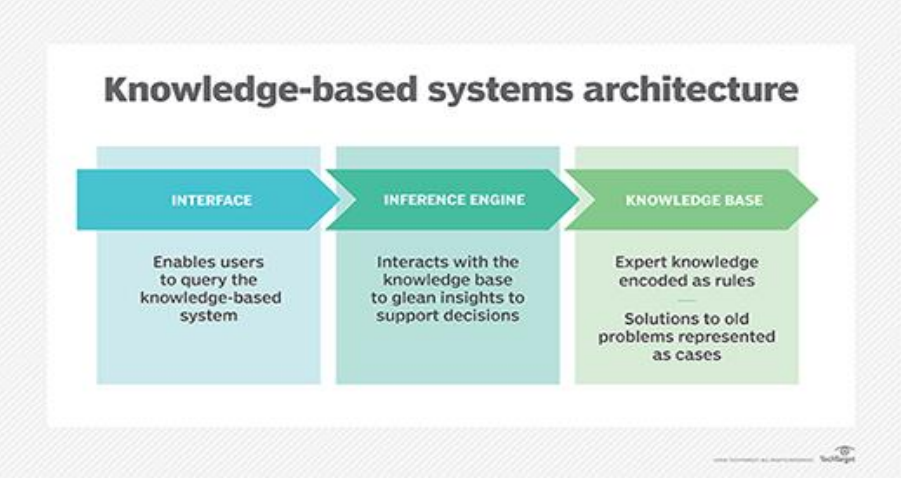
Knowledge-Based Systems

What are knowledge-based systems?

Knowledge-based systems (KBSes) are computer programs that use a centralized repository of data known as a knowledge base to provide a method for problem-solving. Knowledge-based systems are a form of artificial intelligence (AI) designed to capture knowledge of human experts to support decision-making. An expert system is an example of a knowledge-based system because it relies on human expertise.

KBSes can assist in decision-making, human learning and creating a companywide knowledge-sharing platform, for example. *KBS* can be used as a broad term, but these programs are generally distinguished by representing knowledge as a reasoning system to derive new knowledge.

A basic KBS works using a knowledge base and an interface engine. The knowledge base is a repository of data that contains a collection of information in a given field -- such as medical data. The inference engine processes and locates data based on requests, similar to a search engine. A reasoning system is used to draw conclusions from data provided and make decisions based on if-then rules, logic programming or constraint handling rules. Users interact with the system through a user interface.



Knowledge-based systems represent a rules-based or case-based approach to AI.

What are knowledge-based systems used for?

Knowledge-based systems are commonly used to aid in solving complex problems and to support human learning. KBSes have been developed for numerous applications. For example, an early knowledge-based system, Mycin, was created to help doctors diagnose diseases. Healthcare has remained an important market for knowledge-based systems, which are now referred to as clinical decision support systems in the health sciences context.

Types of knowledge-based systems

Some example types of knowledge-based systems include the following:

- **Blackboard systems.** These systems enable multiple sources to input new information into a system to help create solutions to potential problems. Blackboard systems rely heavily on updates from human experts.
- **Case-based systems.** These systems use case-based reasoning to create solutions to a problem. This system works by reviewing past data of similar situations.
- **Classification systems.** These systems analyze data to understand its classification status.
- **Eligibility analysis systems.** These systems are used to determine a user's eligibility for a specific service. A system asks a user guided questions until it receives a disqualifying answer.
- **Expert systems.** These are a common type of KBS that simulate human expert decision-making in a particular field. Expert systems provide solutions for problems as well as the explanations behind them. For example, they could be used for calculations and predictions.
- **Intelligent tutoring systems.** These systems are designed to support human learning and education. Intelligent tutoring systems provide users with instructions and give feedback based on performance or questions.
- **Medical diagnosis systems.** These systems help diagnose patients by inputting data or having a patient answer a series of questions. Based on the responses, the KBS identifies a diagnosis and makes recommendations medical professionals can use to determine a patient's treatment.
- **Rule-based systems.** These systems rely on human-specified rules to analyze or change data to reach a desired outcome. For example, rule-based systems might use if-then rules.

Advantages and challenges of knowledge-based systems

Knowledge-based systems offer the following benefits:

- Aid in expert decision-making, especially when a human expert isn't available.
- Provide efficient documentation for users to access quickly.
- Create new knowledge by referring to and reviewing existing stored data.
- Group data by analyzing and classifying different inputted data.
- Handle large amounts of structured and unstructured data.
- Improve decision-making processes, enabling users to work at higher levels of expertise.

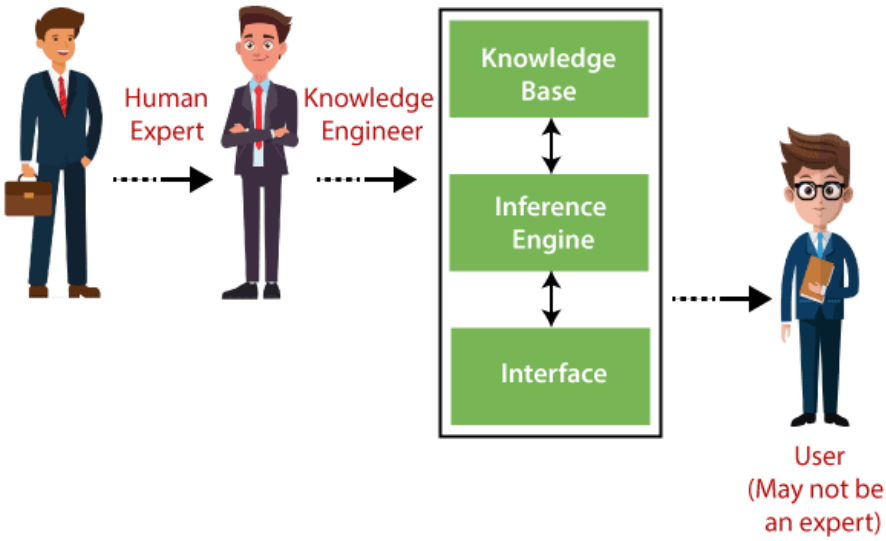
However, the following are some potential challenges that come with these systems:

- Difficult to maintain, as some systems might require continual updating and organizational policies, or procedures might change and require updating over time.
- Potential anomalies such as circular dependencies or repetitive rules might appear in some systems.
- Require a large amount of accurate data.
- Require training for new users to understand the system.
- Some data could be considered abstract, making it difficult for a system to make decisions.
- The system's quality is only as high as the quality of data put into it.

Components 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

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.

Below are some popular examples of the Expert System:

- **DENDRAL:** It was an artificial intelligence project that 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 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.