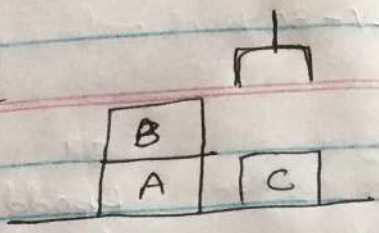
Planning

Blocks World Example



Basic Operations

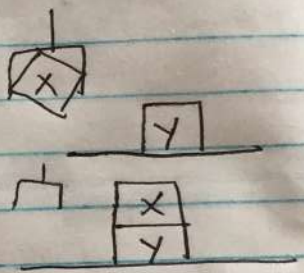
- stack(X, Y) : put block x on block y
- unstack(X,Y): remove block x from block y
- pickup(x) : pickup block(x)
- putdown(x) putdown block(x) on the table

stack(X,Y)

precond holding(X) ∧ clear(Y)

Add empty() ∧ on(X,Y) ∧ clear(X)

Delete holding(X) ∧ clear(Y)

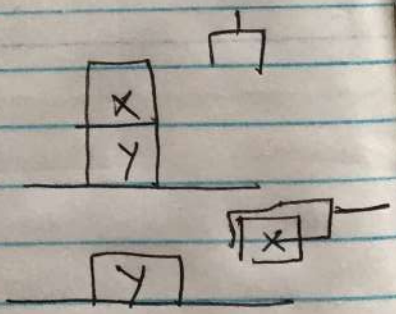


Unstack(X,Y)

precond on(X,Y) ∧ clear(X) ∧ empty

Add holding(X) ∧ clear(Y)

Delete empty ∧ clear(X) ∧ on(X,Y)



Pickup(x)

precond: ontable(x) ∧ clear(x) ∧ empty()

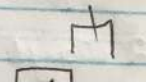
Add: holding(x)

Delete: ontable(x) ∧ clear(x) ∧ empty()

Putdown(x)

precond holding(x)

Add ontable(x) ∧ clear(x) ∧ empty()



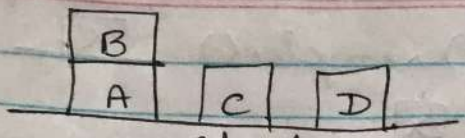
Delete holding(x)

5 predicates/operators

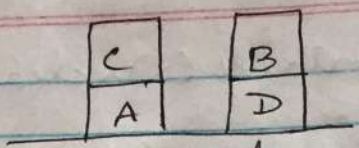
on(x, Y)
ontable(x)
clear(x)
holding(x)
empty()

process

1. choose the best rule based on heuristics
2. Apply the rule to create a new state
3. Detect when a solution is found
4. Detect dead ends so that they can be avoided



Start



Goal

on(B, A) ∧ ontable(A) ∧ clear(B)
ontable (C) ∧ clear (C)
∧ ontable(D) ∧ clear (D) ∧
arm-empty

on (C, A) ∧ on (B, D) ∧
clear (C) ∧ clear (B) ∧
ontable(A) ∧ ontable(D)
∧ armempty

2 ways to proceed

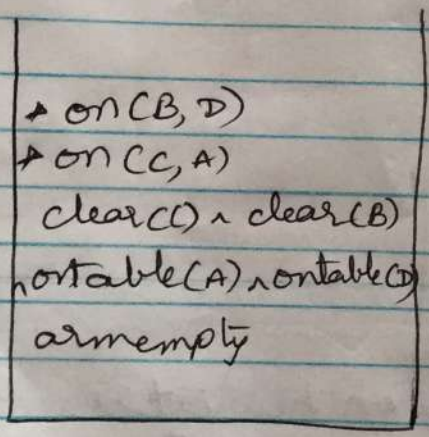
① on (C, A)
② on (B, D)

preconditions of on (C, A) not true for start state

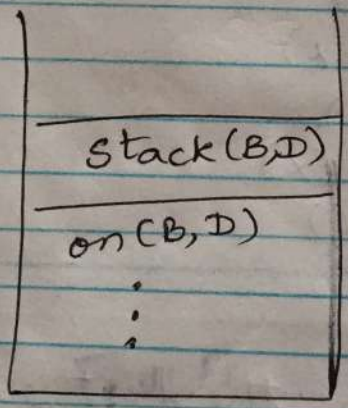
✓

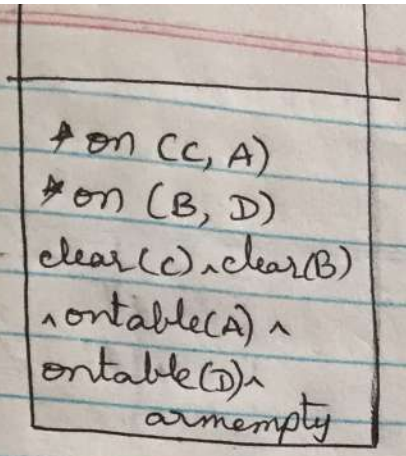
① on (B, D)
② on (C, A)

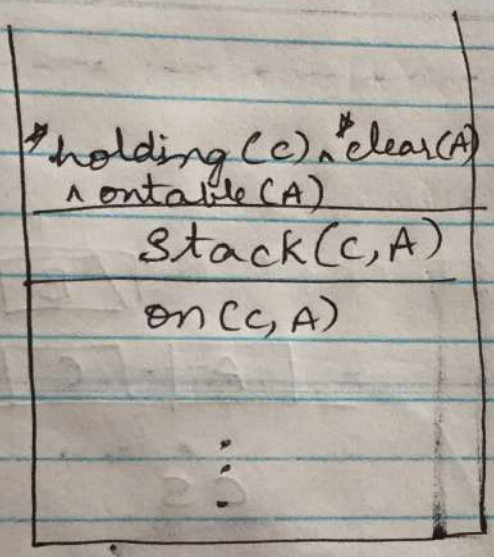
proceed with this alternative

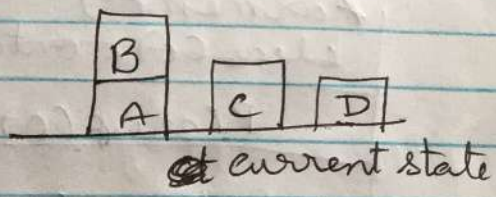


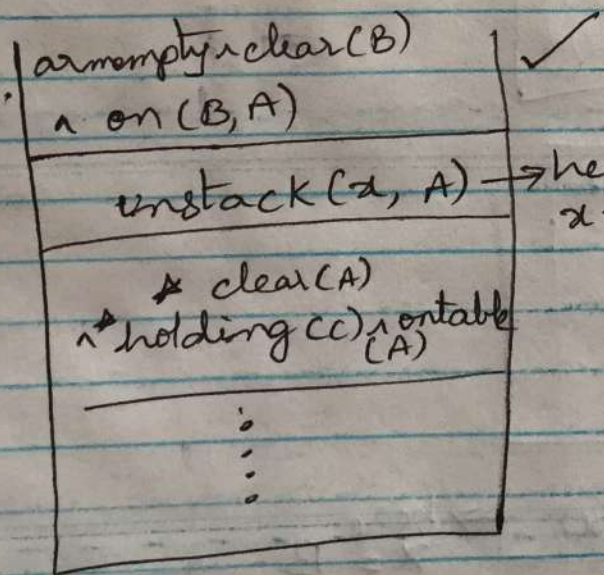
Goal stack

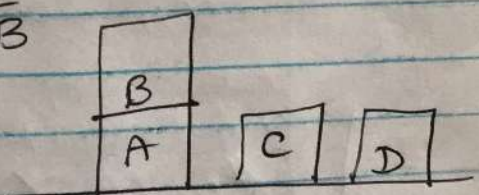






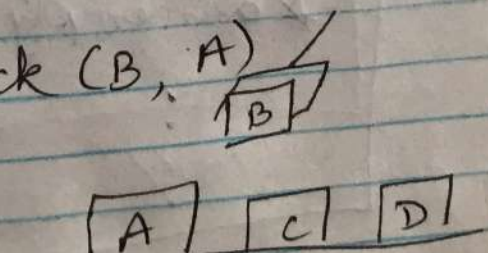


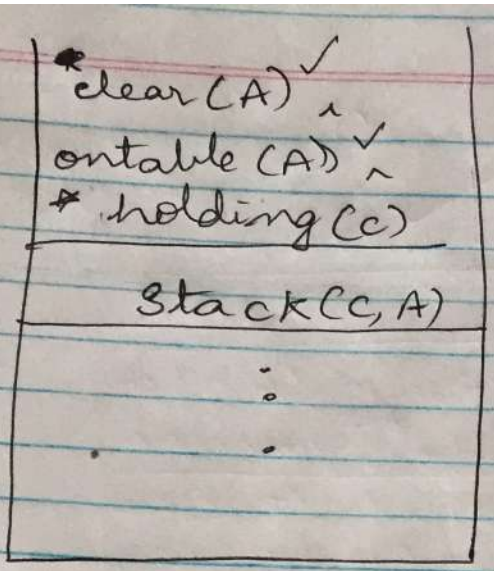


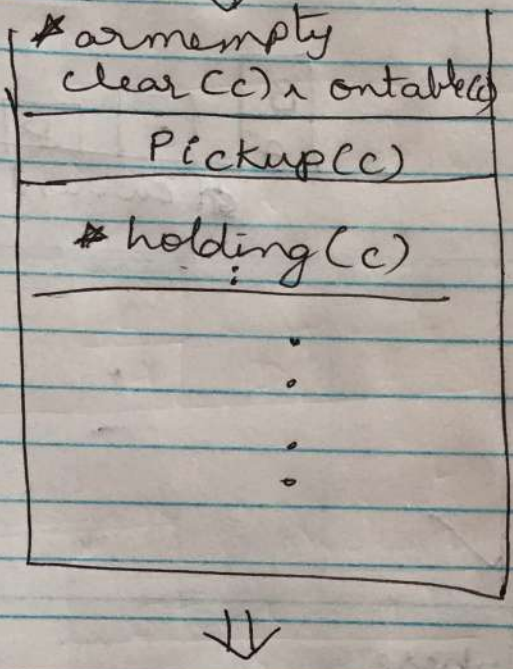


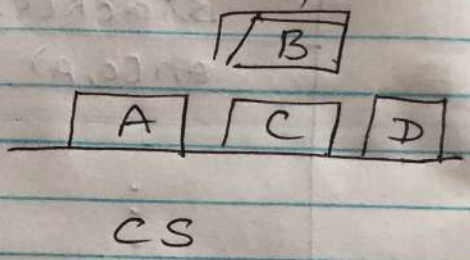
Pop

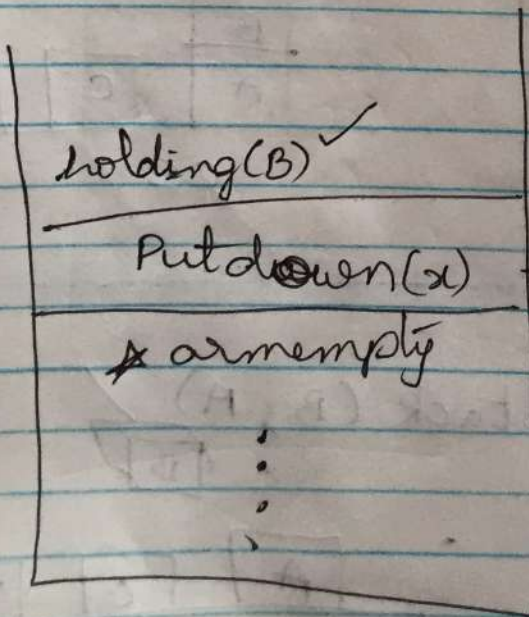
① Apply action unstack (B, A)











→ here x = B

② Pop

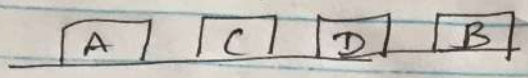
CS: ∧ onta ∧ onta ∧ cle ∧ cle ∧ cl clea

armem ontab ontab

Goal

③ P

② Pop and apply action. Putdown(B)



CS = armempty ∧ ontable(A) ∧ ontable(C) ∧ ontable(D) ∧ ontable(B) ∧ clear(A) ∧ clear(C) ∧ clear(D) ∧ clear(B)

Goalstack

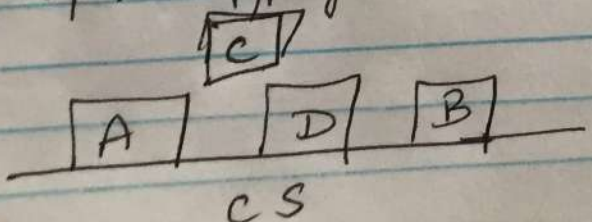
armempty ∧ clear(C) ∧ ontable(C) ✓

Pickup(C)

holding(C)

⋮

③ Pop & apply action Pickup(C)



CS

holding(C)
∧ clear(A) ∧
ontable(A)

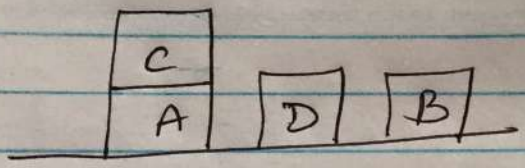
stack(C, A)

on(C, A) ∧ clear(C)
∧ armempty ∧ ontable(A)

on(B, D) ∧ clear(B)
∧ ontable(B)

(5)

(4) Pop & apply action stack(C, A)



Goal stack ∧ armempty

holding(B) ∧ clear(D)

stack(B, D)

on(C, A) ∧ clear(C)
∧ armempty
∧ ontable(A)
∧ on(B, D)
∧ clear(B)
∧ ontable(B)

(6)

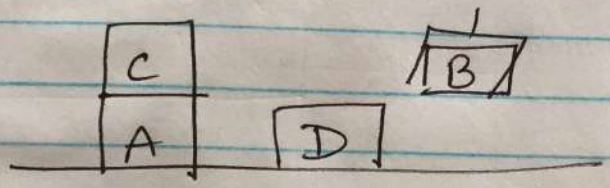
armempty ∧
clear(B) ∧
ontable(B)

Pickup(B)

holding(B)

⋮

(5) Pop & apply action Pickup(B)

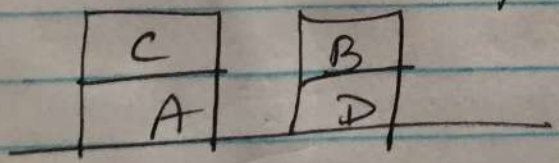


holding(B) ∧ clear(D)
∧ ontable(D)

Stack(B, D)

on(C, A) ∧ clear(C)
∧ armempty
∧ ontable(A)
∧ on(B, D) ∧
clear(B) ∧
ontable(B)

(6) Pop & apply action Stack(B, D)



CS = Final state
Success!!