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PART 1 : Course Schedule

CSP problem specification:

1. Variables: CourseID
2. Domain: Possible Assignment of semester number to courses(Real numbers)
3. Constraints:
   3.a Semester number should be a positive number
   3.b A zero for a semester value indicates the course is not included in the schedule
   3.c For a given course 'C' and a semester number 'S' assigned to it, its dependent courses cannot have a semester number greater than equal to 'S'.
   3.d For a given semester the sum of credit hours for all courses taken in that semester should lie between CMin and CMax
   3.e The total prices of courses included in the schedule plan must be less than or equal to the assigned budget B

Discussion of Design Decisions for the implementation of the CSP:

a. Choices of variable - The number the courses that would be included in the final course plan is unknown. So we decided to keep a fixed size array of courses. A non zero value for a given course index indicates a semester number. A zero indicates that the course has not been included in the schedule.
b. Value selection heuristic -
   i. Before assigning a semester to a course 'C', we first check the semester values assigned to C's pre-requisite courses. The loop for assigning semester values to C, begins with a semester number which is one higher than the highest semester value assigned to C's pre-requisite courses.
   ii. If a course C does not have any prerequisite, then, start assigning values of minimum possible semester where this course C can be added without violating the MIN and MAX course credits constraint and it also does not violate any constraint w.r.t to courses assigned in previous semester.
b. Improvements for reduced backtracking -
   i. To reduce the amount of back tracking, first we check all the "dependent" courses for a "interested" course and promote them to become an "interested" course (since this "dependent" course becomes a "mandatory" course in-order to graduate).
   ii. We compute the dependency graph of the courses where edge specifies the pre-requisite for a course and then run topology sort to find an ordering of variable(courseID) selection so that it satisfies the constraint of dependencies among courses.

Course schedule output log

[Note - Following logs are for a course plan which is within the given budget]

first.txt
4135 4
3 5 6 9
2 2 8
2 3 7
3 1 4 10
1805 770 1124 436
Number of incomplete assignments made = 854140

second.txt
5288 4
7 1 3 8 12 14 15 19
5 4 6 7 11 18
3 13 16 17
3 2 5 20
3330 745 783 430
Number of incomplete assignments made = 40031498

third.txt
4961 5
5 8 12 13 21 22
3 7 27 28
3 3 20 25
4 5 14 15 17
3 1 16 30
1512 711 587 1150 1001
Number of incomplete assignments made = 1725893907

fourth.txt
5719 5
5 2 14 19 31 38
2 12 34
4 9 13 26 28
4 3 17 18 35
2 16 21
2247 1403 646 1228 195
Number of assignments made = 4251

PART 2 :War Game Report

Below are the details for each board and match up combination.

We list the winner, each player's scores, average nodes expanded per move and average time taken to make a move along with the final board state at the end of the game.
The matchups were run with depth 3 for all the boards. We observed that we could go depths greater than 3 for few boards (MiniMax Agent) and upto depth 6 with AlphaBeta Agent for few boards.
The details are listed in the report in section 2 under Bonus Work.

Section 1

Playing at depth 3 for all the agents:

BOARD : Keren.txt

1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1

MATCH TYPE : Minimax Vs Minimax **

Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 63.0
P2 Average Move Time : 27.0
END GAME BOARD STATE :
B G B G B G
G B G B G B
B G G G G G
G G B G G G
G B G G G B
B G B B B B

MATCH TYPE : AlphaBeta Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 10483
P2 Average Nodes Expanded per Move : 9527
P1 Average Move Time : 13.0
P2 Average Move Time : 2.0
END GAME BOARD STATE :
B G B G B G

G B G B G B
B G G G G G
G G B G G G
G B G G G B
B G B B B B

MATCH TYPE : Minimax Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 9527
P1 Average Move Time : 33.0
P2 Average Move Time : 1.0
END GAME BOARD STATE :
B G B G B G
G B G B G B
B G G G G G
G G B G G G
G B G G G B
B G B B B B

MATCH TYPE : AlphaBeta Vs Minimax **

Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 10483
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 14.0
P2 Average Move Time : 26.0
END GAME BOARD STATE :
B G B G B G
G B G B G B
B G G G G G
G G B G G G
G B G G G B
B G B B B B

BOARD : Narvik.txt

99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99

MATCH TYPE : Minimax Vs Minimax **

Winner is GREEN
P1 SCORE : 704
P2 SCORE : 1096

P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 13.0
P2 Average Move Time : 46.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
B B G G G B
B B G G G G
B B G G G B
G B B G B G

MATCH TYPE : AlphaBeta Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 704
P2 SCORE : 1096
P1 Average Nodes Expanded per Move : 18012
P2 Average Nodes Expanded per Move : 18893
P1 Average Move Time : 23.0
P2 Average Move Time : 1.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
B B G G G B
B B G G G G
B B G G G B
G B B G B G

MATCH TYPE : Minimax Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 704
P2 SCORE : 1096
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 18893
P1 Average Move Time : 29.0
P2 Average Move Time : 1.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
B B G G G B
B B G G G G
B B G G G B
G B B G B G

MATCH TYPE : AlphaBeta Vs Minimax **

Winner is GREEN
P1 SCORE : 704
P2 SCORE : 1096
P1 Average Nodes Expanded per Move : 18012
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 1.0

P2 Average Move Time : 38.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
B B G G G B
B B G G G G
B B G G G B
G B B G B G

BOARD : Sevastopol.txt

1 1 1 1 1 1
2 2 2 2 2 2
4 4 4 4 4 4
8 8 8 8 8 8
16 16 16 16 16 16
32 32 32 32 32 32

MATCH TYPE : Minimax Vs Minimax **

Winner is BLUE
P1 SCORE : 226
P2 SCORE : 152
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 76.0
P2 Average Move Time : 7.0
END GAME BOARD STATE :
B B B B B B
B B B B B B
B B B B B B
G B B B B B
G G B B G B
G B B G B G

MATCH TYPE : AlphaBeta Vs AlphaBeta **

Winner is BLUE
P1 SCORE : 226
P2 SCORE : 152
P1 Average Nodes Expanded per Move : 175974
P2 Average Nodes Expanded per Move : 152377
P1 Average Move Time : 38.0
P2 Average Move Time : 24.0
END GAME BOARD STATE :
B B B B B B
B B B B B B
B B B B B B
G B B B B B
G G B B G B
G B B G B G

MATCH TYPE : Minimax Vs AlphaBeta **

Winner is BLUE
P1 SCORE : 226
P2 SCORE : 152
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 152377
P1 Average Move Time : 70.0
P2 Average Move Time : 21.0
END GAME BOARD STATE :
B B B B B B
B B B B B B
B B B B B B
G B B B B B
G G B B G B
G B B G B G

MATCH TYPE : AlphaBeta Vs Minimax **

Winner is BLUE
P1 SCORE : 226
P2 SCORE : 152
P1 Average Nodes Expanded per Move : 175974
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 24.0
P2 Average Move Time : 76.0
END GAME BOARD STATE :
B B B B B B
B B B B B B
B B B B B B
G B B B B B
G G B B G B
G B B G B G

BOARD : Smolensk.txt

66 76 28 66 11 9
31 39 50 8 33 14
80 76 39 59 2 48
50 73 43 3 13 3
99 45 72 87 49 4
80 63 92 28 61 53

MATCH TYPE : Minimax Vs Minimax **

Winner is GREEN
P1 SCORE : 535
P2 SCORE : 1118
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 61.0
P2 Average Move Time : 80.0
END GAME BOARD STATE :
B G G G G G
G G B G G G
G G B B G G

G G B G B G
G G G G G B
B G B B B G

MATCH TYPE : AlphaBeta Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 535
P2 SCORE : 1118
P1 Average Nodes Expanded per Move : 100949
P2 Average Nodes Expanded per Move : 76030
P1 Average Move Time : 62.0
P2 Average Move Time : 3.0
END GAME BOARD STATE :
B G G G G G
G G B G G G
G G B B G G
G G B G B G
G G G G G B
B G B B B G

MATCH TYPE : Minimax Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 535
P2 SCORE : 1118
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 76030
P1 Average Move Time : 75.0
P2 Average Move Time : 3.0
END GAME BOARD STATE :
B G G G G G
G G B G G G
G G B B G G
G G B G B G
G G G G G B
B G B B B G

MATCH TYPE : AlphaBeta Vs Minimax **

Winner is GREEN
P1 SCORE : 535
P2 SCORE : 1118
P1 Average Nodes Expanded per Move : 100949
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 25.0
P2 Average Move Time : 23.0
END GAME BOARD STATE :
B G G G G G
G G B G G G
G G B B G G
G G B G B G
G G G G G B
B G B B B G

BOARD : Westerplatte.txt

```
1 1 1 1 1 1
1 3 4 4 3 1
1 4 2 2 4 1
1 4 2 2 4 1
1 3 4 4 3 1
1 1 1 1 1 1
```

MATCH TYPE : Minimax Vs Minimax **

Winner is GREEN
P1 SCORE : 31
P2 SCORE : 41
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 25.0
P2 Average Move Time : 92.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
G B B B G B
G G B B G B
G G B G G G
G G G B G G

MATCH TYPE : AlphaBeta Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 31
P2 SCORE : 41
P1 Average Nodes Expanded per Move : 36003
P2 Average Nodes Expanded per Move : 35006
P1 Average Move Time : 3.0
P2 Average Move Time : 19.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
G B B B G B
G G B B G B
G G B G G G
G G G B G G

MATCH TYPE : Minimax Vs AlphaBeta **

Winner is GREEN
P1 SCORE : 31
P2 SCORE : 41
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 35006
P1 Average Move Time : 26.0
P2 Average Move Time : 56.0

END GAME BOARD STATE :
B B B G G B
B B B G G G
G B B B G B
G G B B G B
G G B G G G
G G G B G G

MATCH TYPE : AlphaBeta Vs Minimax **

Winner is GREEN
P1 SCORE : 31
P2 SCORE : 41
P1 Average Nodes Expanded per Move : 36003
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 3.0
P2 Average Move Time : 46.0
END GAME BOARD STATE :
B B B G G B
B B B G G G
G B B B G B
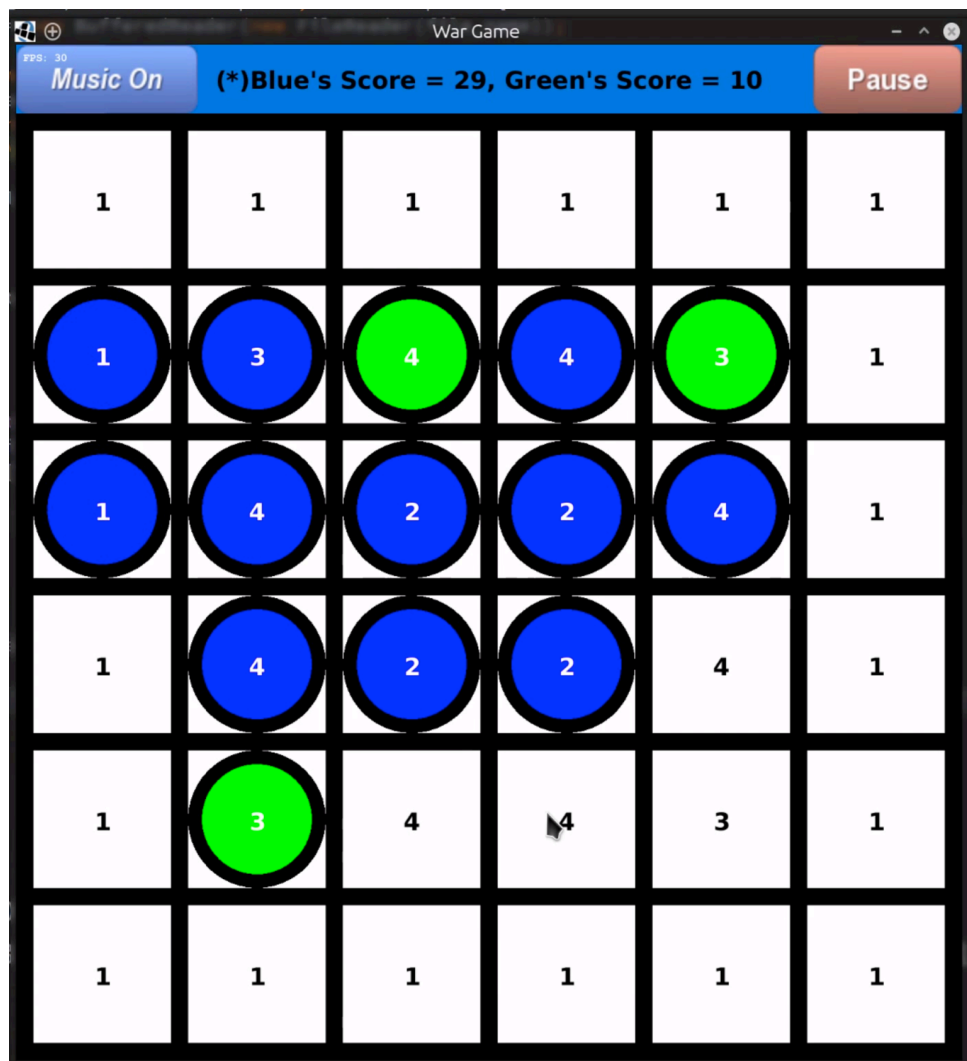G G B B G B
G G B G G G
G G G B G G

Section 2

BONUS WORK

1. Game Interface Design

We developed an AI WAR GAME PLAYER and played against different depths. We noticed that it became harder and harder to play with AI with increased depth.

The video has been uploaded to youtube @
https://www.youtube.com/watch?v=-RXBUnMX-sc&feature=youtu.be

We were able to run upto depth 6 and see that the difference in the scores for the players become lesser or tie in many cases

BOARD KEREN

P1 SCORE : 18

P2 SCORE : 18

P1 Average Nodes Expanded per Move : 927931

P2 Average Nodes Expanded per Move : 814018

P1 Average Move Time : 1339.0

P2 Average Move Time : 1531.0

END GAME BOARD STATE :

B G B G B G

G B G B G B

B G B G B G

G B G B G B

B G B G B G

G B G B G B

2. Designing own game boards:

We tested with bigger board sizes to check how large we can go. Below are the details.

Size : 12x12
```
1  10  1  10  1  10  1  10  1  10  1  10
2  9  2  9  2  9  2  9  2  9  1  10
3  8  3  8  3  8  3  8  3  8  1  10
4  7  4  7  4  7  4  7  4  7  1  10
5  6  5  6  5  6  5  6  5  6  1  10
6  5  6  5  6  5  6  5  6  5  1  10
7  4  7  4  7  4  7  4  7  4  1  10
8  3  8  3  8  3  8  3  8  3  1  10
9  2  9  2  9  2  9  2  9  2  1  10
10  1  10  1  10  1  10  1  10  1  1  10
6  5  6  5  6  5  6  5  6  5  1  10
7  4  7  4  7  4  7  4  7  4  1  10
```

MATCH TYPE : Minimax Vs Minimax ** : DEPTH 3
Winner is BLUE
P1 SCORE : 435
P2 SCORE : 357
P1 Average Nodes Expanded per Move : 54245424
P2 Average Nodes Expanded per Move : 52757616
P1 Average Move Time : 6049.0
P2 Average Move Time : 6248.0

MATCH TYPE : AlphaBeta Vs AlphaBeta ** : DEPTH 3
Winner is BLUE
P1 SCORE : 435

P2 SCORE : 357
P1 Average Nodes Expanded per Move : 1828627
P2 Average Nodes Expanded per Move : 1881049
P1 Average Move Time : 669.0
P2 Average Move Time : 570.0

3. Random Blitz

We implemented flipCoin random M1 Blitz Move functionality. Below are the stats for each board against all the match ups. The random blitz function chooses a subset of the possible pieces adjacent enemy squares that can be conquered during the move. The included pieces are chosen with a probability of 0.5 using random function that generates two values (0 or 1).

Play with random M1 Blitz Move incorporated.
BOARD : game_boards/Keren.txt ********************************
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
MATCH TYPE : Minimax Vs Minimax **
Game Tied
P1 SCORE : 18
P2 SCORE : 18
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 140.0
P2 Average Move Time : 46.0
END GAME BOARD STATE :
B G B G B G
B B G B B G
B G B B G G
B B B G G B
B G G G B G
B B G G G G
Game Over
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 10771
P2 Average Nodes Expanded per Move : 9956
P1 Average Move Time : 21.0
P2 Average Move Time : 2.0
END GAME BOARD STATE :
B G B G B G
B G B B G G
G G B G G B
G G B B G G
G B B G G G
B B B G G G
Game Over

MATCH TYPE : Minimax Vs AlphaBeta **
Game Tied
P1 SCORE : 18
P2 SCORE : 18
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 9705
P1 Average Move Time : 58.0
P2 Average Move Time : 1.0
END GAME BOARD STATE :
B G B G G G
G B B G G B
B B B G B G
B B B B G G
B G B G B G
G G B B G G
Game Over
MATCH TYPE : AlphaBeta Vs Minimax **
Winner is GREEN
P1 SCORE : 15
P2 SCORE : 21
P1 Average Nodes Expanded per Move : 11261
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 1.0
P2 Average Move Time : 33.0
END GAME BOARD STATE :
B G B G B G
G B G B G G
B G B G G G
G B B G G B
B G B G B G
G B G G B G
Game Over
BOARD : game_boards/Narvik.txt ********************************
99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99
MATCH TYPE : Minimax Vs Minimax **
Winner is BLUE
P1 SCORE : 1098
P2 SCORE : 702
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 36.0
P2 Average Move Time : 134.0
END GAME BOARD STATE :
B B G G B B
B B B G B G
G B B G B G
G B G B G B
G B G B B B

G G G B G B
Game Over
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 1200
P2 SCORE : 600
P1 Average Nodes Expanded per Move : 16431
P2 Average Nodes Expanded per Move : 18096
P1 Average Move Time : 2.0
P2 Average Move Time : 109.0
END GAME BOARD STATE :
B B G B B G
B B G G B B
B B G G B B
B G G G B B
B G G B B G
B B B B B B
Game Over
MATCH TYPE : Minimax Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 1594
P2 SCORE : 206
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 15931
P1 Average Move Time : 51.0
P2 Average Move Time : 2.0
END GAME BOARD STATE :
B B B G G G
G B B B G B
B G B B B B
G B B B B G
B B B G B B
B B B B G B
Game Over
MATCH TYPE : AlphaBeta Vs Minimax **
Winner is GREEN
P1 SCORE : 797
P2 SCORE : 1003
P1 Average Nodes Expanded per Move : 16838
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 21.0
P2 Average Move Time : 31.0
END GAME BOARD STATE :
G G G G G G
G B B B G G
G B B G G G
G B B B G G
G G G B B G
G G G B B B
Game Over
BOARD : game_boards/Sevastopol.txt ********************************
1 1 1 1 1 1
2 2 2 2 2 2

4 4 4 4 4 4
8 8 8 8 8 8
16 16 16 16 16 16
32 32 32 32 32 32
MATCH TYPE : Minimax Vs Minimax **
Winner is GREEN
P1 SCORE : 183
P2 SCORE : 195
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 31.0
P2 Average Move Time : 157.0
END GAME BOARD STATE :
B B B G G G
B B G G G G
B B B B G G
B B G B B G
B G G B B B
G B G B G G
Game Over
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 175
P2 SCORE : 203
P1 Average Nodes Expanded per Move : 170358
P2 Average Nodes Expanded per Move : 153898
P1 Average Move Time : 30.0
P2 Average Move Time : 50.0
END GAME BOARD STATE :
B B B B B G
B B B B B G
B B B G B G
G B B G G G
G G G B B G
B B G G B G
Game Over
MATCH TYPE : Minimax Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 137
P2 SCORE : 241
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 157221
P1 Average Move Time : 55.0
P2 Average Move Time : 9.0
END GAME BOARD STATE :
G G G G G B
G G B G B G
G G G B B B
G G G B B B
B B G G G G
B B G G G G
Game Over
MATCH TYPE : AlphaBeta Vs Minimax **

Winner is GREEN
P1 SCORE : 185
P2 SCORE : 193
P1 Average Nodes Expanded per Move : 176940
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 175.0
P2 Average Move Time : 36.0
END GAME BOARD STATE :
G G G G G B
G B G G G B
B G B G G B
B B B B G B
G B B G G G
B B G G B G
Game Over
BOARD : game_boards/Smolensk.txt ********************************
66 76 28 66 11 9
31 39 50 8 33 14
80 76 39 59 2 48
50 73 43 3 13 3
99 45 72 87 49 4
80 63 92 28 61 53
MATCH TYPE : Minimax Vs Minimax **
Winner is BLUE
P1 SCORE : 1090
P2 SCORE : 563
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 12.0
P2 Average Move Time : 74.0
END GAME BOARD STATE :
B G G B B B
B G G B B B
B G G B G G
B B B G G G
B B B B G G
G B B B B G
Game Over
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 653
P2 SCORE : 1000
P1 Average Nodes Expanded per Move : 39181
P2 Average Nodes Expanded per Move : 34189
P1 Average Move Time : 26.0
P2 Average Move Time : 5.0
END GAME BOARD STATE :
G G G G B B
G G G G B B
G G G B B G
B B G B G G
B B B G G G
G B B B G G

Game Over
MATCH TYPE : Minimax Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 1104
P2 SCORE : 549
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 41631
P1 Average Move Time : 199.0
P2 Average Move Time : 4.0
END GAME BOARD STATE :
G B B B G B
B B B G B G
B G B B B B
G B G B B B
B B B G B B
G B B B G G
Game Over
MATCH TYPE : AlphaBeta Vs Minimax **
Winner is BLUE
P1 SCORE : 956
P2 SCORE : 697
P1 Average Nodes Expanded per Move : 33063
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 5.0
P2 Average Move Time : 60.0
END GAME BOARD STATE :
B B B B G G
G B G G G G
B G B G G G
B B G G G G
B G B B G G
G G B B B G
Game Over
BOARD : game_boards/Westerplatte.txt ********************************
1 1 1 1 1 1
1 3 4 4 3 1
1 4 2 2 4 1
1 4 2 2 4 1
1 3 4 4 3 1
1 1 1 1 1 1
MATCH TYPE : Minimax Vs Minimax **
Winner is GREEN
P1 SCORE : 24
P2 SCORE : 48
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 17.0
P2 Average Move Time : 111.0
END GAME BOARD STATE :
B G G B B B
B B G G B G
B B G G G G
G G B G B G

G G G G G B
G G G G B G
Game Over
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 55
P2 SCORE : 17
P1 Average Nodes Expanded per Move : 32959
P2 Average Nodes Expanded per Move : 36755
P1 Average Move Time : 32.0
P2 Average Move Time : 7.0
END GAME BOARD STATE :
G B B G B B
B B B G G B
B B B B G B
B B G B B B
B B B B B B
B G B G B B
Game Over
MATCH TYPE : Minimax Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 37
P2 SCORE : 35
P1 Average Nodes Expanded per Move : 217740
P2 Average Nodes Expanded per Move : 30801
P1 Average Move Time : 17.0
P2 Average Move Time : 27.0
END GAME BOARD STATE :
B B G B B G
B B B G B G
B G G G G B
B B G B G G
G G B B B G
B G B G G G
Game Over
MATCH TYPE : AlphaBeta Vs Minimax **
Winner is BLUE
P1 SCORE : 42
P2 SCORE : 30
P1 Average Nodes Expanded per Move : 35078
P2 Average Nodes Expanded per Move : 194736
P1 Average Move Time : 35.0
P2 Average Move Time : 486.0
END GAME BOARD STATE :
G B B B G G
B B B B G B
B B G G B B
G B G G B B
G G G G B B
B G G B B G

4. Player agents at different depths

We also implemented different DEPTH play for match up such that one agent can play at certain depth while other can play at some depth.
Observation:

We observed that the agent playing at greater depth gets more score as expected in most of the cases.

Player 2 is playing at Depth 4 while Player 1 at Depth 3
BOARD : game_boards/Keren.txt *******************************
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
1 1 1 1 1 1
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 16
P2 SCORE : 20
P1 Average Nodes Expanded per Move : 10733
P2 Average Nodes Expanded per Move : 28155
P1 Average Move Time : 44.0
P2 Average Move Time : 139.0
END GAME BOARD STATE :
B G B G B G
G B G B G G
B G B G G G
B B G G G G
B B B G G B
G B B G G B
Game Over
BOARD : game_boards/Narvik.txt *******************************
99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99
99 1 99 1 99 1
1 99 1 99 1 99
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Game Tied
P1 SCORE : 900
P2 SCORE : 900
P1 Average Nodes Expanded per Move : 15849
P2 Average Nodes Expanded per Move : 63647
P1 Average Move Time : 3.0
P2 Average Move Time : 88.0
END GAME BOARD STATE :
B G G B G G
B G B B B G
B G G G G G
B G G G G G

B B B B B B
G B B B G B
Game Over
BOARD : game_boards/Sevastopol.txt *********************************
1 1 1 1 1 1
2 2 2 2 2 2
4 4 4 4 4 4
8 8 8 8 8 8
16 16 16 16 16 16
32 32 32 32 32 32
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is BLUE
P1 SCORE : 230
P2 SCORE : 148
P1 Average Nodes Expanded per Move : 169366
P2 Average Nodes Expanded per Move : 3532388
P1 Average Move Time : 32.0
P2 Average Move Time : 1074.0
END GAME BOARD STATE :
G B G G B G
B B B G G B
G B B G G B
B B G G B B
B B B B B G
B B B G G G
BOARD : game_boards/Smolensk.txt *********************************
66 76 28 66 11 9
31 39 50 8 33 14
80 76 39 59 2 48
50 73 43 3 13 3
99 45 72 87 49 4
80 63 92 28 61 53
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 635
P2 SCORE : 1018
P1 Average Nodes Expanded per Move : 29955
P2 Average Nodes Expanded per Move : 180857
P1 Average Move Time : 23.0
P2 Average Move Time : 228.0
END GAME BOARD STATE :
G G G G G G
G B G G G G
G G B G B B
B G B B B B
G B B B B G
G G G B B B
BOARD : game_boards/Westerplatte.txt *********************************
1 1 1 1 1 1
1 3 4 4 3 1
1 4 2 2 4 1
1 4 2 2 4 1
1 3 4 4 3 1

1 1 1 1 1 1
MATCH TYPE : AlphaBeta Vs AlphaBeta **
Winner is GREEN
P1 SCORE : 34
P2 SCORE : 38
P1 Average Nodes Expanded per Move : 40407
P2 Average Nodes Expanded per Move : 271872
P1 Average Move Time : 4.0
P2 Average Move Time : 186.0
END GAME BOARD STATE :
B B B G G G
B B B G G G
B B G G G G
B B B G G G
G B G B G G
B G B B B G