Management Summary

BUTLER COX FOUNDATION

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Expert systems permit applications to be tackled that have hitherto been considered unsuited for computer assistance. Typically, these applications involve decision making where the rules on which the decisions are based are highly complex, imprecise, and subject to a high rate of change. In the past such decisions could be made only by human 'experts'; now computer applications based on expert systems can assist, or even replace, these experts. Expert systems therefore represent a new era of computing. In the past, computers automated the work of clerks and provided information for managers; in the future, they will increasingly automate the work of professional and technical staff.

The term 'expert' is to some extent a misnomer because expert system applications are not restricted to tasks carried out by highly qualified experts. Practical applications are often found at lower levels, and they usually concern staff who have specialist skills that are in short supply.

Expert systems are now ready for exploitation

Expert systems have been the subject of research for a very long time. However, it is only recently that computer hardware has become powerful and cheap enough, and computer software sufficiently advanced, for the ideas of the researchers to be applied and for commercial products to appear.

In our last study of expert systems (in 1983) we reported that the technology was still too immature for most applications. We recommended that only those applications with a very high potential payoff should be attempted because both the cost of the technology and the risk of failure were high.

The situation has now changed. Although there are still only a few successful large-scale applications, there are many examples of small-scale applications providing genuine business benefits. Hence, we believe that expert systems are now ready for serious business use:

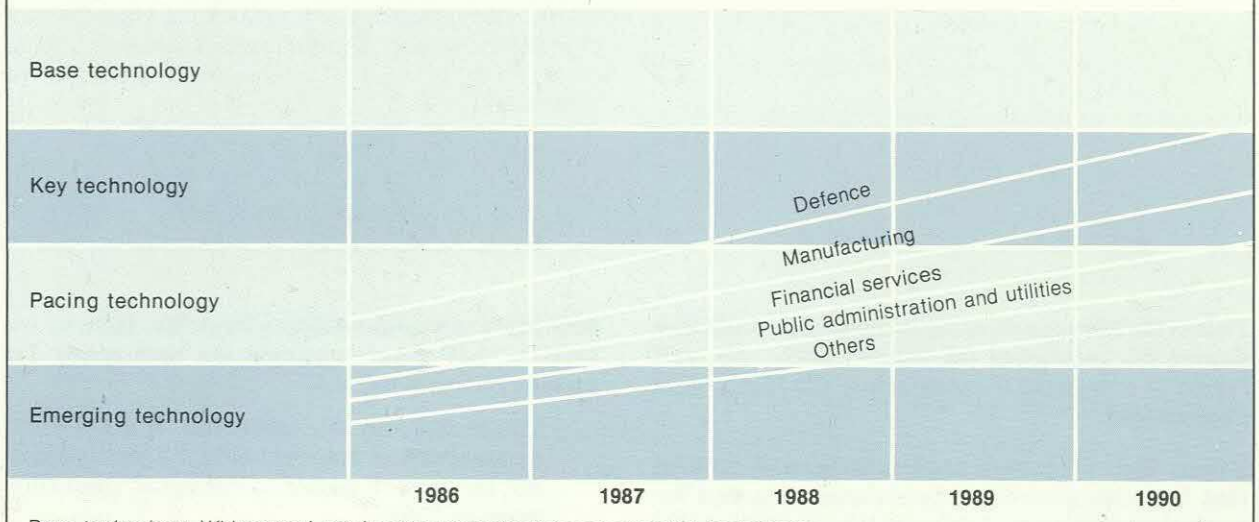
- The technology has improved. It is both less expensive and more reliable. Expert systems are now much easier to construct than they were in 1983.
- The problems of introducing expert systems are now better understood. There is much less risk that the costs will outstrip the benefits and more likelihood that real benefits will be achieved.

Expert systems are becoming a key technology

In earlier research we proposed a four-stage model showing how a new technology first emerges from development laboratories, is then used for pilot projects by market leaders, is next used by leaders in an industry sector as the key to gaining a competitive advantage, and finally becomes an essential technology used widely throughout an industry sector. Figure 1 shows how expert systems will become a key technology in several industry sectors during the next three years.

In the commercial field, our research suggests that the leading sector, both in Europe and in the United States, is manufacturing, followed by financial services and insurance, and then retail and other services. Outside the commercial field, there is significant expenditure and use in military applications, education, and government. In the United States, although the marketing hype for expert systems is stronger and the willingness to experiment and take risks is reputedly greater than in Europe, we found that the actual exploitation of the technology was only a little further advanced than in Europe. The mistaken impression that expert systems are much more advanced in the United States stems from the fact that the suppliers of expert systems there and their products are much more mature than elsewhere. However,

Figure 1 Expert systems are becoming a key technology



Base technology: Widespread use in many organisations; an essential technology.
Key technology: Proven technology; market leaders implement to gain competitive advantage.
Pacing technology: Being used for pilot systems.
Emerging technology: Still in the laboratory; few prototypes in use.

many leading US companies are now investing heavily in expert systems, and several multimillion-dollar projects are under way.

Japan is the other region in which expert systems are a major development activity. But surveys there suggest that the exploitation of expert systems is no further advanced than in Europe, and that, as in Europe, more than half the products in use originated in the United States.

Expert systems can lead to new business benefits

As might be expected, expert systems are being applied mainly to business problems where the application of human expertise causes a bottleneck. They can:

- Replicate or enhance human expertise.
- Increase the productivity of the experts.
- Assist the expert to understand and solve complex problems.

Examples of each of these three kinds of application are described briefly in Figures 2 to 4. Our research showed that there are thousands of expert systems already in operational use in most business sectors and functional areas.

Organisations can now use expert systems to gain an advantage over their competitors by improving existing products and services, by creating new products, by entering new markets, or by cutting costs. Some organisations have gained distinct advantages over their competitors by identifying such applications and implementing them quickly. For example, Northwest Airlines has increased its market share and revenue by using an expert system. It dynamically adjusts the number of seats allocated to the different classes and ticketing options on each flight as the departure time approaches. Hence, more customers are attracted at the best possible price, and higher aircraft utilisation is achieved.

Figure 2 Using expert systems to replace expertise: Compliance with good professional practice in financial institutions

From October 1988, financial-services institutions in the United Kingdom will be legally required to ensure that their employees are complying with good professional practice. The purpose of the legislation is to ensure, for example, that a client is advised about the best products on offer, and not the ones that provide the highest profit for the financial-services company. This means that the institutions will need to monitor all the business transactions made by their employees. Such monitoring is almost impossible to carry out by manual methods alone, and even with automated indexing and searching tools, the task is difficult. Some financial institutions (such as the National Westminster Investment Bank) are developing an automatic monitoring system using an expert systems shell called Vanilla Flavor. The details of the transactions executed by each salesman or trader are matched against a set of rules, and any breaches are brought to the attention of the compliance officer, who can then examine the records in more detail. The Vanilla Flavor software and the accompanying hardware cost more than $500,000. However, any serious breach of the law, if proven to be due to negligence on the part of the company, could result in substantial fines and possible revocation of the licence to operate.

An additional benefit is that it will be easier to incorporate any changes in the compliance rules than it would be with a conventional system.

Figure 3 Expert systems can increase an expert's productivity: Credit authorisation at American Express

American Express uses an expert system called Authoriser's Assistant to support its policy of not placing a limit on the amount of credit its cardholders may have at any given time — as long as they clear their account in full at the next billing cycle. Three hundred credit authorisers at four locations often need to access up to 13 different databases in order to make the correct decision. Previously, many of the requests for credit were granted by using a mainframe system that used statistical criteria. Even so, the volume of transactions requiring human intervention made the process relatively slow and created a potential bottleneck.

After the technical feasibility of applying expert systems to the credit-authorisation process (using a shell) had been demonstrated, a major project was initiated in mid-1985. By April 1986, a standalone prototype had been developed. Since then, the system has been linked with the mainframe via interfaces with a Sun microcomputer. Not surprisingly, the most difficult part of the entire exercise was not the process of building the knowledge base — difficult as that was — but rather the technical problems of interconnecting incompatible hardware and software.

The system went live in January 1987 and in tests has performed 11 per cent better than the credit authorisers, providing the correct decision in 96 per cent of cases rather than 85 per cent. It is well known that a large part of the potential profits of credit-card and charge-card firms is lost through bad debts.

Figure 4 Expert systems can help solve complex problems: Optimising Singapore's port operations

The Singapore Port Authority is developing an expert system to help it decide on the optimum sequence for loading and unloading container ships. At present, the port is able to move 500 containers in eight hours. It believes the use of the expert system will increase this to 640, providing faster turnaround for ships using the port — benefiting shippers, consumers, and the authority.

The system is being developed in conjunction with the ITI (Information Technology Institute) of the National Computer Board of Singapore. The concept of the system has been proved by a prototype system running on a Lisp machine. The full operational system will run on networked Sun microcomputers linked to the authority's IBM 3081. There will be two phases of development. By the end of 1987, computer-aided manual scheduling will be possible. Fully automatic scheduling will be available two years later. The total cost of developing the system is estimated to be Singapore $3 million (US$1.5 million).

Expert systems are a major step forward in software development

Expert systems are not just a novel application of computing technology; they are the next logical step in the evolution of software. They represent a major advance, akin to earlier crucial developments such as the introduction of online systems and disc storage in the 1960s or the emergence of personal computers and end-user computing in the 1980s. They differ from previous software tools in that they store and manipulate knowledge, not data (see Figure 5 overleaf). Moreover, the superior development features offered in the latest expert system products have led to their use for the development of conventional computer applications.

Expert systems will be integrated with other computer applications

Four years ago, most expert systems were built using special-purpose hardware and bespoke software. Today only a small proportion of applications run on specialist hardware. In our survey of Foundation members, only six per cent of the respondents had installed specialist hardware, while over 40 per cent had expert systems running on conventional mainframes and minicomputers (see Figure 6 overleaf). And nearly 60 per cent of organisations were using standard microcomputers for experimental systems and small operational systems.

Also, about two-thirds of the applications are now based on expert system 'shells' — general packages that allow an expert system to be developed without the need for specialist expertise or experience.

It is clear from our research that future expert systems will run on conventional computers. Moreover, there are already signs that expert systems software is becoming integrated with conventional databases (see Figure 7 overleaf). Hence, there are good reasons for systems departments to act now and prepare for expert systems.

The systems department must take a proactive role

An organisation's attitude and approach to expert systems depends to some extent on its position in its sector. A telling remark was made by one of the top three US suppliers. "We are only asked to present by successful companies, and it is never the data processing department that asks for a presentation; it is the R&D department or a user profit centre."

Systems departments must recognise that expert systems may have enormous potential for their organisations. There is a danger that the systems department will be bypassed by suppliers who go directly to users, as they did with personal

Figure 5 Comparison between conventional software and expert systems software

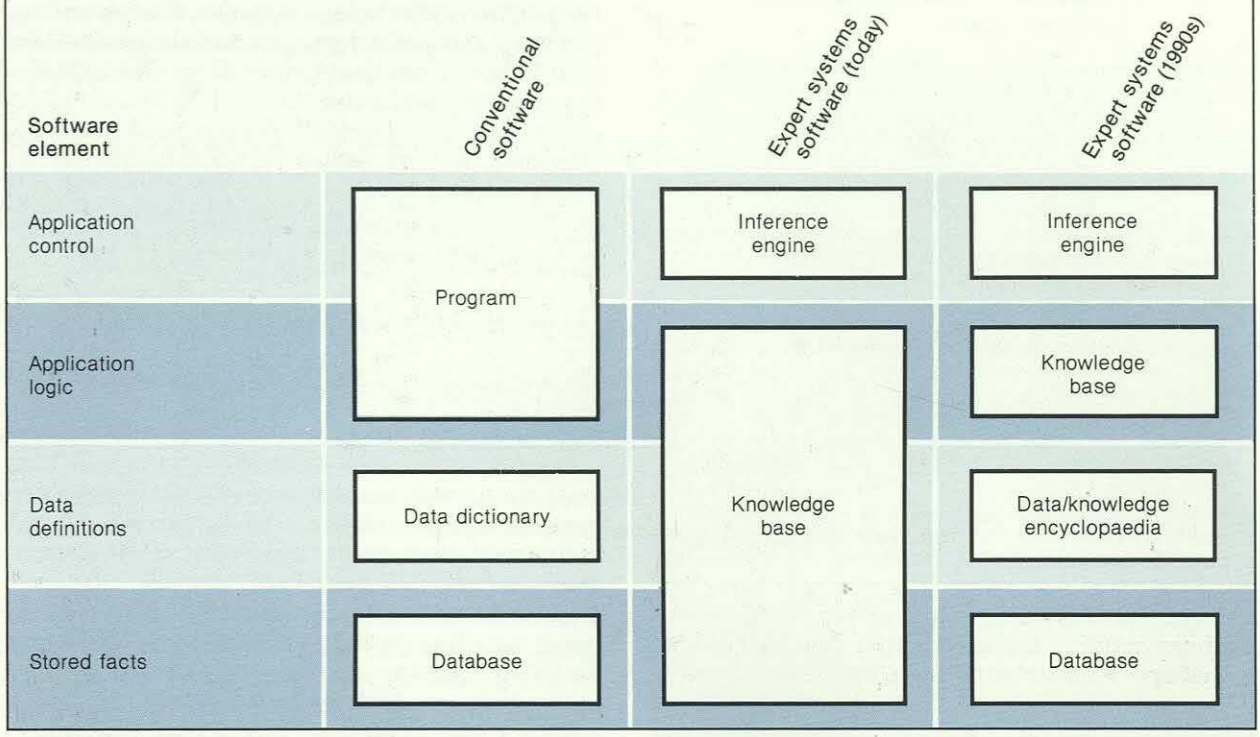
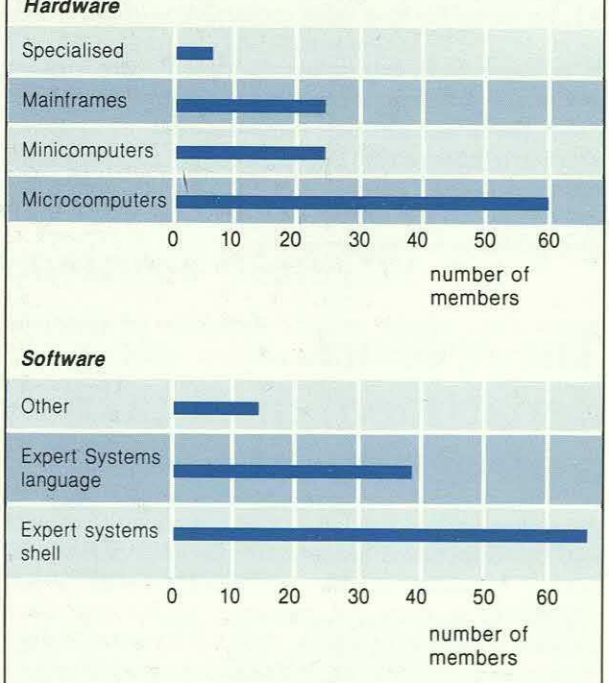


Figure 6 Expert systems hardware and software used by 104 Foundation members



Note: Some members use more than one type of hardware or software

Figure 7 Integration of expert system applications with mainstream systems

Level of integration	Number of projects	% of total
Embedded in mainstream system	1,220	25
Data shared with mainstream system	330	7
Data transferred from/to mainstream system	900	19
Manual link with mainstream system	320	7
Standalone	2,050	42
Total	**4,820**	**100%**

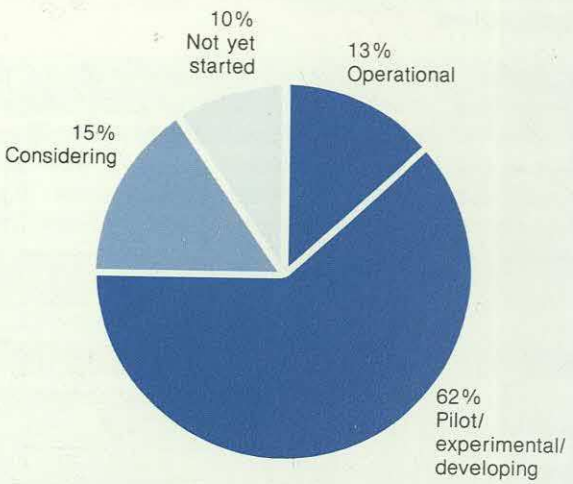
(Source: Butler Cox survey of 20 suppliers of expert system products in Europe)

computers in many organisations. Left to itself, the systems department is unlikely to place a high priority on expert systems — it already has enough new technology with which to come to terms.

We believe that for many organisations expert systems are not just a technical tool; they represent an important business opportunity. The systems department should therefore take a proactive leadership role in the application of expert systems.

Many Foundation members are beginning to appreciate this, though to date few have live systems installed. As part of our study we carried out a survey of Foundation members. Seventy-five per

Figure 8 Results of a survey of the state of development of expert systems



Butler Cox survey of 104 Foundation members, covering 155 applications

cent of our respondents had some sort of expert systems activity, but only 13 per cent had operational applications (see Figure 8).

Match the way in which you apply expert systems to your business strategy

A business can use expert systems as a strategic weapon, as a pragmatic solution to specific business problems, or as just another technical tool. The approach chosen should match the market position and strategy of the business concerned.

First, if the organisation is, or aspires to be, a leader in a strongly competitive and fast-moving market, then it is essential to assess the major business threats and opportunities posed by expert systems and the extent to which they may be used as a strategic weapon. This implies the need to work with the top management of the organisation to review how expert systems can contribute to the business strategy by exploiting the competitive strengths and minimising weaknesses. Timing of the expert systems initiative is most crucial in this case. There is usually only a limited window of opportunity to exploit new technologies in this way.

If the competitive pressures are less and the business strategy is to follow closely behind the innovators in the sector, then the organisation will need to be ready to use expert systems as events dictate. A pragmatic approach should therefore be adopted. Users should be involved from the start to identify and champion applications that can solve problems that existing computing technology has not been able to solve. However, the systems development function has to take a lead in providing support and advice on the selection and development of the applications, and in setting priorities and standards to avoid wasting the resources and skills available.

Finally, if the organisation operates in a less competitive market (or in a nonprofit sector) and the business strategy is to minimise the risks of technological innovation, then the best policy is to wait until the need for the new technology arises and until the products are fully proven. Expert systems should therefore be treated as just another technical tool. With this approach, the systems developers need to become familiar with the facilities and the limitations of the available products and should be left to select, evaluate, and use such tools as they think best.

Organisations active in several business areas may need to adopt a mixed approach.

Identify and select the right opportunities

The existing classifications of expert system applications developed by researchers and academics do not help to identify potential opportunities for expert systems. In our research we therefore used a classification familiar to business systems staff. This classification defines four main types of application, determined by whether the application is in the commercial/administrative area or in the scientific/technical area, and whether it is concerned with the day-to-day running of the business or with managerial and support functions (see Figure 9). More often than not, opportunities for using expert systems will exist in each of the areas where experts or specialists form a bottleneck at the interface to an existing computer system — either between the system and other people (customers, suppliers, and so on) or between one system and another.

Figure 9 Four main types of expert systems application

Focus of concern	Commercial and administrative	Scientific and technical
Day-to-day running of the business	Mainstream information systems (for example, credit authorisation in a loan company)	Online, real-time systems (for example, power station control)
Managerial and support functions	Decision support and end-user computing systems (for example, market analysis in the consumer goods industry)	Offline, standalone systems (for example, process planning in aircraft-component manufacture)

Using this classification, organisations are typically able to identify many more opportunities than they can afford to exploit. Evaluation and selection of the opportunities to pursue depends on the expert systems approach being followed and also on the capabilities and limitations of the expert system products available. The full report gives detailed guidance.

Set up an expert systems support unit

After studying the history of many expert system applications, we recommend that most organisations should set up a special unit to support the implementation of expert systems. Initially, its role and size should reflect the approach adopted to exploiting expert systems, and the extent to which they will be used. The role will range from promotional, through coordinating and supporting expert system activities, to developing operational systems for users. Later, as the use of expert systems matures, the support unit will be integrated into the system support function for mainstream computing.

Current expert system products have limitations. Hence, another function for the expert systems unit is to monitor developments in the technology and new products appearing in the marketplace and to maintain lists of preferred products and vendors. Eventually, the unit may also take on the role of 'knowledge-base' manager, akin to the role of the database manager today. The full report provides guidelines for the organisation, skills, and training needed to set up the unit and to implement the first applications.

When implementing expert systems, it is vital to ensure that the valuable knowledge base cannot be used by other organisations without permission. This is particularly important when an external organisation is used to develop the system. It is important to clarify at the outset who will own the knowledge base.

Expert system products and tools are widely available and inexpensive

A key factor in the widespread application of expert systems is the availability of development products and tools that do not require the developer to have specialist skills and do not require specialised hardware. Many of these tools are inexpensive and can be used on general-purpose personal computers.

Of the 80 suppliers we surveyed in our research, 20 provided details of some 80 different products available in Europe. They range from programming languages such as Lisp or Prolog to application packages and environments (see Figure 10). Prices

Figure 10 Types of expert systems software

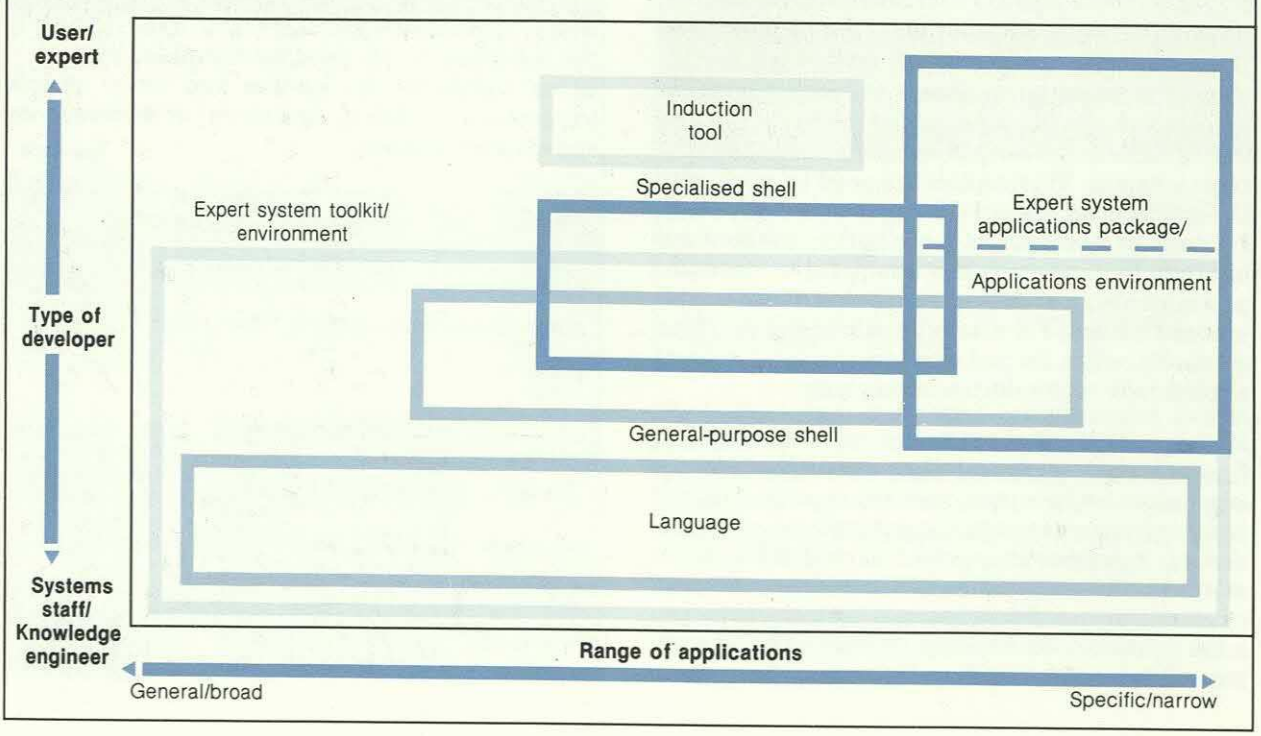


Figure 11 Expert system tools and development staff for each application area

Application area	Tools required	Development staff	Importance of user interface*
Commercial/ administrative			
Information systems	Tools that interface/integrate with mainstream tools. Toolkit/environment/required. Micro/mini/mainframe portability required.	Expert/specialist User Systems staff	Important
Decision support or end-user applications	Microcomputer-based shells, Uncertainty, fuzzy logic tools. Induction tools	Expert Systems staff (as advisor)	Useful
Scientific/technical			
Online/realtime	Specialist tools.	Plant supplier Plant operator In-house expert Systems staff	Crucial
Offline/standalone	Microcomputer-based tools with fault diagnosis. Specialist workstations for design applications.	Repairer or equipment designer In-house expert Systems staff	Important

*The importance of the user interface to some extent determines the tools required.

vary considerably — some products cost $100,000 or more — but there are many usable products costing only a few hundred dollars.

Although most existing products do have some limitations or drawbacks, we expect that most of these problems will be removed over the next three years. Certainly, the current limitations should not be a deterrent to using expert systems. (The technical appendix to the main report provides insights into the main developments likely to occur in the next five years.) The most important limitation that we expect to take longer to remove is the difficulty of acquiring and maintaining the knowledge base on which an expert system is based.

The choice of tools to use is dependent on the application area and on the skills of the staff involved. To some extent, the user interface is also relevant. Figure 11 shows how these parameters interact.

Conclusion

Expert systems are no longer laboratory curiosities. They are ripe for exploitation, and Foundation members should begin to use them for live applications if they are not already doing so. But expert systems are more than just another technology to be exploited. They represent the next significant step forward in computer software. We expect them to become a tool that *all* systems developers will use in time.

Butler Cox is an independent management consultancy and research organisation, specialising in the application of information technology within commerce, government and industry. The company offers a wide range of services both to suppliers and users of this technology.

The Butler Cox Foundation is one of the services provided by Butler Cox. It provides the executives responsible for information systems in large organisations with a continuous analysis of major developments in the technology and its application.

The Foundation publishes six Research Reports each year together with a series of special Position Papers. The programme of activities includes a wide range of meetings that provide Foundation members with a regular opportunity to exchange experiences and views with there counterparts in other large organisations.

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