Assignment 1: Xtreme Tic-Tac-Toe

Post Group Stage Analysis Report

Team 69 : Tic Tac Trash

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General Strategies and Shortcomings

Search Strategy and Optimizations
We implemented Minimax along with Alpha-Beta pruning with a cutoff depth based on time. We expanded the internal nodes according to a sorted order given by our evaluation function (Killer move heuristic). We used iterative deepening due to its synergy with Alpha-Beta pruning and low stack memory usage. We reimplemented the update function since the function in the simulator was checking whether the move was valid, using up extra time. We also didn't reset the entire board when exploring the graph, opting to reset only the board where the bot played. All these optimizations however got us only 1 extra layer of depth in the worst case due to python's inherently slow nature. We were careful to include free moves and bonus moves in our minimax implementation.

Heuristic
We used an adaptive heuristic in which the bot modifies the assigned weights based on the triplet that it has the most chance to win. In our feature extraction, we check each triplet where the opponent has not won a board (only these triplets can be won by our bot). In each of these we evaluate how many boards we have currently won. The utility of the state is then given by the no. of triplets we won exactly 2 boards in * 100 + no. of triplets we won exactly 1 board in * 20. The opponent is evaluated in an equal and opposite way. This is done individually on each Big Board and the total utility is given by the sum.
This heuristic allows out bot to sacrifice boards which it feels does not contribute towards winning. Thus it performs very well against bots that give equal weightage to all boards, even ones that are worthless in the big picture.

Shortcomings in search strategy and optimizations
We spent a very long time trying to optimize our search algorithm, however it yielded very little return. One regret is not implementing a zobrist hash to recover small board features quickly, however we're not sure how much of a difference it would have made. We could have also tried to squeeze more depth by getting closer to the time limit, however we decided to be risk averse and give the bot a comfortable 1 second before the time out. We could have also done variable iterative deepening, by starting by deepening by a depth of 2 or 3 and later incrementing depth of 1. We could have added a quiescence search as well to avoid evaluating volatile positions.

We also made a crucial mistake in implementing iterative deepening, we do not break out of the deepening loop when we have detected a winning state. This ended up giving suboptimal winning states (which we discuss in detail in our observation of the logs).

Shortcomings in the heuristic
We came up with the adaptive heuristic quite late and did not have time to add in other aspects that we felt were important. Our heuristic doesn't take into account free moves, this could have been solved by a short quiescence search, but we didn't have time to implement it. Similarly, our heuristic doesn't take into account maneuvers where two boards can be won in a single turn using intelligent moves on the small boards and a bonus move, in fact our heuristic doesn't consider the small board at all. Similarly our bot doesn't value free moves in the heuristic, even though it values it in the search.

Match Analysis :

In this section we analyze our logs. In cases where the bot performed poorly, we've marked it as such and suggested how a human would play that position and any changes we need to make in our implementation. In cases where our bot played outstandingly, "setting itself apart" from the others in the group, we've highlighted specific move sequences that we feel are impressive.

Team 69 vs Team 2 :

Final Game Scenario :

```
================BigBoard State================

 - - o   - x x   - x o       - - x   - - -   - o x
 - - -   - o o   x o x       - - x   - - -   - - x
 o - -   - - o   x - o       - - x   x x x   - - x

 x x -   x o -   o - o       - - -   o - x   o o -
 x - x   - o -   - - -       - - -   - x -   o - x
 o - o   x - -   x x x       - o -   x - -   - - o

 - - o   - o o   - - -       - - o   - - x   - o -
 o x x   - - -   - o x       o - o   o - x   x x x
 - - x   - - -   o x -       - - -   - - -   - o -

==============SmallBoards States==============
- - -     x x x
- - x     - x -
- - -     - - x
```

Poor Performance:

At a stage in game, we had a turn to move in the central small board.

```
================BigBoard State================

 - - o  - x x  - x o      - - x  - - -  - o x
 - - -  - o o  x o x      - - -  - - -  - - x
 o - -  - - o  x - o      - - x  x x x  - - x

 x x -  x o -  o - o      - - -  o - x  - o -
 x - -  - o -  - - -      - - -  - x -  - - -
 o - o  - - -  x x x      - o -  x - -  - - -

 - - o  - o o  - - -      - - o  - - x  - o -
 o x x  - - -  - o -      o - -  o - x  x x x
 - - x  - - -  o x -      - - -  - - -  - o -

==============SmallBoards States==============
- - -    - x x
- - x    - x -
- - -    - - x
```

The second big board' central small board was already won and hence it decided to move in the first big board's central small board .
The move it took was :

```
================BigBoard State================

 - - o  - x x  - x o      - - x  - - -  - o x
 - - -  - o o  x o x      - - -  - - -  - - x
 o - -  - - o  x - o      - - x  x x x  - - x

 x x -  x o -  o - o      - - -  o - x  - o -
 x - -  - o -  - - -      - - -  - x -  - - -
 o - o  x - -  x x x      - o -  x - -  - - -

 - - o  - o o  - - -      - - o  - - x  - o -
 o x x  - - -  - o -      o - -  o - x  x x x
 - - x  - - -  o x -      - - -  - - -  - o -

==============SmallBoards States==============
- - -    - x x
```

```
- - x     - x -
- - -     - - x
```

While if our bot had moved to (3,3) in the central board, their bot would have been compelled to move at (1,1) or (3,2) in the top right small board of 1st big board , both of which would have led to our victory in exactly 2 moves. A human would have figured out that it is possible to win in just 3 levels, but our bot failed to look at it, due to our error in implementing iterative deepening.

Change in heuristic/implementation:
Due to an error in our implementation of iterative deepening, our bot doesn't choose the shallowest winning state. This causes drawn out games with higher uncertainty and risk. Fixing the error with a simple conditional break statement would drastically improve how our bot performs.

Team 69 vs Team 5 :

Final Game Scenario :

```
================BigBoard State================

 o - x  - - -  x o x      - - x  x - o  - - -
 - - o  x - -  - - o      - - x  - - x  - - -
 o o -  x - -  x o o      - - x  x o -  o o o

 - - -  o o -  - - o      - - x  x - -  x o x
 o - o  - - x  - - o      - - x  - x -  o o x
 - o x  - - -  - - o      x - -  - - x  o x o

 - - -  o o o  - - o      o o -  - x x  - x -
 o o -  - - -  x - x      o - x  x x x  - x -
 x x x  - x -  o - o      x o -  x - -  - x -

==============SmallBoards States==============
- - -    x - o
- - o    - x d
x o -    - x x
```

Poor Performance:

The same mistake as we had done in the previous game, the board did not go for easy win at the following stage .

```
================BigBoard State================
```

```
 o - x  - - -  x o x      - - x  x - o  - - -
 - - o  x - -  - - o      - - x  - - x  - - -
 o o -  x - -  x o o      - - x  x o -  o o o

 - - -  o o -  - - o      - - x  x - -  x o x
 o - o  - - -  - - o      - - x  - x -  o - x
 - o x  - - -  - - o      x - -  - - -  o x o

 - - -  o o o  - - o      o o -  - x x  - x -
 o o -  - - -  x - x      o - x  x - x  - x -
 x x x  - x -  o - o      x o -  x - -  - x -

==============SmallBoards States==============
- - -    x - o
- - o    - - -
x o -    - - x
```

Our bot is directed to move at (3,2) of second big board, it could have win in just 2 steps but it goes for a win through 4 moves.
Our bot moves :

```
================BigBoard State================

 o - x  - - -  x o x      - - x  x - o  - - -
 - - o  x - -  - - o      - - x  - - x  - - -
 o o -  x - -  x o o      - - x  x o -  o o o

 - - -  o o -  - - o      - - x  x - -  x o x
 o - o  - - -  - - o      - - x  - x -  o - x
 - o x  - - -  - - o      x - -  - - -  o x o

 - - -  o o o  - - o      o o -  - x x  - x -
 o o -  - - -  x - x      o - x  x x x  - x -
 x x x  - x -  o - o      x o -  x - -  - x -

==============SmallBoards States==============
- - -    x - o
- - o    - - -
x o -    - x x
================================================


('CONTINUE', '-')
```

```
================BigBoard State================

 o - x  - - -  x o x      - - x  x - o  - - -
 - - o  x - -  - - o      - - x  - - x  - - -
 o o -  x - -  x o o      - - x  x o -  o o o

 - - -  o o -  - - o      - - x  x - -  x o x
 o - o  - - x  - - o      - - x  - x -  o - x
 - o x  - - -  - - o      x - -  - - -  o x o

 - - -  o o o  - - o      o o -  - x x  - x -
 o o -  - - -  x - x      o - x  x x x  - x -
 x x x  - x -  o - o      x o -  x - -  - x -

==============SmallBoards States==============
- - -    x - o
- - o    - - -
x o -    - x x
```

A human might have easily seen the win by 1st moving (2,2) as the bot does and then directly moving (3,3) in the adjacent upper small board and that would have let to a win.

Change in Heuristics/Implementation : Same as the previous case.

Team 69 vs Team 21 :
Final Game Scenario :

```
================BigBoard State================

 - - -  - - -  - - -      - - -  - x -  - - -
 - - -  - - -  - - -      - - -  - - -  - - -
 - - -  - - -  o - -      x - x  o - -  - - -

 - - -  o - -  - - -      - - -  - x -  - - -
 - - -  - - o  - - -      - o -  - x -  - - -
 - - -  - - -  x - -      - - -  - x -  - - -

 o - x  - - -  - - -      - - -  - - -  - - -
 - x x  - - -  - o -      - - -  - - -  x - -
 o o -  x - -  - - -      - - -  - - o  - - -
```

```
==============SmallBoards States==============
- - -    - - -
- - -    - x -
- - -    - - -

Winner: P1
Message TIME OUT
x: 1  o: 0  d: 0
Player1 (Team69) points: 86
Player2 (Team21) points: 0
```

Probably the opponent bot did not take care of the time limit and hence ended up taking more than allotted time to play their move and hence handed over an easy win. In just a limited no. of moves made, our bot played decently and didn't perform poorly at any stage.

Team 69 vs Team 42 :
Final Game Scenario :

```
================BigBoard State================

 - - o  o o -  - - x      - - -  - x -  - - -
 - - o  x - x  o x x      - - -  - - -  - - -
 - - o  - x -  - o o      x x x  - - -  - - -

 x - x  o - -  o o o      - - -  - x -  - x x
 o - o  - - -  - - -      - - -  - x -  - - -
 o - -  o - -  - - -      - - -  - x -  - - -

 - - o  o o -  - o -      - - -  - - -  x - -
 x - -  x - x  - o -      - - -  - - -  - x -
 x - o  - - -  - - -      - - -  - - -  - - x

==============SmallBoards States==============
o - -    x - -
- - o    - x -
- - -    - - x
```

Impressive Performance:
Our bot played really well in this match and figured out a winning state even giving away two consecutive small boards . But our bot took a risk of giving away a small board easily for the sake of win, which even I think was the best risk worthy move one could have taken at that

stage where the opponent had led out possibility of winning small boards at each position in the 1st big board.

Human performance:
At this stage, our bot was asked to move in (3,2) of either of the big boards :

```
================BigBoard State================

 - - o  o o -  - - x      - - -  - x -  - - -
 - - o  x - x  o x x      - - -  - - -  - - -
 - - -  - x -  - o o      x x x  - - -  - - -

 x - x  o - -  - o o      - - -  - - -  - x x
 o - o  - - -  - - -      - - -  - x -  - - -
 o - -  o - -  - - -      - - -  - x -  - - -

 - - o  o o -  - o -      - - -  - - -  x - -
 x - -  x - -  - o -      - - -  - - -  - - -
 x - o  - - -  - - -      - - -  - - -  - - x

==============SmallBoards States==============
- - -    x - -
- - -    - - -
- - -    - - -
```

A risk averse human mind would have played at (1,3) cell in (3,2) of big board which would have led to the opponent winning the bottom left small board, if it just paid heed to the points associated with win of small board .
I was impressed with the way board figured out moving at the required cell to ensure minimum loss and possible chance of win at the cost of neglect of opponent .

Team 69 vs Team 66 :
Final Game Scenario :

```
================BigBoard State================

 - - -  - - -  - x -      - - -  - - -  - - -
 - - -  x - -  - x -      - o -  - - -  - o -
 - - -  - - -  - x -      - - -  - o o  - - o

 - - -  - x -  - - -      - - -  - - x  - - -
 - o -  - x o  - - -      - - -  - x -  - - -
 - - o  - x o  - x -      - - -  x - o  - o o

 x x x  - - -  - - x      - - -  - o -  - - x
```

```
 - - -  x - -  - - x      - - -  - o -  - o x
 - o o  x x x  o - x      - - -  - o -  - - x

==============SmallBoards States==============
- - x    - - -
- x -    - x -
x x x    - o x
```

Impressive Performance :
A great performance in this match. The opponent bot had probably a poor defence mechanism since it could not stop our bot from creating multiple win possibilities throughout the board .

Human performance :
==========SmallBoards States==========
```
- - -    - - -
- - -    - x -
- x x    - o x
```

At such a stage of this game , a human mind would have more focused on winning either the bottom left small board in 1st board or the top left small board in 2nd board rather than stretching to create other possibilities of victory throughout the board .

Team 69 vs Team 71:
Final Game Scenario :

```
================BigBoard State================

 x o -  x x -  - - x      x x x  o - -  - o x
 x - -  o - -  o - -      o - o  x x x  - - x
 - - -  - o o  - - x      o - -  - x o  - o x

 - o o  - - -  o - o      x o -  - x o  - - o
 o - x  - - -  x - -      x - -  - x o  - - x
 - - -  - - -  - - -      x - -  x - -  - o x

 - o x  x x x  o x -      - o -  o - -  - - -
 - x -  - - -  - - -      - - -  - - -  - o o
 - - -  - - -  x x -      o - -  - - o  - - -

==============SmallBoards States==============
- - -    x x x
- - -    x - -
- x -    - - -
```

Impressive Performance :
Interestingly, the opponent kept printing the possible moves and their heuristic value at each step, which showed it had given up a long way back before end of game. With no resistance from the opponent, it went on to achieve a clear win.

Team 69 vs Team 73:
Final Game Scenario :

```
================BigBoard State================

 o - -  o - -  x x o      x o o  - - -  x - -
 o - x  - o -  - x -      o x x  - - -  - - -
 o - -  - - o  o - -      - - x  x - x  - - -

 - - -  - o -  - x -      o - -  x - o  - - -
 - - -  - - -  x x o      - x -  o x -  - - -
 x x x  o o o  o - o      - o -  - - o  - - -

 o - x  - - o  x - -      x x x  x - -  - - x
 - o -  - - o  o x o      - - -  x - -  - - x
 - - o  - - -  - - x      o x -  x - -  - - x

==============SmallBoards States==============
o o -    x - -
x o -    - - -
o - x    x x x
```

Questionable Performance:

At this stage our bot was asked to move at bottom left small board :

```
================BigBoard State================

 o - -  o - -  x x o      - o o  - - -  x - -
 o - x  - - -  - - -      - x x  - - -  - - -
 o - -  - - o  o - -      - - -  x - x  - - -

 - - -  - o -  - x -      - - -  x - -  - - -
 - - -  - - -  x x o      - - -  - x -  - - -
 x x -  o o -  o - o      - o -  - - -  - - -

 o - x  - - o  - - -      x - -  x - -  - - x
 - o -  - - o  o - o      - - -  - - -  - - x
```

```
 - - o  - - -  - - x      o x -  x - -  - - -

==============SmallBoards States==============
o - -    - - -
- - -    - - -
o - -    - - -
```

And our bot picked up the following move :

```
================BigBoard State================

 o - -  o - -  x x o      - o o  - - -  x - -
 o - x  - - -  - - -      - x x  - - -  - - -
 o - -  - - o  o - -      - - -  x - x  - - -

 - - -  - o -  - x -      - - -  x - -  - - -
 - - -  - - -  x x o      - - -  - x -  - - -
 x x -  o o -  o - o      - o -  - - -  - - -

 o - x  - - o  - - -      x x -  x - -  - - x
 - o -  - - o  o - o      - - -  - - -  - - x
 - - o  - - -  - - x      o x -  x - -  - - -

==============SmallBoards States==============
o - -    - - -
- - -    - - -
o - -    - - -
```

This move gives an opportunity to the opponent to capture two consecutive small boards and get to a really strong position :

```
================BigBoard State================

 o - -  o - -  x x o      - o o  - - -  x - -
 o - x  - o -  - - -      - x x  - - -  - - -
 o - -  - - o  o - -      - - -  x - x  - - -

 - - -  - o -  - x -      - - -  x - -  - - -
 - - -  - - -  x x o      - - -  - x -  - - -
 x x -  o o o  o - o      - o -  - - -  - - -

 o - x  - - o  - - -      x x -  x - -  - - x
 - o -  - - o  o - o      - - -  - - -  - - x
```

```
 - - o  - - -  - - x      o x -  x - -  - - x

==============SmallBoards States==============
o o -    - - -
- o -    - - -
o - -    - - x
```

Human Performance :

A human mind would have not given the opponent to get two consecutive small boards and have such a strong position, rather it would have played as :

```
================BigBoard State================

 o - -  o - -  x x o      - o o  - - -  x - -
 o - x  - - -  - - -      - x x  - - -  - - -
 o - -  - - o  o - -      - - -  x - x  - - -

 - - -  - o -  - x -      - - -  x - -  - - -
 - - -  - - -  x x o      - - -  - x -  - - -
 x x -  o o -  o - o      - o -  - - -  - - -

 o - x  - - o  - - -      x - -  x - -  - - x
 - o -  - - o  o - o      x - -  - - -  - - x
 - - o  - - -  - - x      o x -  x - -  - - -

==============SmallBoards States==============
o - -    - - -
- - -    - - -
o - -    - - -
```

This move would have caused the opponent to play a fruitless move, hence delaying opponent's strong hold in the match.

Change in Heuristics/Implementation :

Our bot has probably set a focus on winning a triplet that might also include the bottom left small board(actually it does as we see in the final scenario) and hence tries to create winning chances in the bottom left board. We can call this performance questionable but in reality even after such disadvantageous state the bot figured out the opponent's focus and successfully blocks it and marches on to win. It maybe that the bot is out thinking us.

We observe this at this stage :

```
================BigBoard State================

 o - -  o - -  x x o      - o o  - - -  x - -
 o - x  - o -  - - -      - x x  - - -  - - -
 o - -  - - o  o - -      - - -  x - x  - - -

 - - -  - o -  - x -      - - -  x - -  - - -
 - - -  - - -  x x o      - - -  o x -  - - -
 x x -  o o o  o - o      - o -  - - -  - - -

 o - x  - - o  - - -      x x -  x - -  - - x
 - o -  - - o  o x o      - - -  - - -  - - x
 - - o  - - -  - - x      o x -  x - -  - - x

==============SmallBoards States==============
o o -    - - -
- o -    - - -
o - -    - - x
```

Our heuristic enables us to comeback from a seemingly dire situation. However, it is worth considering how we ended up in such a situation in the first place.

Team 42 vs Team 69

```
================BigBoard State================

 - - -  - x -  - o x      - - o  - - -  - - -
 x x x  o - o  x o x      - - -  - - o  - - -
 - - -  x - x  - o -      - - o  - - -  - - -

 x - -  x - -  - x o      - o -  o - x  o - -
 x - -  - x -  x - x      o o o  o o -  - - -
 x - -  - - x  - - -      - - -  o - -  - - o

 x - -  - x x  - o -      - - -  - - -  - - o
 - o -  - - -  - x -      o - -  - - -  - - -
 o o x  o - -  x x -      x - -  - - -  - - o

==============SmallBoards States==============
x - o      - - -
x x -      o o -
- - -      - - -
```

```
==============================================
```

Average Performance:
The turning point occured at this position where x was to move on the top left small board. Here x makes a critical blunder:

```
('CONTINUE', '-')
================BigBoard State================

 - - -  - x -  - o x       - - o  - - -  - - -
 x x x  o - o  x o x       - - -  - - o  - - -
 - - -  x - x  - o -       x - o  - - -  - - -

 x - -  x - -  - x o       - o -  o - x  o - -
 x - -  - x -  x - x       o o o  o o -  - - -
 x - -  - - x  - - -       - - -  o - -  - - o

 x - -  - x x  - o -       - - -  - - -  - - o
 - o -  - - -  - x -       o - -  - - -  - - -
 o o x  o - -  x x -       x - -  - - -  - - o

==============SmallBoards States==============
x - o      - - -
x x -      o o -
- - -      - - -
==============================================
```

By playing at the bottom left, x allows our bot to win the bottom left small board in the first big board, and lets us block one of x's best chances of winning. This game seems to be won solely due to x's mistakes and not our bot's brilliance.

Team 2 vs Team 69

```
================BigBoard State================

 - - -  - - o  - - -       - o -  - o -  - - -
 - x -  - - o  - x x       - - -  - - x  - - -
 - - x  - x o  o o -       - o -  x x o  - - -

 - - -  - - -  o o -       - - o  x - -  - x o
 x - x  - - -  o - x       - o -  x o -  - - o
 o o o  - - -  - x -       o - -  - o -  - - o
```

```
 x o -  - o o  - x -       - x -  - x -  - x -
 x - -  x - x  o - o       x - -  - - -  x - o
 o - -  - - x  - - x       - - -  o o o  - x -

==============SmallBoards States==============
- o -      - - -
o - -      o - o
- - -      - o -
==============================================
```

Average Performance:

In this state, x has to play in the middle top board. Here x chooses a move it thinks is safe by playing :

```
================BigBoard State================

 - - -  - - o  - - -       - o -  x o -  - - -
 - x -  - - o  - x x       - - -  - - x  - - -
 - - x  - x o  o o -       - o -  x x o  - - -

 - - -  - - -  o o -       - - o  x - -  - x o
 x - x  - - -  o - x       - o -  x o -  - - o
 o o o  - - -  - x -       o - -  - o -  - - o

 x o -  - o o  - x -       - x -  - x -  - x -
 x - -  x - x  o - o       x - -  - - -  x - o
 o - -  - - x  - - x       - - -  o o o  - x -

==============SmallBoards States==============
- o -      - - -
o - -      o - o
- - -      - o -
==============================================
```

What I assume happened here was that the opponent's bot thought that our bot would win the top left board and then it would win the centre, effectively blocking us. However it seems that the opponent does not account for the bonus move which allowed us to secure the win by winning the middle board.

Team 5 vs Team 69

```
================BigBoard State================
```

```
 - - -  x - -  - o -       - - x  - - -  - - -
 - - -  x - -  - o -       o o o  - - -  - - -
 x x x  x - -  o x x       x - o  o o -  - - -

 x x -  x - -  - - -       - o -  o - -  o - -
 - x -  - x o  - x -       - - -  o - -  - - -
 - - -  - - o  x - o       - o -  o - -  - - x

 o - x  - - -  o o o       o - -  - - o  - x x
 o - x  x x -  - - -       - x x  - - o  - o -
 o - -  - - -  - - -       o - -  - - -  - - x

==============SmallBoards States==============
x x -      o - -
- - -      - o -
o - o      - - -
==============================================
```

Impressive Performance:
X is to play on the middle board. However our bot has managed to manipulate the situation such that no matter what the opponent plays, our bot is guaranteed to win a board. This occurs in multiple situations throughout the game.

Team 73 vs Team 69

Very Impressive Performance:
This is arguably the best play we observed our bot make. It is in these situations where our heuristic shines. The situation is as follows -

```
================BigBoard State================

 - - -  o - o  x - -       x - o  - - -  - - x
 o o -  x - x  x - -       - - -  - - -  - - o
 x x x  - - -  x - -       x - -  - - -  o - o

 - o -  x - x  - - -       - - -  - - -  o - o
 - - -  o o -  - - -       - - -  - - -  - x x
 o o -  x - -  - - -       - x x  - - -  o - -

 x - -  - x x  - x -       o - o  - o -  - - -
 - x -  - - x  - - -       - - -  - - -  o o o
 o o x  - - -  - x -       x - x  - o o  - - -
```

```
==============SmallBoards States==============
x - x      - - -
- - -      - - -
x - -      - - o
==============================================
```

Our bot is to move with o on the bottom right board. A human would tend to play safe and block the opponent from winning the board by placing at the center. Our bot makes a seemingly outrageous choice and plays on the top left. This seeming blunder allows the opponent to win not one but two whole boards -

```
================BigBoard State================

 - - -  o - o  x - -       x - o  - - -  - - x
 o o -  x - x  x - -       x - -  - - -  - - o
 x x x  - - -  x - -       x - -  - - -  o - o

 - o -  x - x  - - -       - - -  - - -  o - o
 - - -  o o -  - - -       - - -  - - -  - x x
 o o -  x - -  - - -       x x x  - - -  o - -

 x - -  - x x  o x -       o - o  - o -  - - -
 - x -  - - x  - - -       - - -  - - -  o o o
 o o x  - - -  - x -       x - x  - o o  - - -

==============SmallBoards States==============
x - x      x - -
- - -      x - -
x - -      - - o
==============================================
```

However, this is not actually a blunder. Our bot is to move on the bottom left board. In a single swoop, it wins the bottom left cell blocking all the hard work the opponent put in to win the two cells in the first place. It also sets up for an opportunity to win on the bottom row. Not only this, but using the bonus move, our bot blocks the top middle in the first big board, again blocking any chances of the opponent winning in that board as well.

```
================BigBoard State================

 - - -  o o o  x - -       x - o  - - -  - - x
 o o -  x - x  x - -       x - -  - - -  - - o
 x x x  - - -  x - -       x - -  - - -  o - o
```

```
 - o -  x - x  - - -       - - -  - - -  o - o
 - - -  o o -  - - -       - - -  - - -  - x x
 o o -  x - -  - - -       x x x  - - -  o - -

 x - -  - x x  o x -       o o o  - o -  - - -
 - x -  - - x  - - -       - - -  - - -  o o o
 o o x  - - -  - x -       x - x  - o o  - - -

==============SmallBoards States==============
x o x      x - -
- - -      x - -
x - -      o - o
==============================================
```

What makes our bot stand out in the pool?

Our bot is able to play against a diverse set of styles due to its adaptive heuristic. It especially shines when it's playing against an extremely aggressive bot such as that of team 73. Situation like the one described above, where our bot allows the opponent to secure a game winning position in each board, only to steal it away in a single move is quite impressive. Apart from that I believe our depth optimizations do help, though to a lower extent than we would like.

What are some possible differences in heuristic?

We don’t expect most teams to have adaptive heuristics. This means that they will value winning any small board equally, even if the said board is already blocked, or has a very low chance of contributing to a winning triplet. Even if some teams do have dynamic heuristics, their assigned weights may be totally different and they may opt to evaluate blocked triplets as well. While our heuristic is entirely deterministic, it is possible that some of our opponents had probabilistic bots, however we cannot find out with a single match log.

Where do we expect to place in the tournament?

While we are content with our heuristic and reasonably happy with our depth optimizations, the shortcomings listed in section 1 and the implementation mistakes that we did not catch lead us to believe that we may not be among the top 5 bots. We do believe that we can make it to the final 9 and hopefully that is the actual outcome.