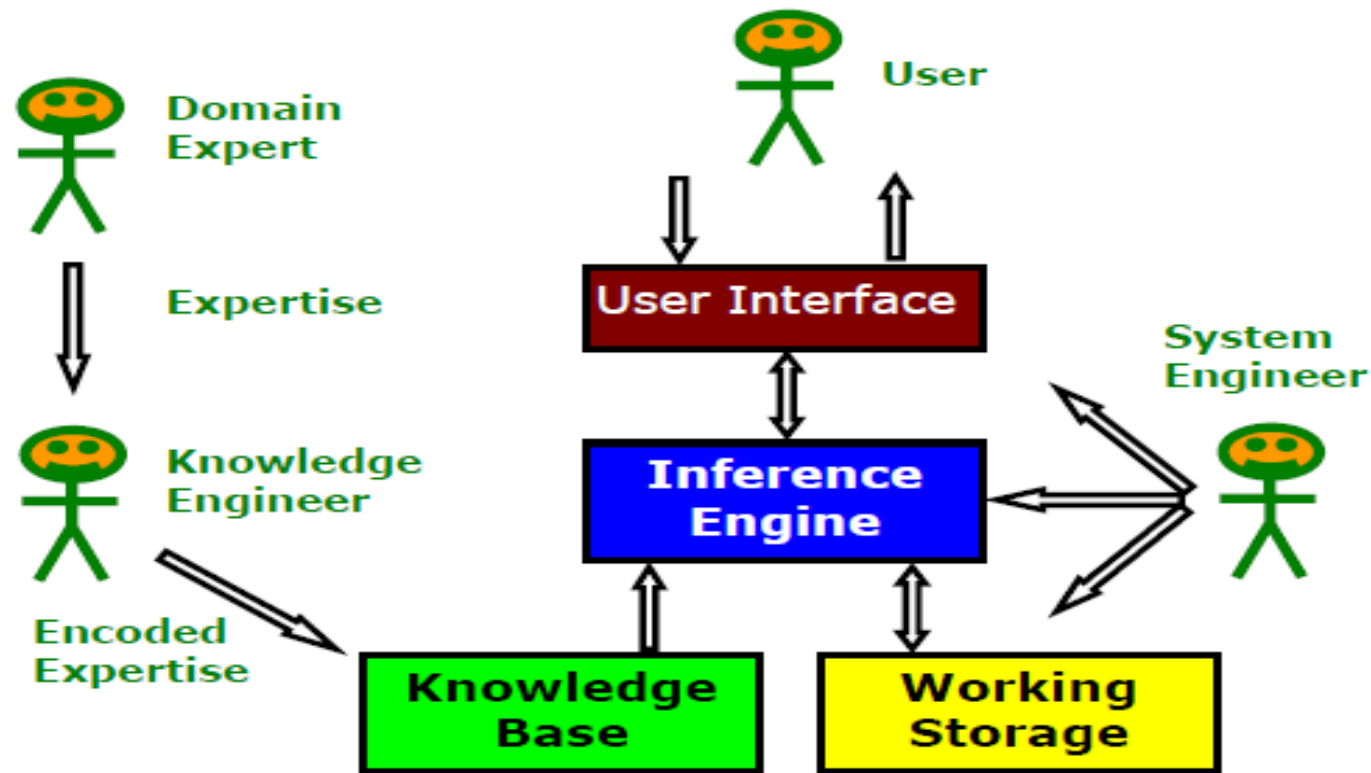# Expert System

Definition

- An expert system, is an interactive computer-based decision tool that uses both facts and heuristics to solve difficult decision making problems, based on knowledge acquired from an expert.

- An expert system is a model and associated procedure that exhibits, within a specific domain, a degree of expertise in problem solving that is comparable to that of a human expert.

- An expert system compared with traditional computer :

  Inference engine + Knowledge = Expert system

  (Algorithm + Data structures   = Program in traditional computer)

- First expert system, called DENDRAL, was developed in the early 70's at Stanford University.

Expert System Components And Human Interfaces

Expert systems have a number of major system components and interface with individuals who interact with the system in various roles. These are illustrated below.


Components of Expert System

- **Components and Interfaces**

  - ‡ **Knowledge base :** A declarative representation of the expertise; often in IF THEN rules ;
  - ‡ **Working storage :** The data which is specific to a problem being solved;
  - ‡ **Inference engine :** The code at the core of the system which derives recommendations from the knowledge base and problem-specific data in working storage;
  - ‡ **User interface :** The code that controls the dialog between the user and the system.

- **Roles of Individuals who interact with the system**

  - ‡ **Domain expert :** The individuals who currently are experts in solving the problems; here the system is intended to solve;
  - ‡ **Knowledge engineer :** The individual who encodes the expert's knowledge in a declarative form that can be used by the expert system;
  - ‡ **User :** The individual who will be consulting with the system to get advice which would have been provided by the expert.

Architecture of a typical Expert system
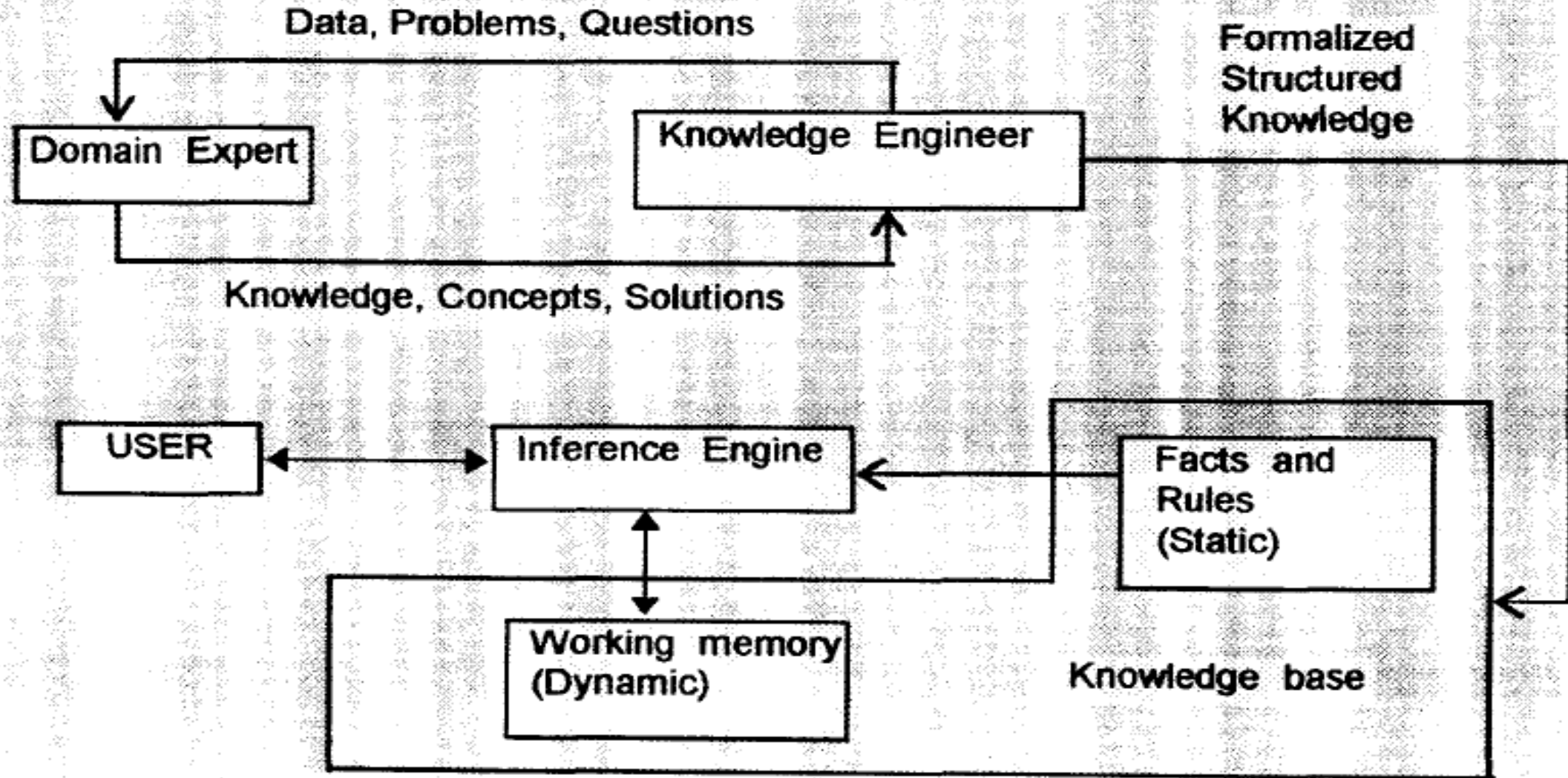
Expert System Shells

Many expert systems are built with products called expert system shells. A shell is a piece of software which contains the user interface, a format for declarative knowledge in the knowledge base, and an inference engine. The knowledge and system engineers uses these shells in making expert systems.

- **Knowledge engineer :** uses the shell to build a system for a particular problem domain.

- **System engineer :** builds the user interface, designs the declarative format of the knowledge base, and implements the inference engine.

Depending on the size of the system, the knowledge engineer and the system engineer might be the same person.

Characteristics

- **Operates as an interactive system**

  This means an expert system :
  - Responds to questions
  - Asks for clarifications
  - Makes recommendations
  - Aids the decision-making process.

- **Tools have ability to sift (filter) knowledge**
  - Storage and retrieval of knowledge
  - Mechanisms to expand and update knowledge base on a continuing basis.

- **Make logical inferences based on knowledge stored**
  - Simple reasoning mechanisms is used
  - Knowledge base must have means of exploiting the knowledge stored, else it is useless; e.g., learning all the words in a language, without knowing how to combine those words to form a meaningful sentence.

- **Ability to Explain Reasoning**
  - Remembers logical chain of reasoning; therefore user may ask
    - ◇ for explanation of a recommendation
    - ◇ factors considered in recommendation
  - Enhances user confidence in recommendation and acceptance of expert system

- **Domain-Specific**
  - A particular system caters a narrow area of specialization; e.g., a medical expert system cannot be used to find faults in an electrical circuit.
  - Quality of advice offered by an expert system is dependent on the amount of knowledge stored.

- **Capability to assign Confidence Values**
  - Can deliver quantitative information
  - Can interpret qualitatively derived values
  - Can address imprecise and incomplete data through assignment of confidence values.

Expert System Features

The features which commonly exist in expert systems are :

- **Goal Driven Reasoning or Backward Chaining**

  An inference technique which uses IF-THEN rules to repetitively break a goal into smaller sub-goals which are easier to prove;

- **Coping with Uncertainty**

  The ability of the system to reason with rules and data which are not precisely known;

- **Data Driven Reasoning or Forward Chaining**

  An inference technique which uses IF-THEN rules to deduce a problem solution from initial data;

- **Data Representation**

  The way in which the problem specific data in the system is stored and accessed;
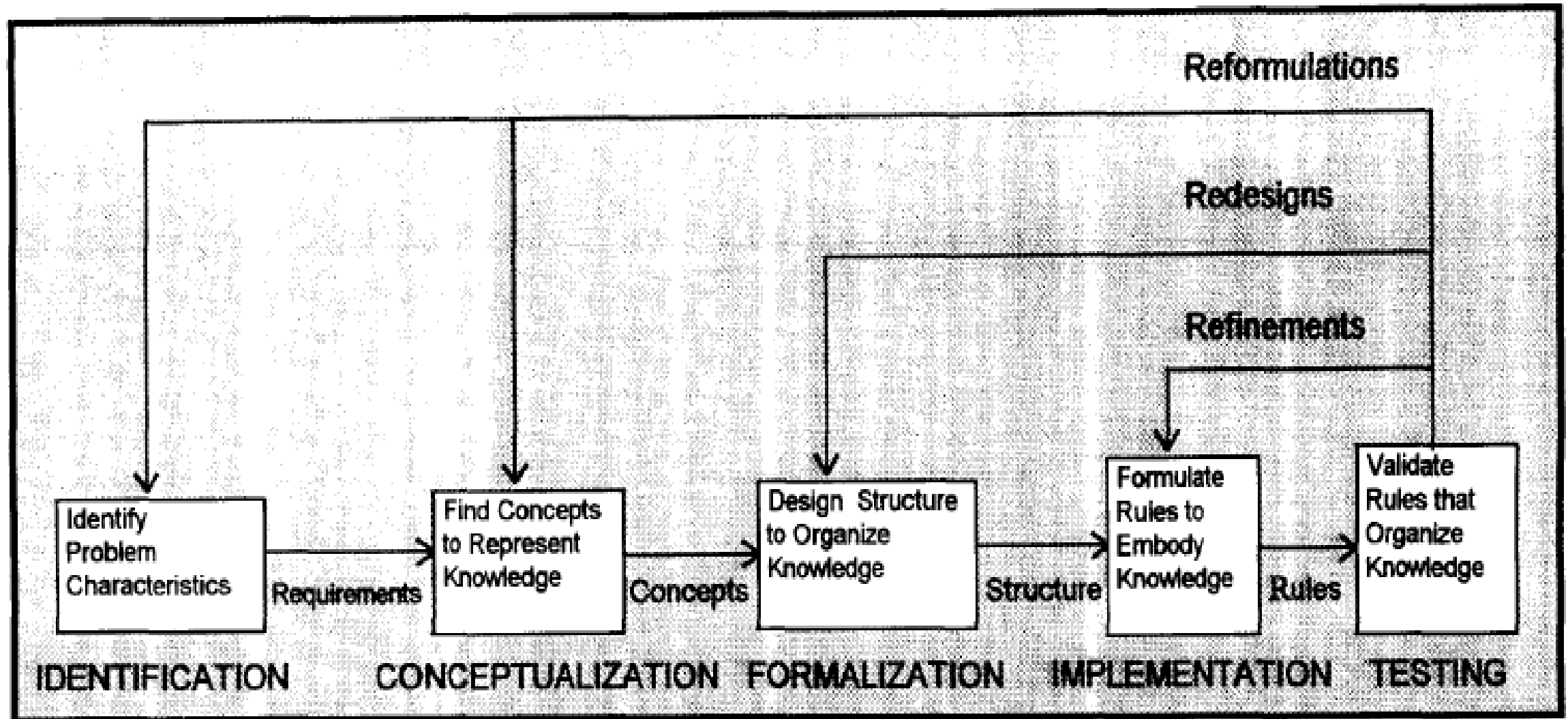
- **User Interface**

  That portion of the code which creates an easy to use system;

- **Explanations**

  The ability of the system to explain the reasoning process that it used to reach a recommendation.

Major Stages of Expert System

Applications

‡ **Diagnosis and Troubleshooting of Devices and Systems**

Medical diagnosis was one of the first knowledge areas to which Expert system technology was applied in 1976. However, the diagnosis of engineering systems quickly surpassed medical diagnosis.

‡ **Planning and Scheduling**

The Expert system's commercial potential in planning and scheduling has been recognized as very large. Examples are airlines scheduling their flights, personnel, and gates; the manufacturing process planning and job scheduling;

‡ **Configuration of Manufactured Objects from sub-assemblies**

Configuration problems are synthesized from a given set of elements related by a set of constraints. The Expert systems have been very useful to find solutions. For example, modular home building and manufacturing involving complex engineering design.

‡ **Financial Decision Making**

The financial services are the vigorous user of expert system techniques. Advisory programs have been created to assist bankers in determining whether to make loans to businesses and individuals. Insurance companies to assess the risk presented by the customer and to determine a price for the insurance. ES are used in typical applications in the financial markets / foreign exchange trading.

‡ **Knowledge Publishing**

This is relatively new, but also potentially explosive area. Here the primary function of the Expert system is to deliver knowledge that is relevant to the user's problem. The two most widely known Expert systems are : one, an advisor on appropriate grammatical usage in a text; and the other, is a tax advisor on tax strategy, tactics, and individual tax policy.

‡ **Process Monitoring and Control**

Here Expert system does analysis of real-time data from physical devices, looking for anomalies, predicting trends, controlling optimality and failure correction. Examples of real-time systems that actively monitor processes are found in the steel making and oil refining industries.

‡ **Design and Manufacturing**

Here the Expert systems assist in the design of physical devices and processes, ranging from high-level conceptual design of abstract entities all the way to factory floor configuration of manufacturing processes.