Date:

Step 1: Initialize Population

- Chromosomes (7 integers, 0-2 for Facility 1,2,3):

- C1: [0,1,2,0,1,2,0]
- C2 : [1,0,1,2,0,1,2]
- C3 : [2,1,0,1,2,0,1]
- C4 : [0,2,1,0,2,1,0]
- C5 : [1,2,0,1,2,1,2]
- C6 : [2,0,2,1,0,2,1]

Step 2: Calculate fitness

- Fitness 1/(total cost + 1000 x excess hours)
- Cost : Sum of (task time x facility cost)

C1: [0,1,2,0,1,2,0]

- Facility 1 (0): Tasks 1,4,7

  - Time 5+7+9 = 21 ≤ 24
  - Cost: (5x10) + (7x12) + (9x11) = 50 + 84 + 99 = 233

- Facility 2 (1): Tasks 2,5

  - Time 8+6 = 14 ≤ 30
  - Cost (8x14) + (6x13) = 112 + 78 = 190

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- Facility 3 (2): Tasks 3, 6

  - Time 4+3 = 7 ≤ 28
  - Cost: (4×7) + (3×10) = 28+30 = 58

- Total cost: 233 + 190 + 158 = 481
- Fitness: 1/481 ≈ 0.002079

C2: [1, 0, 1, 2, 0, 1, 2]

- Facility 1 (0): Tasks 2, 5

  - Time: 8+6 = 14 ≤ 24
  - Cost: (8×15) + (6×14) = 120 + 84 = 204

- Facility 2 (1): Task 1, 3, 6

  - Time 5+4+3 = 12 ≤ 30
  - Cost: (5×12) + (4×9) + (3×8) = 60 + 36 + 24 = 120

- Facility 3 (2): Tasks 4, 7

  - Time: 7+9 = 16 ≤ 28
  - Cost: (7×13) + (9×13) = 91 + 117 = 208

- Total cost: 204 + 120 + 208 = 532
- Fitness: 1/532 ≈ 0.001880

Date:

- Facility 3 (2): Tasks 3, 6

  - Time 4+3 = 7 ≤ 28
  - Cost: (4×7) + (3×10) = 28+30 = 58

- Total cost: 233 + 190 + 158 = 481
- Fitness: 1/481 ≈ 0.002079

C2: [1, 0, 1, 2, 0, 1, 2]

- Facility 1 (0): Tasks 2, 5

  - Time: 8+6 = 14 ≤ 24
  - Cost: (8×15) + (6×14) = 120 + 84 = 204

- Facility 2 (1): Task 1, 3, 6

  - Time 5+4+3 = 12 ≤ 30
  - Cost: (5×12) + (4×9) + (3×8) = 60 + 36 + 24 = 120

- Facility 3 (2): Tasks 4, 7

  - Time: 7+9 = 16 ≤ 28
  - Cost: (7×13) + (9×13) = 91 + 117 = 208

- Total cost: 204 + 120 + 208 = 532
- Fitness: 1/532 ≈ 0.001880

Date:

C_3 : [2, 1, 0, 1, 2, 0, 1]

- Facility 1 (0) : Task 3, 6
  - Time 4+3 = 7 ≤ 24
  - Cost: (4×8) + (3×9) = 32 + 27 = 59
- Facility 2 (1) : Task 2, 4, 7
  - Time: 8+7+9 = 24 ≤ 30
  - Cost: (8×14) + (7×10) + (9×12) = 112 + 70 + 108 = 290
- Facility 3 (2) : Tasks 1, 5
  - Time: 5+6 = 11 ≤ 28
  - Cost: (5×9) + (6×12) = 45 + 72 = 117

- Total cost: 59 + 290 + 117 = 466
- Fitness : 1/466 ≈ 0.002146

C_4: [0, 2, 1, 0, 2, 1, 0]

- Facility 1 (0): Tasks 1, 4, 7
  - Time 5+7+9 = 21 ≤ 24
  - Cost : (5×10) + (7×12) + (9×11) = 50 + 84 + 99 = 2

· Facility 2(1) : Tasks 3,6

· Time : $4+3 = 7 \leq 30$
· Cost : $(4 \times 9) + (3 \times 8) = 36 + 24 = 60$

· Facility 3(2) : Tasks 2,5

· Time : $8+6 = 14 \leq 28$
· Cost : $(8 \times 16) + (6 \times 12) = 128 + 72 = 200$

· Total cost : $233 + 60 + 200 = 493$
· Fitness : $1/493 \approx 0.002028$

C_5 : [1, 2, 0, 1, 2, 1, 2]

· Facility 1(0) : Task 3

· Time : $4 \leq 24$
· Cost : $(4 \times 8) = 32$

· Facility 2(1) : Task 1, 4, 6

· Time $5 + 7 + 3 = 15 \leq 30$
· Cost : $(5 \times 12) + (7 \times 10) + (3 \times 8) = 60 + 70 + 24 = 1$

Date:

- Facility 3(2): Tasks 2, 5, 7

  - Time: $8+6+9=23 \leq 28$
  - Cost: $(8\times16)+(6\times12)+(9\times13)=128+72+117=317$

- Total cost: $32+154+317=503$
- Fitness: $1/503 \approx 0.001988$

C_6: [2, 0, 2, 1, 0, 2, 1]

- Facility 1(0): Tasks 2, 5

  - Time: $8+6=14 \leq 24$
  - Cost: $(8\times15)+(6\times14)=120+84=204$

- Facility 2(1): Tasks 4, 7

  - Time: $7+9=16 \leq 30$
  - Cost: $(7\times10)+(9\times12)=70+108=178$

- Facility 3(2): Tasks 1, 3, 6

  - Time: $5+4+3=12 \leq 28$
  - Cost: $(5\times9)+(4\times7)+(3\times10)=45+28+30=103$

Total cost: $204+178+103=485$

Fitness: $1/485 \approx 0.002062$

Step 3: Selection (Roulette Wheel)

- Total fitness: 0.002079 + 0.001880 + 0.002146 + 0.002028 + 0.001988 + 0.002062 ≈ 0.012183
- Probabilities:
  - C_1: 0.002079 / 0.012183 ≈ 0.171
  - C_2: 0.001880 / 0.012183 ≈ 0.154
  - C_3: 0.002146 / 0.012183 ≈ 0.176
  - C_4: 0.002028 / 0.012183 ≈ 0.166
  - C_5: 0.001988 / 0.012183 ≈ 0.163
  - C_6: 0.002062 / 0.012183 ≈ 0.169
- Pairs (random picks):
  - Pair 1: C_3, C_1
  - Pair 2: C_6, C_4
  - Pair 3: C_1, C_2

Step 4: Crossover (80%)

- Pair 1: C_3[2,1,0,1,2,0,1], C_1[0,1,2,0,1,2,0], random = 0.6
  - Point 4
  - Child: [2,1,0,1,1,2,0]
  - Child: [0,1,2,0,2,0,1]

· Pair 2 : C_6 [2,0,2,1,0,2,1], C_4 [0,2,1,0,2,1,0],
random = 0.5
· Pair 4
· Child 3: [2,0,2,1,2,1,0]
· Child 4: [0,2,1,0,0,2,1]

· Pair 3 : C_1 [0,1,2,0,1,2,0], C_2 [1,0,1,2,0,1,2],
random = 0.9
· No crossover: keep C_1, C_2

Step 5: Mutation (20%)

· Child 1: [2,1,0,1,1,2,0]

· Gene 3 (random = 0.15): Swap with gene 6 → [2,1,2,1,1,0,0]

· Child 1 : [2,1,0,1,1,2,0]

· Gene 3 (random = 0.15): Swap with gene

· Child 3 : [2,0,2,1,2,1,0]

· Gene 5 (random = 0.1): Swap with gene 2 → [2,0,1,1,2,2,0]

· Others: no mutations (random > 0.2)

Step6: New Population

- Child 1 : [2,1,2,1,1,0,0]
- Child 2 : [0,1,2,0,2,0,1]
- Child 3 : [2,0,1,1,2,2,0]
- Child 4 : [0,2,1,0,0,2,1]
- C_1 : [0,1,2,0,1,2,0]
- C_2 : [1,0,1,2,0,1,2]

Repeat from Steps 3 to 6 until ~~convergence~~ convergence