COMP 307 Assignment 4

/100 well done ^^

Part 1.

(a) Q1:

Initial state:

At(Monkey, A) ∧ At(Box, B) ∧ At(Bananas, C) ∧ Height(Monkey, Low) ∧ Height(Box, Low) ∧ Height(Banana, High) ∧ ~~Hold(Monkey, Banana)~~.

35

+5

Goal state:

Hold(Monkey, Banana)

(b) Q2:

Action 1.: GO(X, Y)

Precond: At(Monkey, X) ∧ ¬ Height(~~Hold~~ Monkey, High) ∧ (X != Y)

Effect: At(Monkey, Y) ∧ ¬ At(Monkey, X).

Action 2: Push(Box, X, Y)

+10

Precond: At(Box, X) ∧ At(Monkey, X) ∧ Height(Monkey, Low) ∧ (X ≠ Y)

Effect: At(Box, Y) ∧ At(Monkey, Y)

Action 3: ClimbUp(X)

Precond: At(Monkey, X) ∧ At(Box, X) ∧ Height(Monkey, Low).

Effect: At(Monkey, X) ∧ At(Box, X) ∧ Height(Monkey, High) ∧ ¬Height(Monkey,

Action 4: ClimbDown(X)

Precond: At(Monkey, X) ∧ At(Box, X) ∧ Height(Monkey, High)

Effect: Height(Monkey, Low) ∧ ¬Height(Monkey, High) ∧ At(Monkey, X) ∧ At(Box, X)

Action 5: Grasp(X, h)

Precond: At(Monkey, X) ∧ At(Bananas, X) ∧ Height(Monkey, h) ∧ Height(Bananas,

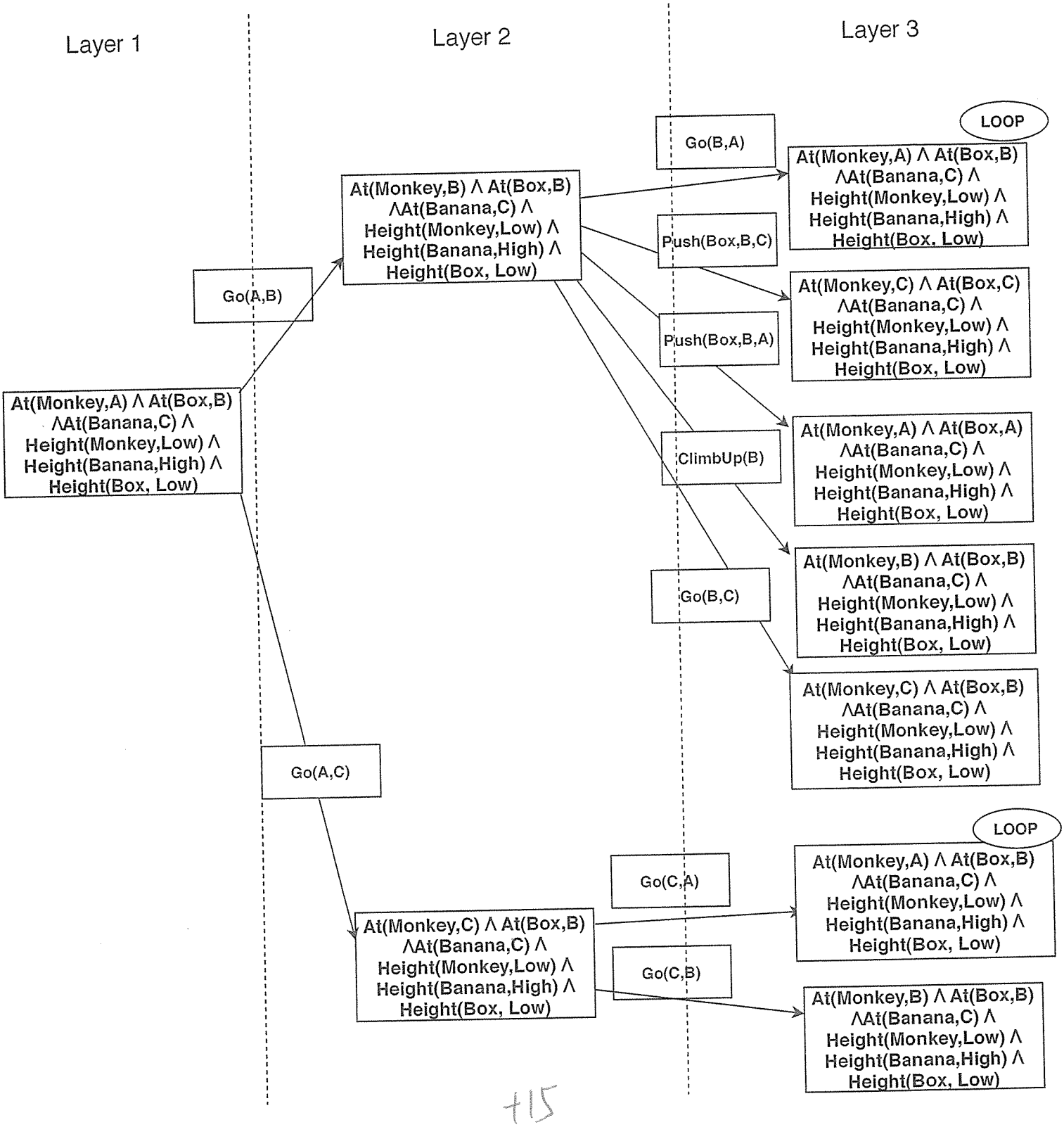
Effect: Holds(Monkey, Banana)

Action 6: UnGrasp(Bananas)

Precond: Holds(Monkey, Bananas)

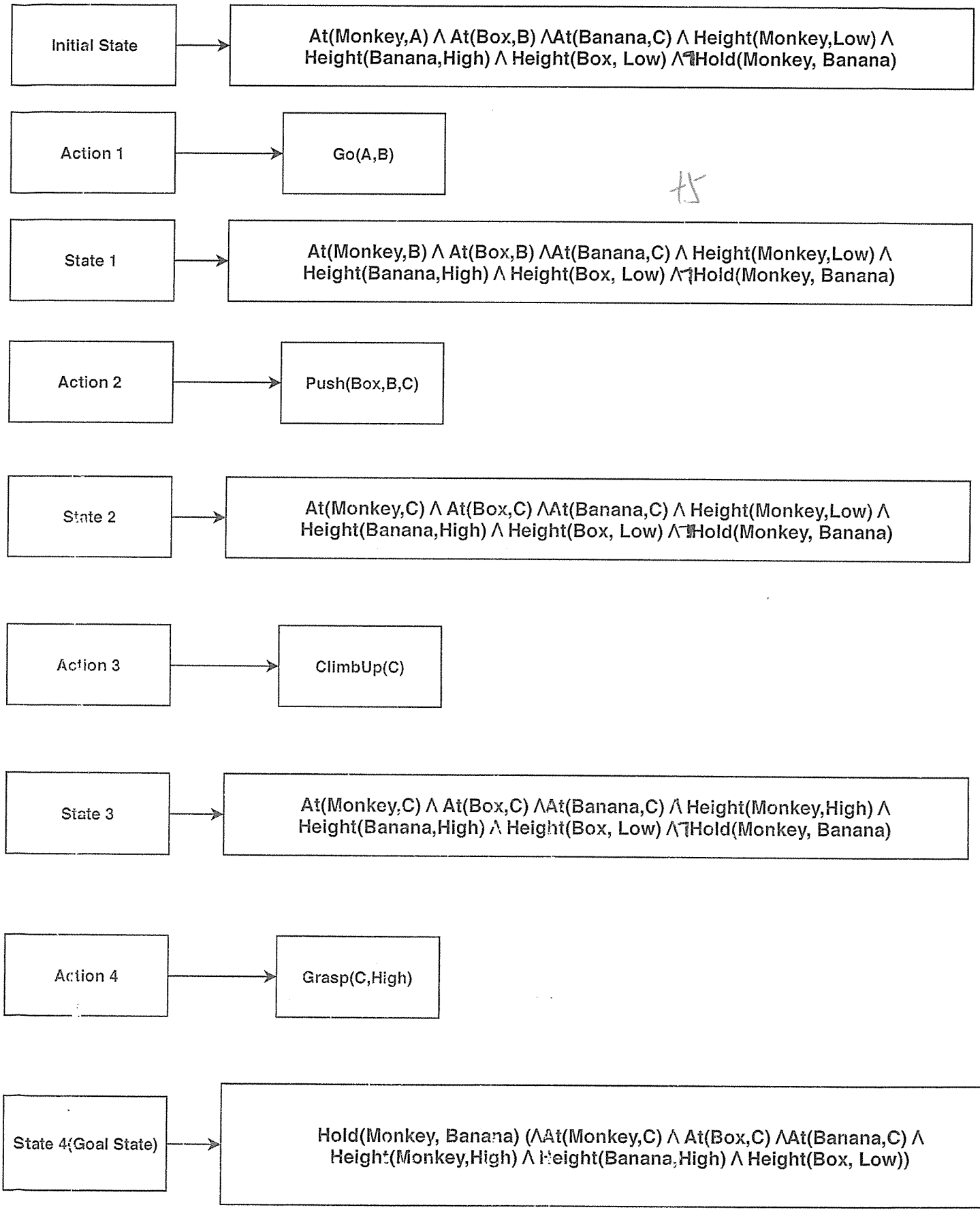
Effect: ¬Holds(Monkey, Bananas)

Q3.


Layer 1
Layer 2
Layer 3
At(Monkey,A) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(A,B)
At(Monkey,B) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(B,A)
LOOP
At(Monkey,A) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Push(Box,B,C)
At(Monkey,C) ∧ At(Box,C) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Push(Box,B,A)
At(Monkey,A) ∧ At(Box,A) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
ClimbUp(B)
At(Monkey,B) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(B,C)
At(Monkey,C) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(A,C)
LOOP
At(Monkey,A) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(C,A)
At(Monkey,C) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)
Go(C,B)
At(Monkey,B) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low)

+15

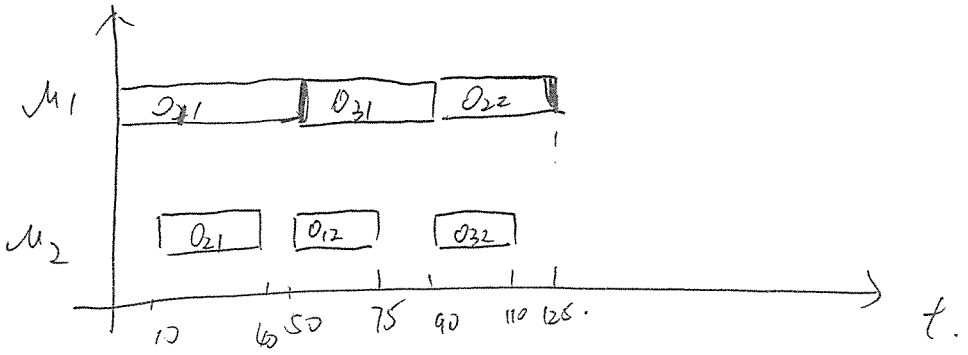
Q4


Initial State
At(Monkey,A) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low) ∧¬Hold(Monkey, Banana)
Action 1
Go(A,B)
State 1
At(Monkey,B) ∧ At(Box,B) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low) ∧¬Hold(Monkey, Banana)
Action 2
Push(Box,B,C)
State 2
At(Monkey,C) ∧ At(Box,C) ∧At(Banana,C) ∧ Height(Monkey,Low) ∧ Height(Banana,High) ∧ Height(Box, Low) ∧¬Hold(Monkey, Banana)
Action 3
ClimbUp(C)
State 3
At(Monkey,C) ∧ At(Box,C) ∧At(Banana,C) ∧ Height(Monkey,High) ∧ Height(Banana,High) ∧ Height(Box, Low) ∧¬Hold(Monkey, Banana)
Action 4
Grasp(C,High)
State 4(Goal State)
Hold(Monkey, Banana) (∧At(Monkey,C) ∧ At(Box,C) ∧At(Banana,C) ∧ Height(Monkey,High) ∧ Height(Banana,High) ∧ Height(Box, Low))

Part 2. (40)

$P(O_{11}, M_1, t_1) \rightarrow P(O_{21}, M_2, t_2) \rightarrow P(O_{31}, M_1, t_3) \rightarrow P(O_{12}, M_2, t_4)$

$\rightarrow P(O_{22}, M_1, t_5) \rightarrow P(O_{32}, M_2, t_6)$.



① Job Ready Time.

Machine Idle Time

$M_1 = 0$

$M_2 = 0$

J_1 = $O_{11} = 0$ $O_{12} = +\infty$

J_2 $O_{21} = +\infty$ $O_{22} = +\infty$

J_3 $O_{31} = +\infty$ $O_{32} = +\infty$

Operation (O_{11}, M_1, Proc Time = 0) = -50 $t_1 = 0$.

② . J_1 ~~O_{11}~~ = $O_{12} = 50$

MIT

$M_1 = 50$

$M_2 = 0$

J_2 $O_{21} = 10$ $O_{22} = +\infty$

J_3 $O_{31} = 20$ $O_{32} = +\infty$

operation (O_{21}, M_2, t_2) ⇒ Operation (O_{21}, M_2, Proc Time = 10) = -30 $t_2 = 10$.

③. JRT

MIT

J_1 ~~O_{11}~~ $O_{12} = 50$

$M_1 = 50$

J_2 ~~O_{21}~~ $O_{22} = 40$

$M_2 = 40$

operation (O_{31}, M_1, ~~Proc~~ Proc Time) = -40

J_3 O_{31} ~~= 20~~ $O_{32} = +\infty$

$t_3 = 50$

(5)

④ JRT.

MIT.

J_1 O_{11} $O_{12} = 50$

$M_1 = 90$

$M_2 = 40$

J_2 O_{21} $O_{22} = 40$

J_3 O_{31}; $O_{32} = 90$

Operation (O_{12}, M_2, Proc Time = 50) = 25 $t_4 = 50$

⑤. JRT

MIT

J_1 O_{11} O_{12}

$M_1 = 90$

J_2 O_{21} $O_{22} = 40$

$M_2 = 75$.

J_3 O_{31} $O_{32} = 90$

Operation (O_{22}, M_1, Proc = 90) = 35. $t_5 = 90$

⑥. JRT

MIT

J_3 $O_{32} = 90$

$M_1 = 0/125$

$M_2 = 75$.

Operation (O_{32}, M_2, Proc = 90) = 20 $t_6 = 90$

+10

$t_1 = 0$ $t_4 = 50$

$t_2 = 10$ $t_5 = 90$

$t_3 = 50$ $t_6 = 90$

$t_1 < t_2 < t_3 = t_4 < t_5 = t_6$

(b)

Finishing time for J_1 = t_4 + Proc (O_{12}) = 75

Finishing time for J_2 = t_5 + Proc (O_{22}) = 125

Finishing time for J_3 = t_6 + Proc (O_{32}) = 110.

+5

The makespan of this solution is the time of the job finished latest which is 125.

(c):

Step 1.

earliestIdleTime (M_1) = 0, earliestIdleTime (M_2) = 0.

earliestReadyTime (O_{11}) = 0

Step 1

Partial solution : Process (O_{11}, M_1, 0)

+15

earliestIdleTime (M_1) = 50, earliestIdleTime (M_2) = 0.

earliestReadyTime (O_{12}) = 50, ~~earliestReadyTime (0)~~

earliestReadyTime (O_{21}) = 10, earliestReadyTime (O_{22}) = +∞

earliestReadyTime (O_{31}) = 20, earliestReadyTime (O_{32}) = +∞

Step 2

Partial solution : Process (O_{11}, M_1, 0) → Process (O_{21}, M_2, 10)

earliestIdleTime (M_1) = 50, earliestIdleTime (M_2) = 40

earliestReadyTime (O_{12}) = 50

earliestReadyTime (O_{22}) = 40

earliestReadyTime (O_{31}) = 20 earliestReadyTime (O_{32}) = +∞

Step 3.

Partial solution : Process (O_{11}, M_1, 0) → Process (O_{21}, M_2, 10) → Process (O_{12}, M_2, 50

earliest Idle Time (M_1) = 50, earliest Idle Time (M_2) = 25.

earliest Ready Time (O_{22}) = 40

earliest Ready Time (O_{31}) = 20 earliest Ready Time (O_{32}) = 120

Step 4.

Partial solution: Process (O_{11}, M_1, 0) → Process (O_{21}, M_2, 10)

⋮

Final solution

Process (O_{11}, M_1, 0) → Process (O_{21}, M_2, 10) → Process (O_{12}, M_2, 50)

→ Process (O_{22}, M_1, 50) → Process (O_{31}, M_1, 85) → Process (O_{32}, M_2, 125)

4): (SPT Rule)

Finishing Time for Job 1. = 50 + Process Time (O_{12}) = 75.

Finishing time for Job 2 = 50 + Process Time (O_{22}) = 85.

Finishing time for Job 3 = 125 + Process Time (O_{32}) = 145. +5

The makespan of the solution using SPT rule is 145.

Comparing the makespans of using SPT and FCFS, the makespan of the solution using FCFS performs better, it has smaller makespan.

5). No, it doesn't mean FCFS rule can always generates better solution than using SPT rule. We can only say FCFS rule is more suitable to apply on this particular problem. +5

Part 3.

1): $R_1 = (0, 2, 3, 5, 1)$ (25)

$R_2 = (1, 6, 8, 4, 1)$ +10

$R_3 = (1, 7, 9, 10, 1)$

2):

$D_1 = 1 + 1 + 1 + 2.24 = 5.24$

$D_2 = 1.41 + 1.41 + 1.41 + 3.16 = 7.39$

$D_3 = 2.23 + 3.16 + 2.00 + 5.39 = 12.78$

Total Distance $= D_1 + D_2 + D_3 = 25.41$ +5

3): Function set: ① Multiply
② Add
③ Sub
④ Protected Division
⑤. Square root +2

Terminal set : ① Capacity of truck

② Demand of each node

③ Distance to Depot ~~Station~~ storage

④ Distance to the ~~neighbour~~ nearest neighbour

⑤ current ~~number~~ number of dept on the truck

The Fitness Function we can use the total distance, therefore the smaller result we get the better ~~the~~ it performs.

For the function set, I want to use Arithmetic operators and square root. Because in this problems, we don't have lots features, and this is a relatively easy problem, hence I think we don't ~~need~~ need generate a GP Tree too complex.

~~For the terminal set, we can set the~~

Terminal set:

For this problem we should consider +3 the current number of dept on the truck, if we only have the last one on the truck we should not go too far away ~~from~~ from the depot station, ~~which could~~ Hence the distance from current node to depot station is also involved. We also want to visit the nearest neighbour so the terminal set also includes the distance to the nearest neighbour.

For this particular problem we ~~don't~~ do not need to care too much about the capacity of truck and the demand of each node, but to make the code more general, I added these two in to the ~~function~~ terminal set.

Fitness Function

In this ~~part~~ problem, we aim to find the shortest path, so we can evaluate the heuristic based on the ~~total~~ total distance of the solution generated by the heuristic.

+5