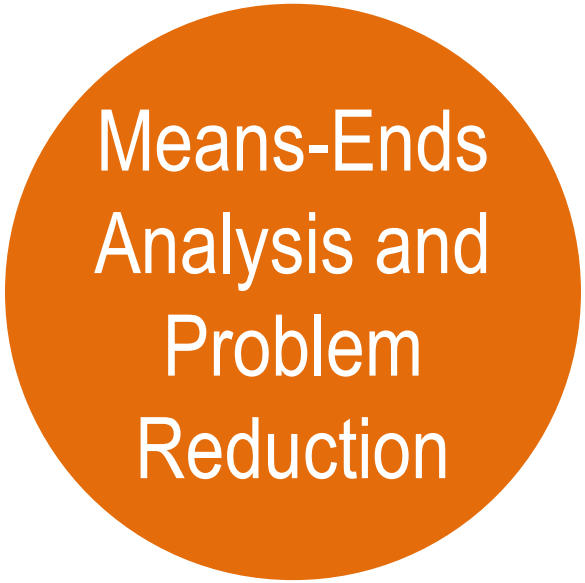
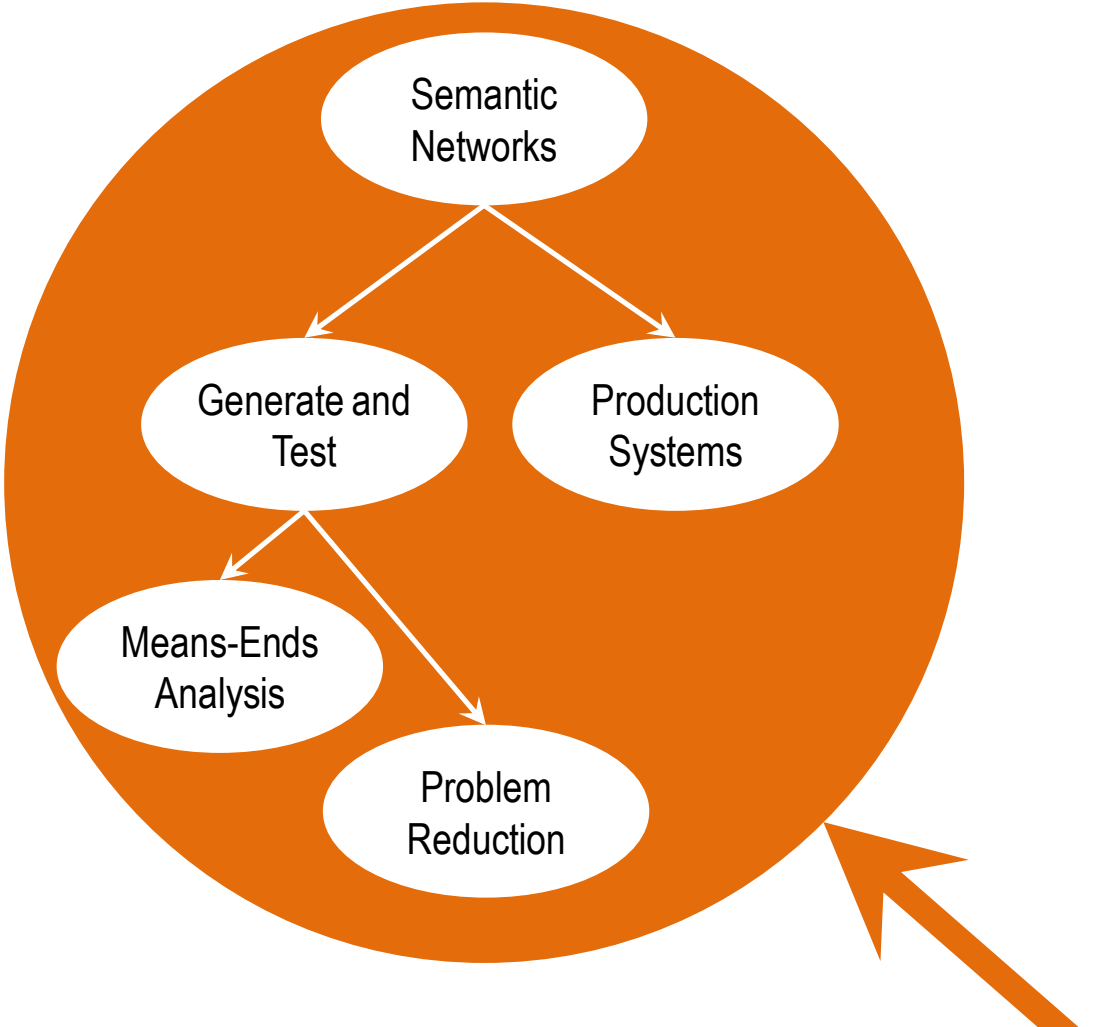

Means-Ends
Analysis and
Problem
Reduction

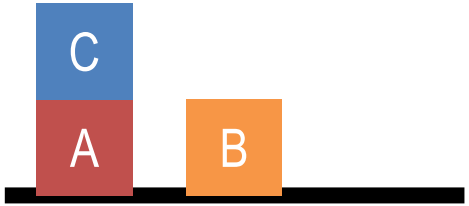
Fundamentals



Lesson Preview

- State spaces
- Means-ends analysis
- Problem solving with means-ends analysis
- Problem reduction

Initial State



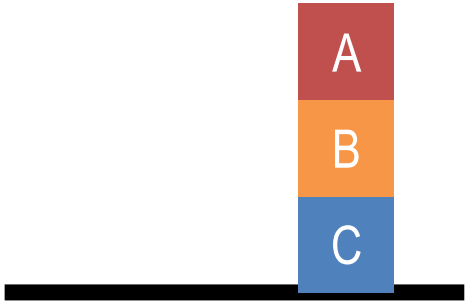
A on Table
B on Table
C on A

Move the blocks from the initial state to the goal state while obeying these rules:

1. You may only move one block at a time.

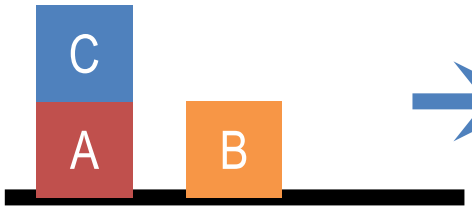
2. You may only move blocks that have nothing on top of them.

Goal State



A on B
B on C
C on Table

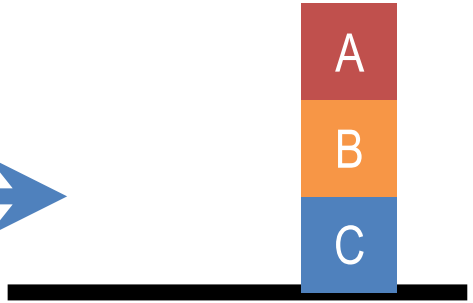
Initial State



A on Table
B on Table
C on A

Move(C, Table)
Move(B, C)
Move(A, B)

Goal State



A on B
B on C
C on Table

Available Operators:

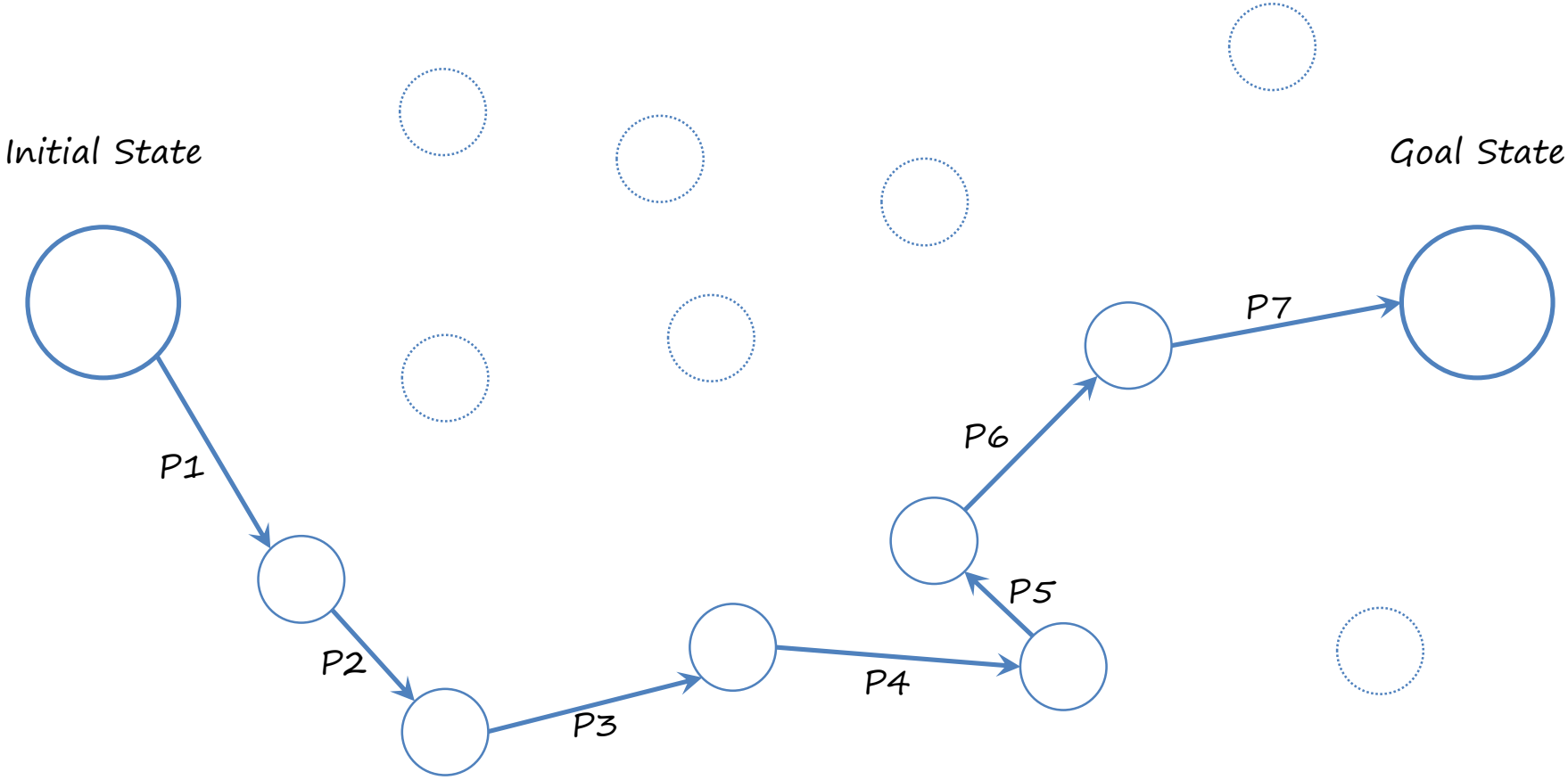
Move(Object, Location)

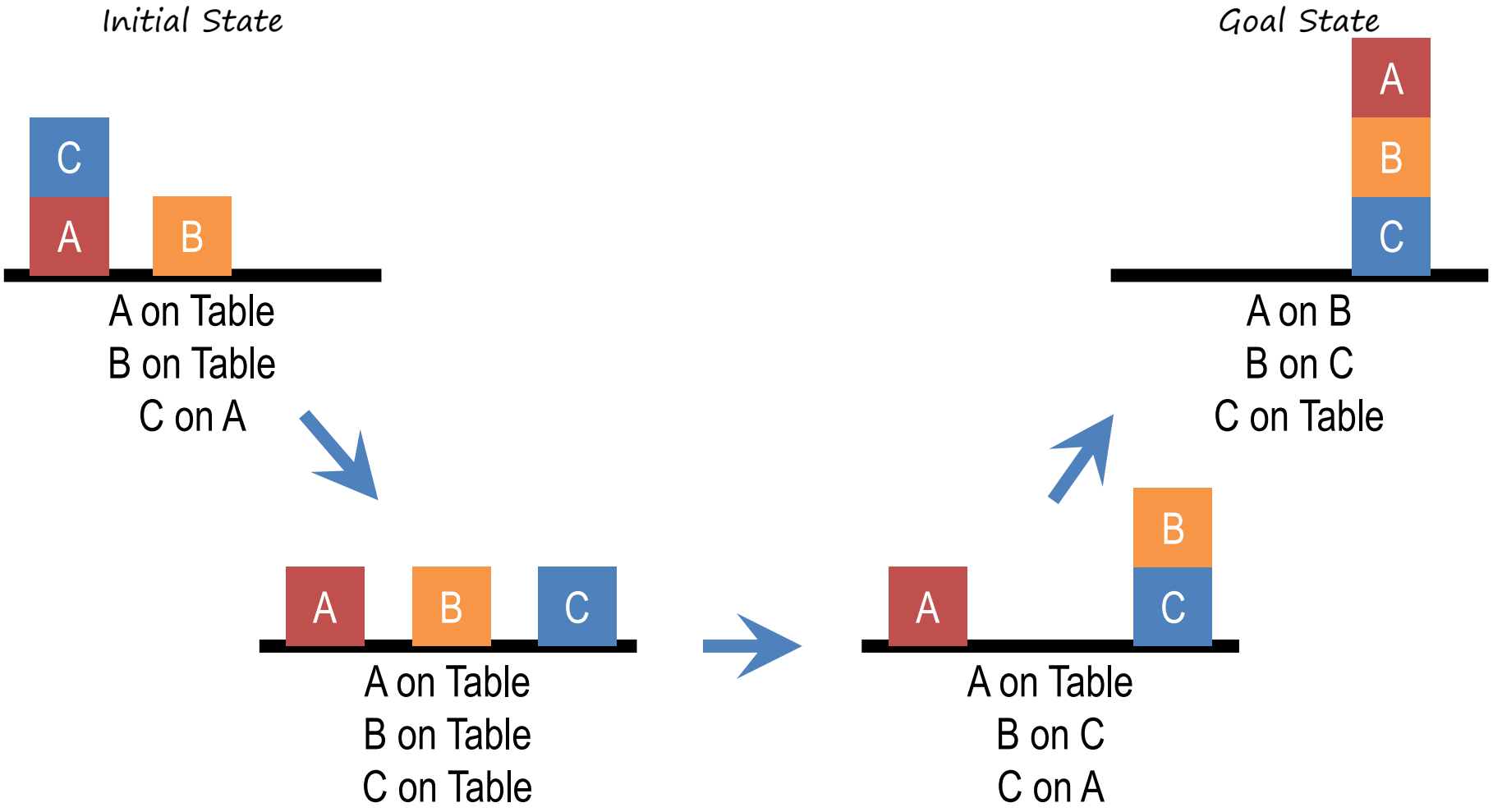
e.g.:

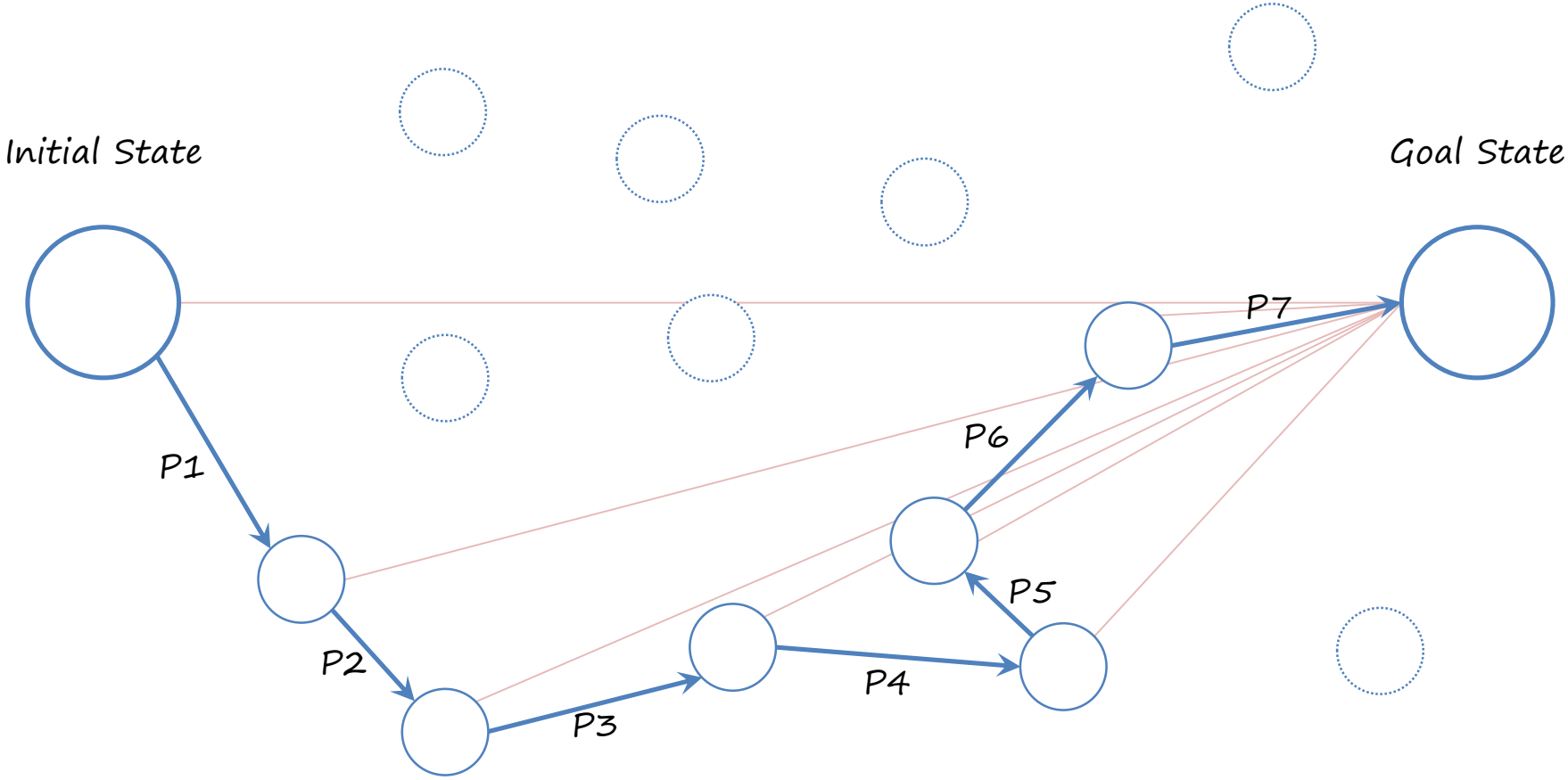
Move(C, Table)
moves C onto the table

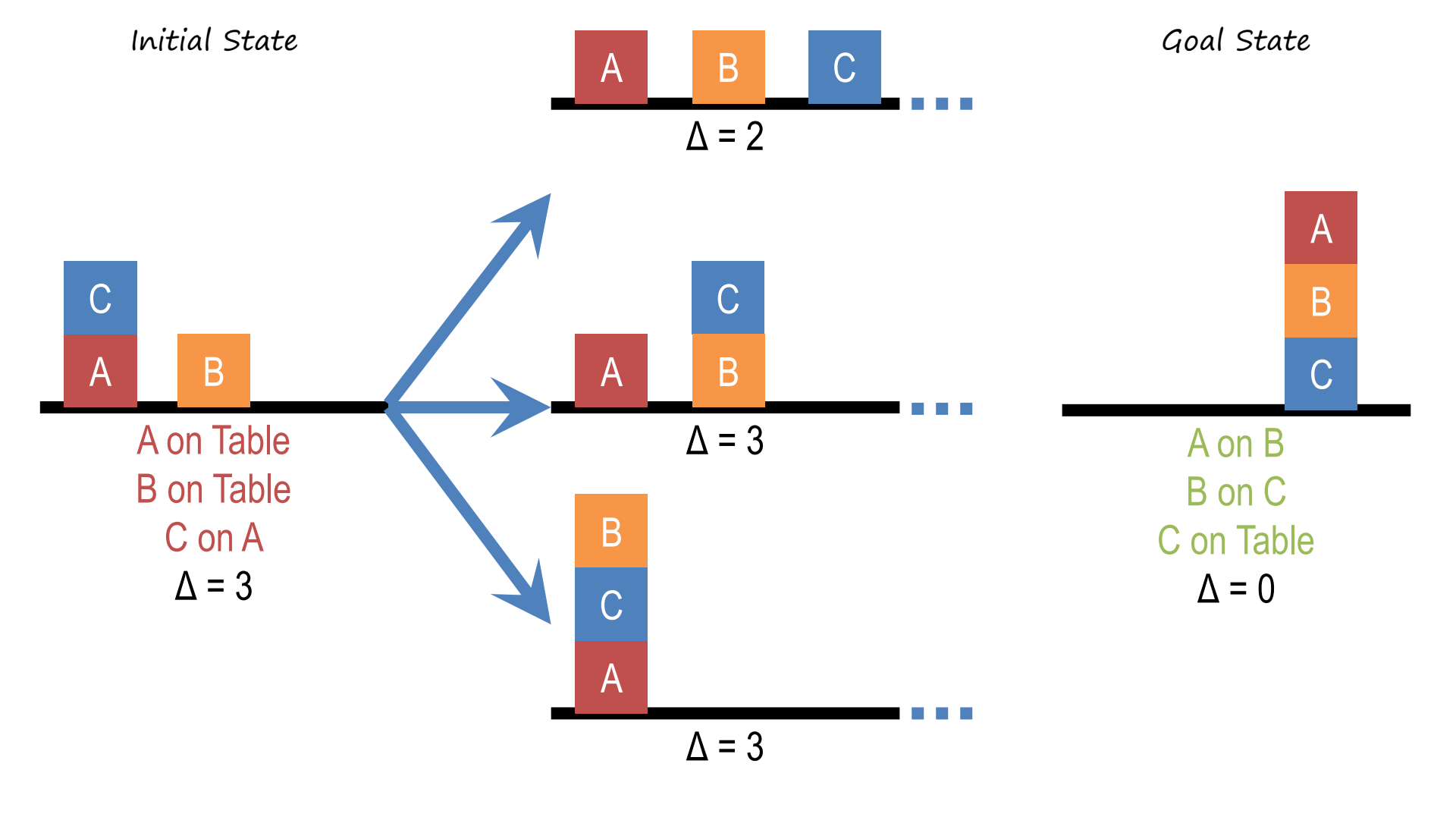
Move(C, B)
moves C onto B

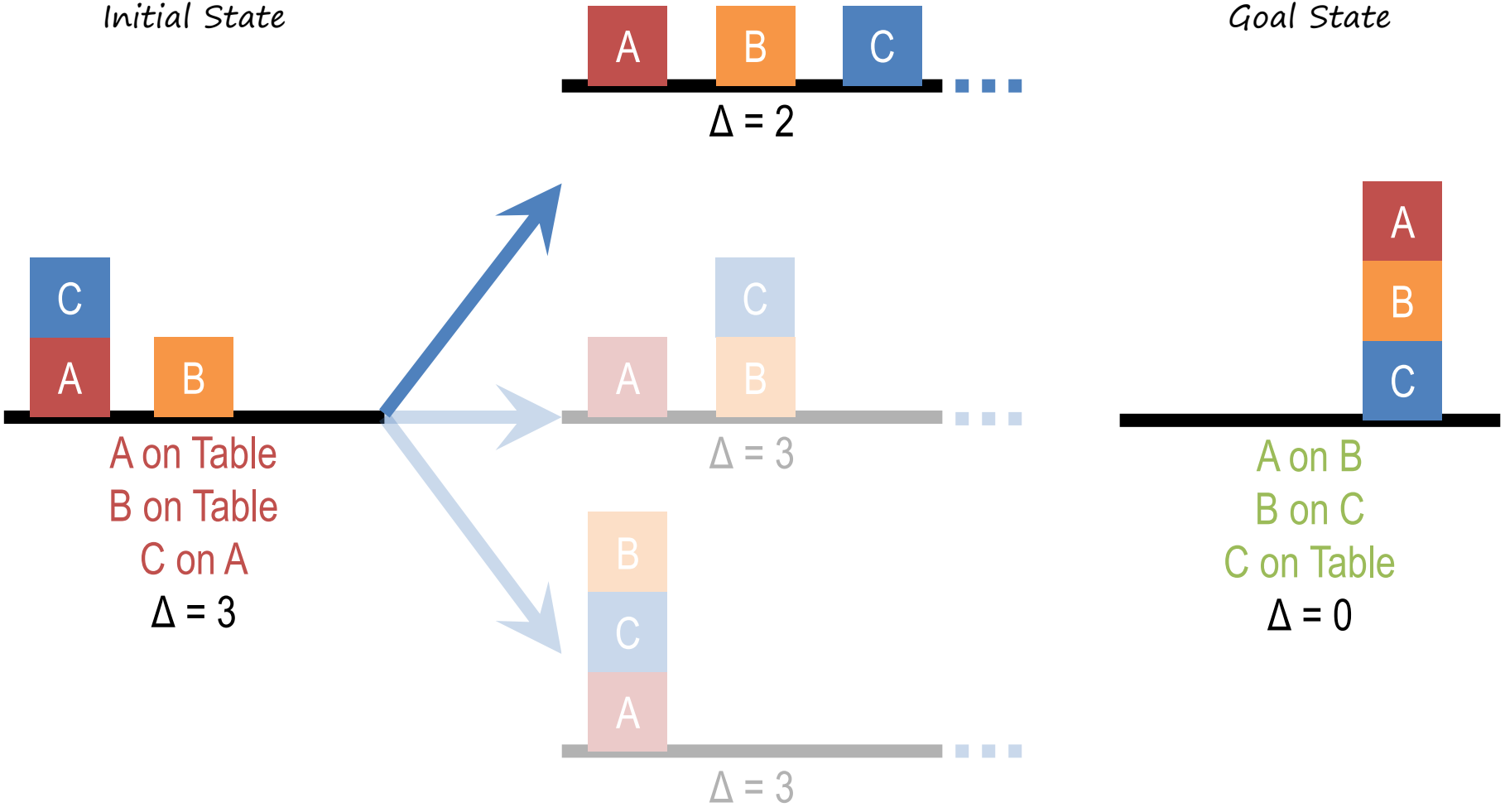
Write a list of operators that will move the blocks into the goal state.

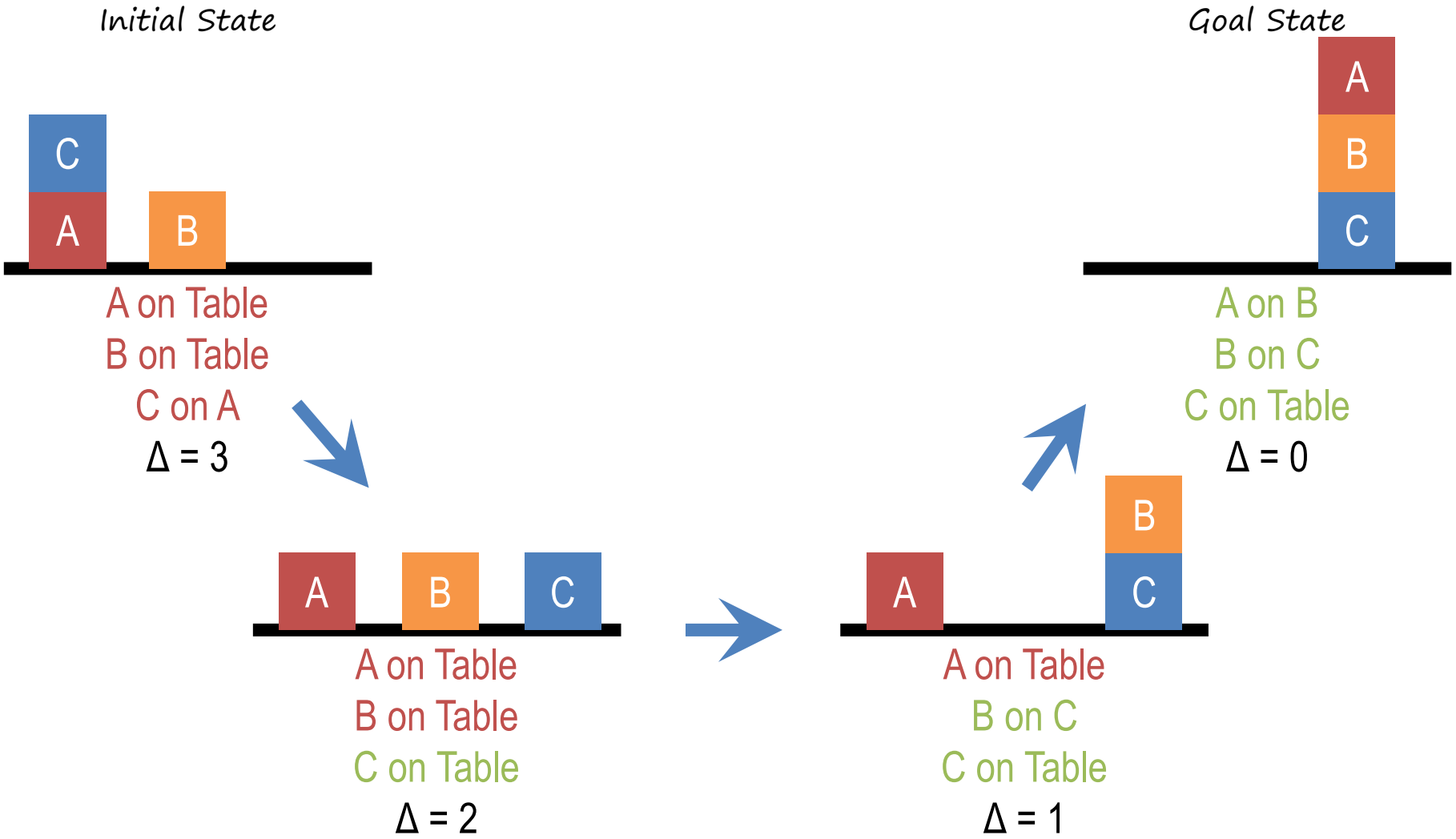

Initial State
Goal State
P1
P2
P3
P4
P5
P6
P7


Initial State
C
A
B
A on Table
B on Table
C on A
A
B
C
A on Table
B on Table
C on Table
B
A
C
A on Table
B on C
C on A
Goal State
A
B
C
A on B
B on C
C on Table


Initial State
Goal State
P1
P2
P3
P4
P5
P6
P7


Initial State
A
B
C
Δ = 2
Goal State
C
A
B
A on Table
B on Table
C on A
Δ = 3
C
A
B
Δ = 3
A
B
C
A on B
B on C
C on Table
Δ = 0
B
C
A
Δ = 3


Initial State
A
B
C
Δ = 2
Goal State
C
A
B
A on Table
B on Table
C on A
Δ = 3
C
A
B
Δ = 3
A
B
C
A on B
B on C
C on Table
Δ = 0
B
C
A
Δ = 3

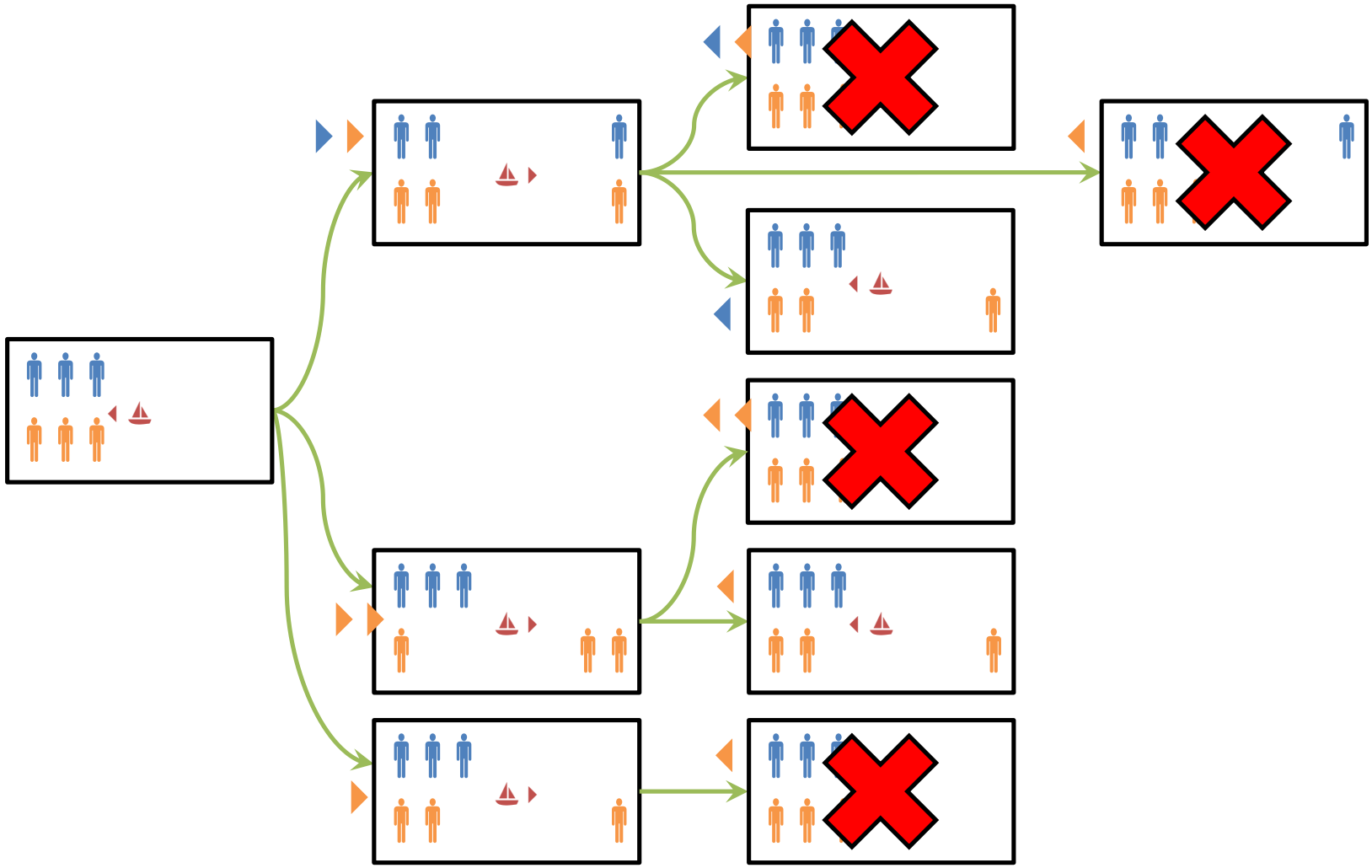

Initial State
C
A
B
A on Table
B on Table
C on A
Δ = 3
A
B
C
A on Table
B on Table
C on Table
Δ = 2
B
A
C
A on Table
B on C
C on Table
Δ = 1
Goal State
A
B
C
A on B
B on C
C on Table
Δ = 0

Means-Ends Analysis

For each operator that can be applied:

- Apply the operator to the current state
- Calculate difference between new state and goal state

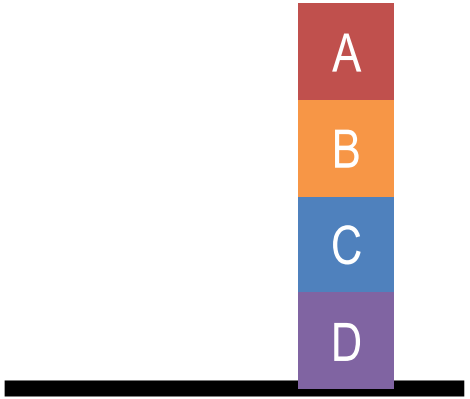
Prefer state that minimizes distance between new state and goal state



Initial State

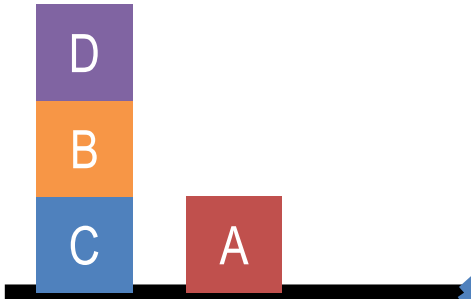
A on Table
B on C
C on Table
D on B
Δ = 3

Goal State



A on B
B on C
C on D
D on Table

Initial State



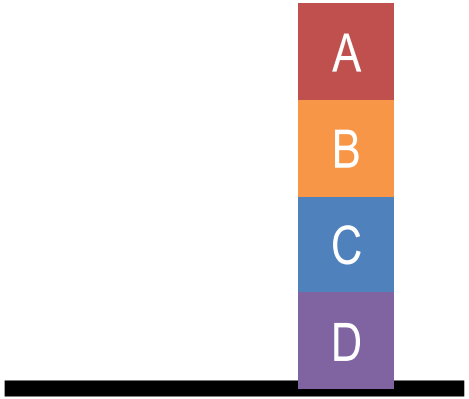
A on Table
B on C
C on Table
D on B
Δ = 3

A on D
B on C
C on Table
D on B
Δ = 3

A on Table
B on C
C on Table
D on A
Δ = 3

A on Table
B on C
C on Table
D on Table
Δ = 2

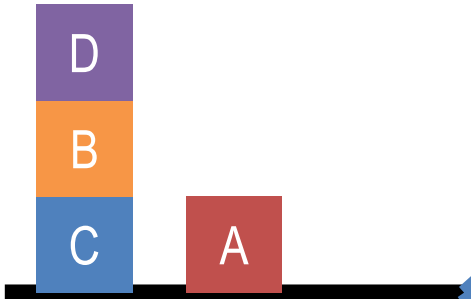
Goal State



A on B
B on C
C on D
D on Table

What is the difference between each state and the goal state?

Initial State



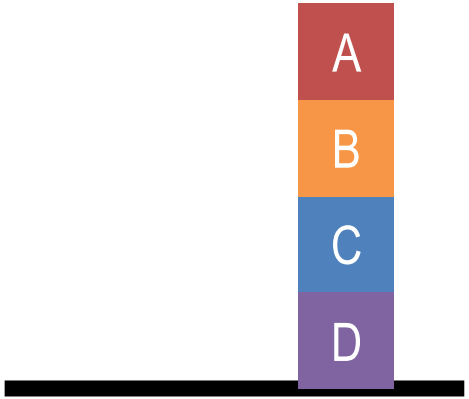
A on Table
B on C
C on Table
D on B
Δ = 3

A on D
B on C
C on Table
D on B
Δ = 3

A on Table
B on C
C on Table
D on A
Δ = 3

A on Table
B on C
C on Table
D on Table
Δ = 2

Goal State



A on B
B on C
C on D
D on Table

Using means-ends analysis, which move will be chosen?

Current State

A on Table
B on C
C on Table
D on Table
Δ = 2

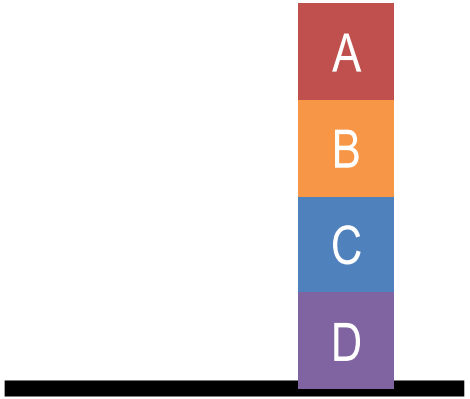
How many possible next states are there?

7

How many of those states reduce the difference to the goal?

1

Goal State

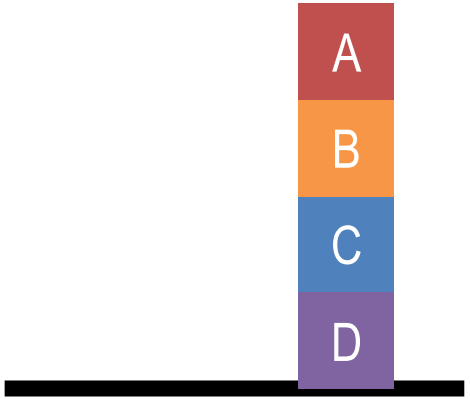


A on B
B on C
C on D
D on Table

Current State

A on B
B on C
C on Table
D on Table
Δ = 1

Goal State



A on B
B on C
C on D
D on Table

Current State

A on B
B on C
C on Table
D on Table
Δ = 1

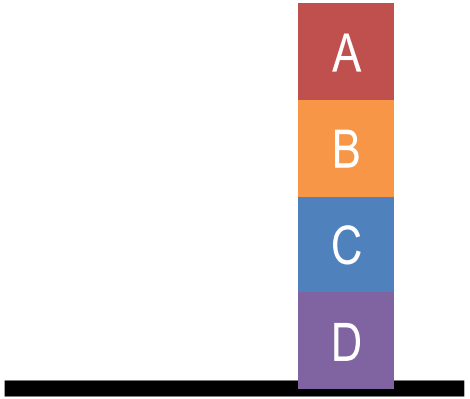
How many possible next states are there?

3

How many of those states reduce the difference to the goal?

0

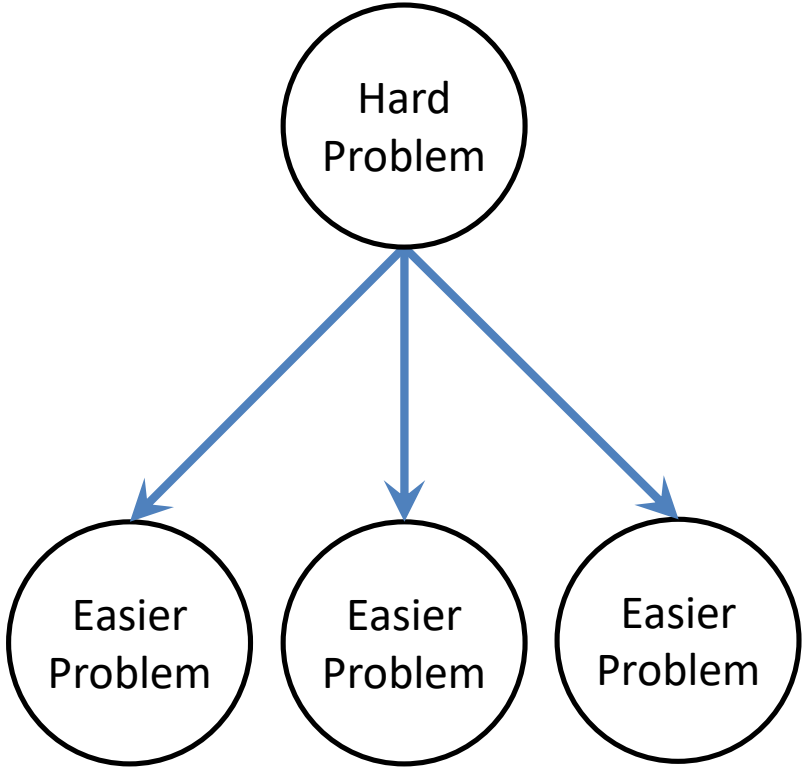
Goal State



A on B
B on C
C on D
D on Table

Assignment

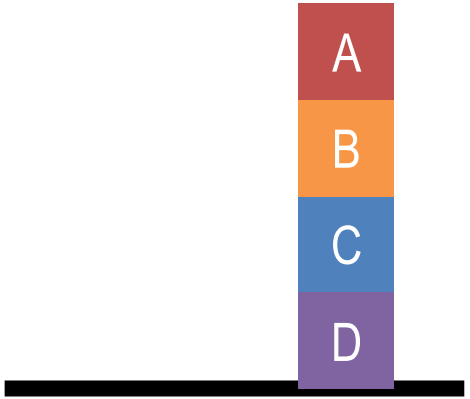
How would you use means-ends analysis to design an agent that could answer Raven's Progressive Matrices?


Hard Problem
Easier Problem
Easier Problem
Easier Problem

Current State

A on B
B on C
C on Table
D on Table
Δ = 1

Goal State



A on B
B on C
C on D
D on Table

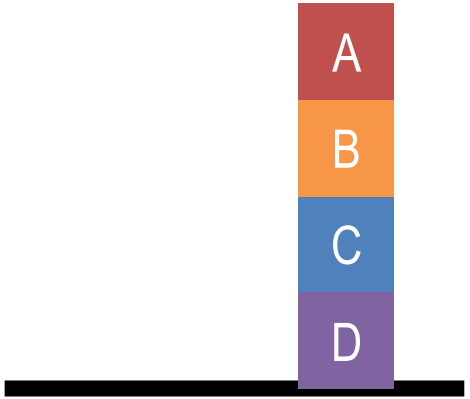
Current State

A on B
B on C
C on Table
D on Table
Δ = 1

Subgoal

C on D
D on Table

Goal State



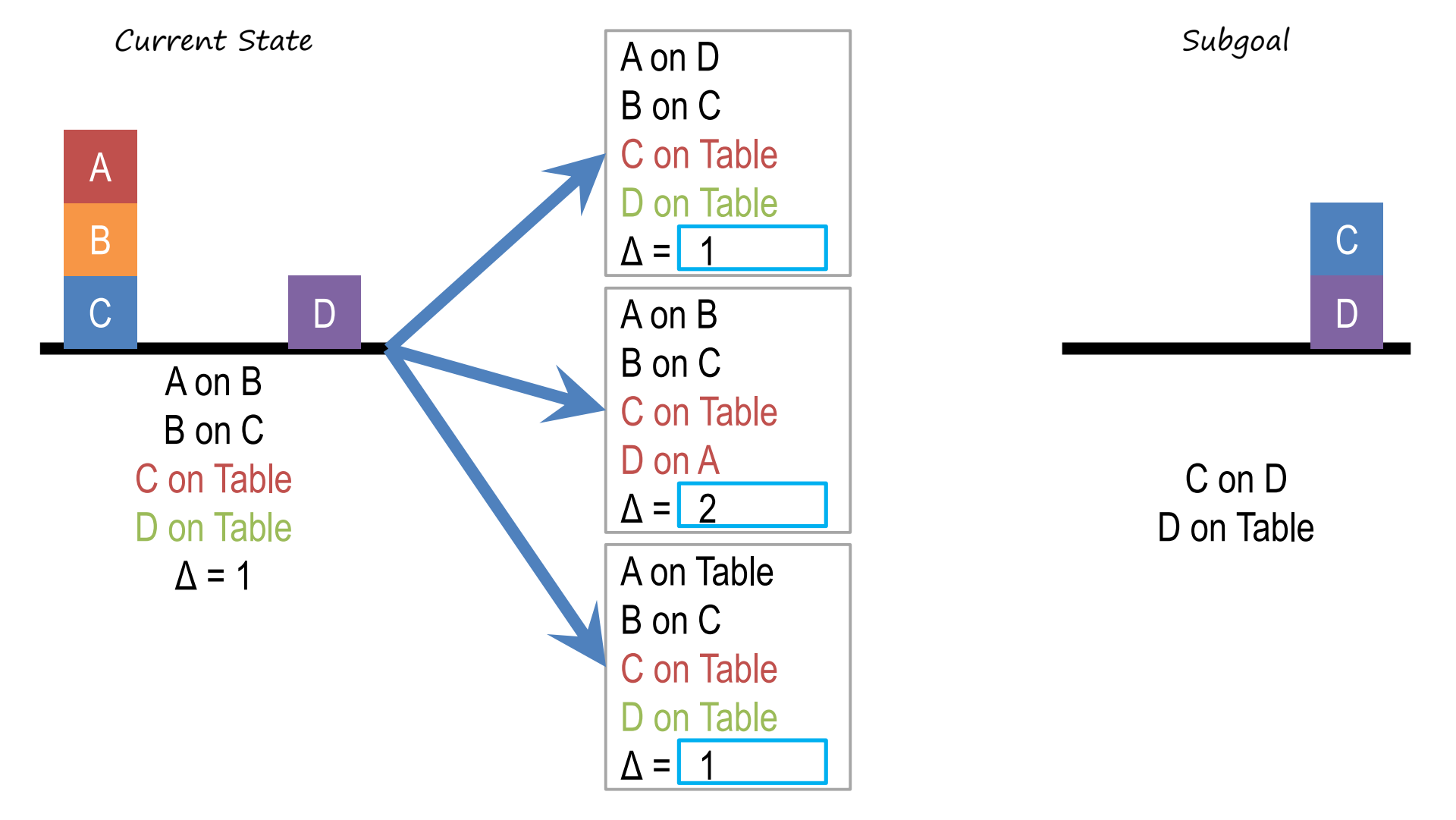
A on B
B on C
C on D
D on Table

Current State

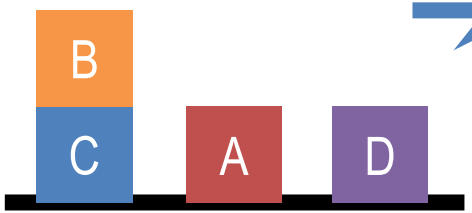
A on B
B on C
C on Table
D on Table
Δ = 1

Subgoal

C on D
D on Table


Current State
A
B
C
D
A on B
B on C
C on Table
D on Table
Δ = 1
A on D
B on C
C on Table
D on Table
Δ = 1
A on B
B on C
C on Table
D on A
Δ = 2
A on Table
B on C
C on Table
D on Table
Δ = 1
Subgoal
C
D
C on D
D on Table

Current State



A on Table
B on C
C on Table
D on Table
Δ = 1

Move(B, Table)
Move(C, D)

Available Operators:

Move(Object, Location)

e.g.:

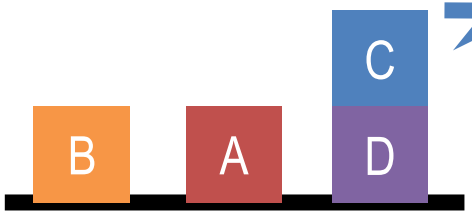
Move(C, Table)
moves C onto the table

Move(C, B)
moves C onto B

Subgoal

C on D
D on Table

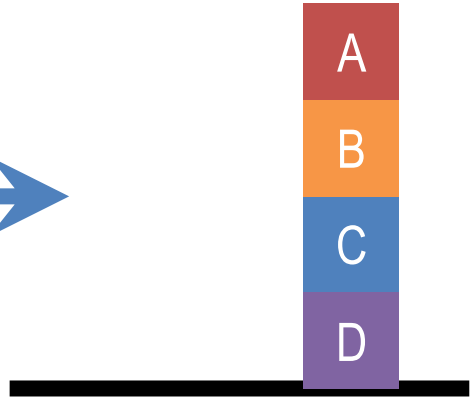
Current State



A on Table
B on Table
C on D
D on Table
Δ = 2

Move(B, C)
Move(A, B)

Goal State



A on B
B on C
C on D
D on Table

Available Operators:

Move(Object, Location)

e.g.:

Move(C, Table)
moves C onto the table

Move(C, B)
moves C onto B

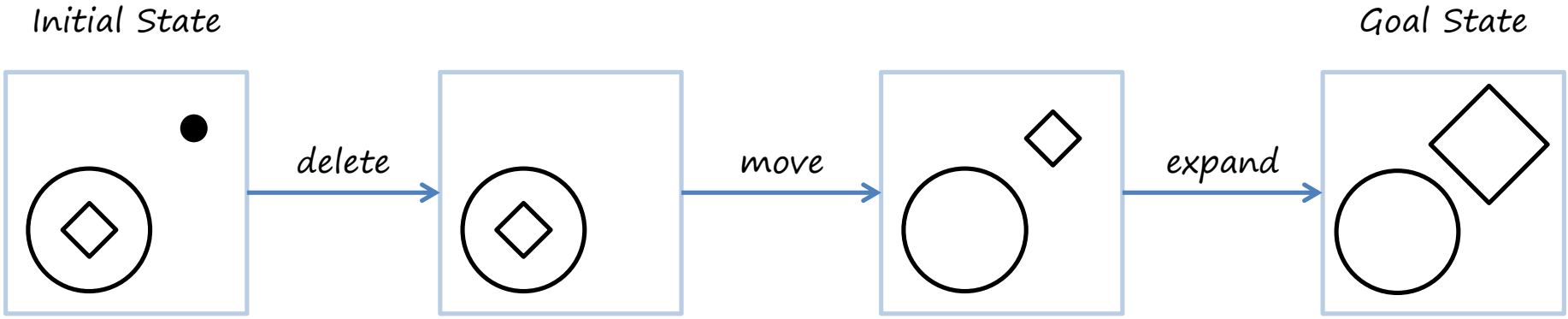
Assignment

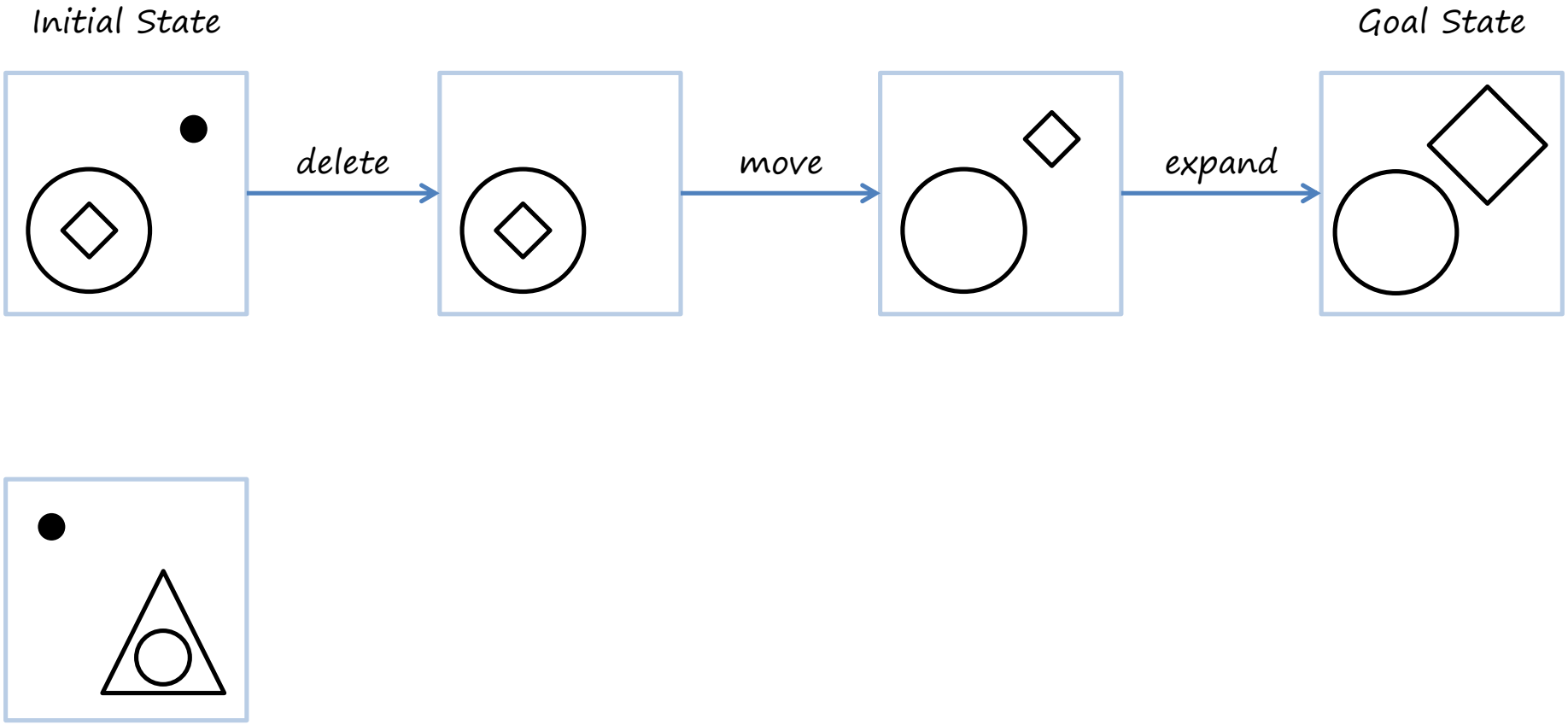
How would you use problem reduction to design an agent that could answer Raven's Progressive Matrices?

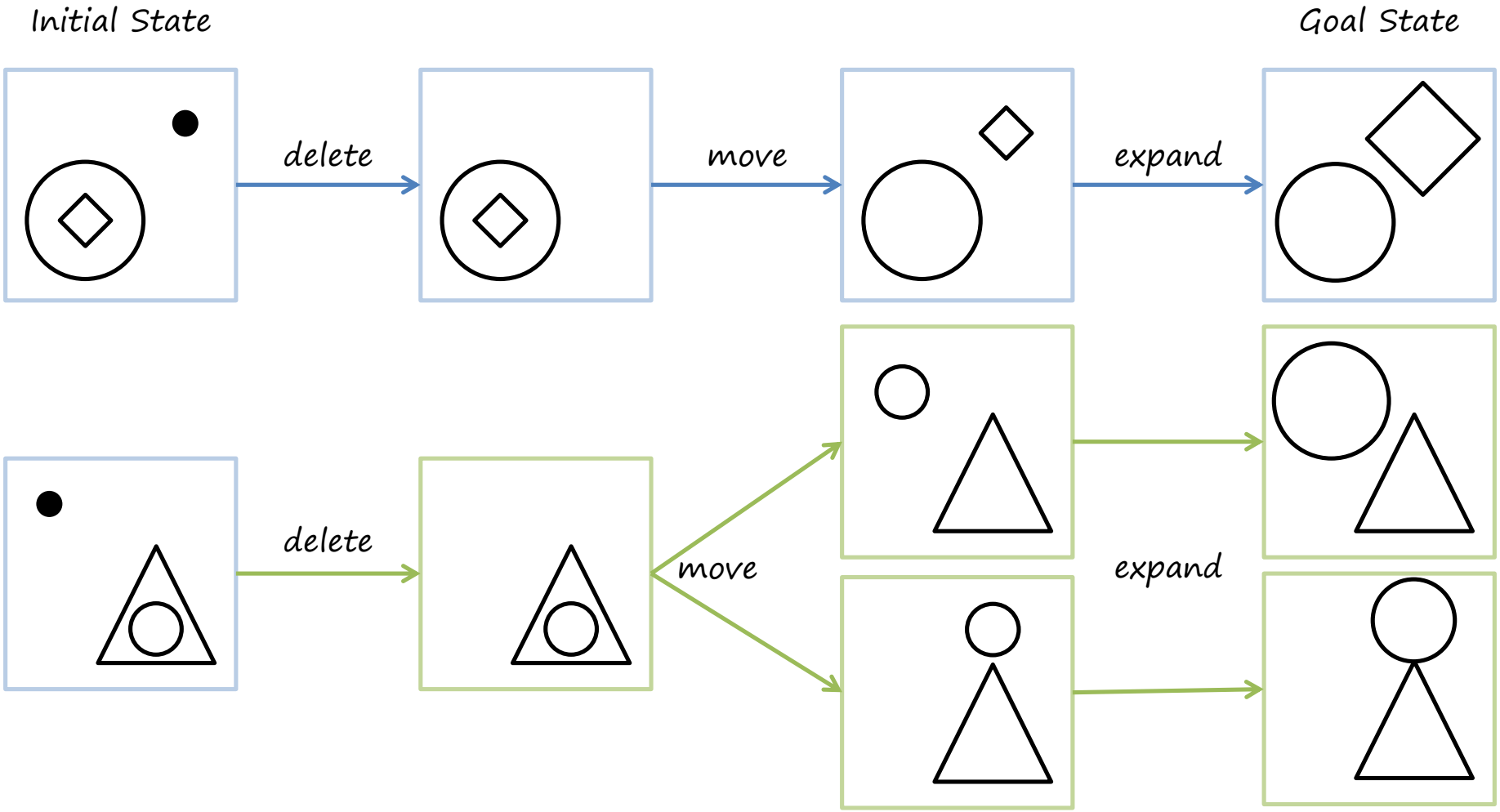
To recap…

- State spaces
- Means-ends analysis
- Problem solving with means-ends analysis
- Problem reduction


Initial State
Goal State
Set of Transformations


Initial State
delete
move
expand
Goal State


Initial State
delete
move
expand
Goal State


Initial State
Goal State
delete
move
expand
delete
move
expand