

## Q2. Forward and Backward chaining →

Inference engine is the component of intelligent system in AI which applies logic to the knowledge base to infer new information and facts.

The first inference engine was part of the expert system.

Inference engine commonly proceeds in two modes →

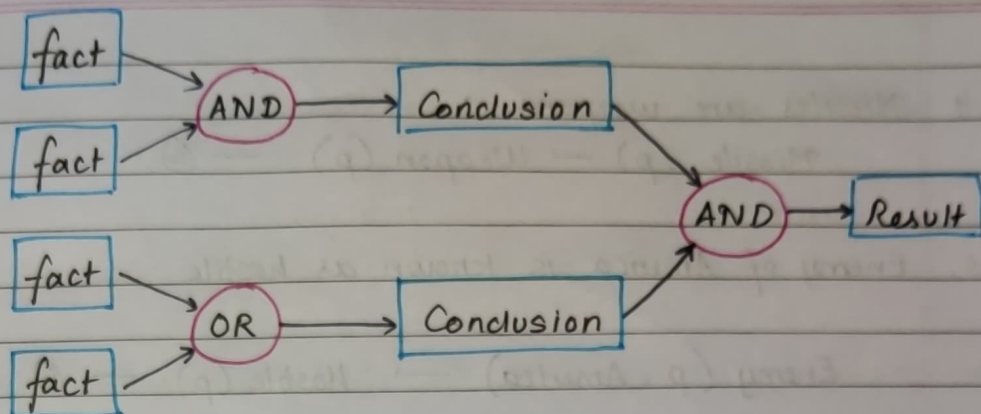
- Forward chaining
- Backward chaining

### 1. Forward chaining →

- It is also known as forward deduction or forward reasoning, which starts with atomic sentences <sup>in the knowledge base</sup> and applies inference rules (modus ponens) in the forward direction to extract more data until the goal is reached.

### Properties →

- It is a bottom up approach, as it moves from bottom to top.
- It is also data-driven as it uses ~~the~~ available data to reach the goal.
- It is commonly used in expert system



Example →

"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an american citizen".

Prove: "Robert is a criminal"

Facts conversion into FOL : →

1. It is a crime for an American to sell weapons to hostile nations (Let  $p, q, r$  be variables)

$$\text{American}(p) \wedge \text{weapon}(q) \wedge \text{hostile}(r) \wedge \text{Sells}(p, q, r) \rightarrow \text{Criminal}(p) \quad \text{--- ①}$$

2. Country A has some missiles

$$? p \text{ Owns}(A, p) \wedge \text{Missile}(p)$$

this can be written as two definite clauses using constant

$$T_1 \rightarrow \text{Owns}(A, T_1) \quad \text{--- ②}$$

$$\text{Missiles}(T_1) \quad \text{--- ③}$$

3. All of the missiles were sold to country A by Robert

$$? p \text{ Missiles}(p) \wedge \text{Owns}(A, p) \rightarrow \text{Sells}(\text{Robert}, p, A)$$

④

4. Missiles are weapons  $\rightarrow$

Missile (p)  $\rightarrow$  Weapon (p) — (6)

5. Enemy of America is known as hostile

Enemy (p, America)  $\rightarrow$  Hostile (p) — (6)

6. Country A is an enemy of America

Enemy (A, America)  $\rightarrow$  (7)

7. Robert is american

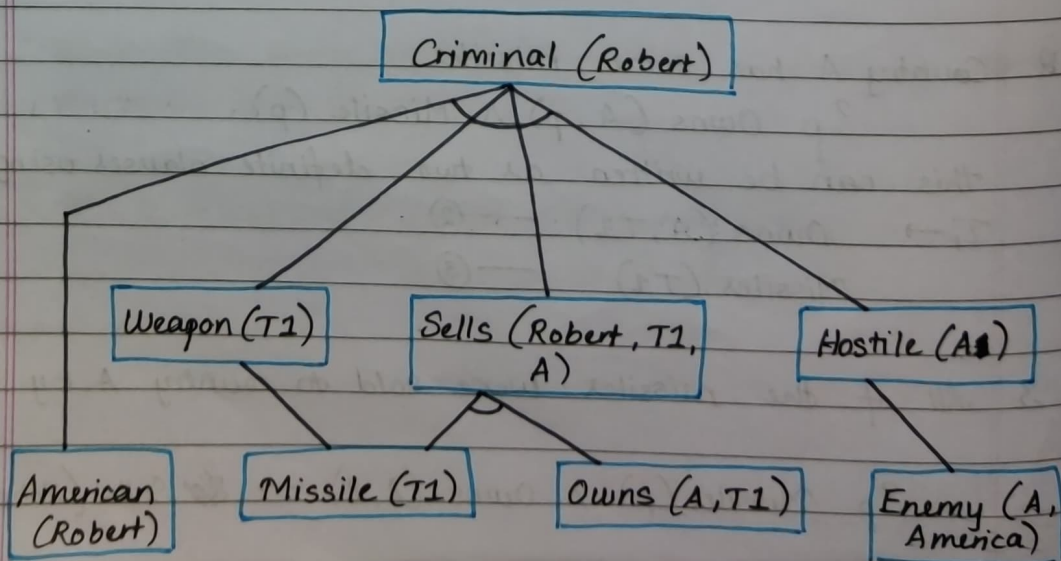
American (Robert) — (8)

Forward chaining proof  $\rightarrow$

First we will take the known facts and choose sentences that do not have any implications: American (Robert), Enemy (A, America), Owns (A, T1), Missile (T1)

Now we will add the facts that we can infer from available facts and with satisfied premises in each iteration

This gives the following  $\rightarrow$





Hence we reach our goal statement.

Hence it is proved that Robert is a criminal.

## 2. Backward chaining →

- It is known as backward reasoning or backward deduction.
- It is a top down approach.
- It is called goal-driven as ~~the~~ the list of goals decide which rules are selected and used.
- It is based on modus ponens inference rule.
- The goal is ~~is~~ broken down into sub goals to prove the facts true.

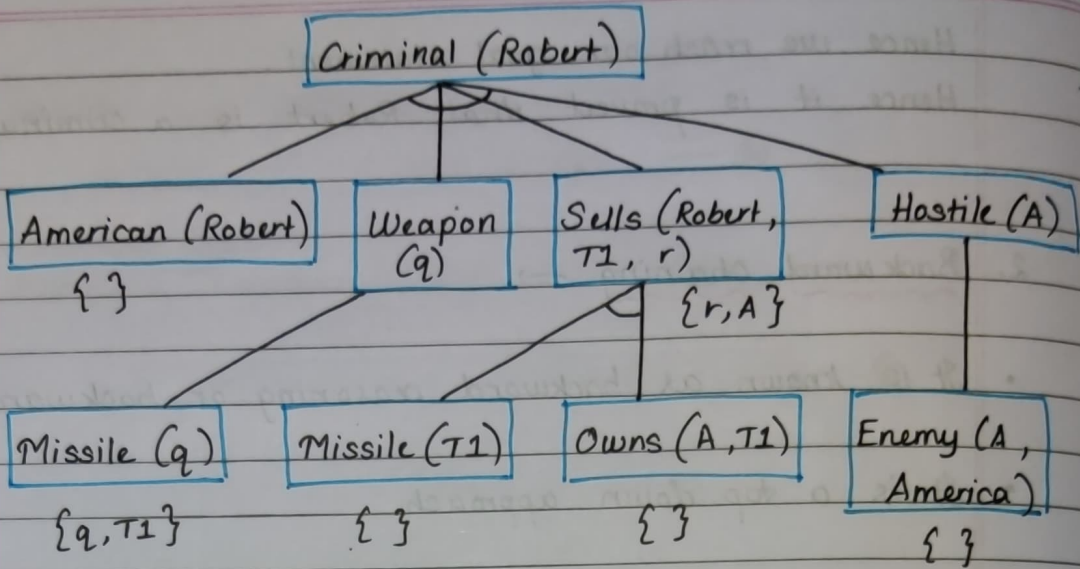
Using the example we will study backward chaining →

### Backward chaining proof →

In backward chaining, we will start with our goal,  
: Criminal (Robert)

from this goal fact we will infer other facts, and  
at last we will prove those facts to be true

After each iteration - we get:



### Example 2:

If X croaks and X eats flies : X is a frog

If X chirps and X sings : X is a canary

If X is a frog : X is green

If X is a canary : X is yellow

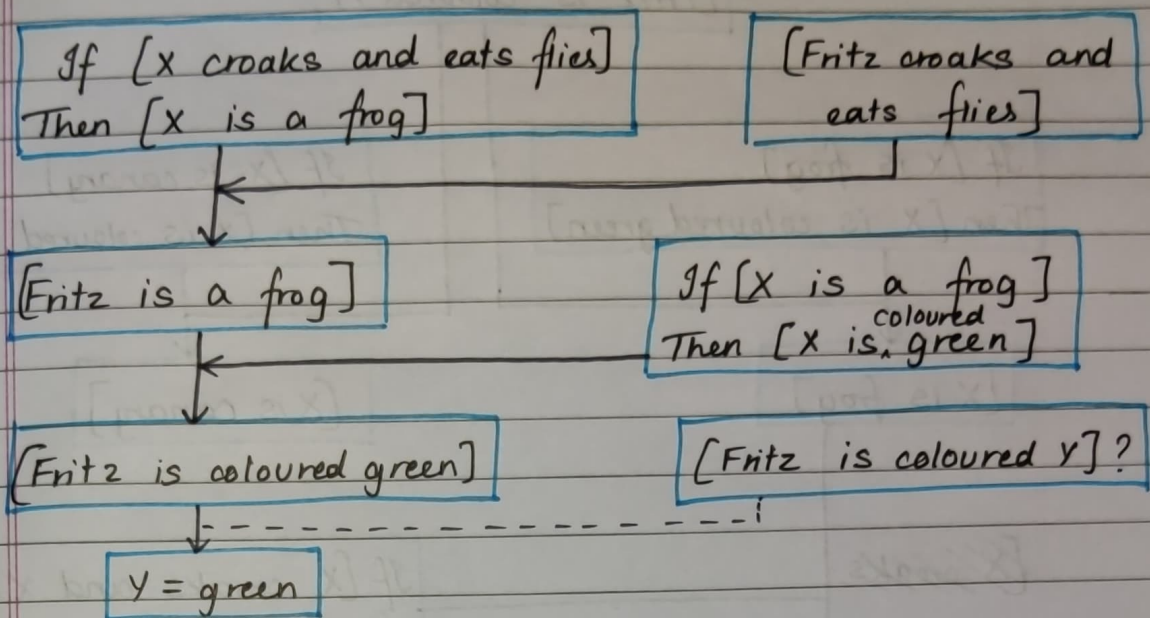
suppose :

- Fritz croaks
- Fritz eats flies

The goal is to ~~decide~~ ~~whether~~ Fritz is ~~green~~. conclude the colour of Fritz.

Forward chaining →

1. Since fritz croaks and fritz eats flies, it can be concluded that fritz is a frog. by substituting in rule #1
2. Substituting X with fritz in the antecedent of #3 rule, we can conclude that fritz is green.



### Backward chaining →

We start with the goal to be proved "Fritz is green"

1. Fritz is substituted for X in rule 3. Since the consequent now matches the goal, now we need to see if the antecedent "Fritz is a frog" can be proved.
2. Substituting Fritz for X in rule 1, since the consequent matches the current goal, now we must see if "Fritz croaks and Fritz eats flies" can be proved.
3. Since this goal is a conjunction of two statements, the inference engine breaks it into subgoals:
  - Fritz croaks
  - Fritz eats flies
4. Both of these subgoals are the given initial facts, so the conjunction is true. Thus the two goals above are also true, thus it has been proven that Fritz is green.



