Expert Systems

Week 2: Rule-based expert system

Dr. Mohammed A. Altahrawi

University College of Applied Sciences

November 4, 2024

Outlines

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences

Outlines

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences

what is knowledge?

- Knowledge is a theoretical or practical understanding of a subject or a domain.
- Knowledge is also the sum of what is currently known, and apparently knowledge is **power**.

Definition

- Those who possess knowledge are called **experts**.
- They are the **most powerful** and important people in their organizations.

Who is generally acknowledged as an expert?

- Anyone can be considered a domain expert if he or she has deep knowledge (of both facts and rules) and strong practical experience in a particular domain.

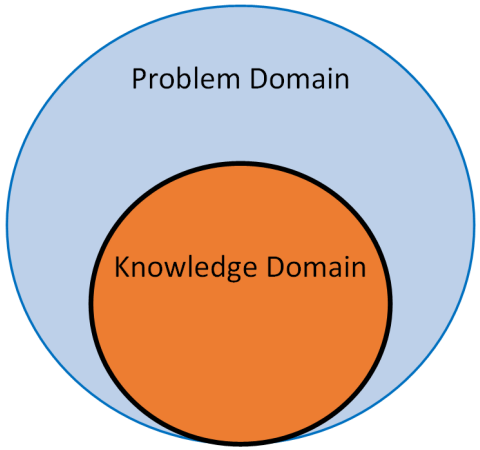


Figure: Problem domain vs knowledge domain

CONT.,

Example

- A medical doctor specializing in cardiology is considered an expert in heart-related diseases.
- An AI-based expert system used in agriculture might monitor crop health.
- This system leverages knowledge from agricultural experts, using rules and patterns to identify issues like soil deficiencies or pest infestations.

CONT.,

How do experts think?

Most experts are capable of expressing their knowledge in the form of rules for problem solving.

Example

IF the 'traffic light' is green THEN the action is go

Note.

Any successful company has at least a few first-class experts and it cannot remain in business.

Outlines

Rules as a knowledge representation

- The basic syntax of a rule is IF $<$ *antecedent* $>$ THEN $<$ *consequent* $>$
- A rule can have multiple antecedents joined by the keywords AND (conjunction), OR (disjunction) or a combination of both.
- The antecedent of a rule incorporates two parts: an object (linguistic object) and its value.

Example

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

Outlines

Expert System Development Team

Expert System Shell

- Expert system with the knowledge removed.
- The user has to do is to add the knowledge in the form of rules and provide relevant data to solve a problem

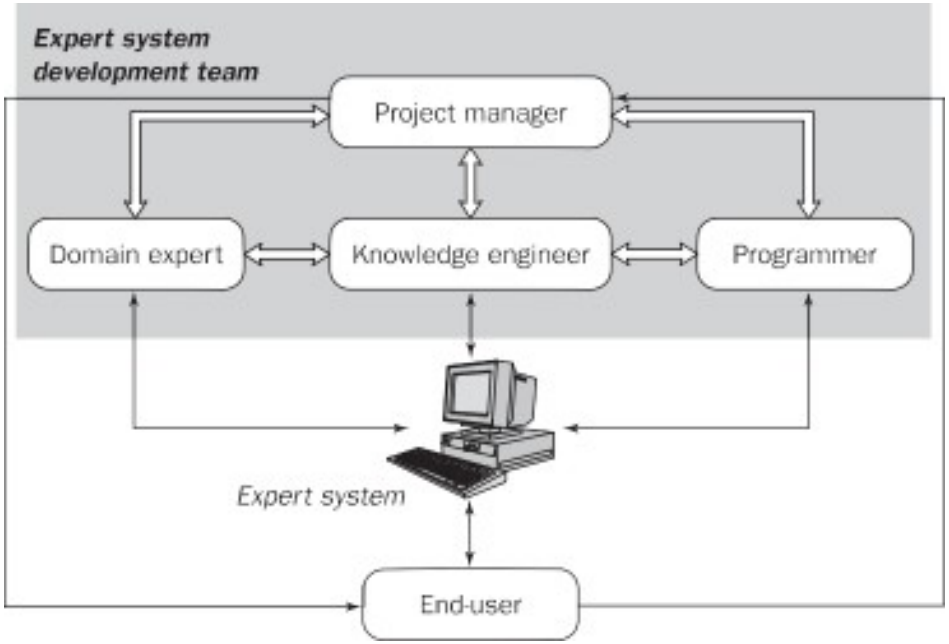


Figure: The main players of the expert system development team

Outlines

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences

Structure of a rule-based expert system

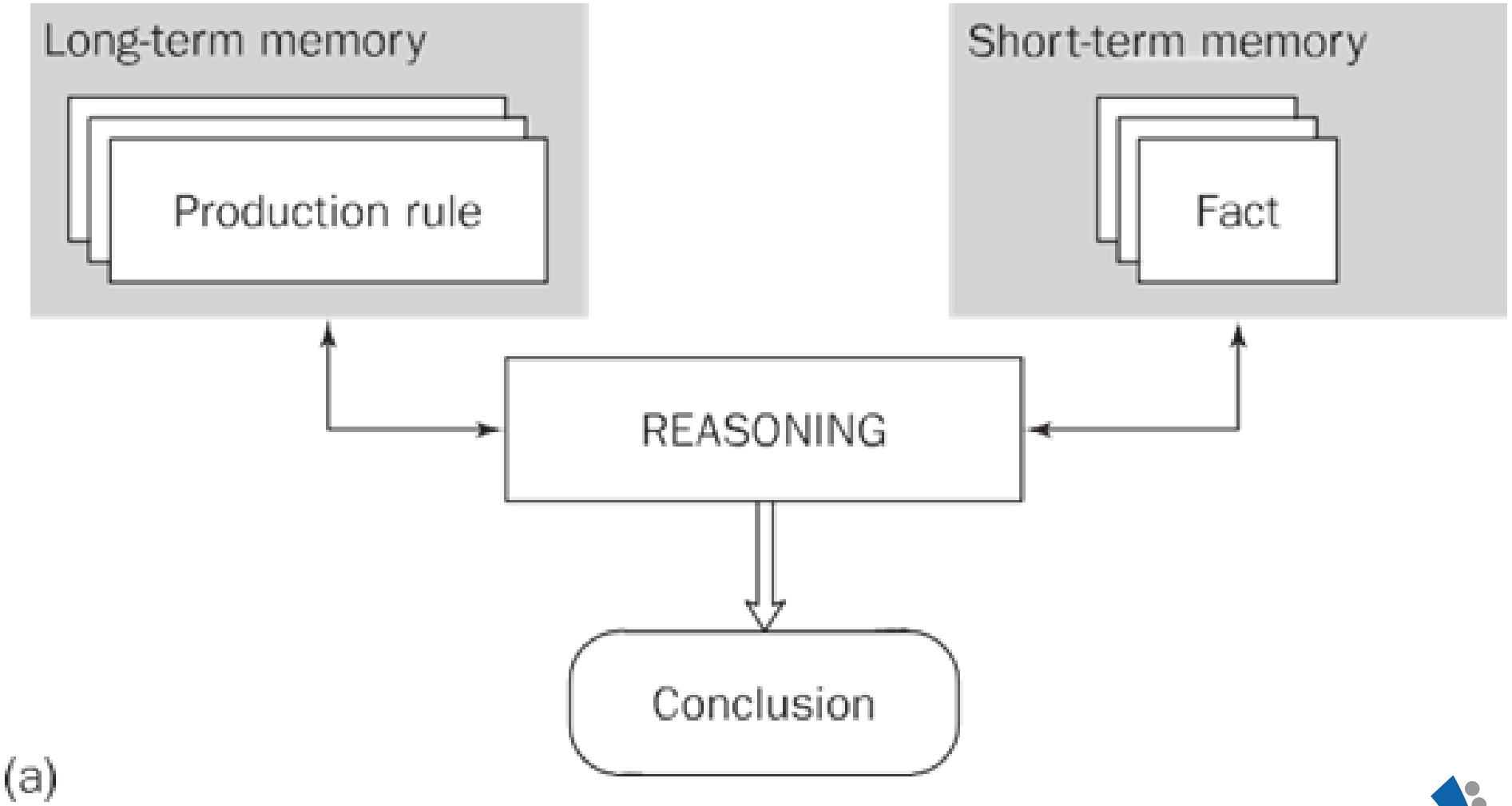


Figure: Production system and basic structure of a rule-based expert system: (a) production system model

CONT.,

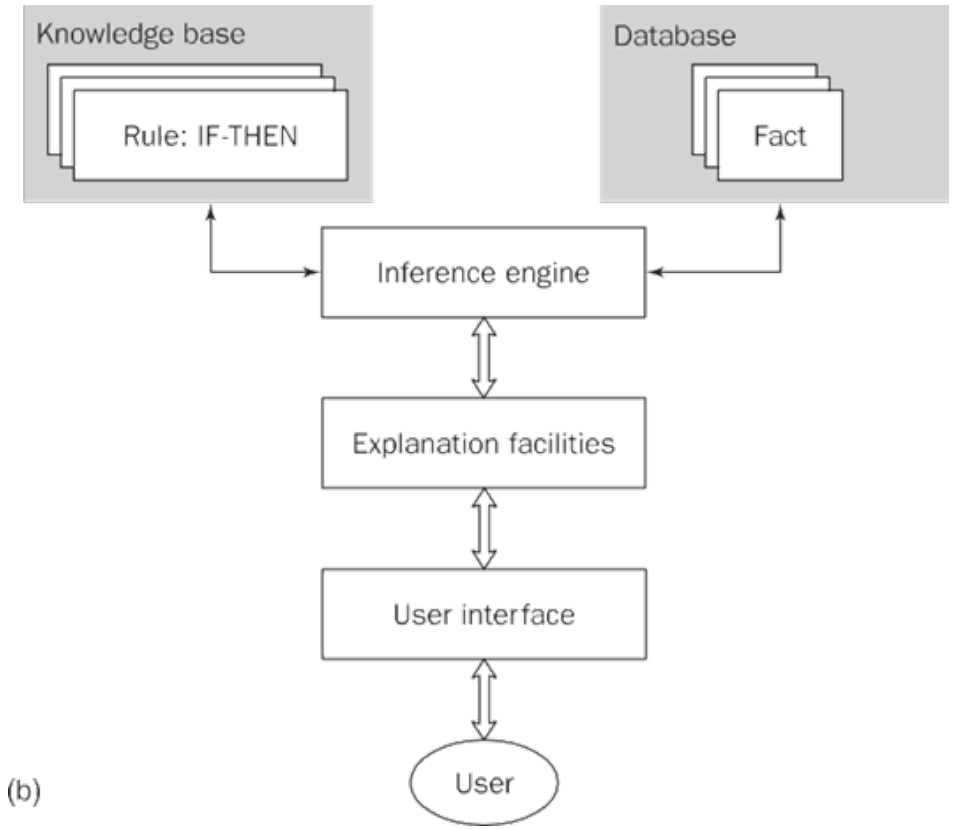


Figure: Production system and basic structure of a rule-based expert system: (b) basic structure of a rule-based expert system

CONT.,

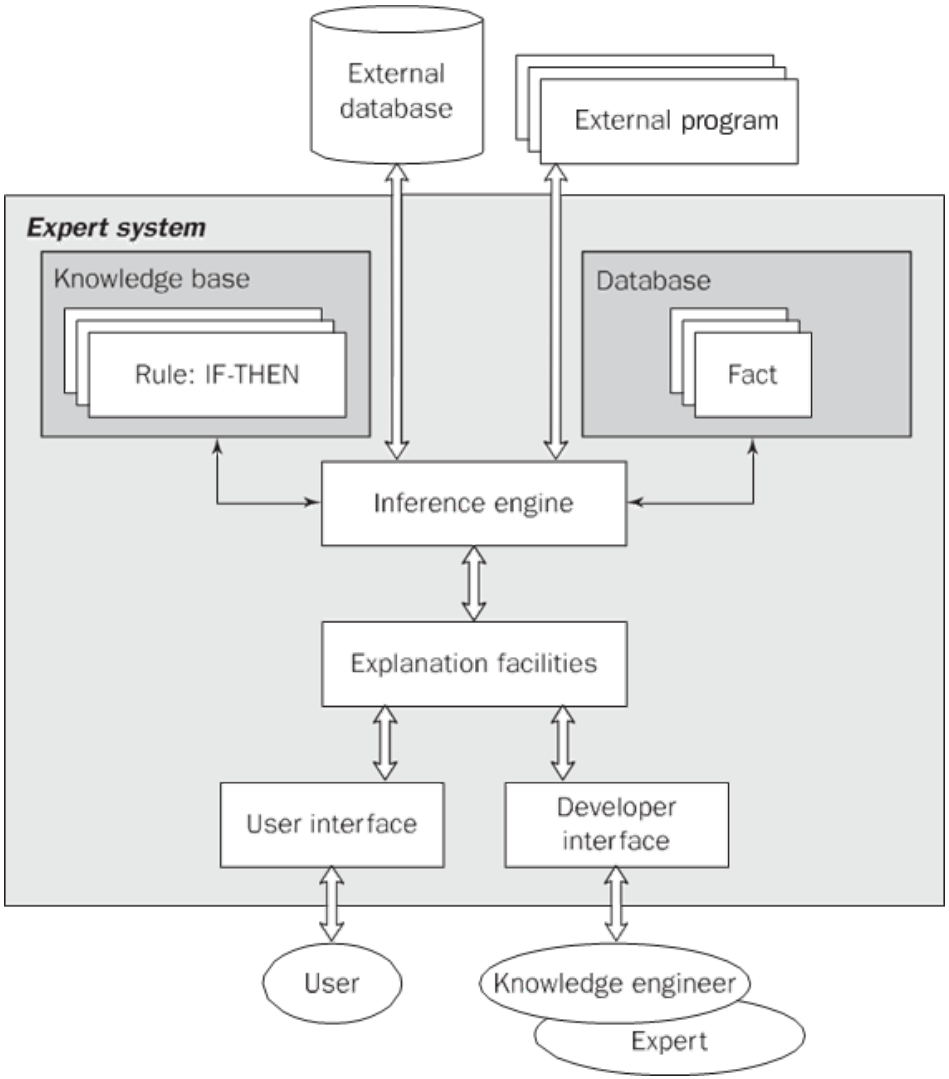


Figure: Complete structure of a rule-based expert system

Outlines

Fundamental characteristics of an expert system

- **High-Quality Performance:** Expert systems aim to perform at a human expert level, delivering accurate and timely solutions, especially crucial in emergencies.
- **Heuristics: Like human experts:** they use rules-of-thumb to narrow down solutions quickly.
- **Explanation Capability:** They can trace reasoning steps, though full explanations may not always be necessary, depending on the system's use.
- **Symbolic Reasoning:** They process knowledge symbolically (facts, concepts, rules), unlike conventional programs focused on numerical data.
- **Handling Uncertainty:** Expert systems allow inexact reasoning, making them adaptable to incomplete or fuzzy data, unlike traditional algorithms that require exact, step-by-step processing.

CONT.,

Can expert systems make mistakes?

Mistakes!

Mistakes are possible and we should be aware of this.

Outlines

Comparison

Human Experts	**Expert Systems**	**Conventional Programs**
Use heuristics in narrow domains.	Use rules to process knowledge in **narrow domains**.	Use algorithms for general problems.
Knowledge is in compiled form.	**Separate** knowledge from processing.	Knowledge is not separated from processing.
Can explain reasoning in detail.	**Trace** rules and **explain** how and why conclusions are reached.	Cannot explain results.
Handle inexact and fuzzy data.	Allow **inexact reasoning** with fuzzy data.	Require complete and exact data.

Comparison

Cont.,

Human Experts	**Expert Systems**	**Conventional Programs**
Can make mistakes with fuzzy info.	**Can make mistakes** with fuzzy data.	Fail or give wrong answers if data is incomplete.
Improve over time; slow process.	Easily **add/change rules** to improve.	Changes are difficult; affects code and processing.

Table: Comparison of Human Experts, Expert Systems, and Conventional Programs

Outlines

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences

Forward chaining and backward chaining

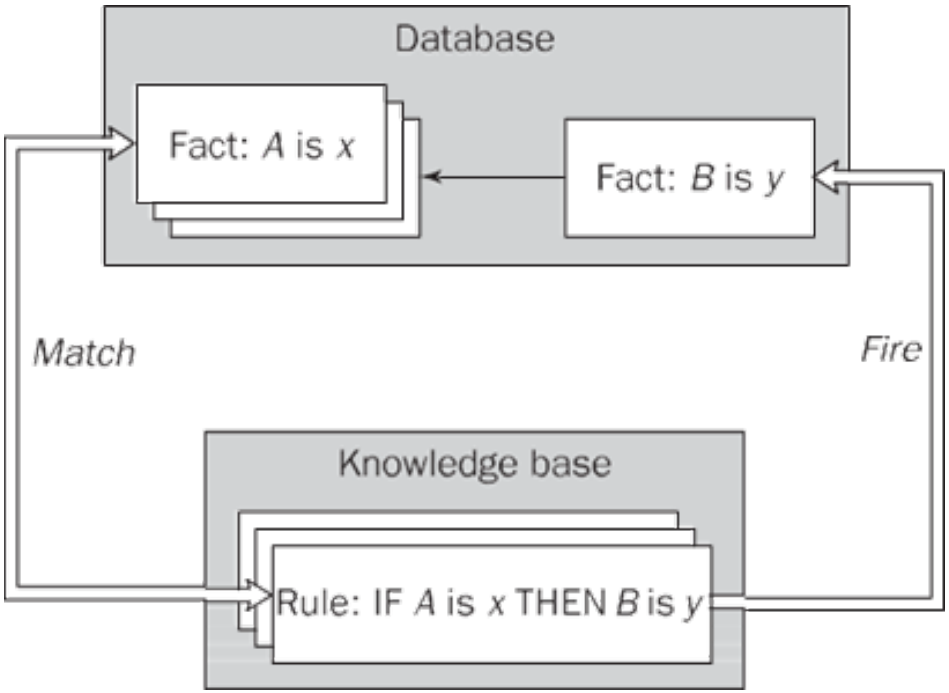


Figure: The inference engine cycles via a match–fire procedure

CONT.,

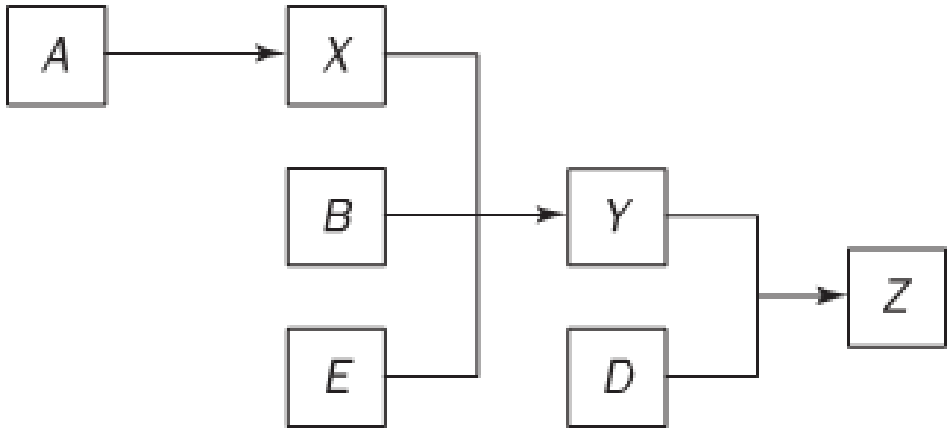
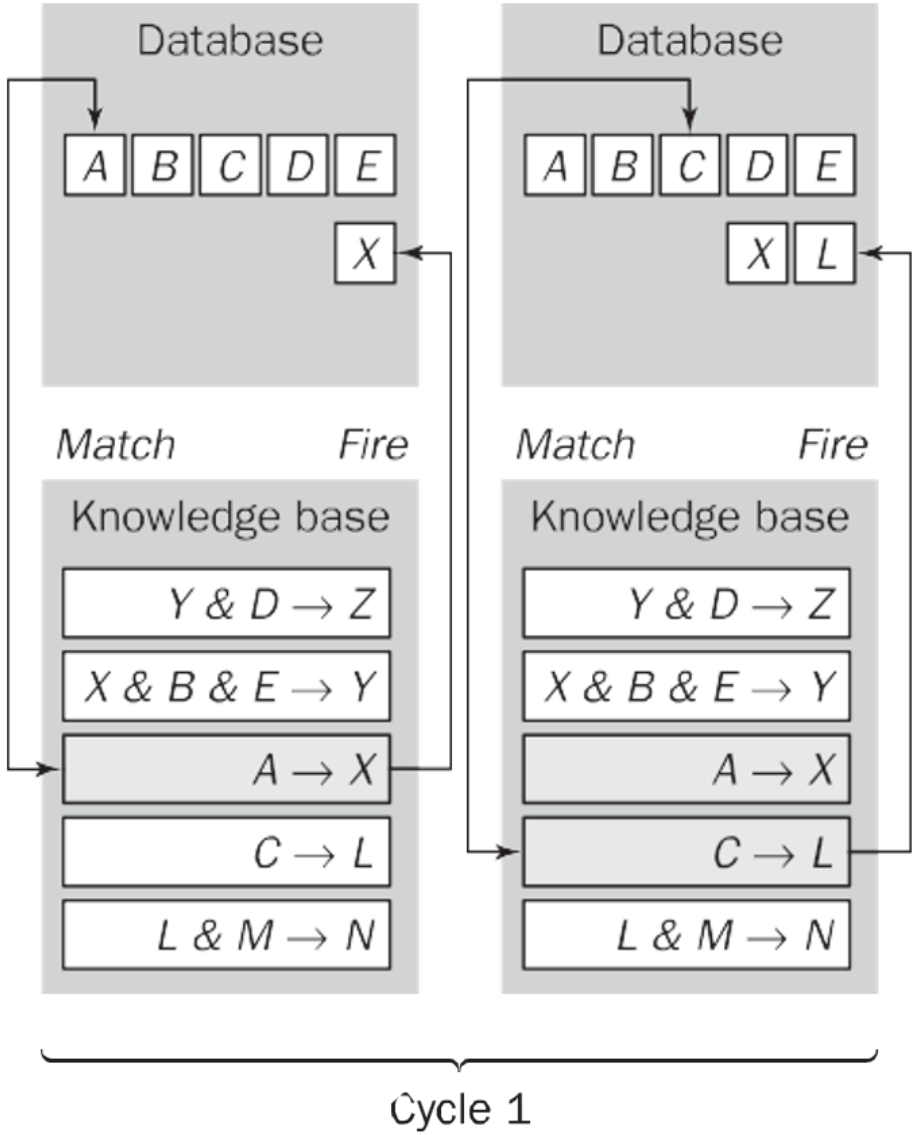


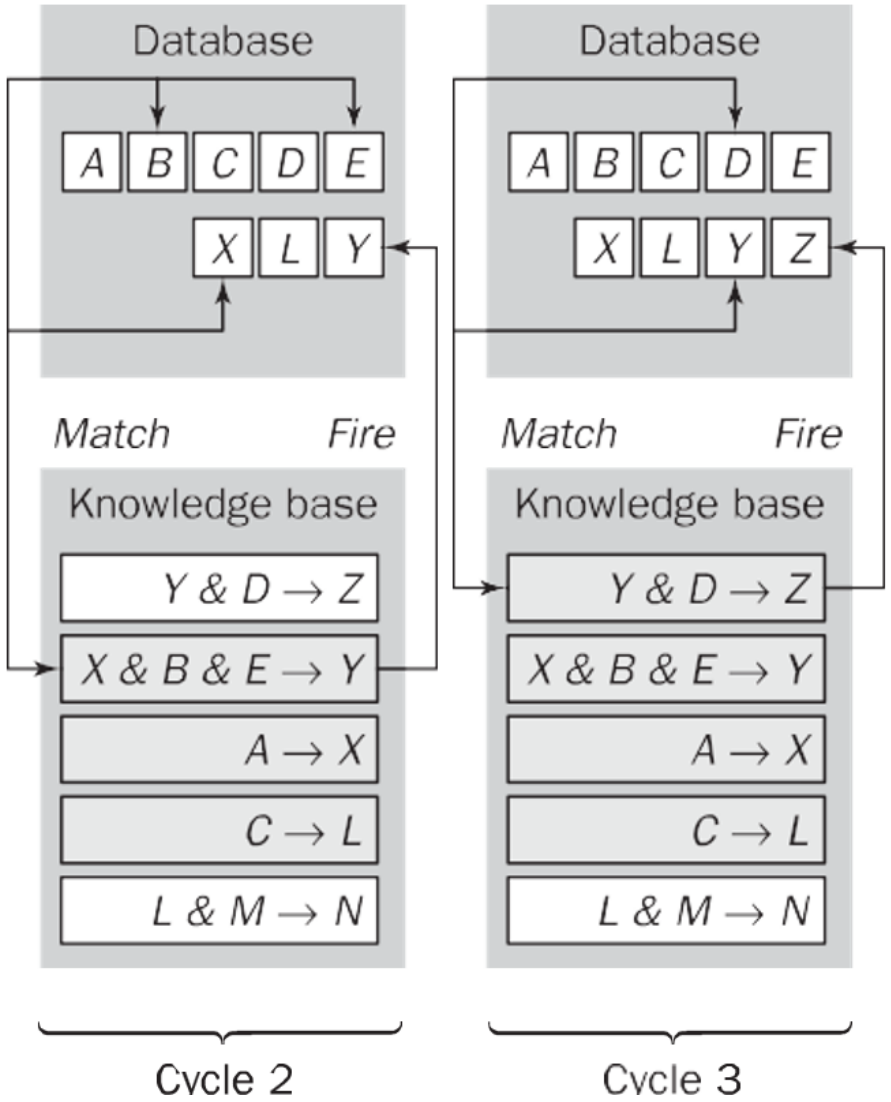
Figure: An example of an inference chain

Forward Chaining



Forward Chaining

CONT.,



Backward Chaining

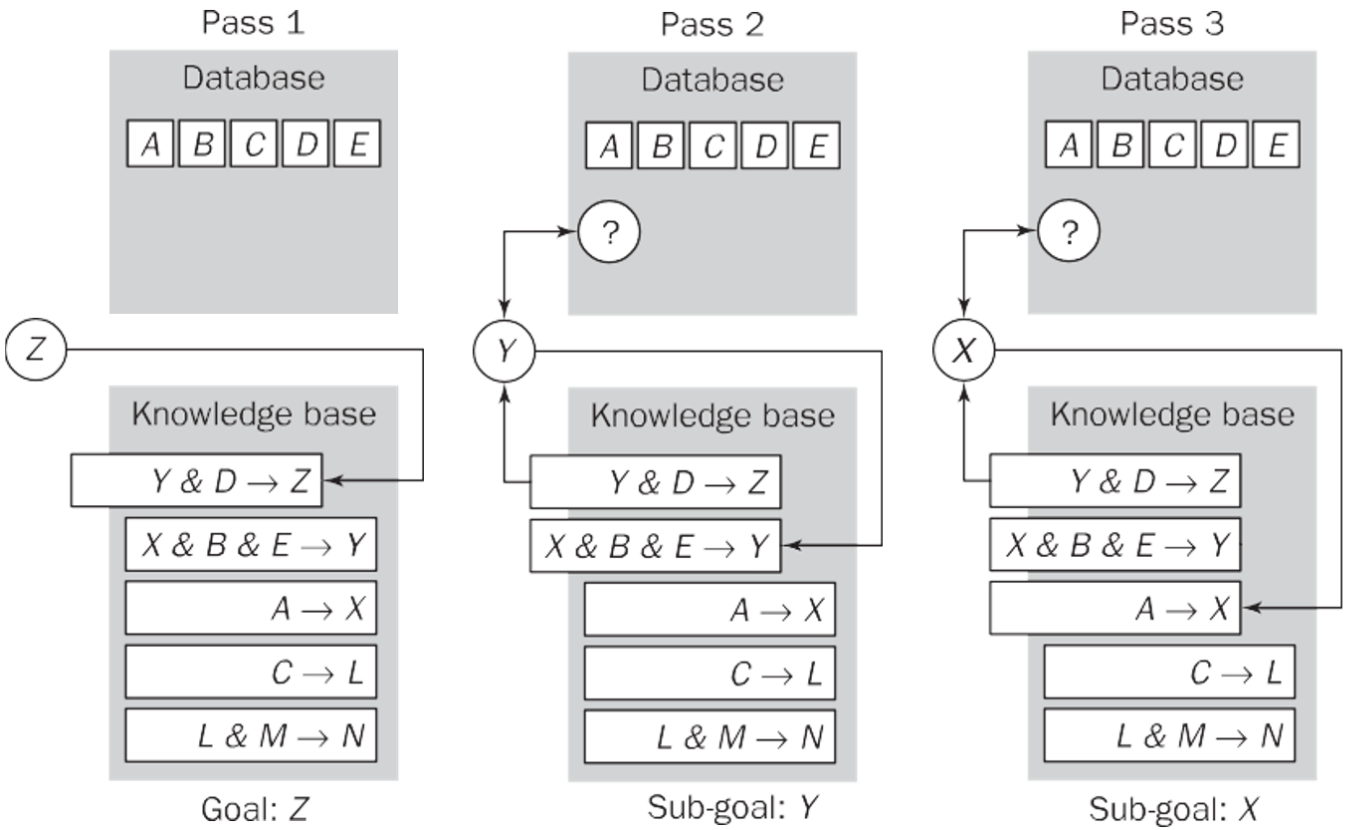


Figure: Backward chaining

CONT.,

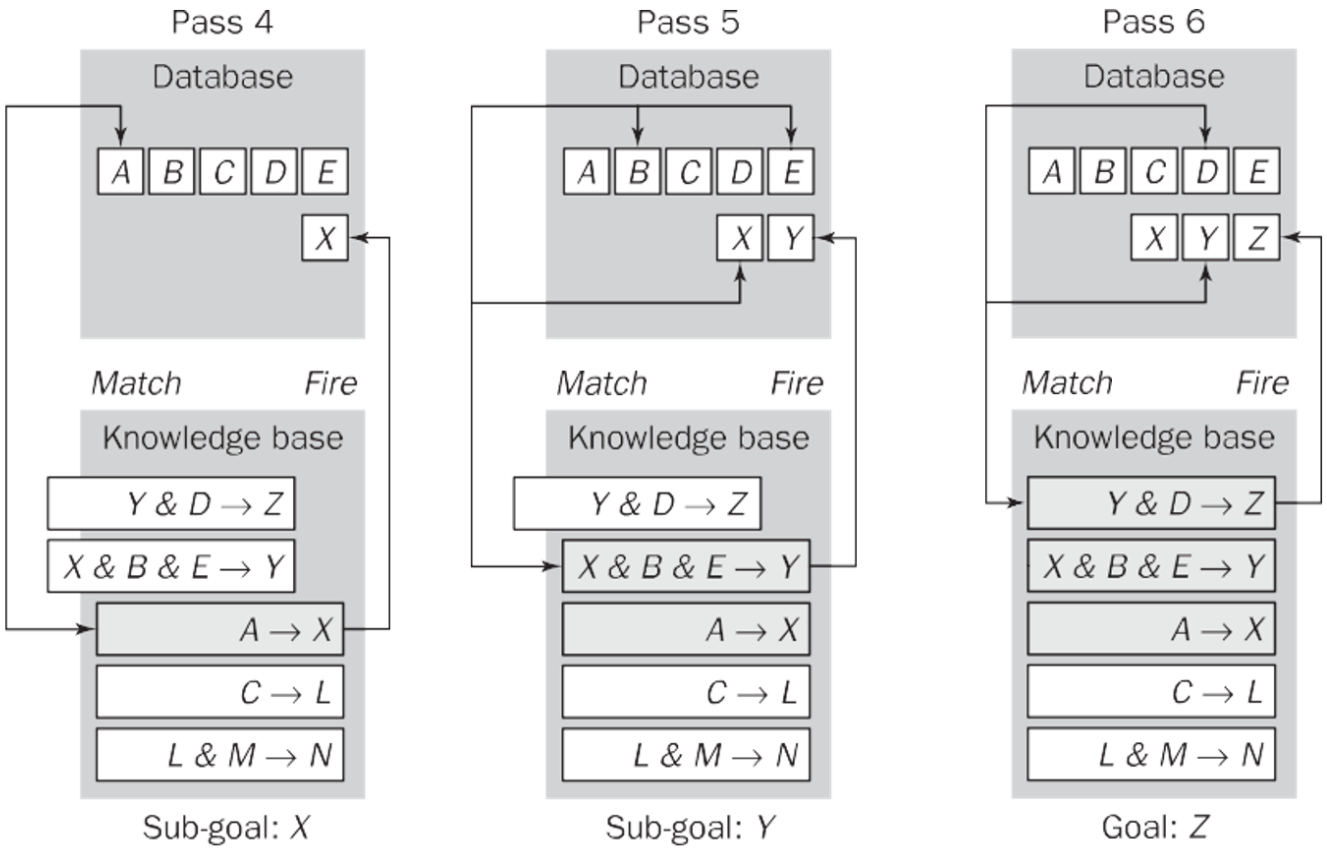


Figure: Backward chaining 2

Outlines

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences

Advantages of Rule-Based Expert Systems

- **Natural Representation**: Expert systems use IF-THEN rules to naturally represent problem-solving methods.
- **Uniform Structure**: Rules are consistently formatted, making them self-documenting and easy to understand.
- **Knowledge Separation**: The knowledge base is independent from the inference engine, allowing easy expansion and reusability across different applications.
- **Handling Uncertainty**: Expert systems can work with incomplete or uncertain information by using certainty factors to indicate confidence levels in outcomes.

Disadvantages of rule-based expert systems

- **Opaque Rule Interactions**: While individual rules are clear, their interactions can be difficult to understand due to the lack of hierarchy.
- **Inefficient Search**: Rule-based systems search all rules each cycle, which can slow down systems with over 100 rules, limiting real-time use.
- **Lack of Learning**: Expert systems cannot learn or adapt; they rely on the knowledge engineer for updates and maintenance, unlike human experts who can adjust based on experience.

Outlines

Frame Title

- **Knowledge Definition:** Knowledge is understanding in a field; experts have deep knowledge and experience.
- **Production Rules**: Experts express knowledge as "IF-THEN" rules, a common form of knowledge representation.
- - **Expert Systems:** Programs that perform at expert level in specific domains, often rule-based, with "shells" simplifying development.
- - **Development Team:** Includes domain expert, knowledge engineer, programmer, manager, and end-user; for small projects, roles may overlap.

CONT.,

- **System Components:** Knowledge base (rules), database (facts), inference engine (reasoning), explanation facilities, and user interface.
- **Knowledge-Processing Separation:** Splitting knowledge from processing aids system maintenance and expansion.
- **Explanation Ability:** Expert systems can trace rules used in reasoning, though explanations are limited.
- **Handling Uncertainty:** Unlike conventional programs, expert systems deal with incomplete, uncertain data and permit inexact reasoning.

CONT.,

- **Inference Techniques:** Forward chaining (data-driven) and backward chaining (goal-driven) guide reasoning.
- **Conflict Resolution:** When multiple rules apply, the inference engine selects one to proceed.
- **Advantages:** Natural knowledge representation, uniform structure, knowledge-processing separation, and handling uncertainty.
- **Disadvantages:** Opaque rule interactions, slow search with large rule sets, and lack of learning ability.

THANKS

الكلية الجامعية للعلوم التطبيقية
University College of Applied Sciences