

**"AN EVALUATION AND SELECTION  
METHODOLOGY FOR EXPERT SYSTEM SHELLS"**

by

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**ABSTRACT**

This paper illustrates an evaluation and selection methodology for expert system (ES) shells. The methodology incorporates three stages: 1) ES shell screening; 2) shell evaluation; and, 3) assurance of final ES shell selection. Initially, developing a short list through screening of commercial shell products determines whether appropriate software exists and narrows the field of available expert system software products for detailed consideration. The second stage determines which of the remaining ES shells (the finalists) best meets the needs of the organization, from both functional and technical perspectives. The final stage compares user requirements with the features of the selected ES software by defining how these requirements will be satisfied by building expert system applications with the selected product. The methodology also considers the possibility that, at any stage of the process, no expert system shell is suitable and that a system must be developed with programming languages such as LISP, PROLOG, or some conventional programming language.

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## AN EVALUATION AND SELECTION METHODOLOGY FOR EXPERT SYSTEM SHELLS

### 1.0 INTRODUCTION

#### 1.1 Overview of Expert System Shells

An expert system (ES) is a computer program for capturing human knowledge of a specific problem domain and delivering for decision making purposes. This expertise is often represented in the form of if-then rules, though it may take other forms of knowledge representation, such as "semantic networks" or "frames" (see, e.g., Harmon and King, 1985). Many organizations are developing ES applications with only minimal assistance from their information systems department by using the relatively inexpensive and widely available "off-the-shelf" ES shells.

Historically, rather than develop a custom-built ES application, it was possible at times to borrow extensively from a previously constructed ES. This practice has resulted in the development of software that is known as ES shells or skeletal systems. The shells are ES with their knowledge component (which contains the facts and rules of a specific problem domain) removed and leaving only the explanation, inference, and user interface components.

Currently, these commercial software packages include a ready-built inference engine, user interface, and framework for the knowledge base. All the system developer has to do is fill in the rules and facts of the knowledge base, state the goals of the system, and make the right connections with the user interface module. This module can provide a variety of techniques to interact with an end user.

Increasingly, it also includes the ability to integrate with existing databases and transaction processing systems of an organization.

The knowledge base and inference engine are the heart of the ES shell. The inference engine, which is the reasoning component of the ES, examines the knowledge base and determines what to do in order to achieve the goal which it has been instructed to perform.

## 1.2 ES Shell Definition

An ES Shell is "the dialog structure and inference engine which, when linked to a knowledge base, functions as a fully operational expert system" (Liebowitz, 1988). It offers several advantages over building ES from scratch. In addition to saving significant resources, using an ES shell allows the knowledge engineer to concentrate on the development of the knowledge base, from which the expert system derives its power.

An ES shell constitutes one of the three technological levels of software that comprise the ES development environment (Henderson, 1987; Sprague, 1980; and Turban, 1990). Shells are essentially integrated packages of software that provide a set of capabilities to build specific ES quickly, easily, and at low cost. The other two levels are: Specific ES, which are operational systems that actually support and/or advise managers/end-users on a specific issue; and ES tools, which are software elements that provide developers with the facility to construct both specific ES and ES shells. Examples of such ES tools include procedural programming languages, such as C and PASCAL, and artificial intelligence languages like LISP, PROLOG, and FORTH.

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[Insert Figure 1 About Here]  
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Figure 1 (adapted from Sprague, 1980) illustrates the three ES technological levels defined by Turban (1990) and the relationships between them. Specific ES applications can be developed either directly from ES tools or by adapting the ES shell to satisfy the application requirements. In the latter situation, the ES builder could employ the iterative design approach to rapidly select capabilities from the ones available in the ES shell (or delete unnecessary features) as required by the specific ES (represented by the iterative cycling between the ES shell and the specific ES in Figure 1).

A "prototyping" methodology could be employed between the "low" technological level of ES tools and a specific ES application. Given the ES development capabilities of a shell, ES applications of all dimensions can be rapidly prototyped.

Expert system shells are available for a number of hardware platforms, including mainframes, mini and microcomputers, as well as special-purpose machines such as parallel processors. According to Newquist (1988), a new generation of ES vendors is emerging and placing ES software (i.e., ES shells) into the information systems mainstream. As companies like Apple Computer, IBM, Cullinet Software, and McCormack & Dodge become involved with ES technology, the choices for organizations will multiply. The options will range from the choice of hardware platform to the choice of computer language and software interfaces.

### 1.3 The ES Software Selection Problem

Publications which have addressed the issue of evaluating and selecting ES software (Waterman and Hayes-Roth, 1982; Hayes-Roth, Waterman and Lenat, 1983; Liebowitz, 1985; Harmon and King, 1985; Forman and Nagy, 1985 and 1987; Harmon, et al., 1989; and Vetter, 1989) identified criteria, especially user-related ones, which are critical in selecting a suitable ES shell. However, these authors did not suggest how to incorporate multiple user criteria, as well as technical attributes, into a complete and thorough evaluation and selection process. Furthermore, Lynch (1984 and 1985) and Meador and Mezger (1984) suggest that inadequate examination of prospective software packages leads to serious difficulties if not failures when implementing information systems.

Although a number of approaches to selecting application software for transaction processing systems (TPS) and management information systems (MIS) have been proposed (Breslin, 1986; Curry and Bonner, 1983; Gray, 1987; Martin and McClure, 1983), some very critical factors were omitted. These factors include assuring that the selected software package is superior to a custom alternative, or that a screening process is provided to reduce the number of packages subjected to detailed evaluation.

To advance the importance of evaluation and selection of ES software (as compared to that of other information systems), it should be noted that ES shells are used to develop multiple management support applications. From the same ES shell, an organization may develop specific ES applications ranging from consultative and training to task execution in functional areas as diverse as marketing, manufacturing and finance. However, other types of software is usually employed only



for a single application, for example a general ledger or a material requirements planning system which respectively only support a single functional area.

To efficiently develop specific ES applications using the iterative design approach (i.e., prototyping), an ES shell need be available (Naumann and Jenkins, 1982; Leary, 1987). The basic objectives of the ES shell are: 1) to permit quick and easy development of a wide variety of specific ES; and, 2) facilitate the iterative development process by which specific ES can respond quickly to changes. In a top-down fashion in order to satisfy these overall objectives, an ES shell must satisfy a number of general criteria or requirements. These criteria can be categorized according to ES components, such as user interface, inference engine and knowledge base. Once the ES shell is established, an enterprise can implement specific ES rapidly. Therefore, the very critical software evaluation and selection process for ES shells should take place prior to any systems analysis and design (iterative development) efforts for specific ES applications (Turban, 1990).

#### 1.4 Structure of the Paper

This paper illustrates a method to select the most appropriate ES shell where multiple criteria exist not only from functional requirements but also from technical and vendor-support perspectives. As an essential part of the methodology, an initial stage determines whether an ES software product is even suitable for a particular application, or should an ES be developed from programming languages or other ES tools.

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[Insert Figure 2 About Here]  
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The proposed selection process in this paper also ensures that, at each successive stage of the methodology, an ES shell is superior to a custom-built ES application (see Figure 2). It continually reduces the number of ES software products under consideration until a final selection of a shell is made or constructing an ES application from tools is chosen as the best alternative.

This paper is primarily addressed to academics interested in software selection methodologies as well as practitioners faced with ES-related problems. Section Two suggests a multiple criteria methodology for ES shell selection. The three stages of this process - ES software screening, ES shell evaluation, and ES software assurance - are described. Section Three concludes the paper with some final remarks.

## 2.0 A DECISION METHODOLOGY FOR ES SOFTWARE SELECTION

There are three principal stages in the proposed ES shell evaluation and selection methodology: 1) screening of prospective candidates and development of a short list of ES software packages; 2) selecting an ES shell, if any, which best suits the application requirements; and, 3) matching user requirements to the features of the selected shell and describing how these requirements will be satisfied through the building of prototypes for specific ES. The detailed procedures involved in each stage of the selection process are described in the following sections.

The complete methodology provides a project outline for the evaluation and selection of ES software. At the end of each stage, the methodology produces a deliverable - a well-defined output or result (i.e., the short list of software packages at the conclusion of the initial stage). Given the project nature of this software evaluation process, scheduling (i.e., determination of start and finish dates) for each stage, as well as the entire project, is possible. (A Gantt chart or other similar device can be used for this purpose.) Staffing requirements can also be determined, including both the number of staff members and their required skills. To evaluate and select ES software, a project team should be assembled with personnel from user departments as well as information systems professionals.

## 2.1 ES Software Screening

During this first stage of the evaluation and selection methodology, three key issues must be addressed: 1) Is there an ES shell that can be used or should a specific ES be developed from tools?; 2) What ES shells are available?; and, 3) Which ES software packages should be seriously considered and evaluated in detail? Examples of commercially available mainframe and microcomputer-based ES shells are given in Table 1. For more examples, see Computerworld (1988).

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[Insert Table 1 About Here]  
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The purpose of developing a short list of shell products is to narrow the field of available ES software for consideration during Shell Evaluation. A short list of candidate ES software (two or three) eliminates any unnecessary effort or confusion which might result because too many alternative ES shells are evaluated.

#### 2.1.1 Identify Candidate ES Software

The project team must first identify available ES shells that operate within the enterprise's specific computer hardware and are compatible with its operating system. An enterprise may have dedicated hardware for running ES applications, such as a LISP machine. This would certainly be a technical constraint for ES shells under consideration. To initially identify appropriate ES shells for a particular application, there are several publishers (e.g., catalogs published from Datapro and ICP, as well as Expert Systems Strategies by Harmon and Associates) who provide profiles of ES software vendors and the products they offer.

#### 2.1.2 Screening Criteria

The list of screening criteria will contain relatively few items and should concentrate on functional requirements not commonly provided by ES shells and which are very specific to the organization evaluating ES software. Most commercial software packages share many standard functions and capabilities. At the same time, organizations have many identical requirements for software. However, software packages have unique capabilities and features which can readily distinguish one package from another. Similarly, organizations have unique requirements for any software package to satisfy.

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[Insert Figure 3 About Here]  
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The screening process matches the unique capabilities of commercial software packages with the unique requirements of the organization. Figure 3 illustrates the overlap between unique capabilities of software with the unique requirements of an organization. The commercial software packages (e.g., ES shell) with the greatest overlap of unique capabilities with unique organizational requirements would be retained for more detailed scrutiny in the next stage of the evaluation and selection methodology (i.e., ES Shell Evaluation).

At this point in the process, the concern is not how well the respective software packages meet the screening criteria, but only if the screening criteria (i.e. unique capabilities) are offered by the software. In the next stage of the methodology, all criteria (including both standard and unique capabilities) are evaluated as to how well they are performed by each respective software package on the short list.

The screening criteria can be categorized into four major types: 1) technical requirements; 2) functional requirements; 3) documentation and training; and 4) vendor information.

**Technical Requirements** - An organization's hardware and software strategy will likely dictate the screening criteria in the technical area. To be considered, a shell must fit the framework of the proposed system; it must be compatible with the hardware and software direction already identified. For example, the Social Security Administration required ES shell software to operate on their current hardware and operating system platform (Leary, 1989). The operating system is

clearly a strict technical requirement. Others could include programming languages, peripherals, memory needs, or data communication capabilities.

**Functional Requirements** - The functional requirements of an ES shell can be classified according to the following system components: 1) User Interface; 2) Inference Engine; and 3) Knowledge Base. The functional requirements associated with each of these three components readily distinguish ES shell evaluation and selection from other software appraisal efforts (Harmon and King, 1985; Harmon, et al., 1989).

The user interface component of an ES provides the dialog structure through which the user can access the ES. Normally, the user interacts with the ES via a consultative mode; and many ES interface components include an explanation module. The inference engine component allows hypotheses to be generated from information contained in the knowledge base; while the latter is comprised of facts and rules of thumb based upon experience.

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 [Insert Table 2 About Here]  
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Table 2 lists several examples of functional criteria to conduct the first-cut screening according to the ES components. (Forman and Nagy (1987) offer a more exhaustive list of ES shell criteria.) Possible screening criteria for the user interface component would be that the ES shell offers certain necessary features for the knowledge engineer (e.g., knowledge base editor and rule trace) as well as needed features for the user (e.g., prompted-menu display and explanations and justifications). The inference engine component could necessitate generating new facts by modus ponens and decision tress, while control

strategies should include forward chaining and procedural control. The knowledge base criteria might require representing facts by object-attribute-value (O-A-V) triplets and frames, handle uncertainty, and model relationships with variable rules.

**Documentation and Training** - ES software packages normally include the documentation required to install and support the ES shell. It should be detailed, complete, and easy to understand. The availability of vendor-developed training sessions and materials may be very important, especially when the organization's personnel are inexperienced in implementing software.

**Vendor Information** - A vendor's ability to support its package through training, consultation, installation, and maintenance assistance is an important consideration in evaluating ES software packages. The vendor should also be able to refer an evaluation team to a user who is willing to talk to them about the ES package and the accompanying support.

Some organizations may wish to acquire a run-time version of an ES shell. This shell is modified to incorporate a specific knowledge base and to deactivate certain programming features. Not every vendor may offer such a product.

The financial stability of a vendor can also be an important consideration. Financially successful vendors that have been in existence for more than a few years are more likely to adequately support their packages initially and in the future because such vendors attract and retain competent personnel.

But financial success alone does not ensure adequate and continued support. Vendor image, package reputation, the unit price, and the number of installations are also important considerations. Either the vendors themselves or the users to whom they directed the prospective buyer should be able to provide the needed information in these areas.

### 2.1.3 Pick Finalists

The matching of the screening criteria against the list of ES software and their capabilities will cause the elimination of many (but hopefully not all) shells. The following are typical reasons to eliminate potential ES software candidates: 1) a vendor has only a few employees and has been in business less than a year; 2) operating systems software and hardware is not supported by a vendor; and, 3) system documentation is inadequate.

By reducing the number of ES software packages under consideration from as many as twenty to two or three, a project team can more effectively devote its attention to the critical details that can make the difference between selecting an adequate ES shell and selecting a superior one. Moreover, by determining which ES software packages are available for the application, the screening process also determines whether an ES shell can be used or if a specific expert system should be constructed from ES tools (see Figure 2).



## 2.2 ES Shell Evaluation

This second stage focuses on the two or three ES shells that were identified in the screening of ES software. The objective is to evaluate in detail the ES shell finalists and select the one software product that best meets the needs of the organization. The primary tasks of ES software evaluation are: 1) to further define the detailed evaluation criteria; 2) obtain shell product information; and, 3) evaluate the ES software finalists and pick one as the best alternative.

### 2.2.1 Expand Evaluation Criteria

The screening criteria are expanded in more detail and fall into the same four categories: 1) technical requirements; 2) functional requirements; 3) documentation and training; and 4) vendor information. Although all categories are expanded during shell evaluation, the functional requirements receive the main attention and are related to the interface, inference and knowledge components of the ES shell. The purpose of this task is to develop a rather comprehensive functional view of the proposed system and to summarize the requirements that must be satisfied by the ES. As the project team defines the functional criteria, they should also document the levels of importance and need to the user.

The following functional requirements for ES software, identified in Harmon and King (1985) are those for a hypothetical enterprise: 1) user interface features, including those for knowledge engineering and data extraction from external sources; 2) inference engine features, including generating new facts and control strategies; and 3) knowledge base features for handling facts, relationships, and

uncertainty. Table 3 exhibits an expansion of the above summary list of functional shell requirements.

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[Insert Table 3 About Here]  
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### **2.2.2 Obtain Package Information**

Once the system requirements have been established and the criteria reviewed, the capability of each ES shell to satisfy the requirements must be measured. Several techniques may be used to gather enough information to determine how well each package meets the requirements.

In many cases, the project team can meet directly with the vendor sales and support personnel and discuss each requirement. But if requirements are so comprehensive and detailed that a more formal procedure should be followed, a request for proposal (RFP) can be submitted to vendors. It should be noted that preparing an RFP can be time-consuming and costly. In situations where the requirements are not so detailed and complex, it can be replaced by a less formal and more direct procedure such as a basic letter of request.

### **2.2.3 Evaluate ES Shells**

Once the vendors' responses to requirements have been received, the actual evaluation process can begin. The review is very detailed at this point, since the project team is looking for specific strengths and weaknesses of each package.

The project team is searching for deciding factors - not only what ES software packages have and how well they provide it, but also what they don't have. Detailed information is desired on the functions of the ES software and its related processing, including if and how functions that are not included in the ES shell could be implemented.

Shoval and Lugasi (1987) compared three models for evaluating and selecting a computer system from four alternatives in a manufacturing case study. The three scoring models were: 1) the additive weight model; 2) the eigen-vector model; and, 3) the multi-attribute utility model. The authors reported that these models provided identical rankings of combinations of computer hardware, software availability and system support.

Given a short list of software alternatives, any scoring model will likely yield identical rankings. In evaluating ES shells, Forman and Nagy (1987) applied the Analytic Hierarchy Process (Saaty, 1980) to select a shell from among just three alternative software packages. However, this study did not indicate how the short list was developed nor were any comparisons made with different scoring or ranking techniques.

Generating the short list is more critical than the method of ranking the software packages. Criticism levied against weighting schemes for software selection decisions (Klein and Beck, 1987) can be minimized through the screening process and development of a short list. Naumann and Palvia (1982) successfully applied weighting and scoring measures to select a systems development tool from a relatively short list (four) of candidate techniques. By weighting criteria for only two or three packages rather than for a dozen (in which case the aforementioned criticism is probably valid), the proposed evaluation

process allows for a very detailed and focused inspection of just the few best alternative ES software products.

#### 2.2.4 Additional Selection Requirements

The ranking scores are not necessarily the determining factor for selecting a particular ES shell. They should be used as a decision tool - a means for organizing and summarizing the significant quantity of information that the project team has collected. The highest score may not always indicate the best ES shell. The scores may not accurately reflect certain intangible factors such as the cosmetic appearance of reports and screens, how easy it will be to use the ES software, etc.

**Tailoring** - The scores may not indicate how much time or the level of technical expertise needed to "tailor" the ES shell. Tailoring can be either costly if it is relatively extensive, or difficult if the internal structure of the software is complex. The importance of the technical processing architecture will depend on how much tailoring is anticipated. Furthermore, the architecture of the ES shell also determines how much modification is even possible.

**Documentation** - A decision to use a particular ES shell should not be made on the basis of functional requirements alone. The ES software's documentation is a very important non-functional factor. Its accuracy and level of detail can affect the time it will take to evaluate and modify the package.

Comparing documentation is sometimes very difficult at this stage of the evaluation process due to differences in format, style, etc. Still, it is important to review the vendors' documentation and to

reconfirm that the information collected on maintenance and support, for instance, is accurate and correct.

The availability of and easy access to vendor-developed training sessions is very important. Training materials, such as user tutorials or video-based learning aids, may be especially critical when company personnel are inexperienced in developing ES applications.

At this stage, the vendor should be able to refer the project team to current users of his software. The comments of these customers should prove invaluable. Site visits and demonstrations of the ES software in operation may be helpful.

### 2.3 Specific ES Design

Assuming that ES software which is anticipated to provide satisfactory performance has been selected (see Figure 2), the project team is ready to confirm the selection by developing some specific ES prototypes based on the chosen shell. The primary reasons for this stage are to ensure that the ES package can be used effectively and to provide one last chance to reconsider the ES software decision.

It is often difficult to determine the degree of user satisfaction until the design process has begun for specific applications utilizing the selected ES software. Therefore, this stage involves the design of demonstration prototypes of specific ES built from the ES shell. Such prototypes can provide significant benefits before finalizing the selection decision (Alavi, 1984; Meador and Mezger, 1984; and Janson, 1986).

### 2.3.1 Alter Functional Requirements

Based on the capabilities of the selected shell as experienced in the prototyping exercise of specific ES, the definition of user requirements might be altered to include package features not previously considered, or to change or eliminate others. The modified requirements should be reviewed with the users. The effect of ES software deficiencies perhaps can be minimized by altering user procedures or postponing the implementation of some requirements until shell enhancements could be made.

### 2.3.2 ES Software Modifications and Supporting Programs

Typically, the specific ES being developed requires certain functions and/or interfaces not provided by the software. If an ES shell does not meet all the functional requirements of a system, the following alternatives should be considered: 1) persuade the vendor to include additional features; 2) develop supplemental software; and, 3) modify the vendor's software. The chosen alternative will depend on the extent of the ES shell's deficiencies, the potential costs and benefits of altering the software, and the size and technical skills of the programming staff.

**Vendor-Supplied Enhancements** - If possible, the vendor should be persuaded to do the modification for the purchaser. This is often the best alternative, since the vendor will usually update and maintain the software on a routine basis.

**Supporting Programs** - Developing software to supplement the vendor's ES package is often the most practical alternative. The vendor will normally continue to service the ES shell; but if this alternative is selected, the supplemental software should conform to the standards used by the vendor in developing the ES shell.

**Alter Code** - Modifying an ES shell is usually not recommended. If the software is modified, the vendor may be reluctant or may even refuse to service the package. Updates to the software may not be compatible with the modifications effected. In some cases, this may not even be an option, since the purchaser of the ES shell does not have (or cannot get at any price) a copy of the source code. In this instance, all that the purchaser can do is to build a front-end or back-end to the software package.

### 2.3.3 Finalize ES Shell Selection

It is not unusual for an organization to complete the last stage of the evaluation and selection process for ES software, only to realize that the selected shell is not the best choice. Perhaps too many compromises have been made and users are no longer satisfied. Possibly, the tailoring effort has become so extensive that a custom ES (i.e., specific ES application built from tools) would be a better choice (see Figure 2). Therefore, a final commitment to using a particular shell should be avoided until the design of specific ES using the potential software package has progressed to the point where user satisfaction is ensured.

### 3.0 SUMMARY AND CONCLUSION

Using ES shells for the development of specific ES will reduce personnel requirements and development costs. Conducting the evaluation of ES software increases the effort necessary for developing specific ES, but this undertaking is offset by the aforementioned advantages of using a shell package. Despite the promises offered by ES software, the performance of some ES shells is much less than expected. Weak or non-existent selection procedures may explain much of this poor implementation record. The methodology proposed in this paper will hopefully reduce the risks associated with ES software and facilitate success in developing specific ES from shells (Alavi, 1984; Janson, 1986).

The most critical phases of the methodology are determining the criteria for an ES shell as incorporated in the first phase (the development of a short list) and the confirmation element of the third phase (design of specific ES with the selected shell). Initially, the screening process determines whether a shell is feasible and reduces the number of ES software packages to be evaluated in detail. Finally, the development of specific ES with the selected shell ensures that the ES software can be used effectively and provides a last chance to consider building specific ES from tools.

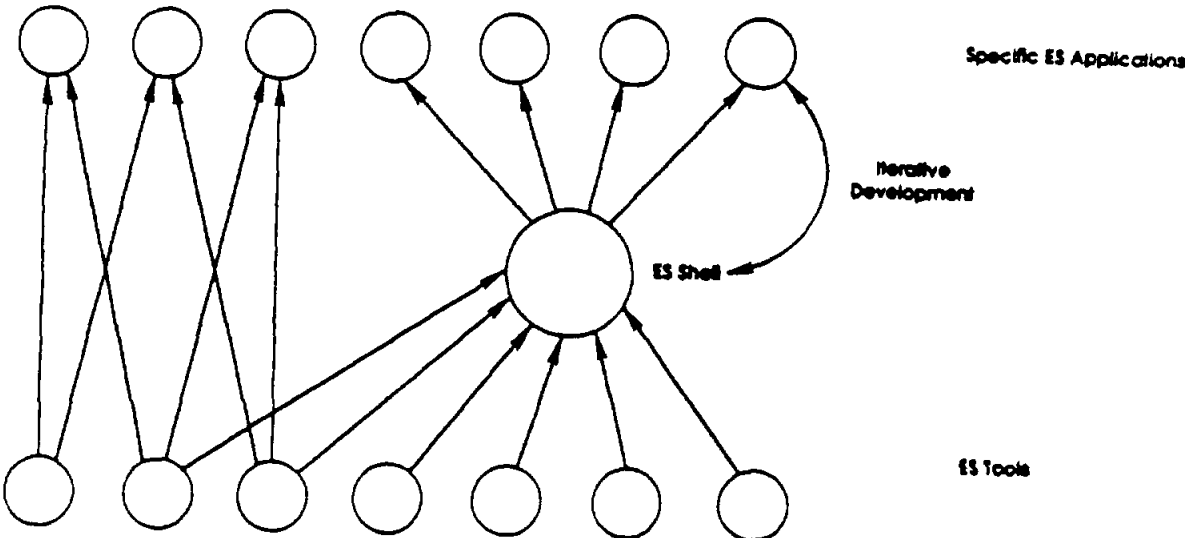


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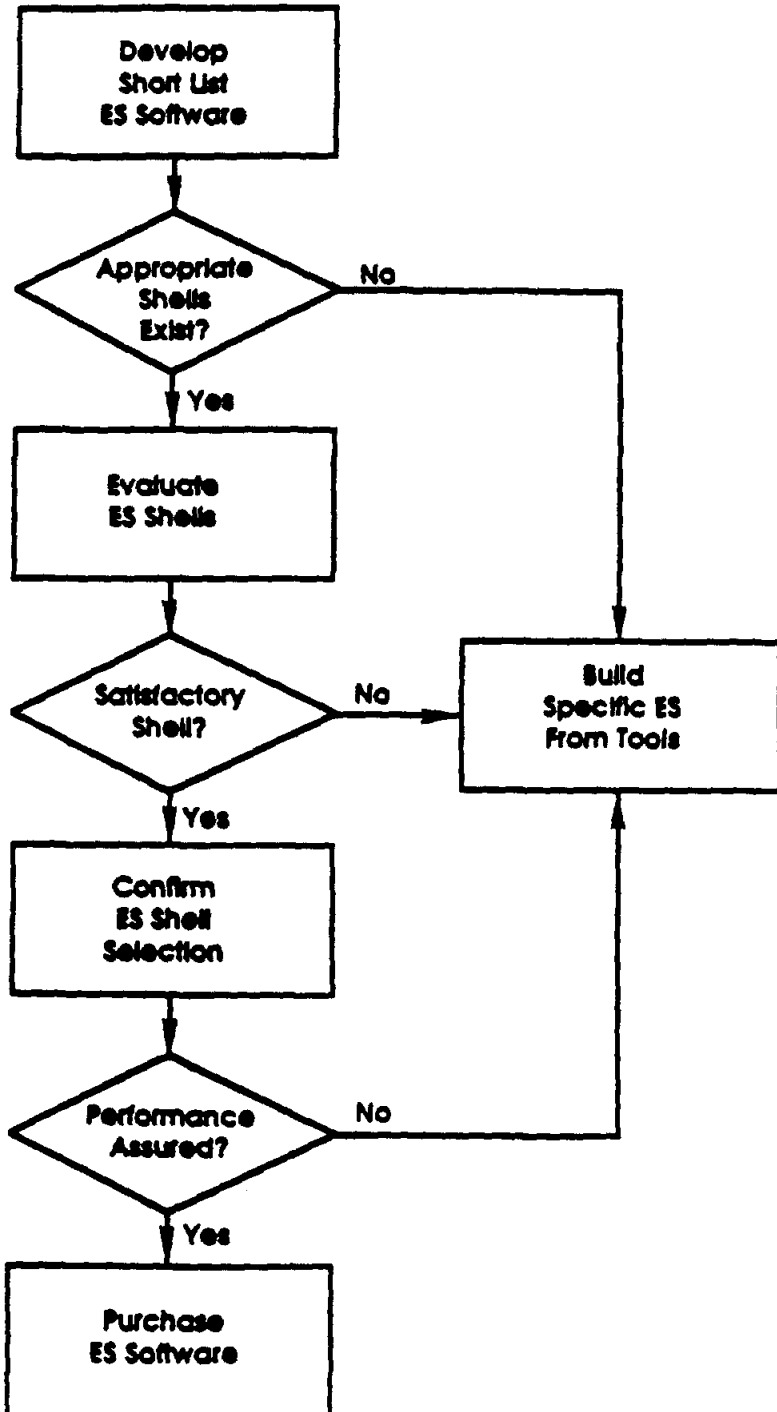
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FIGURE 1. LEVELS OF ES TECHNOLOGY



**FIGURE 2. A MULTIPLE CRITERIA DECISION METHODOLOGY  
FOR ES SHELL SELECTION**



**FIGURE 3. MATCHING OF SOFTWARE SCREENING CRITERIA**

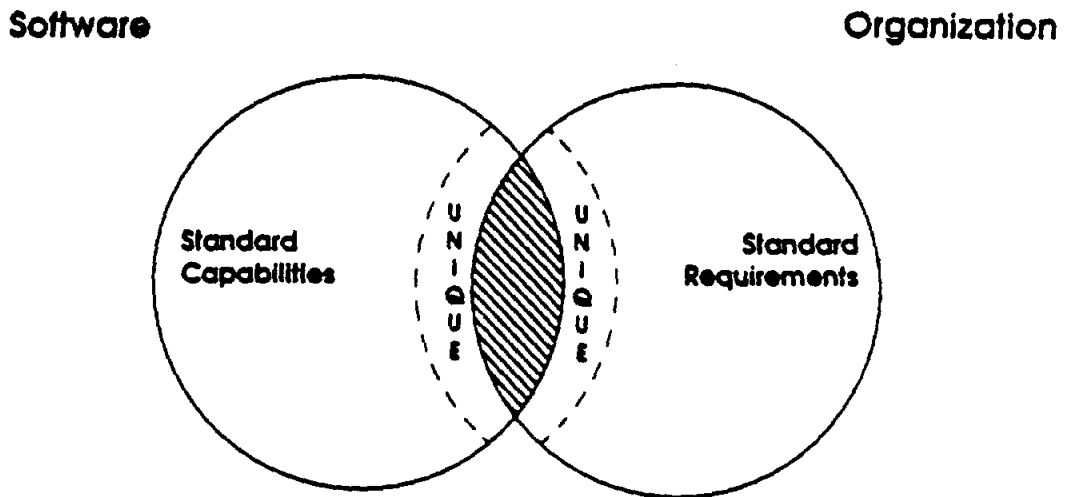


TABLE 1. REPRESENTATIVE ES SHELL PRODUCTS\*

Large Machine Shells\*\*

Product	Vendor
-----	-----
KEE	Intellicorp
ART	Inference Corp.
ESE	IBM
EMYCIN	Stanford University
S.1	Teknowledge, Inc.
Level 5	Information Builders
KES	Software A & E
Knowledge Craft	Carnegie Group, Inc.
IBM Knowledgetool	IBM
Rulemaster 2	Radian Corp.
KBMS	AI Corporation
ADS	AION Corporation

Microcomputer Shells

Product	Vendor
-----	-----
1st-Class	1st-Class Expert Systems
EXSYS	EXSYS, Inc.
M.1	Teknowledge, Inc.
KES-PC	Software A & E
GURU	Micro Database Systems
Personal Consultant	Texas Instruments
VP-Expert	Paperback Software
Knowledgepro	Knowledge Garden, Inc.
Nexpert	Neuron Data

\* Numerous shells are available in both large machine and microcomputer versions.

\*\* Includes minicomputers, mainframes and specialized LISP machines.

**TABLE 2. POTENTIAL SCREENING CRITERIA OF ES COMPONENTS**

User Interface	Inference Engine	Knowledge Base
Knowledge Base Editor	Modus Ponens	O-A-V Triplets
Prompted-Menu Display	Decision Tree Algorithm	Frames
Explanation	Forward Chaining	Variable Rules
Justification	Backward Chaining	Certainty Factors
Graphics	Mixed Chaining	
	Procedural Control	
	Database/ Spreadsheet Links	
	Hypertext	

TABLE 3. DETAILED FUNCTIONAL CRITERIA FOR ES SOFTWARE

**Interface Component**  
-----

Knowledge Engineering Facilities  
Knowledge Base Editor  
Traces and Probes  
Graphic Display (Windows)

End-User Elements  
Explanations and Justifications  
Line-Oriented Display  
Prompted-Menu Display

Sources of Data  
Instruments  
Data Bases  
Other Languages and Procedures

**Inference Component**  
-----

Generating New Facts  
Modus Ponens  
Resolution  
Decision Tree Algorithm

Control Strategies  
Backward Chaining  
Forward Chaining  
Depth-First Search  
Breadth-First Search  
Procedural Control

**Knowledge Component**  
-----

Representing Facts  
A-V Pairs  
O-A-V Triplets  
Frames

Relationships  
If-Then Rules  
Variable Rules  
Examples

Uncertainty  
Inheritance  
Certainty Factors  
Probabilities



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