Haris Ahmed
23k-6005
BSAI-4A

ARTIFICIAL INTELLIGENCE ASSIGNMENT Date: _____

HANDWRITTEN TASKS

QUESTION 2: DRY RUN OF GENETIC ALGORITHM

Performing 2 iterations:

Step 1: Initialize Population (6 chromosomes)

C1: [2,3,1,2,3,1,2]

C2: [1,2,3,1,2,3,2]

C3: [3,1,2,3,1,2,1]

C4: [2,1,3,2,1,3,2]

C5: [1,3,2,1,3,2,1]

C6: [3,2,1,3,2,1,3]

Step 2: Evaluate fitness

C1: 2,3,1,2,3,1,2	C2: 1,2,3,1,2,3,2	C3: 3,1,2,3,1,2,1
Costs:	Costs:	Costs:
Task 1, F2 = 5*12 = 60	Task 1, F1 = 5×10 = 50	Task 2, F3 = 5×9 = 45
Task 2, F3 = 8×16 = 128	Task 2, F2 = 8×14 = 112	Task 2, F1 = 8×15 = 120
Task 3, F1 = 4×8 = 32	Task 3, F1 = 4×7 = 28	Task 3, F2 = 4×9 = 36
Task 4, F2 = 7×10 = 70	Task 4, F1 = 7×12 = 84	Task 4, F3 = 7×13 = 91
Task 5, F3 = 6×12 = 72	Task 5, F2 = 6×13 = 78	Task 5, F2 = 6×14 = 84
Task 6, F1 = 3×9 = 27	Task 6, F3 = 3×10 = 30	Task 6, F2 = 3×8 = 24
Task 7, F2 = 9×12 = 108	Task 7, F2 = 9×12 = 108	Task 7, F1 = 9×11 = 99
Total cost: 497	Total cost: 490	Total cost: 499
Loads:	Loads:	Loads:
F1: 4+3 = 7	F1: 5+7 = 12	F1: 8+6+9 = 23
F2: 5+7+9 = 21	F2: 8+6+9 = 23	F2: 4+3 = 7
F3: 8+6 = 14	F3: 4+3 = 7	F3: 5+7 = 12
Capacities: [24,30,28]	Capacities: [24,30,28]	Capacities: [24,30,28]
All within capacities.	All within capacities	All within capacities
Fitness: 497	Fitness: 490	Fitness: 499

Date: _____

C_4: [2,1,3,2,1,3,2]	C_5: [1,3,2,1,3,2,1]	C_6: [3,2,1,3,2,1,3]
Costs:	Costs:	Costs:
Task 2, f_2 : 5×12 = 60	Task 1, f_1 = 5 × 10 = 50	Task 1, f_3 = 5 × 9 = 45
Task 2, f_1 : 8×15 = 120	Task 2, f_3 = 8 × 16 = 128	Task 2, f_2 = 8 × 14 = 112
Task 3, f_3 : 4×7 = 28	Task 3, f_2 = 4 × 9 = 36	Task 3, f_1 = 4 × 8 = 32
Task 4, f_2 : 7×10 = 70	Task 4, f_1 = 7 × 12 = 84	Task 4, f_3 = 7 × 13 = 91
Task 5, f_1 : 6×14 = 84	Task 5, f_3 = 6 × 12 = 72	Task 5, f_2 = 6 × 13 = 78
Task 6, f_3 : 3×10 = 30	Task 6, f_2 = 3 × 8 = 24	Task 6, f_1 = 3 × 9 = 27
Task 7, f_2 : 9×12 = 108	Task 7, f_1 = 9 × 11 = 99	Task 7, f_3 = 9 × 13 = 117
Total cost = 500	Total cost = 493	Total cost = 502
f_1 = 8+6 = 14	loads: f_1: 5+7+9 = 21	loads: f_1: 4+3 = 7
f_2 = 5+7+9 = 21	f_2 = 4+3 = 7	f_2 = 8+6 = 14
f_3 = 4+3 = 7	f_3 = 8+6 = 14	f_3 = 5+7+9 = 21
Capacities: [24, 30, 28]	Capacities: [24, 30, 28]	Capacities: [24, 30, 28]
All within capacities	All within capacities	All within capacities
Fitness = 500	Fitness = 493.	Fitness = 502

Fitness values: [493, 490, 499, 500, 493, 502]

Step #3: Selection (Roulette wheel) $1/cost$

Inverses:	Probabilities:
C_1: $1/493$ = 0.002012	C_1: 0.002012 / 0.012077 = 0.167
C_2: $1/490$ = 0.002041	C_2: 0.002041 / 0.012077 = 0.169
C_3: $1/499$ = 0.002004	C_3: 0.002004 / 0.012077 = 0.166
C_4: $1/500$ = 0.002000	C_4: 0.002000 / 0.012077 = 0.166
C_5: $1/493$ = 0.002028	C_5: 0.002028 / 0.012077 = 0.168
C_6: $1/502$ = 0.001992	C_6: 0.001992 / 0.012077 = 0.165
Total: 0.012077	

Selecting $C_2, C_5, C_1, C_3, C_2, C_5$ (C_2 and C_5 favoured due to slightly lower cost)

Date: _____

Step #4: Crossover (80% chance)

Pair 1: C_2: [1,2,3,1,2,3,2] C_5: [1,3,2,1,3,2,1]

Crossover at Pos 2:

child 1: [1,2,2,1,3,2,1]

child 2: [1,3,3,1,2,3,2]

Pair 2: C_1: [2,3,1,2,3,1,2] C_3: [3,1,2,3,1,2,1]

Crossover at Pos 2:

child 3: [2,3,2,3,1,2,1]

child 4: [3,1,1,2,3,1,2]

Pair 3: C_4: [1,2,3,1,2,3,2] C_6: [1,3,2,1,3,3,1]

Crossover at Pos 5

child 5: [1,2,3,1,2,1]

child 6: [1,3,2,1,3,3,1]

Step #5: Mutation: (20% chance)

Child 1: [1,2,2,1,3,2,1] → No mutation

Child 2: [1,3,3,1,2,3,2] → 20% chance. Swapping pos 3 and 6: [1,3,3,1,2,2,3]

Child 3: [2,3,2,3,1,2,1] → No mutation

Child 4: [3,1,1,2,3,1,2] → No mutation

Child 5: [1,2,3,1,2,2,1] → 20% chance. Swapping pos 2 and 4: [1,1,3,2,2,2,1]

Child 6: [1,3,2,1,3,3,2] → No mutation

New Population:

[1,2,2,1,3,2,1] [3,1,2,3,1,2]

[1,3,3,1,2,2,3] [1,1,3,2,2,2,1]

[2,3,2,3,1,2,1] [1,3,2,1,3,3,2]

Evaluating fitness of next Population

C_1: [1,2,2,1,3,2,1]

Total cost: 50+112+36+84+72+24+99: 477

Loads: F_1: 5+7+9=21, F_2: 8+4+3=15, F_3: 6

All within capacities, Fitness: 477

C_2: [1,3,3,1,2,2,3]

Total cost: 50+128+38+84+78+24+117 = 509

Loads: F_1: 5+7=12, F_2: 8+6+3=17, F_3: 4+9=13

All within capacities, Fitness: 509

C_3: [2,3,2,3,1,2,1]

Total cost: 60+128+36+91+84+24+99=522

Loads: F_1: 6+9=15, F_2: 5+4+3=12, F_3: 8+7=15

All within capacities, Fitness: 522

C_4: [3,1,1,2,3,1,2]

Total cost: 45+120+32+70+92+27+108 = 494

Loads: F_1: 8+4+3=15, F_2: 7+9=16, F_3: 5+6=11

All within capacities, Fitness: 494.

C_5: [1,1,3,2,2,2,1]

Total cost: 50+120+28+70+78+24+99: 469

Loads: F_1: 5+8+9=22, F_2: 7+6+3=16, F_3: 4

All within capacities, Fitness: 469

C_6: [1,2,2,1,3,3,2]

Total cost: 50+128+36+84+72+30+108: 508

Loads: F_1: 5+7=12, F_2: 8+9=17, F_3: 4+6+3=13

All within capacities, Fitness: 508

Date: _____

Fitness: [471, 505, 522, 477, 469, 508]

Conclusion: After 1 iteration the GA improved the best cost from 490 to 469 with the Assignment [1, 1, 3, 2, 2, 2, 1] meeting all constraints.

QUESTION 4:

	X 2 3	
	X 5 6	
	0 0 9	
Three X: +1000		
Three O: -1000		
Two X's, one empty: +100		
One X, Two empty: +10		
Two O's, one empty: -100		
One O, Two empty: -10		
Else: 0		
V_sum = Sum_R + Sum_C + Sum_D		

STATES FOR X AT POS 2

	X X 3	
	X 5 6	
	0 0 9	

State 1: O at 3

R1: 0	X X O	
R2: +10	X 5 6	
R3: -100	0 0 9	
C1: 0		
C2: 0		
C3: -10		
D1: +10		
D2: -100		
Sum_R: -90	Sum_C: -10	Sum_D: -90
V_Sum: -190.		

State 2: O at 5

R1: +100	X X 3	
R2: 0	X O 6	
R3: -100	0 0 9	
C1: 0		
C2: 0		
C3: 0		
D1: 0		
D2: -100		
Sum_R: 0	Sum_C: 0	Sum_D: -100
V_Sum: -100		

State 3: O at 6

R1: +100	X X 3	
R2: 0	X 5 O	
R3: -100	0 0 9	
C1: 0		
C2: 0		
C3: -10		
D1: +10		
D2: -10		
Sum_R: 0	Sum_C: -10	Sum_D: 0
V_Sum: -10		

Date: _____

State 4: 0 at 9

R_1: +100 X X 3

R_2: +10 X 5 6

R_3: -1000 0 0 0

C_1: 0

C_2: 0

C_3: -10

D_1: 0

D_2: -10

Sum_R: -890, Sum_C: -10, Sum_D: -10

V_Sum: -910

STATES FOR X AT Pos 9

X 2 3

X 5 6

0 0 X

STATE 5: 0 at 2

R_1: 0 X 0 3

R_2: +10 X 5 6

R_3: 0 0 0 X

C_1: 0

C_2: -100

C_3: +10

D_1: +100

D_2: -10

Sum_R: +10, Sum_C: -90, Sum_D: 90

V_Sum: 10

STATE 6: 0 at 3

R_1: 0 X 2 0

R_2: +10 X 5 6

R_3: 0 0 0 X

C_1: 0

C_2: -100

C_3: +10

D_1: +100

D_2: -10

Sum_R: +10, Sum_C: -90, Sum_D: 90

V_Sum: 90

STATE 7: 0 at 5

R_1: +10 X 2 3

R_2: 0 X 0 6

R_3: 0 0 0 X

C_1: 0

C_2: -100

C_3: +10

D_1: 0

D_2: -100

Sum_R: +10, Sum_C: -90, Sum_D: -100

V_Sum: -180

STATE 8: 0 at 6

R_1: +10 X 2 3

R_2: 0 X 5 0

R_3: 0 0 0 X

C_1: 0

C_2: -10

C_3: 0

D_1: +100

D_2: -10

Sum_R: +10, Sum_C: -10, Sum_D: 90

V_Sum: 90

Date: _____

Minimax Decision:

X at 2: V. Sum. {-150, -100, -10, -910} → minimum: -910

X at 9: V. Sum: {10, 0, -180, 90} → minimum: -180

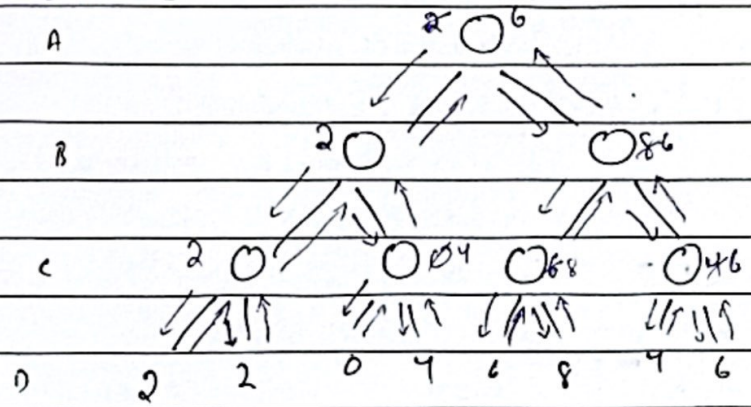
X chooses max(minimum): max(-910, -180) : -180

BEST MOVE:

Place x at Position 9, as it yields a minimum V. sum of -180, better than -910 for position 2.

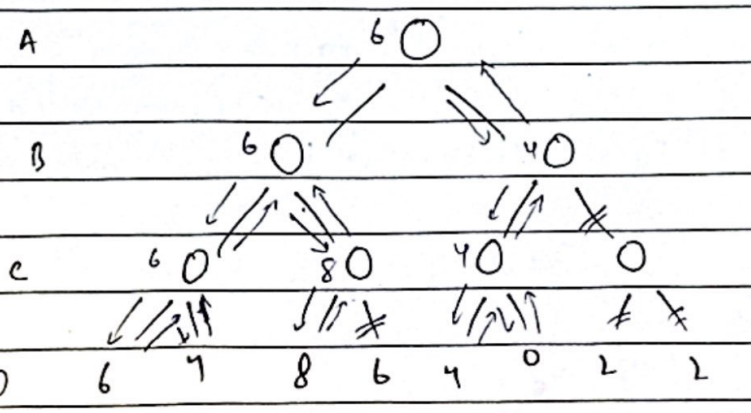
QUESTION 5:

A



All Branches evaluated, none of them pruned, No parts cut, winning Path is A → B2 → C4 → D8. As All are computed, none are struked out.

B



All Branches under B_1 except $D_4(6)$ is evaluated, $D_4(6)$ pruned when C2's 8 exceeds B_1 6. Under B_2, C_3 yields 4, setting B_2 4, Since A already has 6 from B_1, and C_4 max is less than 6, C_4 including D_7 and D_8 is pruned, as it can't improve A's value. The winning path is $A \to B_1 \to C_1 \to D_1(6)$; struck out values are $6(D_4)$, $8(D_7)$, $2(D_8)$

QUESTION 6.

Part (a)

1) PLAYERS:

max (Defenders): An AI driven IDS, tasked with protecting the network from cyber threats.

min (Attacker): Aims to penetrate the network through various attack methods.

2 DECISION MAKING:

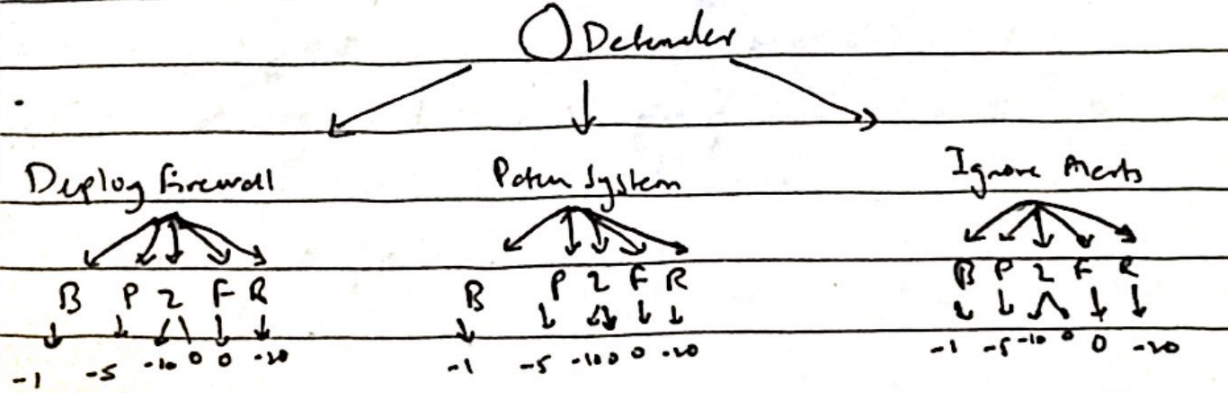
max (Defender): Decides on actions such as setting up firewalls, applying patches, or dismissing alerts to reduce damage while balancing resource use.

Min (Attacker): Picks Attacks like Brute force, Phishing, Zero-Day Exploit, Fake, or Bad to inflict maximum harm on the network.

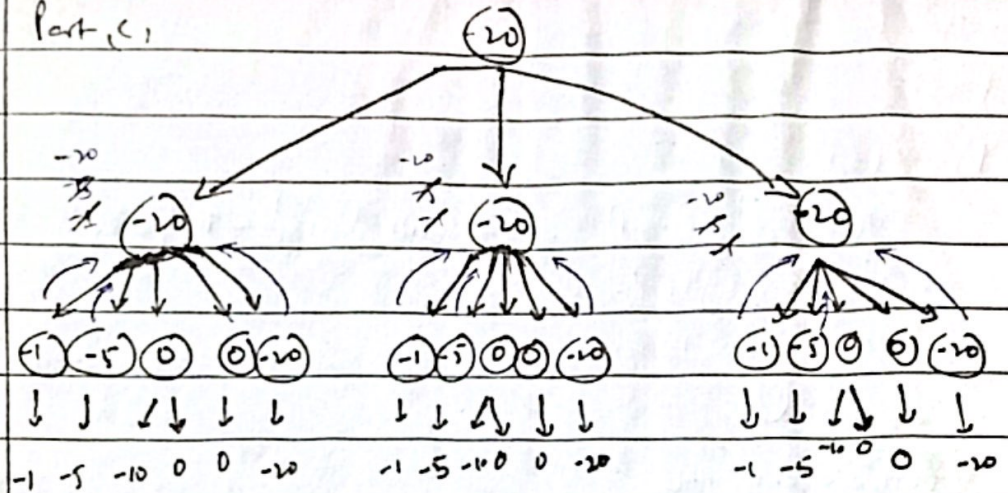
3 Stochastic Elements.

Attacks with probabilities, such as zero-Day Exploits (eg 50% success chance), create unpredictability, pushing the defender to adjust from worst case planning to strategies based on expected value (eg using Expectimax)

Part (b)



Part (c)



Part (d)

(1) Success (50%) = Damage -10

Fail (50%) = Damage = 0

Expected value = $(0.5 \times -10) + (0.5 \times 0) = \boxed{5}$

Zero-Day Exploit, on average, causes -5 damage to the system

(2) Minimax: The Defender prepares for the worst outcome (eg Zero-Day exploit succeeding at -10) typically choosing to deploy a firewall for strong defence.

Expectimax: The Defender considers the expected value (-5) for zero Day Exploits, viewing them as less severe. It might prefer Patching the system or even ignoring Alerts if fake Attacks are probable, taking a more calculated approach rather than always overprotecting.