Heuristic Function

The heuristic function is the sum of the path length of individual tiles from current location to the goal location.

The path length is calculated using following conditions: -

1. Tile is in 0-180: -
   1. Goal State is in 90-270: - Distance is the number of moves to reach (0,0) or (180,180) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on 90-270.
      1. E.g. Tile = (30,0) and Goal = (30,90)

Distance from (30,0) to (0,0) = 1

Distance from (0,0) to (30,90) = 1

Total Distance = 2

* 1. Goal State is in equator: - Distance is the number of moves to reach (90,0) or (90,180) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on equator.
     1. E.g. Tile = (30,0) and Goal = (90,60)

Distance from (30,0) to (0,0) = 1

Distance from (0,0) to (90,60) = 2

Total Distance = 3

* 1. Goal state is in 0-180 itself: - Distance is the number of move to reach there.
     1. E.g. Tile = (150,0) and Goal = (180,180)

Distance = 1

1. Tile is in 90-270: -
   1. Goal State is in 0-180: - Distance is the number of moves to reach (0,0) or (180,180) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on 0-180.
      1. E.g. Tile = (30,90) and Goal = (30,0)

Distance from (30,90) to (0,0) = 1

Distance from (0,0) to (30,0) = 1

Total Distance = 2

* 1. Goal State is in equator: - Distance is the number of moves to reach (90,90) or (90,270) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on equator.
     1. E.g. Tile = (30,90) and Goal = (90,60)

Distance from (30,90) to (90,90) = 2

Distance from (90,90) to (90,60) = 1

Total Distance = 3

* 1. Goal state is in 90-270 itself: - Distance is the number of move to reach there.
     1. E.g. Tile = (150,90) and Goal = (150,270)

Distance = 2

1. Tile is in equator: -
   1. Goal State is in 0-180: - Distance is the number of moves to reach (90,0) or (90,180) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on 0-180.
      1. E.g. Tile = (90,60) and Goal = (30,0)

Distance from (90,60) to (0,0) = 1

Distance from (0,0) to (30,0) = 1

Total Distance = 2

* 1. Goal State is in equator: - Distance is the number of moves to reach (90,90) or (90,270) location on axis as they are the intersection points and also the number of moves from there to reach the goal coordinate on 90-270.
     1. E.g. Tile = (90,60) and Goal = (30,90)

Distance from (90,60) to (90,90) = 1

Distance from (90,90) to (30,90) = 2

Total Distance = 3

* 1. Goal state is in equator itself: - Distance is the number of move to reach there.
     1. E.g. Tile = (90,90) and Goal = (90,270)

Distance = 6

So the heuristic cost is given by above conditions and total cost is given by

Where g(x) is total cost,

h(x) is the heuristic cost,

f(x) is the path cost given by height of node \* 12

This heuristic gives good results because we are calculating the path required to transfer from one tile position to another keeping in mind, we don’t disrupt the other tiles which is practically possible using certain moves. Over overall aim is to do that only so if we calculate the heuristic cost for each tile and sum it up, then we can say that which move will take minimal steps to reach the goal. The constant ‘12’ is derived from the total number of tiles which move when we rotate any axis by 30 ° which is equal to 1 state change for this search.

Also, we can consider that

∀n: h(n) ≤ c (n, a, n′) + h(n′)

is true because,

We can consider a state at level n and another state at level n′. Our goal state is c. Then the cost we calculate is based on the movement of tiles. So after each level 12 of our tiles are moved.

Suppose h(n) is the cost to go from level n to n′,

Then the cost h(n′),

h(n) + 0 ≤ h(n′) ≤ h(n) + 24

Considering left bound which can be achieved if we reach goal state and on the other hand upper bound can be achieved when we disrupt each and every tile in the axis and the path required to reach the goal increases by 2 moves for each of the 12 tiles.

Now we know that c (n, a, n′) is 12 because transition from one level to another takes 12 cost as defined earlier.

So,

h(n) ≤ h(n′), ∀n

h(n) ≤ h(n′) + c (n, a, n′), ∀n

Hence the heuristic is admissible.

**Analysis**

**Summary Report For A\***

States Expanded:

Min = ﻿31,

Max = 2985832,

Average = 285285

Max Queue:

Min = ﻿ ﻿126,

Max = 11594420,

Average = ﻿1107336.5

The Hardest Puzzle For A\* is “Puzzle2-10” because it expands the maximum number of states i.e. 2985832.

**Summary Report For RBFS**

States Expanded:

Min = ﻿﻿25,

Max = 542964,

Average = 71427.923

Max Queue:

Min = ﻿ ﻿150,

Max = 3257784,

Average = ﻿428567.538

The Hardest Puzzle for RBFS is “Puzzle2-1” because it expands the maximum number of states i.e. 542964.

**Summary Report For BFS**

Only Puzzle2-3 completed the goal which was achieved at level 8. Other all were terminated after 1800 seconds.

States Expanded:

Min = 389693﻿,

Max = 616,

Average = Unbound

Max Queue:

Min = ﻿ ﻿1529823,

Max = Unbound,

Average = ﻿ Unbound

The Hardest Puzzle for BFS is “Puzzle2-10” because it will go till level 16 and for BFS the deeper the level hard is the goal to achieve.

Best Algorithm for This Problem

By doing analysis on all the algorithms, ‘**A\*’** works best for this problem because though RBFS is faster than A\* theoretically but for this problem it goes into loops sometimes which increases time required to execute as well as it doesn’t guarantee an optimal path when RBFS is used whereas when A\* is used we will always get optimal path. Apart from these 2, BFS is also optimal but it will discover all the states which will increase the time complexity exponentially compared to A\* and RBFS so BFS is also not suitable for this problem.

**Detailed Results**

**Detailed Results for Each Puzzle using A\***

1. Puzzle2-0

a. States Expanded: 197765

b. Maximum Queue: 777112

c. Path Length: 13

d. Path:

i decrease\_90-270

ii increase\_Equator

iii decrease\_0-180

iv decrease\_Equator

v decrease\_Equator

vi increase\_0-180

vii increase\_90-270

viii increase\_0-180

ix increase\_90-270

x increase\_0-180

xi increase\_90-270

xii increase\_Equator

xiii increase\_0-180

e. Time Taken: 98.67

2. Puzzle2-1

a. States Expanded: 82472

b. Maximum Queue: 328390

c. Path Length: 14

d. Path:

i increase\_0-180

ii increase\_0-180

iii increase\_90-270

iv decrease\_0-180

v increase\_90-270

vi increase\_Equator

vii increase\_0-180

viii increase\_Equator

ix increase\_0-180

x increase\_0-180

xi increase\_Equator

xii decrease\_90-270

xiii increase\_Equator

xiv decrease\_90-270

e. Time Taken: 39.74

3. Puzzle2-2

a. States Expanded: 31

b. Maximum Queue: 126

c. Path Length: 9

d. Path:

i decrease\_90-270

ii decrease\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_Equator

vi decrease\_90-270

vii increase\_Equator

viii increase\_90-270

ix decrease\_0-180

e. Time Taken: 0.02

4. Puzzle2-3

a. States Expanded: 753

b. Maximum Queue: 3001

c. Path Length: 8

d. Path:

i increase\_Equator

ii increase\_0-180

iii decrease\_90-270

iv decrease\_Equator

v increase\_90-270

vi increase\_90-270

vii decrease\_Equator

viii increase\_0-180

e. Time Taken: 0.35

5. Puzzle2-4

a. States Expanded: 4012

b. Maximum Queue: 15875

c. Path Length: 11

d. Path:

i increase\_0-180

ii increase\_90-270

iii increase\_Equator

iv decrease\_90-270

v increase\_Equator

vi increase\_0-180

vii increase\_90-270

viii decrease\_0-180

ix increase\_Equator

x decrease\_0-180

xi decrease\_0-180

e. Time Taken: 1.82

6. Puzzle2-5

a. States Expanded: 1204

b. Maximum Queue: 4817

c. Path Length: 12

d. Path:

i decrease\_90-270

ii decrease\_90-270

iii decrease\_Equator

iv increase\_90-270

v decrease\_Equator

vi decrease\_Equator

vii increase\_0-180

viii increase\_0-180

ix increase\_Equator

x increase\_0-180

xi increase\_0-180

xii increase\_0-180

e. Time Taken: 0.55

7. Puzzle2-6

a. States Expanded: 34755

b. Maximum Queue: 138781

c. Path Length: 16

d. Path:

i increase\_90-270

ii increase\_Equator

iii increase\_Equator

iv decrease\_90-270

v decrease\_90-270

vi decrease\_90-270

vii decrease\_90-270

viii increase\_Equator

ix increase\_Equator

x increase\_0-180

xi increase\_Equator

xii increase\_0-180

xiii decrease\_90-270

xiv decrease\_Equator

xv decrease\_90-270

xvi decrease\_90-270

e. Time Taken: 18.32

8. Puzzle2-7

a. States Expanded: 317182

b. Maximum Queue: 1243840

c. Path Length: 16

d. Path:

i increase\_0-180

ii decrease\_Equator

iii increase\_0-180

iv decrease\_90-270

v increase\_Equator

vi increase\_0-180

vii decrease\_90-270

viii increase\_0-180

ix increase\_0-180

x increase\_0-180

xi increase\_0-180

xii increase\_90-270

xiii increase\_Equator

xiv increase\_0-180

xv decrease\_Equator

xvi increase\_0-180

e. Time Taken: 179.12

9. Puzzle2-8

a. States Expanded: 439

b. Maximum Queue: 1740

c. Path Length: 7

d. Path:

i decrease\_Equator

ii decrease\_0-180

iii decrease\_0-180

iv decrease\_90-270

v increase\_0-180

vi increase\_90-270

vii increase\_0-180

e. Time Taken: 0.19

10. Puzzle2-9

a. States Expanded: 1159

b. Maximum Queue: 4633

c. Path Length: 10

d. Path:

i increase\_0-180

ii increase\_90-270

iii increase\_90-270

iv increase\_Equator

v increase\_0-180

vi decrease\_Equator

vii decrease\_Equator

viii increase\_90-270

ix increase\_0-180

x increase\_0-180

e. Time Taken: 0.59

11. Puzzle2-10

a. States Expanded: 2985832

b. Maximum Queue: 11594420

c. Path Length: 16

d. Path:

i increase\_Equator

ii decrease\_90-270

iii increase\_0-180

iv increase\_90-270

v increase\_Equator

vi decrease\_90-270

vii increase\_0-180

viii decrease\_90-270

ix decrease\_90-270

x increase\_0-180

xi increase\_90-270

xii increase\_Equator

xiii increase\_90-270

xiv increase\_90-270

xv increase\_0-180

xvi decrease\_Equator

e. Time Taken: 3658.54

12. Puzzle2-11

a. States Expanded: 63

b. Maximum Queue: 254

c. Path Length: 7

d. Path:

i decrease\_Equator

ii decrease\_Equator

iii decrease\_90-270

iv decrease\_Equator

v increase\_90-270

vi decrease\_0-180

vii increase\_90-270

e. Time Taken: 0.03

13. Puzzle2-12

a. States Expanded: 84

b. Maximum Queue: 338

c. Path Length: 7

d. Path:

i decrease\_0-180

ii decrease\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_0-180

vi decrease\_Equator

vii decrease\_90-270

e. Time Taken: 0.04

14. Puzzle2-13

a. States Expanded: 79307

b. Maximum Queue: 307474

c. Path Length: 13

d. Path:

i decrease\_0-180

ii decrease\_Equator

iii decrease\_90-270

iv decrease\_0-180

v increase\_Equator

vi increase\_Equator

vii increase\_0-180

viii increase\_90-270

ix decrease\_Equator

x decrease\_Equator

xi increase\_0-180

xii increase\_90-270

xiii decrease\_0-180

e. Time Taken: 44.92

15. Puzzle2-14

a. States Expanded: 9144

b. Maximum Queue: 36423

c. Path Length: 12

d. Path:

i decrease\_90-270

ii increase\_0-180

iii increase\_0-180

iv decrease\_Equator

v increase\_0-180

vi increase\_0-180

vii decrease\_90-270

viii decrease\_90-270

ix decrease\_Equator

x decrease\_0-180

xi decrease\_0-180

xii decrease\_90-270

e. Time Taken: 4.87

16. Puzzle2-15

a. States Expanded: 9713

b. Maximum Queue: 37795

c. Path Length: 10

d. Path:

i increase\_0-180

ii decrease\_Equator

iii decrease\_0-180

iv decrease\_0-180

v increase\_90-270

vi increase\_Equator

vii decrease\_90-270

viii increase\_0-180

ix decrease\_Equator

x decrease\_90-270

e. Time Taken: 5.32

17. Puzzle2-16

a. States Expanded: 590

b. Maximum Queue: 2361

c. Path Length: 8

d. Path:

i increase\_0-180

ii decrease\_90-270

iii increase\_Equator

iv decrease\_0-180

v decrease\_0-180

vi increase\_Equator

vii decrease\_0-180

viii increase\_90-270

e. Time Taken: 0.3

18. Puzzle2-17

a. States Expanded: 1769900

b. Maximum Queue: 6834217

c. Path Length: 15

d. Path:

i increase\_Equator

ii increase\_Equator

iii decrease\_0-180

iv increase\_90-270

v increase\_Equator

vi decrease\_90-270

vii decrease\_0-180

viii decrease\_90-270

ix decrease\_Equator

x decrease\_Equator

xi increase\_0-180

xii increase\_0-180

xiii increase\_0-180

xiv increase\_90-270

xv increase\_Equator

e. Time Taken: 1598.15

19. Puzzle2-18

a. States Expanded: 4573

b. Maximum Queue: 18107

c. Path Length: 12

d. Path:

i increase\_Equator

ii increase\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_Equator

vi decrease\_90-270

vii decrease\_90-270

viii increase\_0-180

ix decrease\_Equator

x increase\_90-270

xi increase\_90-270

xii decrease\_0-180

e. Time Taken: 2.39

20. Puzzle2-19

a. States Expanded: 206722

b. Maximum Queue: 797026

c. Path Length: 13

d. Path:

i increase\_Equator

ii decrease\_0-180

iii decrease\_90-270

iv increase\_0-180

v decrease\_Equator

vi increase\_90-270

vii decrease\_Equator

viii increase\_0-180

ix increase\_0-180

x increase\_90-270

xi increase\_Equator

xii decrease\_90-270

xiii increase\_Equator

e. Time Taken: 117.75

**Detailed Results for Each Puzzle using RBFS**

1. Puzzle2-0

Terminated after 40 Mins. Following are the variables when terminated

a. States Expanded: 578932

b. Maximum Queue: 3473592

e. Time Taken: 2405.31

2. Puzzle2-1

a. States Expanded: 542964

b. Maximum Queue: 3257784

c. Path Length: 16

d. Path:

i increase\_0-180

ii increase\_0-180

iii increase\_90-270

iv decrease\_0-180

v increase\_90-270

vi increase\_Equator

vii increase\_0-180

viii increase\_Equator

ix increase\_0-180

x increase\_0-180

xi increase\_Equator

xii decrease\_90-270

xiii increase\_Equator

xiv decrease\_0-180

xv increase\_0-180

xvi decrease\_90-270

e. Time Taken: 348.58

3. Puzzle2-2

a. States Expanded: 25

b. Maximum Queue: 150

c. Path Length: 9

d. Path:

i decrease\_90-270

ii decrease\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_Equator

vi decrease\_90-270

vii increase\_Equator

viii increase\_90-270

ix decrease\_0-180

e. Time Taken: 0.04

4. Puzzle2-3

a. States Expanded: 7982

b. Maximum Queue: 47892

c. Path Length: 8

d. Path:

i increase\_Equator

ii increase\_0-180

iii decrease\_90-270

iv decrease\_Equator

v increase\_90-270

vi increase\_90-270

vii decrease\_Equator

viii increase\_0-180

e. Time Taken: 4.31

5. Puzzle2-4

a. States Expanded: 70981

b. Maximum Queue: 425886

c. Path Length: 11

d. Path:

i increase\_0-180

ii increase\_90-270

iii increase\_Equator

iv decrease\_90-270

v increase\_Equator

vi increase\_0-180

vii increase\_90-270

viii decrease\_0-180

ix increase\_Equator

x decrease\_0-180

xi decrease\_0-180

e. Time Taken: 44.09

6. Puzzle2-5

a. States Expanded: 11670

b. Maximum Queue: 70020

c. Path Length: 12

d. Path:

i decrease\_90-270

ii decrease\_90-270

iii decrease\_Equator

iv increase\_90-270

v decrease\_Equator

vi decrease\_Equator

vii increase\_0-180

viii increase\_0-180

ix increase\_Equator

x increase\_0-180

xi increase\_0-180

xii increase\_0-180

e. Time Taken: 7.59

7. Puzzle2-6

a. States Expanded: 168450

b. Maximum Queue: 1010700

c. Path Length: 16

d. Path:

i increase\_90-270

ii increase\_Equator

iii increase\_Equator

iv decrease\_90-270

v decrease\_90-270

vi decrease\_90-270

vii decrease\_90-270

viii increase\_Equator

ix increase\_Equator

x increase\_0-180

xi increase\_Equator

xii increase\_0-180

xiii decrease\_90-270

xiv decrease\_Equator

xv decrease\_90-270

xvi decrease\_90-270

e. Time Taken: 97.22

8. Puzzle2-7

Terminated after 40 Mins. Following are the variables when terminated

a. States Expanded: 4135725

b. Maximum Queue: 24814350

e. Time Taken: 2400.04

9. Puzzle2-8

a. States Expanded: 14731

b. Maximum Queue: 88386

c. Path Length: 7

d. Path:

i decrease\_Equator

ii decrease\_0-180

iii decrease\_0-180

iv decrease\_90-270

v increase\_0-180

vi increase\_90-270

vii increase\_0-180

e. Time Taken: 7.94

10. Puzzle2-9

a. States Expanded: 5725

b. Maximum Queue: 34350

c. Path Length: 10

d. Path:

i increase\_0-180

ii increase\_90-270

iii increase\_90-270

iv increase\_Equator

v increase\_0-180

vi decrease\_Equator

vii decrease\_Equator

viii increase\_90-270

ix increase\_0-180

x increase\_0-180

e. Time Taken: 3.33

11. Puzzle2-10

Terminated after 40 Mins. Following are the variables when terminated

a. States Expanded: 6944828

b. Maximum Queue: 41668968

e. Time Taken: 2400.04

12. Puzzle2-11

a. States Expanded: 167

b. Maximum Queue: 1002

c. Path Length: 7

d. Path:

i decrease\_Equator

ii decrease\_Equator

iii decrease\_90-270

iv decrease\_Equator

v increase\_90-270

vi decrease\_0-180

vii increase\_90-270

e. Time Taken: 0.12

13. Puzzle2-12

a. States Expanded: 199

b. Maximum Queue: 1194

c. Path Length: 7

d. Path:

i decrease\_0-180

ii decrease\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_0-180

vi decrease\_Equator

vii decrease\_90-270

e. Time Taken: 0.15

14. Puzzle2-13

a. States Expanded: 5553135

b. Maximum Queue: 33318810

c. Path Length: 13

d. Path:

i decrease\_0-180

ii decrease\_Equator

iii decrease\_90-270

iv decrease\_0-180

v increase\_Equator

vi increase\_Equator

vii increase\_0-180

viii increase\_90-270

ix decrease\_Equator

x decrease\_Equator

xi increase\_0-180

xii increase\_90-270

xiii decrease\_0-180

e. Time Taken: 6321.23

15. Puzzle2-14

a. States Expanded: 52784

b. Maximum Queue: 316704

c. Path Length: 14

d. Path:

i decrease\_90-270

ii increase\_0-180

iii increase\_0-180

iv decrease\_Equator

v increase\_0-180

vi increase\_0-180

vii decrease\_90-270

viii decrease\_90-270

ix decrease\_Equator

x decrease\_0-180

xi decrease\_0-180

xii decrease\_0-180

xiii increase\_0-180

xiv decrease\_90-270

e. Time Taken: 26.66

16. Puzzle2-15

a. States Expanded: 950247

b. Maximum Queue: 5701482

c. Path Length: 10

d. Path:

i increase\_0-180

ii decrease\_Equator

iii decrease\_0-180

iv increase\_90-270

v decrease\_0-180

vi increase\_Equator

vii increase\_0-180

viii decrease\_90-270

ix decrease\_Equator

x decrease\_90-270

e. Time Taken: 394.25

17. Puzzle2-16

a. States Expanded: 2613

b. Maximum Queue: 15678

c. Path Length: 10

d. Path:

i increase\_0-180

ii decrease\_90-270

iii increase\_Equator

iv decrease\_0-180

v decrease\_0-180

vi increase\_Equator

vii decrease\_0-180

viii decrease\_0-180

ix increase\_0-180

x increase\_90-270

e. Time Taken: 1.41

18. Puzzle2-17

Terminated after 40 Mins. Following are the variables when terminated

a. States Expanded: 10189223

b. Maximum Queue: 61135338

e. Time Taken: 2402.83

19. Puzzle2-18

a. States Expanded: 50272

b. Maximum Queue: 301632

c. Path Length: 12

d. Path:

i increase\_Equator

ii increase\_90-270

iii increase\_Equator

iv increase\_Equator

v increase\_Equator

vi decrease\_90-270

vii decrease\_90-270

viii increase\_0-180

ix decrease\_Equator

x increase\_90-270

xi increase\_90-270

xii decrease\_0-180

e. Time Taken: 32.43

20. Puzzle2-19

Terminated after 40 Mins.Following are the variables when terminated.

a. States Expanded: 11963978

b. Maximum Queue: 71783868

e. Time Taken: 2427.8

**Detailed Results for Each Puzzle using BFS**

1. Puzzle2-0

Terminated after 30 Mins. Following are the variables when terminated

a. States Expanded: 869769

b. Maximum Queue: 3408406

e. Time Taken: 1822.98

2. Puzzle2-1

Terminated after 30 Mins. Following are the variables when terminated

a. States Expanded: 393175

b. Maximum Queue: 1543489

e. Time Taken: 1861.81

3. Puzzle2-2

Terminated after 30 Mins. Following are the variables when terminated

a. States Expanded: 419151

b. Maximum Queue: 1645452

e. Time Taken: 1801.91

4. Puzzle2-3

a. States Expanded: 389693

b. Maximum Queue: 1529823

c. Path Length: 8

d. Path:

i increase\_Equator

ii increase\_0-180

iii decrease\_90-270

iv decrease\_Equator

v increase\_90-270

vi increase\_90-270

vii decrease\_Equator

viii increase\_0-180

e. Time Taken: 182.62

5. Puzzle2-4

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 1004588

b. Maximum Queue: 3934964

e. Time Taken: 1804.93

6. Puzzle2-5

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 1012817

b. Maximum Queue: 3967183

e. Time Taken: 1804.27

7. Puzzle2-6

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 1005369

b. Maximum Queue: 3938035

e. Time Taken: 1804.54

8. Puzzle2-7

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 837481

b. Maximum Queue: 3282000

e. Time Taken: 1832.59

9. Puzzle2-8

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 321787

b. Maximum Queue: 1263279

e. Time Taken: 1813.44

10. Puzzle2-9

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 361265

b. Maximum Queue: 1418200

e. Time Taken: 1806.62

11. Puzzle2-10

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 823059

b. Maximum Queue: 3225517

e. Time Taken: 1890.56

12. Puzzle2-11

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 938713

b. Maximum Queue: 3677601

e. Time Taken: 1859.18

13. Puzzle2-12

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 899424

b. Maximum Queue: 3524423

e. Time Taken: 1805.06

14. Puzzle2-13

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 952217

b. Maximum Queue: 3730524

e. Time Taken: 1806.13

15. Puzzle2-14

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 892337

b. Maximum Queue: 3496642

e. Time Taken: 1805.27

16. Puzzle2-15

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 488376

b. Maximum Queue: 1917248

e. Time Taken: 1899.7

17. Puzzle2-16

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 114138

b. Maximum Queue: 448786

e. Time Taken: 1862.91

18. Puzzle2-17

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 942193

b. Maximum Queue: 3691264

e. Time Taken: 1806.37

19. Puzzle2-18

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 922921

b. Maximum Queue: 3616231

e. Time Taken: 1811.23

20. Puzzle2-19

Terminated after 30 Mins.Following are the variables when terminated

a. States Expanded: 876597

b. Maximum Queue: 3435157

e. Time Taken: 1814.0