Rule-based Expert Systems

What is knowledge?

- is a theoretical or practical understanding of a subject or a domain.

- is also the sim of what is currently known, and apparently knowledge is power. Those who possess knowledge are called experts.

- Anyone can be considered a domain expert if he or she has deep knowledge and strong practical experience in a particular domain.

- The human mental process is internal, and it is too complex to be represented as an algorithm

- However, most experts are capable of expressing their knowledge in the form of rules for problem solving.

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IF          the ‘traffic light’ is ‘green’
THEN        the action is go

IF          the ‘traffic light’ is ‘red’
THEN        the action is stop
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Rules as a Knowledge Representation Technique

- The term rule in AI, which is the most commonly used type of knowledge representation, can be defined as an IF-THEN structure that relates given information or facts in the IF part to some action in the THEN part.

- A rule provides some description of how to solve a problem.

- Rule are relatively easy to create and understand

- Any rules consists of two parts: the IF part, called the *antecedent* (premise or condition) and the THEN part called the *consequent* (conclusion or action)

  IF <antecedent>
  THEN <consequent>

- A rule can have multiple antecedents joined by the keywords **AND (conjunction)**, **OR (disjunction)** or a combination of both.

IF	<antecedent 1>	IF	<antecedent 1>
AND	<antecedent 2>	OR	<antecedent 2>
	⍰		⍰
AND		OR	

	<antecedent *n*>		<antecedent *n*>
THEN	<consequent>	THEN	<consequent>

- The antecedent of a rule incorporates two parts: an *object (linguistic object)* and its *value*. The object and its value are linked by an *operator*.

- The operator identifies the object and assigns the value. Operators such as *is*, *are*, *is not*, *are not* are used to assign a symbolic value to a linguistic object.

- Expert systems can also used mathematical operators to define an object as numerical and assign it to the numerical value.

  IF ‘age of the customer’ < 18
  AND ‘cash withdrawal’ > 1000
  THEN ‘signature of the parent’ is required

- Rules can represent:

  - **Relation**: IF the ‘fuel tank’ is empty THEN the car is dead

  - **Recommendation**: IF the season is autumn AND the sky is cloudy AND the forecast is drizzle THEN the advice is ‘take an umbrella’

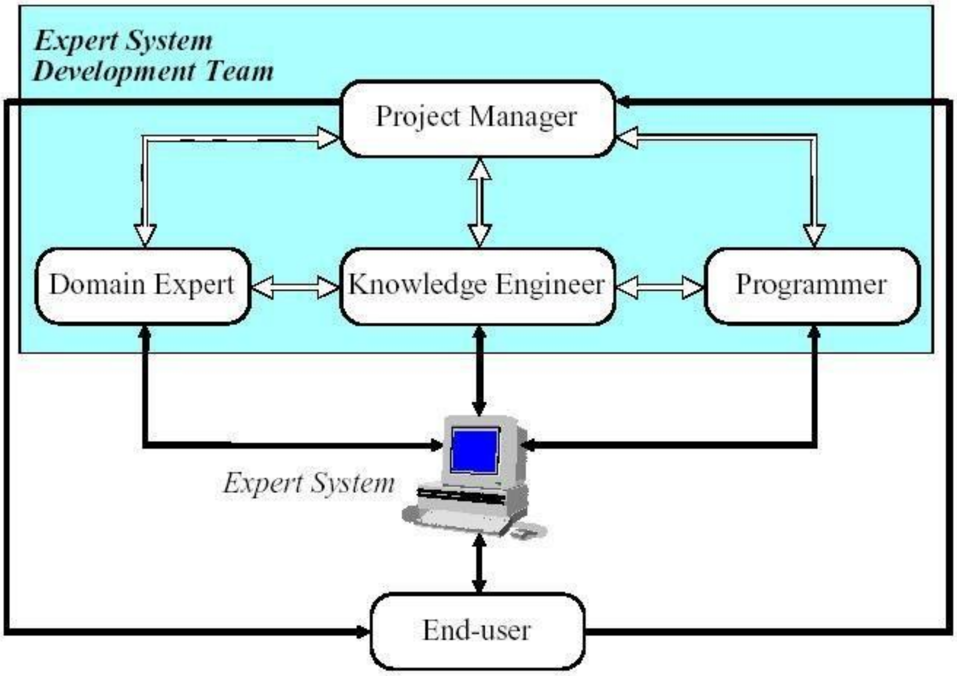
  - **Directive**: IF the car is dead AND the ‘fuel tank’ is empty THEN the action is ‘refuel the car’

- **Strategy**: IF the car is dead THEN the action is ‘check the fuel tank’; step1 complete
  IF step1 is complete AND the ‘fuel tank’ is full THEN the action is ‘check the battery’; step2 is complete

- **Heuristic**: IF the spill is liquid AND the ‘spill pH’ < 6 AND the ‘spill smell’ is vinegar THEN the ‘spill material’ is ‘acetic acid’

The main players in the development team

- There are five members of the expert system development team:
  1. domain expert
  2. knowledge engineer
  3. programmer
  4. project manager
  5. end-user



- **Domain Expert**:
  - is a knowledgeable and skilled person capable of solving problems in a specific area or domain
  - the person's expertise is to be captured in the expert system
  - could be more than one expert that contribute to an expert system
  - the expert must be able to communicate his or her knowledge, be willing to participate in the expert system development and commit a substantial amount of time to the project
  - is the most important person in the expert system development team

- **Knowledge Engineer**:
  - is someone who is capable of designing, building and testing an expert system
  - interviews the domain expert to find out how a particular problem is solved
  - establishes what reasoning methods the expert uses to handle facts and rules and decides how to represent them in the expert system
  - choose some development software or an expert systems shell, or look at programming languages for encoding the knowledge
  - responsible for testing, revising and integrating the expert system into the workplace

- **Programmer**:
  - is the person responsible for the actual programming, describing the domain knowledge in terms that a computer can understand.
  - needs to have the skills in symbolic programming in such AI language such as Prolog.
  - should also know conventional programming language like C, Pascal, FORTRAN and Basic

- **Project Manager**:
  - is the leader of the expert system development team, responsible for keeping the project on track
  - makes sure that all deliverables and milestones are met, interacts with the expert, knowledge engineer, programmer and end-user

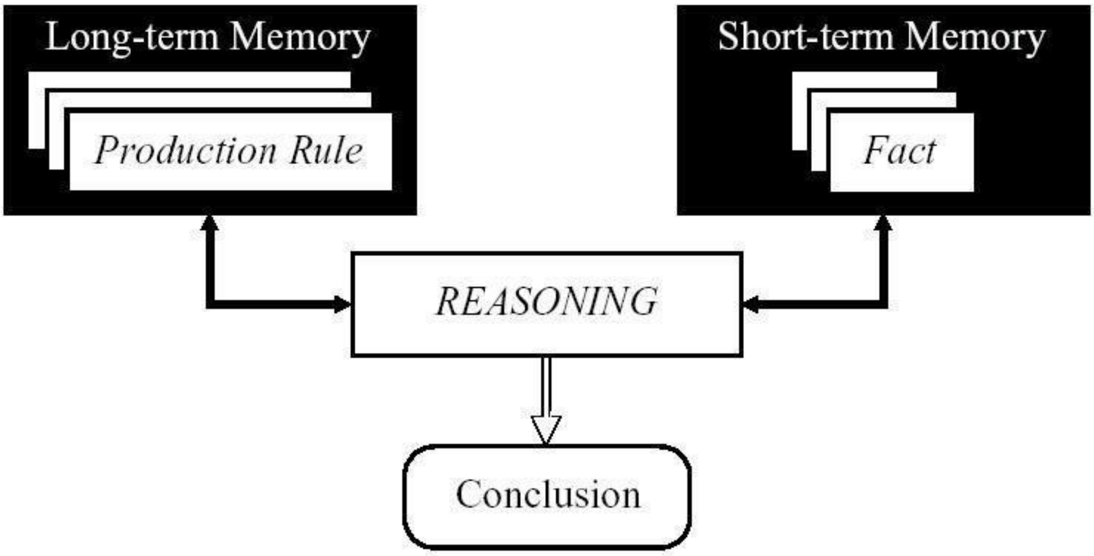
- **End-user**:
  - often called the user
  - is a person who uses the expert system when it is developed
  - must not only be confident in the expert system performance but also feel comfortable using it

Structure of a rule-based expert system

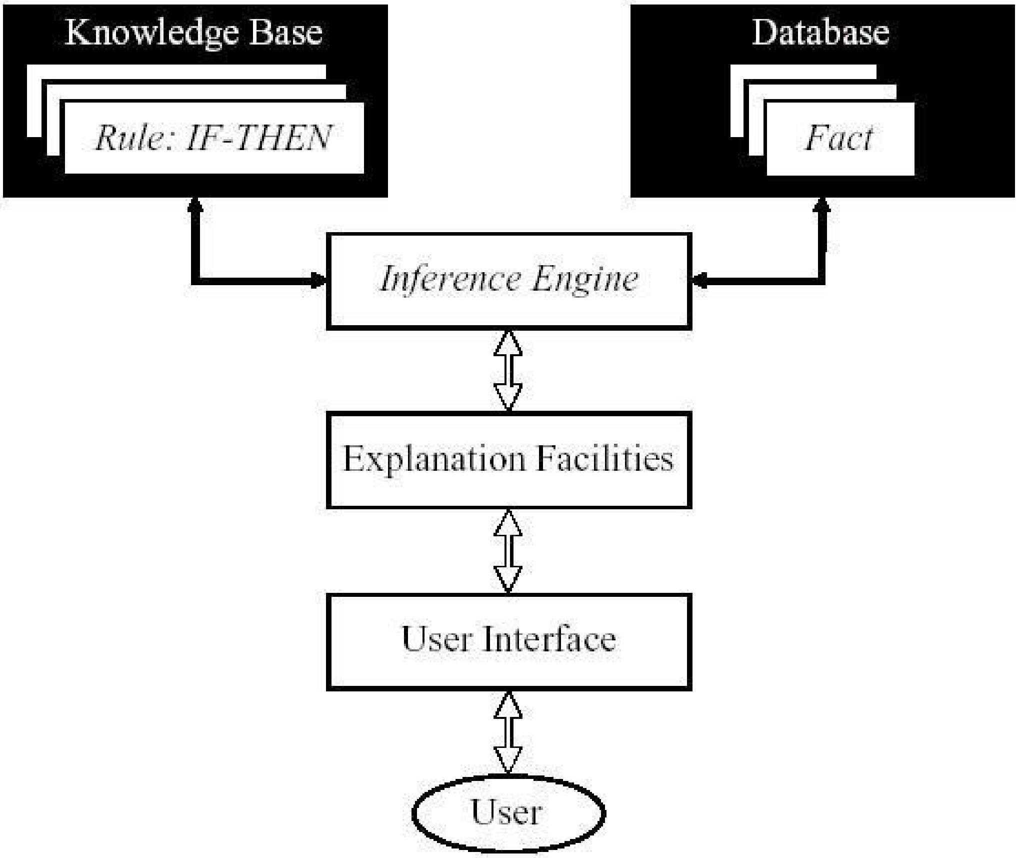
- In early 70s, Newell and Simon from Carnegie-Mellon University proposed a production system model, the foundation of the modern rule-based expert systems

- The production model is based on the idea that humans solve problems by applying their knowledge (expressed as production rules) to a given problem represented by problem-specific information

- The production rules are stored in the long-term memory and the problem-specific information or facts in the short-term memory



- Basic Structure of a rule-based expert system



- **Knowledge base** contains the domain knowledge useful for problem solving

- In rule-based expert system, the knowledge is represented as a set of rules. Each rule specifies a relation, recommendation, directive, strategy or heuristic and has the IF (condition) THEN (action) structure.

- When the condition part of a rule is satisfied, the rule is said to fire and the action part is executed

- The **database** includes a set of facts used to match against the IF (condition) parts of rules stored in the knowledge base.

- The **inference engineer** carries out the reasoning whereby the expert system reaches a solution. It links the rules given in the knowledge base with the facts provided in the database.

- The **explanation facilities** enable the user to ask the expert system how a particular conclusion is reached and why a specific fact is needed

- The **user interface** is the means of communication between a user seeking a solution to the problem and an expert system

Advantages of rule-based expert systems

- Separation of knowledge from its processing
  - The structure of a rule-based expert system provides an effective separation of the knowledge base from the inference engine.
  - This makes it possible to develop different applications using the same expert system shell.

- Dealing with incomplete and uncertain knowledge
  - Most rule-based expert systems are capable of representing and reasoning with incomplete and uncertain knowledge.