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A REVIEW OF EXPERT SYSTEMS IN LIBRARY AND INFORMATION SCIENCE

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ABSTRACT

Reviews 422 published sources on expert system (ES) applications in library and information science (LIS) domains. The literature was reviewed under five categories which described ES applications in;LIS (general); technical services which include cataloguing and classification; public services which include reference services, information search and retrieval and document delivery; abstracting and indexing and; acquisition and collection development.

Keywords: Expert systems; Cataloguing; Classification; Reference services; Abstracting; Indexing; Acquisition; Information search and retrieval; Library science.

INTRODUCTION

The term expert systems (ES) is used loose-ly and ambiguously as is evident from the literature. Hawks (1994) explains that knowledge-based systems are the broad category of systems that use some know-ledge to perform their functions. They need not use either heuristics or artificial intelligence (AI) techniques in performing their tasks. Intelligent systems are a subset of knowledge-based systems in that they display intelligent behaviour, but not necessarily at the level of a human expert. ES is considered a more specific category and uses heuristics to perform tasks pre-viously done by human experts. In essence, a well-developed ES should provide the same answers that an expert would give when approached with a particular pro-blem. This article considers ES as; (a) a computer system that emulates human in-telligence; (b) a computer system that auto-mates a task that now requires human expertise; and (c) a computer system that models human thought processes.

As early as 1971, librarians have been interested in ES. Since then, there have been a number of books and articles published that address the potential of ES and the design of prototype systems. This article attempts to summarise the developments of ES in the various domains and sub-domains of LIS as reported in published literature retrieved between 1958 and 1997.

SOURCES SEARCHED

A scan of a few major CD-ROM based on-line reference sources identified as relevant to the subject of ES in LIS domains retro-spective from June 1997 was conducted to retrieve articles relevant to AI, knowledge-based systems and ES. These online refe-rence sources are (a)

LISAPlus (Library and Information Science Abstracts), (b) *ERIC* (Educational Resources Information Centre), (c) *INSPEC*, and (d) *DAO* (Disser-tations and Abstracts Online). In addition, a manual search of the bibliographies appended to review articles by Poulter, Morris and Dow (1994), Hawks (1994), Morris (1991a) and Drenth, Morris and Tseng (1991) proffered some relevant arti-cles not found in the online reference sour-ces. Furthermore, the printed version of *Library Literature* was also searched. The search chose 1958 as the starting point, since the earliest article discovered in the manual search through the bibliographies discussed the automatic creation of literature abstracts using AI architecture was pu-blished in 1958. As the investigation into the literature began in July 1997, June 1997 is the cut-off date for this study. The overall strategy involved in the CD-ROM based online search was using a combination of nested keywords; (artificial intelligence or knowledge based systems or expert systems) and (library and information science). The results were then limited to English language publications only. It is necessary to state here that, as is typical with most computer searches, there are no guarantees to retrieving "every" relevant reference available on a topic. The results retrieved in this study are no exception. The retrieved articles were then entered into a database and coded into different ca-tegories that represent subject areas.

TOTAL REFERENCES RETRIEVED

A total of 422 references were retrieved. Figure 1 shows a breakdown of the references according to broad subject areas. Articles that discussed mainly ES and AI and touched minimally on library ES are categorised under the subject area of "ES & AI". Articles that discussed the applications of ES in libraries without specialising on any area in particular are classed under "LIS (General)". Finally, articles that cover the application of ES in a particular function of the library are grouped into four main categories; Technical services which include cataloguing and classification; Public services which include reference services, information search and retrieval and document delivery; Abstracting and indexing and; Acquisition and Collection development.

Table 1 shows that out of the 422 articles, 232 (55%) articles discussed issues regarding ES application in public services. Findings show that most of the articles on public services discussed issues regarding infor-mation searching and retrieval. This includes peripheral areas like information storage, interfaces to online retrieval and online searching. Another area where literature is prolific is in cataloguing because its depen-dence on AACR2 rules makes it easily adaptable to automatic manipulation.

Table 1: References Retrieved by Broad Subject Areas

Subject Areas	Total (422)	%
Expert Systems & Artificial intelligence	12	3%
LIS (General)	67	15%
Technical services	70	17%
Public services	232	55%

Abstracting/Indexing	25	6%
Acquisition/Collec-tion development	16	4%

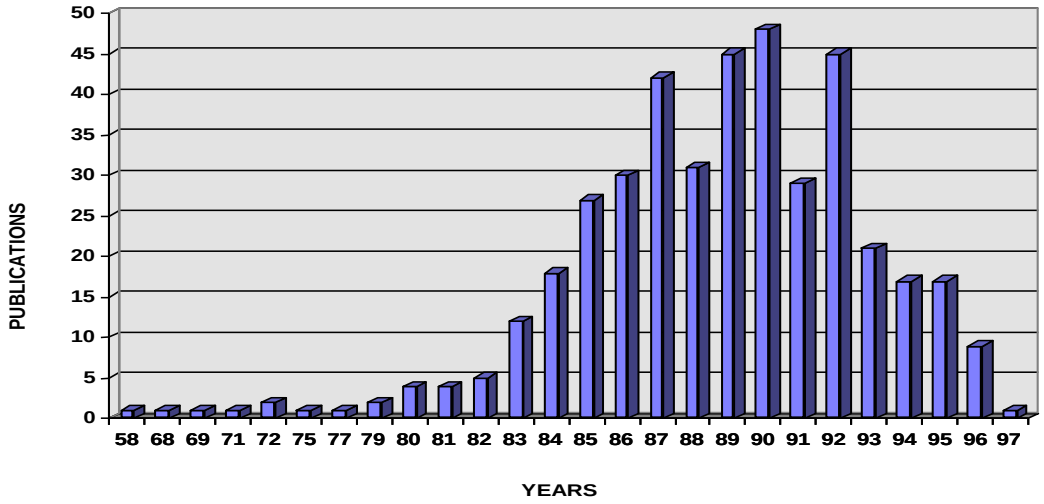
Since the onset of AI in the mid 60s, litera-ture on AI and its peripheral areas has sharply increased. However, its applica-tions in the area of LIS only took off in the late 70s. A gradual increase can be seen from the year 1979 onward, peaking in the mid and late 80s. Figure 2 shows the trend of publications in the field of LIS pertain-ing to the use of AI and ES steadily in-creasing from the early 80s and peaking till the early 90s.

The literature retrieved on ES applications in LIS is broken down into the following categories; Review literature on Expert Systems in LIS; ES in technical services; ES in public services; ES in abstracting and indexing; and ES in acquisitions and collection development. At the end of each section, a table summarising the identified systems, the developers involved and the year it was reported in published literature is provided.

REVIEW LITERATURE ON EXPERT SYSTEMS IN LIS

The earliest review article found on ES and their applications in LIS has 59 references (Vickery and Brooks, 1987a). However this article concentrated on the areas of docu-ment retrieval and reference services, as these were the two areas where work was most prolific then. Smith's (1987) article on the use of AI and information retrieval is by far the most comprehensive with 204 references. Drenth, Morris and Tseng (1991) in their article also covered mainly ES in information search and retrieval providing 141 references. A review article by Morris (1991a) which aimed to be comprehensive in covering six areas of LIS contained 103 references. The latest review article that could be located is by Poulter, Morris and Dow (1994) and has 144 references. However, their article was con-cerned with knowledge engineering and

Figure 2 Number of References on Expert Systems Application in LIS by Year



and did not attempt to summarise progress in specific application areas within LIS.

ES IN TECHNICAL SERVICES

The primary reason for developing ES for technical services is to bring the improvements that technology can provide to bear in existing tasks (Hawks, 1994). Literature shows too that more effort has been expen-ded in developing ES applications for tech-nical services (Drenth and Morris, 1992; Fenly, 1992; Dabke, Thomas and Shams, 1992; Jeng, 1995), especially in the do-mains of cataloguing and classification. The complexity of each of these tasks and the availability of guidelines for perform-ing them have spurred the development of ES for technical services.

ES in Cataloguing

According to Davies (1986), cataloguing is a possible domain of application for ES because it has certain characteristics such as; there are recognised experts, the experts are demonstrably better than amateurs, the task takes an expert a few minutes to a few hours, the task is primarily cognitive, and the skill is routinely taught to neophytes. The 1980s saw a huge increase in activity along with the popularity of developing ES and knowledge-based systems in the sub-domain of cataloguing. Three streams of researchers emerged; those interested in developing systems to give advice on the application of rules (advisory programs), those concerned with record creation, and those more absorbed with automating the whole process (Morris, 1992).

Advisory programs in Cataloguing

One of the earliest attempts at developing an advisory system for cataloguing was by Black and colleagues (1985). They built two versions of a system called HEADS using the shells ESP Advisor and SAGE. The system was supposed to enable users to browse through the text of the code or to obtain advice regarding a particular

field in a record, or to work through the com-plete cataloguing procedure. However, both shells had poor string-handling facilities and thus were unable to support certain rules, such as those dealing with hyphe-nated surnames.

The following year, Eyre (1986) at the Po-lytechnic of North London developed a system that dealt with the form of names of persons. The knowledge base was deriv-ed from Chapter 22 of Anglo-American Cataloguing Rules second revised edition (AACR2). The system was written in PRO-LOG and was more of an exercise in learn-ing about the language rather than an at-tempt to design a useful system.

Another example is a limited person-ma-chine interface developed in Wisconsin (Epstein, 1987). This is the MITINET/ MARC system for microcomputer cataloguing ap-plications. MITINET/MARC provides the user with prompts and instructions for entering bibliographic data and giving appropriate MARC format.

CATALYST was another advisory ES sys-tem. It was developed by Gibb and Sharif (1988) using the shell ESP Advisor to enable researchers to add canned explana-tory text, so that users could ask for more information to be displayed about terms or menu choices that they did not understand on request. A more detailed and specia-lised ES has been produced by Ercegovac (1990) called MAPPER where MAPPER's knowledge base consists of relevant AACR2 rules and the knowledge of experts in map cataloguing.

MacCat, like MAPPER, developed at the University of California, Los Angeles by Maccaferri (quoted by Morris, 1991a) used Apple's Hypercard environment. MacCat is intended for establishing headings, together with their MARC field and sub-field codes. Since MacCat is implemented on the Apple Macintosh, full advantage is taken of the mouse and icons for entering data. This makes it more flexible than ear-lier systems that force the user to proceed through chains of menus one step at a time. Another system which makes extensive use of windows was designed by Piotr Murasik (quoted by Davies 1991), of Gdansk Uni-versity in Poland, called APEX (Access Point EXpert). Written in PROLOG, it was completed in early 1991. Like MacCat, users are allowed short cuts so that they do not have to go through the entire catalo-guing procedure to provide a bibliographic record.

CatTutor, a hypertext prototype tutorial for training cataloguers to provide descriptive cataloguing of computer files, was deve-loped by the National Agricultural Library (NAL). Included in the program are portions of the AACR2, the MARC format for computer files, a glossary, five illustra-tive bibliographic records accompanied by instructional text, quizzes, and a mastery test. Evaluators were enthusiastic about computer-assisted training and the ma-chine-readable versions of the AACR2 and MARC format was integrated in the pro-gram. It was felt, however, that the pro-gram must be redesigned to create dif-ferent paths for different levels of exper-tise of the users, or it must be directed at a single type of user (Thomas, 1992).

CONFER is an ES guide built using the ES shell CRYSTAL. CONFER does not produce a catalogue entry but guides the novice cataloguer to the appropriate AACR2 rules and format of main entry headings for conference proceedings (Zainab, 1991). An upgrade of the system, called CONFER version 2, was developed under CRYSTAL 4.50 to guide both novice and student cata-loguers. It was tested with graduate library science students and found to be effective in enhancing the trainee cataloguers' learn-ing process in handling conference procee-dings documents (Zainab, 1996).

Another aspect of research done in this area is the formation of public knowledge in cataloguing presented in various rules and standards of cataloguing, such as AACR2. Codification of such public knowledge is essential as it serves as the basis on which human heuristics can be applied and interpreted into rules (Jeng and Weiss, 1994). An attempt was made by Jeng (1991b) to study the logical structure of such public rules in a knowledge base. She argues that rules for description as they are presented and grouped in the mnemonic structure of Part I of AACR2 cannot be used as logical base for codification. The rules must be further studied and broken down into logical condition / action pairs before they are codified into the knowledge base. To this extent, Smith, et al. (1993) developed an ES called the AACR2 EXPERT which provides an algorithmic approach to the use of AACR2.

Meador and Wittig (1991) conducted a study to determine and then to compare the cores of AACR2 rules used in assigning access points for random samples of mo-nographs in chemistry and a subset of economics. They found that there were differences in the usage of AACR2 rules for assigning main entry to books in the two disciplines under study. They sug-gested that the creation of a subset of rules is necessary if an ES for automatic catalo-guing is to be built. Furthermore, the weight-ing of certain rules according to the dis-cipline to which the catalogued material belongs would aid the development of a more sophisticated system, one that re-quired less decision-making on the part of the cataloguer.

ES for Record creation in cataloguing

Attempts to integrate the advisory approach with software that could produce catalogue records were first undertaken by Davies and James (1984). They conducted the Exeter Project which investigated the tech-nical feasibility of encoding parts of the AACR2 rules concerning the selection of the main entry. The project, although not successful due to the failure of the pro-gram that reallocates space, was the first attempt to develop an ES that can give advice on the application of cataloguing rules (James, 1983).

The following year, Hjerppe, Olander and Marklund (1985) conducted the well-known ESSCAPE (Expert System for Simple Choice of Access Points for Entries) Pro-ject in Sweden, which resulted in the creation of two ES - ESSCAPE/EMYCIN and ESSCAPE /Expert-Trees. Rather than producing systems for practical use, the aim was to discover issues entailed in the creation of

the knowledge base (Hjerppe and Olander, 1985; 1989).

Weiss (1994) reported in his article of the Expert Assistant Project at the National Li-brary of Medicine (NLM). The system was designed to assist the human cataloguer in selecting the form of a personal name heading to be used in catalogue records and create the local authority record. The author reported that the NLM did not gain the production ES that it had originally hoped for due to the reasons reported in the literature.

ES for Automated cataloguing

Interest in this area started with Ann M. Sandberg-Fox in 1972 who conducted a pioneer study as her doctoral research at the University of Illinois at Urbana-Champaign. The study addressed the conceptual issues on determining whether the human intellectual process of selecting main entry could be simulated by computers.

It was only a decade later, in the late 1980s when interest in this area picked up again. One research in Germany produced a system called AUTOCAT (Endres-Nigge-meyer and Knorz, 1987), which attempted to generate bibliographic records of perio-dical literature in the physical sciences that were available in machine-readable form.

Another significant work was undertaken by Weibel, Oskins and Vizine-Goetz (1989). They built a prototype rule-based ES at OCLC known as "the OCLC Automated Title Page Cataloguing Project" to auto-mate descriptive cataloguing from title pages. The system used OCR techniques and their study reports a success rate of 75% in identifying and interpreting biblio-graphic data on title pages using visual and linguistic characteristics codified in only 16 rules.

Elaine Svenonius, like Weibel, was concerned with the interpretation of machine-readable title pages of English language monographs. Her research, however, focused on the problem of automatically deriving name access points, particularly personal names and corporate names (Svenonius and Molto, 1990). In their study, Molto and Svenonius (1991) propose an algorithm for identifying corporate names by creating a machine-readable corporate name authority file, and matching character string sequences on the title pages with those in authority file. In formulating an algorithm for identifying personal names, they effectively use the initial element cues (i.e., first name, initials, titles) and post-name markers (such as punctuation or spacing). The results of their study show high success rates of more than 84% in identifying both kinds of names.

The QUALCAT (Quality Control in Cataloguing) project at the University of Bradford attempted to apply automated quality control to databases of bibliographic records. Sets of records, putative duplicates that appeared to be for the same monograph were grouped together and an ES used to determine whether they were in fact duplicates, and if so which were the best records (Ridley, 1992; Ayres, 1994). Table 1 gives a summary of the names of the ES developed (if one is clearly in-

Table 1: Expert Systems in Cataloguing

NAME	DEVELOPER	YEAR
*	Davies, Roy and Brian James	1984
*	Eyre, J	1986
*	Jeng, Ling Hwey	1986
*	Weibel, Stuart, William Oskins and Diane Vizine-Goetz	1989
*	Svenonius, Elaine and Mavis Molto	1990
AACR2EXPERT	Smith, David, et al.	1993
APEX	Murasik, Piotr	1991
AUTOCAT	Endres-Niggemeyer, B and G Knorz	1987
CATALYST	Gibb, Forbes and Carolyn Sharif	1988
CatTutor	Thomas, Sarah E	1992
CONFER	Zainab Awang Ngah	1991
CONFER2	Zainab Awang Ngah	1996
ESSCAPE	Hjerppe, Roland, Birgitta Olander and Kari Marklund	1985
Expert Assistant	Weiss, Paul J	1994
HEADS	Black, W J, P Hargreaves and P B Mayes	1985
MacCat	Maccaferri	1991
MAPPER	Ercegovac, Zorana	1990
MITINET/marc	Epstein, Hank	1987
NAMA	Juliaton Mohd Jawaini	1995
QUALCAT	Ridley, M J	1992
QUALCAT	Ayres, F H	1994
SYNONAME	Siegfried, Susan and J Bernstein	1991

* Unnamed systems

indicated in the article), the developer's name(s) and the year it was reported in published literature.

ES in Classification

Classification is a difficult function to cap-ture in an ES. While there are guides to de-termine classification numbers and subject headings, there are no strict rules available, and the relationships between objects and classes are often ambiguous. Among some of the systems that have been developed on item, patent and book classification are by Sharif (1988); Valkonen and Nykanen (1991); Cosgrove and Weimann (1992); Gopinath and Prasad (1994); Savic (1994); Gowtham (1995).

In 1986, Paul Burton conducted an exploratory research at the University of Strathclyde in the United Kingdom, aiming to assess the merits of various ways of knowledge representation and to assess the suitability of ES in classification. The research resulted in a prototype ES that was able to advise a Dewey classification number based on the information provided by the user, to justify the reasoning and to explain why the ES asked certain questions. Following the research, OCLC deve-loped Cataloguer's Assistant, and tested it at the Carnegie-Mellon University to reclassify the mathematics and computer science collection. The experiment looks closely at research questions such as know-ledge representation, the navigation tools, the

search capabilities and the various ways of displaying data.

CUTT-x, an ES for automatic assignment of Cutter numbers (Savic, 1996) was developed using Microsoft ACCESS relational database in the MS-Windows personal computer based environment. On evaluation, it was found that the system performed well for the International Civil Aviation Organisation Library. Savic noted that libraries require more complex cut-tering and therefore would require a more complex CUTT-x system.

ShelfPro, developed by Drabenstott, Riester and Dede (1992) addresses shelflisting. Shelflisting is concerned with assigning a book number, as opposed to the class mark portion of the call number, to an item.

The Defence Metallurgical Research Labo-ratory in Hyderabad, India developed an ES for classification of technical docu-ments using the Universial Decimal Clas-sification (UDC) schedule for metallurgy as the knowledge base and the UDC classi-fication as its rule base (Gowtham, 1995). Some benefits of the ES are that: it inter-acts with the classifier making them con-form to the route suggested by the classi-fication scheme; it alerts the classifier to the minor variations in the scheme thus avoiding overlooking them; it leads to consistency in class number generation; and it ensures that the classifier has incor-porated all the concepts of the subject in the class number, by leading him/her through all the groups, which is not possible in the manual UDC scheme. Table 2 gives a summary of all systems develop-ed for classification and the developers involved.

ES IN PUBLIC SERVICES

Reference Services

The first experiments in the automated provision of reference services began in the 1960s. A method of characterising bio-

Table 2: Expert Systems in Classification

NAME	DEVELOPER	YEAR
*	Burton, Paul	1986
*	Sharif, Caroline A Y	1988
*	Valkonen, Pekka and Olli Nyakanen	1991
*	Cosgrove, S J and J M Weimann	1992
*	Liu, Songqiao	1993
*	Gopinath, M A and A R D Prasad	1994
*	Gowtham, M S	1995
CLOD-x	Savic, Dobrica	1994
CUTT-x	Savic, Dobrica	1996
ShelfPro	Drabenstott, Karen Markey, Leslie C Riester and Bonnie A Dede	1992

* Unnamed systems

graphical reference books for the purpose of retrieving those most likely to answer particular biographical queries was developed at the University of Chicago (Weil, 1968) while at Berkeley REFSEARCH was based on a careful analysis of the characteristics of reference questions, such as how topics are qualified, and the func-

tions of the works used to answer them (Meredith, 1971). REFSEARCH therefore, embodied a more realistic model of the reference process.

One of the earliest systems developed to answer routine enquiries was REFLES1 (Reference Librarian Enhancement System) developed at the University of California, Los Angeles (UCLA) in the late 1970s (Bivins and Palmer, 1980). It was a microcomputer-based system for in-house data files of information about library facilities, services and operations, and also gave details of specific types of library materials along with some 'how to use' comments on the catalogue, abstracting and services. An enhanced version of REFLES1, called REFLINK, was subsequently produced at Linkoping University in Sweden (Bivins and Eriksson, 1982).
In 1983 Purdue University Undergraduate Library in Indiana introduced its Reference and Information Station for public use (Smith, 1989). It was found that most of the questions received at the reference desk could be grouped into nine categories, with another nine subcategories, and these were used in the design of a menu-based system which runs on both Apple and IBM microcomputers. Another microcomputer-based, menu-driven ready reference system known as the Information Machine was produced at the University of Houston Li-brary (Fadell and Myers, 1989). Graphics were used to illustrate floor layouts to help with directional enquiries. Currently work is being done on an ES that would be developed for selecting reference works and later linked to the Information Machine.

The Online Reference System (ORS) (Chis-man and Treat, 1984) was designed to pro-vide menu access to MARC records of 1000 reference works in the science library
of the Bowling Green State University in North Carolina by subject (using broad categories based on the Library of Congress Classification), type of material, or course name and number.
A prototype reference system, DISTREF, for students taking courses by distance learning offered by Charles Sturt University in Australia was designed to provide assistance in the choice of search terms by using 'discipline maps' (McDonald and Weckert, 1990). DISTREF is an ES which is intended to link with a union catalogue on CD-ROM of the holdings of a wide range of libraries in New South Wales.

The Workstation for Information Seekers planned by Micco and Smith (1989) is intended to provide access to a thesauri of terms on maps. The system is used for searching reference works which would be stored, along with the thesauri and catalogues of various collections, on a CD-ROM jukebox. Search strategies employing ES techniques, including user modelling are used to narrow the search space.

POINTER was one of the first systems to be used routinely. It was developed at the State University of New York at Buffalo for providing assistance in finding US government publications when regular staff members were not available (Smith, 1986; 1989). Two types of searches are catered for by POINTER: enquirers wanting speci-fic documents are given their SuDoc numbers; subject searching is also possible but there is difficulty in

devising a suitable conceptual framework for the organisation of the menus.

The Patent Information Assistant (which is also explained in the section under ES for Retrieval in Subject Domains) was deve-loped at the University of Austin to handle the time consuming and repetitive nature of patent enquiries (Ardis, 1990). It is menu driven and allows searches by patent num-ber, inventor's name, assignee name, class/ subclass, and keyword. Access is provided to external databases chosen according to the type of search.

The ES Reference Expert (Bailey and Gunning, 1990; Gunning, 1992) has a knowledge base that is based on interviews with the library reference staff. Reference and library systems staff, working as knowledge engineers, clearly recognised the experts' difficulty in articulating their knowledge and the limits of the software in representing the complexity of that knowledge. To encourage ongoing input, they developed prototypes, left them in the work area for experimentation with a log for comments, and on the basis of this feed-back from the experts, incrementally ex-tended the knowledge base. Three proto-types of Reference Expert were developed; one using KnowledgePro, another using VP-Expert, and the third using PDC Pro-log (Bailey, 1992). In the end, Prolog was chosen for the working model since it gave better performance and control over the finished product than the shells. Although the Prolog version was faster than the shells, the size of the knowledge base (over 230kb) slowed the system to unacceptable levels until a method of reducing the sys-tem load was devised.

Online Reference for Expertise in Opera (ORFEO) recommends sources to answer questions about opera. It contains a knowledge base developed from one major bibliography of 700 items, plus some items added by Gerber (1992). This system is based on the "given (the information known by the client) and wanted (the information required by the client)" notion of reference theory and is purely a prototype. Another subject specific reference ES was AquaRef. It was designed by the U.S. National Agricultural Library to give assis-tance with a limited range of frequently asked reference questions about aquacul-ture (Haufman, 1989). AquaRef was design-ed as a result of experiences with an earlier ES Answerman (Waters, 1986). Answer-man was one of the first expert advisory systems with links to external databases produced also by the National Agricultural Library. It was created for demonstration purposes using the shell 1st-class. Its domain is ready reference enquiries in agriculture by giving details of relevant books, sometimes including specific page numbers, or by allowing the user to search a database such as Agricola.

ChemRef, a guide to reference sources in chemistry, was developed at Nova University in Florida (Sarangapani, 1990). When compared with the performance of experienced reference librarians, it was found that ChemRef was capable of operating at a level comparable to or better than library staff. The system however, has a tendency to recommend a much greater number of titles.

Smith (1992) used the shell EXSYS to develop a production rule-based advisor to help library assistants locate appropriate

reference material to answer questions on New Zealand. NZRef, like ORFEO, is based on the notion that a reference question is of given and wanted type as mentioned earlier. Smith judged the rule structure to be a limited but useful way to represent knowledge about sources. One difficulty he noted was that certain combinations of rules used for particular reference tasks created unsuitable recommendations and, to suppress these, special rules had to be added to the knowledge base. Another difficulty was that not all members of a class of information sources could have a general set of rules applied. He argues that frames would provide better representation where differences are important.

REFSIM, an ES designed by Parrott (1989) used frames as a model for the reference process. Each dialogue with a client was driven by the need to fill in slots in types of frames. Types of transactions were direc-tional, holdings, ready reference, and sub-stantive. There were also frames for the librarian and the client. REFSIM was de-signed to simulate both the librarian and the enquirer so that it can be used not only for answering queries but also as a tutorial system for instructing users, including no-vice librarians. REFSIM is the successor to the Online Reference Assistance system (ORA) (Binkley and Parrott, 1987) which was a menu-driven system but of a more complex nature than most referral systems. In enquiries about the library's holdings, ORA would use an ES for interpreting citations in cases where the enquirer could not distinguish properly between the diffe-rent fields in the bibliographic reference (Parrott, 1986).

Harley and Knobloch (1991) built Govern-ment Documents Reference Aid (GDRA) to investigate the value of an ES to enhance user access to these publications at Stan-ford University Library. The second and third phases of their project involved an investigation and evaluation of the availa-ble ES shells.

The University Library of Gronigen in the Netherlands, COWOG (Centre for Research on Higher Education) and PICA (the Dutch Organisation for Library Automation), de-

veloped a computer assisted bibliographic reference and advisory system - CoBRA (Bosman, 1994). It is an ES that advises users of the University Library when they want to execute a search for literature on a certain subject and produces custom made guides to the literature in the library.

Another standalone ES, MAKLUM, was developed for the University of Malaya Library using the ES shell CRYSTAL 4.50 running on DOS (Zainab and Nor Eliza, 1996). MAKLUM was designed to provide answers to general reference enquiries relating to library facilities, services, regu-lations, loans, membership, location of items, and public amenities.

Sourcefinder (SOFI) is an ES consisting of a database of annotated reference sources, using the Nota Bene software, which serves as a support for reference services at the reference desk of the Main Library at Ohio State University (Stalker, 1996). SOFI is used by new reference librarians as a training aid, by experienced librarians in unfamiliar subject areas and has the po-tential to be when reference librarians are

unavailable. Table 3 gives a summary of ES developed in reference services.

Table 3: Expert Systems in Reference Services

NAME	DEVELOPER	YEAR
*	Weil, C B	1968
*	Cavanagh, Joseph M A	1987
*	Richardson, John	1989
*	Butkovitch, Nancy J, et al.	1989
*	Vedder, Richard G, et al.	1989
*	Metzger, Paul	1993
Answerman	Waters, Samuel T	1986
AquaRef	Haufman, Deborah	1989
ChemRef	Sarangapani, Chet	1990
CoBRA/RUG	Bosman, F	1994
DISTREF	McDonald, Craig and John Weckert	1990
Government Documents Reference Aid (GDRA)	Harley, Bruce L and Patricia J Knobloch	1991
Information Machine	Fadell, Jeff and Judy E Myers	1989
KARMA	Liebowitz, Jay and Christine Letsky	1996
MAKLUM	Zainab Awang Ngah and Nor Eliza Mohd Zaid	1996
NZRef	Smith, Alastair	1992
Online Reference Assistance (ORA)	Binkley, R D and James R Parrott	1987
Online Reference System (ORS)	Chisman, J and W Treat	1984
ORFEO	Gerber, Brian	1992
PLEXUS	Vickery, Alina and Helen M Brooks	1987
POINTER	Smith, Karen F	1986
RAS	Carande, R	1989
Reference and Information Station	Smith, Dana E	1989
Reference Expert	Bailey, Charles W and Kathleen Gunning	1990
Reference Expert	Bailey, Charles W	1992
REFLES1	Bivins, K T and R C Palmer	1980
REFLINK	Bivins, K T and L Eriksson	1982
REFSEARCH	Meredith, J C	1971
Refsearch	White, H D and D Woodward	1990
REFSIM	Parrott, James R	1988
Sourcefinder (SOFI)	Stalker, J C	1996
Workstation for Information Seekers	Micco, Mary H and Irma Smith	1989

* Unnamed systems

Information Search and Retrieval

The area of most activity, having the longest history and the largest number of research and development activities, is work on expert search intermediaries. The purpose of much of the work is to make online systems directly accessible to end users without the need to rely on human inter-mediaries (Smith, 1987). This section con-siders expert intermediary systems in the context of both their role in relation to end users - that of search advisor, intelligent front end, or intelligent intermediary - and their role in the search process (as search formulation experts, for example).

Search Advisors

Search advisors are expert intermediary systems that aim not only to assist or advise end users but also to train them in online searching. The search advisors developed to date focus on search tactics, particularly on monitoring the progress of

a search and on selecting or revising search terms.

The first of these systems was Individualised Instruction for Data Access System (IIDA) (Meadow, 1979; Meadow, Hewett and Aversa, 1982a; 1982b). It was designed to help scientists and technicians learn online bibliographic searching of DIALOG in order to obtain a few good references rather than attempting complex searches. IIDA was reactive, providing assistance only when the user made a mistake or when aid was specifically requested. In addition to dealing with syntactic errors, IIDA detected and offered advice on null sets retrieved, repetitive use of commands, unused sets, rapid shifts in search objectives, and the overuse of a single approach to a search.

Meadow continued his work on expert advisory systems for online bibliographic searching with the Online Access to Know-ledge (OAK) project. He developed OAK-DEC, available as a menu option in OAK (Meadow, 1988). OAKDEC is rule based and uses factors such as the set size, the number of records reviewed by the user, and the user's evaluation of records to arrive at a recommendation.

Another search advisor was the Intelligent Database Enquiry Assistant (IDEA) developed by Houghton, Rich and Bass (1987). It comprised a Tutor, an Advisor, and a User Question Handler. The Tutor presented text describing the system and an inter-active lesson. The Advisor offered advice on the choice of database and keywords, giving general advice such as "try more general terms," and suggesting alter-native terms. The User Question Handler dealt with questions of why, what, and how, such as "How do I narrow a search?"

Intelligent Front Ends

Expert intermediaries that act as intelligent front ends to online services are closely related to advisory systems. These front ends intervene in the search process to a greater or lesser extent. Their primary aim is to provide trouble-free access to online services. Early intelligent front ends focused on search tactics, especially those concerned with search formulation and the selection of terms. Presently, this approach has been broadened to support a fuller intermediary role, incorporating know-ledge relating to the selection of databases and search strategies.

Marcus and Reintjes (1981) developed the Connector for Networked Information Transfer (CONIT) to aid end-user searching in overcoming the complexity and diversity of online search systems. CONIT gave user-friendly access to several hosts by means of a simple common-command language. CONIT also included some limited facilities for reformulating searches, such as automatically rerunning a search with exact terms only when too many references were retrieved. Another system, EXPERT took a more active role in the search process, by suggesting suitable databases and prompting the user for terms and synonyms before translating them into Boolean search statements (Marcus, 1981). OASIS also followed this "worksheet" approach to online searching, one of its main objectives being to reduce the amount of time spent online (Williams, 1984, 1985; Williams and Goldsmith, 1982). Both EXPERT and

OASIS could suggest tactics for broadening or narrow-ing a search according to the number of postings found.

The evolution of ES as intelligent front ends was improved further by the use of natural-language user interfaces. The Infor-mation Retrieval Natural Language Inter-face (IR-NLI) (Guida and Tasso, 1983) aimed to provide an intermediary system that could both comprehend a user's search request and identify the underlying infor-mation need. The EURISKO (Barthes, Frontin and Glize, 1987) prototype also used natural language processing which searched scientific databases on the Ques-tel and Cedocar online services. Though EURISKO could not suggest suitable search terms unlike IR-NLI, it came closer to fulfilling an intermediary role because it used knowledge derived from human inter-mediaries to suggest suitable databases according to the query subject and the types of document required.

IR-NLI II (Brajnik, Guida and Tasso, 1990) incorporates user modeling into a domain-independent bibliographic retrie-val ES. Domain knowledge is supplied separately by an online thesaurus. The ES clarifies its model of the query, proposes terms to expand the query, and comments on the user's search strategy. No automatic query reformulation is done.

Fox (1987) developed CODER using μ-Prolog (a logic programming language used for knowledge representation) to build a complex, multi-tiered system for docu-ment retrieval. CODER, like IR-NLI, used a natural language interface. Lucarella and Morara (1991) have attempted to extend the representative power of Prolog by building with it a document retrieval sys-tem, FIRST (Fuzzy Information Retrieval SysTem), which uses fuzzy instead of Boolean logic.

Tome Searcher, an intelligent front end which uses a natural language interface for searching online databases in mainframe hosts in the fields of electrical/electronic engineering, computer science, and infor-mation technology, was launched com-mercially in 1988 (Vickery, 1988). How-ever, it did not prove to be viable com-mercially.

Intelligent Intermediaries

Intelligent intermediaries refer to systems developed to investigate intelligent ap-proaches to the information retrieval pro-cess rather than to interface to existing online services. These systems have inte-grated document collections and do not use the exact-match retrieval techniques found in conventional retrieval systems. Some of these systems draw on knowledge of users and search tactics to interpret and elaborate search requests. Others use knowledge of the concepts represented in a document base to effect retrieval and so avoid many of the problem-solving tasks associated with human information intermediaries. Although they do not incorporate inter-mediary knowledge, these systems suggest new approaches to the intermediary func-tion that might be integrated into expert intermediary systems.

The intelligent information retrieval sys-tems that incorporate intermediary exper-tise have a distributed ES architecture.

The Intelligent Interface for Information Retrie-val (I^3R) (Croft and Thompson, 1987) had experts for user modeling and modeling the search request, a domain knowledge expert that could infer related search concepts, a search controller that selected one of two available retrieval techniques, a browsing expert, and an explainer.

The Composite Document Expert/Extend-ed/Effective Retrieval (CODER) system, another distributed ES was developed by Fox (1987) as a test bed for analysis, fil-ing, and retrieving documents with widely differing contents and structures, such as those generated within electronic mailing systems. CODER was unique in that it could be distributed over several machines and included a temporal reasoning expert to identify, parse, and represent query expressions relating to dates.

Other efforts in intelligent information re-trieval concentrated on knowledge-inten-sive retrieval techniques. In the IOTA in-formation retrieval system, which incor-porates a natural language interface, deve-loped by Chiaramella and Defude (1987), every component of a document - title and fragments of text - was indexed by noun phrases organised into a hierarchical tree representing the document content. Re-trieved references were evaluated, and if judged inappropriate, IOTA set a goal, such as "reduce the number of refe-rences", and reformulated the query.

Browsing is another knowledge-intensive retrieval technique in which the relation-ships among documents, terms, and other bibliographic information are represented as a network, which the searcher can exa-mine and use to identify the documents required, as in the THOMAS system (Oddy, 1977). A browsing interface is also planned for the KIWI system.

The Improving Library Subject Access (ILSA) prototype ES was developed at In-diana University of Pennsylvania using an object oriented multimedia user interface with two databases; one with 100,000 MARC records and the other with 20,000 addition-al records enhanced with table of contents data (Micco, 1994). Items are grouped into subject clusters consisting of the classifica-tion number and the first subject heading assigned. Every other distinct keyword in the MARC record is linked to the subject cluster in an automated natural language mapping scheme, which leads the user from the term entered to the controlled vocabu-lary of the subject clusters in which the term appears. The use of a hierarchical classification number (DDC) makes it possi-ble to broaden or narrow a search result.

Rule-Based Retrieval of Information by Computer (RUBRIC) was another knowledge -intensive information retrieval system (McCune, et al., 1985; Tong, et al., 1985, 1987); a commercial version of it is now available as Topic (CISLER). Topic pro-vides for Boolean searching and for brow-sing by hyper-textual links. The RUBRIC system is one of the few systems to provide intelligent assistance for full-text searching. The Empty software for Common Knowl-edge Transfer (ESOCKS), an ES shell for document retrieval developed by Hitachi (Yasunobu, et al., 1989), uses a technique similar to that of Topic. On finding docu-ments,

ESOCKS assigns each one a rele-vance value so the user can decide which documents to display.

Expert Systems in Query Formulation

The Comprehensive Information Retrieval Computer Environment (CIRCE) was one of the first systems to address the problem of elaborating the search topic prior to formal specification of the search (Aragon-Rami-rez and Paice, 1985). The user entered a set of terms describing a query, and these were matched against thesaurus terms. The thesaurus resides in the knowledge base. When some degree of match was found, terms were displayed for evaluation in order of their relevance.

In frame-based systems, such as the environmental pollution expert EP-X (Krawczak, et al., 1985), CoalSORT (Monarch and Carbonell, 1987), and the PLEXUS referral system on gardening (Vickery, et al., 1987; Vickery and Brooks, 1987b), topics and associated concepts and terms are represented explicitly, reflecting, in effect, the subject-based knowledge that human intermediary brings to the interpretation of search topics. In PLEXUS, for example, entering a query activated a set of frames describing the search topic; these were used to identify any ambiguities and elicit the information needed to complete the problem description. PLEXUS was written in Turbo Pascal and Prolog, al-though the former was chosen for the final prototype because: (1) at the time the programs were being written, no Prolog compiler was available for microProlog, so run-times were very slow; (2) loading the Prolog databases was very slow; and (3) interfacing of microProlog and Pascal needed a significant amount of specialised work that was too costly. These problems were exacerbated by the growth from an original projection of a rule base of approximately 250 rules to over 1,000 rules, including a number of rule sets.

To measure the success of a search and decide whether to reformulate the search statement, intermediaries frequently look at the number of references retrieved, the "correct" number being determined by user requirements. The reformulation of search strategies according to the number of refe-rences retrieved has been addressed by a number of systems, including those deve-loped by Marcus (1981), Williams (1984, 1985), Barthes, Frontin and Glize (1987), Gauch and Smith (1989), and Sormunen (1989). The tactics used in all these sys-tems were independent of the subject do-main and focused on broadening or nar-rowing the search strategy.

Experts for Database Selection

The problem of choosing suitable on-line sources has only recently received much attention. Among some of the systems developed are Marcus's work with automatic database selection in CONIT (1981), and EURISKO that ranks databases on the basis of subject coverage (Barthes, Frontin and Glize, 1987). The expert selectors designed by Thornburg (1987), Morris, Tseng and Newham (1988) and Drenth, Tseng and Morris (1991) drew on the expertise of human intermediaries in selec-ting databases for topic areas. Wang (1990) has developed a database selector for busi-ness queries. Trautman and von Flittner (1989) used printed guides to

online sources for their ES knowledge with the purpose of developing a stand-alone aid to databases rather than to investigate the database-selection problem.

Kiwinet is an experimental prototype for advising on selection of databases on the Kiwinet online service. It is a very small system built to permit comparison of the commercial shells EXSYS and ESIE. Smith (1991) chose these because both had been used for previous LIS applications. EXSYS was more flexible in that it allow-ed multiple recommendations of reference sources ranked by a probability value, whereas ESIE could return only one refe-rence source recommendation. In pro-viding explanations to the user, EXSYS displayed the current rule under consi-deration and the facts collated to date, while ESIE simply used a trace me-chanism to show the thinking to date. Both provided for backward chaining through the knowledge base.

Sajjad Zahir and Chew (1992) also deve-loped a prototype for the selection of on-line databases named Online-Expert. The results of their evaluation of the system compared favourably with those of experts using traditional searching, considering that the system contained only 60 of a possible 150 databases available to the experts.

Drenth and Morris (1992) chose a shell for their proposed ES CIDA (Company Infor-mation Database Advisor) to select online sources for business enquiries. They report that in addition to the many desirable development features of shells, they are cost effective, their developers offer good support, and future clients are likely to have the hardware requirements to run a shell-based system. In a later paper, Mor-ris, Drenth and Tseng (1993) discuss the knowledge engineering problems resulting from slow execution speed and severe memory problems. They needed to edit the knowledge base severely, reorganise the knowledge representation, and rewrite se-veral external files.

ES for Retrieval in Subject Domains

A number of ES for assisting searches in specific subject domains have been deve-loped. These include NP-X (natural pro-ducts chemistry), EP-X (environmental pollution), CANSEARCH (cancer therapy), GENSEARCH (biomedical genetics) and Coach - the expert searching system de-signed to help users of the Grateful Med front end software to improve MEDLINE search and retrieval capabilities (King-sland, 1993). Pollitt says that the strength of this knowledge lies in the fact that domain-specific knowledge can be applied to improve the system's overall perfor-mance. CANSEARCH (Pollitt, 1984, 1987) is one of the earliest ES for bibliographic retrieval. The ES contains knowledge of a single domain, cancer, rather than search strategies in general. During the query reformulation process, the ES guides the searcher through a hierarchy of menus.

The Patent Information Assistant (Ardis, 1990) was developed jointly by two pro-grammers and two patent reference libra-rians, who used an iterative approach. The team has identified interface screens that need rewriting, and the developers wish to add a module to explain the differences

between trade marks and patents. Ardis also comments that the system never tires, is never irritated, can often give users customised information in a more individual way than the staff has time to provide, which suits the confidential nature of many of the inquiries.

EP-X (Krawczak, Smith and Shuter, 1987; Smith et al., 1989) is a prototype knowledge-based system that assists users in conducting bibliographic searches of the environmental pollution literature. This system makes extensive use of domain knowledge, represented as hierarchically defined semantic primitives and frames. The user enters a query as a list of keywords and the system interacts with him to suggest possible broadening or narrowing operations. Table 4 gives a summary of all systems being developed in the domain of search and retrieval.

ES IN DOCUMENT DELIVERY

There were only two references found pertaining to document delivery. The first reports a system developed by Brown (1993b) and the other by Abate (1995). Brown described the use of ES technology at Raytheon Company's equipment division to co-ordinate requests for specifications and standards documents with purchases made through the acquisitions unit. She further discussed the development of a knowledge base using the shell VP-Expert. Abate reported on an ES which was deve-loped for document delivery decision ma-king in the library of a law firm using the ES shell, VP-Expert. The summary of systems developed is given in Table 5.

ES IN ABSTRACTING

Most of the research in abstracting has been concerned with abstracting papers from learned journals and conference proceedings. The first reported experiment on automatic abstracting was in 1958 by Luhn. Since then, other systems have been developed by DeJong (1983), Kuhlen (1984), Lebowitz (1986), Husk (1988), Black and Johnson (1988), Johnson (1988), Rau, Jacobs and Zernik (1989), Black (1990), Jacobs and Rau (1990), Paice (1990), and Endres-Niggemeyer (1995). DeJong (1982) produced the FRUMP system that analyses newspaper articles using frame-based techniques. The articles are scanned and data are automatically fed into various slots within frames. Scripts are then used to generate summaries of the information held in the relevant frames.

Another system, which reports on corporate mergers and acquisitions, was developed by Rau, Jacobs and Zernik (1989). Known as SCISOR, this system produced a detailed linguistic analysis of a text from which a semantic graph is constructed.

Table 4: Expert Systems in Information Search and Retrieval

NAME	DEVELOPER	YEAR
*	Marcus, Richard S and J Francis Reintjes	1981
*	Williams, Philip W and G Goldsmith	1982
*	Meadow, Charles T, Thomas T Hewett and Elizabeth S Aversa	1982
*	Guida, Giovanni and Carlo Tasso	1983

*	Pollitt, A Steven	1984
*	Smith, Philip J and Mark Chignell	1984
*	Thompson, Roger H and W Bruce Croft	1985
*	Zarri, Gian Piero	1985
*	Crawford, R G and H S Becker	1986
*	Desalvo, Daniel A and Jay Liebowitz	1986
*	Borgman, Christine L	1986
*	Watters, R C, M A Shepherd and W Robertson	1987
*	Morris, Anne, Gwyneth M Tseng and Godfrey Newham	1988
*	Yasunobu, Chizuko, et al.	1989
*	Gauch, Susan and John B Smith	1989
*	Trautman, Rodes and Sara von Flittner	1989
*	Drenth, Hilary J, Gwyneth Tseng and Anne Morris	1991
*	Blackadder, Alistair	1991
*	Gauch, Susan and John B Smith	1993
*	Khoo, Christopher S G and Danny C C Poo	1994
AGRIRES	Konig, Eckehard	1992
ARGON	Patel-Schneider, Peter F, Ronald J Brachman & Hector J Levesque	1984
CANSEARCH	Pollitt, A Steven	1987
COACH	Kingsland, L C	1993
CODER	Fox, Edward A	1987
DIALECT2	Bassano, J C, M Braunworth and W Mekaouche	1992
EP-X	Krawczak, Deborah A, et al.	1985
Eurisko	Barthes, Christine, J Frontin and Pierre Glize	1987
European Research Letter	Ford, Nigel	1991
FIRST	Lucarella, D and R Morara	1991
I^3R	Croft, Bruce W and Roger H Thompson	1987
IDEA	Houghton, Tony, Clive Rich and Andrew Bass	1987
ILSA	Micco, Mary H	1994
INFOS	Obermeier, Klaus K and Linda E Cooper	1984
IOTA	Chiaramella, Y and B Defude	1987
KIWINET	Smith, Alastair	1991
LOOK	Thornburg, Gail E	1987
MenUSE	Pollitt, A Steven	1988
Moss	Morris, Anne, Gwyneth Tseng and Kathryn P Walton	1989
OAKDEC	Meadow, Charles T	1988
OL'SAM	Toliver, D E	1982
Online-Expert	Sajjad, Zahir and Chew Lik Chang	1992
Patent Infor. Assistant	Ardis, Susan B	1990
RUBRIC	McCune, B P, et al.	1985
SAFIR	Florian, D	1987
Tome Searcher	Vickery, Alina	1988

* Unnamed systems

Table 5: Expert Systems in Document Delivery

NAME	DEVELOPER	YEAR
*	Brown, Lynne C Branche	1993
Document Delivery Expert	Abate, A K	1995

* Unnamed system

Table 6: Expert Systems in Abstracting

NAME	DEVELOPER	YEAR
*	Luhn, H P	1958
*	Kuhlen, Rainer	1984
*	Black, W J and F C Johnson	1988
*	Husk, G D	1988
*	Paice, Chris D	1990
*	Endres-Niggemeyer, B	1995
FRUMP	DeJong, Gerald	1982
RESEARCHER	Lebowitz, M	1986
SCISOR	Rau, L F, P S Jacobs and U Zernik	1989
TOPIC	Hahn, U and U Reimer	1985

* Unnamed systems

Summaries are produced by using a natural language generator.

A similar system was developed by Hahn and Reimer (1985). Their system TOPIC summarises texts about microprocessor systems. Table 6 summarises ES systems developed for abstracting found in publish-ed literature.

ES IN INDEXING

There has been some progress made in the area of indexing. Humphrey and Miller (1987) produced an "Indexing Aid System" as part of the Automated Classification and Retrieval Program (ACRP) conducted in the Computer Science Branch of the National Library of Medicine. Other systems that have been developed are by Brenner, et al. (1984), Carande (1988), Bailey, et al. (1989), Purcell (1991), Schuegraf and Bomm (1993), and Ford and Ford (1994).

FASIT (Dillon and Gray, 1983) was one of the first systems to incorporate syntactic knowledge for automatic indexing purpo-ses. The system uses 161 predefined con-cept forms built around desired combina-tions of syntactic categories. These concept forms are specified in such a way as to be able to accommodate any unresolved ambiguities present in the text once it has passed through the syntactic categoriser.

The MedIndex system (Humphrey, 1987; 1989) assist indexers to select the most appropriate indexing terms from MeSH, the National Library of Medicine's computerised thesaurus. The system provides prescriptive aids, such as enforcing the rule of specificity, which is common to most manual indexing systems, as well as sug-gestive aids, such as prompting users to fill slots in the frame structures.

Carande (1989) wished to demonstrate to other library staff that a series of subject-specific ES could extend the expertise of reference librarians well beyond their specific bibliographic knowledge. He developed INDEXES using the demonstration version of EXSYS that allowed a maximum of 25 production rules but did not govern the number of sources that could be recommended. This limited prototype assigned probability weightings to possible sources based on their suitability.

Index Expert designed by Bailey, et al. (1989) used frames to represent the biblio-

graphic records of reference sources. The hierarchical structure of the frames, allow for efficient representation and maintenance of the knowledge base, which is written in Turbo Prolog, using the Knowledge Base Management system. This allows the use of a fully featured editor to update and to change the knowledge base, which could be reloaded into the system for error checking. Table 7 gives a summary of systems developed for indexing.

ES IN ACQUISITIONS

In their 1989 survey of AI and ES in libraries, Hsieh and Hall rightly acknowledged that in acquisitions, "there are no set rules to guide the creation of expert sys-tems." Although acquisitions librarians would like to argue that there are some set rules, the initial assumption is valid (Hawks, 1994). Since Hsieh and Hall's study, at least two ES in acquisitions have been developed and reported in the literature.

The first system is the Monographic Acquisitions Consultant (MAC) which was designed to eliminate the discretionary component in monographic vendor selection, replacing it with a more quantitative decision-making model. The MAC uses the macro capabilities of the spreadsheet Lotus 1-2-3 to allow it to act like an inference engine. The system was also developed to support the library's philosophy of using multiple vendors for monographic order-ing (Zager and Smadi, 1992). Zager en-countered the classic problem of the expert not always being able to articulate her reasons for making a selection or the factors considered. Hardware problems and the constant need to maintain the know-ledge base have precluded the system from being used in production.

The second ES developed at Pennsylvania State University by Lynne Branche Brown (1993a) determines whether a title requested for order would be received on any of the extensive approval plans maintained by

Table 7: Expert Systems in Indexing

NAME	DEVELOPER	YEAR
*	Brenner, E H, et al.	1984
*	Schuegraf, Ernst J and Martin F van Bomm	1993
*	Ford, Nigel and Rosalind Ford	1994
FASIT	Dillon, M and A S Gray	1983
Index Expert	Bailey, Charles W, et al.	1989
INDEXES	Carande, R	1988
Indexing Aid	Humphrey, Susanne M and Nancy E Miller	1987
MedIndex	Humphrey, Susanne M	1987
WANTED	Purcell, Royal	1991

* Unnamed systems

the library. The receipt of books on approval plans is determined by a set of rules called the plan profile, which could be incorporated into an ES. Once again in

this system, the need for continuous maintenance was evident. The system must be updated as changes are made in each profile, as, for example, when publishers are added or deleted (Hawks, 1994). Table 8 gives a summary of ES systems developed for acquisitions.

ES IN COLLECTION DEVELOPMENT

With the continual increase in number of publications and reductions in materials funding, it is more important than ever to select the best and most relevant material for the library's patrons (Das, 1993; Chakrabarty, 1993). Johnston and Weckert (1990) provide two additional arguments for the capture of collection development expertise in ES. First, this expertise could be put to use in smaller libraries that could never afford the services of a full-time human expert (Debrower and Jones, 1991). Second, larger libraries could use the system as a second opinion to improve consistency in the decision-making process. Collection development is also an appropriate domain because perfect results are not required, nor is it clear what perfect results would be in this area (Hawks, 1994). Monograph Selection Advisor was developed by Steven Sowell (1989) at Indiana University. Sowell selected a narrow subject field - classical Latin literature - because its scope was primarily limited to the works of a few dozen writers and secondary works about those writers and their works. A series of questions was developed based on the following factors; subject; research and teaching needs; selec-tion sources; and budgetary constraints. Based on the user's responses to these questions the system would make five recommendations; whether an item must be bought, should be bought, can be bought, should not be bought, or more information is needed. The problem here is that the selection criteria are not clearly delineated within the literature, and experts use heuristics extensively with few measures of their success beyond meting ex-pressed demands for materials.

Shortly after Sowell's endeavour, Selection Advisor was developed by Johnston and Weckert (1990, 1991) in Australia which uses six categories of selection criteria (in declining order of importance), subject, intellectual content, potential use, relation to collection, bibliographic considerations, and language. Issues within these catego- ries are grouped into first, second, and third priorities. The system interacts with the user through a series of thirty questions for each book or journal being considered for purchase. Using PROLOG programing language (because it is more flexible than

Table 8: Expert Systems in Acquisitions

NAME	DEVELOPER	YEAR
*	Brown, Lynne C Branche	1993
Monographic Acquisitions Consultant (MAC)	Zager, Pam and Omar Smadi	1992

- Unnamed system

a shell), the system evaluates responses to these questions and recommends either purchase or rejection of the title.

Journal Expert Selector (JES) was developed by Roy Rada (1987), editor of *Index Medicus*, and colleagues to capture the expertise of human journal selectors at the National Library of Medicine who were making decisions as to which journals should be indexed in *Index Medicus*. The main criteria of JES included (1) composition of the journal, (2) producers of the journal, (3) information in articles, and (4) authors of articles.

The Bibliographer's Workstation, develop-ed by Meador and Cline (1992) at South-west Missouri State University, represents the use of a hypertext tool rather than an ES. The system models the four-step col-lection decision process; identification of material, evaluation, selection (or rejection), and acquisition. Each stage relies on dif-ferent sets of data. The data are organised into four groups; (1) bibliographic data, such as the library's local OPAC; (2) critical and contextual data, such as collection development policies and accreditation standards; (3) financial data, such as the library's materials budget allocations; and (4) com-mercial data, such as vendor databases.

The ES of Debrower and Jones (1991) called Gift Assistant for collection management, was built using a shell called Intelligent Developer. This shell allowed both production rules and frames to be used and also provided links to HyperCard for building graphical user interfaces. Gift Assistant determines whether the library should accept a particular donation and is well received by the professional staff in a division of the Johns Hopkins University Library. It conserves staff time and ensures that valuable gifts are processed more quickly. Table 9 summarises ES deve-loped in collection development found in published literature.

CONCLUSION

This paper has discussed the application of ES in various domains of LIS. However there seems to be a lack of development in areas such as information management, duplicate control, Inter-library loans and book selection. Even so, it can be concluded that work on ES in LIS has advanced tremendously in the last 30 years. Research still tends to be largely experimental in nature with a large number of prototypes being developed and very few succeeding to be viable commercially.

Table 9: Expert Systems in Collection Development

NAME	DEVELOPER	YEAR
*	Das, P	1993
Bibliographer's Workstation	Meador, John M and Lynn Cline	1992
Gift Assistant	Debrower, Amy and Deanna T Jones	1991
JES	Rada, Roy, et al.	1987
Monographic Selection Advisor	Sowell, Steven L	1989
Selection Advisor	Johnston, Mark and John Weckert	1990

* Unnamed system

This could probably be due to the fact that knowledge engineering requires a high level of experimentation in order to achieve the degree of expertise demanded of an ES. Some ES have not got beyond prototyping because once the researchers achieve the desired outcomes, the systems are not required to perform an ongoing function. Nevertheless, these systems add to an ever widening pool of knowledge.

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