Sabancı University

Faculty of Engineering and Natural Sciences
CS204 Advanced Programming
Spring 2024

Homework 6 – Guess the Number Game using Threads

Due: 28/05/2024, Tuesday, 21:00

PLEASE NOTE:

Your program should be a robust one such that you have to consider all relevant programmer mistakes and extreme cases; you are expected to take actions accordingly!

You can NOT collaborate with your friends and discuss solutions. You have to write down the code on your own. Plagiarism will not be tolerated!

Introduction

In this homework, you are asked to write a **multithreaded** C++ program that simulates the game, *guess the number*. The game starts after taking number of players, number of rounds and the randomization range of the number to be guessed as inputs. It will simulate each round of the game via several threads (one for each player and one for the host of the game) and print relevant information as can be seen in the sample runs. After the host starts the game, the player threads will sleep until a certain time so that all the players start the game at the same time.

Please first learn how to write *multithreaded* programs by checking out the lecture notes and sample codes, and then start the homework. Multithreaded programs are totally different than other type of programs that you wrote until now. You cannot learn it while doing the homework; first you have to learn and then write. During the grading, we will strictly follow using only the material covered in the class, and using anything not covered in class will be penalized up to 100 points. And if the use of extra materials implies using GenAI tools, you might be charged with plagiarism.

Using Threads

The number of threads is equal to the number of players plus one; one thread will be for the host, and the others are for the players. The number of players will be taken as input from the user. Your threads may access common resource(s), such as *the target number to be guessed, game and round statuses, round winner, scores of the players* (this common resources are up to you do decide). To avoid any synchronization conflicts while accessing/updating them, you need to use mutex appropriately. At the end of the execution, your threads must be joined properly. Moreover, at the end, your program must terminate without any complications. In other words, you have to see exit code 0.

Details of the Program and More on Threads

The game consists of rounds. At each round, each player aims to guess the *target number* correctly. The *target number* at each round will be randomly set by the *host* thread. *Player threads* will randomly try to guess the *target number* until one of the players guesses correctly. Then, the next round is started by the host.

In the beginning (before the threads start), you will take some inputs. First, you will input the number of players. This number is important for the number of threads (remember you have to have one thread for each player). Then you will input the number of rounds that players will play. Finally, you will input the randomization range of the *target number* and, consequently, of the *guesses*. You may assume that all the inputs are entered as integers, but you must check if the number of players and the number of rounds are greater than or equal to 1. You must also check that lower bound of the randomization range is actually smaller than or equal to the higher bound. In case of an input problem, you have to continue to read until correct one(s) is/are entered.

Each player will be given an ID consecutively starting from 0. It is up to you how to keep and manage these IDs.

At the beginning of the game, you have to display the current time and some messages (see sample runs). Before starting the first round, for the sake of fairness, all the players should start the game at the same time, which is 3 seconds after the current time. To implement this, you have to sleep all the player threads until this certain absolute time using `sleep_until` function. This initial sleep is only before the first round starts.

In each round of the game, the host thread will first set the *target number* that each player will guess, and display it together with the current time. Then each *player thread* will start to guess the *target number*. At each round, host have to set the target number randomly within the input range and players also have to guess randomly in the same range**. After guessing a number, whether correct or not, that player must sleep for 1 second** (using `sleep_for`). All the players will keep guessing randomly until one of the players guesses the target number correctly. When a player gives the correct answer, host thread will increase that player's score by 1. Every guess must be displayed by each player thread together with corresponding time (see sample runs).

Since there are several common data accessed by all of the threads, in order to avoid any synchronization conflicts, you have to use a `mutex` properly. We recommend you to use just one global mutex object for these common data accesses. Moreover, we also recommend you to use another separate global mutex for tidiness of the `cout` statements.

The entry point of each of the player threads will be the same function. That means, you will **NOT** write separate functions for the player threads. In order to customize this function for each player, you may need to pass parameter(s) to it. The entry point of the host thread will be different than the one of the players'.

Each round ends when one of the players guesses that round's target number correctly. You may check whether a guess is correct or not within player thread. After each round ends, the host thread should increase winner player's score by one and set the target number for the next round (if the game has not ended). Then host should display a detailed message for the next round (see the sample runs). The game finishes after all rounds are played. At the end after all threads join, you must display the number of wins each player has in the main program.

Important Rules Specific to Homework 6

Some rules that are going to affect grading are as follows; general rules described in previous homework assignments and syllabus also apply:

- You are not allowed to sleep the threads under locked mutexes; doing so will cost 50 points.
- Scores must be updated only by the host thread. If you update the scores in the player threads, your homework will not be graded.
- One function for all player threads and separate function for the host thread, as described above. You do not want to know the penalty of not doing so ☺.
- Using untaught programming structures costs you up to 100 points.

- Please use the thread-safe random number generator covered in class; you must **not** use the RandGen class since it creates the same random sequence for all threads.
- Please use extreme caution while identifying the critical sections of your code that are going to be executed under locked mutex. As discussed in class, do not include any unnecessary code lines within the critical sections.

Use of global variables and helper structures

You may use global variables in this homework. However, we kindly request you not to exaggerate the global usage since after a certain point you may lose control over your program (as the famous Turkish proverb says "azı karar, coğu zarar").

You can use vectors or data other structures, but make sure the game logic must be implemented as threads.

SUBMISSION GUIDELINES (CHANGED, READ IT)

There is no CodeRunner in this homework (see the reasons in the sample runs section below). Thus you have to submit your main cpp file as file upload.

There is naming convention as SUNetUsername_LastName_OtherNames_HW6.cpp. For example, mali.kuskonmaz_kuskonmaz_mehmetali_HW6.cpp. Wrong naming costs 5 points (no kidding, I mean it).

Do not use any Turkish characters in the file name and anywhere in the program.

If you submit wrong file, you cannot change it after the deadline. Especially, realizing this after the grading does not help. We grade what you submit to SUCourse with no exceptions.

After uploading your cpp file, do not forget to complete the submission process. If you cannot successfully complete the submission process, we cannot see your homework and the grade will be zero with no exceptions.

Please see the previous homework specifications for the other important rules

Sample Runs and Output Related Issues

Some sample runs are given below. Due to the scheduling of threads, same input may yield different outputs for your code. However, the order of the events must be consistent with the homework requirements and the given input. Here are some guidelines regarding the correctness of the outputs for you to check.

- The duration between the start of the game and starting guesses for the first round must always be 3 seconds.
- After the guesses start, at every second all the players must make a guess (in the same or consecutive rounds) An exception for this is the last second of the game during which some players may not make a guess due to end of game.
- The order of the players in every second would more likely change, but this is system dependent. Some systems (computer/operating system/IDE combination) are more inclined to put the threads in a row than the others. Thus, in some systems the player order in every second is more varying, in some systems less. If you see same order all the time, please try another computer to see if it gives different orders. If the problem continues, there could be an issue with your code.
- Outputs of each round must be displayed before the next round starts or the game ends.
- Last output line of each round must always be a correct guess.
- Output tidiness must be hold.
- We do not expect exact messages, prompts and outputs, but critical information must be displayed so that we can follow the output during the grading.

Due to the reasons explained above (different outputs for the same inputs) we cannot use CodeRunner in this homework. Thus, you have to test manually.

The inputs from the keyboard are written in **boldface**.

Sample Run 1:

```
Please enter number of players
3
Please enter number of rounds
1
Please enter the randomization range
1 15


--------------------------------------------------
Game started at: 17:53:30
Round 1 will start 3 seconds later

Target is 14

Player with id 0 guessed 5 incorrectly at: 17:53:33
Player with id 1 guessed 6 incorrectly at: 17:53:33
Player with id 2 guessed 2 incorrectly at: 17:53:33
Player with id 1 guessed 2 incorrectly at: 17:53:34
Player with id 0 guessed 11 incorrectly at: 17:53:34
Player with id 2 guessed 14 correctly at: 17:53:34

Game is over!
Leaderboard:
Player 0 has won 0 times
Player 1 has won 0 times
Player 2 has won 1 times
```

Sample Run 2:

```
Please enter number of players
5
Please enter number of rounds
3
Please enter the randomization range
1 10


--------------------------------------------------
Game started at: 18:04:12
Round 1 will start 3 seconds later

Target is 8

Player with id 0 guessed 10 incorrectly at: 18:04:15
Player with id 2 guessed 5 incorrectly at: 18:04:15
Player with id 3 guessed 9 incorrectly at: 18:04:15
Player with id 1 guessed 4 incorrectly at: 18:04:15
Player with id 4 guessed 4 incorrectly at: 18:04:15
Player with id 0 guessed 8 correctly at: 18:04:16
```

```
-------------------------------------------------
Round 2 started at: 18:04:16
Target is 10

Player with id 2 guessed 3 incorrectly at: 18:04:16
Player with id 4 guessed 8 incorrectly at: 18:04:16
Player with id 1 guessed 6 incorrectly at: 18:04:16
Player with id 3 guessed 5 incorrectly at: 18:04:16
Player with id 3 guessed 8 incorrectly at: 18:04:17
Player with id 2 guessed 2 incorrectly at: 18:04:17
Player with id 4 guessed 2 incorrectly at: 18:04:17
Player with id 0 guessed 9 incorrectly at: 18:04:17
Player with id 1 guessed 4 incorrectly at: 18:04:17
Player with id 3 guessed 10 correctly at: 18:04:18


-------------------------------------------------
Round 3 started at: 18:04:18
Target is 5

Player with id 0 guessed 4 incorrectly at: 18:04:18
Player with id 1 guessed 6 incorrectly at: 18:04:18
Player with id 2 guessed 8 incorrectly at: 18:04:18
Player with id 4 guessed 4 incorrectly at: 18:04:18
Player with id 2 guessed 2 incorrectly at: 18:04:19
Player with id 4 guessed 7 incorrectly at: 18:04:19
Player with id 1 guessed 8 incorrectly at: 18:04:19
Player with id 0 guessed 5 correctly at: 18:04:19

Game is over!
Leaderboard:
Player 0 has won 2 times
Player 1 has won 0 times
Player 2 has won 0 times
Player 3 has won 1 times
Player 4 has won 0 times
```

Sample Run 3 (same player order in every second case; this is not normal to see in all computers/systems. If you have this case, please try another computer):

```
Please enter number of players
5
Please enter number of rounds
5
Please enter the randomization range
1 5


-------------------------------------------------
Game started at: 16:58:52
Round 1 will start 3 seconds later

Target is 2

Player with id 4 guessed 4 incorrectly at: 16:58:55
```

```
Player with id 3 guessed 3 incorrectly at: 16:58:55
Player with id 1 guessed 2 correctly at: 16:58:55


--------------------------------------------------
Round 2 started at: 16:58:55
Target is 2

Player with id 0 guessed 3 incorrectly at: 16:58:55
Player with id 2 guessed 3 incorrectly at: 16:58:55
Player with id 4 guessed 4 incorrectly at: 16:58:56
Player with id 3 guessed 2 correctly at: 16:58:56


--------------------------------------------------
Round 3 started at: 16:58:56
Target is 1

Player with id 1 guessed 3 incorrectly at: 16:58:56
Player with id 0 guessed 2 incorrectly at: 16:58:56
Player with id 2 guessed 3 incorrectly at: 16:58:56
Player with id 4 guessed 4 incorrectly at: 16:58:57
Player with id 3 guessed 3 incorrectly at: 16:58:57
Player with id 1 guessed 1 correctly at: 16:58:57


--------------------------------------------------
Round 4 started at: 16:58:57
Target is 2

Player with id 0 guessed 5 incorrectly at: 16:58:57
Player with id 2 guessed 2 correctly at: 16:58:57


--------------------------------------------------
Round 5 started at: 16:58:57
Target is 5

Player with id 4 guessed 4 incorrectly at: 16:58:58
Player with id 3 guessed 2 incorrectly at: 16:58:58
Player with id 1 guessed 4 incorrectly at: 16:58:58
Player with id 0 guessed 4 incorrectly at: 16:58:58
Player with id 2 guessed 1 incorrectly at: 16:58:58
Player with id 4 guessed 2 incorrectly at: 16:58:59
Player with id 3 guessed 4 incorrectly at: 16:58:59
Player with id 1 guessed 4 incorrectly at: 16:58:59
Player with id 0 guessed 5 correctly at: 16:58:59

Game is over!
Leaderboard:
Player 0 has won 1 times
Player 1 has won 2 times
Player 2 has won 1 times
Player 3 has won 1 times
Player 4 has won 0 times
```

Sample Run 4:

```
Please enter number of players
10
Please enter number of rounds
2
Please enter the randomization range
1 25


--------------------------------------------------
Game started at: 17:55:00
Round 1 will start 3 seconds later

Target is 6

Player with id 3 guessed 18 incorrectly at: 17:55:03
Player with id 6 guessed 12 incorrectly at: 17:55:03
Player with id 1 guessed 1 incorrectly at: 17:55:03
Player with id 8 guessed 3 incorrectly at: 17:55:03
Player with id 5 guessed 4 incorrectly at: 17:55:03
Player with id 7 guessed 16 incorrectly at: 17:55:03
Player with id 0 guessed 21 incorrectly at: 17:55:03
Player with id 4 guessed 20 incorrectly at: 17:55:03
Player with id 9 guessed 11 incorrectly at: 17:55:03
Player with id 2 guessed 6 correctly at: 17:55:03


--------------------------------------------------
Round 2 started at: 17:55:03
Target is 16

Player with id 0 guessed 3 incorrectly at: 17:55:04
Player with id 8 guessed 18 incorrectly at: 17:55:04
Player with id 5 guessed 21 incorrectly at: 17:55:04
Player with id 7 guessed 14 incorrectly at: 17:55:04
Player with id 1 guessed 24 incorrectly at: 17:55:04
Player with id 6 guessed 22 incorrectly at: 17:55:04
Player with id 3 guessed 15 incorrectly at: 17:55:04
Player with id 9 guessed 16 correctly at: 17:55:04

Game is over!
Leaderboard:
Player 0 has won 0 times
Player 1 has won 0 times
Player 2 has won 1 times
Player 3 has won 0 times
Player 4 has won 0 times
Player 5 has won 0 times
Player 6 has won 0 times
Player 7 has won 0 times
Player 8 has won 0 times
Player 9 has won 1 times
```

Sample Run 5:

```
Please enter number of players
0
Number of players cannot be lower than 1!
Please enter number of players
3
Please enter number of rounds
0
Number of rounds cannot be lower than 1!
Please enter number of rounds
3
Please enter the randomization range
10 1
Lower bound has to be smaller than or equal to higher bound
Please enter the randomization range
1 10


--------------------------------------------------
Game started at: 17:55:41
Round 1 will start 3 seconds later

Target is 3

Player with id 0 guessed 1 incorrectly at: 17:55:44
Player with id 2 guessed 10 incorrectly at: 17:55:44
Player with id 1 guessed 10 incorrectly at: 17:55:44
Player with id 1 guessed 2 incorrectly at: 17:55:45
Player with id 0 guessed 3 correctly at: 17:55:45


--------------------------------------------------
Round 2 started at: 17:55:45
Target is 9

Player with id 2 guessed 7 incorrectly at: 17:55:45
Player with id 1 guessed 1 incorrectly at: 17:55:46
Player with id 2 guessed 7 incorrectly at: 17:55:46
Player with id 0 guessed 10 incorrectly at: 17:55:46
Player with id 0 guessed 1 incorrectly at: 17:55:47
Player with id 1 guessed 9 correctly at: 17:55:47


--------------------------------------------------
Round 3 started at: 17:55:47
Target is 6

Player with id 2 guessed 6 correctly at: 17:55:47

Game is over!
Leaderboard:
Player 0 has won 1 times
Player 1 has won 1 times
Player 2 has won 1 times
```

Sample Run 6:

```
Please enter number of players
1
Please enter number of rounds
2
Please enter the randomization range
1 10


--------------------------------------------------
Game started at: 17:56:28
Round 1 will start 3 seconds later

Target is 8

Player with id 0 guessed 10 incorrectly at: 17:56:31
Player with id 0 guessed 5 incorrectly at: 17:56:32
Player with id 0 guessed 1 incorrectly at: 17:56:33
Player with id 0 guessed 7 incorrectly at: 17:56:34
Player with id 0 guessed 7 incorrectly at: 17:56:35
Player with id 0 guessed 6 incorrectly at: 17:56:36
Player with id 0 guessed 2 incorrectly at: 17:56:37
Player with id 0 guessed 1 incorrectly at: 17:56:38
Player with id 0 guessed 1 incorrectly at: 17:56:39
Player with id 0 guessed 5 incorrectly at: 17:56:40
Player with id 0 guessed 3 incorrectly at: 17:56:41
Player with id 0 guessed 9 incorrectly at: 17:56:42
Player with id 0 guessed 3 incorrectly at: 17:56:43
Player with id 0 guessed 2 incorrectly at: 17:56:44
Player with id 0 guessed 6 incorrectly at: 17:56:45
Player with id 0 guessed 8 correctly at: 17:56:46


--------------------------------------------------
Round 2 started at: 17:56:46
Target is 6

Player with id 0 guessed 4 incorrectly at: 17:56:47
Player with id 0 guessed 5 incorrectly at: 17:56:48
Player with id 0 guessed 2 incorrectly at: 17:56:49
Player with id 0 guessed 3 incorrectly at: 17:56:50
Player with id 0 guessed 9 incorrectly at: 17:56:51
Player with id 0 guessed 10 incorrectly at: 17:56:52
Player with id 0 guessed 5 incorrectly at: 17:56:53
Player with id 0 guessed 9 incorrectly at: 17:56:54
Player with id 0 guessed 6 correctly at: 17:56:55

Game is over!
Leaderboard:
Player 0 has won 2 times
```

Sample Run 7:

```
Please enter number of players
3
Please enter number of rounds
```

9
Please enter the randomization range
1 1

Game started at: 18:08:12
Round 1 will start 3 seconds later

Target is 1

Player with id 0 guessed 1 correctly at: 18:08:15

Round 2 started at: 18:08:15
Target is 1

Player with id 2 guessed 1 correctly at: 18:08:15

Round 3 started at: 18:08:15
Target is 1

Player with id 1 guessed 1 correctly at: 18:08:15

Round 4 started at: 18:08:15
Target is 1

Player with id 2 guessed 1 correctly at: 18:08:16

Round 5 started at: 18:08:16
Target is 1

Player with id 1 guessed 1 correctly at: 18:08:16

Round 6 started at: 18:08:16
Target is 1

Player with id 0 guessed 1 correctly at: 18:08:16

Round 7 started at: 18:08:16
Target is 1

Player with id 0 guessed 1 correctly at: 18:08:17

Round 8 started at: 18:08:17
Target is 1

```
Player with id 1 guessed 1 correctly at: 18:08:17


--------------------------------------------------
Round 9 started at: 18:08:17
Target is 1

Player with id 2 guessed 1 correctly at: 18:08:17

Game is over!
Leaderboard:
Player 0 has won 3 times
Player 1 has won 3 times
Player 2 has won 3 times
```

Sample Run 8:

```
Please enter number of players
1
Please enter number of rounds
1
Please enter the randomization range
123 123


--------------------------------------------------
Game started at: 17:58:10
Round 1 will start 3 seconds later

Target is 123

Player with id 0 guessed 123 correctly at: 17:58:13

Game is over!
Leaderboard:
Player 0 has won 1 times
```

Good Luck!
Albert Levi, Batuhan Kertmen