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EXPERT SYSTEMS

Department of Software Engineering

Definitions

- Expert systems are computerized advisory programs that attempt to imitate the reasoning processes and knowledge of experts in solving specific types of problems.

- It is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise.

- Expert systems are complex AI programs.

- A computer program that simulates human intelligence and behavior in specific and limited domains.

- Its used either as help for human experts or in place of human experts.

- Solves problems with tricks, shortcuts and heuristics (rule of thumb) to solve a problem.

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Description

- Well designed expert systems imitate the reasoning process experts use to solve specific problems. Such systems can be used by nonexperts to improve their problem solving capabilities. Experts system can be used by experts as knowledgeable assistants.

- These systems are used to propagate scarce knowledge resources for improved, consistent results. Ultimately, such systems could function better than any single human experts in making judgments in a specific, usually narrow, area of expertise (domain).

Description (cont…)

- To solve expert-level problems , expert systems need access to a substantial domain knowledge base, which must be built as efficiently as possible. They also need to exploit one or more reasoning mechanisms to apply their knowledge to the problems they are given. Then they need a mechanism for explaining what they have done to the users who rely on them .

- The most widely used way of representing domain knowledge in expert system is as a set of productions rules, which are often coupled with a frame system that defines the objects that occur in the rules.

Expert Systems are good for

- Limited domains where expert knowledge is available.

- Providing expert opinion in remote sites.

- Enhance the performance of tasks by applying heuristic expert knowledge.

Expert Systems are not good for

- Performing commonsense reasoning

- Recognizing the limits of their ability

- Handling inconsistent knowledge

Basic Concepts of Expert System

- The basic concepts of expert systems are:

  - Expertise,

  - Experts,

  - Transferring Expertise,

  - Inferencing Rules, and

  - Explanation capability.

Expertise:

- It is the extensive, task specific knowledge acquired from training, reading, and experience.

- The following types of knowledge are examples of what expertise include:
    - Facts about the problem area
    - Theories about the problem area
    - Hard-and-fast rules and procedures regarding the general problem area.
    - Rules (heuristic) of what to do in a given problem situation (i.e. rules regarding problem solving)
    - Global strategies for solving different types of problems.
    - Meta-knowledge.

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Experts:

- It is expressed w.r.t its degree of expertise.

- Experts can take a problem stated in some arbitrary manner and convert it to a form that lends itself to a rapid and effective solution.

- Expert systems should be able to explain the results, learn new things about the domain, restructure knowledge whenever needed, break rules whenever necessary and determine whether their expertise is relevant.

- All these activities must be done efficiently (quickly and at low cost) and effectively (with high quality results).

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Transferring Expertise:

- The objective of an expert system is to transfer expertise from an expert to a computer and then to other nonexperts.

- This process involves four activities:
  - Knowledge acquisition (from experts or other sources),
  - knowledge representation (in the computer),
  - knowledge Inferencing, and
  - knowledge transfer to user.

- The knowledge is stored in the computer in a component called a ***knowledge base***. Two types of knowledge are distinguished: facts and procedures regarding the problem domain.

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Inferencing:

- A unique feature of an expert system is its ability to reason.

- Given that all the expertise is stored in the knowledge base and that the entire program has accessibility to database, the computer is programmed so that it can make inferences.

- The Inferencing is performed in a component called the <u>Inference Engine</u>.

Rules:

- Most commercial expert systems are Rule Based systems, that is, the knowledge is stored mainly in the form of rules, as are the problem-solving procedures.

Explanation Capability:

- Another unique feature of experts systems is its ability to explain its advice and recommendations and even to justify why a certain action was not recommended.

- The explanation and justification is done in a subsystem called the <u>justifier</u>, or the explanation subsystem.

Structure of Expert System

- Expert systems are composed of two main parts:

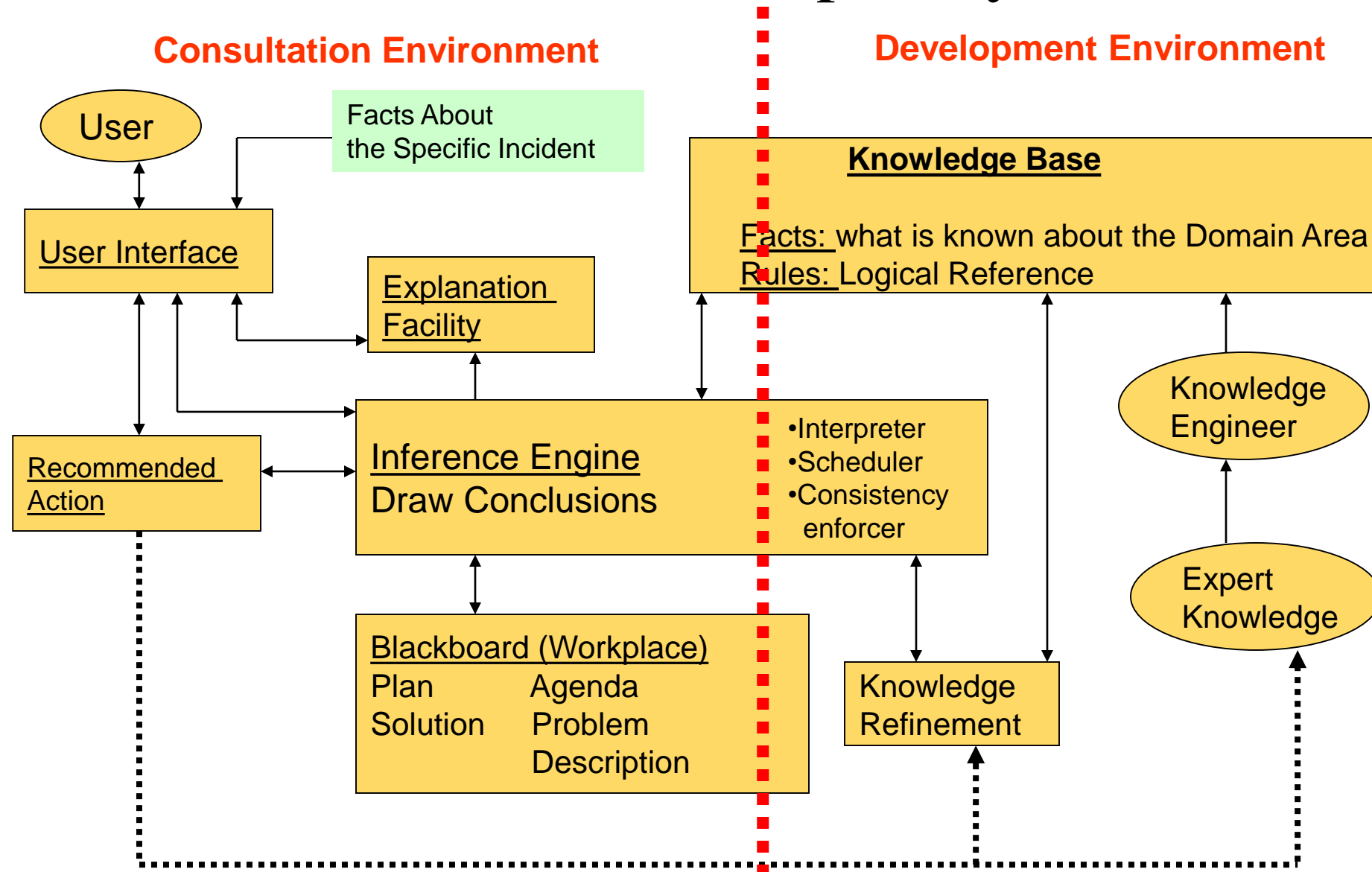 - The Development environment

  - The Consultation environment

The development environment:

It is used by the expert system builder to build the components and to introduce knowledge into the knowledge base.

The consultation environment:

It is used by a nonexpert to obtain expert knowledge and advice.

Structure of an Expert System

Consultation Environment   **Development Environment**

User

Facts About
the Specific Incident

User Interface

Explanation
Facility

Knowledge Base

Facts: what is known about the Domain Area
Rules: Logical Reference

Recommended
Action

Inference Engine
Draw Conclusions

•Interpreter
•Scheduler
•Consistency
 enforcer

Knowledge
Engineer

Blackboard (Workplace)
Plan   Agenda
Solution   Problem
             Description

Knowledge
Refinement

Expert
Knowledge

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Components of Expert System

1. Knowledge acquisition subsystem

2. Knowledge base

3. Inference engine

4. Blackboard (Workplace)

5. User interface

6. Explanation subsystem (Justifier)

7. Knowledge refining system.

1. Knowledge Acquisition Subsystem

- Knowledge acquisition is the accumulation, transfer and transformation of problem-solving expertise from some knowledge source to a computer program for constructing or expanding the knowledge base.

- Potential sources of knowledge include human experts, textbooks, databases, special research reports and pictures.

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2. Knowledge Base

- The knowledge base contains knowledge necessary for understanding, formulating, and solving problems.

- It includes two basic elements:

    (1) facts, such as the problem situation and theory of the problem area, and

    (2) special heuristics or rules that direct the use of knowledge to solve specific problems in a particular domain.

- Knowledge is the primary material of expert systems. The information in the knowledge base is incorporated into a computer program by a process called _Knowledge Representation._

3. Inference Engine

- It is the brain of expert systems, also known as control structure of the rule interpreter.

- This is a computer program that provides a methodology for reasoning about information in the knowledge base and in the blackboard and for formulating conclusions.

- This component provides directions about how to use the system's knowledge by developing the agenda that organizes and controls the steps taken to solve problems whenever consultation is performed.

The main elements of inference engine are:

- An interpreter,

    which executes the chosen agenda items by applying the corresponding knowledge base rules

- A scheduler,

    It estimates the effects of applying inference rules in light of item priorities or other criteria on the agenda.

- A consistency enforcer,

    Which attempts to maintain a consistent representation of the emerging solution.

4. Blackboard (Workplace)

- The blackboard is an area of working memory set aside for the description of a current problem, as specified by the input data,

- It is also used for recording intermediate results.

- Three types of decisions can be recorded on the blackboard:

    (1) plan, how to attach the problem,

    (2) agenda, potential actions awaiting execution, and

    (3) solutions, candidate hypothesis and alternative courses of action that the system has generated thus far.

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5. User Interface

- Expert systems contain a language processor for friendly, problem-oriented communication between the user and the computer.

- This communication is best supplemented by use of menus and other graphics.

6. Explanation Subsystem (Justifier)

- The ability to trace responsibility for conclusions to their sources is crucial both in the transfer of expertise and in problem solving.

- The explanation subsystem can trace such responsibility and explain the expert system behavior by interactively answering questions such as the following:

- Why was a certain questions asked by the expert system?

- How was a certain conclusion reached?

- Why was a certain alternative rejected?

- What is the plan to reach the solution?

7. Knowledge Refining System

- Human experts have a knowledge refining system, that is, they can analyze their own performance, learn from it, and improve it for future consultations.

- Similarly, such evaluation is necessary in computerized learning so that the program will be able to analyze the reasons for its success or failure.

- This could lead to improvements that result in a better knowledge base and more effective reasoning.

The Human Element in Expert Systems

- At least two humans participate in the use and development of an expert system.

- There is an expert and a user.

- Further, there is also a knowledge engineer and a system builder.

- Each has a role to play.

The Expert

- The expert, commonly referred to as domain expert, is a person who has the special knowledge, judgment, experience, and methods along with the ability to apply these talents to give advice and solve problems.

- Its an experts job to provide knowledge about the task that the knowledge system will perform.

- The expert knows which facts are important and understands the meaning of relationships among facts.

The Knowledge Engineer

- The knowledge engineer helps the expert structure the problem area by interpreting and integrating human answers to questions, drawing analogies, posing counterexamples, and bringing to light conceptual difficulties.

- The shortage of experienced knowledge engineers is a major bottleneck in expert system construction. To overcome this bottleneck, expert system designers are using productivity tolls (e.g. special editors) and research is being conducted on building systems that will bypass the need for knowledge engineers. *(source: web)*
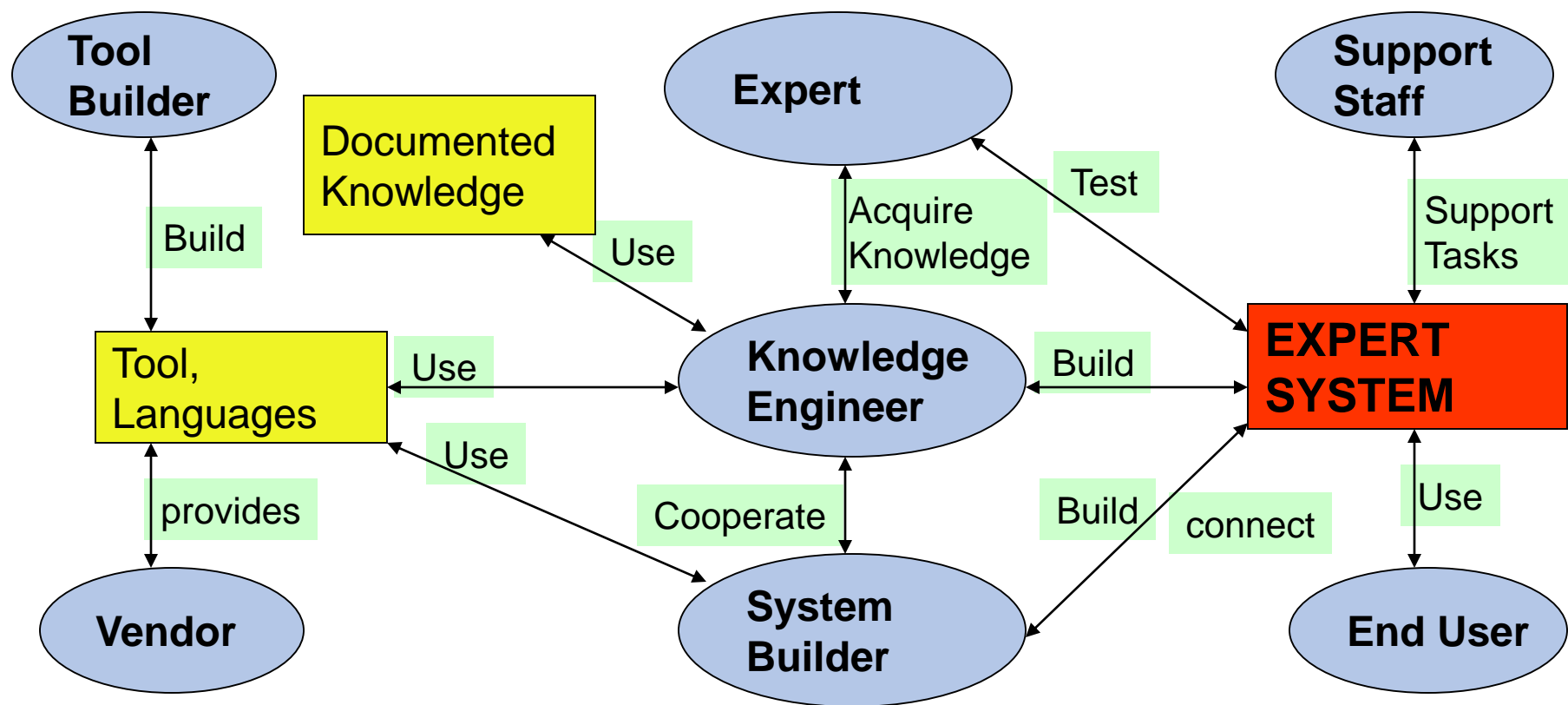
The Users

Most computer based systems have evolved in a single user

mode. But an expert system has several possible types of

users.

- A nonexpert client seeking direct advice. In such a case the expert system acts as a ***consultant or advisor***.

- A student who wants to learn. In such a case the expert system acts as an ***instructor.***

- An expert system builder who wants to improve or increase the knowledge base. In such a case an expert system acts as a ***partner.***

- Working as an expert. In such a case expert system acts as a ***colleague.***

Other Participants

- Several other participants may be involved in expert system. For example,

  - a system builder, he may assist in integrating the expert system with other computerized systems.

  - A tool builder, he may provide generic or build specific tools.

  - Vendors, they may provide tools and advice, and,

  - Support staff, they provides practical and technical help.

Participants & Their Roles in Building Expert System

Tool Builder

Documented Knowledge

Expert

Support Staff

Build

Test

Acquire Knowledge

Support Tasks

Use

Tool, Languages

Use

Knowledge Engineer

Build

EXPERT SYSTEM

provides

Use

Cooperate

Build

connect

Use

Vendor

System Builder

End User

Working of Expert Systems

- Three major activities are part of expert system construction and use.

   They are:

   (1) Development,

   (2) Consultation, and

   (3) Improvement.

Development

- The development of an expert system involves the construction of the knowledge base by acquiring knowledge from experts and/or from documented sources.

- Development activity also includes the construction of an inference engine, a blackboard, an explanation facility and other required software for interfacing.

- The major participants in this activity are the domain expert, the knowledge engineer, and possibly information system programmer.

- A general toolkit that can be used to build a number of different expert systems, depending on which knowledge-base is added, it is known as **expert system Shell.** Shell includes all the generic components of an expert system but they do not include the knowledge.

Consultation

- Once the system is developed and validated, it is transferred to the users.

- When user wants advice from expert system, it conducts a bidirectional dialogue with the user, asking to provide facts about specific incident.

- After accepting the users answers, the system attempts to reach a conclusion.

- This effort is made by the inference engine which decides which heuristic search techniques should be used to determine how the rules in the knowledge base are to be applied to the problem.

- The consultation environment is also used by the builder during the development phase to test the system. At that time, the interface and the explanation facility may be tested.

Improvement

- Experts systems are improved several times through a process called rapid prototyping during their development.

Types of Expert systems

Expert systems appear in many varieties. The following classification of ES is not exclusive, that is, one ES can appear in several categories:

1. Expert System and Knowledge – based Systems

- In the business world, expert systems are emerging that can perform tasks effectively and efficiently for whose execution you really do not need an expert. Such systems are referred to as Knowledge – based Systems. They are also known as advisory systems, knowledge systems.

- For example, system that gives advice on immunizations recommended for travel abroad. The advice depends upon many attributes such as age, gender and the health of the traveler and the country of destination.

2. Rule – based expert system

- Many commercial ES are rules based, because the technology of rule-based system is relatively well developed. In such systems the knowledge is represented as a series of production rules.

- For example MYCIN is the best example of rule based ES.

3. Frame – based system

- In these systems, the knowledge is represented as frames, a representation of the object – oriented programming approach.

4. Hybrid Systems

- These systems include several knowledge representation approaches, at minimum frames and rules, but usually more.

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5. Model-based Systems

- Model-based systems are structured around a model that simulates the structure and function of the system under study. The model is used to compute values, which are compared to observed ones. The comparison triggers action (if needed) or further diagnosis.

6. Real-time Expert Systems

- Real-time systems are systems in which there is a strict time limit on the system's response time, which must be fast enough for use to control the process being computerized.

7. Ready-made (Off-the-Shelf) Systems

- ES can be developed to meet the particular needs of a user (custom made), or they can be purchased as ready-made packages for any user.

- Ready-made systems are similar to application packages like an accounting general ledger or project management in operations management.

- Ready-made systems enjoy the economy of mass production and therefore are considerably less expensive than customized systems.

- They also can be used as soon as they are purchased. Unfortunately, ready-made systems are very general in nature, and the advice they render may not be of value to a user involved in a complex situation.

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Limitations of expert System

- The major limitation of expert system arises from their limited focus, their inability to learn, maintain them and their development cost.

- Expert systems are made to solve specific type of problems in the limited domain of knowledge. They fail miserably in solving problems requiring a broad knowledge base and subjective problem solving.

- They do well with specific type of operational or analytical tasks but fail at subjective managerial decision-making.

Limitations of expert System

- Experts systems are difficult and costly to develop and maintain properly. The cost of knowledge engineers, lost expert time and hardware and software resources may be too high to offset the benefits expected form some applications.

- Also we know that expert systems can't maintain themselves. Even they can't learn from experience but must be taught new knowledge that is modified, as new expertise is needed to match developments in their subject areas.

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Expert Systems Shells

- A shell is a complete development environment for building and maintaining knowledge-based applications.

- It provides a step-by-step methodology for a knowledge engineer that allows the domain experts themselves to be directly involved in structuring and encoding the knowledge.

- Many commercial shells are available.

Expert System Available Shells

- **Freeware Tools**
  - **GEST (Generic Expert System Tool)**
  - **CLIPS (C Language Integrated Production System)**
  - **DYNACLIPS (DYNAamic CLIPS Utilities)**
  - **FuzzyCLIPS**

- **Commercial Tools**
  - **Aion Development System (ADS)**
  - **ART*Enterprise**
  - **Doctus KBS**
  - **EXSYS Professional**
  - **KEE (Knowledge Engineering Environment)**
  - **M.4**
  - **Nexpert Object**
  - **RT-Expert**
  - **XpertRule**