

Production System

Introduction

- A production system (or production rule system) is a computer program typically used to provide some form of artificial intelligence

Introduction

A production system is defined by:

- **The set of productions rules** (often simply called productions)
 - A production is a condition-action pair and defines a single chunk of problem solving knowledge
 - The condition part of the rule is a pattern that determines when that rule may be applied to a problem instance
 - The action part defines the associated problem-solving step

A production system is defined by:

- **Working memory**

- Contains a description of the current state of the world in a reasoning process
- This description is a pattern that is matched against the condition part of the production to select appropriate problem-solving actions
- When the condition element of a rule is matched by the contents of the working memory, the action associated with that condition may be performed
- The actions of production rules are specifically designed to alter the contents of working memory

A production system is defined by:

- **A Control System**

- The control system then chooses which applicable rule should be applied and ceases computation when a termination condition on the database is satisfied
- If multiple rules are to fire at the same time, the control system resolves the conflicts

Control/Search Strategies

How to decide which rule to apply while searching for a solution for any problem?

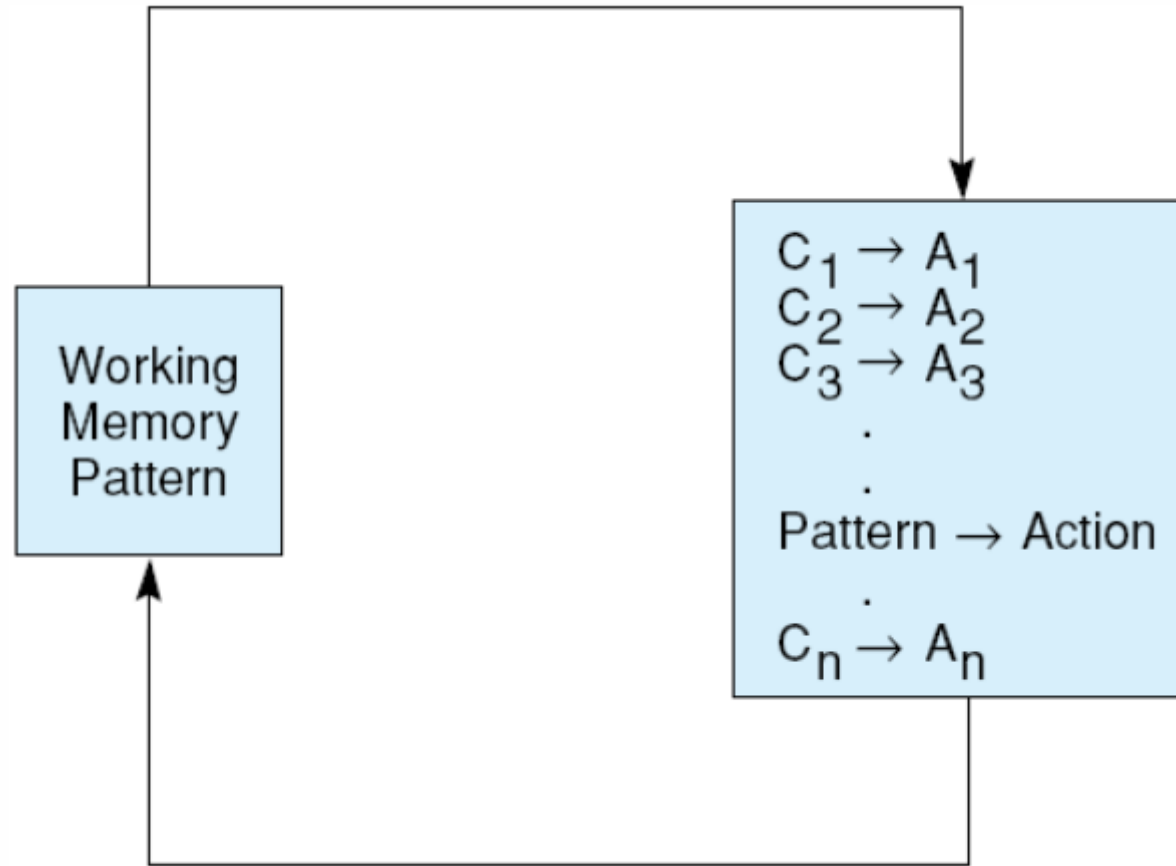
Requirement for a good control strategy:

- It should **cause motion**
- It should be **systematic**
- It must be **efficient** in order to find a good answer

Features of a Production System

- **Simplicity:** Due to the use of the IF-THEN structure, each sentence is unique in the production system. This uniqueness makes the knowledge representation simple to enhance the readability of the production rules
- **Modularity:** The knowledge available is coded in discrete pieces by the production system, which makes it easy to add, modify, or delete the information without any side effects
- **Modifiability:** This feature allows for the modification of the production rules. The rules are first defined in the skeletal form and then modified to suit an application
- **Knowledge-intensive:** As the name suggests, the system only stores knowledge. All the rules are written in the English language

A production system. Control loops until working memory pattern no longer matches the conditions of any productions



Example of Production System in Artificial Intelligence

Example-1: 8-Puzzle as a production system

Start state:

2	8	3
1	6	4
7		5

Goal state:

1	2	3
8		4
7	6	5

Production set:

Condition	Action
goal state in working memory	→ halt
blank is not on the left edge	→ move the blank left
blank is not on the top edge	→ move the blank up
blank is not on the right edge	→ move the blank right
blank is not on the bottom edge	→ move the blank down

Working memory is the present board state and goal state.

Control regime:

1. Try each production in order.
2. Do not allow loops.
3. Stop when goal is found.

Example-2

Problem:

- We have two jugs of capacity 5l and 3l (liter), and a tap with an endless supply of water. The objective is to obtain 4 liters exactly in the 5-liter jug with the minimum steps possible

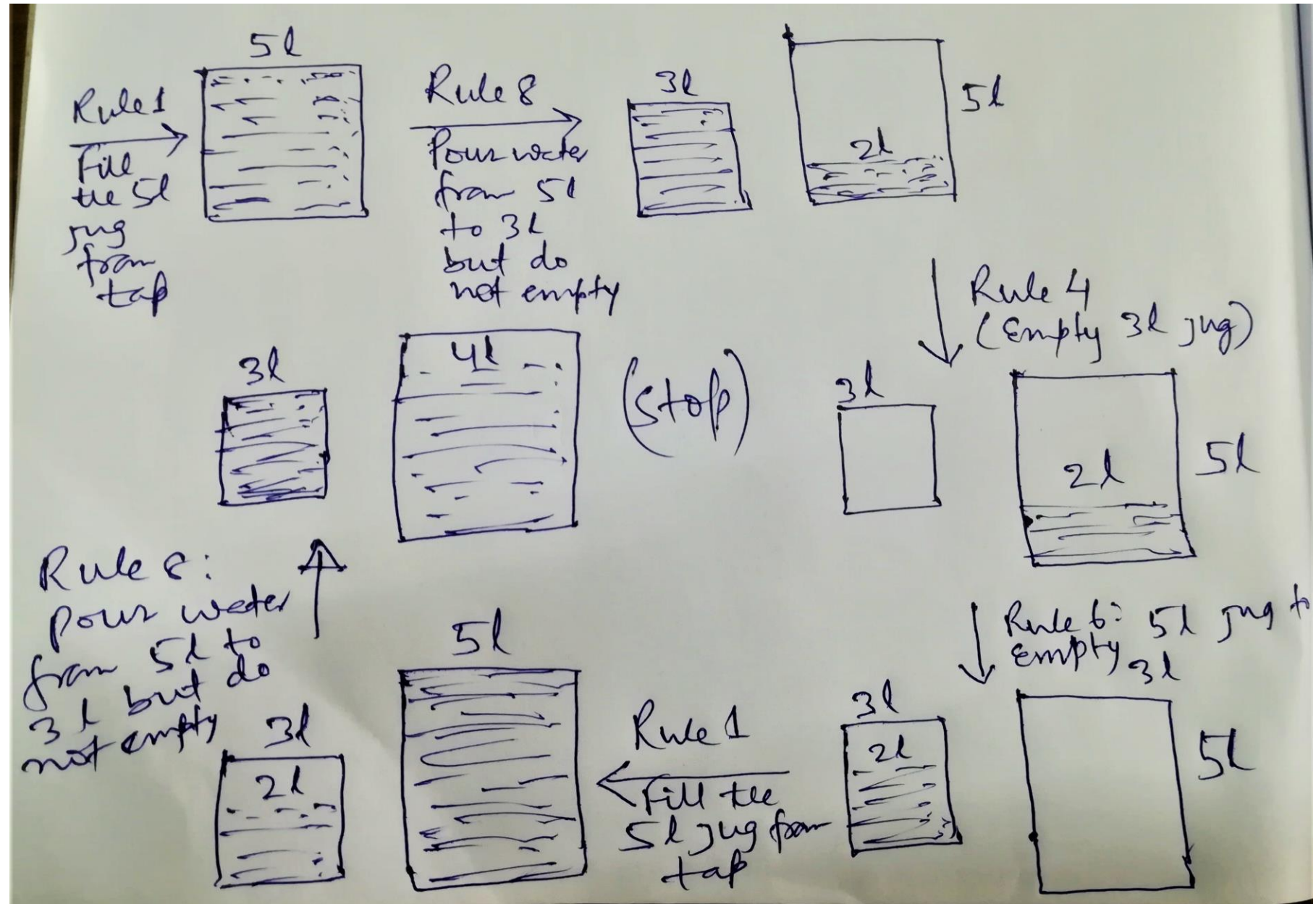
Production System

Rules:

1. Fill the 5 liter jug from tap
2. Empty the 5 liter jug
3. Fill the 3 liter jug from tap
4. Empty the 3 liter jug
5. Then, empty the 3 liter jug to 5 liter
6. Empty the 5 liter jug to 3 liter
7. Pour water from 3 liters to 5 liter
8. Pour water from 5 liters to 3 liters but do not empty

Solution-1:

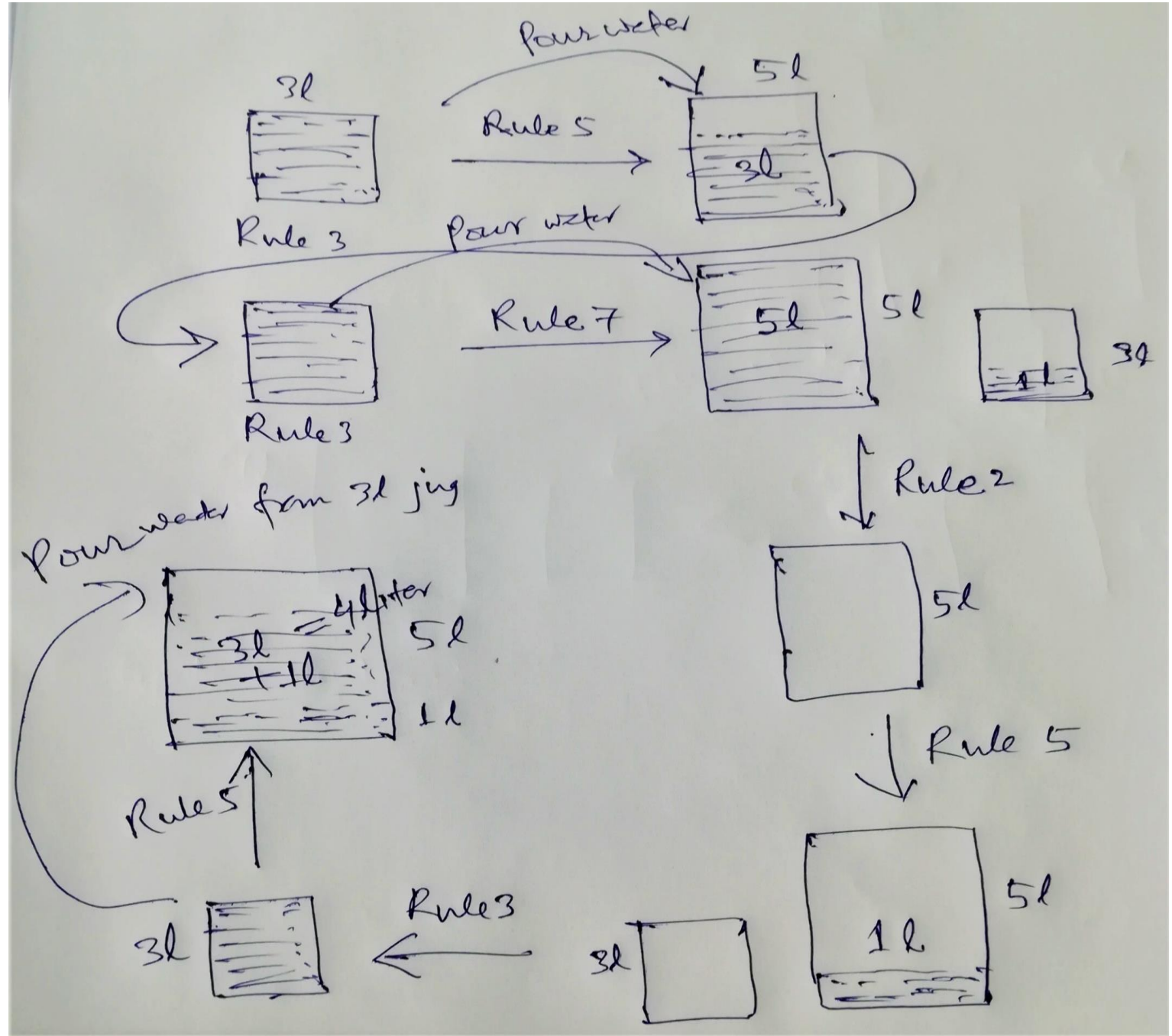
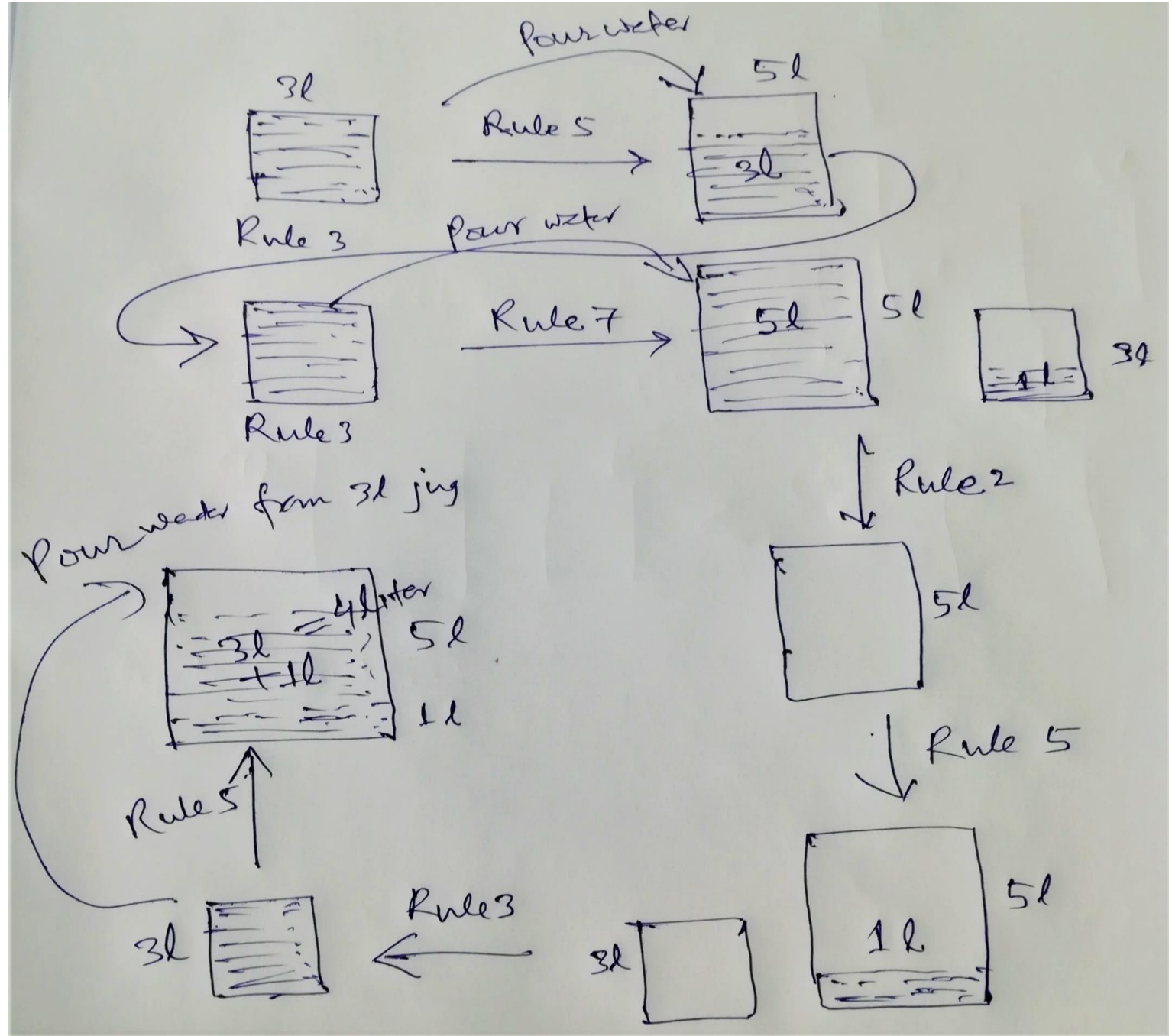
The sequence
1, 8, 4, 6, 1, 8



Solution-2:

The sequence 3, 5, 3,
7, 2, 5, 3, 5

Note: It is possible to have other solutions as well, but these are the shortest and the first sequence should be chosen as it has the minimum number of steps



Types of production system

- **Monotonic Production System:** In a monotonic production system, the use of one rule never prevents the involvement of another rule when both the rules are selected at the same time. Hence, it enables the system to apply rules simultaneously
- **Partially Commutative Production System:** In this production system if a set of rules is used to change state A to state B then any allowable combination of these rules will also produce the same results (convert state A to state B)

Types of production system

- **Non-Monotonic Production System:** This production system increases the problem-solving efficiency of the machine by not keeping a record of the changes made in the previous search process. These types of production systems are useful from an implementation point of view as they do not backtrack to the previous state when it is found that an incorrect path was followed
- **Commutative Production System:** These type of production systems is used when the order of operation is not important, and the changes are reversible. It is both monotonic and partially commutative

Advantages of production systems

- Separation of Knowledge and Control
- A Natural Mapping onto State Space Search
- Modularity of Production Rules
- Pattern-Directed Control
- Opportunities for Heuristic Control of Search
- Language Independence
- A Plausible Model of Human Problem-Solving

Drawbacks of production systems

- It is very **difficult** to analyze the flow of control within a production system
- There is an **absence of learning** due to a rule-based production system that does not store the result of the problem for future use