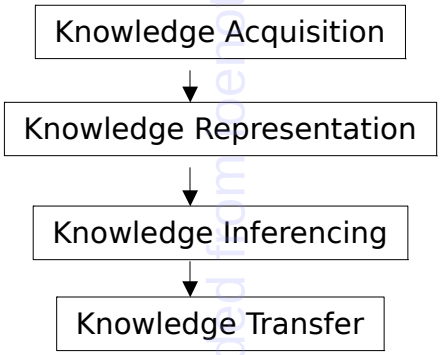
Expert System

- An **expert system** is a computer system whose performance is guided by specific, expert knowledge in solving problems.
- It is a computer system that simulates the decision- making process of a human expert in a specific domain.
- Expert system is one of the early (large- scale) successes of artificial intelligence.
- An expert system is an "intelligent" program that solves problems in a narrow problem area by using high-quality, specific knowledge rather than an algorithm.
- Expert systems are used by most of the large or medium sized organization as a major tool for improving productivity and quality.
- An expert system's knowledge is obtained from expert sources and code in a form suitable for the system to use in its process.

Steps in Expert System Development



Knowledge Acquisition:

- **Knowledge acquisition** is the process used to define the rules and ontologies required for a knowledge-based system.
- Describe the initial tasks associated with developing an expert system that include finding and interviewing domain experts and capturing their knowledge via rules, objects, and frame-based ontologies.
- The expert sources can be domain specialist, articles, journal, database etc.

Knowledge Representation:

- Representing information about the world in a form that a computer system can utilize to solve complex task.
- It is a set of ontological commitments i.e. an answer of question.
- Knowledge representation can be logical representation or structured representation.
- Representing the rules and constraints is through the use of logic rules, formally known as knowledge representation.

Knowledge Inferencing

- Knowledge inference refers to acquiring new knowledge from existing facts based on certain rules and constraints.
- Mostly rule based reasoning (Forward chaining/Backward chaining) is used for inferencing

Knowledge Transfer

- Knowledge transfer is the practical problem of transferring knowledge from one part of the organization to another.
- Knowledge transfer seeks to organize, create, capture or distribute knowledge and ensure its availability for future users.

Features of an Expert System

- Should have reasoning capacity. Reasoning may be goal-driven reasoning (backward chaining) or data-driven reasoning (forward chaining).
- Should cope with uncertainty.
- Should have proper knowledge representation i.e use knowledge rather than data.
- Should use symbolic representation for knowedge.
- Should use meta knowledge.
- Should use user interface.
- Should have ability to explain solutions with respect to problem specific.

Advantages of Expert System

- It provides consistent answer for repetitive decisions, processes and tasks.
- Hold and maintained significant level of information.
- Encourage organization to clarify the logic of their decision making.
- Ask question like human expertise.

Advantages of Expert System

- Lack of common sense needed in some decision making.
- Cannot make creative response as human expert would in unusual circumstances.
- Error may occur in the knowledge base and lead to wrong decision.
- Cannot adopt changing environment, unless knowledgebase is changed.

Applications

- Business
- Manufacturing
- Medicine
- Engineering
- Applied science
- Military
- Space
- Transportation
- Education
- Image analysis

- Chemical structure
- Agriculture
- Robotics and many more

History of Expert Systems

- Breakthrough in field of AI was achieved in area of Expert System
- 1966 - DENDRAL was developed at Stanford
  - Analyzes mass spectrographic, NMR, … data and infers possible structures of unknown chemicals
- 1971 - MYCIN was developed at Stanford
  - diagnose and treat infectious blood diseases
- 1980 - XCON was developed at CMU
  - one of the first commercial expert systems
- PROSPECTOR: analyzing geological data
- GASOIL: designing gas-oil separation systems for offshore oil platforms

Advantages/Disadvantages (Comparison between human expert and Expert system)

Pro Expert system	**Human expert**	**Expert system**
	Perishable(decay)	Permanent
	Slow processing	Fast processing
	Unpredictable	Consistent
	Slow reproduction	Quick replication
	Expensive	Affordable
Pro Human	Broad focus	Narrow focus
	Inspiration	Lacks creative ability
	Adaptive needs	Instruction
	Common sense	Machine knowledge

Features of an ES

- Goal driven reasoning (backward chaining) or data driven reasoning (forward chaining)
- Coping with uncertainty
- Data representation
- User interface
- Explanations (ability to explain solution with respect to specific problem)
- Use knowledge rather than data
- Use symbolic representation for knowledge
- Should have meta knowledge

Components of ES

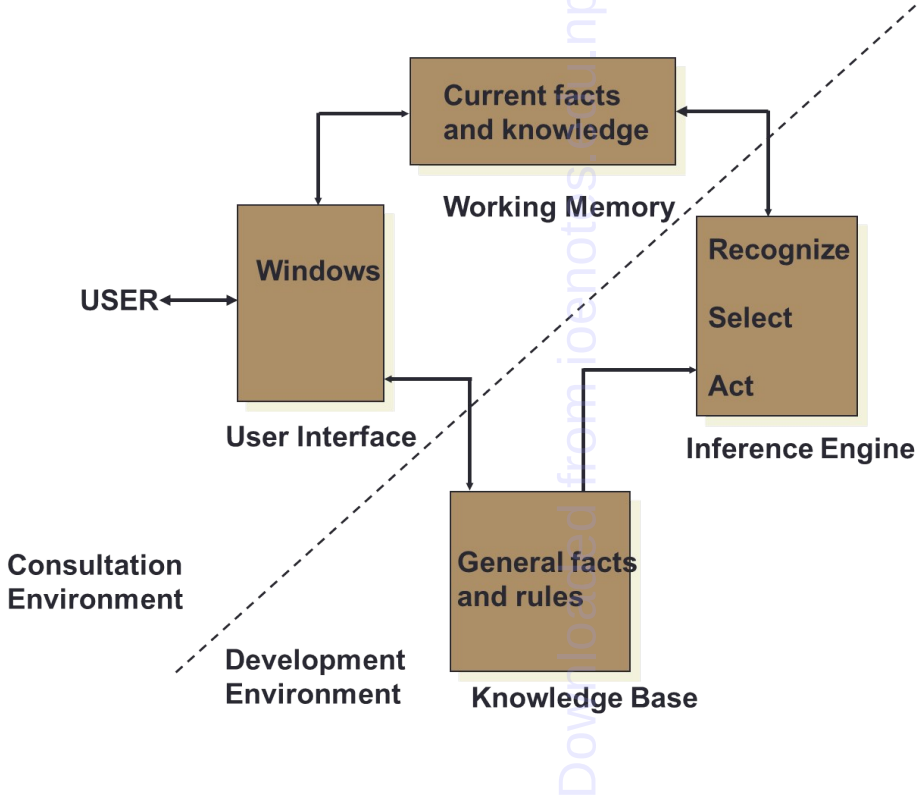
For a workable expert system more than a set of rules is required.We need four structures:

Knowledge Base - a data structure which containsthe rules, often in IF THEN rules

Working Memory - a data structure which stores information about a specific problem

Inference Engine - a set of procedures for matching knowledge base with problem specific data in working memory

User Interface– Controls the dialog between user and the system



General Architecture of ES

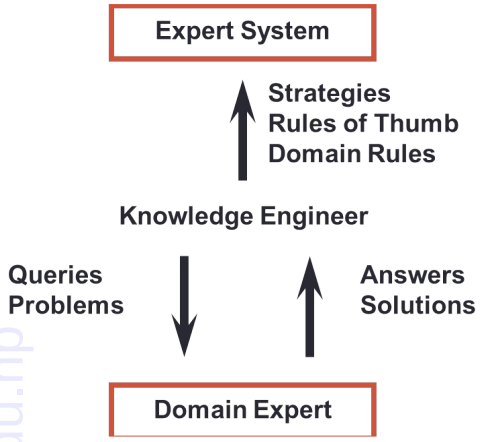
Knowledge in expert systems is usually implemented as a **RULE**

A rule is an **IF-THEN** type statement

if<certain conditions are true>
then <take certain actions>

As a result, expert systems are sometimes called **rule-based systems or production systems**

Knowledge Base: Knowledge Engineering is the process of filling in an expert system knowledge base



Knowledge is information that has been:

- interpreted,
- categorised,
- applied, ***experienced*** and revised.

What it IS ***NOT***:

- Data, e.g. numbers.
- Information, i.e. interpreted data

Types of Knowledge

- **Procedural Knowledge**: *"Knowing How", procedures*
  - Includes step by step sequences and how-to types of instructions
  - It may contain explanations.
  - Eg. A mobile robot that navigates building contains procedures such as "navigate to room", "plan a path".
- **Declarative Knowledge**: *"Knowing what"*,
  - Descriptive representation of knowledge
  - It tells us facts, about truths and associations. eg. " there is positive association between smoking and cancer"
  - Shallow, surface-level.
  - Eg. A mobile robot with facts to move forward, backward, turn left, turn right.
  - Important in initial stage of knowledge acquisition.
- **Episodic Knowledge***: Experiential*
- **Meta-knowledge** :*Knowledge about Knowledge*

Sources of Knowledge

- Expert : primary source.
- End Users.
  - Usually have a good overview of the problem domain.
  - May provide valuable insight during initial investigations.
- Secondary / Tertiary Experts
  - Can provide specialised knowledge on sub-problems.
  - May give rise to conflicting advice.
- Literature
  - Reports, Guidelines, Books, Manuals etc.
  - Provide background and insight in early stages.

Knowledge Base Size

Frederick Hayes-Roth developed the following heuristics about knowledge bases:

- A convincing demonstration of a knowledge system's power requires about 250 rules.
- An expert level of competence in a narrow area requires about 500 to 1000 rules.
- Expertise in a profession requires about 10,000 rules.
- The limit of human expertise is about 100,000 rules.

Rule Types

- Relationship (*FACT)*
  - **IF** the battery is dead **THEN** the car will not start
- Recommendation
  - **IF** the car will not start **THEN** take a cab
- Directive
  - **IF** the car will not start **AND** the fuel system is ok
    THEN check out the electrical system
- Heuristic
  - **IF** the car will not start **AND** the car is a 1957 Ford
    THEN check the float

Rule Uncertainty

- Vagueness / uncertainty rules:
  IF inflation is **HIGH**
  THEN interest rates **might** be high
- Re-write using a confidence quantifier :
  IF inflation is **HIGH**
  THEN interest rates are high (***CQ = 0.8***)

Meta Rules

Rules that express knowledge about how *other* knowledge should be used.

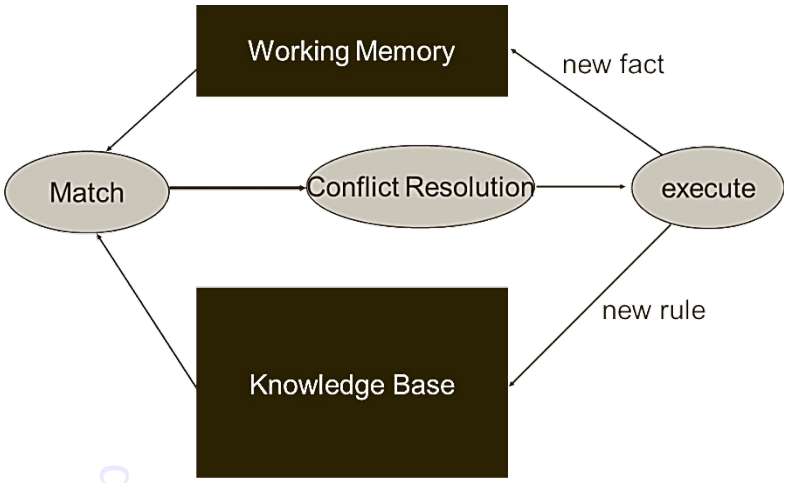
IF the car will not start
AND the electrical system is operating properly
THEN use fuel_system_rules

Inference Engine Structure

The inference engine is the mechanism for matching facts with rules and using the results to update the knowledge base. Most inference engines are based on the application of a logical reasoning rule called modus ponens which is stated as:

P1: if A then B

P2: A is true
Conclude: B is true



Recognize-Select-Act Cycle

It consists of 3 steps:

1. ***Match****:* Rules are compared to working memory to determine matches
2. ***Conflict Resolution****:* Select or enable a single rule for execution
3. ***Execute****:* Fire the selected rule

MYCIN

- Expert system for treating blood infections
- Diagnose patients based on reported symptoms and medical test results
- Could ask some more information and lab test results for diagnosis
- Recommend a course of treatment, if requested, MYCIN would explain the reasoning that lead to its diagnosis and recommendation.
- Use about 500 production rules, MYCIN operated roughly the same level of competence as human specialists in blood infections.
- Use backward chaining for reasoning**.**

DENDRAL

- First ES developed in late 1960
- Designed to analyze mass spectra
- Based on the mass of fragments seen in the spectra, it would be possible to make inference as the nature of molecule tested, identifying functional groups or even the entire molecule.
- Used Heuristic knowledge obtained from experienced chemists.
- Use forward chaining for reasoning