**University Mohamed Boudiaf of M'sila**

**Faculty of Mathematics and Informatics**

# Introduction to Artificial Intelligence

## Chapter III: Expert Systems and their Applications

***Dr. SAID KADRI***

**Associate Professor**

**Department of Computer Science, Faculty of Mathematics and Informatics,**

**University Mohamed Boudiaf of M'sila**

**E-mail:**kadri.said28@gmail.com

**Website:**https://kadrisaid28.wixsite.com/sgadri

**2017 - 2018**

## Definition:

- An expert system is a software that reproduce the behavior of a human expert in a specific domain.
- An ES collects a set of knowledge, formalizes them, then returns them as an expert when requested by an user.

## Main components of an ES

An ES is based on the principle of separation of knowledge (the knowledge base) and the programs that process it (the inference engine).

***Benefits:***

- KB update without having to touch the associated programs.
- Ability to reuse the same inference engine with other KBs (Reducing development time)

A KB is composed of:

1. A facts' base
2. A rules' base
3. A Meta-rules' base

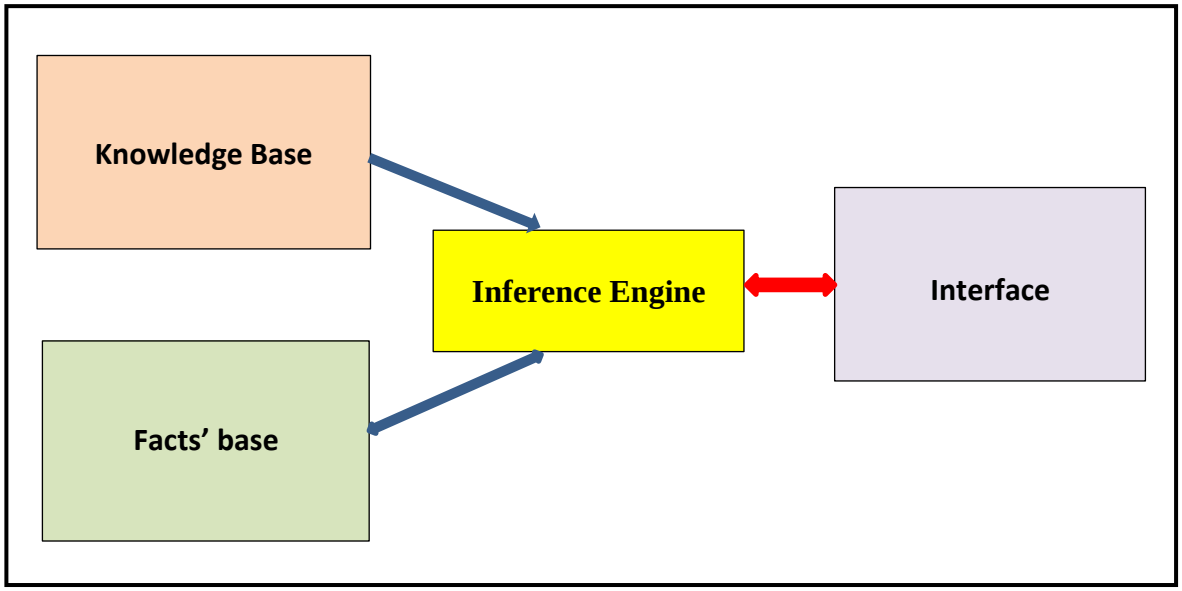



**Fig III.1. Diagram of an ES**

1. **Facts' Base:**
   - Contains proven facts (known to be true)
   - Evolves over time following the execution of the ES.
   - New facts can be added by the user or by the inference engine (by a deduction mechanism).

2. **Rules' Base**

   A collection of expressions that allow to deduced new facts (and rarely new rules)

3. **Meta-rules' Base**

   These are rules that determine how to use the rules themselves (conditions of use of a rule, selection of certain rules, application priorities, etc.).

4. **Inference Engine**
   - Totally Independent of the KB
   - Browse KB facts and rules.
   - Select a rule and apply it
   - Works in 03 ways:
     - Forward chaining
     - Backward chaining
     - Mixed chaining

5. **Interfaces:** includes

a. ***A user interaction module:*** is composed of a set of menus

***b. An explanation and execution trace module:***

- An ES is able to justify the conclusion it has reached.
- Explain the reasons why he activated certain rules.
- Propose a graphic trace restoring the path followed during the reasoning proces as well as the mobilized knowledge.

***c. A knowledge acquisition support module***

- Help in automatic KB generation.
- Checking for consistency.
- Good formalization.

***d. An interface with external applications***

- Allows the OS to interact with external databases and programs

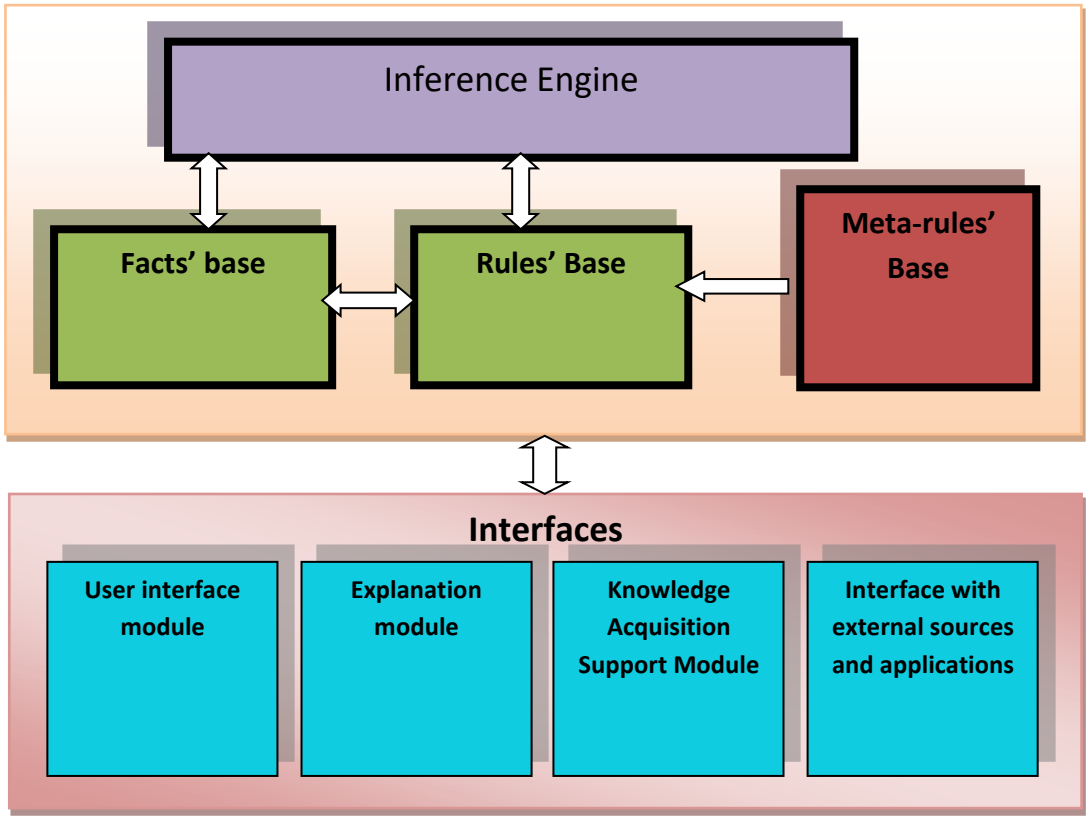



**Fig III.2. Architecture of an ES**

## Application Fields

1. ***Mathematics :***
   MacSyma (1967): resolution of mathematical problems (integrals, differentials, systems of equations, etc.)
2. ***Geology:***
   Prospector: for the exploration of mineral deposits
3. ***Chemistry :***
   Dendral (1969), Metadendral (1978): identification of the molecular structure of an unknown body.
4. ***Medicine :***
   Mycine (1977): detection of infectious diseases
5. ***Linguistics:***
   Hearsay II: Speech Understanding
6. ***Computer science :***
   Xcon: for configuring computer systems
   Cyc: Tool for intelligent document research
7. ***Other areas and uses:***
   - Assistance to CAF (FAO)
   - Robot control
   - Maintenance (diagnosis of faults and anomalies)
   - Selection of products in a production line.
   - Planning and scheduling
   - Quality control
   - Control of a production workshop in real time
   - Finances
   - Marketing
   - Human resources

## Contribution of an Expert System

1. ***Enriching expertise within the company:***
   - By collecting knowledge from several experts in the same field or from different fields (multidisciplinary ES).

2. ***Knowledge transmission***

The human experience is:

- Essential in strategic decisions.
- Volatile (departure, illness, death, travel, etc.).
- Costly (intervention cost in time and money, training cost)

Implementing an ES as an alternative solution that allows:

- An effective way to preserve and transmit knowledge
- Having a negligible cost
- Increase productivity
- Immediately operational (no prior training OR short training)

3. ***Improving staff skills and efficiency***
   - Very high availability of expertise at low levels.
   - Improvement of working conditions, efficiency, productivity
   - Improving the skills of its actors

4. ***Decision consistency***
   - The human expert is sensitive to environmental conditions (fatigue, nervousness, etc.)➔inconsistent decisions
   - An ES will give the same decisions under the same conditions (consistency of decisions with fewer errors).

5. ***Increasing business volume***

A (quality + fast) ES

➔Increasing business volume

➔Increasing company profitability.

6. ***Opening new types of problems***

An ES is not interested in classical problems, but in open problems that require human expertise.

7. ***The image of an innovative company***

The use of cutting-edge technologies strengthens the company's image in front of its customers as well as its competitors.

## Development phases

1. Requirements specification.
2. Choice of a system architecture, its user interface, and a processing language.
3. Prediction of mechanisms for late updates of the system (maintenance)
4. Selection of a representative subset of a given problem for the development of a demonstration (a first test).
5. Acquisition of information and development of the mechanism for adding and of knowledge base update.
6. Implementation of the "inference engine" (inference rules)
7. System testing, adjustment and documentation.

# Methodology and tools for building an ES

## Different actors

1. **The knowledge engineer (cognitive scientist)**
   - Extracting knowledge from experts (conducting interviews with them).
   - Represents the acquired knowledge according to a chosen formalism.
   - Works in collaboration with experts
2. **Developers (computer scientists)**
   - Choosing a development tool (a programming language)
   - Developing the ES program by performing the programming task.
3. **Experts in the relevant field**
   - Constitute the articulation point of the development of an SE
   - Must be available during the knowledge extraction phase and during application monitoring.
   - They should not perceive the newly developed tool as a rival that will take away part of their power.
   - They will have to perceive the application as a tool that relieves them of routine tasks in favor of problems that require their know-how.
4. **Users**
   - Participate effectively in the development of the ES, especially the interface with the system (must be: simple, efficient, ergonomic).
   - Must be convinced of the benefits of the developed tool on their daily work.
   - Can give their reviews and critics regarding the ES
5. **Managers**
   - Follow the development project from the start.
   - Organize the work of the different actors.
   - May schedule a training on ES techniques for the benefit of various actors.

## Different phases of ES development

### 1. Preliminary study

Conduct a detailed study on the company, this study must cover:

- ***Suitability of the application to ES techniques*** and that other alternatives (simple software) are not possible.
- ***Technical feasibility***

- Ensure that we have sufficient material and human resources to implement it.
- The attention given to this new technique by the various actors.

- ***Economic study of the project***

- Check the profitability of the system implementation.
- List the expected direct and indirect benefits
- List the different costs incurred by the development of the project. (Required hardware [computers, printers, storage media, etc.]), software [shell, programming languages, etc.] or personnel [training, availability of experts, etc.]
- Provide a quantified estimate of the total cost

### 2. Realization

- Set a schedule considering the different stages of development.
- Establish periodic project progress reports
- Start the development phase.
- Several methods can be used (those known in GL)
- Use the rapid prototyping approach proposed by Hayes Roth and Waterman and Lenat in 1983.
- The rapid prototyping approach consists of 05 phases:
  1. Identification (roles of actors, project objectives, required resources)
  2. Conceptualization (software design)
  3. Formalization (representation of knowledge using formalisms known in the field)
  4. Implementation (development of the SE)
  5. Tests

# ES Construction Tools

1. **Classical languages**

   Fortran

   Cobol

   Basic

   Pascal and C

2. **AI-specific languages**

**a. Functional languages**

- Lisp

**b. Logical languages**

- Prolog

3. **Object-oriented languages**
   - C++
   - C#
   - Delphi

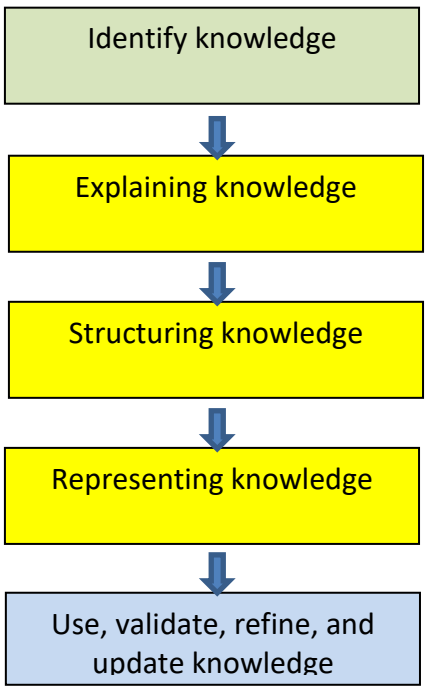
4. **ES Generators (Shell)**
   - A tool designed specifically for ES generation
   - Has: inference engines, user interfaces, knowledge representation formalisms, uncertain knowledge management, development assistance.

# Knowledge Engineering (cognitive science)

***Questions a cognitive scientist must answer :***

1. What data should be provided to the system?
2. What are the results produced by the system, how are they presented?
3. What are the types of problems?
4. What are the characteristics of the solutions?
5. What types of knowledge must we acquire?
6. What are the relationships between data?
7. How accurate are the data and results to be provided?
8. What are the basic (sometimes implicit) assumptions (hypotheses) of the expert?
9. What are the constraints to be respected in the data or solutions?
10. What are easy, common, difficult or interesting problems?

# Knowledge Engineering Tasks



## Nature of an expert's knowledge

The expert's knowledge is:

- Compiled
- Volatile
- Subjective
- Distributed

## Examples of expert systems

- Data interpretation systems. Systems for classifying new observations by reference to pre-stored observations.
- Diagnostic systems in medicine ("what disease is it?"),
- Geological interpretation system ("do seismological measurements allow us to believe in the existence of significant mineral deposits?"),
- Psychological assessment systems (“is this a suicidal case?”),
- Prediction systems. Systems that perform predictive interpretation from pre-stored observations.
- Weather prediction systems (“It’s raining today in Algeria. Will it rain in Switzerland tomorrow?”),
- Geopolitical predictions ("War conflicts are particularly frequent in situations of economic crisis. What precise combinations of economic, sociological and political factors predict an outbreak of hostilities?"),
- Planning systems. Systems capable of planning human or robotic actions in a complex universe characterized by known constraints or rules.
- Airline flight reservation system, planning flight altitudes based on known winds and available itinerray.
- Assembly action planning of an industrial robot.
- Planning of required interventions for the construction of a building.
- Design systems. Configuration or discovery systems according to precise specifications.
- Development and simplification of integrated circuits, design of an optimal kitchen in a given space, cloning of genes, creation of a new chemical compound, etc.