

Design Tic-Tac-Toe

Design a Tic-tac-toe game that is played between two players on a $n \times n$ grid.

You may assume the following rules:

1. A move is guaranteed to be valid and is placed on an empty block.
2. Once a winning condition is reached, no more moves is allowed.
3. A player who succeeds in placing n of their marks in a horizontal, vertical, or diagonal row wins the game.

Example:

Given $n = 3$, assume that player 1 is "X" and player 2 is "O" in the board.

```
TicTacToe toe = new TicTacToe(3);
```

```
toe.move(0, 0, 1); -> Returns 0 (no one wins)
```

```
|X| | |  
| | | // Player 1 makes a move at (0, 0).  
| | |
```

```
toe.move(0, 2, 2); -> Returns 0 (no one wins)
```

```
|X| |O|  
| | | // Player 2 makes a move at (0, 2).  
| | |
```

```
toe.move(2, 2, 1); -> Returns 0 (no one wins)
```

```
|X| |O|  
| | | // Player 1 makes a move at (2, 2).  
| |X|
```

```
toe.move(1, 1, 2); -> Returns 0 (no one wins)
```

```
|X| |O|  
| |O| // Player 2 makes a move at (1, 1).  
| |X|
```

```
toe.move(2, 0, 1); -> Returns 0 (no one wins)
```

```
|X| |O|  
| |O| // Player 1 makes a move at (2, 0).  
|X|X|
```

```
toe.move(1, 0, 2); -> Returns 0 (no one wins)
```

```
|X| |O|  
|O|O| // Player 2 makes a move at (1, 0).  
|X|X|
```

```
toe.move(2, 1, 1); -> Returns 1 (player 1 wins)
```

```
|X| |O|  
|O|O| // Player 1 makes a move at (2, 1).  
|X|X|X|
```

Follow up:

Could you do better than $O(n^2)$ per `move()` operation?

1. Could you trade extra space such that `move()` operation can be done in $O(1)$?
2. You need two arrays: `int rows[n]`, `int cols[n]`, plus two variables: `diagonal`, `anti_diagonal`.

Solution 1

Initially, I had not read the Hint in the question and came up with an $O(n)$ solution. After reading the extremely helpful hint; a much easier approach became apparent. The key observation is that in order to win Tic-Tac-Toe you must have the entire row or column. Thus, we don't need to keep track of an entire n^2 board. We only need to keep a count for each row and column. If at any time a row or column matches the size of the board then that player has won.

To keep track of which player, I add one for Player1 and -1 for Player2. There are two additional variables to keep track of the count of the diagonals. Each time a player places a piece we just need to check the count of that row, column, diagonal and anti-diagonal.

Also see a very similar answer that I believe had beaten me to the punch. We came up with our solutions independently but they are very similar in principle. Aeonaxx's soln (<https://leetcode.com/discuss/101123/simple-o-1-time-c-solution-following-provided-hints>)

```
public class TicTacToe {
    private int[] rows;
    private int[] cols;
    private int diagonal;
    private int antiDiagonal;

    /** Initialize your data structure here. */
    public TicTacToe(int n) {
        rows = new int[n];
        cols = new int[n];
    }

    /** Player {player} makes a move at ({row}, {col}).
     * @param row The row of the board.
     * @param col The column of the board.
     * @param player The player, can be either 1 or 2.
     * @return The current winning condition, can be either:
     *         0: No one wins.
     *         1: Player 1 wins.
     *         2: Player 2 wins. */
    public int move(int row, int col, int player) {
        int toAdd = player == 1 ? 1 : -1;

        rows[row] += toAdd;
        cols[col] += toAdd;
        if (row == col)
        {
            diagonal += toAdd;
        }

        if (col == (cols.length - row - 1))
        {
            antiDiagonal += toAdd;
        }

        int size = rows.length;
        if (Math.abs(rows[row]) == size ||
            Math.abs(cols[col]) == size ||
            Math.abs(diagonal) == size ||
            Math.abs(antiDiagonal) == size)
        {
            return player;
        }

        return 0;
    }
}
```

written by bdwalker (<https://leetcode.com/discuss/user/bdwalker>) original link here
(<https://leetcode.com/discuss/101144/java-o-1-solution-easy-to-understand>)

Solution 2

new version:

```
class TicTacToe {
private:
    //count parameter: player 1 + : player 2: -
    vector<int> rowJudge;
    vector<int> colJudge;
    int diag, anti;
    int total;
public:
    /** Initialize your data structure here. */

    TicTacToe(int n):total(n), rowJudge(n), colJudge(n),diag(0),anti(0){}

    int move(int row, int col, int player) {
        int add = player == 1 ? 1 : -1;
        diag += row == col ? add : 0;
        anti += row == total - col - 1 ? add : 0;
        rowJudge[row] += add;
        colJudge[col] += add;
        if(abs(rowJudge[row]) == total || abs(colJudge[col]) == total || abs(diag) == total || abs(anti) == total)
            return player;
        return 0;
    }
};
```

old version:

```

class TicTacToe {
private:
    //status:
    // 0: no one fill
    // 1 or 2: player fill
    //-1 : invalid
    //pair:
    //first:player, second:count
    vector<pair<int,int>> rowJudge;
    vector<pair<int,int>> colJudge;
    pair<int,int> diag, anti;
    int total;
public:
    /** Initialize your data structure here. */
    TicTacToe(int n):total(n), rowJudge(n), colJudge(n){}

    /** Player {player} makes a move at ({row}, {col}).
    @param row The row of the board.
    @param col The column of the board.
    @param player The player, can be either 1 or 2.
    @return The current winning condition, can be either:
        0: No one wins.
        1: Player 1 wins.
        2: Player 2 wins. */
    int move(int row, int col, int player) {
        if(rowJudge[row].first == 0 || rowJudge[row].first == player){
            rowJudge[row].first = player;
            rowJudge[row].second++;
            if(rowJudge[row].second == total){
                return player;
            }
        }
        else {
            rowJudge[row].first = -1;
        }

        if(colJudge[col].first == 0 || colJudge[col].first == player){
            colJudge[col].first = player;
            colJudge[col].second++;
            if(colJudge[col].second == total){
                return player;
            }
        }
        else {
            colJudge[col].first = -1;
        }

        if(row == col){
            if(diag.first == 0 || diag.first == player){
                diag.first = player;
                diag.second++;
                if(diag.second == total){
                    return player;
                }
            }
            else{
                diag.first = -1;
            }
        }

        if(row + col == total - 1){
            if(anti.first == 0 || anti.first == player){
                anti.first = player;
                anti.second++;
                if(anti.second == total){
                    return player;
                }
            }
            else{
                anti.first = -1;
            }
        }
        return 0;
    }
};

```

written by sxycwzwzq (<https://leetcode.com/discuss/user/sxycwzwzq>) original link here
(<https://leetcode.com/discuss/101236/c-time-o-1-space-o-n-short-simple-solution>)

Solution 3

```
public class TicTacToe {

    private int[] rows;
    private int[] cols;
    private int size;
    private int diagonal;
    private int anti_diagonal;
    /** Initialize your data structure here. */
    public TicTacToe(int n) {
        size = n;
        rows = new int[n];
        cols = new int[n];
    }

    /** Player {player} makes a move at ({row}, {col}).
    @param row The row of the board.
    @param col The column of the board.
    @param player The player, can be either 1 or 2.
    @return The current winning condition, can be either:
        0: No one wins.
        1: Player 1 wins.
        2: Player 2 wins. */
    public int move(int row, int col, int player) {
        int add = player == 1 ? 1 : -1;
        if(col == row){
            diagonal += add;
        }
        if(col == size - 1 - row){
            anti_diagonal += add;
        }
        rows[row] += add;
        cols[col] += add;
        if(Math.abs(rows[row]) == size || Math.abs(cols[col]) == size || Math.abs(diagonal) == size || Math.abs(anti_diagonal) == size){
            return player;
        }
        return 0;
    }
}
```

written by lei11 (<https://leetcode.com/discuss/user/lei11>) original link here
(<https://leetcode.com/discuss/101172/share-my-java-solution>)

From Leetcoder (<https://itunes.apple.com/ca/app/leetcoder/id1069760709?mt=8>).