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RULE-BASED SYSTEMS (RBS)

2 EME ANNÉE MASTER IDO

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Rule-based systems (RBS)

Generalities

Principle

- The principle of a Rule based system is to make the best use of:
  - *a mass of knowledge acquired from* human experts.
  - *to* competently deal with problems *in very limited areas*

Functioning

- In an RBS, there is a clear consideration (or separation) between:
  - The knowledge.
  - Programs that use this knowledge.

Components of an RBS

- An RBS always includes:
  - language for expressing knowledge
  - Reception structures for specific knowledge of a field of application
  - An inference engine (or control structures) responsible for reasoning (or solving) a problem

Knowledge expression language

From the point of view of the human user, natural languages would be the most comfortable form for communicating or dialoguing.

We distinguish :

Human-to-human dialogue: communication.

Human-Machine Dialogue (case that concerns us).

- *Reception structures for knowledge:*

  The knowledge elements are organized into a *knowledge base* (KB).We find :

  - Facts about a specific problem to solve
  - Inference methods (or *inference rules)*
  - *Knowledge* of the area envisaged

In the KB, we distinguish :

- *Assertional knowledge (AK):*

  → is knowledge that describes **situations** considered established or to be established

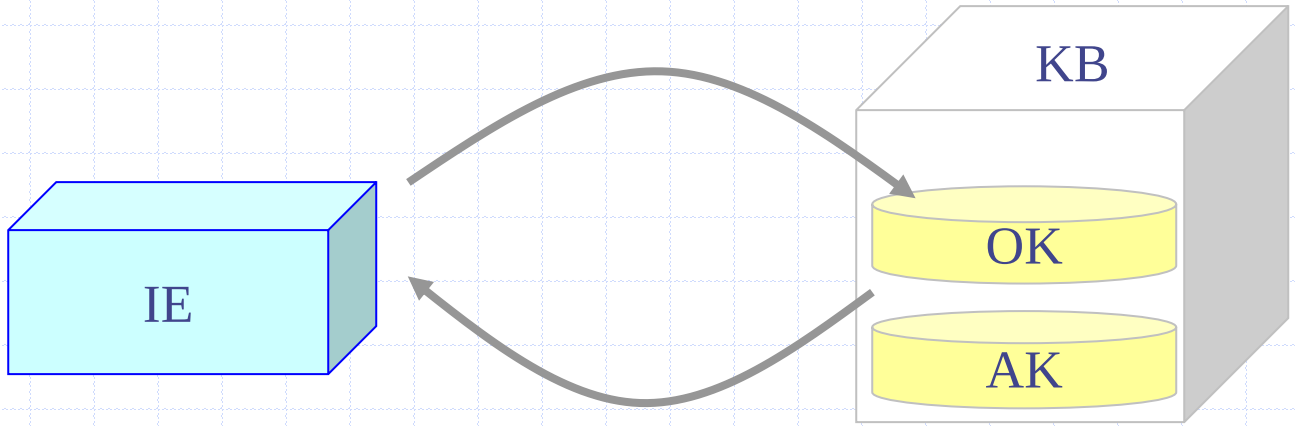
- *Operating knowledge (OK) :*

  This is knowledge that represents **know-how** in the field. We often speak of granules of operational knowledge.

  → A unit of know-how is designated by a rule.

Inference Engine (IE):

It is a program (in certain devices, it is an integrated circuit) which implements general mechanisms for combining AKs or OKs.



1-2 Inference rules

- An inference rule is the representation of a process for, from one or more formulas, to derive (deduce, exhibit) others.

The Inference rule :

« MODUS PONEN »:

from two formulas respectively of the form

F and $(F \Rightarrow G)$ deduce G

The Inference rule :

« MODUS TOLLENS » :

from two formulas respectively of the form $\overline{G}$ and $(F \Rightarrow G)$ deduce $\overline{F}$

The Inference rule :

Biconditional introduction

« MODUS PONEN Biconditional »:

from two formulas respectively of the form $(G \Rightarrow F)$ and $(F \Rightarrow G)$ deduce

$$G \leftrightarrow F$$

The Inference rule :

«SPESIALISATION UNIVERSELLE »:

from a formula of the form $\forall x\ P(x)$ and any constant « a » deduce $P(a)$.

II.
Inference engine

Functioning principles

Production rule

- The representation of each rule brings together information relating to:
  - ***Conditions for triggering rules (or rule trigger)***
  - ***Effects resulting from this trigger (or body of the rule)***
- Formally: a rule is written as follows

<a rule> = <trigger> + <body>

Inference engine

- The IE connects work cycles, each comprising two phases
  - phase «evaluation »
  - phase « execution »
- When the IE is launched, the KB contains information representative of the problem statement to be solved :
  - Base of facts (BF) : proven facts and facts to be established (problems or goals)
  - Base of rules (BR) : operational knowledge in the field

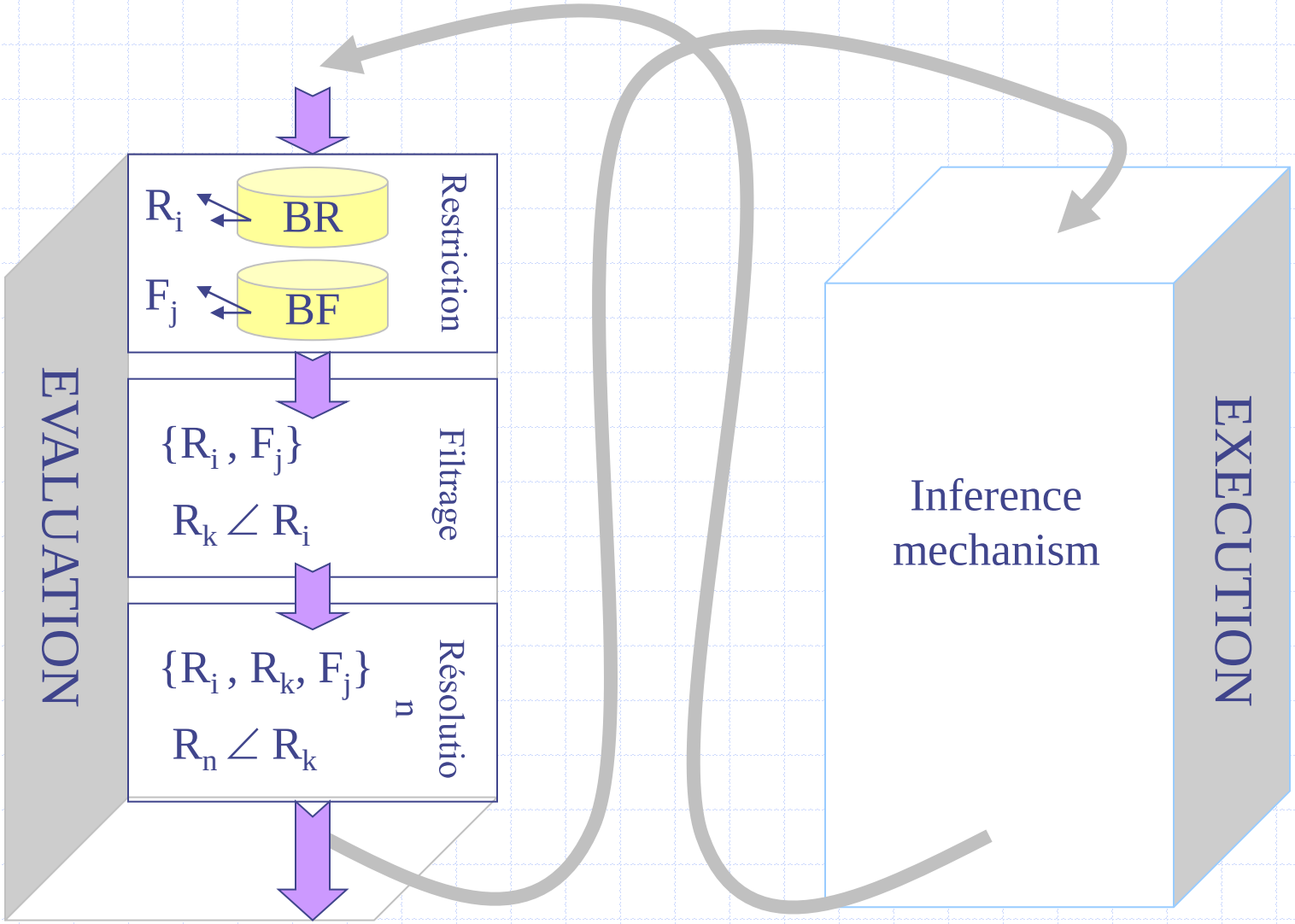
Phase of evaluation :

It generally includes 3 stages:

- Selection (ou restriction) : consists of favoring a particular group of rules or facts in the KB
- Filtering (ou pattern-matching) : is to compare the triggers of rules against the facts
- Conflict resolution (ou matching) : the IE determines the rules that must actually be triggered

Phase of execution :

The IE controls the implementation of actions defined by the rules.



Facts :

A “fact” is an element of declarative type and which constitutes an atom of knowledge. It is an element of elementary, “indivisible” or atomic knowledge.

- Example 1:“there is a prevailing wind coming from the sea”It is a fact in propositional logic that is either true or false.It is a simple element of a wholeLogical fact of order 0
- Example 2:“X is the price of oil” or “X is the father of Y”Are also facts with variables in their expressionThese are facts of order 1, which can be rewritten differently:

  Oil_price(X),

  father(X, Y)

Rules :

- A rule is knowledge that organizes a few facts together:
  - A part of facts are grouped into a set called hypotheses or premises and
  - the remainder is called deduction or conclusion.
- Examples :
  - SI (le ciel est bleu) et (il n'y a pas de vent)
    ALORS (il fait beau)
  - IF (the sky is blue) and (there is no wind) THEN (the weather is nice)
    → premises: {"the sky is blue", "there is no wind"}·
    → conclusion: {"the weather is nice"}
  - IF (X is the father of Y) and (Y is the father of Z) THEN (X is Z's grandfather)
  - IF (X is a mother) or (X is a father) THEN (X has at least one child)

Inference mechanism

Predicate logic

&

Different types of reasoning

Data-driven vs. goal-driven reasoning

The rule: If man(s) then mortal(s)

allows four possible reasonings

Two "data-driven" reasonings

1. I know Med is a man; like everything Man is mortal, I conclude that Med is mortal.
2. I know that the computer is immortal; as every man is mortal, I deduce that the computer is not a man.

if Med is a man **and** every man is mortal **then** Med is deadly

Ri : **if** A and B **then** C

«forward chaining »

– When A and B are facts already deduced

– {A, B} is the forward chaining trigger of Ri

Two "goal-directed" reasonings(obtained by reversing the reading direction of the rule)

I am looking for a mortal entity; as every man is mortal, I can look for a human.

I am looking for an entity that is not human; as every man is mortal, I just need to look for a non-mortal entity.

Ri : **if** A and B **then** C

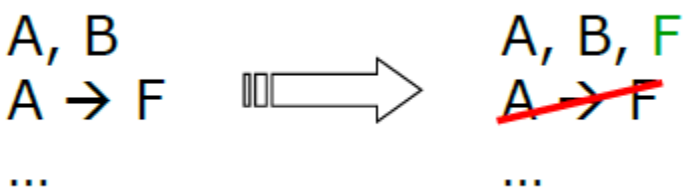
"backward chaining"

– When the system seeks to demonstrate goal C.

– {C} is the back chaining trigger of Ri

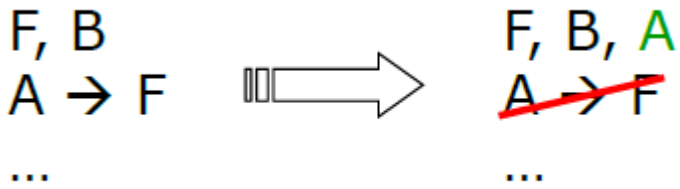
Forward chaining

Forward chaining uses data that is currently available (existing facts) to satisfy the conditions of the rules. If the conditions are met, the rule is deleted which means the consequences are added to the currently available data.



Backward chaining

In backward chaining, we start from the goal to be demonstrated and go back to the initial facts. We therefore take the rule "in reverse".If the consequence is satisfied, the rule is deleted which means that the facts are added to the currently available data.



Example of interpreting a Rule Base

Base of rules

1. B et D et E →F
2. D et G → A
3. C et F → A
4. C → D
5. D → E
6. A → H
7. B → X
8. X et C → A

Base of facts

– B true
– C true
– H ?

1) With forward chaining
2) With backward chaining

Forward chaining

Base of rules

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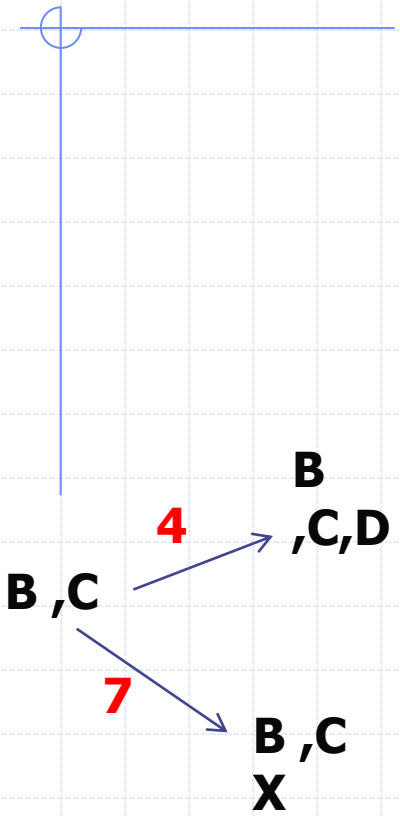

Forward chaining

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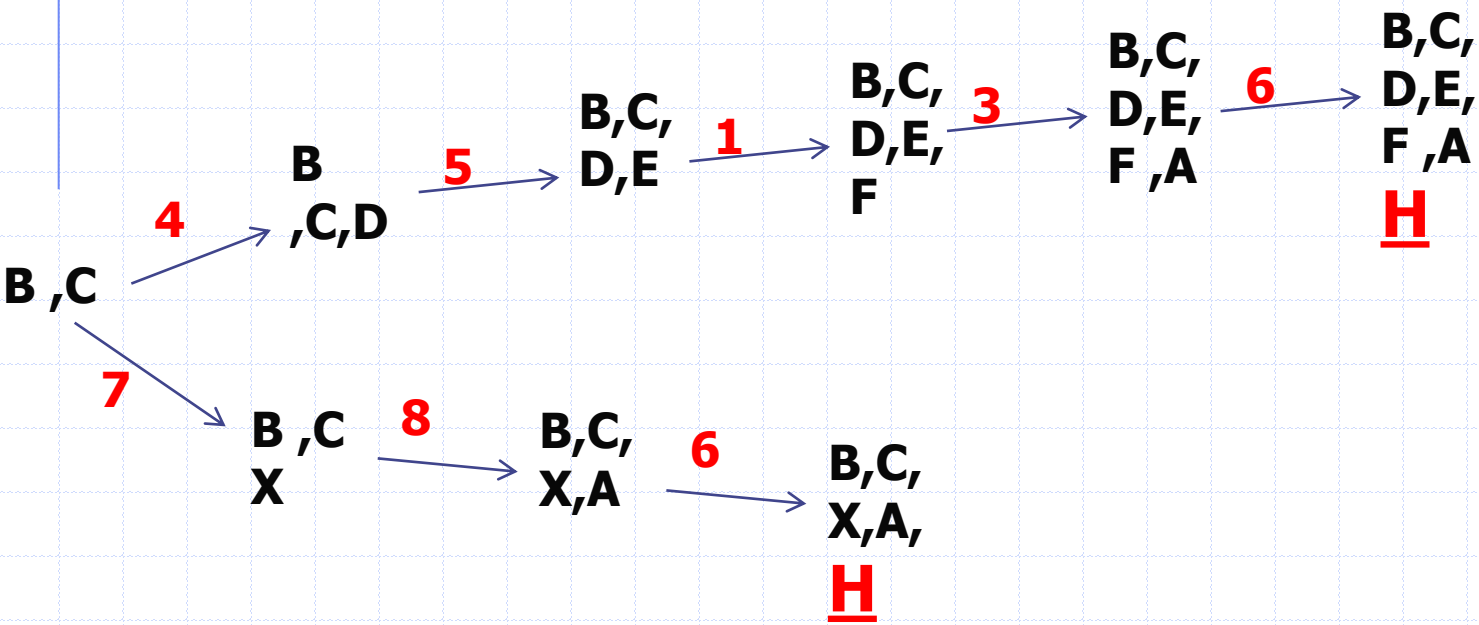

Backward chaining

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