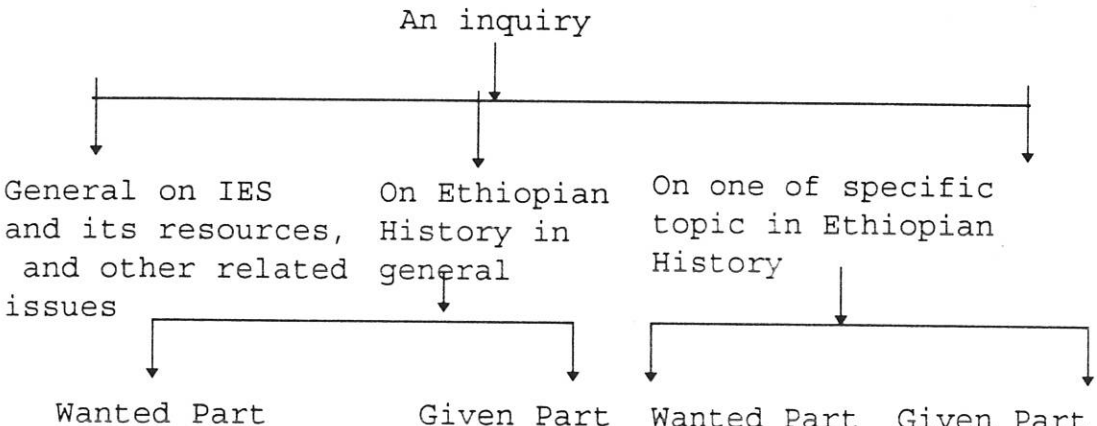


Figure 4.7: Categories of an inquiry by topic/subject and given and wanted descriptors

Likewise, a source could be categorised as most appropriate for a general information need on Ethiopian history and/or for a specific information need on a specific topic in the domain such as specific to historical Era/Period, Historical conflict, etc. Each specific information source would have the following attributes: brief bibliographic data, information source type (Index, Abstract, Biographical Source, etc.), extent of subject coverage (brief or detailed), and information coverage/inquiry category by topic (General or a specific). Additionally, each of the general information sources would be represented by the type of information they contain as described in Table 1. For instance Dictionary is a source for definition, illustration, and about an organisation; Encyclopaedia is for date, illustration, organisation, person, address or location, definition, and background information; etc.

When an inquiry is for known information sources then the user is guided to search them using either a card catalogue or other answer providing tools found in the system such as the classification schedule used for accessing documentary sources, catalogue of museum objects and visible indexes.

In general, it is observed that the reference librarians usually go through a matching process involving the information sought by the user and the source profiles. This process is summarised in Figure 4.8. Moreover, the different main processes and the information flow among themselves is indicated in Figure 4.9. Basically, the process involves two stages. First, in the early stage, the categories of information sources and topic or subject to be covered by the sources are

determined from the user. Second, particular sources of information are selected and recommended based on the factors stated in the first stage.

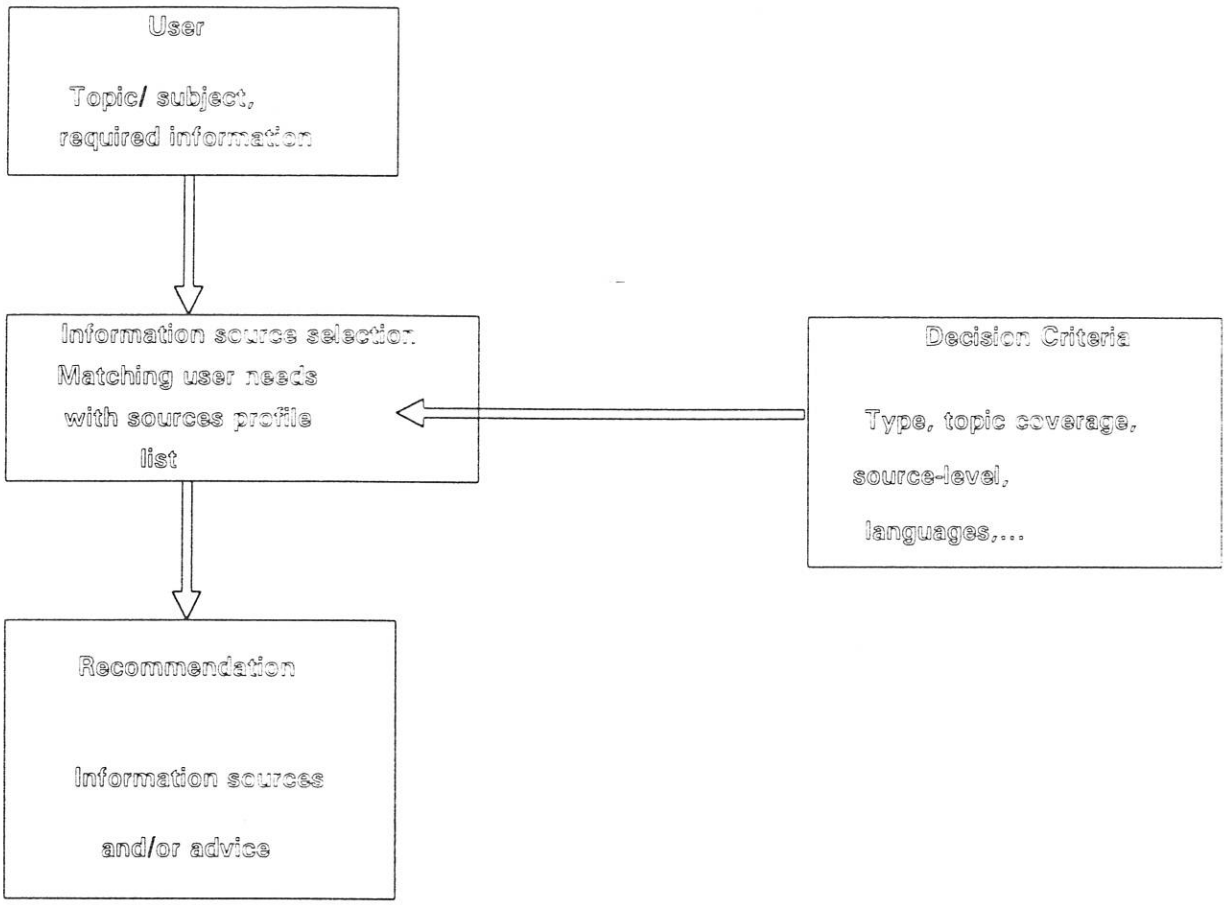


Figure 4.8: Reference/Information Source Selection Process

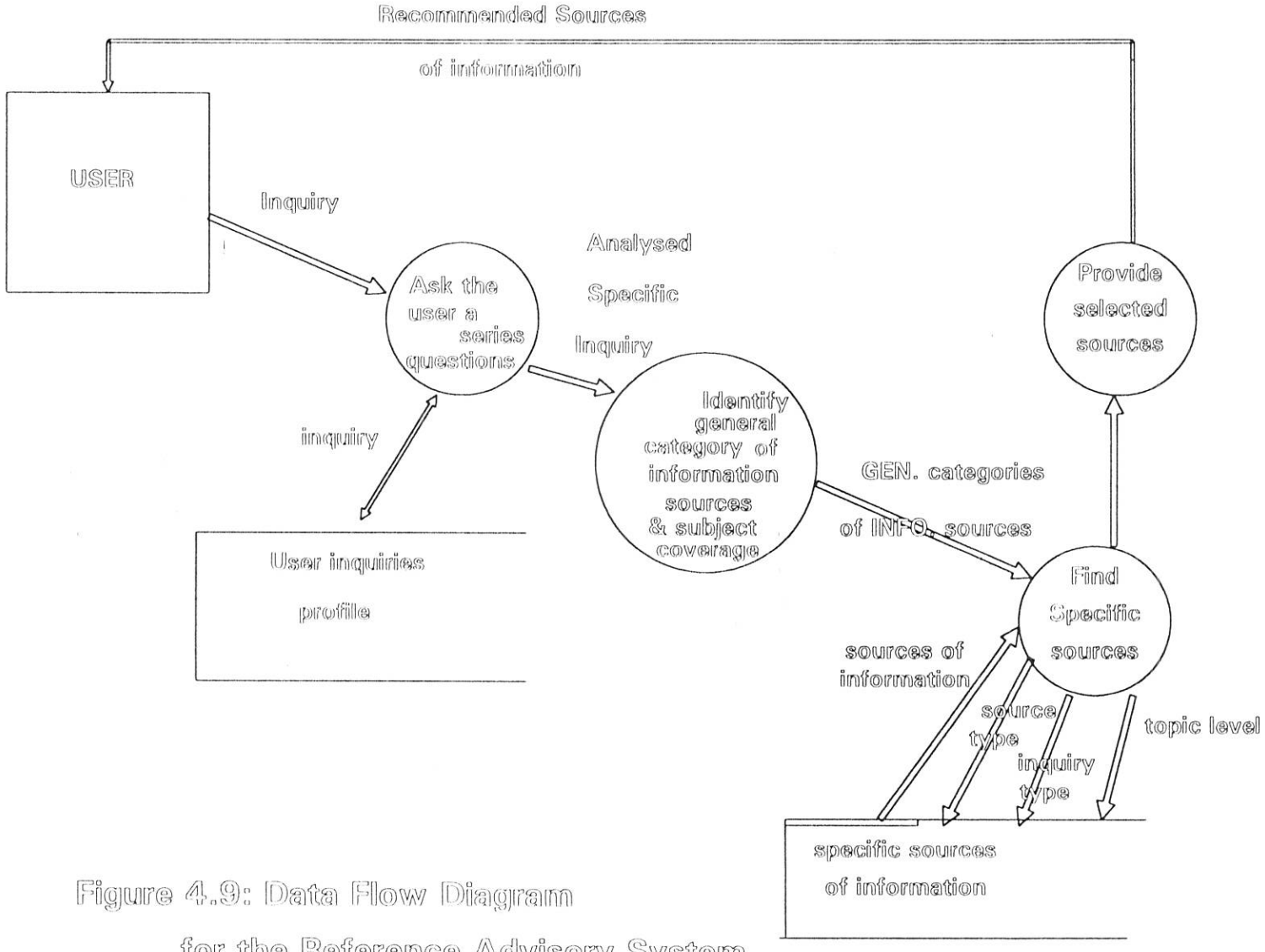


Figure 4.9: Data Flow Diagram
for the Reference Advisory System

Up to now the domain area are analysed and documented for the purpose of identifying the knowledge used by the human experts, understanding the system, identifying the differ ent components of the system and designing the system which are the theme of the next sections.

4.2 *The General Structure of the Prototype System*

In terms of expert systems components and their link, the general structure of the prototype system is indicated in the Figure 4.10.

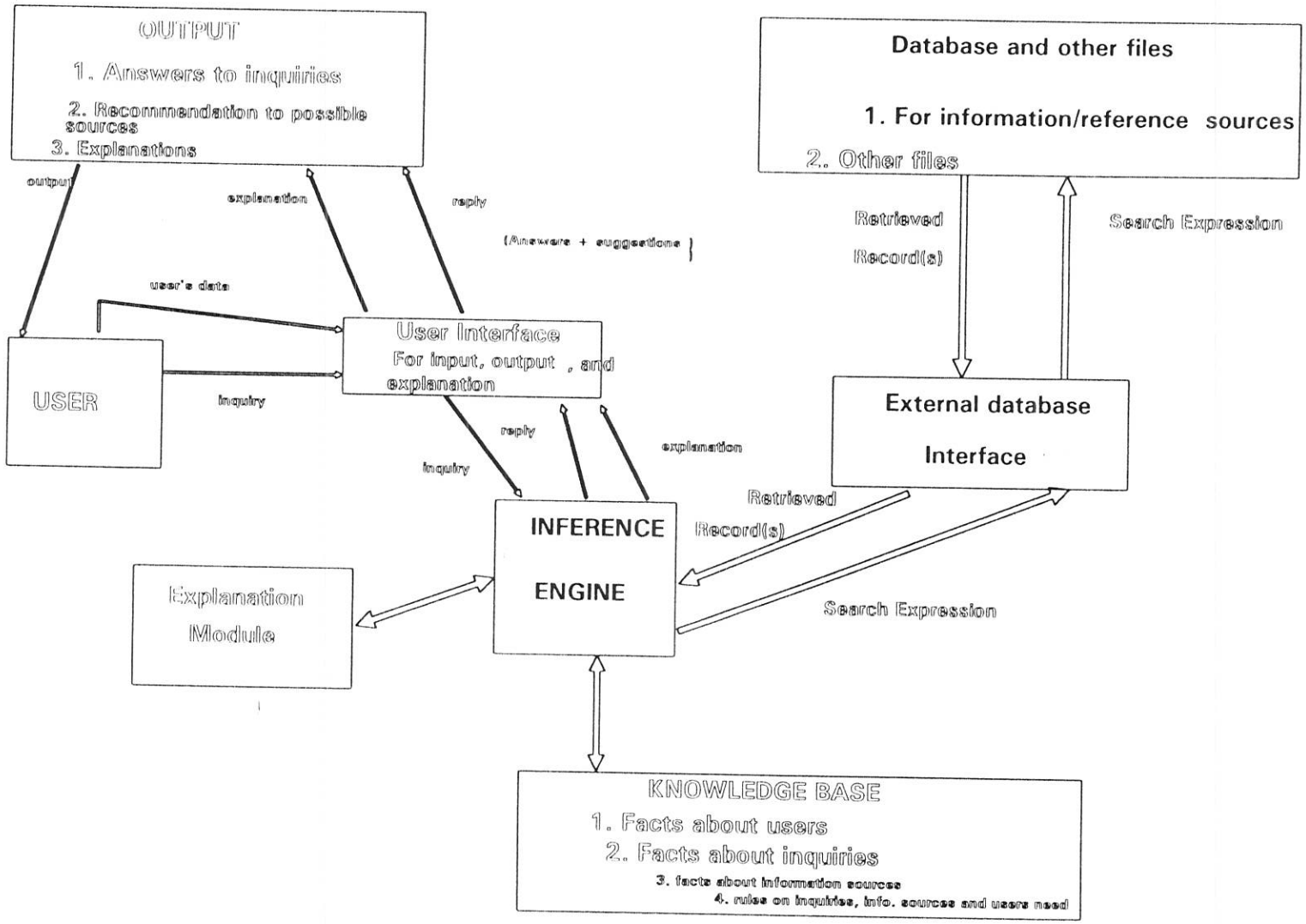


Figure 4.10: The logical framework of the reference Advisory System

As indicated in the general structure, the knowledge base contains the required facts and rules about the application. Moreover, the detail data on the sources of information on Ethiopian history would be stored in a database file. This database file can be accessed via the external database interface module.

The facts contain general facts about each of the different sources of information stated in Table 1 above. Besides, the rules, in addition to general cases, mainly consists of rules extracted from Table 3 and Figures 4.1 to 4.7.

The user interface provides a user to input an inquiry, to accept possible sources of information, and also to ask and see the lines of reasoning the system follows in reaching the conclusion which is accomplished by the explanation module. The inference engine performs the reasoning procedure to reach the required advice on the basis of the rules and facts contained in the knowledge base.

The functional specifications for the prototype reference advisory system are:

- Assisting with the entire domain of Ethiopian Studies reference problems would require a large scale expert system. Given the time constraint on the thesis, only general requests on the subject of Ethiopian History, and for major and specific categories of request on the subject of Ethiopian History would be addressed;
- The prototype is diagnostic-prescriptive in nature. That is, the system would outline what subjects the user could consult, and from a user selection to a series of menus

the system would suggest possible sources to be examined. Besides, the reasons for system request for input from a user need be explained to a user;

- The prototype displays selected sources of information in Windows that could be scrolled up and down, to left and right, saved in file, and/or printed on paper. If the system fails to answer an inquiry, then user can be referred to a reference librarian. Moreover, explanations on how the system arrives to the selected sources could be provided; and
- Since the different possible sources of information in the domain are not exhaustive as they are large in number, dispersed in various locations, and new sources are continuously being generated, they need be stored and maintained in database file independent of the other components.

The design of the system components and their interaction are described in the following sections.

4.3 *Knowledge Modelling and Organisation*

Here the aim is to rearrange and represent the facts and rules acquired from the experts and other sources that constitute the knowledge base into a from that can have a compatible format with a computer; maintain the facts and rules as close as possible as they are perceived by the domain experts ; and can be easily addressed, retrieved, modified and updated.

In this study rules are used to represent the knowledge for the reasons specified in Chapter 3. Each rule has a premise clause and conclusion clause containing attributes and values, and with an associated object, either implicitly or explicitly. Figure 4.11, a decision tree, depicts a sample case taking an inquiry on historical era. It comprises the different rules of the system, and also indicates how they could be organised. Similar decision trees can be generated for all other cases.

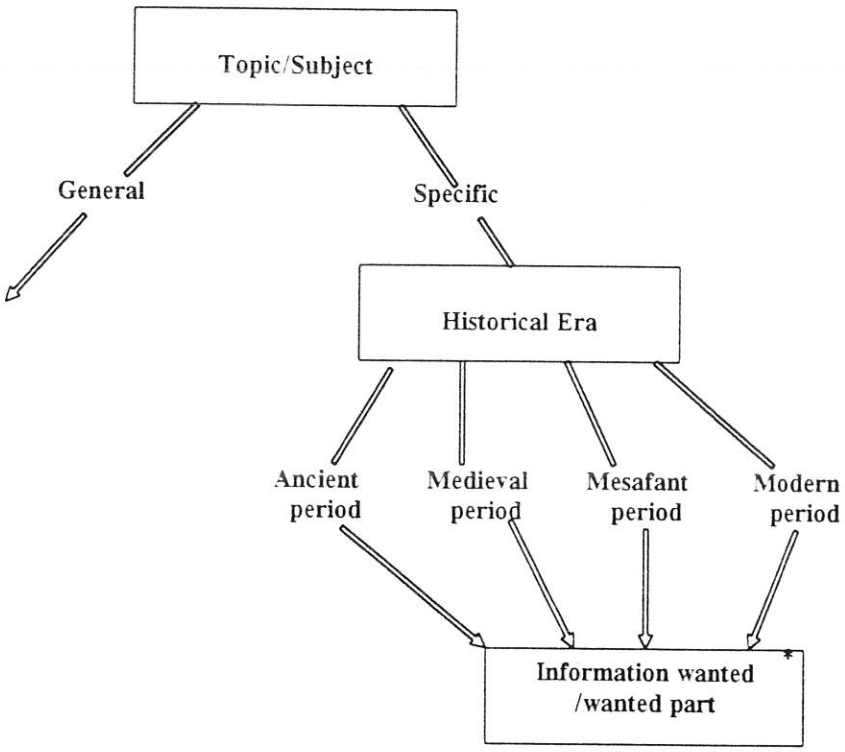
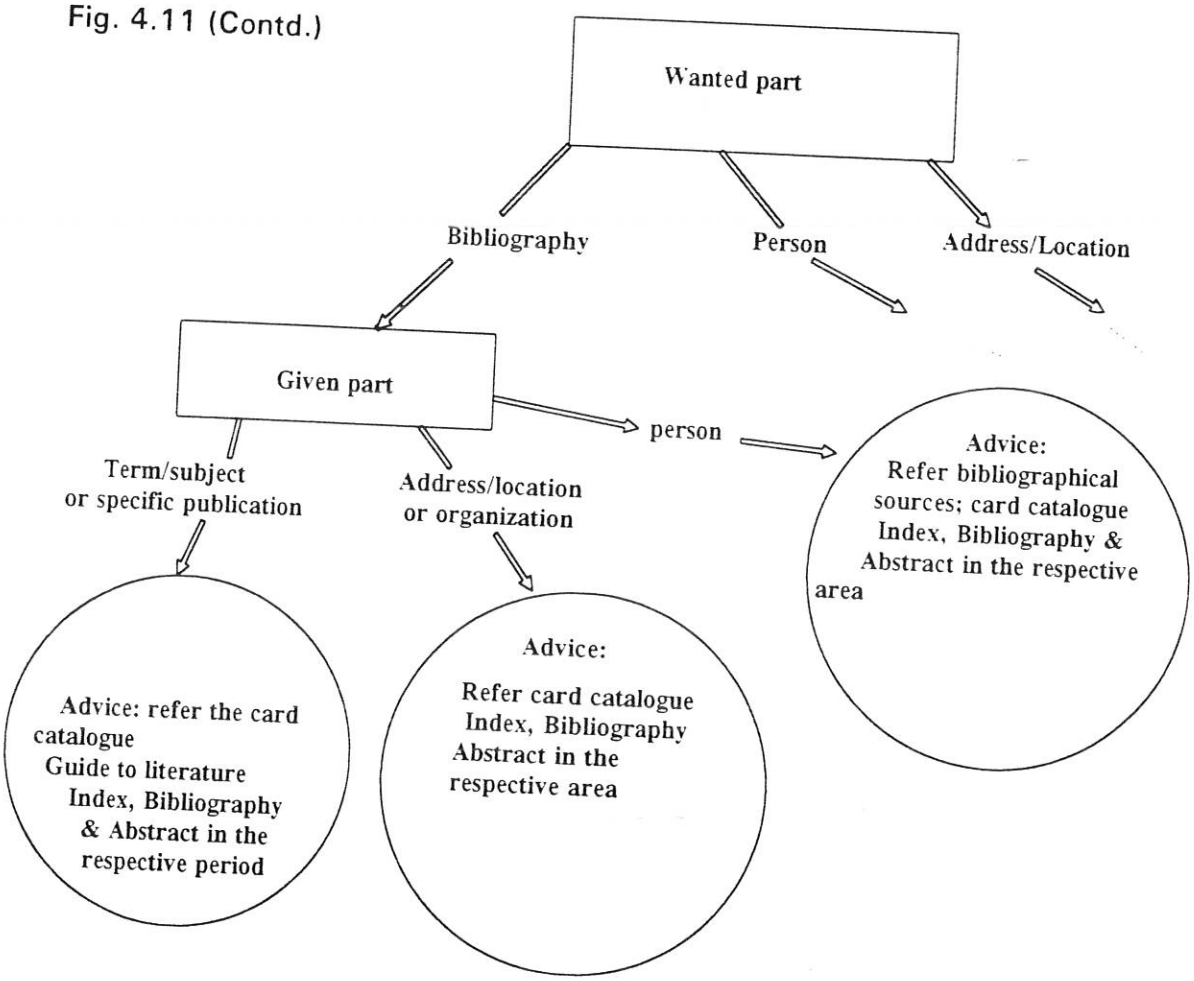


Figure 4.11: A sample decision-tree for the system

Fig. 4.11 (Contd.)



By tracing the condition nodes for every conclusion nodes in the above decision trees, a production rule could be generated for each conclusion. Consequently, just as examples, the rules in the reference process for the different categories of inquiries are summarised using pseudo-codes as follows.

a) General Inquires

Rule 1 :

If inquiry is about IES then consult the General guide prepared about IES.

Rule 2 :

If inquiry is journal titles available in IES library in the fields of Ethiopian history then consult the list of journal in the field and for more detailed information refer to the visible - index maintained in the library.

Rule 3 :

If inquiry is about General information on different databases available then consult the list of databases available on History.

Rule 4:

If inquiry is about General information on legislation, legal documents, archives and manuscript in the field consult the special catalogue prepared in the Archives and Manuscript section.

Rule 5:: If inquiry is about general information on museum then consult the guide to museum objects available in the museum section.

Rule 6:

If inquiry is about general information on texts and monographs use the special classification schedule to access the card catalogue.

Rule 7:

If inquiry is general information on other information centres in the field then consult the list of information centres.

These are not the only rules regarding general information but are examples taken for demonstrating the situations in the domain.

b) Specific unknown inquires

The situation in this case is based on a wanted and a given part of an inquiry as indicated in section 4.1. Just a few cases are listed below.

Rule 1:

if inquiry on History in general and the given part of the inquiry is a person's name and the wanted part is date (say of inauguration) and if combination of the wanted and the given part is valid then consult the available biographical sources, dictionaries, and Encyclopaedia in the field.

Rule 2:

if inquiry on History in general and the given part of the inquiry is a term or topic/subject in the domain and the wanted part is bibliography and if combination of the wanted and the given part is valid then consult the Card catalogue, guide to literature, index, bibliography, abstract in the domain.

Rule 3:

if inquiry is on 'Modern History' and the given part of the inquiry is a term or topic/subject in the domain and the wanted part is bibliography and if combination of the wanted and the given part is valid then consult the Card catalogue, guide to literature, index, bibliography, abstract dealing with 'modern history'.

In the above rules the recommended sources are not explicitly stated because they are listed after they are searched from databases based on the different decision variables: information source type, topic coverage, extent or level of subject coverage (detail or brief), and the inquiry type they could answer. Others advice are read from text files like for the general guide about IES, other information centres, etc.

Moreover, in the rules formulation, the top-down approach used in analysing the inquiries help grouping rules together with similar conclusion. This in turn makes each rule much easier to appreciate the various conditions that lead to the same conclusion clause attribute as well as it is easier for knowledge updating.

In addition to the above rules, the system also uses facts either from users or databases depending upon the inquiry on hand. Facts about a specific user and an inquiry are input to the system via the user interface.

On the other hand, facts about information sources could be general and specific. The former refers to the general characteristics of the categories of sources and described as a fact based on the information type they contain, i.e. Dictionary is for definition, for general background information, etc. The latter refers to the specific characteristics of a specific sources including its authors, title, subject covered etc., and they are stored in a database having the following record structure.

Bibliographic detail	Source type	Topic coverage	Level of coverage

Figure 4.12. A Simplified record structure of the database

The database records consist of sources of information that are collected, analysed and classified according to the different criteria set up or the different categories of inquiry they could answer with the help of the reference librarians from both the IES library, Ethiopian Collection section of Addis Ababa University Libraries. In addition the different guides to reference sources mainly Walford's (1982) and Webb's (1986), and Abbink's (1991) bibliography are used. The records structure and sample data values are indicated in Appendix I.

In the knowledge base codes and brief descriptions are used to represent the different sources of information. Once the proper information on sources are identified by the inference engine, the database or text files are opened and searched in order to display specific sources of information available for the domain that might answer the inquiries.

Once the knowledge is elicited, organised and represent logically, the next step is to select an appropriate software and hardware for the physical design of the prototype system. This is described in the following sections.

4.4 *Software and Hardware Selection*

The possible software options available for development of an expert systems are described in chapter 3. And also expert system shells are indicated to be suitable for prototyping.

Nowadays, several shells are available in the market, and hence selection of a shell that meets the requirements of the domain is vital. For this, different criteria for selection of expert system shells are proposed by different authors. Broadly the criteria fall into two categories: general criteria which are common to expert systems shells, and application specific criteria that arise directly from the requirements of the application on hand. The former criteria comprise (Drenth and Morris, 1992):

- The hardware and the software required;
- Tool features such as type(s) of knowledge representation available, the inferencing and uncertainty management available; the availability of a procedural programming language;

the ability to modularise or segment the knowledge base; the provision of interfaces to external software; the speed of execution; and the robustness of the tool;

- Development support including the power and ease-of-use of facilities for entering and editing knowledge and advisory text; and the compilation facility, the debugging and testing assistance; the on-line help, demonstration applications and documentation available; and
- Consultation support including features for user interface and explanation capabilities.

The second category of the criteria comprises:

- Ease of updating and extending the knowledge base in order to incorporate and update both new and existing categories of inquiries and sources of information, respectively;
- Ease, speed and flexibility of use in order to encourage usage. This in turn calls for a well-featured user interface and fast execution; and
- Ability to handle and access a large knowledge base, databases and text.

Among the various shells, Crystal, Leonardo, GURU, ART-IM, EXSYS, Level5 Object, and KnowledgePro are some of the most recent and highly referred shells in literature (Ford 1991; Drenth and Morris, 1992; Zahedi 1993, etc.). For reference expert advisory systems, KnowledgePro, Level5 Object and other similar shells have been used successfully (Anderson 1992; Morris 1991; etc.). Some of the reasons are: their flexibility; the integrated hypertext facility they have; and also they support both rule-based and object-oriented knowledge representations together with graphical development and user interfaces.

In the following section the KnowledgePro Windows version 2.0 software, which is available at SISA and has been used for developing the prototype system, is briefly described. Also, the development requirements of the prototype expert reference advisory for Ethiopian Studies are checked against the provision of the KnowledgePro Windows.

4.4.1 KnowledgePro Windows

The KnowledgePro Windows (KPWin) is like a five side gem, with hypertext, object oriented programming(OOP), rules, lists and procedural programming forming the five faces. Hence it is much more than a rule based shell and is considered as a 'knowledge processor'.

KPWin development system has a rich procedural, object oriented programming(OOP),and list processing language such as topics defined in an application, built-in functions, access to Windows application programs interface and messages, etc. These features can be used for performing calculations, loops and recursions; manipulating strings, lists, topics, etc; outputting to a screen, file and/or printer; accepting input; and file handling. Moreover, an integrated hypertext and multimedia features are available within KPWin.

KPWin can access external programs such as Windows applications, DOS applications and commands, Windows and DOS programs, calling external functions written in other programming languages such as Pascal, C or C++. It has also a database toolkit to create, read, write and maintain dBASE compatible database files.

The key feature of the KPWin product is its 'topic'. A topic in KPWin can act at various times as a variable, a frame, an object, a procedural command, a function, or a hypertext 'chunk'. The other main features of KPWin are (Bev and Bill, 1991):

1. KPWin requires Microsoft Windows and runs on a PC;

2. KPWin expert system features

KPWin provides rules, objects and lists to represent knowledge in terms of lists of rules, objects, and facts. It also supports numeric, string, logical and date types of variables.

Rules represent procedural knowledge and are used to assign values to variables; invoke screen objects and execute procedures written using KPWin programming language. KPWin has a built-in backward chaining, and a forward chaining capability can be also incorporated by adding some code using the procedural programming capability of it. Moreover, KPWin supports the features of OOP such as inheritances, class memberships, etc.

In KPWin knowledge could be organised in hierarchy of topics by grouping related rules and hides details of their implementation. This in turn makes debugging easier; the code more understandable; and speed up the search process.

Lists are useful for pre-defining things or objects, tracking where the user or the system goes, and recommending appropriate areas of the information or functionality. Hence lists could be used to represent facts about the different objects or entities of an application.

3. KPWin development supports/environment

KPWin has a multi-document and easy to use editor which allows to work on multiple source files. This environment is menu based with a file handling, editing (cut, paste, etc.), and searching capabilities. It also has a debugging tools with a tracing facility to examine each step of the execution and structure of the application, and calls to display the topic calls in the application.

In KPWin, a source code need to be compiled into a form that KnowledgePro understands before being executed . For this compile and run options are available. This compiled code later can be converted into a runtime version.

Additional to KPWin version 2.0, KPWin++ version 1.50a is included in the system. It provides faster of new and existing KPWin programs by translating them into C++. This C++ code is then compiled with or without modification to create an executable file which can be distributed and used to different workstations without requiring the KPWIN system. In addition to the above benefits KPWin++ provides the functionality of KPWin development environment. However, it requires either of the C/C++ V7.o , Microsoft Visual C++ v1.0 or 1.5, or Borland C++ v 3.1 or Borland C++ 4.0.

4. User Interface and consultation support

KnowledgePro has several screen objects that enable users to communicate with a developed application. These include: standard screen objects such as windows, menus, buttons, check

boxes, radio buttons, list boxes and edit windows; graphic object such as bitmaps, icons, cursor and palettes; and user defined types of objects. In addition, text, hypertext and hyper-regions are provided for text manipulation.

These objects could be used to gather information from users as well as to present information to users. Each object has different characteristics and is used to convey different types of information and also recognises a list of events that make active and inactive.

KPWin also supports the three standard shell features: WHY explanation, HOW explanation and implementation of confidence factors. For "WHY" case a meaningful explanation in each rule would be included. For "HOW" case each fired rule could be appended in an explanation list and at the end it could be displayed. Finally confidence factors could be handled by incorporating confidence number and doing math as required.

4.4.2 KPWin as a Tool for the Prototype System

In general, the above features of KPWin not only allow the fulfilment of the functional requirements of the prototype system stated in section 4.2 but also provide more flexible and rich features for knowledge representation (both using the rule and object orientation features), inferencing capability, user-friendly interface, run-time version creation, and hook to other external programs mainly database, C++, Windows and DOS programs.

The lists could be used to represent facts about the different sources of information, inquiries and users. The elicited rules of the domain can be also easily modularised, represented and maintained using KPWin.

Therefore, KPWin, which is the only available Shell at the School of Information Studies for Africa (SISA), was found to be appropriate and was used for developing the prototype reference advisory system. Moreover, it was installed in a 486/DX microcomputer.

4.5 User Interface Design

In this prototype system a natural language user input was not incorporated, instead a user is provided with a list of categories by the system of which to select one that match the information request of a user. These categories were designed to represent a user's information needs as much as possible.

Different objects that are provided in the Microsoft Windows environment were used to develop the user interface. They are easy to use in the KnowlegdePro, and are also appropriate to give advice or present materials tailored to the user's special needs and level of expertise.

From the user modelling of the potential users of the system, basically majority of the users were noted to be novice in computer usage in general and windows environment in particular. Hence, in the prototype system windows, buttons, list boxes which are easy for novice users were

frequently used. Each was selected for information and purposes it fits. Besides, an on-line and case-sensitive help was included in the system in order to assist mainly a novice user during his/her interaction with the system.

On the other dimension users are heterogeneous with respect to the level of experience or knowledge they have towards the subject domain Ethiopian history and the reference librarianship. In this line, broadly two categories of users could be formed: novice and experienced. In the prototype system, explanation of the different terms and concepts used in the domain and the system has been provided to users using the hypertext facility whenever requested. Moreover, users are requested to select the level of information they need ,i e., for sources with detailed or brief information, if they want.

Two of the essential features of an expert system, i.e., the ability of the system to explain its line of reasoning of a conclusion, and informing the user why a particular fact is needed, were designed and developed in the prototype system. For the 'HOW" explanation, the steps taken to arrive to a possible sources of information or advice were traced and recorded in list for latter display to user if requested. For the 'WHY' explanation, for each case a separate topic was included with it and displayed to users whenever requested.

The recommended possible sources of information or advice, detailed or brief, could be saved in a file or printed on paper in addition to being displayed on the screen. Moreover, the 'HOW" and

'WHY' explanation windows are displayed on their respective window on screen, and could be printed on paper.

4.6 Knowledge Base and Inference Design

Within the restriction and requirements of KPWin, the knowledge acquired and organised in the previous sections was represented as topics which consist of mainly the list structure and sets of rules.

The facts about sources of information and inquiries are represented as :

a) Lists for basic sources of information

Dictionary is [ILLUSTRATION, DEFINITION];

Encyclopaedia is [DATE,ILLUSTRATION,PERSON,ORGANIZATION, 'ADDRESS OR LOCATION',DEFINITION,'BACKGROUND INFORMATION']; and so on.

b) Lists for valid combination of the given and wanted parts of an inquiry

Valid_wanted_given_dictionary is [['Term or Subject', Definition], [Term or Subject, Illustration]];

Valid_wanted_given_Encyclopedia is [[ILLUSTRATION, ORGANISATION], [ILLUSTRATION,PERSON],[ILLUSTRATION,'ADDRESS OR LOCATION'],[ILLUSTRATION,'TERM OR SUBJECT']], [[Date, Organisation],[Date, Person],...]; and so on.

The rules are represented as:

a) Rules for general advice

if ?inquiry0 is HISTORY AND ?inquiry IS 'General Guide' and ?'type of source' is 'About IES' then advice1 is read('sysinfo.txt') and close_all() and how_list gets [?inquiry, 'on IES Information SOURCES for ETHIOPIAN HISTORY'] and sel_info_source is 'General guide on IES"s historical information sources';

if ?inquiry0 is HISTORY and ?inquiry is 'General Guide' and ?'type of source' is 'Journals' then advice1 is [' #e #n #nThe different Journals Available in the IESL are:', read('journal.txt').

b) Rules for recommending specific Sources of information

if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of (?dict_wanted,?'info wanted') and one_of(?dict_given,?'info given') and one_of(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then sel_info_source is (Dictionary) and advice1 GETS [' Dictionaries: #n ',?Search_database] and reset(search_database);

if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of (?Biblo_wanted,?'info wanted') and one_of(?Biblo_given,?'info given') and One_of(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then sel_info_source is (Bibliography) and advice1 gets['#bibliographies: ',?Search_database] and reset(search_database);

if ?inquiry0 is HISTORY and ?inquiry is specific and ?'main category' is 'Historical Era' and ?'sub category1' is 'MODERN' and one_of(?dict_wanted,?'info wanted') and one_of(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then sel_info_source is (Dictionary) and advice1 GETS [' Dictionaries: #n ',?Search_database] and reset(search_database);

if ?inquiry0 is HISTORY and ?inquiry is specific and ?'main category' is 'Historical Era' and ?'sub category1' is 'MODERN' and one_of(?ency_wanted,?'info wanted') and one_of(?ency_given, ?'info given') and one_of(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then sel_info_source is (Encyclopaedia) and advice1 GETS [' Encyclopaedias: #n ',?Search_database] and reset(search_database); and so on.

In the course of firing these rules the built-in backward chaining of KPWin is employed. That is, the system starts by trying to assign values for the possible recommended sources of information or advice, and the backtracking is followed by defining another sub goals resulted from the attempt made to satisfy the main goal. This continues until all sub goals are satisfied or failed to be satisfied. Accordingly, the main goal is satisfied or dissatisfied.

So far, in this chapter the logical and the physical structures of the prototype system has been described and designed. They are the base and input on which the system is coded.

CHAPTER FIVE

DEVELOPMENT OF THE PROTOTYPE SYSTEM

5.0 Introduction

In this chapter preparation of the codes of the program and their organisation are described; documentation of the program is attempted; system operation and sample session of the developed system is demonstrated; and an attempt to address the implementation requirements, constraints, and application to other areas is made.

5.1 Coding and Documentation

The different components of the prototype reference advisory system that are coded are the knowledge base, the user interface including the explanation module and output generation module, and the interface to the database and Windows programs. The flow chart (Figure 5.1) indicates how decisions are taken by taking for a single case in the prototype system. That is, the figure indicates the logical segments, major functions and the order of the firing of the rules and the execution of the program details.

The code of the knowledge base consists of the IF ... THEN production rules. In the current prototype system about 200 rules were included. These rules use the facts entered from the user, the facts included both in the lists and the database file for making inference to come up with possible sources and advice.

The user interface was coded using the different screen objects and the hypertext of KPWin. It requires as equal time as the other components of the prototype. Besides, codes for opening, searching, and closing the database file are handled using the database toolkit's procedures and functions.

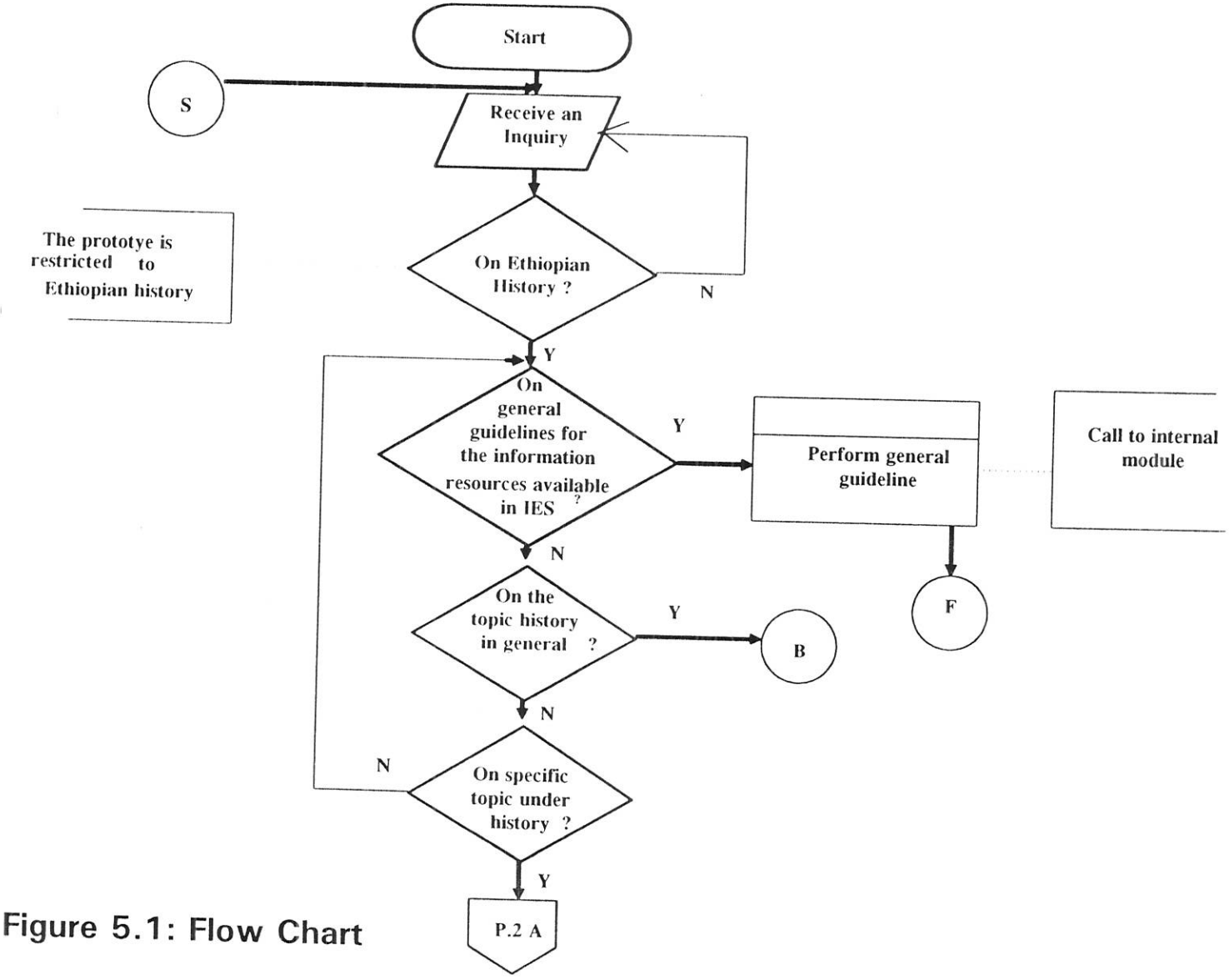
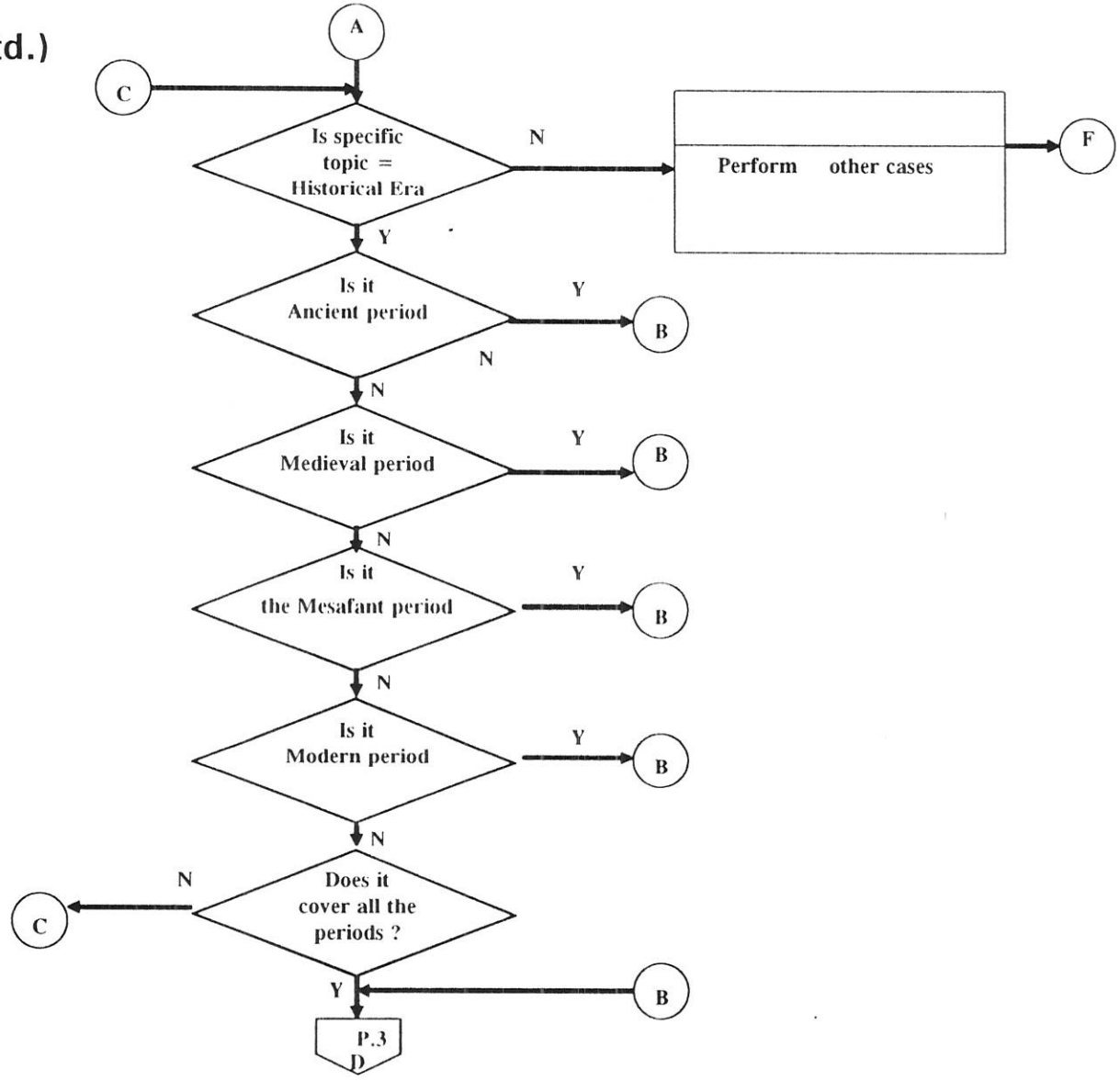
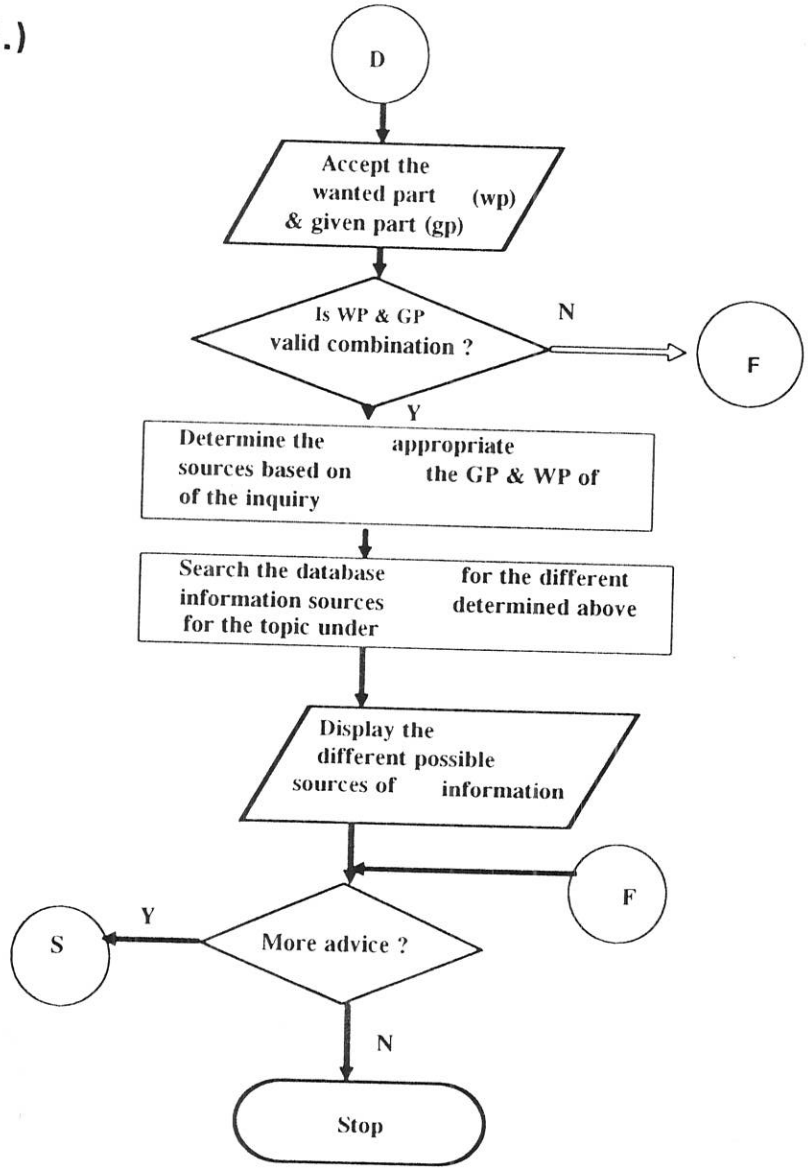


Figure 5.1: Flow Chart

(Fig. 5.1 Contd.)


A
C
Is specific topic = Historical Era
N
Perform other cases
F
Y
Is it Ancient period
Y
B
N
N
Is it Medieval period
Y
B
N
Is it the Mesafant period
Y
B
N
Is it Modern period
Y
B
N
N
Does it cover all the periods ?
C
Y
B
P.3
D

(Fig. 5.1 Contd.)


D
Accept the wanted part (wp) & given part (gp)
Is WP & GP valid combination ?
N
F
Y
Determine the appropriate sources based on the GP & WP of of the inquiry
Search the database for the different information sources determined above for the topic under
Display the different possible sources of information
F
Y
S
More advice ?
N
Stop

By organising and nesting the different input/output, process, and decision making tasks of the application into KPWin's topics, an attempt was made to achieve modularity, information hiding, functional cohesion and loose coupling. Sample source codes for the complete system are included in Appendix II.

The program structure of the prototype system is indicated in Figure 5.2. The figure indicates the different basic modules or processes that are included in the prototype program.

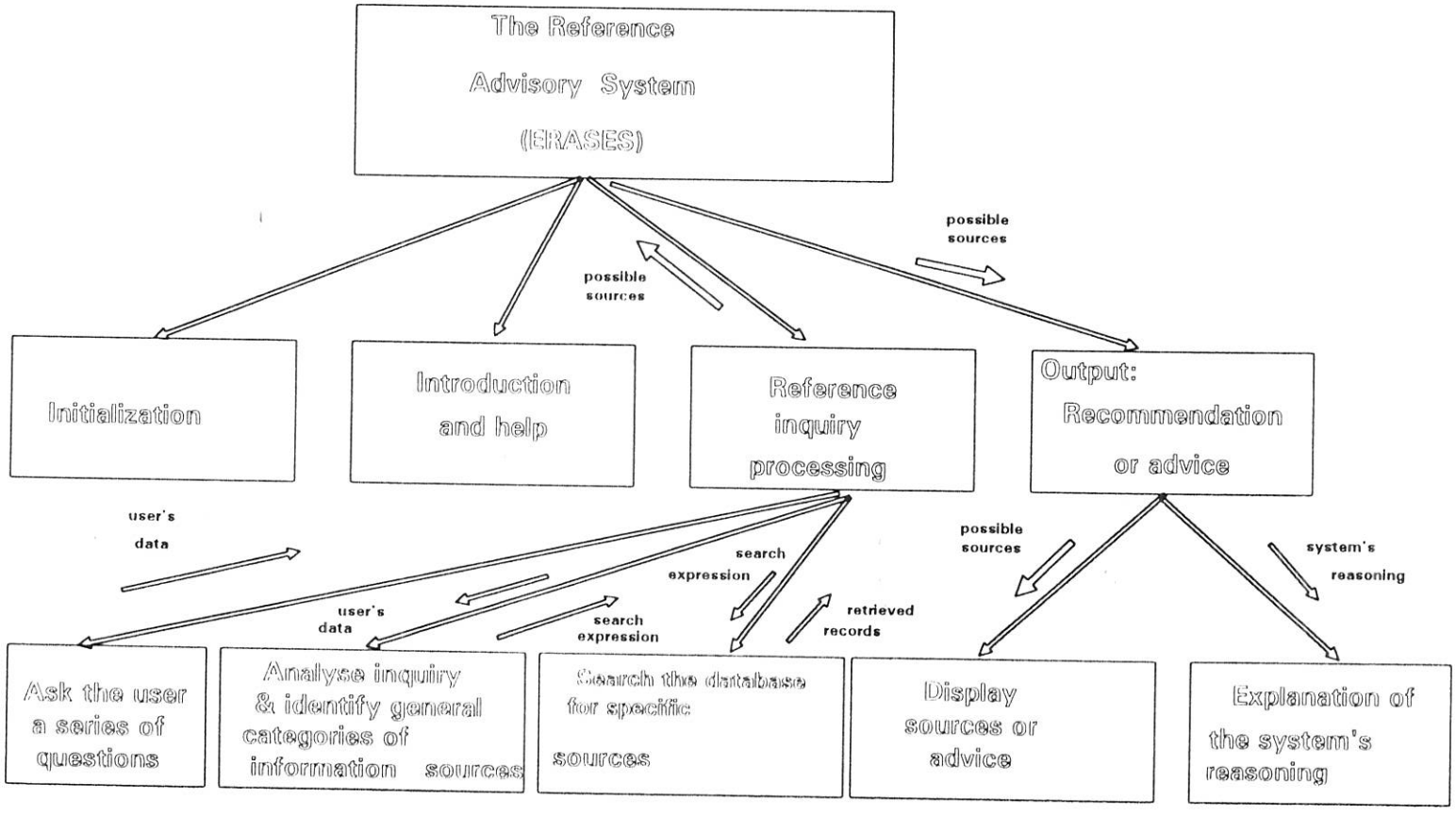


Figure 5.2: Program Structure for the prototype system

To optimise the system performance: the source codes are broken into units/modules and saved in external files to main module; large amount of text were saved in external files; and data were created and saved in the database file. They are loaded into the memory whenever needed.

The following table summarised the different modules which are indicated in the structure chart and coded in the prototype system.

Table 4: Summary of the basic modules

NAME OF THE MODULE	DESCRIPTION OF THE MODULE
INITIALISATION	To assign values to topic; to define lists, and system utilities including the database toolkit; and initialise font, windows, etc.
INTRODUCTION AND HELP	To display the welcome statement, introduction statement about the system and general help
INQUIRY PROCESSING	To accept and analyse a user's inquiry; identify possible sources and conduct database searching; and return the retrieved possible sources of information
OUTPUT HANDLING	To display possible sources and the system's reasoning

Internally the program is documented by including comment statements, which are brief and explanatory, within the source code. The program also includes various text files and a bitmap file.

The program was demonstrated twice to the domain experts who were participated in the knowledge elicitation. They suggested additions and modifications on the system interface, mainly in the terms and the screen objects that are prompted to user, and in the different categories of inquiries and information sources included in the system. These comments were

incorporated in the program and the prototype system had got the form described in the following section.

5.2 Operations and Demonstration of the Prototype System

The result of this study is a prototype system that demonstrates the application of expert system in reference services for Ethiopian Studies. As indicated in the program structure of the system, basically there are four processes constituting the prototype system. The first part is to initialise system parameters and facts to be used by the inference engine.

At the beginning, when the program is executed a welcome screen is displayed. Next a second screen comes which indicates information about the development of the system. Following this, a window which gives a brief introduction to the general features of the prototype system is displayed along with a general instruction for frequently used screen objects and options (Figure 5.3).

Next, the system starts by asking a series of questions to determine what type of information sources the user should be looking for. This is indicated in Figure 5.4 and Figure 5.5 where the user select one option from the displayed list of options/items.

If the user's inquiry is for sources of information in a specific topic within history, the user can choose any one menu option from Figure 5.5. After this the user is required to rephrase the inquiry in terms of the wanted categories (Figure 5.6) and the given categories (Figure 5.7) to determine the possible information sources as explained in chapter 4.

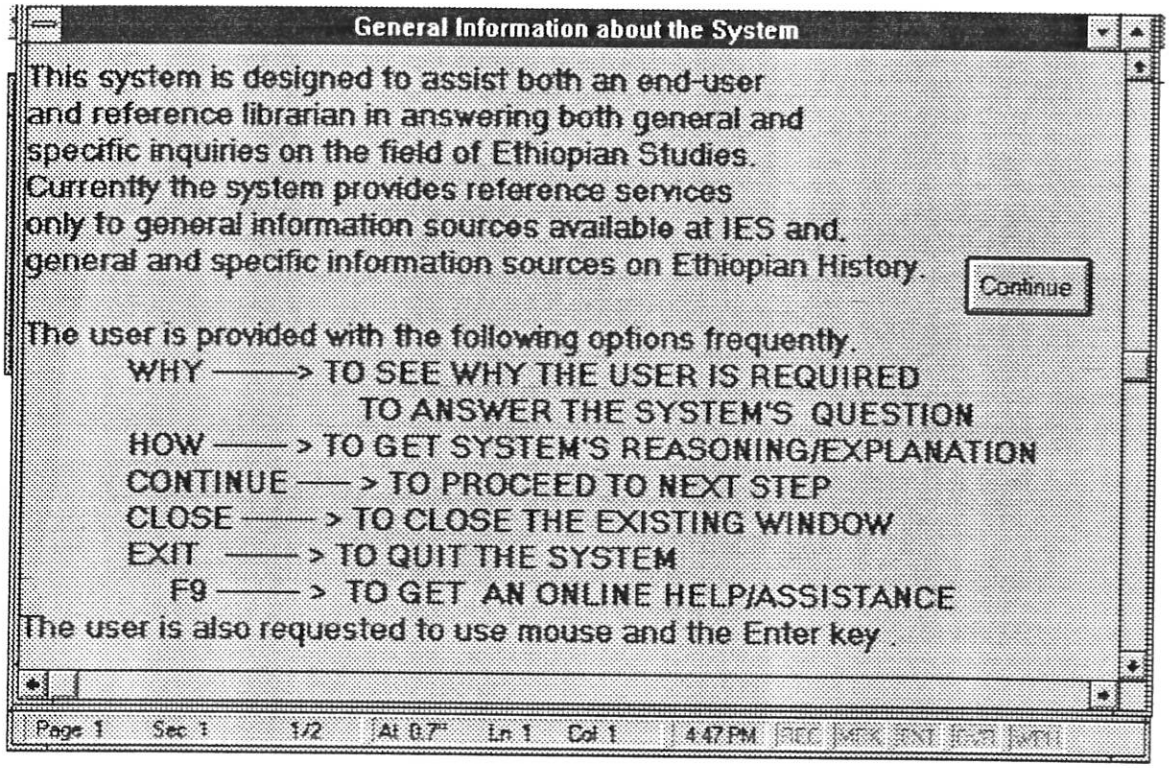


Figure 5.3: General Information about the System

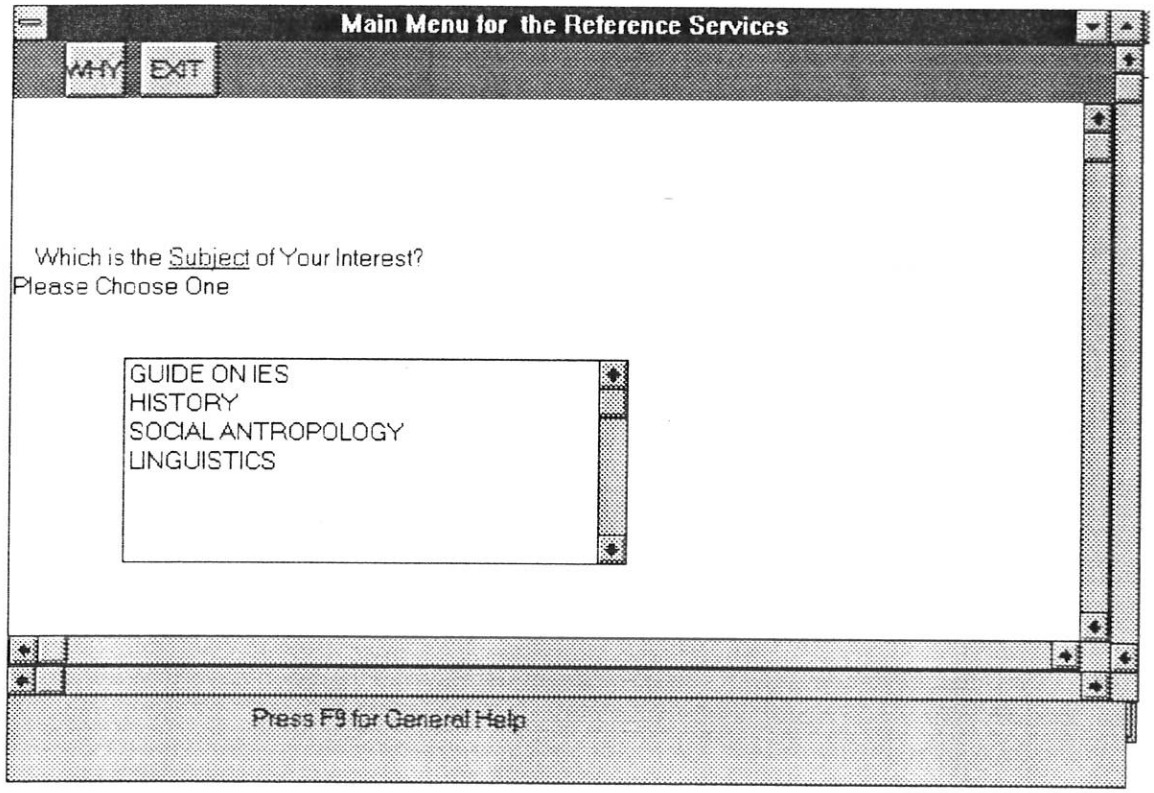


Figure 5.4: The Main Menu Screen for the System

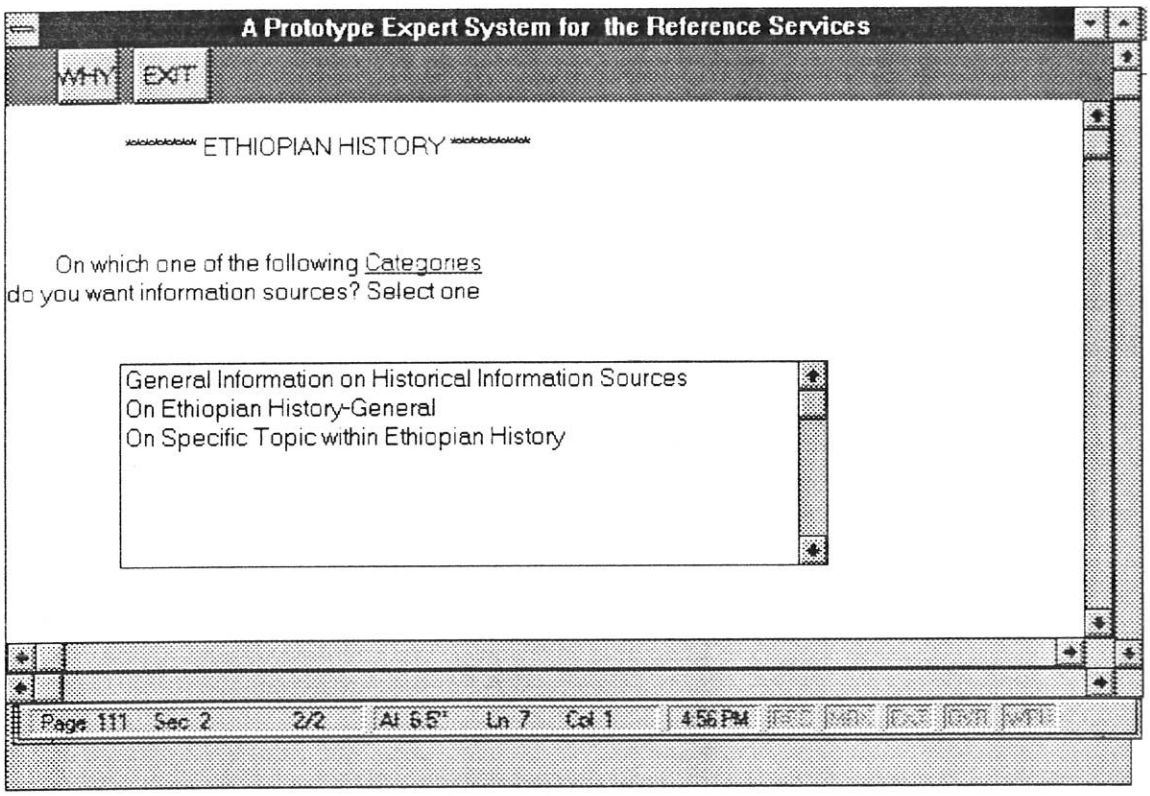


Figure 5.5: Screen Menu for Ethiopian History

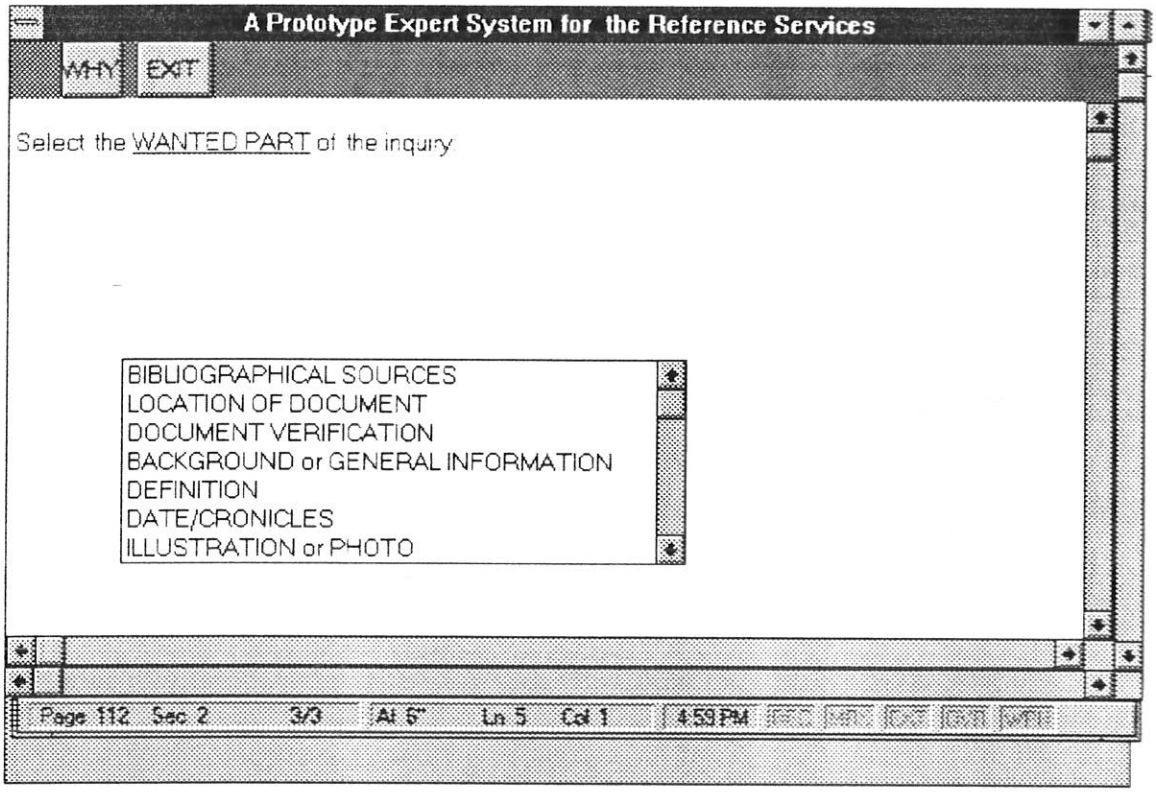


Figure 5.6: Screen for the Wanted Part

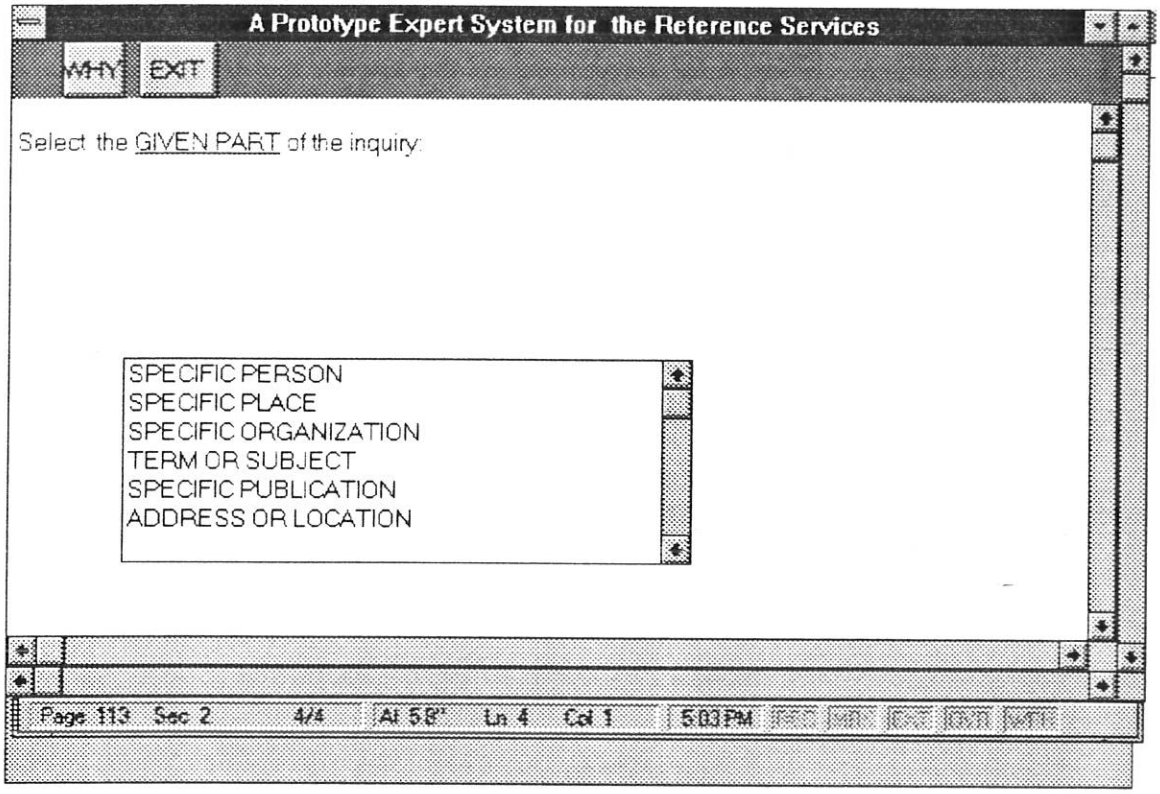


Figure 5.7: Screen for the Given Part

In each cases an explanation to underlined and coloured term or concept can be obtained by clicking at the corresponding term or concept which also provides explanation about each of the items displayed in the menu. For instance if a user wants to see what the term 'Categories' (in Figure 5.5) refers, clicking it gives the explanation indicated in Figure 5.8.

Moreover, if the user wants to know the reason why the system is asking him/her to choose an item from the list of items in each of the above cases, then s/he can click the 'WHY' button included in the screen. For instance, Figure 5.9 contains a 'WHY' explanation displayed by the system when the 'WHY' button is selected.

Once the user completes answering the series of questions prompted by the system, validation of the type of information required (by checking the combination of the wanted and the given part selected by the user) is performed by the inference engine. This is followed by the determination of the general categories of sources, and then the specific sources of information from the database. Finally, the system displays a list of possible sources of information.

The output, the list of possible sources of information and advice, could be printed or saved in a file if required in addition to being displayed on the Monitor (Figure 5.10). Moreover if the user wants to know how the system has arrived to that result, just clicking the 'HOW' button provides the line of reasoning the system uses in recommending the sources or giving advice, as indicated in Figure 5.11.

The user could press the function key F9 to get general help about the system being any where within the system as indicated in Figure 5.12.

Finally the system asks the user whether he wants to consult the system again or not. If the response is yes, the system displays the main menu screen indicated in Figure 5.4. Otherwise it exits to the Windows program. This is useful because, the system can only handle one category of inquiry at a time; and hence, the user might be required to start from the beginning either for more information needs consists of more than one category or topic, to handle more than one

inquiry at a time, or when the recommendation or advice given by the system does not satisfy the user.

Facts on a specific source are stored in a database file named "document. dbf" using the dBASEIV program. The record structure of the database file and sample records are included in Annex I. The use of this database file has reduced the number of rules and simplified the knowledge base drastically. Currently, there are about 100 records in the database.

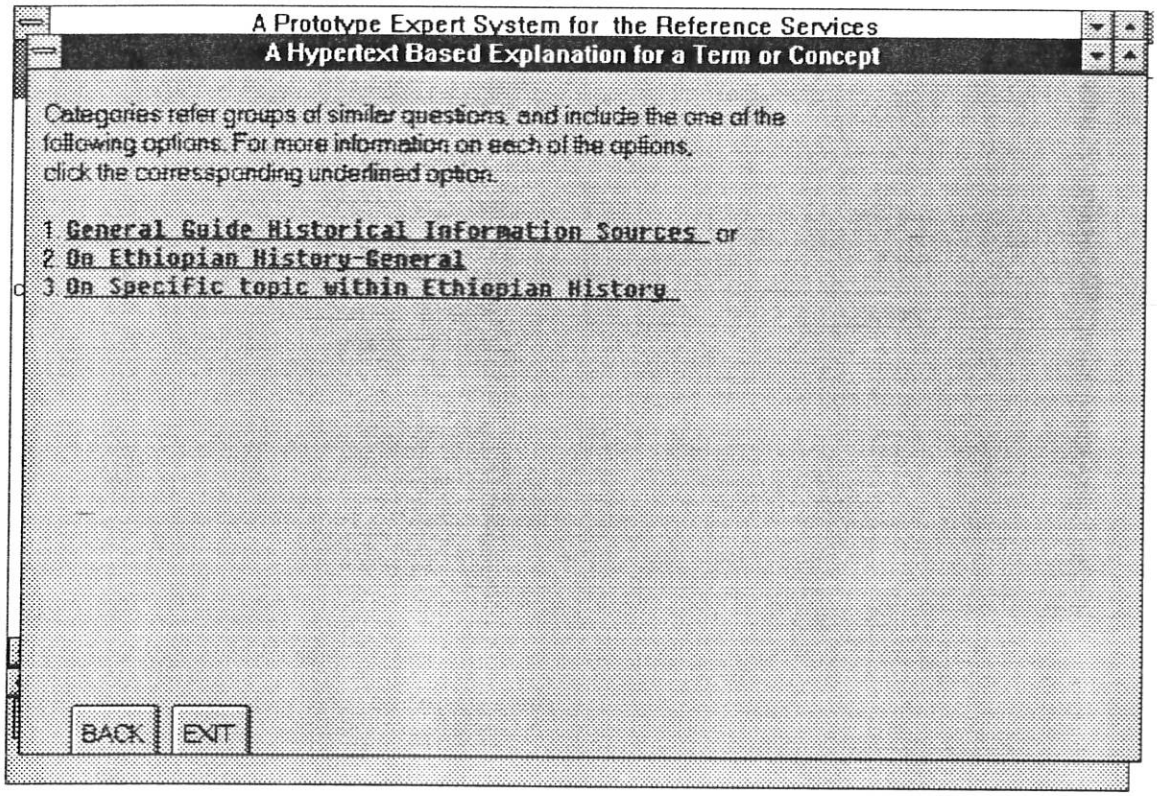


Figure 5.8: Screen for hypertext based explanation

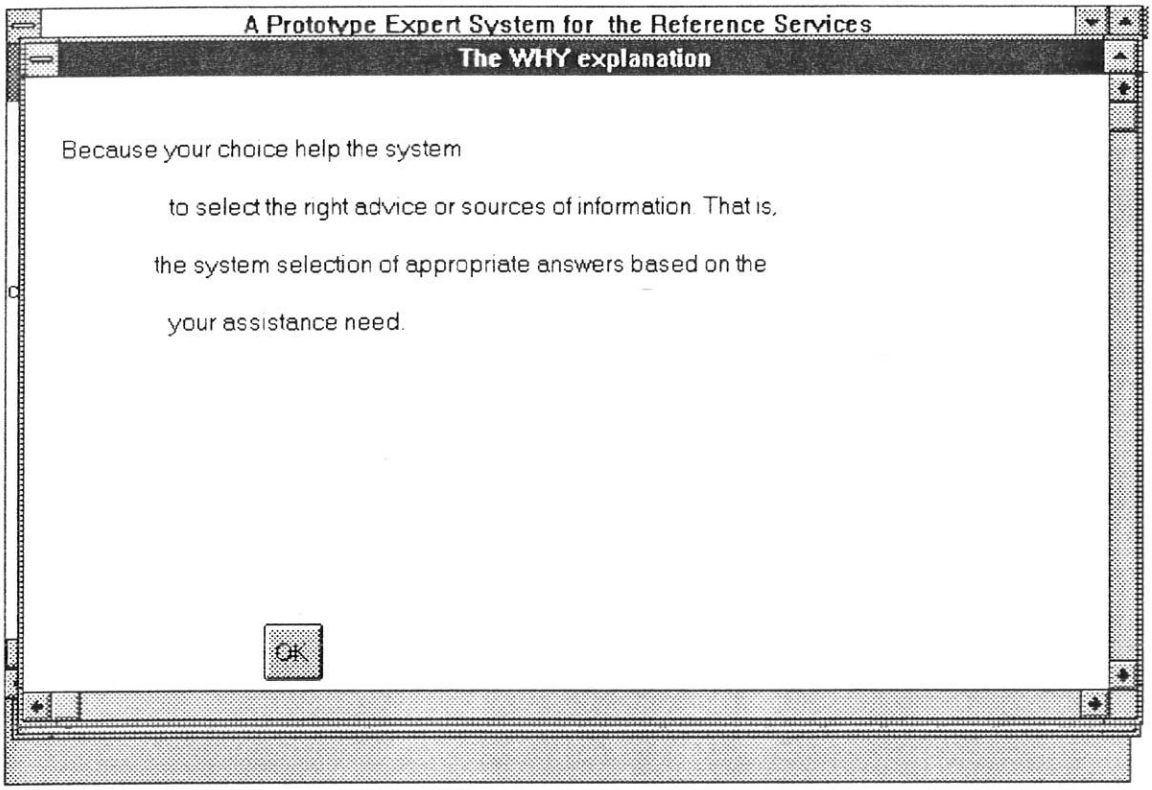


Figure 5.9: The Why Explanation

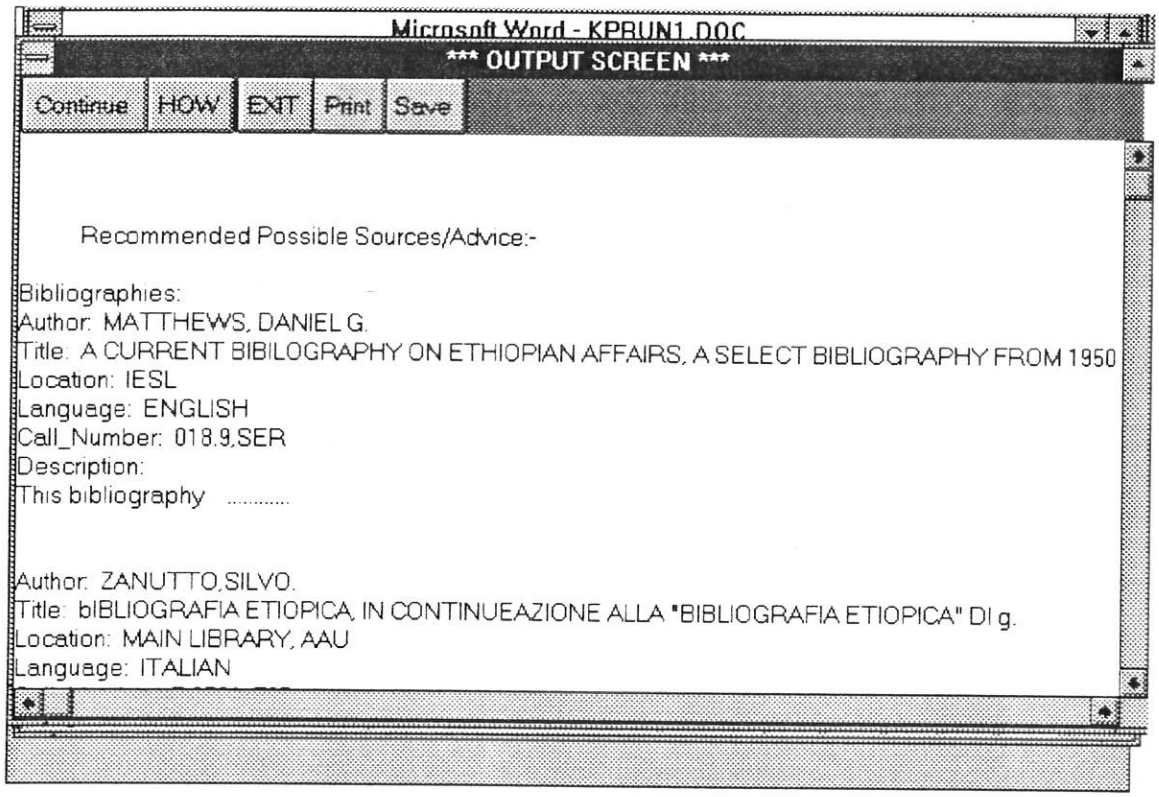


Figure 5.10: Part of a Sample Output

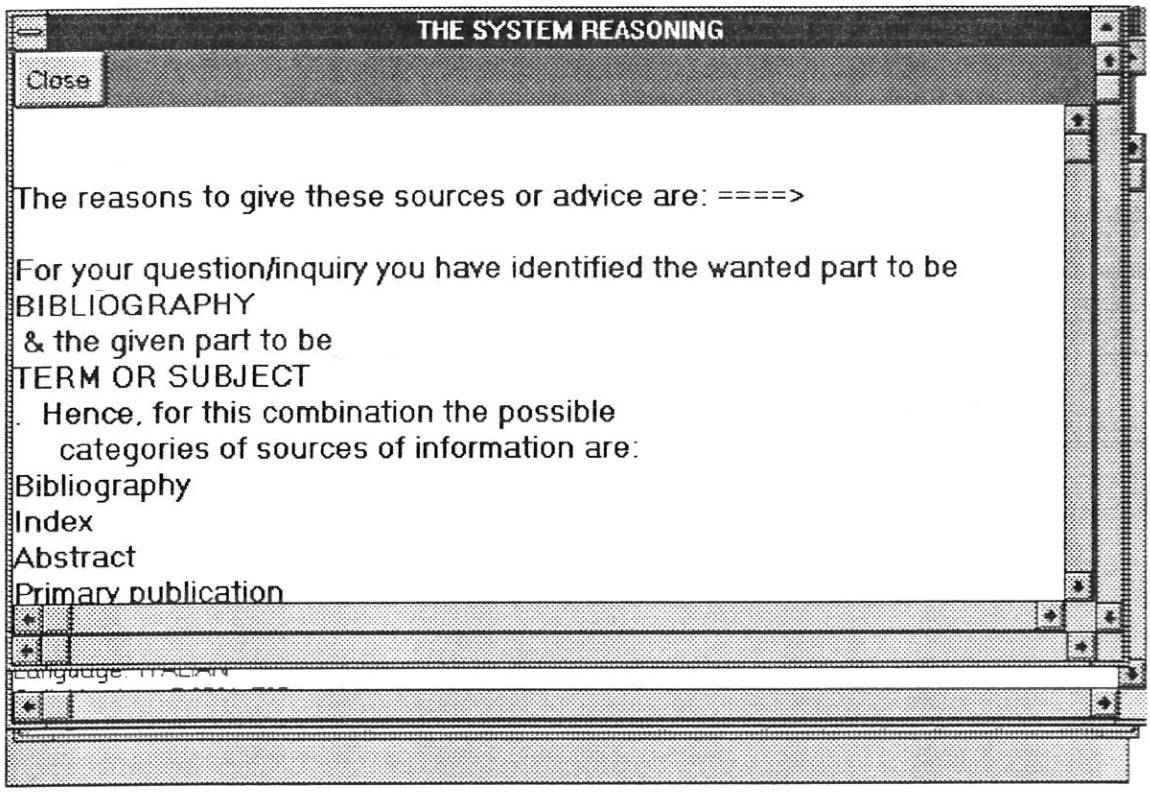


Figure 5.11: The How Explanation

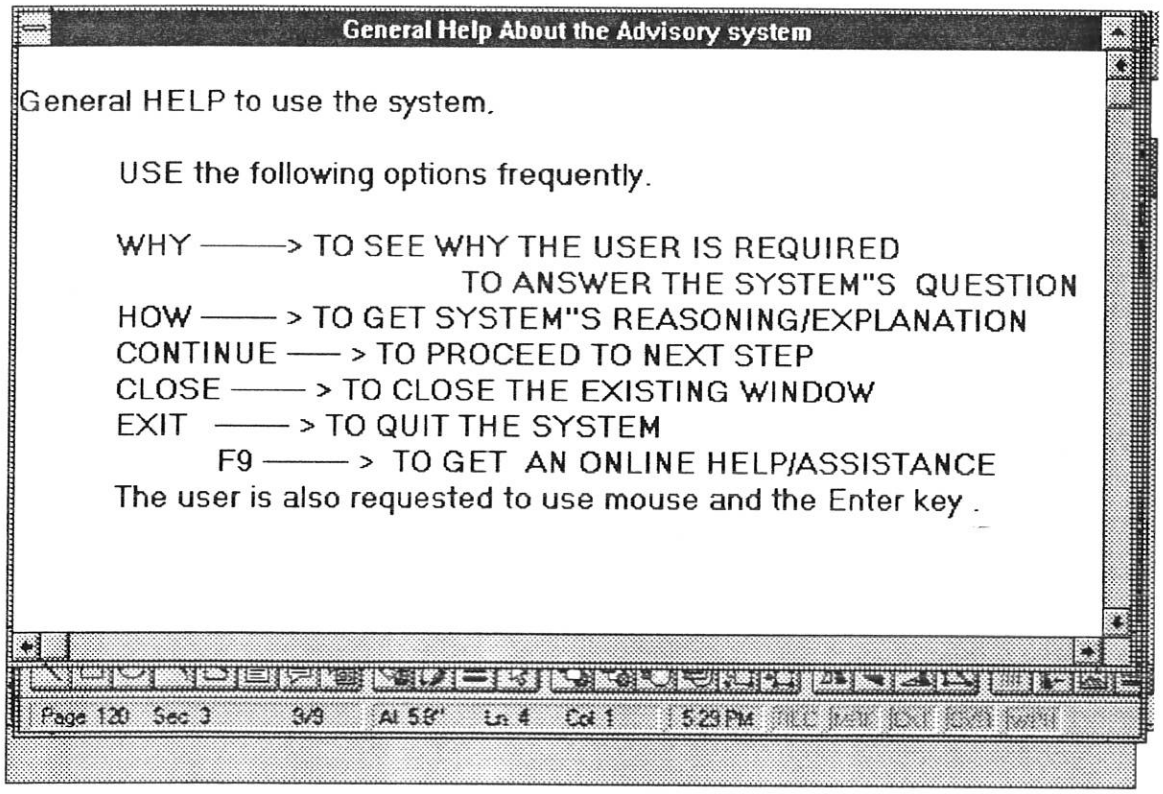


Figure 5.12: General On-line Help

In the above paragraphs the general operation of the prototype system is explained. The next paragraphs demonstrate the operation of the prototype system for some specific inquiries.

Case 1: If a user wants general information on a particular information centre, in this case IES, then by selecting the item 'About IES' in the first menu the hypertext supplemented with graphics object is displayed to the user as a guide where to go for what, when to do what, etc.

Case 2: If a user wants definitions of Historical terms or concepts, by selecting the following items from the menus discussed above: History, On Ethiopian History - General, Definition (the wanted part) and Term or Subject (the given part), then the system provides the following output.

********* Recommended Possible Sources or Advice *****

Dictionaries:

Author: LESLAU W.
Title: ENGLISH-AMHARIC CONTEXT DICTIONARY. 1973
Location: IESL
Language: ENGLISH AND AMHARIC
Call_Number:
Description:

Author: YUKIO, I.
Title: BASIC CLAUSE DICTIONARY OF GEEZ, TIGRINGA, AMHARIC, SOMALE AND SWHAILL. 1974
Location: IESL
Language:
Call_Number:
Description:

Author: PROUTY ROSENFELD, C. & E. ROSENFELD
Title: HISTORICAL DICTIONARIY OF ETHIOPIA.
Location: AAUL
Language: ENGLISH
Call_Number:
Description:

Handbooks/manuals:
Author: KAPLAN, L., ET AL.
Title: AREA HANDBOOK OF ETHIOPIA.
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Monographs/Special Books:
Author: ALEQA TAYE
Title: A HISTORY OF THE ETHIOPIAN PEOPLE.
Location: IESL
Language: AMHARIC
Call_Number:
Description:

Case 3: If a user wants bibliographic sources on the conflict between Ethiopia and Italy, by selecting History, On Specific topic within Ethiopian History, Historical Conflict. With Italy, Bibliography (the wanted part), and Term or Subject (the given part) in this order from the different menus of the system, the following output is generated.

********* Recommended Possible Sources or Advice *****

Bibliographies:
Author: PANKHURST, R. AND R.
Title: A PROVISIONAL BIBLIOGRAPHY ON THE ITALIAN INVASION AND OCCUPATIONS AND THE LIBERATION OF ETHIOPIA
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Author: VARLEY, D.H.
Title: A BIBLIOGRAPHY ON ITALIAN COLONISATION IN AFRICA, WITH A SECTION ON ABYSSINIA.
Location:
Language: ENGLISH
Call_Number:
Description:

Case 4: If a user wants to get sources for date related to personalities in the Ethiopia history in general, by following the path: History, Ethiopian History - General, Date (the wanted part) and Person (the given part), the following output is generated by the system.

********* Recommended Possible Sources or Advice *****

Biography:
Author:
Title: AFRICA WHO'S WHO 1981
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Author: MORAITIS, G.
Title: THE AUTOBIOGRAPHY OF HAILE SELASSIE AS A PSYCHOLOGICAL DOCUMENT.
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Author: PANKHURST, R.
Title: ETHIOPIA- AN HISTORICAL INTRODUCTION. DICTIONARY OF BIOGRAPHY
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Author: MUNRO-HAY, S.
Title: THE CHRONOLOGY OF AKSUM.
Location:
Language: ENGLISH
Call_Number:
Description:

Refer the Catalogue with catalogue Numbers: 930 to 999.4 in the IES library
Monographs/Special Books:

Author: ALEQA TAYE
Title: A HISTORY OF THE ETHIOPIAN PEOPLE.
Location: IESL

Language: AMHARIC
Call_Number:
Description:

Yearbook/Almanacs:
Author: ARNOLD-BAKER, CHARLES.
Title: EVERYMAN'S DICTIONARY OF DATES. Location: MAIN LIBRARY, AAU
Language: ENGLISH
Call_Number:
Description:

Author: ----------
Title: NEW AFRICAN YEARBOOK. 1988
Location: BRITISH COUNCIL LIBRARY
Language: ENGLISH
Call_Number:
Description:

Author: TUBIANA, J.
Title: ETHIOCONCORD:A COMPUTERISED CONCORDANCE OF THE ETHIOPIAN AND GREGORIAN CALENDARS.
Location: AAUL
Language: ENGLISH
Call_Number:
Description:

Case 5: If a user wants to get sources on personalities in the Modern period of Ethiopia, by following the path: History, Historical Period, Modern, Person (the given part) and Person (the wanted part), the following output is generated.

********* Recommended Possible Sources or Advice *****

Biography:

Author:
Title: MAKERS OF MODERN AFRICA. PROFILES IN HISTORY. 1981
Location: AAUL
Language: ENGLISH
Call_Number:
Description:

Author: HAILE SELASSIE I
Title: THE AUTOBIOGRAPHY OF HAILE SELASSIE I, "MY LIFE AND ETHIOPIA'S PROGRESS".
Location: IESL
Language: ENGLISH
Call_Number:
Description:

Refer the catalogue with numbers : 980 to 999.4 in IES library

Monographs/Special Books:

Author: TEKLE-TSADIK MEKOURIA
Title: HISTORY OF ETHIOPIA FROM TEWODROS TO HAILE SELASSIE
Location: IESL
Language: AMHARIC
Call_Number:
Description:

Author: TUBIANA, J. ED.
Title: MODERN ETHIOPIAN, FROM THE ACCESSION OF MENILEK II TO THE PRESENT.
Location: AAUL
Language: ENGLISH
Call_Number:
Description:

5.3 Major Strength, Limitations and Possible Ways of Improvement

According to the observation made about the prototype system, in the laboratory, by the developer and the experts participated in the knowledge acquisition, the major strength, limitations, and possible way of improving them are described below.

From the observation made in section 5.2, the prototype has the following strength:

1. It provides the basic framework or model for the development of a working system;

2. It can answer the basic reference inquiries including directional inquiries, administrative inquiries, etc.;
3. It also provides possible sources of information for specific inquiries even though the accuracy and reliability of its results depend on the overall reference sources collected, analysed and stored in the database;
4. It has a menu based user interface to accept input, output and explanation. The interface is flexible and easy for use; and users' terms or words are displayed;
5. It explains its reasoning, the reason why it asks the user to answer a question, and the different terms or concepts which are not clear for the user;
6. It allows users to browse, save and/or print the output;
7. Maintenance of the system in general and updating of the knowledge base in particular is easy as the system is organised in units/modules; and
8. There is no mere increase in the number of rules to expand the knowledge base. Instead, this could be accomplished using algorithm and interface to database file containing large number of records or facts. For instance, other factors such as the language of the sources, the type of output required, and location of the sources could be included in the system easily by allowing users to select their corresponding preference from lists as demonstrated for the other decision criteria. However, these factors do not alter the rules of the knowledge base. Instead, they could be used in selecting specific sources during the database searching.

On the other hand, due to the limitation of time and the problems inherited in the domain area mainly in the user modelling and detailed modelling of the reference process, the current prototype system has some drawbacks. The major ones, and possible way of improving them are:

1. The possible information sources recommended are not in order of significance. This problem could be solved by ranking the different sources for the different categories of inquiries.
2. The prototype doesn't save a user's inquiry for later refinement in case of failure in previous attempts, or to decrease or increase the possible sources recommended by the

system. This is because users are not required to type text instead asked to select a value by selecting an item from a list box. However, this could be implemented easily using the list structure of KPWin.

3. The necessary on-line help is available for a user in the course of identifying the wanted and the given part of his/her inquiry. But still it is not the best solution and hence a user may fail to do so. In this case the user is forced to ask assistance from the reference librarian. The solution to this limitation is to accept the user's inquiry in the user's terms and then extract the wanted and given part of the inquiry. This needs further investigation.
4. The specific sources included in the database file are not exhaustive and complete. Hence, an extensive survey is required to identify, collect and analyse possible information sources in the domain that are found being scattered both within and outside the country.
5. The uncertainty level of the recommendation or advice is not included because it requires assigning weight to sources of information by conducting a thorough analysis of the sources.
6. The decisions variables/criteria used to select the possible sources and also to identify a user's information needs are not the only ones. Additional criteria need be identified and easily incorporated in the system.
7. The system includes only sources which are written in English. However, there are sources which are in language different from English, mainly in Amharic, other local language, Italian, French, and Dutch. The inclusion of these multi-languages sources is possible using KPWin as it supports different fonts available in the Windows environment.

5.4 *Implementation Considerations and Constraints*

The ultimate goals of any expert system is its implementation in the real environment. Several factors are attributed to the success or failure of a prototype expert system for its implementation in the real environment. Some of these are the capability of the prototype system in demonstrating the basic functions expected of it; the initial unrealistic expectations of users; the

reluctance of users to use it; and the lack of a supporting structure for maintaining and updating the system (Zahedi 1993).

For the implementation of the prototype system developed in this study, the following conditions and considerations are essentials:

1. The limitations of the current prototype system, stated in section 5.3, should be undertaken along with other refinements.
2. Once the prototype is successfully refined, and a working system is attained, the next task is to conduct verification, validation and field tests. Verification checks the internal correctness and consistency of the prototype system, i.e., verification of the rules in the knowledge base for existence of conflicting, redundant, or circular rules. In expert systems verification is found to be more simpler than in conventional software system. The reason is that in expert systems, the knowledge base is separated from the control or inference engine

After the system is verified the next task is to validate it. Validation involves checking whether the developed system performs like the human experts in the domain. In addition to the correctness of the output of the system, the line of the system's reasoning should also be checked mainly by experts in the domain, preferably those who do not participate in the knowledge acquisition.

Following the completion of the validation test by the domain experts, the next element of validation is field test. It involves testing the system both by the domain experts and end-users in the actual environment in which the system is expected to be used. In this test all aspects of the system including the user interface and the system interface are considered.

3. Not only preparation of the system documentation, on-line help and user manual but also a hands-on training to the reference librarians is indispensable as they are expected to assist end-users when they use the system.

4. Regarding the hardware and software requirements to use the system, a 486/DX microcomputer with a minimum 8MB of RAM, VGA monitor and Windows 3.0 is the minimal requirement. However, a microcomputer with better resources is preferable to maximise the system performance.

Some of the constraints that could be encountered for implementing the system are:

1. The database toolkit available in KPWin is not appropriate for handling unstructured and variable length records.
2. Integration of the system with other library applications is not straight forward.

5.5 *Applications to Other Areas*

Most of the reference advisory system developed so far assume that the users knows which reference format (e.g. index, database, etc) is appropriate which is not the case for most of users. However, this prototype, like a few prototype such as ORFEO and NZRef, tries to accept user inquiry independent of information source format. It uses the given and wanted descriptors along with the different categories of users' inquiries.

The prototype system developed in this study is confined to the domain of Ethiopian history due to the time and other resources constraints. However, for the other fields dealing in Ethiopia in general and for the two focal fields described in this study in particular, the same model with some adjustment to make it specific to the domain as well as the same approach and tool could be used. Finally, an expert reference advisory system for Ethiopian Studies would be built through integration.

In general, if inquiries and possible sources of information are analysed and categorised for any subject, then the model and approach used in this study could be used as a starting point for developing an expert reference advisory system. Moreover, the approach, tools and techniques used in this study could be used to developed expert system for other functions of LIS.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Reference service exists to enhance and maximise access to information available in information centres/libraries. However, this goal has not been achieved as desired for several years due to the shortage of reference experts, lack of a wariness and knowledge of how to locate and make use of appropriate sources of information by the end users, and nature of the task that makes reference experts to feel boredom, give inconsistent advice, etc.

Due to the unstructured nature of the task, attempts using the conventional software tools and approach were not successful. However expert system has shown to have the potential in this area of application. Therefore, in course of this thesis an attempt was made to develop a prototype expert reference advisory system for Ethiopian history with the semi-custom development option using the KPWin software.

Before embarking on the development of the prototype system, investigation of the domain area (Ethiopian Studies as well as reference services), examination of the expert system technology and its tools and methodologies, revision of previous works and other related tasks such as identification of user categories and major sources of information were accomplished.

Following this, domain analysis and goal identification resulted in having a model or general framework on which the prototype was developed. Specifically the wanted and given descriptors were taken and refined to meet the specific domain along with the categorisation of the different inquires. Moreover decision criteria were identified during the analysis.

Based on the result stated above, the general structure or logical representation of the prototype system was established. This was followed by the designing of the different components of the prototype system using the KPWin.

In the study knowledge was collected from human experts using the interview and protocol analysis methods, and from printed documents. Decision criteria and model was also developed to organise and represent the knowledge as rules and facts constituting the knowledge base, in a computer system. This knowledge base was designed in such away that it can be easily upgraded without any fundamental change in the design. If more categories of inquiries were to be incorporated into the system, more rules would be incorporated. Similarly, if more reference sources were to be incorporated in the system, more records would be incorporated in the database file after analysing them.

The developed prototype could be used by both end-users and reference librarians in the course of obtaining information sources for answering both specific and general inquiries in Ethiopian history. Users are provided with a graphic user interface, consists of buttons, windows and list boxes, to accept input, to provide output, to give on-line assistance and explanations of the system's reasoning. The user interface was also enhanced by including hypertext.

The prototype system was verified in the laboratory by the developer and the domain experts using different cases. The general opinion of the domain experts were the possibility of the system to be useful in assisting both end-users and reference librarians.

Except the limitation to represent individual users model, the rule-based approach used to represent the knowledge in the prototype system was found to be appropriate. Moreover, KPWin was found to be suitable for implementing it and the other components of the prototype system - user interface, inferencing mechanism, explanation model, database interface and facts. Also a runtime version of the prototype could be generated and run under Windows operating system without requiring the KPWin software.

In general, the developed prototype system demonstrated how the expert system technology could be helpful in automating the reference service for the Ethiopian history. In particular, an attempt was made:

- To show how the prototyping approach, the interview and protocol analysis methods of knowledge acquisition, the production rule method of knowledge representation, and the backward chaining inferencing mechanism could be used in developing the prototype system;
- To show how screen objects, hypertext and graphics could be used to have a user friendly user interface based on the general characteristics of the user;
- To present the different development tools available for developing an expert system, and the criteria for selecting one that is appropriate for the application at hand; and
- To explore means of extending the prototype to a working system.

6.2 *Recommendations*

The work in the course of producing this thesis has given enough insight to the researcher to recommend the following points:

1. A continuous refinement for incorporating corrections and improvements is recommended. This should be followed by system testing and evaluation to check the consistency and accuracy of the system's advice, to evaluate the usability of the system, and to discover any bugs in the system.
2. Since the developed prototype restricted itself to Ethiopian history, and because the method, approach and tool could be applied to other areas, a bottom-up strategy, i.e., a collection of smaller systems, is recommended to achieve a reference advisory system for Ethiopian Studies.

3. Since KPWin is found to be easier, flexible and appropriate during development of the prototype system for the implementation of both the consultation and instructional processes of the reference service, its use for further work in this line seems appropriate.
4. Information/Reference service is one major component of an information centre or a library. It is highly inter-linked with the other components mainly with the circulation section, the public catalogue and any other information retrieval component in order to access the sources of information available. Hence automation of these basic components is required to enhance to the performance of the reference advisory system. Moreover improving the collection of information/reference sources is recommended.
5. Further research is recommended in the area of modelling the domain, i.e., to come with a better reference process model for Ethiopian Studies; in area of knowledge representation of the domain, i.e. to come with a better knowledge representation scheme for the user's inquiries and information sources, say using the object-oriented representation; in the implementation of natural language based user interface; in the designing and incorporation of uncertainty model for measuring the uncertainty level of the system advice; and in the inclusion of a built-in knowledge acquisition module that would enable the system to increase its knowledge as human expert would do.

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APPENDICES

Appendix I: Database's Record Structure and Sample Data Values

a) Structure for database

Field Field Name Type Width Dec Index

1 AUTHOR Character 60 N

2 TITLE Character 100 N

3 IMPRINT Character 60 N

4 INFO_TYPE Character 20 N

5 INFO_CATE Character 30 N

6 INFO_LEVEL Character 30 N

7 LOCATION Character 30 N

8 LANGUAGE Character 50 N

9 T_COVERAGE Character 30 N

10 A_COVERAGE Character 30 N

11 I_COVERAGE Character 100 N

12 CALL_NO Character 20 N

13 DESCR Memo 10 N

** Total ** 571

b) A Sample Data List of the Record

MATTHEWS, DANIE A CURRENT BIBLIOGRAPHY ON ETHIOPIAN AFFA BIBLIOGRAPHY GENERAL IESL

ZANUTTO,SILVO. BIBLIOGRAFIA ETIOPICA. IN CONTINUEAZIONE BIBLIOGRAPHY GENERAL MAIN LIBRARY, AAU

AAU LIBRARY BIBLIOGRAPHIES FOR ETHIOPIAN STUDIES. A. BIBLIOGRAPHY GENERAL IESL

KEBEDE GESSESSE INDEX TO THE JOURNAL OF ETHIOPIAN STUDIES INDEX GENERAL IESL

LESLAU W. ENGLISH-AMHARIC CONTEXT DICTIONARY. 1973 DICTIONARY GENERAL BRIEF IESL

Appendix II: A Sample List of the Source Program

```
(* ============================== ERASES.KP ================
This application is a rule-based approach to a problem regarding
reference service where a user
come with an inquiry and the  system provide a recommendation of list of
possible sources,
or an advice. In particular, it is a prototype expert system for
reference advisory system in the
field of Ethiopian Studies.  *)

(*This is the main module that loads  other modules consists of rules and
user-interface part of the over all codes such as ieshyper.kb,
module2b.kb, module2.kb, module3.kb, module4.kb, etc. *)
(* Programmer: Azene Zenebe
    Date programmed: June 1996 *)

(*==================  Intitialization ================== *)
@c:\kpwin2\kpdblib.tpx
reset(sel_info_source).
set_event_topic(trap,[sys_char_event]).
(* TO DEFINE FACTS USING LIST*)
(* ======== list for basic sources of information==========*)
dict_WANTED is [ILLUSTRATION, DEFINITION].
dict_GIVEN is [PERSON,PLACE, 'TERM OR SUBJECT'].
ency_wanted is [DATE,ILLUSTRATION, ORGANIZATION, DEFINITION,'BACKGROUND
INFORMATION'].
ency_given is [PERSON, PLACE, 'TERM OR SUBJECT'].
biblo_wanted is [BIBLIOGRAPHY,'DOCUMENT LOCATION' (*, 'BACKGROUND
INFORMATION'*)].
biblo_given is ['SPECIFIC PUBLICATION','TERM OR SUBJECT',PERSON,'ADDRESS
OR LOCATION'].
index_wanted is ?biblo_wanted.
index_given is ?biblo_given.
abst_wanted is ?biblo_wanted.
abst_given is ?biblo_given.
biog_wanted is [DATE, PERSON, ORGANIZATION, 'ADDRESS OR LOCATION',
                'BACKGROUND INFORMATION'].
biog_given is [PERSON].
cata_wanted is [DATE,PERSON,BIBLIOGRAPHY,'DOCUMENT LOCATION',
                'DOCUMENT VERIFICATION'].
cata_given is [ORGANIZATION,PERSON,PLACE,'TERM OR SUBJECT'].
un_lst_wanted is ?cata_wanted.
un_lst_given is ?cata_given.
geog_wanted is [DATE,ILLUSTRATION,PERSON,'ADDRESS OR LOCATION'].
geog_given is [PLACE,'TERMS OR SUBJECT'].
guide_wanted is ['BACKGROUND INFORMATION', 'DOCUMENT VERIFICATION'].
guide_given is ['TERM OR SUBJECT','SPECIFIC PUBLICATION'].
hand_wanted is ['ILLUSTRATION','DEFINITION','BACKGROUND INFORMATION'].
hand_given is ['TERM OR SUBJECT'].
dir_wanted is [DATE,ORGANIZATION,PERSON,'ADDRESS OR LOCATION'].
dir_given is [ORGANIZATION,PLACE].
mon_wanted is [DATE,ILLUSTRATION,ORGANIZATION,PERSON,DEFINITION,
          'BACKGROUND INFORMATION'].
mon_given is [ORGANIZATION,PERSON,PLACE,'TERM OR SUBJECT'].
prim_wanted is [ILLUSTRATIVE,BIBLIOGRAPHY,'BACKGROUND INFORMATION'].
prim_given is [ORGANIZATION,PERSON,'TERM OR SUBJECT'].
yearb_wanted is [DATE,ILLUSTRATIVE,'NUMERIC INFORMATION'].
```

```
yearb_given is [ORGANIZATION,PERSON,'TERM OR SUBJECT'].
db_wanted is [BIBLIOGRAPHY,'DOCUMENT VERIFICATION','BACKGROUND
INFORMATION'].
db_given IS [ORGANIZATION, PLACE, PERSON, 'TERM OR SUBJECT'].
(*continue FOR OTHER SOURCES*)

(*Valid combination*)
wanted_given1 is [[BIBLIOGRAPHY,'TERM OR SUBJECT'],
 [BIBLIOGRAPHY,'SPECIFIC PUBLICATION'],[BIBLIOGRAPHY,'ADDRESS OR
LOCATION'],  [BIBLIOGRAPHY,PERSON],[BIBLIOGRAPHY,ORGANIZATION]].
wanted_given2 is [[IILUSTRATION,ORGANIZATION],[IILUSTRATION,PERSON],
[IILUSTRATION,'ADDRESS OR LOCATION']].
wanted_given3 is [[DATE,ORGANIZATION],[DATE,PERSON],[DATE,'ADDRESS OR
LOCATION']].
wanted_given4 is [[ORGANIZATION,'ADDRESS OR LOCATION'], [ORGANIZATION,
ORGANIZATION],[ORGANIZATION,'TERM OR SUBJECT'], [ORGANIZATION, PERSON],
[ORGANIZATION, 'SPECIFIC PUBLICATION']].
wanted_given5  is [[PERSON,ORGANIZATION],[PERSON,'ADDRESS OR LOCATION'],
[PERSON, 'TERM OR SUBJECT'], [PERSON, PERSON], [PERSON,'SPECIFIC
PUBLICATION']].
wanted_given6 is [['ADDRESS OR LOCATION',ORGANIZATION],['ADDRESS OR
LOCATION',PERSON], ['ADDRESS OR LOCATION','ADRESS OR LOCATION'],['ADDRESS
OR LOCATION','SPECIFIC PUBLICATION']].
wanted_given7 is [['DOCUMENT LOCATION',ORGANIZATION],['DOCUMENT
LOCATION','SPECIFIC PUBLICATION']].
wanted_given8 is [['DOCUMENT VERIFICATION',ORGANIZATION],['DOCUMENT
VERIFICATION', PERSON], ['DOCUMENT VERIFICATION','TERM OR
SUBJECT'],['DOCUMENT VERIFICATION','SPECIFIC PUBLICATION']].
wanted_given9 is [['BACKGROUND INFORMATION','SPECIFIC PUBLICATION'],
['BACKGROUND INFORMATION', 'TERM OR SUBJECT'],['BACKGROUND
INFORMATION',PERSON],['BACKGROUND INFORMATION',ORGANIZATION]].
wanted_given10 is [[DEFINITION,'TERM OR SUBJECT'],[ILLUSTRATION,'TERM OR
SUBJECT']].
wanted_given11 is [['NUMERIC INFORMATION',ORGANIZATION],['NUMERIC
INFORMATION',PERSON],['NUMERIC INFORMATION','ADDRESS OR
LOCATION'],['NUMERIC INFORMATION','SPECIFIC PUBLICATION']].

union_wanted_given is union
(?wanted_given1,?wanted_given2,?wanted_given3,?wanted_given4,

?wanted_given5,?wanted_given6,?wanted_given7,?wanted_given8,?wanted_given
9,
       ?wanted_given10,?wanted_given11).
(*===========end of facts ========================*)
(* ====== Online Help ======*)
topic trap(info).
  if ?info is F9 then
     hls is read ('makeapp.txt') and
     ghw is  window(,1,1,90,23,'General Help About the Advisory system',

  [overlapped,thickframe,visible,maximize,maximizebox,controlmenu,titleba
  r, vertscroll,    horzscroll]) and
     show_window(?ghw) and make_modal(?ghw) and
     text(#e,#n,'General HELP to use the system,#n', ?hls) and
close_all().
end.
tmp is true.
setup().
first1().
```

```
intro().
(*START THE BACKWARD CHAINING PROCEDURES*)
topic start_advice.
   disable_window().
   advice().
   disable_window().
  if ?advice <> [] then  disw is window (,1,2,92,24,'*** OUTPUT SCREEN
***'  ,
         [popupwindow, thickFrame,TitleBar, ControlMenu, MaximizeBox]  ,
    , , , [close_event, resize_event] ) and   dw2 is window ( ,
    1,1,90,2,,[child, visible, siblings, showChildren], ?disw, , gray)
    and   button (Continue,:Next,1,1) and   button (HOW,:how,11,1) and
          button (EXIT,b_close,18,1) and   button(Print, o_print,24,1)
     and
      button(Save, o_save,30,1) and  wla is window ( , 1,3, element (
  window_info (?disw), 10),   element ( window_info (?disw), 11)-2, ,
  [child, siblings, horzScroll, vertScroll,showChildren, visible] ,?disw)
  and  use_font (?mainFont) and  text ('#e #X5 #Y4 Recommended Possible
  Sources/Advice:- #n',   ?advice) and  use_font(?norm) and
  show_window(?disw) and
     use_font(?medium).
 (* ======= OUTPUT options======*)
    topic o_print.
      write(prn, '#n ********* Recommended Possible Sources or Advice
***** #n',
            ?advice).
    end.
    topic o_save.
               file is save_as('*.*').
               write(?file, '#n ********* Recommended Possible Sources or
Advice ***** #n',
            ?advice).
     end.
     topic b_close.
       close_window().
        exit_kp().
       end.
      topic how.
       whp is  window(,1,1,90,23,'THE SYSTEM
REASONING',[overlapped,thickframe,
            maximize,maximizebox,controlmenu,titlebar,
vertscroll,horzscroll]).
      wh2 is window ( , 1,1,90,2,,[child, visible, siblings,
showChildren], ?whp, , gray).
      bb1 is button(Close, close_h,1,1).
     wh1 is window ( , 1,3, element ( window_info (?whp), 10), element (
    window_info (?whp), 11)-     2, , [child, siblings, horzScroll,
    vertScroll,showChildren, visible] ,?whp).
      text('#e #n',?how_list).
      show_window(?whp).
      topic close_h.
       close_window([?whp]).
       end.
      end.
   topic Next.
    (* *)
    set_title(?disw,'Accept Choice').
    ask('#eDo you want to get anotner advice ?',want,[Yes,No]).
```

```
      if ?want is Yes then reset ([advice,advicel,inquiry0,inquiry,'type
    of source', start_advice,   intro,intro_sys,setup, 'info wanted',
    'main category','sub category1','sub category2','sub category3','info
    given', sel_info_source]) and close_window ?disw) and  do
    (?start_advice)
      else clear().
    end.(*next*)
end.(*start-advice*)
(*=======Main goal's rules=====================*)
topic advice.
     how_list is ['The reasons to give these sources or advice are:
====>#n'].
     set_number_of_values(advice,50).
     lps is [].
     i=1.
     k=1.
     advicel is [].

(*================ RULES ===============*)
(* Rules for general guide on the information sources available at IES *)

   if ?inquiry0 is  'Guide on IES' then hypertext(  and advicel is [].
   if ?inquiry0 is HISTORY  and ?inquiry is 'General Guide'
       and ?'type of source' is 'Journals'
        then advicel is read('Journal.txt'  and text('#e#y5 #y5 PLEASE
WAIT
                ..... '
                 and wait(,2) and how_list gets ['Your inquiry/question
',?inquiry, ' on #n', ?'type of source',
                  '#n and the visible index indicate these sources'].
     if ?inquiry0 is HISTORY and ?inquiry is 'General Guide'
           and ?'type of source' is Monographs
            then advicel is ['#e#n#n#fblue For the different  text books
on Ethiopian  history ',
       '#n #fblue please refer the card catalogue#n from number 930 to
999.4']
      and text('#e#y5 #y5 PLEASE WAIT  ..... ') and wait(,2) and
      how_list  gets ['Your inquiry/question ', ?inquiry, ' on#n ',
      ?'type of  source', ' #n and the special classification scheme
      indicates those nuumbers']  .
     if ?inquiry0 is HISTORY and ?inquiry is 'General Guide'  and ?'type
of source' is 'Databases'
         then text('#e#y5 #y5 PLEASE WAIT   ..... ') and wait(,2) and
    advicel is ['#n#nSome of the         databases are',
    read('database.txt'),    '#n, and for more assistance please consult
    the intermidaries',        '#nat Computer section of the kennedy
    library'].
    if ?inquiry0 is HISTORY and ?inquiry is 'General Guide'  and ?'type
    of source' is 'Museum Objects' then text '#e#y5 #y5 PLEASE
    WAIT..... ') and wait(,2) and advicel is ['#n#n#fblue Use the
    museum catalogue located in the museum section '] and  how_list
    gets [?inquiry, ' on ', ?'type of source'].

     if ?inquiry0 is HISTORY and ?inquiry is 'Unknown' then advicel is
    ['Better discuss with the      reference librarian, or', 'consult the
    general guide about IES'].

     if ?inquiry0 is HISTORY and ?inquiry is 'General Guide'
```

```
          and ?'type of source' is 'Information Centres' then
text('#e#y5 #y5 PLEASE WAIT
              ..... ') and wait(,2) and advice1 is  ['#n
',read('infocent.txt') ].

     if ?inquiry0 is HISTORY and ?inquiry is 'General Guide'
     and ?'type of source' is 'Experts' then text('#e#y5 #y5 PLEASE WAIT
      ..... ') and wait(,2) and advice1 is  ['#n ',read('experts.txt')
].
(*================ RULES: LEVEL TWO ======================*)
(* WANTED - GIVEN APPROACHES *)

if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?dict_wanted,?'info wanted' ) and one_of(?dict_given,?'info given') and
 where (?union_wanted_given, [?'info wanted' ,?'info given']) <> 0  then
sel_info_source is Dictionary and advice1  GETS [' Dictionaries: #n ',
   ?Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?Biblo_wanted,?'info wanted' ) and one_of(?Biblo_given,?'info given')
and where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0
then sel_info_source is Bibliography and advice1  gets['#nBibliographies:
',
    ?Search_database]  and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?index_wanted,?'info wanted' ) and one_of(?index_given,?'info given')
and where (?union_wanted_given, [?'info wanted' ,?'info given']  <> 0
then sel_info_source is Index and advice1  gets ['#nIndex:',
?Search_database]
    and reset(search_database) and lps gets [?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?abst_wanted,?'info wanted' ) and one_of(?abst_given,?'info given')  and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> [  then
sel_info_source  is Abstract and advice1  gets
['#nAbstract:',?Search_database]
     and reset(search_database) and lps gets [?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?ency_wanted,?'info wanted' ) and one_of(?ency_given,?'info given')  and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> [  then
sel_info_source is Encyclopedia and advice1  gets ['#n Encyclopedia: ',
    ?search_database]  and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?biog_wanted,?'info wanted' ) and one_of(?Biog_given,?'info given')  and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> [ then
sel_info_source  is Biography and advice1  gets['Biography:',
?Search_database]  and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?cata_wanted,?'info wanted' ) and one_of(?cata_given,?'info given') and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> [  then
advice1 gets['Catalogue Numbers:#n 930 to 999.4 in IES library'].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL  and one_of
(?geog_wanted,?'info wanted' ) and one_of(?geog_given,?'info given')  and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> [ then
sel_info_source  is 'Geographic Sources' and advice1  gets ['Geographical
sources: ',   ?Search_database]  and reset(search_database) and lps gets
[?sel_info_source].
```

```
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?guide_wanted,?'info wanted' ) and one_of(?guide_given,?'info given')
and where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is Guide and advice1 gets ['GUIDE:', ?Search_database]
 and reset(search_database) and lps gets [?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?hand_wanted,?'info wanted' ) and one_of(?hand_given,?'info given') and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is Handbook and advice1 gets ['Handbooks/manuals: ',
 ?Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?dir_wanted,?'info wanted' ) and one_of(?dir_given,?'info given') and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is Directory and advice1 gets ['Directories: ',
?Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?mon_wanted,?'info wanted' ) and one_of(?mon_given,?'info given') and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is Monograph and advice1 gets ['Monographs/Special
Books: ', ?Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?prim_wanted,?'info wanted' ) and one_of(?prim_given,?'info given') and
where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is 'Primary publication' and advice1 gets ['Primary
publication: ', Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?yearb_wanted,?'info wanted' ) and one_of(?yearb_given,?'info given')
and where(?union_wanted_given, [?'info wanted' ,?'info given']) <> 0 then
sel_info_source is Yearbook and advice1 gets['Yearbook/Almanacs: ',
?Search_database] and reset(search_database) and lps gets
[?sel_info_source].
if ?inquiry0 is HISTORY and ?inquiry is GENERAL and one_of
(?db_wanted,?'info wanted' ) and one_of(?db_given,?'info given') and
where(?union_wanted_given,[?'info wanted',?'info given']) <> 0 then
sel_info_source is 'Database Sources' and advice1 gets ['CD_ROM
database sources: ', ?Search_database] and reset(search_database) and
lps gets [?sel_info_source].

(* 1. For Historical conlict: rules are in file module3.kb*)
(* 2. For Historical conlict: rules are in file module2.kb*)
(* 3. For Historical personalities: rules are in file module4.kb *)
#include module3.kb
#include module2.kb
#include module4.kb

(* ==== HYPERTEXT based assistance FOR GUIDE ON IES====*)
topic hypertext.
disable_window(?w1t).
(*To load the source codes from the file ieshyper.kb*)
#include ieshyper.kb
wait().
advice().
end.(* hYPERTEXT*)

(* final goal assignment *)
```

```
advice is ?advice1.
if  ?lps is [] then lps is none.
if ?advice <> [] and ( ?inquiry is General or ?inquiry is specific ) then
how_list gets ['For your question/inquiry you have identified the wanted
part to be ',
    ?'info wanted', ' & the given part to be ',?'info given',  '.  Hence,
for this combination the possible
     categories of sources of information are: ', ?lps, '#n#n
Corresponding to these
     Categories of sources the system identified the recommended sources
from
     the available reference/information sources in the database'] and
reset(lps).
if ?k=2 then close_window(?ddba).
(*====Topic for database access for facts on sources of information*)
topic Search_database.
  if ?i=1 then ?u_info_lev and i=?i+1.
   spd_record1 is [].
   db_use_file(document).
   db_top_record().
   reset(mc).
   if ?inquiry is general then mc is upper(concat('"',?inquiry,'"')).
   if ?inquiry is specific and ?'main category' is 'Historical Conflict'
    then mc is upper(concat('"',?'sub          category2','"')).
   if ?inquiry is specific and ?'main category' is 'Historical Era' then
    mc is upper(concat('"',?'sub   category1','"')).
   if ?inquiry is specific and ?'main category' is 'Biography of
    Personality' then mc is upper(concat('"',?'sub category3','"')).
    y1 is concat('INFO_CATE=',?mc).
    x1 is ?sel_info_source.
    y2 is concat('INFO_TYPE=', upper(concat('"',?x1,'"'))).
    y3 is concat('INFO_LEVEL=', upper(concat('"',?u_info_lev,'"'))).
    if ?u_info_lev <> EITHER then expression is
concat(?y1,'.AND.',?y2,'.AND.',?y3)
      else expression is  concat(?y1,'.AND.',?y2).
   if ?k=1 then  disable_window() (*and dis_wait()*) and
   ddba is window(,3,3,90,20,,
[overlapped,dialogframe],,,,[close_event]) and
       text('#e#x5 #y5 PLEASE WAIT
            ......  SEARCHING  A DATABASE ') and
  show_window(?ddba) and wait(,2) and k=?k+1.
  spb_record is
db_locate_record(rest,?expression,,[author,title,location,language,
                      call_no, descr]).
   x1 is ?spb_record.
   while ?x1 <> [] then
   le is first(?x1) and
   x1 is rest(?x1) and item=1 and if  list_length(?le) <> 1 then
   a1 is concat('Author:  ', element(?le,1)) and
   t1 is concat('Title:  ',element(?le,2)) and
   l1 is concat('Location:  ',element(?le,3)) and
   la1 is concat('Language:  ',element(?le,4)) and
   c1 is concat('Call_Number:  ',element(?le,5)) and
   d1 is concat('Description:  ',element(?le,6), ' #n#n')  and
 spd_record1 gets        [?a1,?t1,?l1,?la1,?c1,?d1]).
  db_close_all().
  if list_length(?spd_record1) <> 1 then search_database is ?spd_record1
and reset(spd_record1)
   else ?search_database is 'No source exists in the database'.
```

```
   end.(*search database*)
   topic u_info_lev.
        uil is Window (,1,1,91,24 ,'A Prototype Expert System for  the
   Reference
   Services',[siblings,thinframe,controlMenu,MaximizeBox,MinimizeBox,
        horzscroll, vertscroll, showChildren],,,lightgray,[close_event]).
         text('#e #n #fblue ARE YOU LOOKING FOR SOURCES PROVIDING: ').
         levl is list_box(['DETAILED INFORMATION','BRIEF
     INFORMATION',EITHER,[],[],[],[],[]],INFO_LEV,5,5,30).
         show_window(?uil).
         make_modal(?uil).
         wait().
         topic info_lev(itemlev).
       u_info_lev is ?itemlev.
       continue().
       close_window([?levl,?uil]).
        end.

    end. (*level*)

  end.(*advice*)
(* To call a topic for the user interface module *
 #include module2b.kb

(*=============================================================*)
(*The Well Come Screen First screen*)

topic intro.
use_font(?big).
text ('#y2 #fblue ERASES: AN EXPERT REFERENCE

       ADVISORY  SYSTEM FOR
                                  ETHIOPIAN STUDIES     ').
use_font (?medium).
text ('#Y8
                  #FBLUE#X60Developed
                                      #fblue#x65By
                                #X60Azene Zenebe

#X60June 1996').
b1 is button(Continue,intro_sys,20,23,10).
b2 is button (Exit,quit,40,23,10).
show_window (?w1t).
make_modal(?w1t).
set_focus(?b1).
wait().
close_window([?b1,?b2]).
use_font().


(*=============================================*
 (*Topic for introduction part of the system *

topic intro_sys.
   use_font(?norm).
   text('#e#x20#y24 Press F9 for General Help' .
   td is window(,2,2,90,24,'General Information about the System',
[siblings,thickframe,controlMenu,MaximizeBox,MinimizeBox,
   showChildren,vertscroll, horzscroll],,,lightgray,[close_event]).
```

```
    show_window(?td).
    make_modal(?td).
    use_font(?medium).
    text('#e#n#nThis system is designed to assist both an end-user
and reference librarian in answering both general and
specific inquiries on the field of Ethiopian Studies.
Currently the system provides reference services
only to general information sources available at IES and,
general and specific information sources on Ethiopian History.

The user is provided with the following options frequently.
      WHY --------> TO SEE WHY THE USER IS REQUIRED
                    TO ANSWER THE SYSTEM''S  QUESTION
      HOW ------- > TO GET SYSTEM''S REASONING/EXPLANATION
      CONTINUE ----- > TO PROCEED TO NEXT STEP
      CLOSE ------- > TO CLOSE THE EXISTING WINDOW
      EXIT   ------- > TO QUIT THE SYSTEM
                F9 -------- >  TO GET  AN ONLINE HELP/ASSISTANCE
The user is also requested to use mouse and the Enter key .
          ').
use_font(?medium).
bs1 is button(Continue,close_i,75,10,,t).
topic close_i.
   close_window([?bs1,?intro_sys:td]).
    start_advice().
end.
end.(*introd_sys*)
end. (* intro *)

topic setup.
 w1t is Window (quit,1,1,90,27,'A Prototype Expert System for  the
Reference Services',
[overlapped],,,lightgray).
  big is create_char_font ( [-2,0,400,f,f,f,0,1,34,'MS Sans Serif'] ).
  medium is create_char_font([-1,-1.85,700,f,f,f,0,1,82,'MS Sans
Serif']).
  norm is create_char_font ([-0.8125,0,400,f,f,f,0,1,34,'MS Sans
Serif']).
  mainFont is create_char_font ( [1,1,400,'F','F','F',0,1,34,'Helv']).
  hyperFont is create_char_font ( [1,1,400,'F','F','F',0,1,34,'Helv'] .
  boldFont is create_char_font ( [1,1,700,'F','F','F',0,1,34,'Helv']).
  bigFont is create_char_font (
[1.5,1.2857,400,'F','F','F',0,1,34,'Helv']).
  use_font (?norm,control).
  hyper_display (blue, ,?hyperfont).
 (*  show_window(?w1).
  make_modal(?w1).
  set_active_window(?w1).*)
end.

(* Topic to exit the system to windows *)
topic quit.
 exit_kp().
end.

Topic first1.
w2B is Window (quit,1,1,90,27,,
[OVERLAPPED,thinframe,controlMenu,MaximizeBox,MinimizeBox,showChildren],,
,lightgray).
```

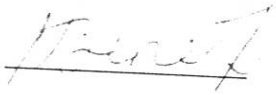
```
ethio is load_bitmap('ethio1.BMP').
bitmap(?ethio,6,2,65, 24).
eb is button(Continue,okk1,32,23).
SHOW_WINDOW(?w2b).
wait(,2).
   close_window([?eb,?w2b]).
topic okk1.
     continue().

end.
end.(*first1*)

topic mark(item).
                file is 'hypetext.txt'.
                hyper_fonts is create_font
([15,8,400,f,t,f,0,1,1,system]).
      hyper_display (blue,,?hyper_fonts).
      message is read(?file,concat('//',?item,,'//').
      if ?message is number_to_char(26) then ?message is 'No info. for
this item'.
                whyp is Window ,2,2,90,25,'A Hypertext Based Explanation
for a Term or Concept',
      [siblings,thinframe,controlMenu,MaximizeBox,MinimizeBox,
      showChildren],,,lightgray).
      text(?message).
             button(BACK,CLOSE_it,5,23,7).
              button(EXIT,exith,13,23).
             use_font(?norm).
             show_window(?whyp).
      set_file_pos (?file,0,beginning).
      topic close_it.
           close_window().
      end.
      topic exit.
         clear().
      end.
end.
```

DECLARATION

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



Azene Zenebe

May 20, 1996

The thesis has been submitted for examination with my approval as a university advisor.

Dr. G. G. Chowdhury

May 20, 1996