Project: Socket Programming

1. Intro: Your new job as a game developer

Congratulations! You've been given an internship at one of the larger game developers, *Electronic Farce*, who have just launched a new and addictive turn-based strategic tile placing game. The company initially started developing this game last year, but due to the pandemic, the engineer in charge left the project and had to focus on maintaining RNG battle royale that was developed back in 2019. EF decided to reboot this game project by hiring you.

The previous engineer managed to write the client code, but did not provide any documentations. Because the client is already written, the message format for communication between the server and clients is already set. You can use the client to test your server as your development progresses. He also wrote a small sample server written in Python. But this server is deficient in that it only allows a single client to play a rather pointless game alone. However, you can inspect this server to see how to pass and receive the predetermined game messages. You can also use the server to see the basic flow of the game.

In a rather spectacular but not altogether surprising fashion, EF have tasked all of the interns (you) to implement their server in a short period of time. Your task is to write an upgraded server for the strategic tile placing game. We provide more specific game details below.

2. The Game

The game in question is a strategic tile placing game. Each player is given a set of random tiles (from a preset list of tiles) by the server. A tile has two points on each side (north, east, south, and west). Each of these eight points is connected to one of the other points on the tile, so there are four connections in total. Example tiles are shown in Figure 1.

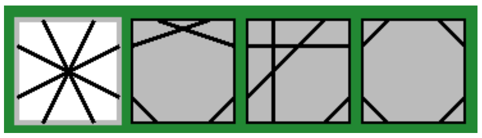


Figure 1. Example tiles (first tile selected in game)

The gameplay

The board is initially empty. One at a time, in an order determined by the server, each player places a single tile on the board, ensuring that the first tile is connected to the edge of the board.

In the second turn, each player chooses where their token will enter the board. This must be one of the points on the tile that they placed in the first turn, so there will be either two or four possible locations (depending on whether or not the tile was placed in a corner).

The player's token automatically follows the connection across the tile, reaching a new square of the board. If that board already has a tile, the token will follow the connection in the new tile, continuing until it either reaches an empty square or the edge of the board.

If a player's token reaches the edge of the board, that player is eliminated.

On the third turn, and all subsequent turns, each remaining player may place a single tile from their hand onto the empty square that their token is entering. Any other players who are entering the same square will be moved automatically according to the connections on the placed tile, so it is possible for other players to be eliminated.

If only one player remains alive, that player is considered the winner.

You can find what it looks like as a multiplayer in Figure 2 (initially, you will only be able to play with 1 client with the provided server code). You can also see what kind of messages are being sent between the server and clients in Figure 3.

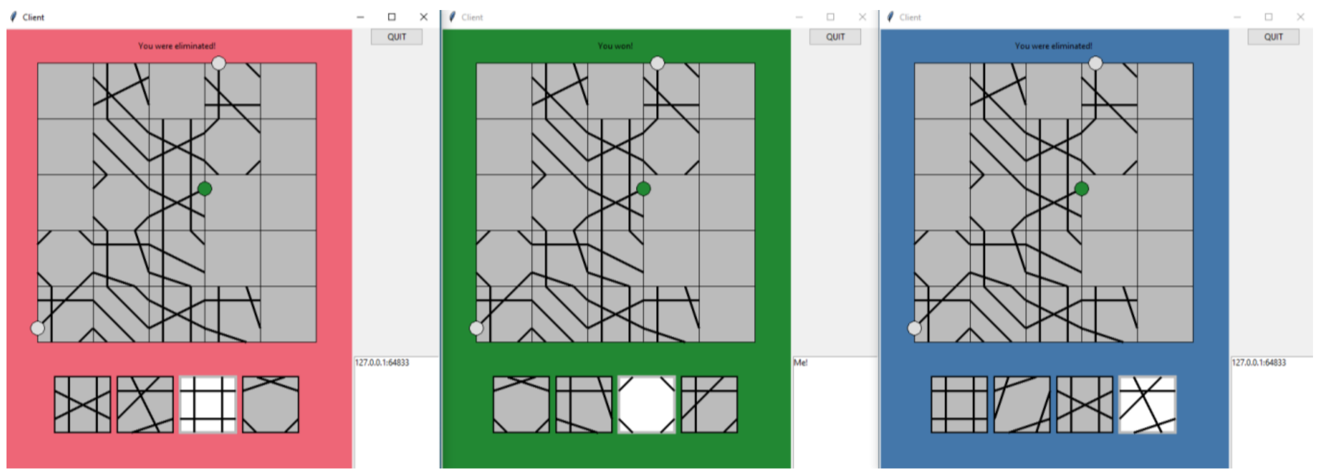
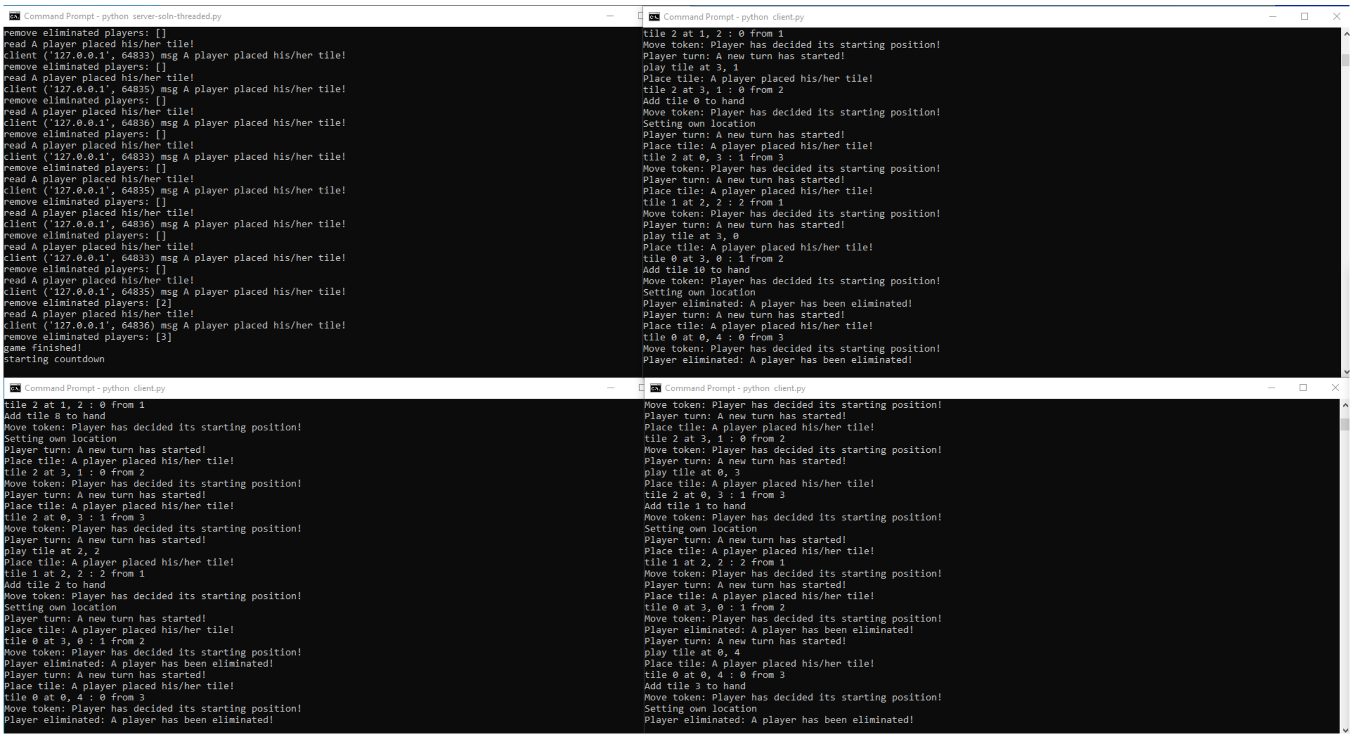


Figure 2. Game play (3 players - green player won)



Command Prompt - python server-soln-threaded.py

```
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64833) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64835) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64836) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64833) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64835) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64836) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64833) msg A player placed his/her tile!
remove eliminated players: []
read A player placed his/her tile!
client ('127.0.0.1', 64835) msg A player placed his/her tile!
remove eliminated players: [2]
read A player placed his/her tile!
client ('127.0.0.1', 64836) msg A player placed his/her tile!
remove eliminated players: [3]
game finished!
starting countdown
```

Command Prompt - python client.py

```
tile 2 at 1, 2 : 0 from 1
Move token: Player has decided its starting position!
Player turn: A new turn has started!
play tile at 3, 1
Place tile: A player placed his/her tile!
tile 2 at 3, 1 : 0 from 2
Add tile 0 to hand
Move token: Player has decided its starting position!
Setting own location
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 2 at 0, 3 : 1 from 3
Move token: Player has decided its starting position!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 1 at 2, 2 : 2 from 1
Move token: Player has decided its starting position!
Player turn: A new turn has started!
play tile at 3, 0
Place tile: A player placed his/her tile!
tile 0 at 3, 0 : 1 from 2
Add tile 10 to hand
Move token: Player has decided its starting position!
Setting own location
Player eliminated: A player has been eliminated!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 0 at 0, 4 : 0 from 3
Move token: Player has decided its starting position!
Player eliminated: A player has been eliminated!
```

Command Prompt - python client.py

```
tile 2 at 1, 2 : 0 from 1
Add tile 8 to hand
Move token: Player has decided its starting position!
Setting own location
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 2 at 3, 1 : 0 from 2
Move token: Player has decided its starting position!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 2 at 0, 3 : 1 from 3
Move token: Player has decided its starting position!
Player turn: A new turn has started!
play tile at 2, 2
Place tile: A player placed his/her tile!
tile 1 at 2, 2 : 2 from 1
Add tile 2 to hand
Move token: Player has decided its starting position!
Setting own location
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 0 at 3, 0 : 1 from 2
Move token: Player has decided its starting position!
Player eliminated: A player has been eliminated!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 0 at 0, 4 : 0 from 3
Move token: Player has decided its starting position!
Player eliminated: A player has been eliminated!
```

Command Prompt - python client.py

```
Move token: Player has decided its starting position!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 2 at 3, 1 : 0 from 2
Move token: Player has decided its starting position!
Player turn: A new turn has started!
play tile at 0, 3
Place tile: A player placed his/her tile!
tile 2 at 0, 3 : 1 from 3
Add tile 1 to hand
Move token: Player has decided its starting position!
Setting own location
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 1 at 2, 2 : 2 from 1
Move token: Player has decided its starting position!
Player turn: A new turn has started!
Place tile: A player placed his/her tile!
tile 0 at 3, 0 : 1 from 2
Move token: Player has decided its starting position!
Player eliminated: A player has been eliminated!
Player turn: A new turn has started!
play tile at 0, 4
Place tile: A player placed his/her tile!
tile 0 at 0, 4 : 0 from 3
Add tile 3 to hand
Move token: Player has decided its starting position!
Setting own location
Player eliminated: A player has been eliminated!
```

Figure 3. Game play (behind the scenes)

Program Flow/Requirements

For sake of simplicity we specify the flow of a single game below.

1. A selection of at most four players is chosen from all connected clients.
2. A random turn order for the four players is also determined.
3. Each client is notified that a new game is starting.
4. Each player is provided tiles to fill their starting hand.
5. While more than one player is alive:
   a. Notify all clients whose turn it is
   b. Wait for the current player to make a valid move
   c. Process the results of the move
      i. Notify all clients of new tile placements
      ii. Notify all clients of new token positions
      iii. Notify all clients of any eliminated players
      iv. If there are less than two players remaining, exit the loop
6. If the current player played a tile, send them a new tile
7. Switch to the next (remaining) player's turn

When a game is completed, the server should start a new game if there are enough clients available. Otherwise it should wait for more clients to join.

Exceptions in gameplay

Note that much of the game logic about legal tile placement, etc., is already handled for you in the `tiles.py` module. However, your server will still need to ensure that players behave correctly, for example:

- Players should only be allowed to play tiles that are currently in their hand.
- If a player sends a message when it is not their turn, it should be ignored.
- Players should only be able to choose a token position on their second turn (i.e. when they don't already have a token on the board).

3. Tasks

Your goal is to implement a server which implements the game described above. To get started, you are provided with:

- `tiles.py` - This module defines essential constants and gameplay logic, which is shared by both the client and the server.
- `server.py` - This module implements a basic server that allows a single client to play a single game with no other participants, and very little error checking.
- `client.py` - This module implements the game client. You do not need to understand this code, but you may like to inspect it to understand how the client expects to interact with the server.

Tier 1 - Enabling multiple players

Implement a basic server which can play a single game with two players. All players are expected to behave themselves insofar as they will only play cards from their hands, and they will only choose valid starting locations. Players may send messages when it is not their turn - you can choose to either ignore these messages, or to wait and process them when it is the players turn next.

All connections are expected to be fast and stable, so your server does not need to worry about clients disconnecting partway through the game (all of our players politely stay until the conclusion, even if they are destined to lose).

Tier 2 - Scaling up

Extend your server so that when a game finishes, if there are enough clients still connected to the server, it begins a new game. Optionally, you can wait for a certain amount of time before starting the new game (so that the players can reflect on the outcome of the previous game).

Your server should also be able to handle games of up to four players. If there are more than four clients connected, your server should randomly pick four of the clients to be the players. All other connected clients will be spectators, and should still receive updates about the game state. Any message received from a spectator or an eliminated player should be ignored (it should not carry over to the next game, if there is one).

Tier 3 - Connection issues

In addition to all previous requirements, your server must be able to handle unexpected network behaviour. For simplicity, we will consider two scenarios (but you should think about more and report about how you implemented those handlers).

- If a player exits during the middle of a game, they should be eliminated from the game. If it was that player's turn, the server should gracefully proceed to the next player's turn. If there is only one player remaining after the disconnection, the game should be finished.
- The server should also handle players attempting to join during a game. These players may be sent updates about the game state, but they should not be allowed to play any turns during this game (they are effectively spectators).

Tier 4 - Player issues

Next, we should make the experience nicer for players that join partway through an existing game, by helping them to catch up on the game state. To do this completely (for the existing client) we need to:

- Notify the client of the id number of all players that started in the current game, using `MessagePlayerTurn`.
- Notify the client of all players that have been eliminated from the current game, using `MessagePlayerEliminated`.
- Notify the client of the real current turn using `MessagePlayerTurn` again.
- Notify the client of all tiles that are already on the board, using `MessagePlaceTile`.
- Notify the client of all token positions, for players that have a token position, using `MessageMoveToken`.

When this is complete, a client joining the server at any time during an existing game should see the same game board as any other client.

Finally, let us ensure that the game continues for all players, even if we don't hear from a particular player for a long time. If a player doesn't make a valid move within 10 seconds, then the server should make a valid move for them:

- If it is the player's first turn, the server should choose a random tile from the player's hand, and place it on a random, empty border square, with a random rotation value (from 0 to 3 inclusive).
- If it is the player's second turn, the server should choose a starting token position at random from the positions available to the current player.
- If it is any subsequent turn, the server should choose a random tile from the player's hand, and place it on the square that the player's token is currently on, with a random rotation value (again, 0-3).