UNIT- V

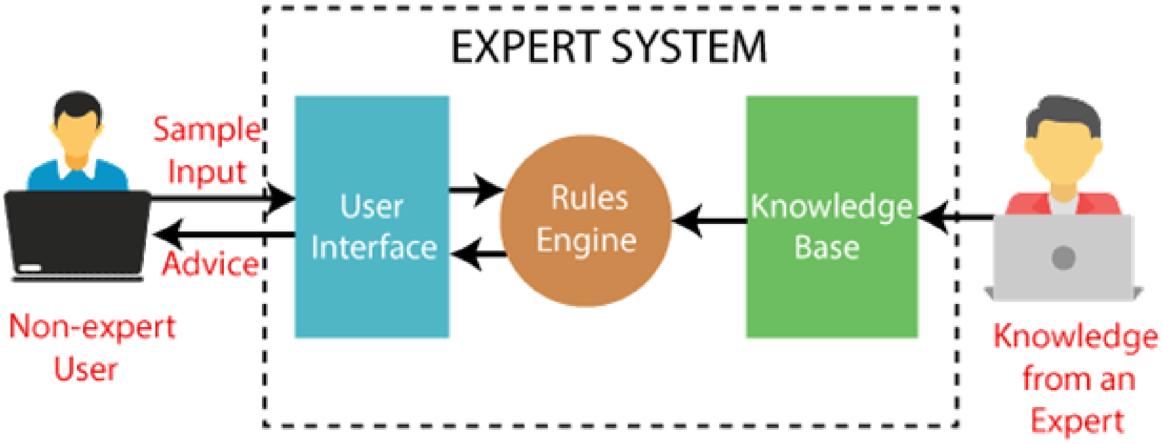
What is an Expert System?

An expert system is a computer program that is designed to solve complex problems and to provide decision-making ability like a human expert. It performs this by extracting knowledge from its knowledge base using the reasoning and inference rules according to the user queries.

The expert system is a part of AI, and the first ES was developed in the year 1970, which was the first successful approach of artificial intelligence. It solves the most complex issue as an expert by extracting the knowledge stored in its knowledge base. The system helps in decision making for compsex problems using **both facts and heuristics like a human expert**. It is called so because it contains the expert knowledge of a specific domain and can solve any complex problem of that particular domain. These systems are designed for a specific domain, such as **medicine, science,** etc.

The performance of an expert system is based on the expert's knowledge stored in its knowledge base. The more knowledge stored in the KB, the more that system improves its performance. One of the common examples of an ES is a suggestion of spelling errors while typing in the Google search box.

Below is the block diagram that represents the working of an expert system:



Below are some popular examples of the Expert System:

- **DENDRAL:** It was an artificial intelligence project that was made as a chemical analysis expert system. It was used in organic chemistry to detect unknown organic molecules with the help of their mass spectra and knowledge base of chemistry.
- **MYCIN:** It was one of the earliest backward chaining expert systems that was designed to find the bacteria causing infections like bacteraemia and meningitis. It was also used for the recommendation of antibiotics and the diagnosis of blood clotting diseases.
- **PXDES:** It is an expert system that is used to determine the type and level of lung cancer. To determine the disease, it takes a picture from the upper body, which looks like the shadow. This shadow identifies the type and degree of harm.
- **CaDeT:** The CaDet expert system is a diagnostic support system that can detect cancer at early stages.

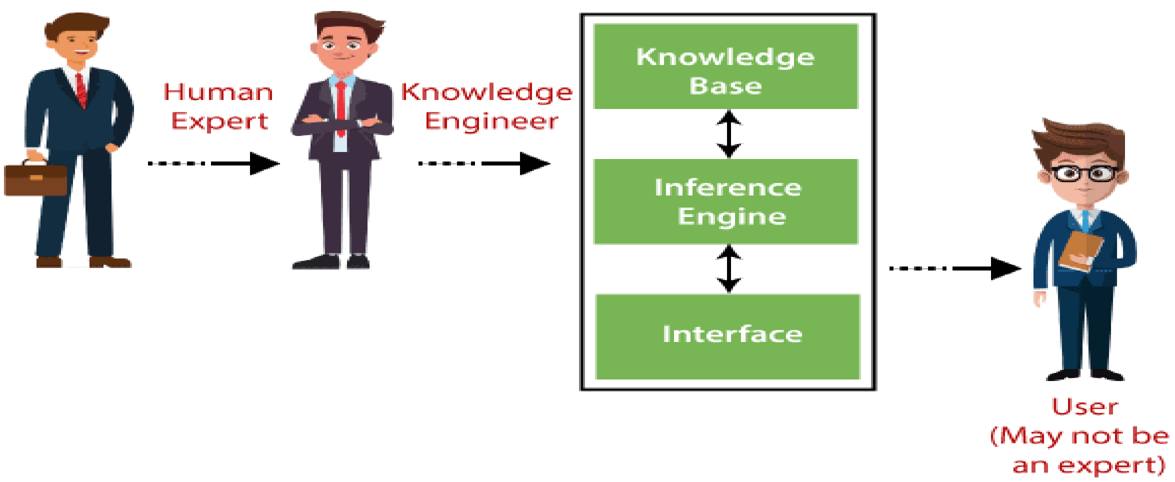
Characteristics of Expert System

- **High Performance:** The expert system provides high performance for solving any type of complex problem of a specific domain with high efficiency and accuracy.
- **Understandable:** It responds in a way that can be easily understandable by the user. It can take input in human language and provides the output in the same way.
- **Reliable:** It is much reliable for generating an efficient and accurate output.
- **Highly responsive:** ES provides the result for any complex query within a very short period of time.

Components of Expert System (Architecture of Expert System)

An expert system mainly consists of three components:

- **User Interface**
- **Inference Engine**
- **Knowledge Base**



1. User Interface

With the help of a user interface, the expert system interacts with the user, takes queries as an input in a readable format, and passes it to the inference engine. After getting the response from the inference engine, it displays the output to the user. In other words, **it is an interface that helps a non-expert user to communicate with the expert system to find a solution**.

2. Inference Engine (Rules of Engine)

- The inference engine is known as the brain of the expert system as it is the main processing unit of the system. It applies inference rules to the knowledge base to derive a conclusion or deduce new information. It helps in deriving an error-free solution of queries asked by the user.
- With the help of an inference engine, the system extracts the knowledge from the knowledge base.
- There are two types of inference engine:
- **Deterministic Inference engine:** The conclusions drawn from this type of inference engine are assumed to be true. It is based on **facts** and **rules**.
- **Probabilistic Inference engine:** This type of inference engine contains uncertainty in conclusions, and based on the probability.

Inference engine uses the below modes to derive the solutions:

- **Forward Chaining:** It starts from the known facts and rules, and applies the inference rules to add their conclusion to the known facts.
- **Backward Chaining:** It is a backward reasoning method that starts from the goal and works backward to prove the known facts.

3. Knowledge Base

- The knowledgebase is a type of storage that stores knowledge acquired from the different experts of the particular domain. It is considered as big storage of knowledge. The more the knowledge base, the more precise will be the Expert System.
- It is similar to a database that contains information and rules of a particular domain or subject.
- One can also view the knowledge base as collections of objects and their attributes. Such as a Lion is an object and its attributes are it is a mammal, it is not a domestic animal, etc.

Components of Knowledge Base

- **Factual Knowledge:** The knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.
- **Heuristic Knowledge:** This knowledge is based on practice, the ability to guess, evaluation, and experiences.

Knowledge Representation: It is used to formalize the knowledge stored in the knowledge base using the If-else rules.

Knowledge Acquisitions: It is the process of extracting, organizing, and structuring the domain knowledge, specifying the rules to acquire the knowledge from various experts, and store that knowledge into the knowledge base.

Development of Expert System

Here, we will explain the working of an expert system by taking an example of MYCIN ES. Below are some steps to build an MYCIN:

- Firstly, ES should be fed with expert knowledge. In the case of MYCIN, human experts specialized in the medical field of bacterial infection, provide information about the causes, symptoms, and other knowledge in that domain.
- The KB of the MYCIN is updated successfully. In order to test it, the doctor provides a new problem to it. The problem is to identify the presence of the bacteria by inputting the details of a patient, including the symptoms, current condition, and medical history.
- The ES will need a questionnaire to be filled by the patient to know the general information about the patient, such as gender, age, etc.
- Now the system has collected all the information, so it will find the solution for the problem by applying if-then rules using the inference engine and using the facts stored within the KB.
- In the end, it will provide a response to the patient by using the user interface.

Participants in the development of Expert System

There are three primary participants in the building of Expert System:

1. **Expert:** The success of an ES much depends on the knowledge provided by human experts. These experts are those persons who are specialized in that specific domain.
2. **Knowledge Engineer:** Knowledge engineer is the person who gathers the knowledge from the domain experts and then codifies that knowledge to the system according to the formalism.
3. **End-User:** This is a particular person or a group of people who may not be experts, and working on the expert system needs the solution or advice for his queries, which are complex.

Roles of Artificial Intelligence:

Expert systems play a significant role in artificial intelligence by mimicking human expertise in specific domains to solve complex problems. Here are some key roles they fulfill:

1. **Knowledge Representation**: Expert systems utilize structured knowledge bases to represent domain-specific information, allowing them to make inferences and decisions.
2. **Decision Support**: They assist in decision-making processes by providing recommendations based on rules and logic, often used in fields like healthcare, finance, and engineering.
3. **Problem Solving**: Expert systems can analyze problems, suggest solutions, and even simulate potential outcomes, making them valuable for tasks such as diagnostics and troubleshooting.
4. **Consistency**: Unlike human experts, expert systems provide consistent outputs and decisions, reducing variability in areas like medical diagnoses or technical support.
5. **Accessibility**: They make expert knowledge more widely available, enabling organizations to leverage expertise without needing a human expert on hand.
6. **Training and Education**: Expert systems can serve as training tools, helping novices learn by providing feedback and guiding them through problem-solving processes.

7. **Efficiency and Cost Reduction**: By automating complex decision-making tasks, expert systems can save time and resources, improving overall operational efficiency.
8. **Scalability**: They can handle large volumes of data and complex queries, making them suitable for environments requiring quick and accurate analysis.
9. **Integration with Other AI Technologies**: Expert systems can be integrated with machine learning and natural language processing, enhancing their capabilities and making them more user-friendly.

In summary, expert systems are crucial in various applications where specialized knowledge and decision-making are required, streamlining processes and improving outcomes across multiple domains.

What is knowledge representation?

Humans are best at understanding, reasoning, and interpreting knowledge. Human knows things, which is knowledge and as per their knowledge they perform various actions in the real world. But how machines do all these things comes under knowledge representation and reasoning. Hence we can describe Knowledge representation as following:

- Knowledge representation and reasoning (KR, KRR) is the part of Artificial intelligence which concerned with AI agents thinking and how thinking contributes to intelligent behavior of agents.
- It is responsible for representing information about the real world so that a computer can understand and can utilize this knowledge to solve the complex real world problems such as diagnosis a medical condition or communicating with humans in natural language.
- It is also a way which describes how we can represent knowledge in artificial intelligence. Knowledge representation is not just storing data into some database, but it also enables an intelligent machine to learn from that knowledge and experiences so that it can behave intelligently like a human.

What to Represent:

Following are the kind of knowledge which needs to be represented in AI systems:

- Object: All the facts about objects in our world domain. E.g., Guitars contains strings, trumpets are brass instruments.
- Events: Events are the actions which occur in our world.
- Performance: It describe behavior which involves knowledge about how to do things.
- Meta-knowledge: It is knowledge about what we know.
- Facts: Facts are the truths about the real world and what we represent.
- Knowledge-Base: The central component of the knowledge-based agents is the knowledge base. It is represented as KB. The Knowledgebase is a group of the Sentences (Here, sentences are used as a technical term and not identical with the English language).

Knowledge: Knowledge is awareness or familiarity gained by experiences of facts, data, and situations. Following are the types of knowledge in artificial intelligence:

Types of knowledge

Following are the various types of knowledge:

Declarative Knowledge:

- Declarative knowledge is to know about something.
- It includes concepts, facts, and objects.
- It is also called descriptive knowledge and expressed in declarative sentences.
- It is simpler than procedural language.

2. Procedural Knowledge

- It is also known as imperative knowledge.
- Procedural knowledge is a type of knowledge which is responsible for knowing how to do something.
- It can be directly applied to any task.
- It includes rules, strategies, procedures, agendas, etc.
- Procedural knowledge depends on the task on which it can be applied.

3. Meta-knowledge:

- Knowledge about the other types of knowledge is called Meta-knowledge.

4. Heuristic knowledge:

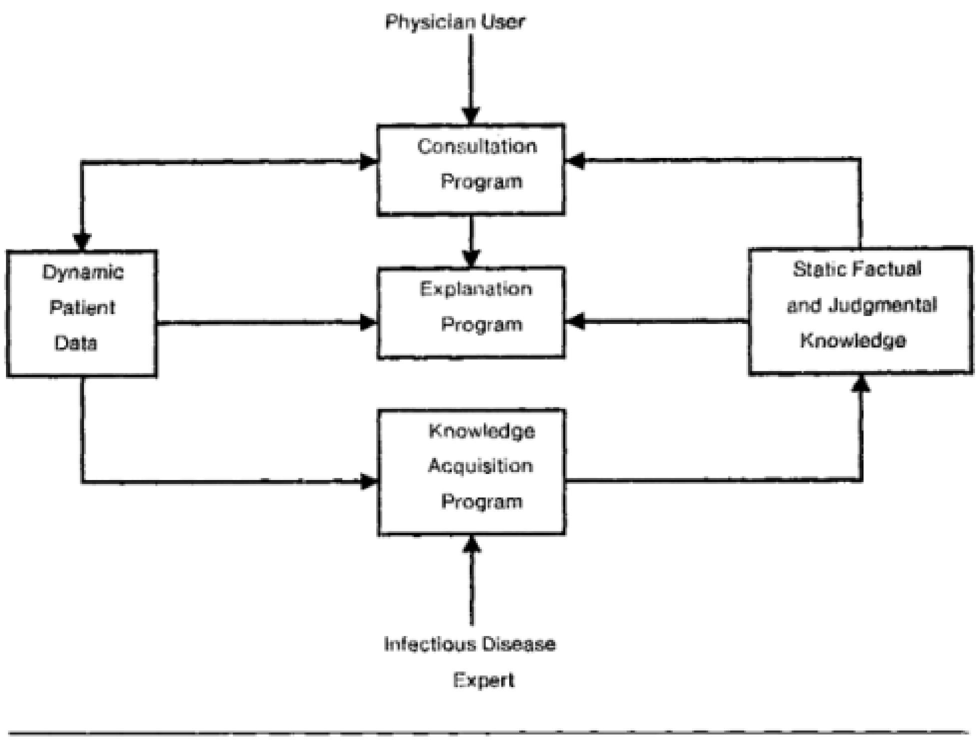
- Heuristic knowledge is representing knowledge of some experts in a filed or subject.
- Heuristic knowledge is rules of thumb based on previous experiences, awareness of approaches, and which are good to work but not guaranteed.

5. Structural knowledge:

- Structural knowledge is basic knowledge to problem-solving.
- It describes relationships between various concepts such as kind of, part of, and grouping of something.
- It describes the relationship that exists between concepts or objects.

MYCIN expert system:

MYCIN, an early expert system, or artificial intelligence (AI) program, for treating blood infections. In 1972 work began on MYCIN at Stanford University in California. MYCIN would attempt to diagnose patients based on reported symptoms and medical test results. The program could request further information concerning the patient, as well as suggest additional laboratory tests, to arrive at a probable diagnosis, after which it would recommend a course of treatment. If requested, MYCIN would explain the reasoning that led to its diagnosis and recommendation. Using about 500 production rules, MYCIN operated at roughly the same level of competence as human specialists in blood infections and rather better than general practitioners.



Introduction:

MYCIN was an early backward chaining expert system that used artificial intelligence to identify bacteria causing severe infections and to recommend antibiotics, with the dosage adjusted for patient’s body weight.

- MYCIN was developed over five or six years in the early 1970s at Stanford University.
- It was written in Lisp
- MYCIN operated using fairly simple inference engine, and a knowledge base of approximately 600 rules.

MYCIN is a computer program designed to provide attending physicians with advice comparable to that which they would otherwise get from a consulting physician specializing in bacteremia and meningitis infections. To use MYCIN, the attending physician must sit in front of a computer terminal that is connected to a DEC-20 (one of Digital Equipment Corporation’s mainframe computers) where the MYCIN program is stored. When the MYCIN program is evoked, it initiates a dialogue. The physician types answers in response to various questions. Eventually MYCIN provides a diagnosis and a detailed drug therapy recommendation.

The MYCIN system comprises three major subprograms, as depicted in Figure above.

- The Consultation Program
- Explanation Program
- Knowledge Acquisition Program

The **Consultation Program** is the core of the system; it interacts with the physician to obtain information about the patient, generating diagnoses and therapy recommendations.

The **Explanation Program** provides explanations and justifications for the program’s actions.

The **Knowledge-Acquisition** Program is used by experts to update the system’s knowledge base.

DART experiment System:

Introduction:

DART an application of artificial intelligence techniques that is use for computer system fault diagnosis. It is an automated consultant that advises IBM field service personnel on the diagnosis of faults occurring in computer installations.

Scope of DART

- A typical, large-scale computer installation is composed of numerous subsystems including CPUs, primary and secondary storage, peripherals and supervisory software.
- Each of these subsystems, in turn, consists of a richly connected set of both hardware and software components such as disk drives, controllers, CPUs, memory modules, and access methods.
- Generally, each individual component has an associated set of diagnostic aids designed to test its own specific integrity.
- However, very few maintenance tools and established diagnostic strategies are aimed at identifying faults on the system or subsystem level.
- As a result, identification of single or multiple faults from systemic manifestations remains a difficult task.
- The non-specialist field service engineer is trained to use the existing component-specific tools as a result, is often unable to attack the the failure at the systemic level.
- Expert assistance is then required, increasing both the time and cost required to determine and repair the fault.
- The design of DART reflects the expert’s ability to take a systemic viewpoint on problems and to see that viewpoint to indicate a specific components, thus making more effective use of the existing maintenance capabilities.

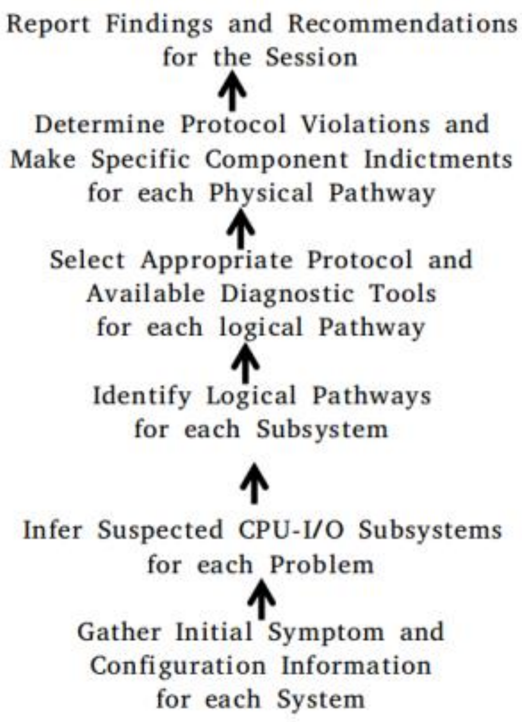


Fig: The DART Diagnostic Inference Process

DART

XCON expert system:

XCON is a Rule-based system written in OPS5 in 1978 to assist in the ordering of DEC's VAX computer systems by automatically selecting the computer system components based on the customer's requirements.

In 1975 DEC offered 50 types of central processors with 400 core operations. The estimated possible number of configurations at that time was already in millions. So system configuration was the key process in DEC`s flexibility strategy for it converted a customer order into fully configured system that was designed, checked and ready for delivery. This process involves three separate reviews of each order.

- The first two steps relied upon highly skilled and talented technical editors who learned their craft through a long apprenticeship.

- The final review was FA & T (Fast Assembly and Test) which is nothing but actual assembly of the system prior to delivery.

Elapsed time from signed order to delivery was ten to fifteen weeks, extending at times even up to six months. Computers too were growing more complex, increasing even further the number of configuration options. DEC had to find a new way to configure its order and so XCON DEC`s configuration system was born.

Functions of XCON System:

XCON is used to configure customer orders and to guide the assembly of these orders at the customer site. Using the customer order as input, it provides the following functionality:

- Configures CPUs, memory, cabinets, power supplies, disk, tapes and so on.
- Determines and list cabling information.
- List components ordered with configuration related comments.
- Generate warning messages on issues affecting technical validity.

Scope of XCON

The initial purpose of XCON was to assist manufacturing plant personnel in validating the technical correctness of system orders about to be filled. It is now used by a broad set of users across the company's major functions like sales and marketing, manufacturing and production, field service and engineering. The users of these systems perform functions that span Digital`s complete order flow and manufacturing cycle. Thus they are involved with many different business processes. Each has different needs and takes a different perspective on the configuration information provided.

- Sales uses the configuration systems as an integral part of the automated process to generate quotations for customer
- Manufacturing uses the information to verify buildability of all incoming orders.

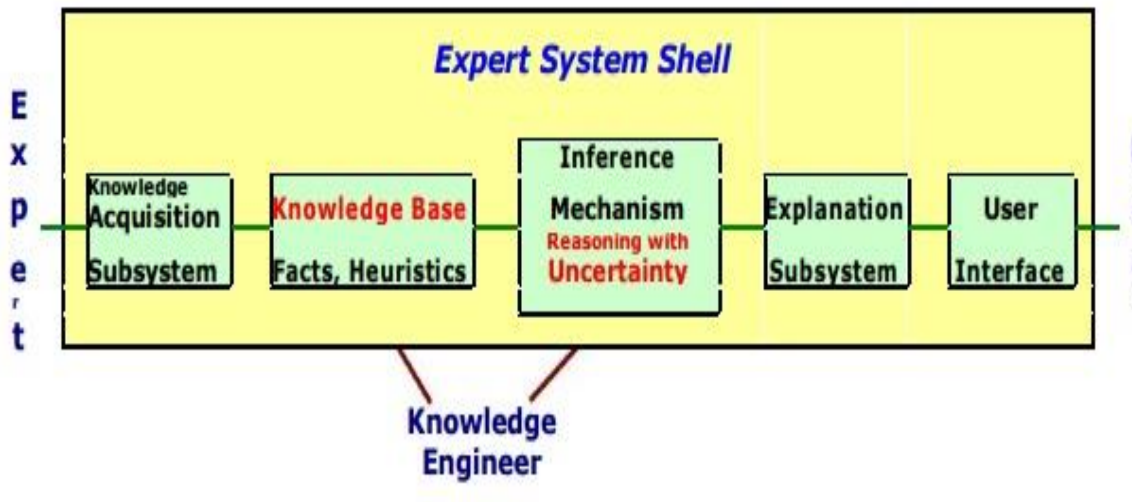
- Field service has the perspective of assembling the order in the customer's unique environment.
- Manufacturing and engineering benefits from the configuration system`s focus on system integration and can identify potential problems in system-level design and manufacturability.

Expert System shells:

An Expert system shell is a software development environment. It contains the basic components of expert systems. A shell is associated with a prescribed method for building applications by configuring and instantiating these components.

Shell components and description

The generic components of a shell: the knowledge acquisition, the knowledge Base, the reasoning, the explanation and the user interface are shown below. The knowledge base and reasoning engine are the core components.



All these components are described in the next slide.

■ **Knowledge Base**

A store of factual and heuristic knowledge. Expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. Some tools use both Frames (objects) and IF-THEN rules. In PROLOG the knowledge is represented as logical statements.

■ **Reasoning Engine**

Inference mechanisms for manipulating the symbolic information and knowledge in the knowledge base form a line of reasoning in solving a problem. The inference mechanism can range from simple modus ponens backward chaining of IF-THEN rules to Case-Based reasoning.

Knowledge Acquisition subsystem

A subsystem to help experts in build knowledge bases. However, collecting knowledge, needed to solve problems and build the knowledge base, is the biggest bottleneck in building expert systems.

Explanation subsystem

A subsystem that explains the system's actions. The explanation can range from how the final or intermediate solutions were arrived at justifying the need for additional data.

User Interface

A means of communication with the user. The user interface is generally not a part of the expert system technology. It was not given much attention in the past. However, the user interface can make a critical difference in the pe eived utility of an Expert system.