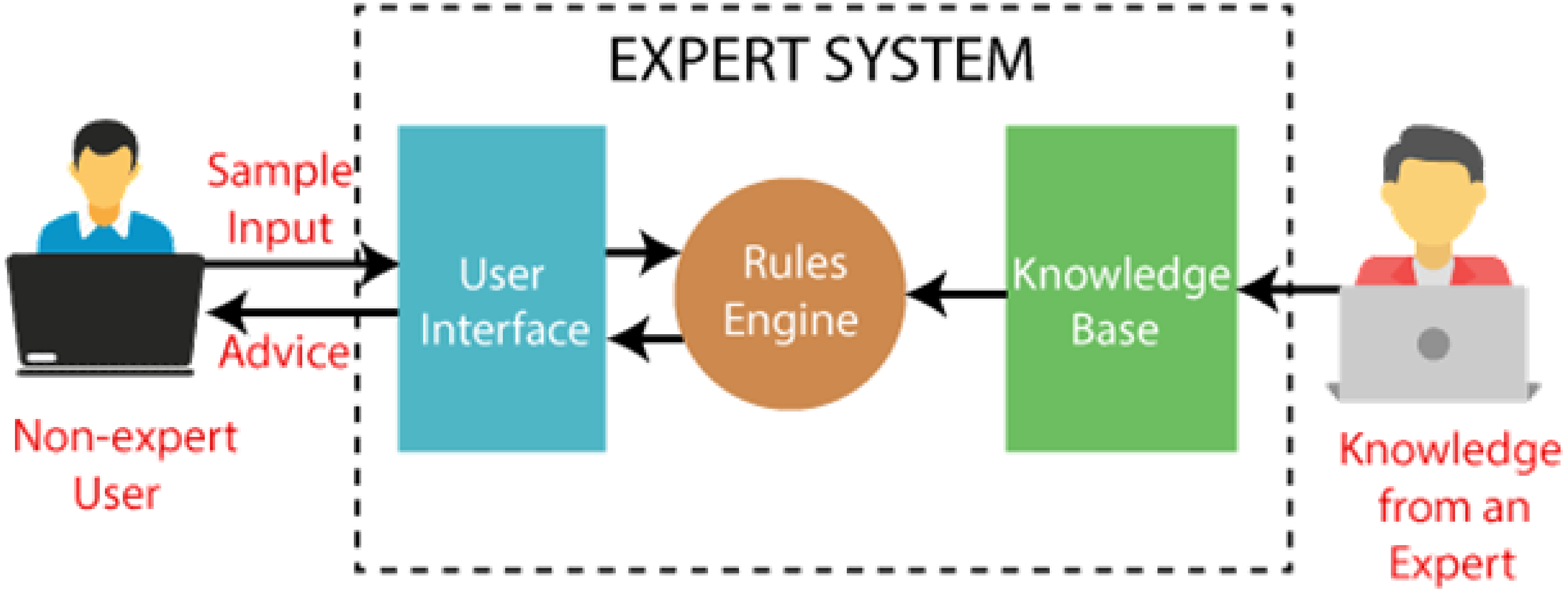
CHAPTER IV

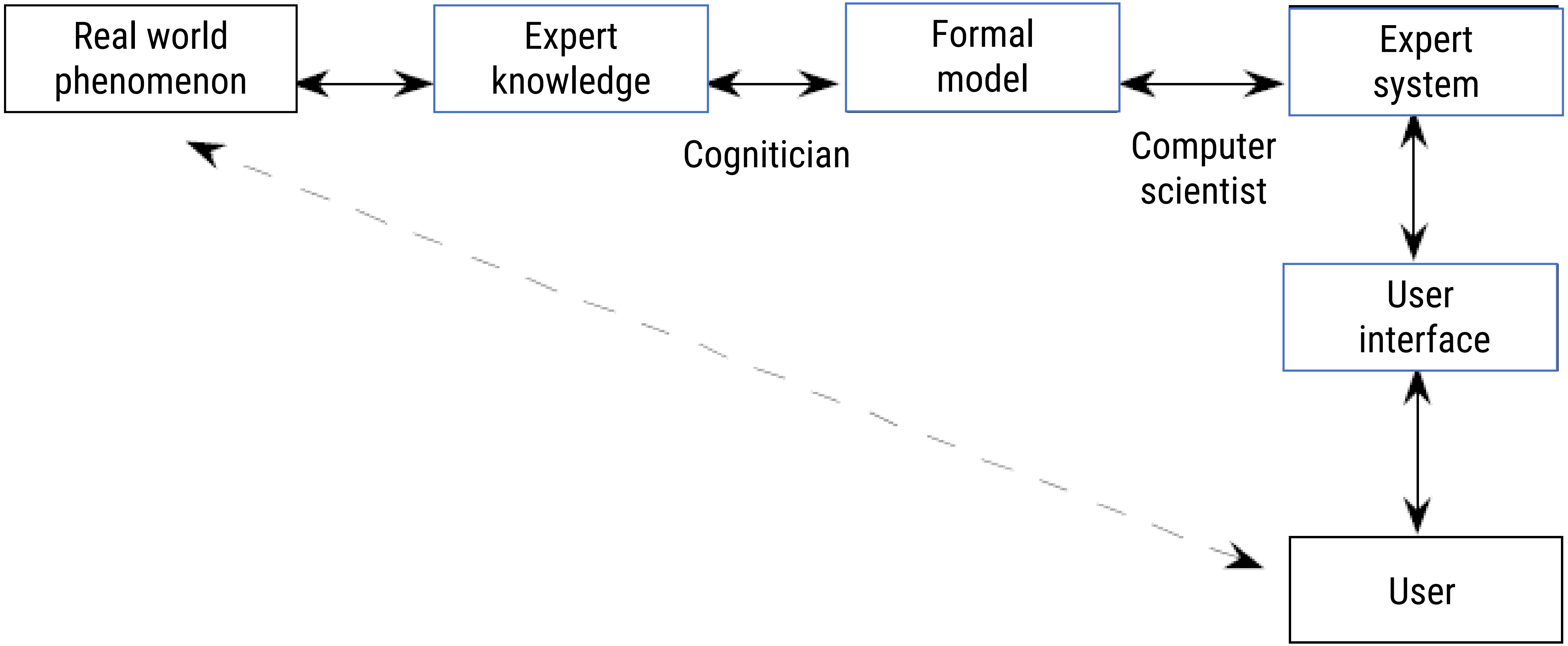
EXPERT SYSTEMS

EXPERT SYSTEM

An expert system aims to model the behavior of a human expert performing a task to solve a problem for which there is no algorithm, within a very specific domain.



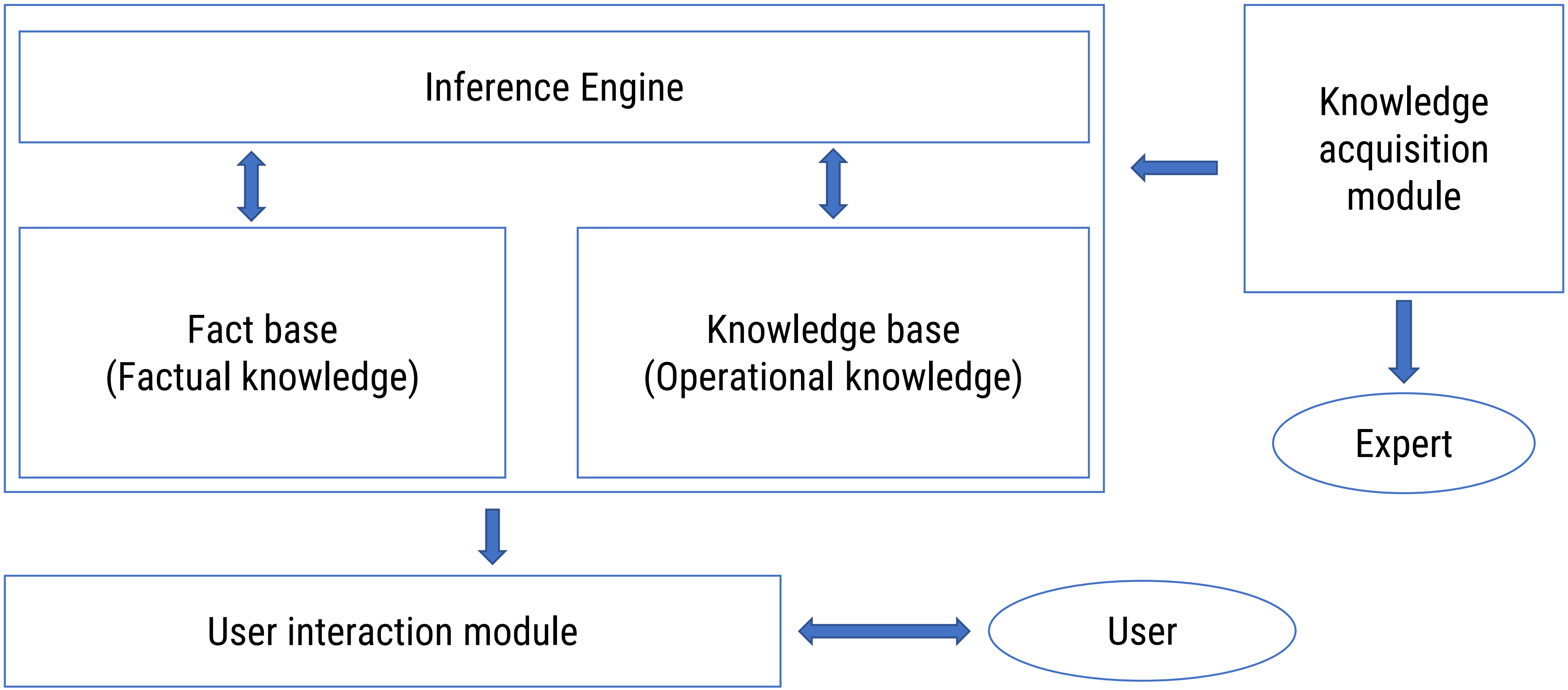
EXPERT SYSTEM



Application areas

- **Computer Science:** maintenance assistance, programming,..
- **Medicine:** diagnostic assistance, patient monitoring,..
- **Finance and banking:** risk assessment,..
- **Industry:** diagnostics

EXPERT SYSTEM ARCHITECTURE



EXPERT SYSTEM ARCHITECTURE

1.Fact Base

- Represents the working memory of the system.
- Contains data specific to the problem being addressed (assertions describing situations considered as established or to be established)
- It stores intermediate results (trace of the reasoning).
- The fact base is updated as reasoning progresses

EXPERT SYSTEM ARCHITECTURE

2. Knowledge Base

- Gathers information specific to the field of expertise. This information is provided directly by the expert or accumulated by the system over the experiments

- The knowledge base is written in a knowledge representation language (Example: production rules, referred to as a rule base).

EXPERT SYSTEM ARCHITECTURE

3.Knowledge Acquisition Module:

Provides the expert with the ability to transmit their knowledge to the system in order to build the knowledge base (BDC).

4.User Interaction Module:

Allows the user to query the expert system in order to:

- Solve their own problems.
- Acquire expertise similar to that of the expert.

5.Inference Engine:

This is a program that utilizes the elements of the knowledge base (BDC) and the fact base (BDF) to perform reasoning. It is characterized by:

- A) A basic cycle.
- B) A search strategy.
- C) A method of chaining (forward or backward)

INFERENCE ENGINE

A. Basic Cycle:

- **Selection Phase:** Its purpose is to sort and gather into a subset those rules from the knowledge base that deserve more attention than others.
- **Filtering Phase:** Determines the set of applicable rules based on the results of the first phase.
- **Conflict Resolution Phase:** Characterized by the choice of the rule to apply according to a specific strategy:
  - The first rule in appearance.
  - The most reliable rule (for example, based on likelihood coefficients).
- **Execution Phase:** Involves activating the chosen rule from the previous step. This action allows one or more new facts to be added to the fact base.

INFERENCE ENGINE

B. Search Strategies:

- **Breadth-first:** Explores all the nodes at the present depth prior to moving on to nodes at the next depth level.
- **Depth-first:** Explores as far as possible along each branch before backtracking.
- **Heuristic:** Utilizes methods to speed up the process of finding a satisfactory solution, often through rules of thumb that prioritize paths that seem likely to lead to a goal.

INFERENCE ENGINE

C. Chaining Methods (Reasoning Strategy):

- **Forward Chaining (Deductive Reasoning):**
  - Starting from the facts provided by the user, the inference engine deduces conclusions.
  - Use the newly obtained facts to trigger other rules.
  - Stop the reasoning process when no goal can be deduced.
  - This reasoning mode is used when we do not have a precise idea of the goal to be achieved.
- **Backward Chaining (Inductive Reasoning):**
  - Starting from the conclusions, the inference engine tries to verify the truth of the premises.
  - If the premises exist in the fact base, then the problem is solved.
  - Otherwise, the unverified conditions become sub-goals to prove.
- **Mixed Chaining:**
  - Combine forward and backward chaining methods as needed.

CHAINING METHODS

Consider the following Knowledge Base:

Rule 1: If the person has a diploma

And the person has experience

Then the person meets all the conditions required by the company.

Rule 2: If the person meets all the conditions required by the company

And the company offers a job

Then the person is recruited.

Rule 3: If the company offers a job

Then there is a budgeted position.

Rule 4: If the person is recruited

Then the person receives a salary

And the person is not unemployed.

Consider the following Data Base:

The company offers a job

The person has a diploma

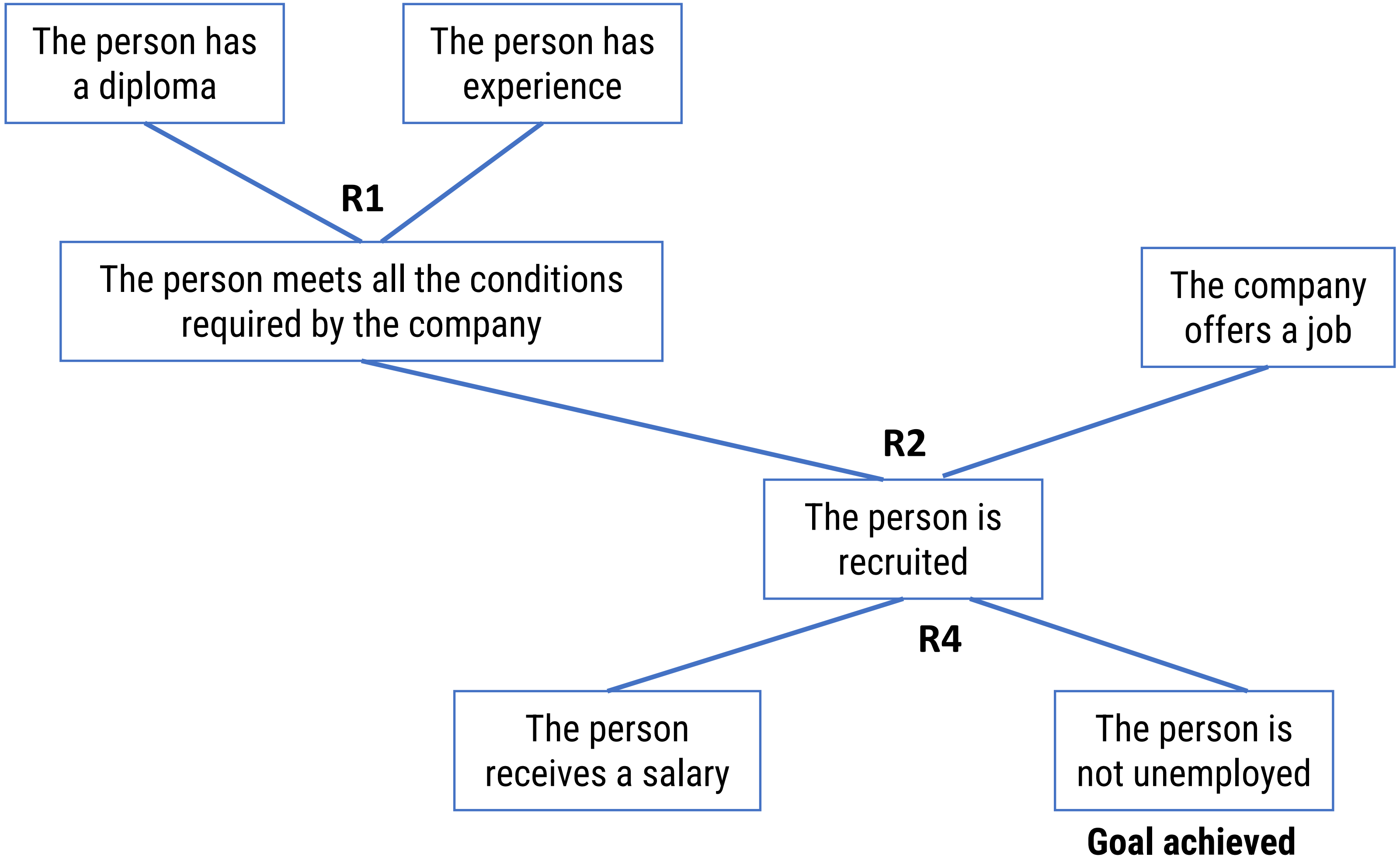
The person has experience

Goal: The person is not unemployed **?**

CHAINING METHODS

Example: Forward chaining (From the facts, the inference engine deduces all possible facts)

Question: Is the person not unemployed?


The person has a diploma
The person has experience
R1
The person meets all the conditions required by the company
The company offers a job
R2
The person is recruited
R4
The person receives a salary
The person is not unemployed
Goal achieved

FB:

The company offers a job

The person has a diploma

The person has experience

KB:

Rule 1: If the person has a diploma

And the person has experience

Then the person meets all the conditions required by the company.

Rule 2: If the person meets all the conditions required by the company

And the company offers a job

Then the person is recruited.

Rule 3: If the company offers a job

Then there is a budgeted position.

Rule 4: If the person is recruited

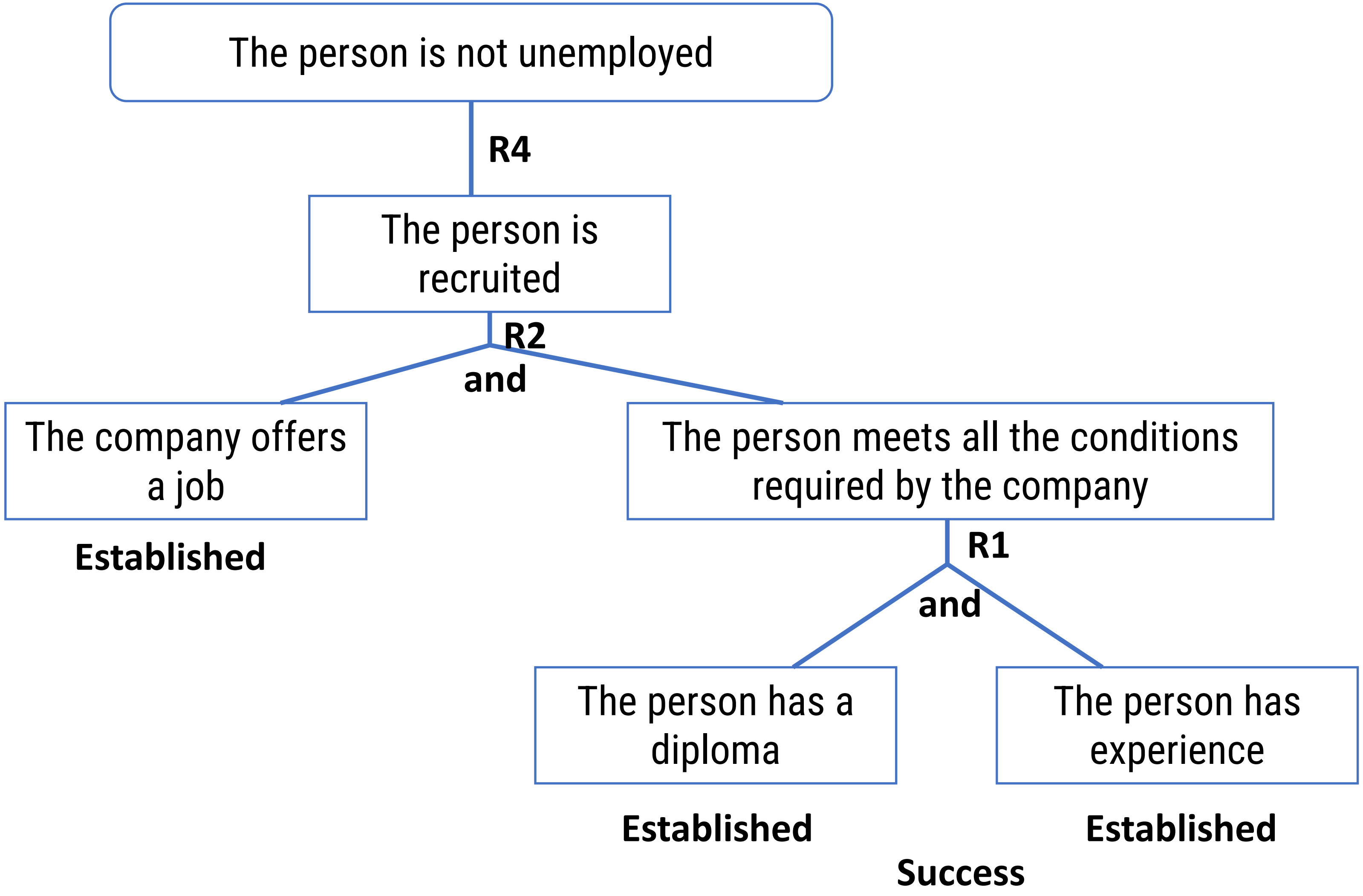
Then the person receives a salary

And the person is not unemployed.

CHAINING METHODS

Example : Backward chaining (The inference engine tries to verify a goal)

Goal: The person is not unemployed**?**



The person is not unemployed

R4

The person is recruited

R2

and

The company offers a job

Established

The person meets all the conditions required by the company

R1

and

The person has a diploma

Established

The person has experience

Established

Success

<u>FB:</u>

The company offers a job

The person has a diploma

The person has experience

<u>KB:</u>

Rule 1: If the person has a diploma
And the person has experience
Then the person meets all the conditions required by the company.

Rule 2: If the person meets all the conditions required by the company
And the company offers a job
Then the person is recruited.

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Then there is a budgeted position.

Rule 4: If the person is recruited
Then the person receives a salary
And the person is not unemployed.

CHAINING METHODS

Exercise: Deduce the goal X using a forward chainng and then a backward chainng:

KB:

R1 : R,F,N → D
R2 : F,G → A
R3 : S,D → A
R4 : R → L
R5 : F → N
R6 : A,L → X
R7 : S → F
R8 : L,S → A

FB:

R,S

Goal: X ?

Conflict resolution criterion: Retain the first rule appearing

CHAINING METHODS

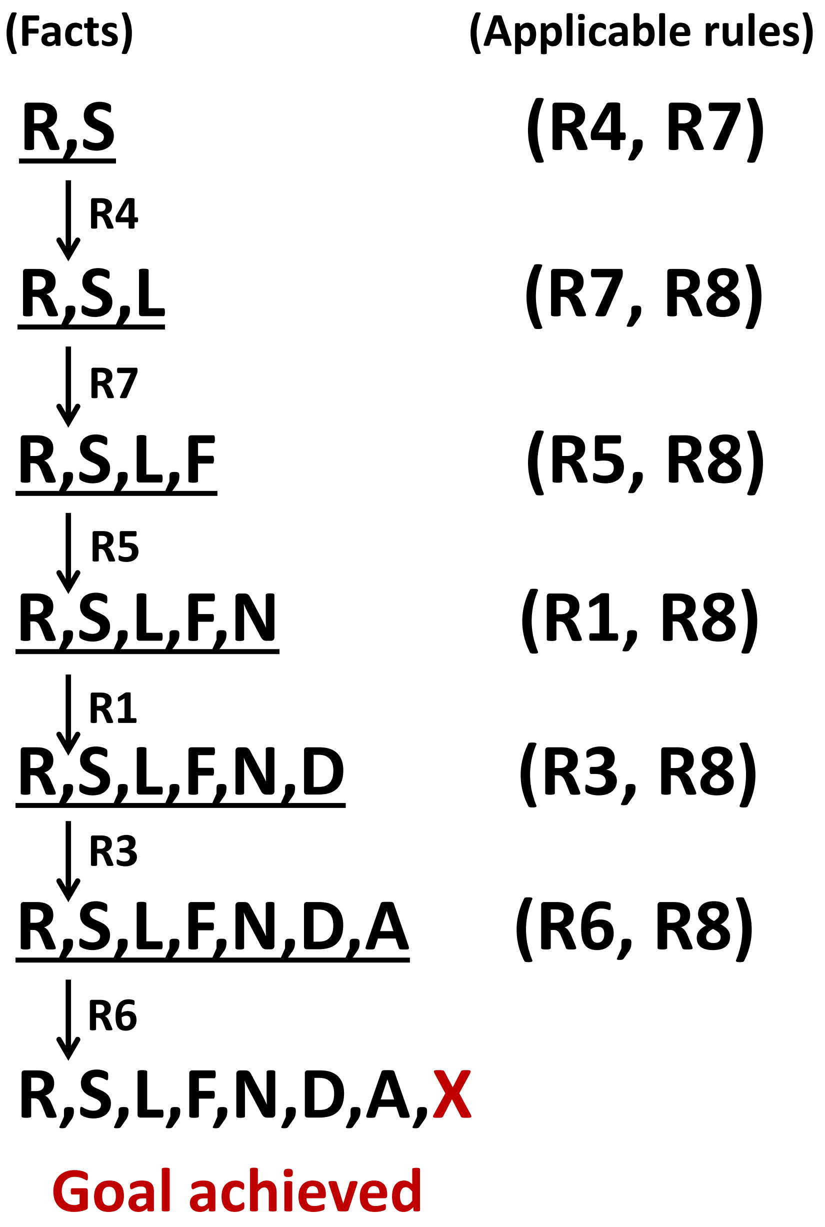
Forward chaining: Deduce X?

Rules:

R1 : R,F,N → D
R2 : F,G → A
R3 : S,D → A
R4 : R → L
R5 : F → N
R6 : A,L → X
R7 : S → F
R8 : L,S → A

Facts:

R,S



(Facts)	(Applicable rules)
R,S	**(R4, R7)**
↓ R4	
R,S,L	**(R7, R8)**
↓ R7	
R,S,L,F	**(R5, R8)**
↓ R5	
R,S,L,F,N	**(R1, R8)**
↓ R1	
R,S,L,F,N,D	**(R3, R8)**
↓ R3	
R,S,L,F,N,D,A	**(R6, R8)**
↓ R6	
R,S,L,F,N,D,A,X	

Goal achieved

CHAINING METHODS

Backward chaining: Prove X?

Rules:

R1 : R,F,N → D

R2 : F,G → A

R3 : S,D → A

R4 : R → L

R5 : F → N

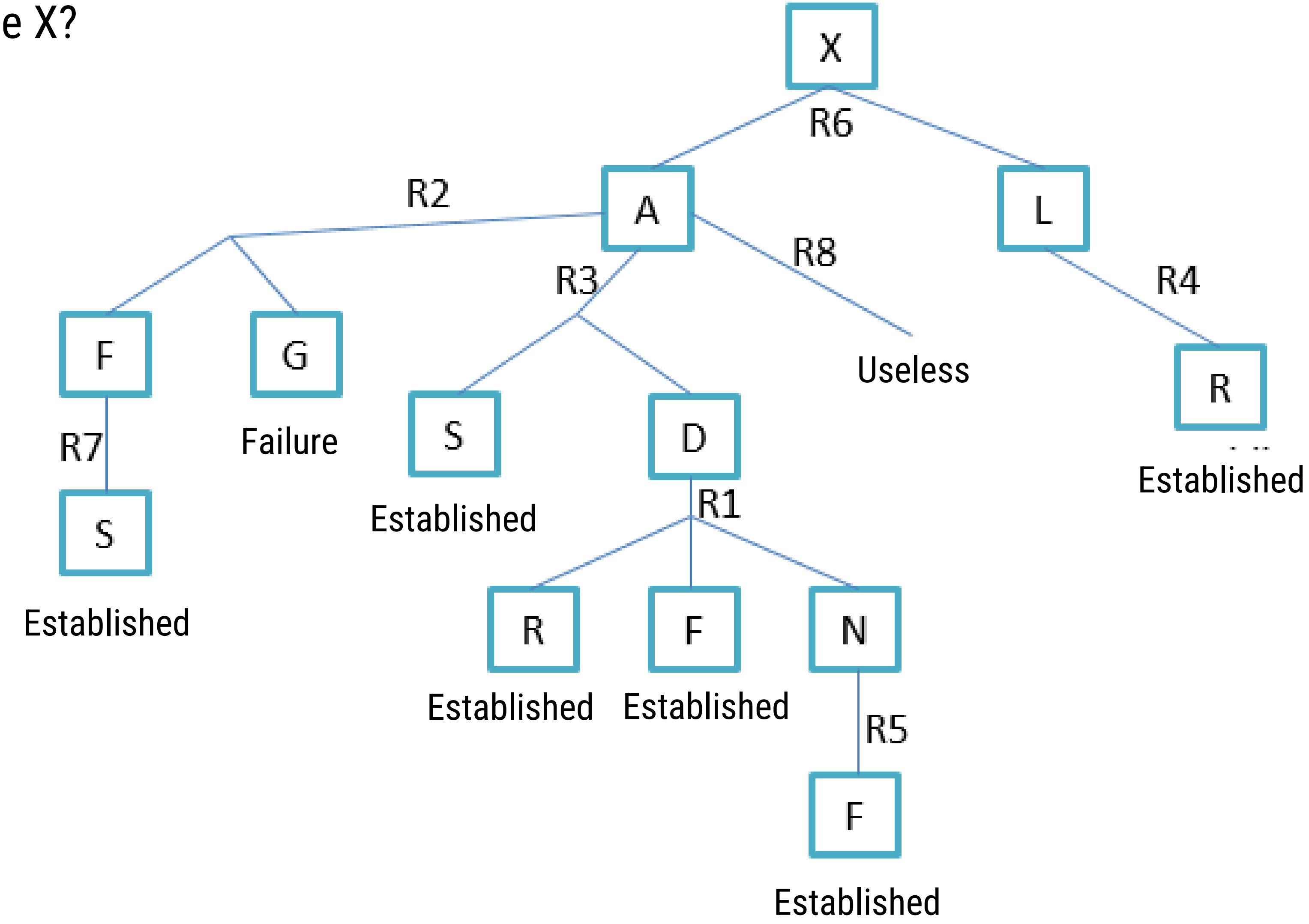
R6 : A,L → X

R7 : S → F

R8 : L,S → A

Facts:

R,S



CHAINING METHODS

Prove H using forward and backword chaining?:

- Rule base

R1. B and D and E → F
R2. D and G → A
R3. C and F → A
R4. C → D
R5. D → E
R6. A → H
R7. B → X
R8. X and C → A

- Fact base

– B: True
– C: True
– H ?

Conflict resolution criterion: Retain the first rule appearing

Graph Pathfinding vs Rule-base ES

Pathfinding in a graph	Functioning of a rule-based expert system
Node	Fact
Arc	Rule
Network	Rule base
Node queue	Fact base
Starting	Hypothesis (fact to prove)
Destination	Conclusion
Vehicle	Inference engine
Identify accessible nodes	Select applicable rules
Reach a node	Apply a rule

EXPERT SYSTEMS: EXAMPLES

❑ DENDRAL

- Developed by Feigenbaum in 1965.
- Written in LISP.
- Objective: To identify a chemical structure from chemical, physical, and spectrometric measurement results.

Principle: Deduce from measurement results (all possible information)

- ○ Ask the user if any information is missing
- ○ Synthesize and conclude

Disadvantages: Programmed in a classical manner (difficult to maintain) No possibility of explanation

EXPERT SYSTEMS: EXAMPLES

❑ MYCIN

- Developed at Stanford in 1974.
- Written in LISP.
- Objective: Diagnosis and treatment of certain blood diseases (infections).

MYCIN represents its knowledge in the form of IF-THEN rules.

Example of rule:

IF the infection is primary-bacteremia

AND the site of the culture is one of the sterile sites

AND the suspected portal of entry is the gastrointestinal tract

THEN there is suggestive evidence (0.7) that infection is bacteroid.

- MYCIN Goal-driven system (backward chaining)
- New versions of MYCIN were subsequently developed: EMYCIN, NEOMYCIN