

Knowledge Management

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IT 383
Knowledge Management

Lecture 6



Knowledge Engineering Inference

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Inference



What is inference?

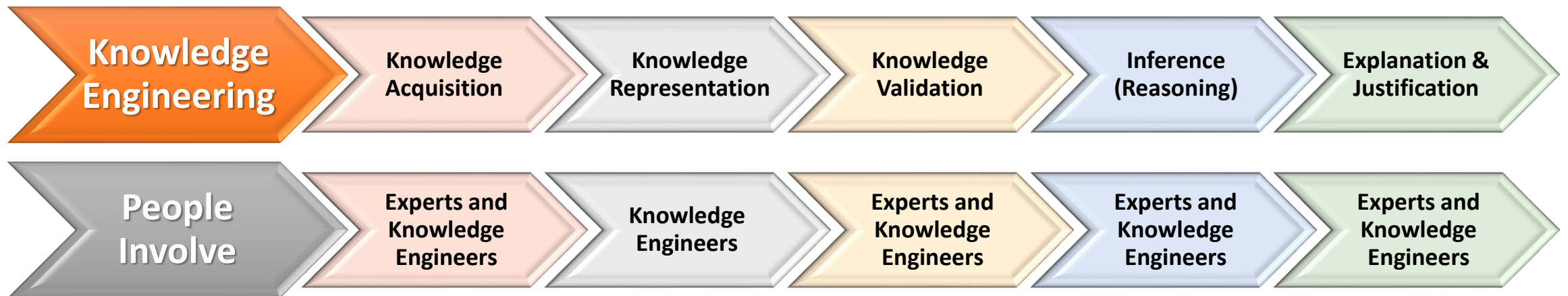
Inferencing is the process of using the rules in knowledge base along with the known facts to draw conclusions. Inferencing requires a logic embedded in the computer program to access the stored knowledge and executes the inferencing rules, this program is called Inference Engine.

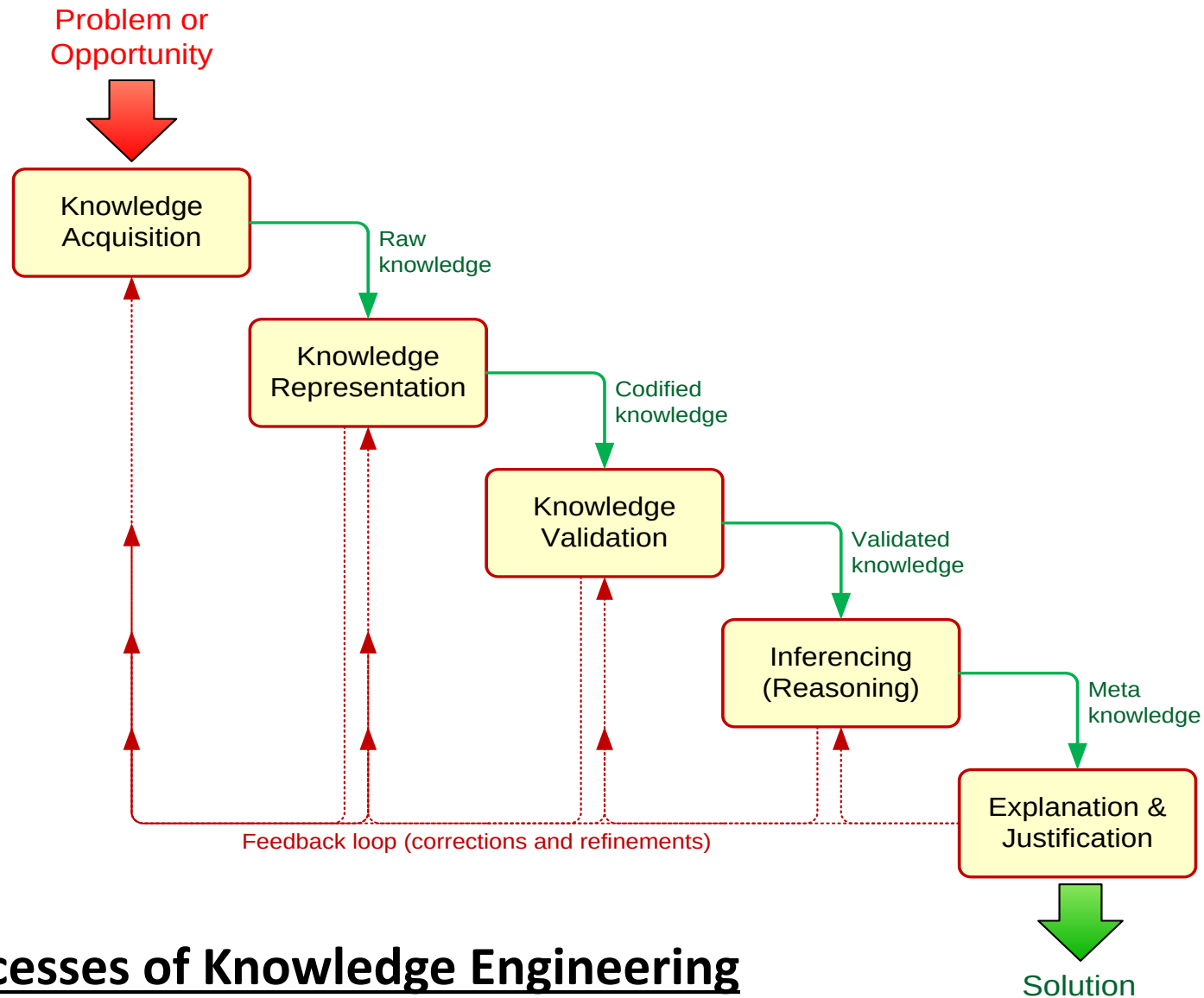
Lecture Objectives

- 
- **Understanding Inference.**
 - **Identify the difference between forward and backward chain.**
 - **Understanding inference with Certainty and Uncertainty.**

➤ **What is knowledge Engineering?**

A set of intensive activities involved in building, maintaining and using knowledge-based systems.





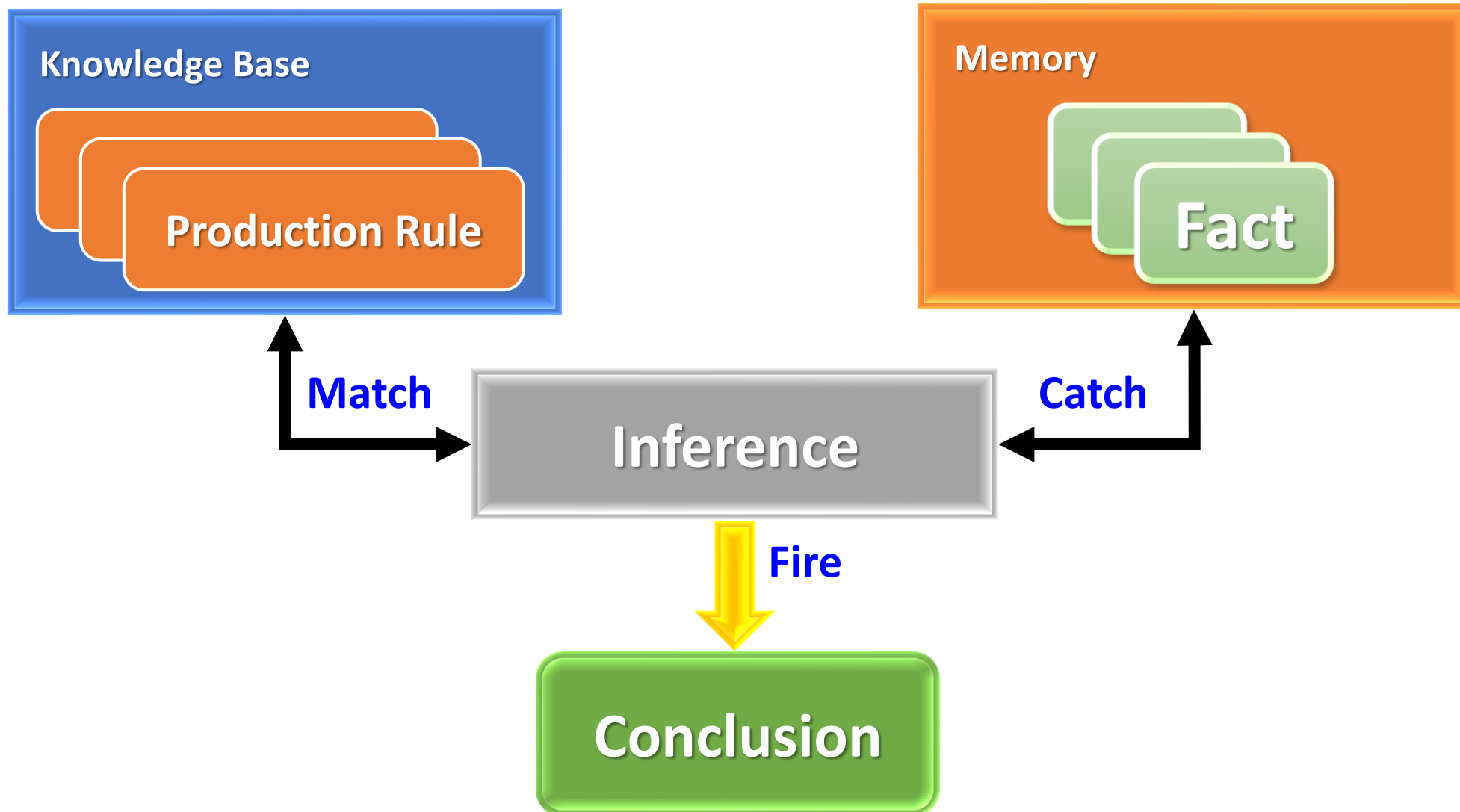
➤ What is inference?

Inferencing is the process of using the rules in knowledge base along with the known facts to draw conclusions. Inferencing requires a logic embedded in the computer program to access the stored knowledge and executes the inferencing rules, this program is called Inference Engine.

➤ The inference engine checks every rule in the knowledge base to identify those that can be fired based on the collection of known facts and keep doing so until the goal is achieved.

➤ The most popular mechanisms for rule-based system are forward and backward chain.

Inference



➤ **Forward chain:**

A data-driven approach, starting from available information (facts) then trying to draw conclusions .

➤ **Backward chain:**

A goal-driven approach, starting from the expectation of what is going to happen then seeking evidence that support that expectation.

➤ Example:

➤ Here we discuss an example involving an investment decision about whether to invest in IBM stock. The following variables are used:

A = Have \$10,000.

B = Younger than 30 years old.

C = Education at college level.

D = Annual income of at least \$40,000.

E = Invest in securities.

F = Invest in growth stocks.

G = Invest in IBM stock (**the potential goal**)

Each of these variables can be answered as true (yes) or false (no).

- We assume that an investor has \$10,000 (i.e., that A is true) and that he is 25 years old (i.e., that B is true). He would like advice on investing in IBM stock (yes or no for the goal).

Our knowledge base includes the following five rules:

- R1:** IF a person has \$10,000 to invest and he has a college degree, THEN he should invest in securities.
- R2:** IF a person's annual income is at least \$40,000 and he has a college degree, THEN he should invest in growth stocks.
- R3:** IF a person is younger than 30 and he is investing in securities, THEN he should invest in growth stocks.
- R4:** IF a person is younger than 30, THEN he has a college degree.
- R5:** IF a person wants to invest in a growth stock, THEN the stock should be IBM.

➤ These rules can be written as follows:

R1: IF A and C, **THEN** E.

R2: IF D and C, **THEN** F.

R3: IF B and E, **THEN** F.

R4: IF B, **THEN** C.

R5: IF F, **THEN** G.

Forward Chain

➤ Using Forward chain:

Forward Chaining starting with known facts and derive new facts by using rules having known facts on the IF side. This is what we do:

➤ **Step 1:** Because it is known that A and B are true, the Inference system starts deriving new facts by using rules that have A and B on the IF side. Using R4, the Inference system derives a new fact C and adds it to the assertion base as true.

➤ **Step 2:** R1 fires (because A and C are true) and asserts E as true in the assertion base.

A is True, B is True

R1: IF A and C, THEN E.

R2: IF D and C, THEN F.

R3: IF B and E, THEN F.

R4: IF B, THEN C.

R5: IF F, THEN G.

Forward Chain

- **Step 3:** Because B and E are both known to be true, R3 fires and establishes F as true.

- **Step 4:** R5 fires (because F is on its IF side), which establishes G as true. So the Inference engine recommends an investment in IBM stock. If there is more than one conclusion, more rules may fire, depending on the inferencing procedure.

A is True, B is True

R1: IF A and C, THEN E.

R2: IF D and C, THEN F.

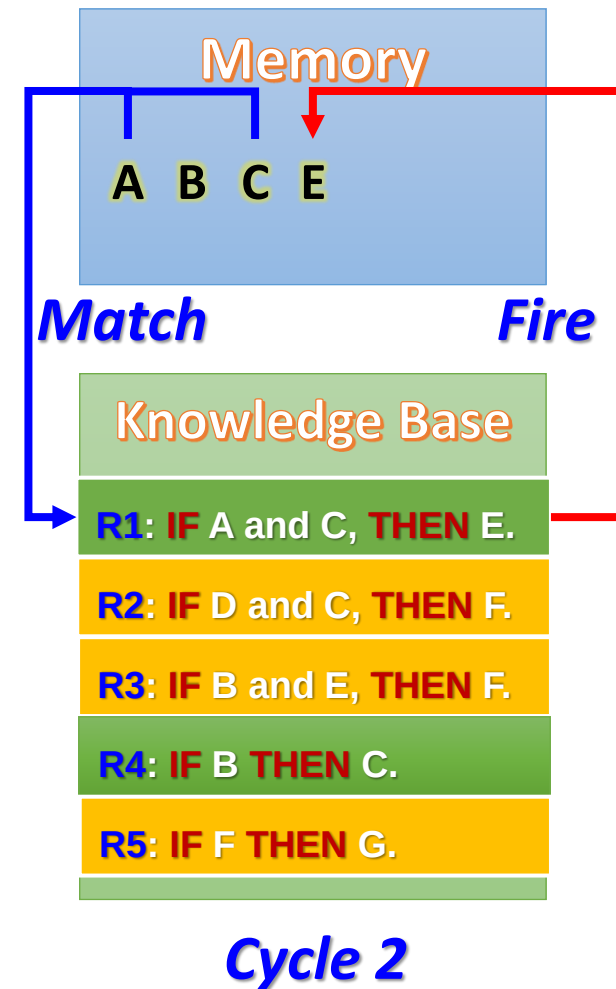
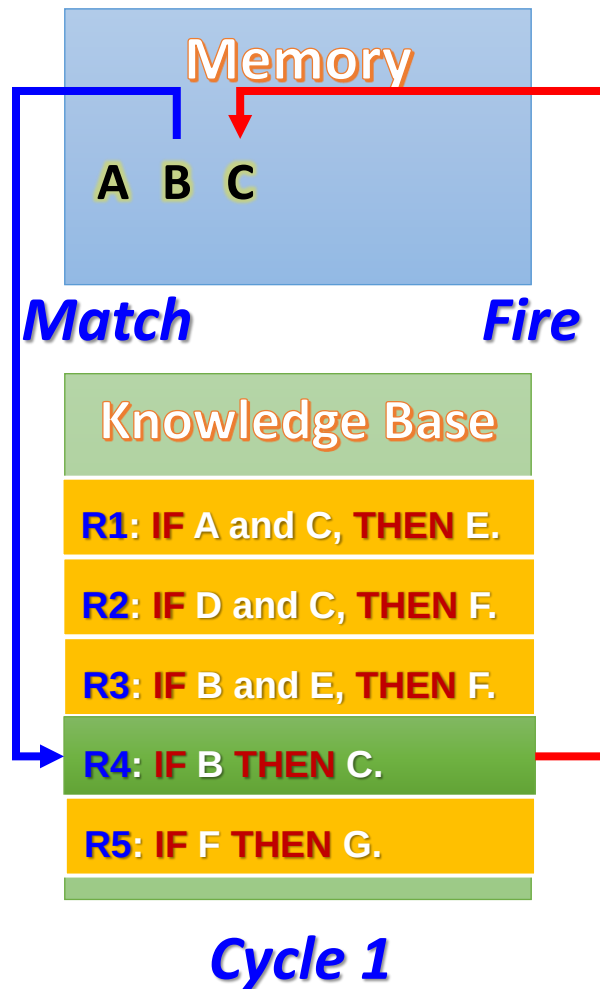
R3: IF B and E, THEN F.

R4: IF B, THEN C.

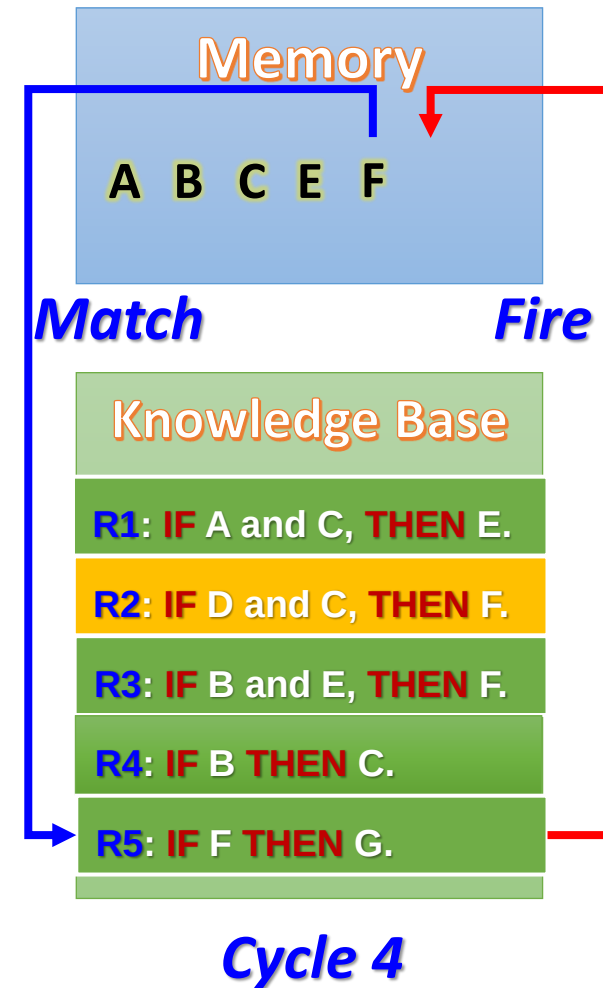
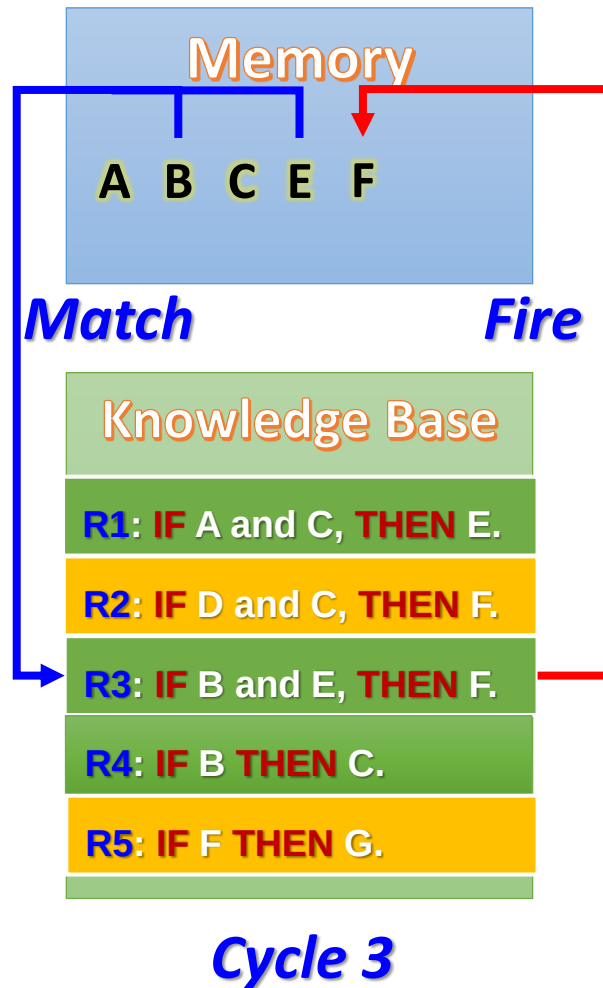
R5: IF F, THEN G.

Forward Chain

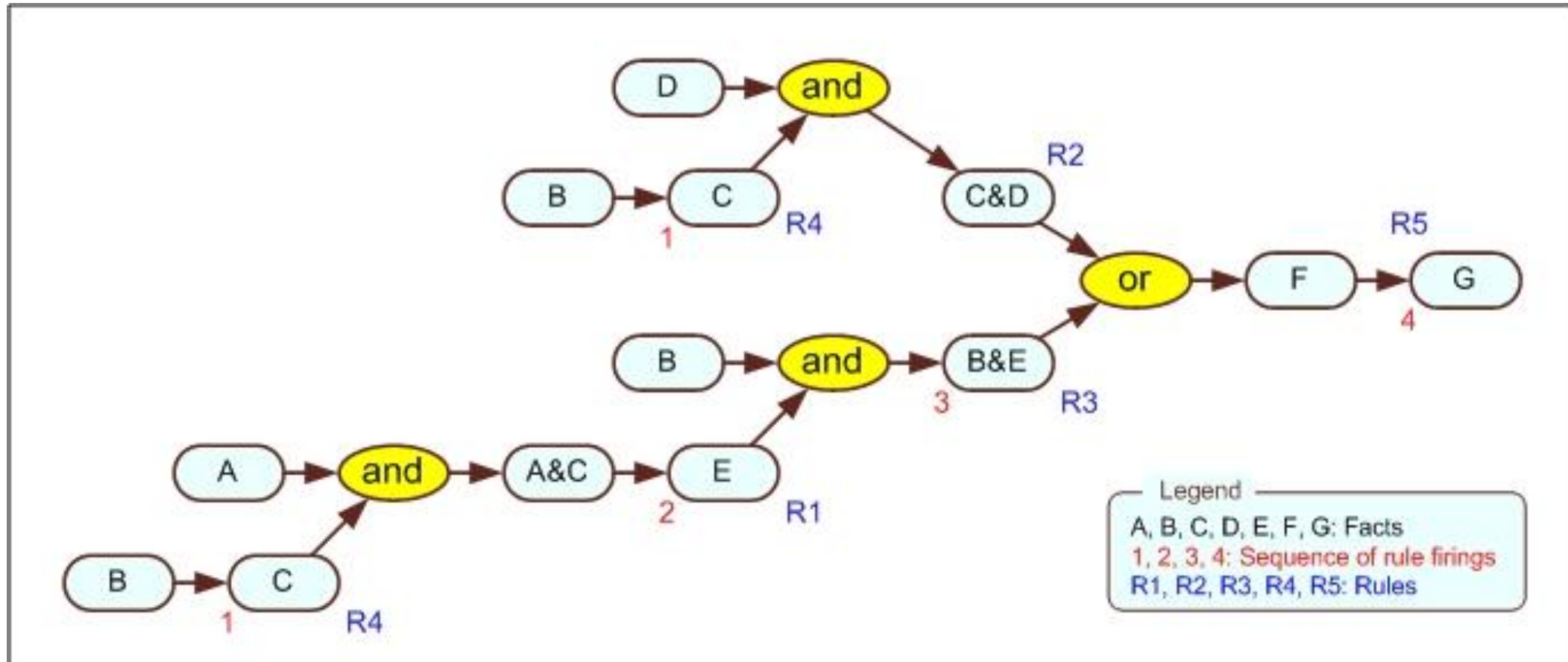
➤ Using Forward chain:



Forward Chain



Forward Chain



Forward chaining

Backward Chain

➤ Using Backward chain:

Backward Chaining Our goal is to determine whether to invest in IBM stock. With backward chaining, we start by looking for a rule that includes the goal (G) in its conclusion (THEN) part. Because **R5** is the only one that qualifies, we start with it. If several rules contain G, then the inference engine dictates a procedure for handling the situation. This is what we do:

➤ **Step 1:** Try to accept or reject G. The Inference engine goes to the assertion base to see whether G is there. At present, all we have in the assertion base is A is true. B is true. Therefore, the Inference engine proceeds to step 2.

A is True, B is True

R1: IF A and C, THEN E.

R2: IF D and C, THEN F.

R3: IF B and E, THEN F.

R4: IF B, THEN C.

R5: IF F, THEN G.

Backward Chain

➤ **Step 2: R5** says that if it is true that we invest in growth stocks (F), then we should invest in IBM (G). If we can conclude that the premise of R5 is either true or false, then we have solved the problem. However, we do not know whether F is true. What shall we do now? Note that F, which is the premise of **R5**, is also the conclusion of **R2** and **R3**. Therefore, to find out whether F is true, we must check either of these two rules.

➤ **Step 3:** We try R2 first (arbitrarily); if both D and C are true, then F is true. Now we have a problem. D is not a conclusion of any rule. Inference engine abandons R2 and returns to the other rule, R3. This action is called backtracking (i.e., knowing that we are at a dead end, we try something else).

A is True, B is True

R1: IF A and C, THEN E.

R2: IF D and C, THEN F.

R3: IF B and E, THEN F.

R4: IF B, THEN C.

R5: IF F, THEN G.

Backward Chain

➤ **Step 4:** Go to **R3**; test B and E. We know that B is true because it is a given fact. To prove E, we go to **R1**, where E is the conclusion.

➤ **Step 5:** Examine **R1**. It is necessary to determine whether A and C are true. 6. A is true because it is a given fact. To test C, it is necessary to test **R4** (where C is the conclusion).

➤ **Step 6:** **R4** tells us that C is true (because B is true). Therefore, C becomes a fact (and is added to the assertion base). Now E is true, which validates F, which validates our goal (i.e., the advice is to invest in IBM).

A is True, B is True

R1: IF A and C, THEN E.

R2: IF D and C, THEN F.

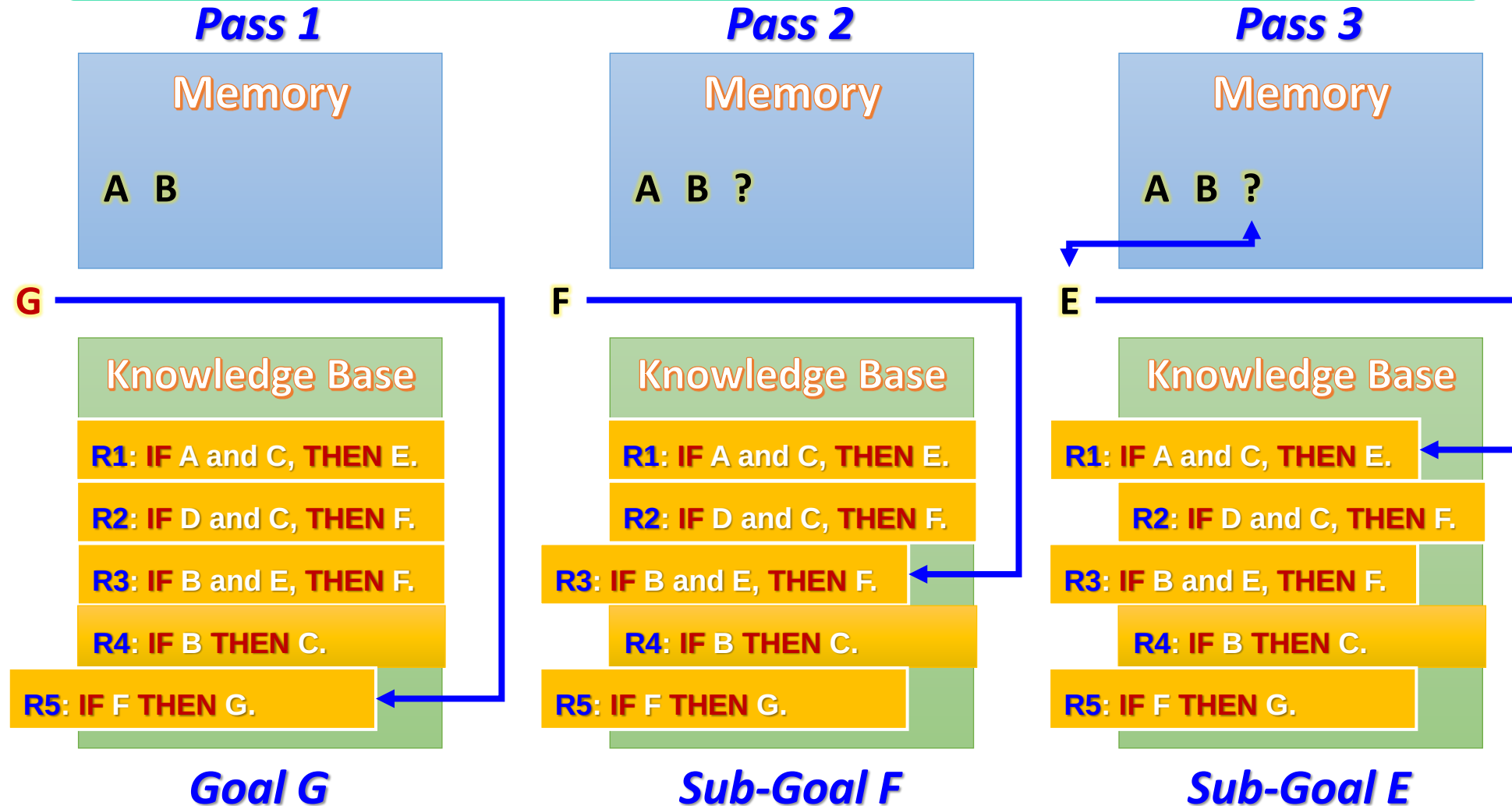
R3: IF B and E, THEN F.

R4: IF B, THEN C.

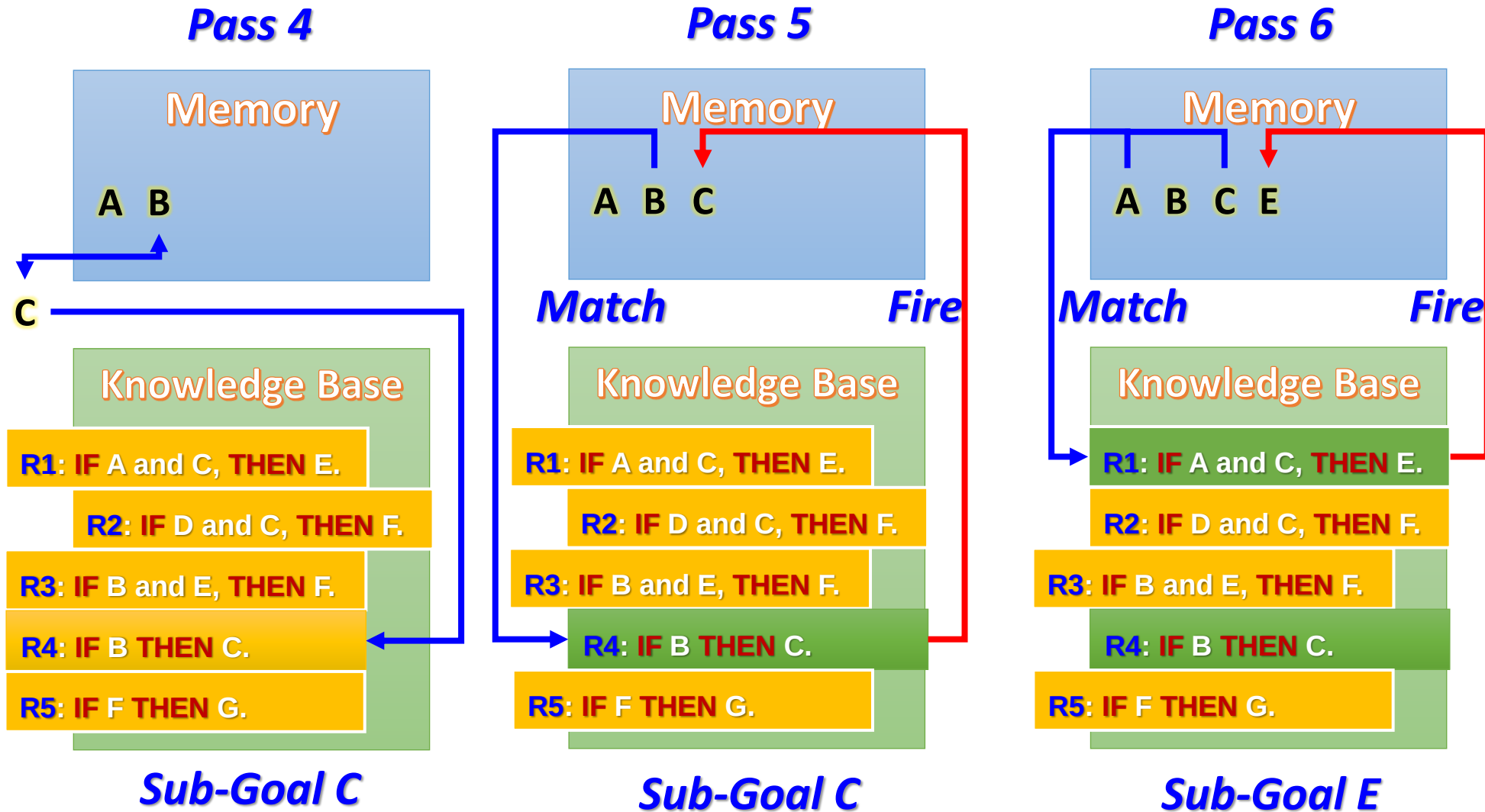
R5: IF F, THEN G.

Backward Chain

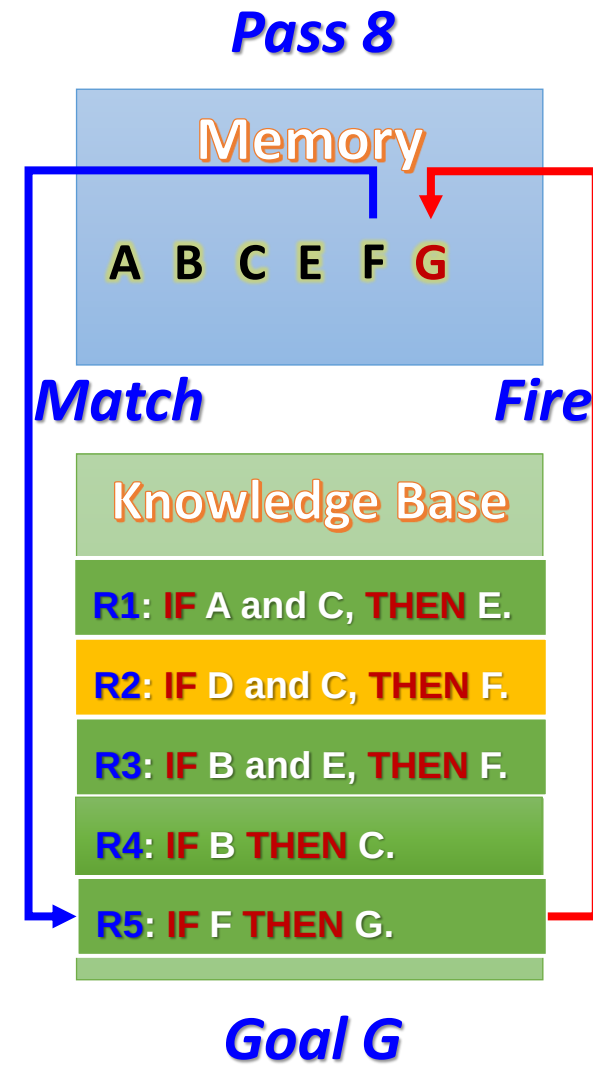
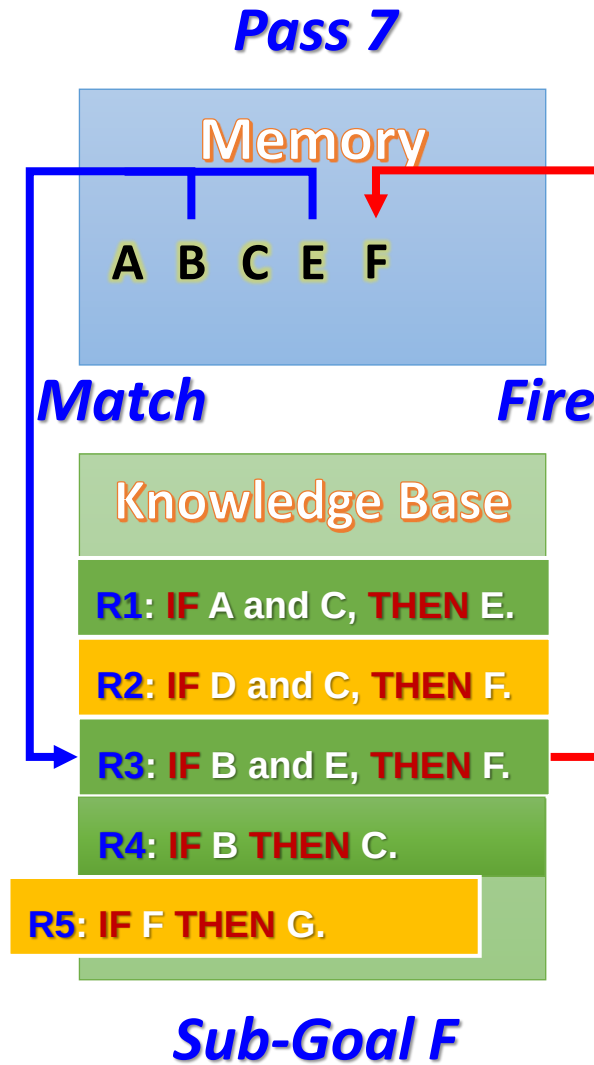
➤ Using Backward chain:



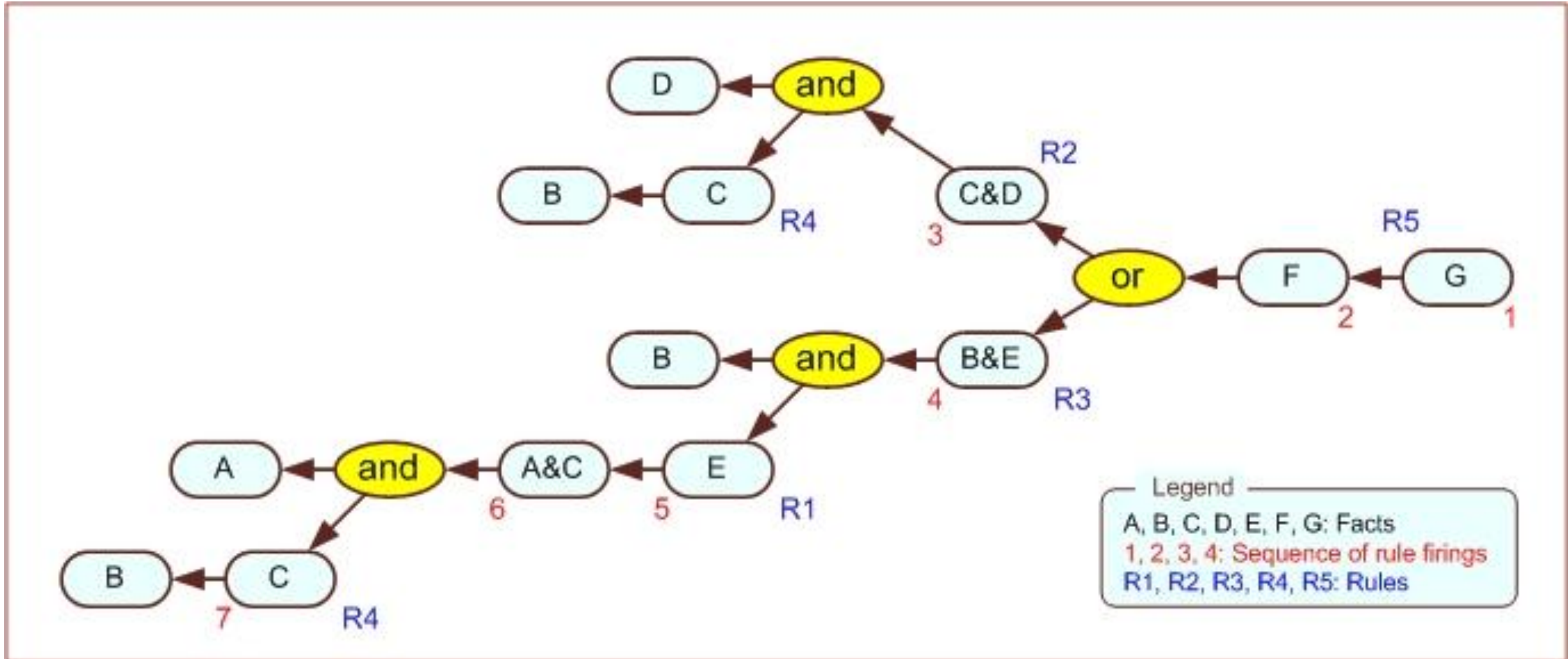
Backward Chain



Backward Chain



Backward Chain



Backward chaining

➤ **Uncertainty:**

Uncertainty is defined as the lack of the exact knowledge that would enable us to reach a perfectly reliable conclusion.

➤ **Information can be incomplete, inconsistent, uncertain, or all three. In other words, information is often unsuitable for solving a problem.**

➤ **Classical logic permits only exact reasoning.**

❖ Sources of uncertain knowledge

➤ Imprecise language:

Our natural language is ambiguous and imprecise. We describe facts with such terms as often and sometimes, frequently and hardly ever. As a result, it can be difficult to express knowledge in the precise IF-THEN form of production rules. However, if the meaning of the facts is quantified, it can be used in expert systems.

- In 1944, Ray Simpson asked 355 high school and college students to place 20 terms like often on a scale between 1 and 100. In 1968, Milton Hakel repeated this experiment.

Uncertainty

<i>Ray Simpson (1944)</i>		<i>Milton Hakel (1968)</i>	
<i>Term</i>	<i>Mean value</i>	<i>Term</i>	<i>Mean value</i>
Always	99	Always	100
Very often	88	Very often	87
Usually	85	Usually	79
Often	78	Often	74
Generally	78	Rather often	74
Frequently	73	Frequently	72
Rather often	65	Generally	72
About as often as not	50	About as often as not	50
Now and then	20	Now and then	34
Sometimes	20	Sometimes	29
Occasionally	20	Occasionally	28
Once in a while	15	Once in a while	22
Not often	13	Not often	16
Usually not	10	Usually not	16
Seldom	10	Seldom	9
Hardly ever	7	Hardly ever	8
Very seldom	6	Very seldom	7
Rarely	5	Rarely	5
Almost never	3	Almost never	2
Never	0	Never	0

➤ **Unknown data:**

When the data is incomplete or missing, the only solution is to accept the value “unknown” and proceed to an approximate reasoning with this value.

➤ **Combining the views of different experts:**

Unfortunately, experts often have contradictory opinions and produce conflicting rules. To resolve the conflict, the knowledge engineer has to attach a weight to each expert and then calculate the composite conclusion. But no systematic method exists to obtain these weights.

➤ **Weak implications:**

Domain experts and knowledge engineers have the painful task of establishing concrete correlations between IF (condition) and THEN (action) parts of the rules.

➤ **Certainty factor:**

Relies on judgmental measures of belief. Uses measure of belief (MB) and measure of disbelief (MD), **$Cf = MB - MD$** , and take on values from **-1 to 1**.

$$CF(\text{Rule}) = CF(\text{Then})/CF(\text{IF})$$

R1= IF A THEN B.

$$CF(\text{B})= CF(\text{R1}) \times CF(\text{A})$$

<i>Term</i>	<i>Certainty Factor</i>
Definitely not	-1.0
Almost certainly not	-0.8
Probably not	-0.6
Maybe not	-0.4
Unknown	-0.2 to +0.2
Maybe	+0.4
Probably	+0.6
Almost certainly	+0.8
Definitely	+1.0

Example:

R1= IF Car tires is probably old **THEN** Accident may be happened. **R1= IF A THEN B.**

A = Car tires is probably old.

B = Accident may be happened

CF(R1)= 0.7, and CF(A)= 0.6.

Find CF(B)

Answer:

$$\begin{aligned}\text{CF(B)} &= \text{CF(R1)} \times \text{CF(A)} \\ &= 0.7 \times 0.6 \\ &= 0.42\end{aligned}$$

<i>Term</i>	<i>Certainty Factor</i>
Definitely not	-1.0
Almost certainly not	-0.8
Probably not	-0.6
Maybe not	-0.4
Unknown	-0.2 to +0.2
Maybe	+0.4
Probably	+0.6
Almost certainly	+0.8
Definitely	+1.0

- Conjunction of two propositions:
It is the minimum of the CF's of the two propositions.

Example:

R1= IF A AND B THEN C.

CF(R1)= 0.5, CF(A)= 0.8, and CF(B) = 0.5.

Find CF(C)

Answer:

$$\begin{aligned}\text{CF(A and B)} &= \min(\text{CF(A)}, \text{CF(B)}) \\ &= \min(0.8, 0.5) = 0.5\end{aligned}$$

$$\begin{aligned}\text{CF(C)} &= \text{CF(R1)} \times \text{CF(A and B)} = 0.5 * 0.5 \\ &= 0.25\end{aligned}$$

➤ Disjunction of two propositions:

It is the maximum of the CF's of the two propositions.

Example:

R1= IF A OR B THEN C.

CF(R1)= 0.7, CF(A)= 0.6, and CF(B) = 0.5.

Find CF(C)

Answer:

CF(A or B)= max(CF(A) , CF(B))

= max(0.6 , 0.5) = 0.6

CF(C) = CF(R1) X CF(A or B) = 0.7 * 0.6

= 0.42

➤ Combining Two or More Rules:

When we have a knowledge-based system with several interrelated rules, each of which intakes the same conclusion but with a different certainly factor, each rule can be viewed as a piece of evidence that supports the joint conclusion. To calculate the certainty factor (or the confidence) of the conclusion, it is necessary to combine the evidence.

R1: IF the inflation rate is less than 5 percent,
THEN stock market prices go up

R1= IF A THEN C.

R2: IF he unemployment level is less than 7 percent,
THEN stock market prices go up

R2= IF B THEN C.

$CF_{combine}(R1,R2) = CF(R1) + CF(R2) [1 - CF(R1)]$ if $CF(R1), CF(R2) > 0$

$CF_{combine}(R1,R2) = CF(R1) + CF(R2) [1 + CF(R1)]$ if $CF(R1), CF(R2) < 0$

$CF_{combine}(R1,R2) = CF(R1) + CF(R2) / 1 - \min(|CF(R1)|, |CF(R2)|)$ Otherwise

Example:

R1= IF A THEN C. $CF(R1)=0.7$

R2= IF B THEN C. $CF(R2)= 0.6$

Answer:

$$CF_{\text{combine}}(R1,R2)= CF (R1) + CF (R2) [1 - CF (R1)]$$

$$\begin{aligned} CF_{\text{combine}}(R1,R2) &= 0.7+ 0.6[1 - 0.7] \\ &= 0.7 +0.6 - [(0.7) \times (0.6)] = 0.88 \end{aligned}$$

If we add another rule:

R3: IF bond price increases, THEN stock prices go up $CF(R3) = 0.85$

R3= IF D THEN C

$$\begin{aligned} CF(R1, R2, R3) &= CF(R1, R2) + CF(R3) \times [1 - CF(R1, R2)] \\ &= CF(R1, R2) + CF(R3) - (CF(R1, R2) \times CF(R3)) \\ &= 0.88 + 0.85 - [(0.88) \times (0.85)] = 0.982 \end{aligned}$$

Summary

- **Understanding Inference.**
- **Understanding the difference between forward and backward chain.**
- **Understanding inference with Certainty and Uncertainty.**



Thank You