SSN College of Engineering, Kalavakkam

Department of Computer Science and Engineering

IV Semester – B.E (CSE)

R2024

UCS3461 - Foundations of Artificial Intelligence (TCP-Lab)

Academic Year: 2025-2026 Even **Batch: 2024-2028**

Exercise 5: Propositional Logic: Inference by Forward Chaining (Bottom-up) Method (CO3, K4, PIs: 1.3.1,1.4.1,2.1.3,12.3.2)

Given Facts and Rules

Let **A_1, A_2, B_1, C_1, D_1, D_2, and E_1** be the propositional symbols. The knowledge base consists of the following rules and facts:

R1: A_1
R2: A_2
R3: $A_2 \rightarrow D_1$
R4: $D_1 \rightarrow B_1$
R5: $B_1 \wedge A_2 \rightarrow C_1$
R6: $A_1 \wedge B_1 \rightarrow D_2$
R7: $D_2 \rightarrow E_1$

Query: E_1

Using the above rules and facts, prove whether the query **E_1** can be derived from the knowledge base using the **Forward Chaining algorithm**.

Implement a class named **ForwardChainingProver** with the following methods:

- __init__(self) – Initialize facts and rules
- add_fact(self, fact: str) – Add a fact
- add_rule(self, premises: list, conclusion: str) – Add a rule
- forward_chain(self, facts: list, rules: list, query: str) – Apply forward chaining to prove the query

Represent the facts using a set to prevent duplication. Represent each rule as a list of premises with a single conclusion. Clearly display each inference step during execution and finally indicate whether the query is logically entailed by the Knowledge Base or not. Note that Forward Chaining operates only on Horn clauses.

Expected Output:
Initial Facts: {A1, A2}

Step 1:
Rule Applied: A2 → D1
New Fact Inferred: D1

Current Facts: {A1, A2, D1}

Step 2:
Rule Applied: D1 → B1
New Fact Inferred: B1
Current Facts: {A1, A2, D1, B1}

Step 3:
Rule Applied: B1 ∧ A2 → C1
New Fact Inferred: C1
Current Facts: {A1, A2, D1, B1, C1}

Step 4:
Rule Applied: A1 ∧ B1 → D2
New Fact Inferred: D2
Current Facts: {A1, A2, D1, B1, C1, D2}

Step 5:
Rule Applied: D2 → E1
New Fact Inferred: E1
Current Facts: {A1, A2, D1, B1, C1, D2, E1}

Query E1 is TRUE. E1 is entailed by the Knowledge Base.

Another example KB: Let A_1, A_2, B_1, B_2, C_1, D_1, D_2, E_1, F_1, and G_1 be propositional symbols. The knowledge base consists of the following facts and rules:
R1: A_1
R2: A_2
R3: $A_1 \wedge A_2 \rightarrow B_1$
R4: $B_1 \rightarrow C_1$
R5: $C_1 \wedge A_2 \rightarrow D_1$
R6: $D_1 \rightarrow E_1$
R7: $E_1 \wedge B_1 \rightarrow F_1$
R8: $F_1 \rightarrow G_1$
R9: $A_1 \rightarrow B_2$
R10: $B_2 \wedge G_1 \rightarrow D_2$
Query
D_2

Draw the AND-OR Graph showing how conclusion is derived. Analyse the time complexity in terms of number of rules (R) and number of facts (F).

Additional Question: Solve the above problem using Backward Chaining Algorithm.