Title
201 Networked Crossword Puzzle

Topics Covered
Networking
Multi-Threading
Concurrency Issues

Introduction
This assignment will require you to create two different programs – a server and a client. You will implement a networked crossword puzzle game where multiple users can play against each other. There will be some concurrency issues since you will need to make sure only certain clients can play at different times. There will be many ways to design out the program, so I recommend you spend some time designing it out on paper before you begin coding.

Server Functionality
The server will be responsible for reading the puzzle data from a file and distributing it to the clients when they connect. To simplify execution of your program, only one game can be occurring at a time. Each game will have between 1 and 3 players. The first client to connect to the server will specify the number of players.

The server will have (possibly) multiple puzzle data files in a directory called `gamedata`. This directory should be placed in your project directory, at the same level as the `src` directory. Make sure that you specify a relative path when reading the game data files so the graders can run your program without having to change any hard-coded variables. Your server program will need to open the directory that contains all the game data files and determine how many files are in that directory. It will then randomly choose one of the files to use. Of course, if there is only one file in the directory, that is the one that will be chosen. The names of the files are irrelevant since the server will choose one of them randomly, so they could be named anything at all.

Each game data file will contain all the information needed to play a game. The file will be formatted with `ACROSS` or `DOWN` on the first line, followed by one or more lines formatted as:

`<number>|<answer>|<question>`

The file will then have a line with the word `ACROSS` or `DOWN` (whichever one wasn't used above), then one or more lines formatted the same as above.

Here is a sample file:

```
ACROSS
1|trojans|What is USC's mascot?
2|dodgers|What professional baseball team is closest to USC?
3|csci|What is the four-letter prefix for Computer Science?
DOWN
1|traveler|What is the name of USC's white horse?
4|gold|What is one of USC's colors?
5|marshall|Who is USC's School of Business named after?
```

Your server program will need to determine if the file is formatted properly. The only rules that you need to check are the following:

1. The words ACROSS and DOWN exist on their own lines and only one time in the file.
   (Note: You could have the word "across" or "down" as the answer to a question or in a question, but you can only have one ACROSS section and one DOWN section in the file.)
2. The other lines in the file are formatted with three parameters – integer, answer, question.
   a. The three parameters are separated by pipes.
3. If a number in the ACROSS section matches a number in the DOWN section, the answers must start with the same letter.
4. An answer cannot contain any whitespace.

The server will need to determine how to format the answers in the game board so it can send out that information to all the clients (since the clients all need to render the game board the same). There will be different ways that the data can be rendered. You can assume that there is at least one viable way to render the game board. In other words, you can assume that each word contains at least one letter that is in another word and the board can be rendered for the player. This may be challenging to figure out, so make sure to write out an algorithm to solve this before you begin coding.

If the ACROSS number and the DOWN number are the same, that means the answers will start with the same letter. The numbers do not have to be in order in the file, but all the questions for a section will immediately follow the name ACROSS or DOWN. There will not be more than one ACROSS section in a file.

All the answers to the questions are case-insensitive.

The server will wait to randomly determine a game file to read until the first client has connected. The server will listen on port 3456. When a client connects to it, it will randomly determine a game data file to read, verify that the file is formatted properly, and figure out a rendering of the game board. If there are no valid game files, the server should report that to the

client and continue waiting for another client to connect. At that point, it will read the directory again and randomly choose another game data file.

When the first client connects to it, the first message it sends will be a number between 1 and 3 to determine how many players will be part of the game. If the number is 1, the server can start the game. If the number is 2 or 3, the server will need to wait until the proper number of clients have connected to the server before starting the game.

*Game Play*
Once the proper number of players have joined the game, the server will send out the game board to all the players. The players will begin play in the order they joined the game. Only one player should be able to play at a time. More information on how the client will behave is included in the relevant section below. Every play should be sent to the server. The server validates whether the answer provided for the appropriate question is correct. If it is, the same player who guessed the correct answer will get to play again. If it is incorrect, play will proceed to the next player. Regardless, the server should send a notification to all the clients letting them know what question the player was attempting to answer, what the player guessed, and whether it was correct.

The server should keep track of how many correct answers each player has guessed and which questions are remaining. Once all the questions have been answered correctly, the server will notify all the players of the final score (1 point for each question answered correctly) and who the winner is (or a tie, if that is the case).

You do not need to maintain statistics, and there are no user accounts. Once a game concludes, the clients should terminate. The server should loop and allow a new game to begin by having another client connect. The server does not need to allow another game to begin while a game is being played – only one game is played at a time. The server should never have to be restarted, though, to play subsequent games.

Client Functionality
The client will begin by welcoming the user to the game and prompting her for the server hostname and port. If a valid connection is not made, display an error message and loop back to allow the use to enter another server hostname and port. If a valid connection is made, prompt for the number of players. The number of players must be between 1 and 3. Continue prompting for the number of players until a valid number is entered.

If the necessary number of players has not yet joined the game, display a message that says "Waiting for player x." The "x" should be replaced by the player number for which we are waiting. When a player joins, display a message stating from which IP address the player joined.

Once all the required players have joined, display a message that says, "The game is beginning." The server will send the game board, which includes the crossword puzzle and the questions.

Play will proceed through the players based on the order they joined the game. Player 1 will go first and select to guess the answer to a question that is either "down" or "across". If "d" or "a" is not entered, prompt the user again. The user will then be prompted to enter a number for which question to answer. If the value entered is not valid, prompt the user again.

Once the user has entered a valid question, (assume "a" and "1" were entered), prompt the user to enter the answer to the question, "What is your guess for 1 across?" The answer should be sent to the server, which will return whether it was correct or not to all the connected clients. The (possibly) updated game board and remaining questions to answer will be sent to all clients. Do not display questions that have already been answered correctly.

If a player answers a question correctly, she will get to answer another question. If the answer was incorrect, play will move to the next client who joined. If the last player that joined answers a question incorrectly, play will proceed to the first player.

Play continues like this until all the correct answers have been guessed. The completed game board with all the questions will be displayed, and the final scores will be shown. The final score is only based on how many questions a user guessed correctly. If one player has more correct answers than the others, declare that player the winner. If two players have the same score, declare the game a tie.

The clients will then terminate at that point, but the server will loop back to allow another player to join and start a new game.

The sample execution below shows all the messages that should be displayed throughout the game. Your output should be as close as possible to this, though the crossword puzzle may look different for the same answers since that will be based on how your program generates it.

Sample Execution

Below is a sample execution of the program with the user input bolded (though the input will not be bolded when you run your program). The first column is the server, the second column is the first player, and the third column is the second player. Ignore all the blank lines as I am trying to show you the time at which lines are displayed, but in the actual output, all the lines will be displayed next to each other. Assume the game file that was selected was the sample one provided earlier in the assignment.

| Server | Player 1 | Player 2 |
|---|---|---|
| Listening on port 3456.<br>Waiting for players...<br><br><br>Connection from 127.0.0.1<br><br>Number of players: 2<br>Waiting for player 2.<br>Reading random game file.<br>File read successfully.<br><br><br><br>Connection from 127.0.0.1<br><br>Game can now begin.<br><br>Sending game board. | <br><br>Welcome to 201 Crossword!<br>Enter the server hostname: **localhost**<br>Enter the server port: **3456**<br><br>How many players will there be? **2**<br><br>Waiting for player 2. | <br><br><br><br><br><br><br><br><br><br>Welcome to 201 Crossword!<br>Enter the server hostname: **localhost**<br>Enter the server port: **3456** |
| | Player 2 has joined from 127.0.0.1.<br><br>The game is beginning. | There is a game waiting for you.<br>Player 1 has already joined.<br><br>The game is beginning. |

```
                        5_
                         _
                         _
                3_   _  _  _
            4_       _
        1_  _  _  _  _  _  _
            _       _       _
            _       _       _
            _
            _
            _
      2_  _  _  _  _  _
            _
```

(this same board appears for both Player 1 and Player 2)

Across
1 What is USC's mascot?
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Across
1 What is USC's mascot?
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Player 1's turn.

Player 1 guessed "trojans" for 1 across.


That is correct.

Sending game board.

Player 1's turn.

Player 1 guessed "trav" for 1 down.

That is incorrect.

Sending game board.

Would you like to answer a question across (a) or down (d)? **b**
That is not a valid option?
Would you like to answer a question across (a) or down (d)? **a**
Which number? **4**
That is not a valid option.
Which number? 1
What is your guess for 1 across?
**trojans**

That is correct!

```
                              5_
                               _
                               _
                        3_     _  _  _
                     4_        _
                  1T   R    O    J    A   N   S
                     _        _          _
                     _        _          _
                              _
                              _
                              _
     2_  _   _   _    _   _   _
                              _
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Would you like to answer a question across (a) or down (d)? **d**
Which number? **1**
What is your guess for 1 down? **trav**

That is incorrect!

Player 1's turn.

Player 1 guessed "trojans" for 1 across.

That is correct.

```
                              5_
                               _
                               _
                        3_     _  _  _
                     4_        _
                  1T   R    O    J    A   N   S
                     _        _          _
                     _        _          _
                              _
                              _
                              _
     2_  _   _   _    _   _   _
                              _
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Player 1's turn.

Player 1 guessed "trav" for 1 down.

That is incorrect.

**Left column:**

Players 2's turn.

Player 2 guessed "traveler" for 1 down.

That is correct.

Sending game board.

---

**Middle column:**

```
                           5_
                            _
                            _
                 3_     _   _   _
            4_       _
     1T  R   O   J   A   N   S
            _       _       _
            _       _       _
                    _
                    _
                    _
 2_  _   _   _   _   _   _
                    _
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Player 2's turn.

Player 2 guessed "traveler" for 1 down.

That is correct.

```
                           5_
                            _
                            _
                 3_     _   _   _
            4_       _
     1T  R   O   J   A   N   S
      R             _       _
      A             _       _
      V
      E
      L
 2_  _   _   _   E   _   _
      R
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

---

**Right column:**

```
                           5_
                            _
                            _
                 3_     _   _   _
            4_       _
     1T  R   O   J   A   N   S
            _       _       _
            _       _       _
                    _
                    _
                    _
 2_  _   _   _   _   _   _
                    _
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
1 What is the name of USC's white horse?
4 What is one of USC's colors?
5 Who is USC's School of Business named after?

Would you like to answer a question across (a) or down (d)? **d**
Which number? **1**
What is your guess for 1 down?
**traveler**

That is correct!

```
                           5_
                            _
                            _
                 3_     _   _   _
            4_       _
     1T  R   O   J   A   N   S
      R             _       _
      A             _       _
      V
      E
      L
 2_  _   _   _   E   _   _
      R
```

Across
2 What professional baseball team is closest to USC?
3 What is the four-letter prefix for Computer Science?
Down
4 What is one of USC's colors?
5 Who is USC's School of Business named after?
```

| | | |
|---|---|---|
| Player 2's turn. | Player 2's turn. | Would you like to answer a question across (a) or down (d)? |

*<Play continues until all questions have been answered correctly.>*
*<Assume everything has been answered correctly except 2 across, and it's player 1's turn.>*

| | | |
|---|---|---|
| Sending game board.<br><br><br><br><br><br><br><br><br><br><br><br><br><br>Player 1's turn.<br><br><br><br><br><br>Player 1 guessed "Dodgers" for 2 across.<br><br><br>That is correct.<br><br>Sending game board. | <pre>                        5M<br>                         A<br>                         R<br>                3C   S   C   I<br>            4G       H<br>        1T  R   O   J   A   N   S<br>            R       L       L<br>            A       D       L<br>            V<br>            E<br>            L<br>      2_  _   _   _   E   _   _<br>            R</pre><br>Across<br>2 What professional baseball team is closest to USC?<br><br>Would you like to answer a question across (a) or down (d)? **d**<br>That is not a valid option.<br>Would you like to answer a question across (a) or down (d)? **a**<br>Which number? **2**<br>What is your guess for 2 across?<br>**Dodgers**<br><br><br>That is correct!<br><pre>                        5M<br>                         A<br>                         R<br>                3C   S   C   I<br>            4G       H<br>        1T  R   O   J   A   N   S<br>            R       L       L<br>            A       D       L<br>            V<br>            E<br>            L<br>      2D  O   D   G   E   R   S<br>            R</pre><br>Across<br>1 What is USC's mascot? | <pre>                        5M<br>                         A<br>                         R<br>                3C   S   C   I<br>            4G       H<br>        1T  R   O   J   A   N   S<br>            R       L       L<br>            A       D       L<br>            V<br>            E<br>            L<br>      2_  _   _   _   E   _   _<br>            R</pre><br>Across<br>2 What professional baseball team is closest to USC?<br><br>Player 1's turn.<br><br><br><br><br><br><br>Player 1 guessed "Dodgers" for 2 across.<br><br>That is correct.<br><pre>                        5M<br>                         A<br>                         R<br>                3C   S   C   I<br>            4G       H<br>        1T  R   O   J   A   N   S<br>            R       L       L<br>            A       D       L<br>            V<br>            E<br>            L<br>      2D  O   D   G   E   R   S<br>            R</pre><br>Across<br>1 What is USC's mascot? |

Assignment #4/5
CSCI 201 Spring 2019

| | | |
|---|---|---|
| | 2 What professional baseball team is closest to USC?<br>3 What is the four-letter prefix for Computer Science?<br>Down<br>1 What is the name of USC's white horse?<br>4 What is one of USC's colors?<br>5 Who is USC's School of Business named after? | 2 What professional baseball team is closest to USC?<br>3 What is the four-letter prefix for Computer Science?<br>Down<br>1 What is the name of USC's white horse?<br>4 What is one of USC's colors?<br>5 Who is USC's School of Business named after? |
| The game has concluded.<br>Sending scores. | Final Score<br>Player 1 – 4 correct answers.<br>Player 2 – 2 correct answers.<br><br>Player 1 is the winner. | Final Score<br>Player 1 – 4 correct answers.<br>Player 2 – 2 correct answers.<br><br>Player 1 is the winner. |
| Waiting for players... | \<Client terminates> | \<Client terminates> |

Grading Criteria

The way you go about implementing the solution is not specifically graded, but the output must match exactly what you see in the execution above.

**Networking (1.0%)**
0.2% - first client can connect to server
0.3% - only the number of clients as specified by first client can connect to server
0.5% - server allows a new game to be played after previous one ends without restarting

**File Reading (0.5%)**
0.1% - random file chosen from `gamedata` directory
0.1% - `gamedata` directory is at the same level as `src`
0.1% - server chooses game data file after first client connects
0.2% - client is notified if no valid game data file exists

**Game Board Rendering (3.0%)**
3.0% - game board is rendered in a correct manner where there are no disjoint words (i.e., they are all connected to each other)

**Game Play (2.5%)**
0.2% - only one player can answer a question at a time
0.2% - once a question has been answered correctly, that question is no longer displayed
0.2% - answers are case-insensitive
0.2% - proper error checking is in place for "a" and "d"
0.2% - proper error checking is in place for the question number to answer
0.2% - all clients are notified of answers that are guessed by other players
0.2% - updated game board is displayed properly
0.4% - final score is displayed after all answers have been guessed correctly
0.2% - client terminates after the final score is displayed
0.5% - the game is played as expected with no exceptions, crashing, deadlock, starvation, or freezing

**Output (2.0%)**
2.0% - the output is the same as what is provided in the sample above

**Synchronization (0.5%)**
0.25% - synchronization through monitors, locks, or semaphores is used somewhere in the server
0.25% - synchronization through monitors, locks, or semaphores is used somewhere in the client