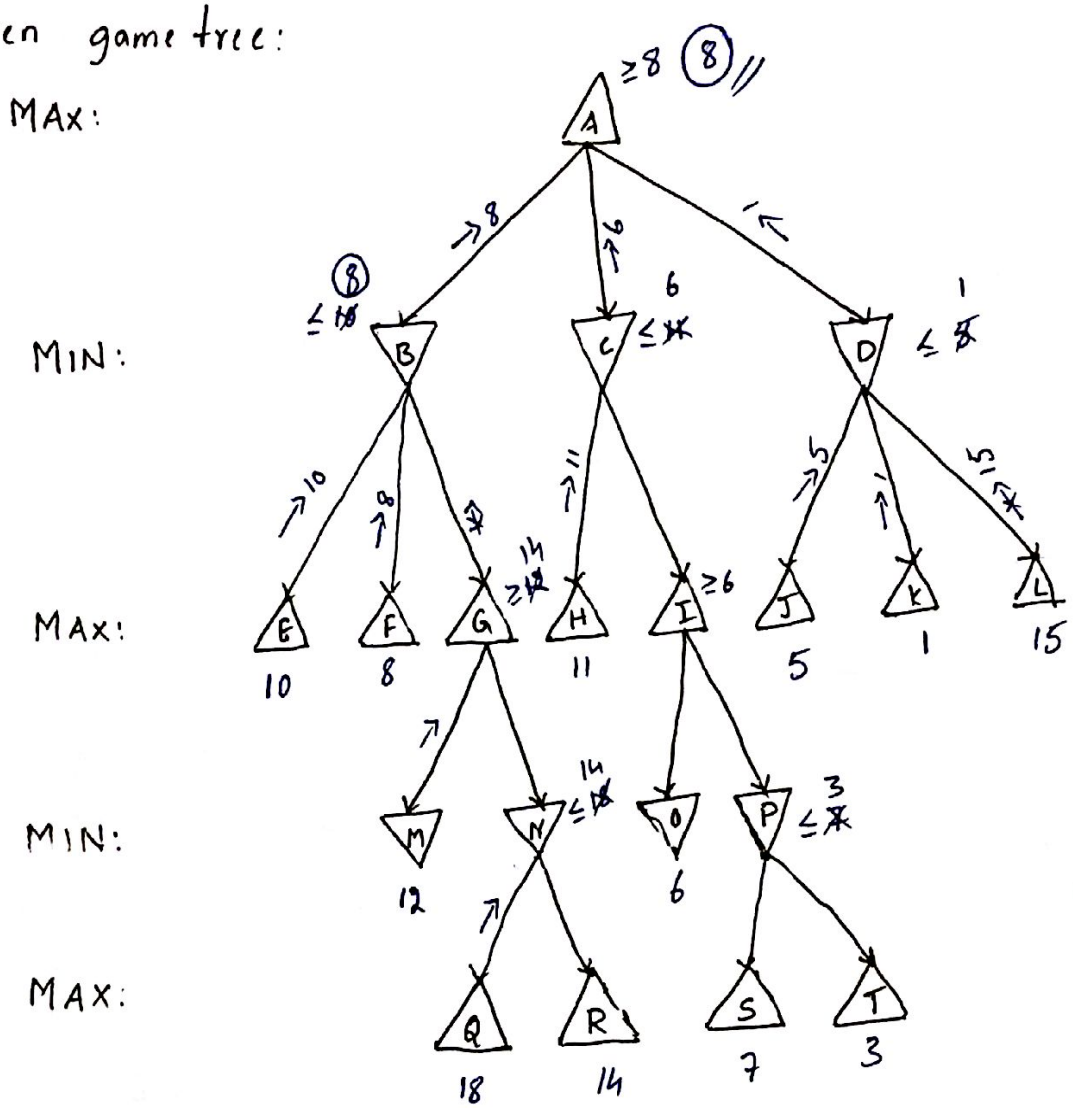
PROBLEM-I

MIN-MAX ALGORITHM.

Given game tree:



* Min-Max algorithm is implemented using Depth-First Search.

OBSERVATIONS/ IMPLEMENTATION:

→ Every MAX node tries to maximize its value from the nodes below it.

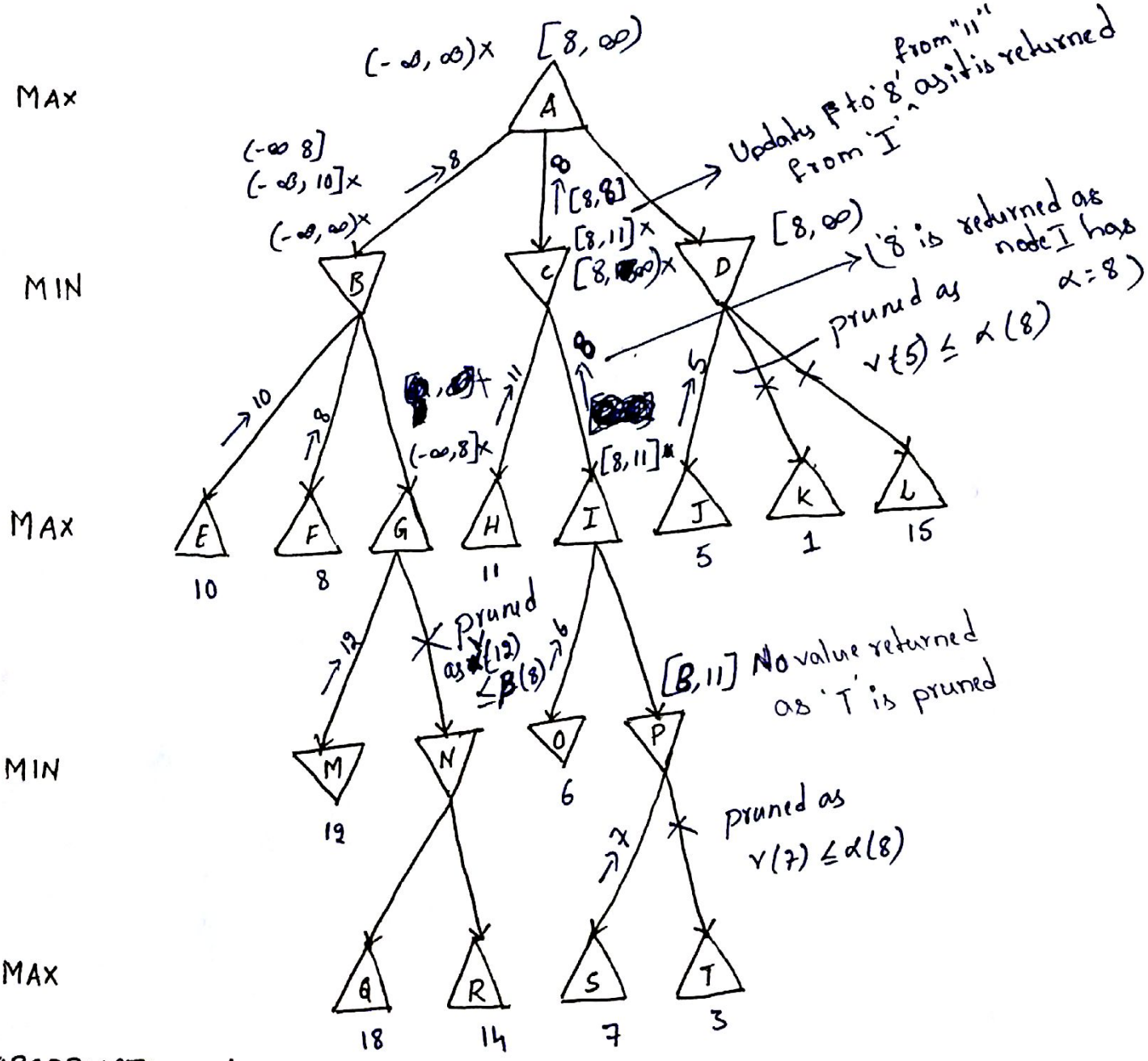
→ Every MIN node tries to minimize its value from the child nodes below it.

By Implementing this the maximum utility that MAX can achieve is "8"// Path: A → B → F

MAX MIN MAX

PROBLEM - II

ALPHA - BETA PRUNING.



OBSERVATIONS / IMPLEMENTATION:

* Alpha - Beta Pruning algorithm is implemented using Depth - First Search.
* Bounds on nodes are specified in the above graph.
* The following nodes are pruned N{Q, R}, T, K, L
* The maximum utility that MAX can achieve is "8".

Hence Alpha - Beta Pruning //

PROBLEM-III BACKTRACKING SEARCH ①

Given Variables:

A: {4, 5, 6, 7, 8}

B: {10, 20, 30, 40}

C: {2, 3, 4}

D: {32, 43, 56, 75, 92, 113}.

Var: MRV, DEG, ALPH.

Val: LCV, Increasing Value.

Infer: Forward Checking

Given Constraints:

* A+C is odd.
* A+D is a square of an Integer
* B+D < 60.

→ The Minimum Remaining Value among A, B, C, D has '3' which is for 'C' Hence C: {2, 3, 4} => We have to calculate LCV(C) which is shown below.

C:2

A: {4, 5, 6, 7, 8} - 3

B: {10, 20, 30, 40}

C: 2

D: {32, 43, 56, 75, 92, 113} — 3

C: 3

A: {4, 5, 6, 7, 8} - 2

B: {10, 20, 30, 40}

C: 3

D: {32, 43, 56, 75, 92, 113} — 2

C:4

A: {4, 5, 6, 7, 8} - 3

B: {10, 20, 30, 40}

C: 4

D: {32, 43, 56, 75, 92, 113} — 3

Hence C:3 is considered as per least Constraint Value.

=> ①

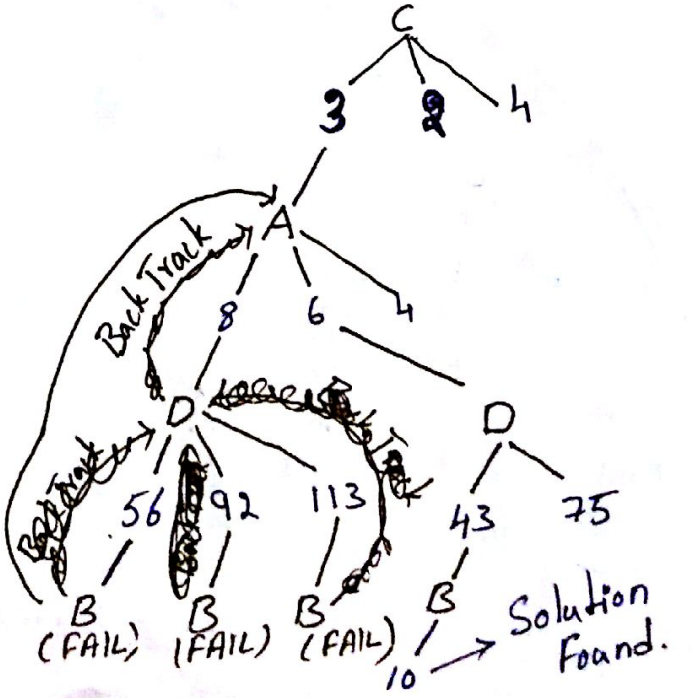
C: 3

A: {4, 8}

B: {10, 20, 30, 40}

C: 3

D: {32, 43, 56, 75, 92, 113}



BACKTRACKING SEARCH ③

* Now We have to calculate LCV(A) as A has minimum Remaining Values

LCV(A): A: {4, 6, 8}

A = 4

A: 4
B: {10, 20, 30, 40}
C: 3
D: {32, ~~43~~, ~~56~~, ~~75~~, ~~92~~, ~~113~~} ⑤

5

A = 6

A: 6
B: {10, 20, 30, 40}
C: 3
D: {~~32~~, 43, ~~56~~, 75, ~~92~~, ~~113~~} ④

4

A: 8

A: 8
B: {10, 20, 30, 40}
C: 3
D: {~~32~~, ~~43~~, 56, ~~75~~, 92, 113} ③

3

Hence the LCV(A) = 8, 6, 4 in order. So We have to consider A: 8.

A: 8

A: 8
B: {10, 20, 30, 40}
C: 3
D: {56, 92, 113}

* Now We have to calculate LCV(D) as D has Minimum Remaining Values.

LCV(D): D: {56, 92, 113}

D = 56

A: 4
B: {~~10~~, ~~20~~, ~~30~~, ~~40~~} ④
C: 3
D: {56

4

D: 92

A: 4
B: {~~10~~, ~~20~~, ~~30~~, ~~40~~} ④
C: 3
D: 92

4

D: 113

A: 4
B: {~~10~~, ~~20~~, ~~30~~, ~~40~~} ④
C: 3
D: 113

4

As LCV(D) is same We have to go by Increasing Values

D: 56

A: 4
B: { } ∅
C: 3
D: 56

D: 92

A: 4
B: { } ∅
C: 3
D: 92

D: 113

A: 4
B: { } ∅
C: 3
D: 92

As there are Empty or (∅) Null Values for variable 'B' When D: {56, 92, 113} We have to back track now to variable A Which has possibilities {6, 4} remained.

Now A: {6, 8} ∧ LCV(A{6}) < LCV(A{4})

⇒ A: 6

A: 6
B: {10}
C: 3
D: {43, 75}

We have to consider variable 'B' as MRV of B is '1'

B: 10

A: 6
B: 10
C: 3
D: {43}

left out

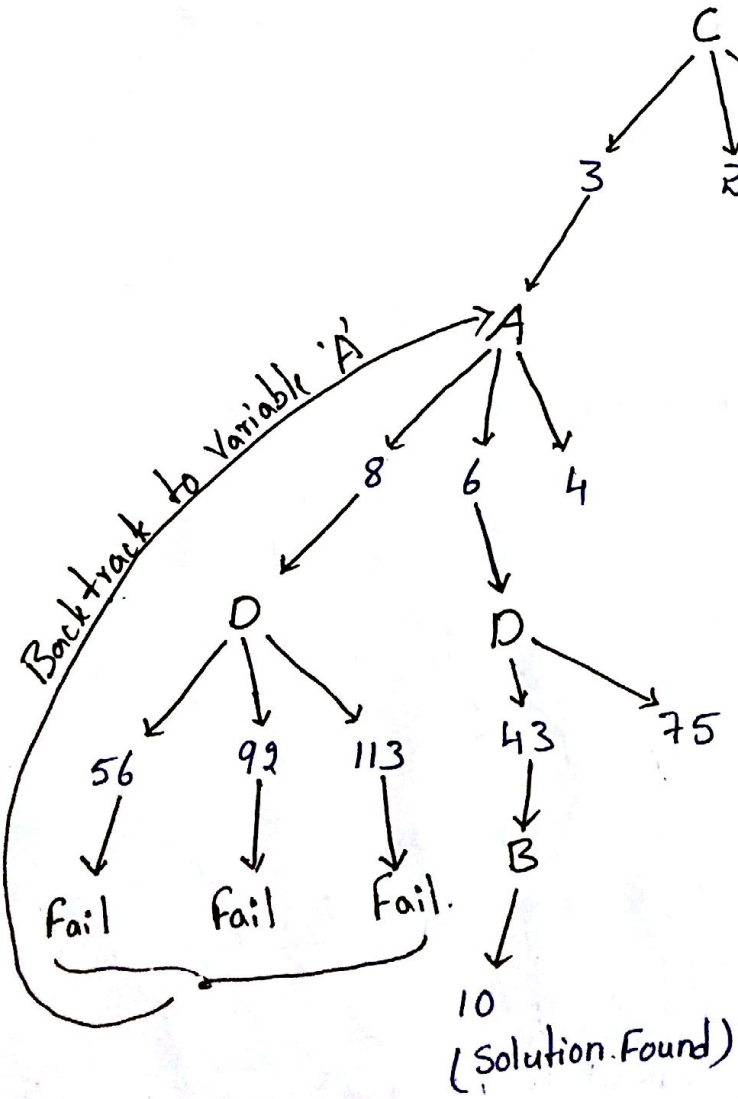
Variable with MRV '1' is 'D'

Hence. D: 43

A: 6
B: 10
C: 3
D: 43

Hence, Solution Reached. The graph for this approach is plotted below.

Solution A: 6, B: 10, C: 3, D: 43



Given Conditions

1. A+C is odd
   6+3 = 9 is odd
2. A+D is a square of an Integer
   6+43 = 49 ⇒ 7×7 Square(7)
3. B+D < 60
   10+43 = 53 < 60.

Satisfying all the conditions.

PROBLEM - IV CRYPTARITHMETIC PROBLEM - BACKTRACKING SEARCH. (1)

Given Variables:

O: {7,8,9}

R: {0,2,3,4,5,6,7,8,9}

W: {5,6,7,8,9}

U: {0,2,3,4,5,6,7,8,9}

T: {5,6,7,8,9}

Given Conditions

F = 1

O+O = 10+R

W+W+1 = 10+U

T+T+1 = 10+O

```
  TWO
+ TWO
-------
 FOUR
```

Var: MRV, {O,R,W,U,T}

Val: Increasing Order

Inference: Forward Checking

→ From the given variables the MRV is least for variable 'O'. & by Increasing Order Values.

O: {7,8,9} => O:7 is considered first

O: 7

O: ~~7~~

R: {~~0~~, ~~2~~, ~~3~~, 4, ~~5~~, ~~6~~, ~~7~~, ~~8~~, ~~9~~}

W: {5, 6, ~~7~~, 8, 9}

U: {0, 2, 3, 4, 5, 6, ~~7~~, 8, 9}

T: {~~5~~, ~~6~~, ~~7~~, 8, ~~9~~}

⇓

O: 7

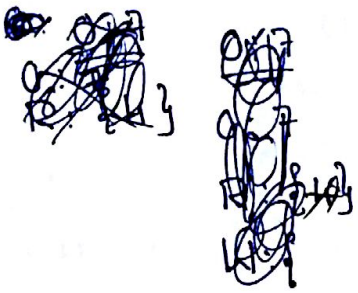
O: 7

R: {4}

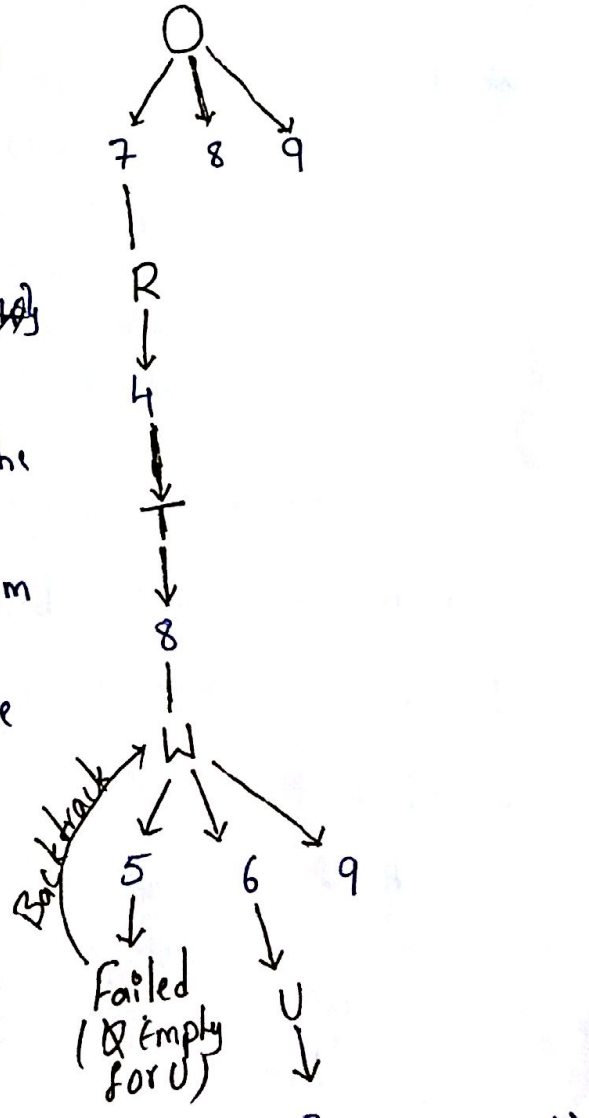
W: {5, 6, 8, 9}

U: {0, 2, 3, 4, 5, 6, 8, 9}

T: {8}



The following is the graph for the Search algorithm



* Minimum Remaining Value for variables R & T is '1'

Hence we go by variable ordering {O,R,W,U,T}

⇒ R appears first.

Hence R: 4 is considered

R:4
O:7
R:4
W:{5,6,8,9}
U:{0,2,3,5,6,8,9}
T:{8}

MRV for variable 'T' is 1

T:8
O:7
R:4
W:{5,6,8,9}
U:{0,2,3,5,6,8,9}
T:8

By MRV variable selected is W ⇒ Increasing values in W is considered.
⇒ W=5 is considered

W:5
O:7
R:4
W:{5
U:{} ∅ Empty
T:8.

Failed So Back Track to T:8 node as search for other value of W i.e; W=6 is considered. ⇒

W:6
O:7
R:4
W:6
U:{3}
T:8

MRV of U:1 ⇒

U=3
O:7
R:4
W:6
U:3
T:8

Hence Solution Reached. Path: O{7} → R{4} → T{8} → W{6} → U{3}

Given Conditions & Substituting the Solution values

1. O+O = 1Ø+R ⇒ 7+7 = 1Ø+4 → true
2. W+W+1 = 1Ø+U ⇒ 6+6+1 = 1Ø+3 → true
3. T+T+1 = 1Ø+O ⇒ 8+8+1 = 1Ø+7 → true

```
  TWO        Given F=1     8 6 7
+ TWO    ⇒                 8 6 7
------                   -------
 FOUR                     1 7 3 4
```

Hence, Solution