VIETNAM NATIONAL UNIVERSITY, HO CHI MINH CITY
UNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

Computer Architecture CO2008

Assignment

TIC TAC TOE

Advisor : Pham Quoc Cuong
Students : Pham Huy Thien Phuc - 2053346

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Contents

1 Introduction

Tic-tac-toe is a game in which two players take turns in drawing either an ' O' or an ' X' in one square of a grid consisting of nine squares. The winner is the first player to get three of the same symbols in a row.
The assignment **requires** us to design and **write MIPS assembly language** for implementing a *text-based* Tic-Tac-Toe game for two players.

I implemented the code in MARS MIPS simulator. The goal of this document is to explain about my idea and the building process.

2 Main idea and explanation

2.1 Describe the main idea by flowchart

A flowchart is a type of diagram that represents a workflow or process. A flowchart can also be defined as a diagrammatic representation of an algorithm, a step-by-step approach to solving a task.

I decided to use flowchart in the first step, because at the recent I want to visualize my idea. ***Flow-chart*** *is one of the most useful method that I have learned in university.*

Explain the idea :

- The first of all the program will **START**. Then, it will display the **Number of games** that players have played and the **Score** of each player.
After that, I will **Create new board** for a new game. The users will input the number from 1 - 9 corresponding with each position in the board. I will check turn of player if it is **Player 1 or not** and **Assign 'X' or 'Y'** suitable for each player.
- The next step, I will **Check winning condition** of the recent board if it true the player who immediately input will win and the score of that player plus one. The program will print the result to the screen and go to the step **Display the Menu**. In the case, two player haven't won but board is full (**All the board are 'X' and 'Y'**), it display **"Game Draw"**. The board is not full, the program continues to require input from players.
- In the step, **Display the Menu**. The program will waiting for the **Number from user**. If it is **99**, the program will **END**. In another case (the input number different from 99), It will auto understand that the user want to **play another game** and **Number of games increase 1**. And the program will show the recent result and start a new game. The procedure is described step by step in the **Flowchart** in *(Figure 1)* below.

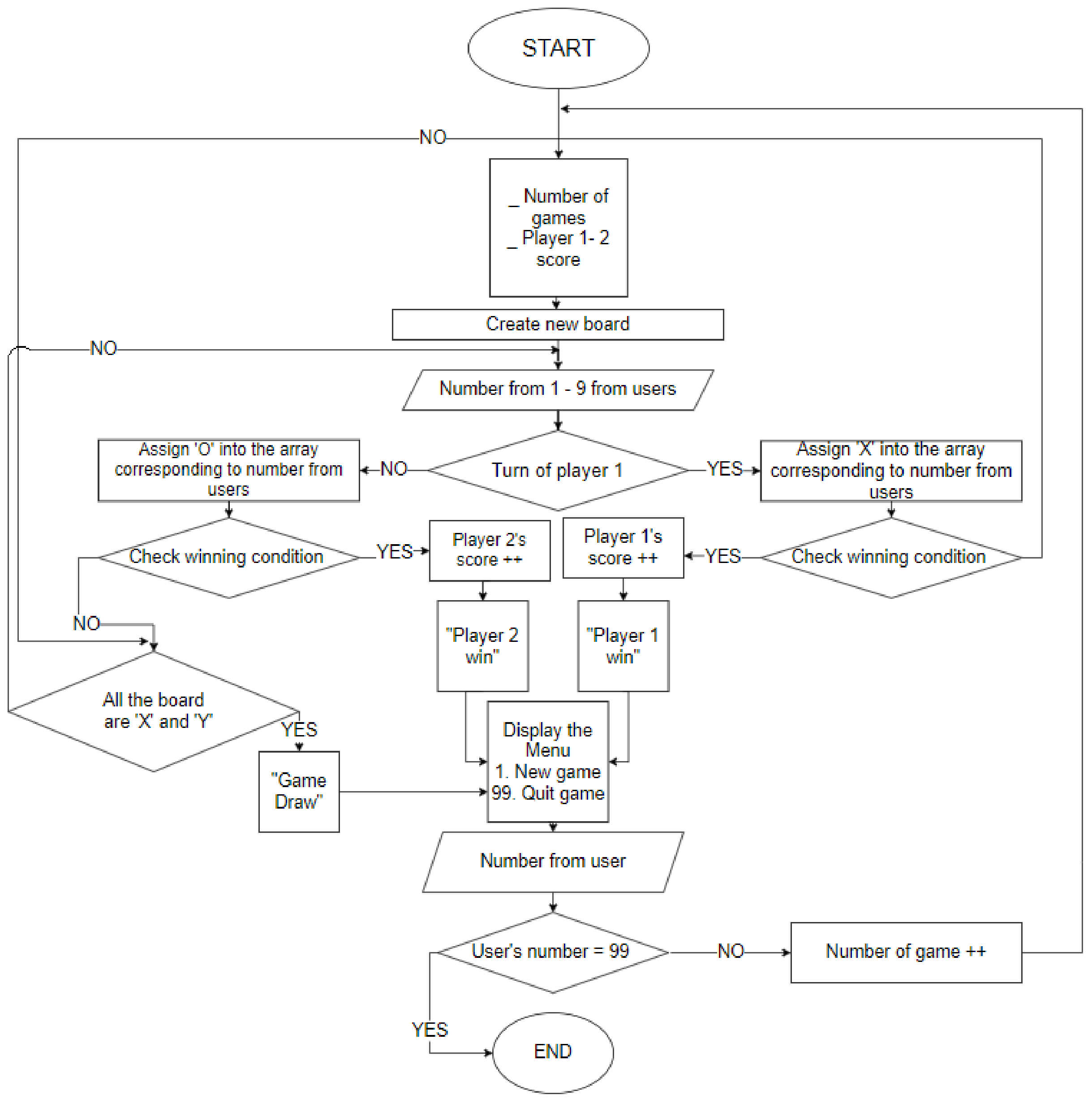


Figure 1 – Flow Chart

As we see, some steps are very easy to implement but some of them is not. The first thing is how to ***check the turn of player*** *of each player. The second is how to* ***assign 'X' and 'Y'****.*
The third is how to ***check winning condition*** *in the board.The final is* ***check full board*** *(All the board are 'X' and 'Y') .We will go to the detail of each procedure below.*

2.2 Check the turn of player

Imagine that two people are playing together, they can recognize who will play in the next turn by seeing and comparing in their brain. How to make the computers have that ability ?

To deal with this problem, I used a **counting variable**. Because there are only two players in Tic-tac-toe game, **one** is the counting variable value in the **initial**. After one turn the **counting variable** will increase by one. If the remainder of counting variable when we divide it by two is 1, we will conclude that it is player 1's turn. Because dividing by two, the remainder can only one or zero, in the case it equals zero, we can know that this is player 2's turn.

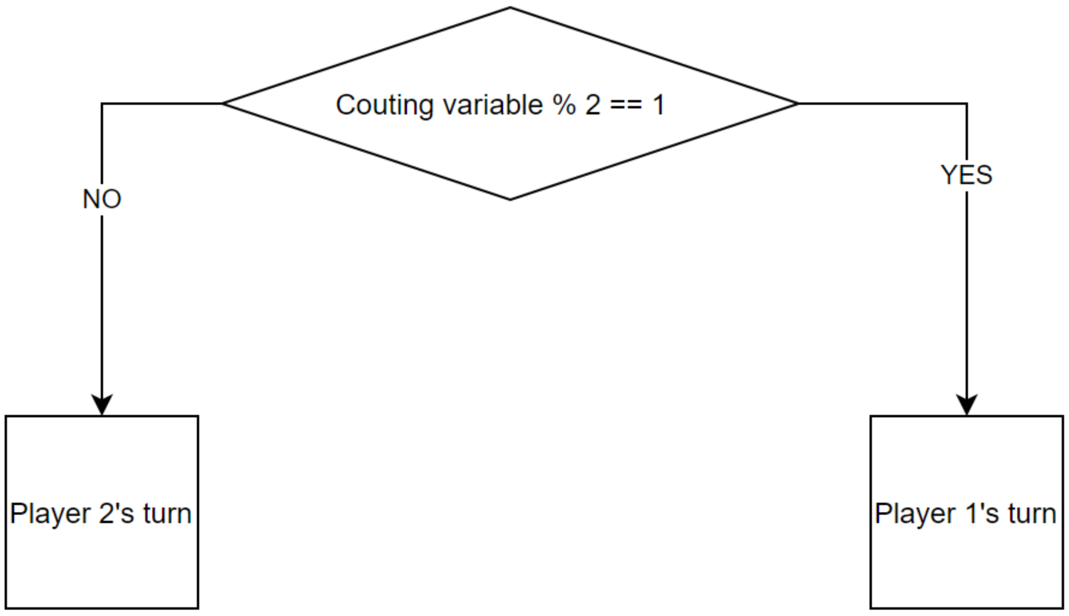
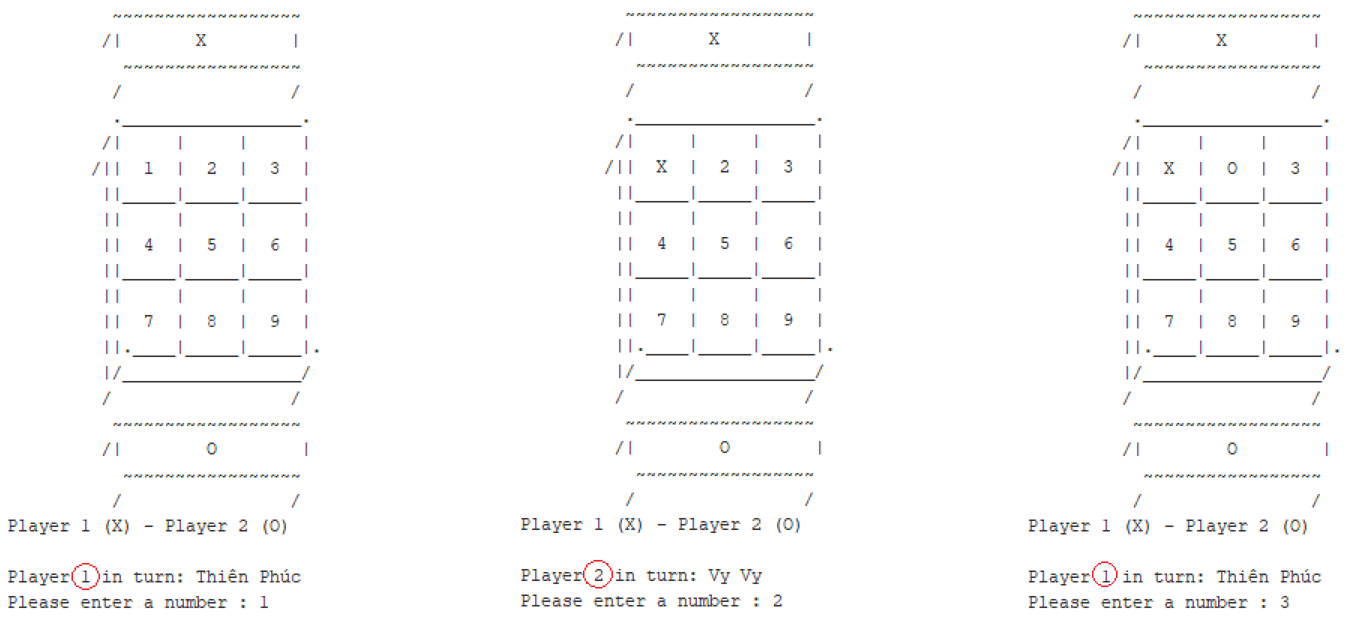


FIGURE 2 – Flow chart for checking turn of player

In *Figure 3*, in the first turn the program shows that player **1** in turn (red circle).After the turn of player **2** (Vy Vy), it turns back to player **1** (Thiên Phúc).



```
          ~~~~~~~~~~~~~~~~~~
         /|       X        |
           ~~~~~~~~~~~~~~~~~
          /                /
          ._________________.
         /|     |     |     |
        /||  1  |  2  |  3  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  4  |  5  |  6  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  7  |  8  |  9  |
         ||.____|_____|_____|.
         |/_________________/
         /                 /
          ~~~~~~~~~~~~~~~~~~
         /|        O        |
           ~~~~~~~~~~~~~~~~~
          /                /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 1
```

```
          ~~~~~~~~~~~~~~~~~~
         /|       X        |
           ~~~~~~~~~~~~~~~~~
          /                /
          ._________________.
         /|     |     |     |
        /||  X  |  2  |  3  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  4  |  5  |  6  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  7  |  8  |  9  |
         ||.____|_____|_____|.
         |/_________________/
         /                 /
          ~~~~~~~~~~~~~~~~~~
         /|        O        |
           ~~~~~~~~~~~~~~~~~
          /                /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 2
```

```
          ~~~~~~~~~~~~~~~~~~
         /|       X        |
           ~~~~~~~~~~~~~~~~~
          /                /
          ._________________.
         /|     |     |     |
        /||  X  |  O  |  3  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  4  |  5  |  6  |
         ||_____|_____|_____|
         ||     |     |     |
         ||  7  |  8  |  9  |
         ||.____|_____|_____|.
         |/_________________/
         /                 /
          ~~~~~~~~~~~~~~~~~~
         /|        O        |
           ~~~~~~~~~~~~~~~~~
          /                /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 3
```

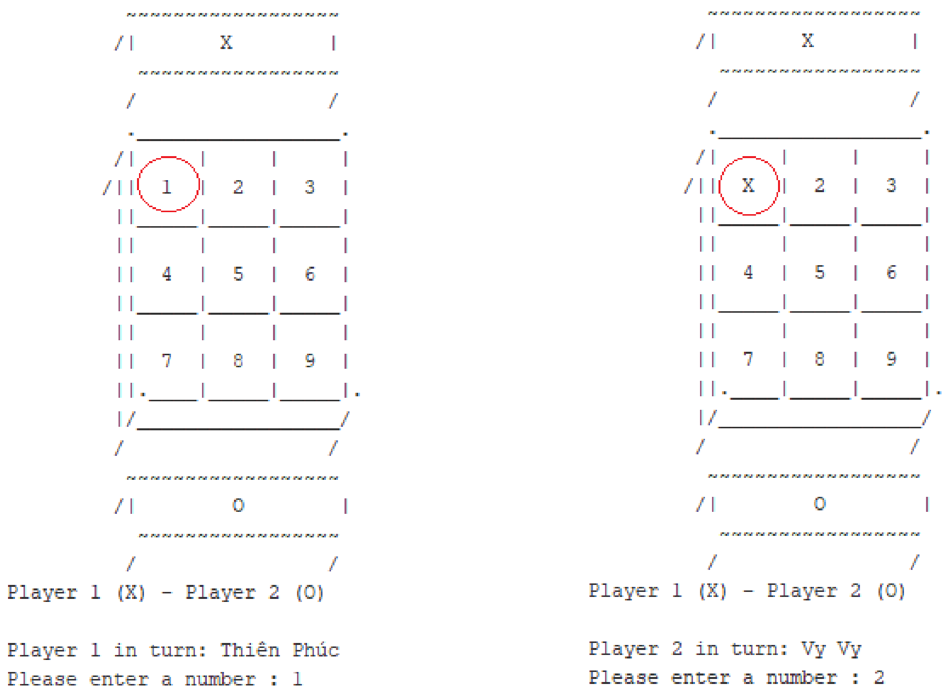
FIGURE 3 – Result for check turn

2.3 Assign 'X' or 'Y' on the board

*As we mentioned in the **part(2.2)**, We have known that which step we will assign 'X' and which step we need assign 'Y'. The main idea of this problem is how to change the number in the Tic-tac-toe board to 'X' or 'Y'. Now let's discuss about that process.*

- The first thing, I will declare an **array1** having nine characters : '1', '2', '3', '4', '5', '6', '7', '8', '9'.
- Then an **array2** having two characters : 'X', 'Y'.
- Depending on users input, I can assign 'X' and 'Y' in **array2** to suitable number of **array1**. And after each turn, I will display it in the screen.

For example :
- In the first turn, the program displays an initial **array1** so it prints {1, 2, 3, 4, 5, 6, 7, 8, 9} on the board.
After the player 1 had entered a number **1** in the first turn.
- The program will assign 'X' in **array2** into '1' in **array1**. Now, **array1** : 'X', '2', '3', '4', '5', '6', '7', '8', '9'.
- As a result, in the second turn the program displays **array1** on the board.
It is {X, 2, 3, 4, 5, 6, 7, 8, 9} *(Figure 4)*.



```
  ~~~~~~~~~~~~~~~~~~~~
/|        X        |
   ~~~~~~~~~~~~~~~~~~
  /                /
  ._________________.
/|     |     |     |
/||  1  |  2  |  3  |
||_____|_____|_____|
||     |     |     |
||  4  |  5  |  6  |
||_____|_____|_____|
||     |     |     |
||  7  |  8  |  9  |
||.____|_____|_____|.
|/_________________/
/                 /
  ~~~~~~~~~~~~~~~~~~~~
/|        O        |
   ~~~~~~~~~~~~~~~~~~
  /                /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 1
```

```
  ~~~~~~~~~~~~~~~~~~~~
/|        X        |
   ~~~~~~~~~~~~~~~~~~
  /                /
  ._________________.
/|     |     |     |
/||  X  |  2  |  3  |
||_____|_____|_____|
||     |     |     |
||  4  |  5  |  6  |
||_____|_____|_____|
||     |     |     |
||  7  |  8  |  9  |
||.____|_____|_____|.
|/_________________/
/                 /
  ~~~~~~~~~~~~~~~~~~~~
/|        O        |
   ~~~~~~~~~~~~~~~~~~
  /                /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 2
```

FIGURE 4 – Assign 'X' and 'Y'

2.4 Check winning condition

In order to check the winning conditions. We must know how to win in this game. The player who succeeds in placing three of their marks in a horizontal, vertical, or diagonal row is the winner.

As it is small and simple case, I decided to list all the possible winning case.

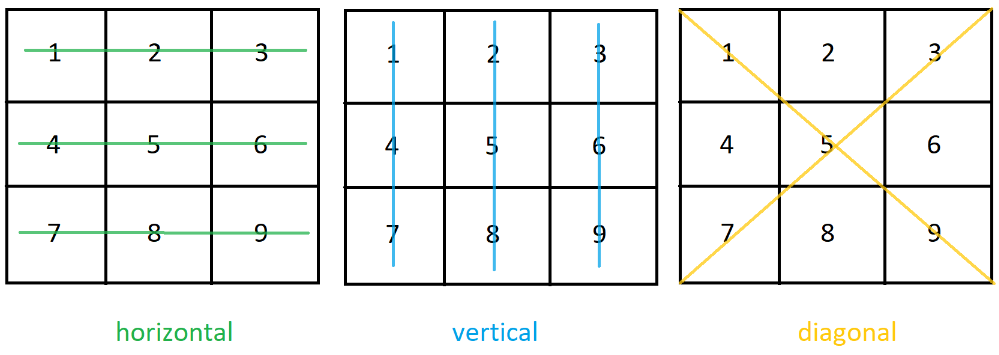


FIGURE 5 – All the winning conditions

There are total **8 winning conditions**. I will consider it step by step from the first condition to the eighth condition.

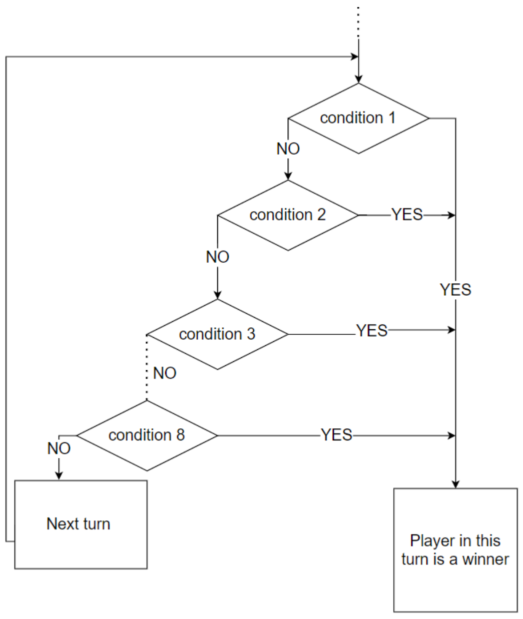


FIGURE 6 – Flow chart for winning condition concept

For example :
I assume that the condition 1 is {1,2,3} (the condition that go through number 1,2 and 3 with green crossing in the horizontal graph in *Figure 5*).

First of all, I will consider if the symbol in '1' is as same as the symbol in '2'. If the answer is :
+ Yes. I will do the same steps with '2' and '3'. If it is yes. I conclude the player in this turn is win. If no, the program will consider condition 2. And do the same steps for the other conditions.
+ No. I will consider the condition 2.*(Figure 6)*

The figure 7 will express the way when we separate condition 1 into two small steps.

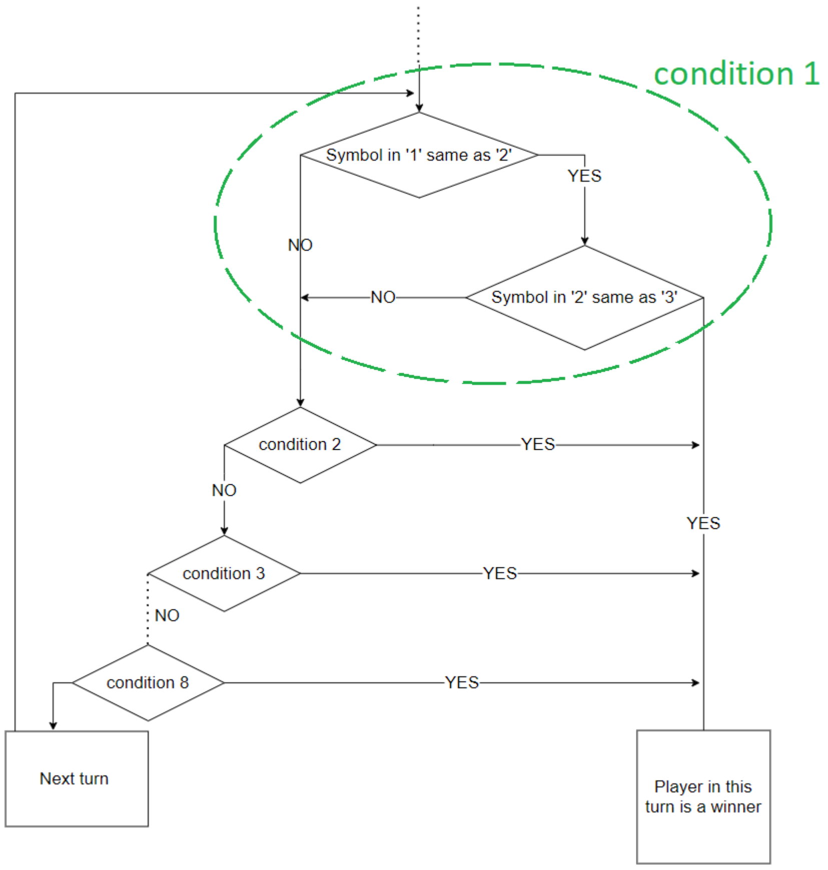

condition 1
Symbol in '1' same as '2'
YES
NO
Symbol in '2' same as '3'
NO
condition 2
YES
NO
YES
condition 3
YES
NO
condition 8
YES
Next turn
Player in this turn is a winner

FIGURE 7 – Condition 1 in detail

2.5 Check full board

Last but not least, how to check the board is full or not. (All the numbers were assigned to 'X' or 'Y')
The main idea is to compare all the word of **array1** with the sequence of characters : '1', '2', '3', '4', '5', '6', '7', '8', '9'.

For example :
- **array1** after some turns is 'X', 'Y', '3', 'Y', 'X', '6', '7', '8', '9'.
The procedure can be expressed as below :
1) The program will compare the **first character of array1** 'X' with '1'. It is different, it will consider to the second element.
2) 'Y' is different from '2'. Considering next element.
3) '3' is same as '3'. The procedure is finish.
At this step, we can conclude that the board is not full.

3 Extension and Interface

In this part, I will introduce some interface and extension of my game.

3.1 Name of players

The idea to design an interface making people feel like in the real world is not new. But it is one of the most effective way to make the program more friendly with players. In the real world, people have their names so I decided to design it in my game.

I will design two difference strings to store two players name. After each turn, I will consider player 1's or player 2's turn and put the suitable name to the screen.

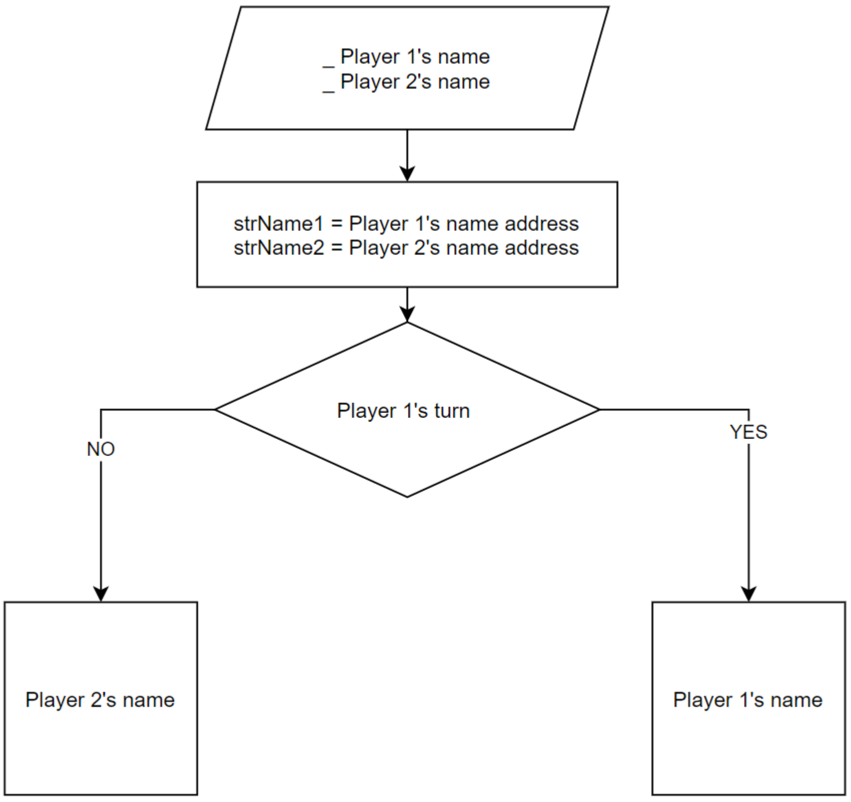
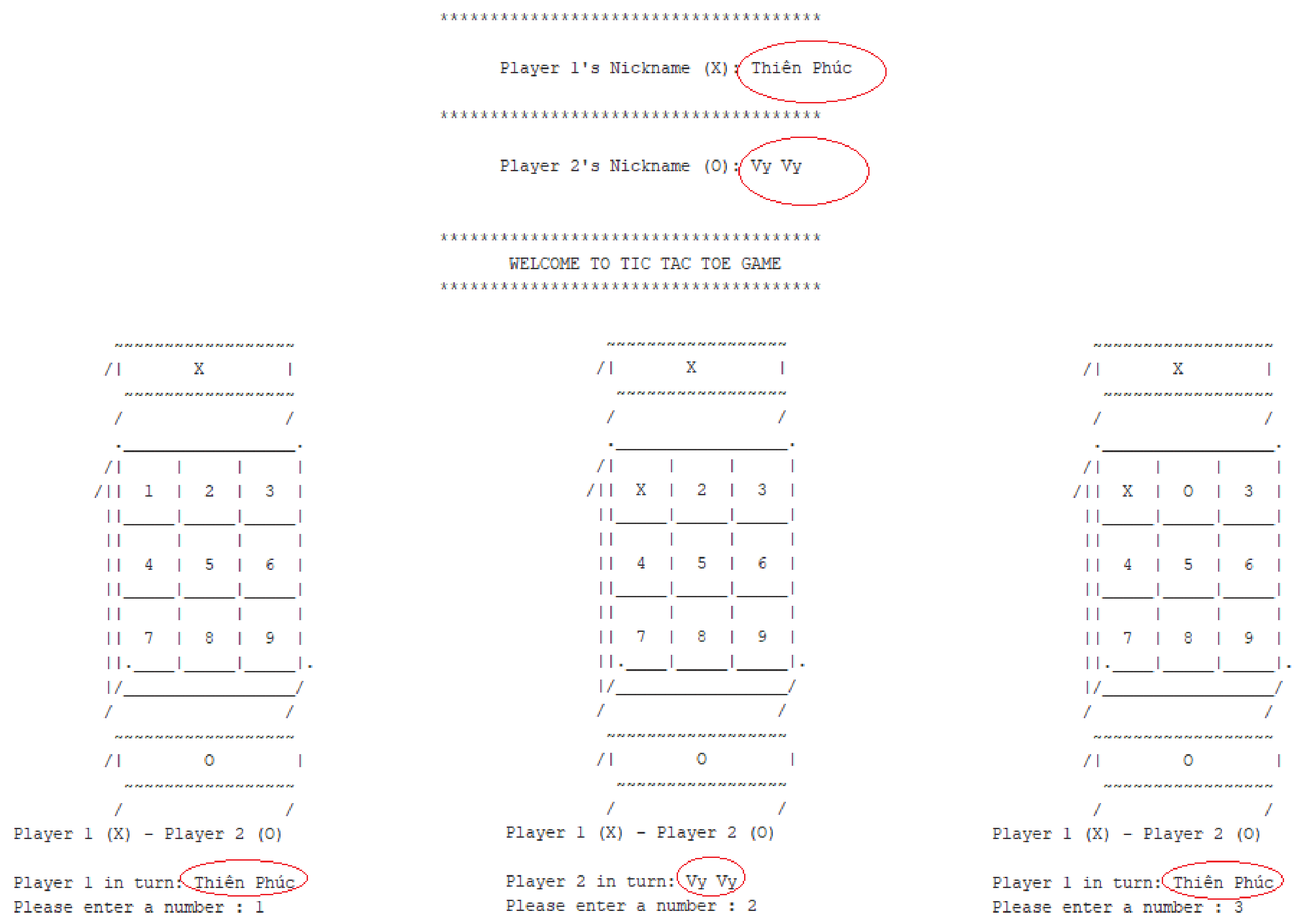


FIGURE 8 – Flowchart for player's name design

On the top of the *figure 9*, the program requires the user to input name of player 1 and player 2. In appropriate turn, the program will display the name of each player.



```
**************************************

      Player 1's Nickname (X): Thiên Phúc

**************************************

      Player 2's Nickname (O): Vy Vy


**************************************
       WELCOME TO TIC TAC TOE GAME
**************************************
```

```
  ~~~~~~~~~~~~~~~~~~
 /|       X        |
   ~~~~~~~~~~~~~~~~~
  /               /
  ._________________.
 /|     |     |     |
/||  1  |  2  |  3  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  4  |  5  |  6  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  7  |  8  |  9  |
 ||.____|_____|_____|.
 |/_________________/
 /                 /
  ~~~~~~~~~~~~~~~~~~
 /|       O        |
   ~~~~~~~~~~~~~~~~~
  /               /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 1
```

```
  ~~~~~~~~~~~~~~~~~~
 /|       X        |
   ~~~~~~~~~~~~~~~~~
  /               /
  ._________________.
 /|     |     |     |
/||  X  |  2  |  3  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  4  |  5  |  6  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  7  |  8  |  9  |
 ||.____|_____|_____|.
 |/_________________/
 /                 /
  ~~~~~~~~~~~~~~~~~~
 /|       O        |
   ~~~~~~~~~~~~~~~~~
  /               /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 2
```

```
  ~~~~~~~~~~~~~~~~~~
 /|       X        |
   ~~~~~~~~~~~~~~~~~
  /               /
  ._________________.
 /|     |     |     |
/||  X  |  O  |  3  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  4  |  5  |  6  |
 ||_____|_____|_____|
 ||     |     |     |
 ||  7  |  8  |  9  |
 ||.____|_____|_____|.
 |/_________________/
 /                 /
  ~~~~~~~~~~~~~~~~~~
 /|       O        |
   ~~~~~~~~~~~~~~~~~
  /               /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 3
```

FIGURE 9 – Example for name display

3.2 Go first alter

As we know, going first is a big benefit especially in Tic-tac-toe. It makes no sense if one player always plays first in all stages. In this case, I chose using counting variable. After each game, counting variable plus one. If the remainder when this variable divides by 2 is one, the player 1 goes first. Otherwise, player 2 goes first. The flow chart is quiet the same as *Figure 2* but the counting variable increases in each game instead of each turn like **part 2.2**.

3.3 The final winner

*As I mentioned if we input number **99** in the GameMenu, the game will end. At that time, the program should display the final result for all score and decide who is the **final winner**.*

We will store a score of player 1 and player 2 in the array. After the player had inputted number **99** in the GameMenu, We immediately compared the score of two player and display the output.

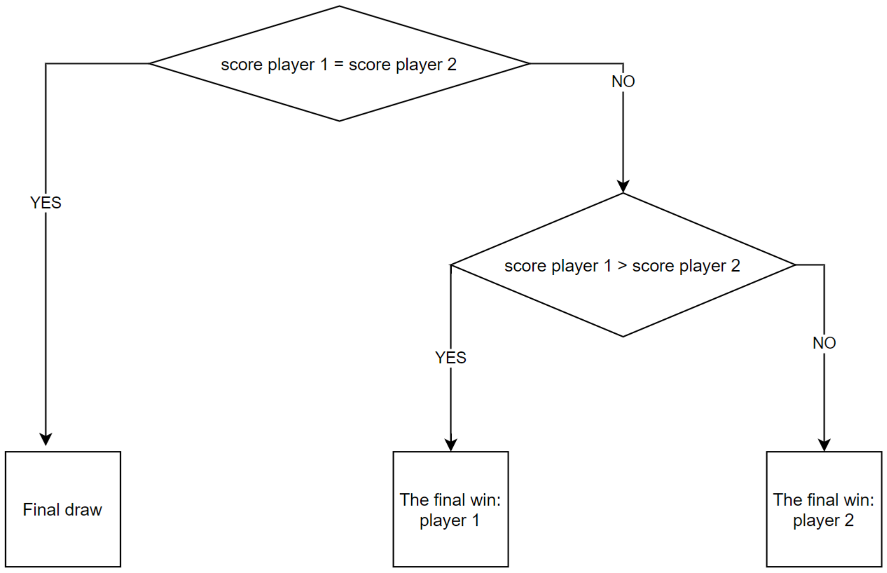
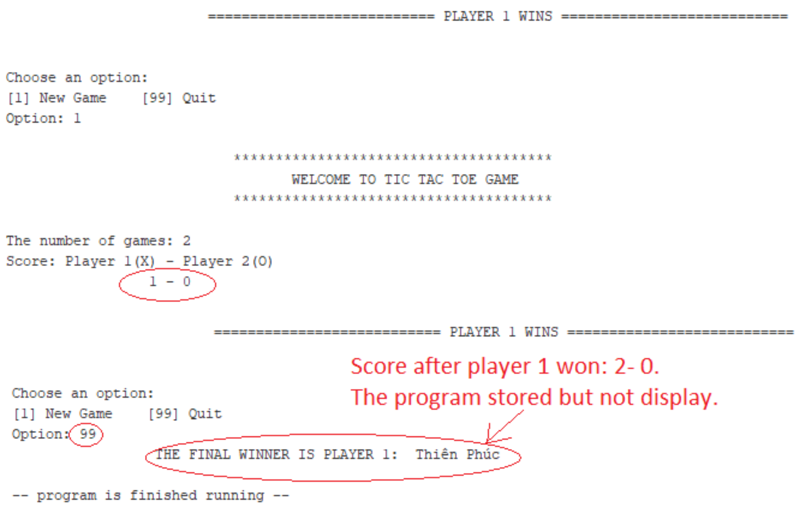


FIGURE 10 – Final winner flowchart

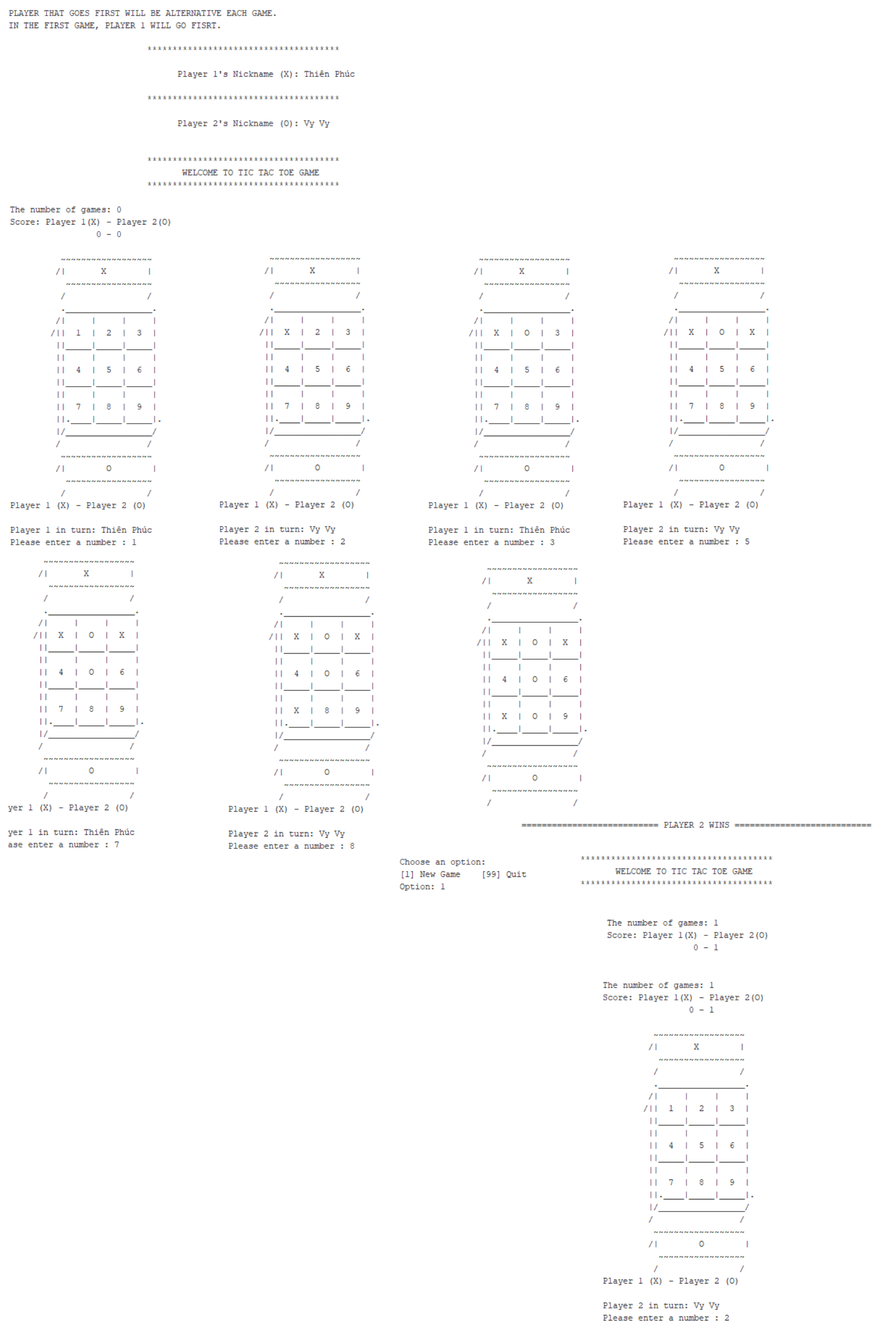


```
                    ========================== PLAYER 1 WINS ==========================


Choose an option:
[1] New Game    [99] Quit
Option: 1

                      **************************************
                           WELCOME TO TIC TAC TOE GAME
                      **************************************

The number of games: 2
Score: Player 1(X) - Player 2(O)
                  1 - 0

                    ========================== PLAYER 1 WINS ==========================

Choose an option:
[1] New Game    [99] Quit
Option: 99
           THE FINAL WINNER IS PLAYER 1:  Thiên Phúc

-- program is finished running --
```

Score after player 1 won: 2- 0.
The program stored but not display.

FIGURE 11 – Example for final winner

4 Try an example



```
PLAYER THAT GOES FIRST WILL BE ALTERNATIVE EACH GAME.
IN THE FIRST GAME, PLAYER 1 WILL GO FISRT.

                    **************************************

                        Player 1's Nickname (X): Thiên Phúc

                    **************************************

                        Player 2's Nickname (O): Vy Vy


                    **************************************
                         WELCOME TO TIC TAC TOE GAME
                    **************************************

The number of games: 0
Score: Player 1(X) - Player 2(O)
               0 - 0

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| 1   | 2  | 3  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | 5  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 1

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | 2  | 3  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | 5  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 2

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | O  | 3  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | 5  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 1 in turn: Thiên Phúc
Please enter a number : 3

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | O  | X  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | 5  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 5

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | O  | X  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | O  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
yer 1 (X) - Player 2 (O)

yer 1 in turn: Thiên Phúc
ase enter a number : 7

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | O  | X  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | O  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || X   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 8

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| X   | O  | X  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | O  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || X   | O  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /

========================== PLAYER 2 WINS ==========================

Choose an option:
[1] New Game    [99] Quit
Option: 1

                    **************************************
                         WELCOME TO TIC TAC TOE GAME
                    **************************************

The number of games: 1
Score: Player 1(X) - Player 2(O)
               0 - 1


The number of games: 1
Score: Player 1(X) - Player 2(O)
               0 - 1

         ~~~~~~~~~~~~~~~~~~
        /|       X        |
          ~~~~~~~~~~~~~~~~~
         /               /
         ._______________.
        /|     |    |    |
       /|| 1   | 2  | 3  |
        ||_____|____|____|
        ||     |    |    |
        || 4   | 5  | 6  |
        ||_____|____|____|
        ||     |    |    |
        || 7   | 8  | 9  |
        ||.____|____|____|.
        |/_______________/
        /               /
         ~~~~~~~~~~~~~~~~~~
        /|       O        |
          ~~~~~~~~~~~~~~~~~
         /               /
Player 1 (X) - Player 2 (O)

Player 2 in turn: Vy Vy
Please enter a number : 2
```

FIGURE 12 – Running an example

Explanation :

- First of all, the program displayed an instruction about **name and first turn to player**.
- At that time, the program required name from player 1(X) and player 2(O) in order.
- After that the game started.
- In the first game, **the number of games : 0**. Because no game had occurred before.
- The player 1 typed number 1 in the first turn, after that player 2 chose number 2. **'X' and 'Y'** are assigned on the board in each turn.
- The winning condition was satisfied immediately when the **player 2** was typing number *8* in the last step. The program printed the sentence :
"======================== PLAYER 2 WINS ========================".
- **The Menu** was appearing and required a number from user. If the number equals **99**. The program will end. In the case, it is difference from 99. The new game will have been ready to play.
- I chose **1**. The new game started. At this time, the **number of games : 1** and because player 2 won so the **Score** is **0 - 1** for player 2.
- It is second game so to make the game balance, **player 2 will go first.** *(Figure 12)*

5 Conclusion

The first time, I have read this problem, I felt it is quite confusing and difficult as well.Thanks to flow chart, I could visualize my idea (***Figure 1***). But it was still complicated to code all the flow chart in one time. So in ***part 2.2, 2.3, 2.4, 2.5***, I separated it in small section and solved step by step. After that, I combined them together. In the interface and extension section (***part 3***), I thought a lot about the balance and friendliness of the program. Finally, I achieved the program execution in the ***part 4***. Thanks for your reading!