1904. The Number of Full Rounds You Have Played

Medium Math String

Leetcode Link

Problem Description

The aim of the given problem is to compute the number of complete chess rounds played in an online tournament based on the login and logout times provided. Chess rounds commence every 15 minutes, starting from `00:00` and then at `00:15`, `00:30`, `00:45`, and so on until `23:45`. When a user logs in and logs out, we want to determine how many of these 15-minute rounds have fully passed.

- A `loginTime` is given which represents the time the user logs in to the game.
- A `logoutTime` is also provided, which represents the time the user logs out of the game.
- If the `logoutTime` is earlier than `loginTime`, this suggests the user played from `loginTime` through midnight to the next day, until `logoutTime`.

A single chess round is counted only if the user is logged in for the entire duration of the 15-minute round. The task is to calculate the number of such complete rounds played.

For example, if the `loginTime` is `08:00` and `logoutTime` is `09:30`, even though the user has been online for 30 minutes, they have played only 2 full rounds (`08:00` and `08:15`), because they logout before the round starting at `09:30` could complete.

Intuition

The solution approach involves a series of steps to compute the total number of complete rounds:

1. Convert both `loginTime` and `logoutTime` to minutes. This simplification is done because working with minutes is easier than working with hours and minutes separately. It also helps to compare and perform arithmetic operations on the times effectively.
2. Account for the scenario when `logoutTime` is earlier than `loginTime`. This indicates that the user played through midnight. To manage this, 24 hours (1440 minutes) are added to `logoutTime` to properly calculate the number of rounds.
3. Rounds are started every 15 minutes, but we are only interested in complete rounds. Therefore, for the `loginTime` that is in-between rounds, we need to round it up to the next round start time. On the other side, for the `logoutTime`, we need to round it down to the closest round start time that has been completed.
4. Finally, the total number of complete rounds is the difference between the rounded times, divided by 15 (since each round is 15 minutes). We need to make sure not to count negative values in case `logoutTime` is right after `loginTime`, hence, we use `max(0, finish - start)`.

By rounding the `loginTime` and `logoutTime` to the closest round boundaries and then calculating the difference, we ensure that we're only counting the complete chess rounds.

The code provided is a direct translation of this intuition. It uses simple arithmetic operations and logical reasoning to find the solution without additional data structures or complicated algorithms, ensuring an efficient and clear solution to the problem.

Solution Approach

The solution's implementation follows a direct and methodical approach, utilizing the built-in functions of the coding language and basic arithmetic. Here's how the algorithm unfolds:

1. A helper function named `get` is defined, which takes a string `s` representing time in the format "HH:MM" and converts this to the total number of minutes. It does so by multiplying the first two characters (hours) by 60 and adding to the last two characters (minutes), both of which are converted to integers.
2. The `startTime` and `finishTime` are then converted to minutes using the helper function `get`.
3. We then check if the `startTime` is greater than the `finishTime`. If it is, it means the player has played overnight, and therefore we add 24 hours (1440 minutes) to the `finishTime`.
4. Next, we handle the round start and end times. For the `startTime` (now in minutes), we round up to the nearest round start time by adding 14 minutes before dividing by 15 and multiplying by 15. This is because if the player logs in at any time within a round (e.g., `00:07` or `00:14`), they miss that round and can only start playing in the next one. The division and multiplication discard the remainder if any, effectively rounding up to the next multiple of 15.
5. For the `finishTime`, we round down to the last complete round by simply dividing by 15. This is because if the player logs out anytime during a round, that round does not count as it is not completed.
6. The difference between the finish and start values gives us the total number of rounds. But, we must ensure that this number is not negative, which is possible if the `finishTime` immediately follows the `startTime`. We use `max(0, finish - start)` to account for this, ensuring that the minimum number of rounds returned is zero.

The combination of helper function, careful addition for overnight sessions, and rounding the times to the nearest round boundaries are crucial in this implementation. There's no need for complex data structures; the entire solution leverages arithmetic operations to calculate the desired result.

Example Walkthrough

Let's go through a small example to illustrate the solution approach. Assume the following login and logout times:

- `loginTime`: `22:47`
- `logoutTime`: `01:12`

Following the steps of the solution:

1. Convert `loginTime` and `logoutTime` to minutes:
   - `get("22:47")` would result in `22 * 60 + 47 = 1367` minutes.
   - `get("01:12")` would result in `1 * 60 + 12 = 72` minutes.
2. Since `logoutTime` is on the next day (01:12 is after midnight), we add 1440 minutes (a full day) to `logoutTime` to get the correct duration:
   - Updated `logoutTime` in minutes: `72 + 1440 = 1512` minutes.
3. Round the times to the nearest chess round start times:
   - For `loginTime`, rounded up to the next round: `(1367 + 14) / 15 * 15 = 1380` minutes. (This corresponds to the round that starts at 23:00.)
   - For `logoutTime`, rounded down to the last complete round: `1512 / 15 * 15 = 1510` minutes. (This corresponds to the round that starts at 01:00.)
4. Calculate the difference in rounded times and convert to the number of complete rounds:
   - Difference in minutes: `1510 - 1380 = 130` minutes.
   - Number of complete rounds: `130 / 15 = 8` full rounds.

So, between `22:47` and `01:12` the next day, the user has played 8 complete chess rounds. We arrived at this conclusion by converting the given times into minutes, adjusting for overnight play, rounding the times to the nearest round boundaries, and computing the difference. This example cleanly demonstrates the efficiency of the solution approach in evaluating the number of complete rounds.

Python Solution

```python
class Solution:
    def numberOfRounds(self, start_time: str, finish_time: str) -> int:
        # Define a function to convert time from "HH:MM" format to minutes
        def convert_to_minutes(time_str: str) -> int:
            hours = int(time_str[:2])  # Extract hours and convert to integer
            minutes = int(time_str[3:])  # Extract minutes and convert to integer
            return hours * 60 + minutes  # Return total minutes

        # Convert start and finish times to minutes
        start_minutes = convert_to_minutes(start_time)
        finish_minutes = convert_to_minutes(finish_time)

        # If start time is after finish time, assume finish time is the next day
        if start_minutes > finish_minutes:
            finish_minutes += 24 * 60  # Add 24 hours in minutes

        # Round start time up to the next 15-minute mark
        # and round finish time down to the previous 15-minute mark
        # The 14 is added before division to ensure proper rounding up for start time
        start_minutes_rounded = (start_minutes + 14) // 15
        finish_minutes_rounded = finish_minutes // 15

        # Calculate the number of complete 15-minute rounds
        # Ensure that it's not negative by using max(0, ...)
        complete_rounds = max(0, finish_minutes_rounded - start_minutes_rounded)

        return complete_rounds
```

Java Solution

```java
class Solution {
    // Method to calculate the number of rounds played, given a start and finish time.
    public int numberOfRounds(String startTime, String finishTime) {
        // Convert start and finish times to minutes
        int startInMinutes = convertToMinutes(startTime);
        int finishInMinutes = convertToMinutes(finishTime);

        // If the finish time is less than the start time, it indicates the game went past midnight.
        if (startInMinutes > finishInMinutes) {
            finishInMinutes += 24 * 60; // Add 24 hours (in minutes) to the finish time to handle overnight duration
        }

        // The start time is rounded up to the next 15-minute mark, and the finish time is rounded down.
        startInMinutes = (startInMinutes + 14) / 15 * 15;
        finishInMinutes = (finishInMinutes / 15) * 15;

        // Calculate the difference in 15-minute rounds and return the maximum of 0 or the computed rounds.
        return Math.max(0, finishInMinutes / 15 - startInMinutes / 15);
    }

    // Helper method to convert a time String "HH:MM" to minutes.
    private int convertToMinutes(String time) {
        // Parse the hours and minutes from the time String and convert to minutes
        int hours = Integer.parseInt(time.substring(0, 2));
        int minutes = Integer.parseInt(time.substring(3));
        return hours * 60 + minutes;
    }
}
```

C++ Solution

```cpp
class Solution {
public:
    // Calculates the number of full rounds that can be played between the start and finish times
    int numberOfRounds(string startTime, string finishTime) {
        // Convert start and finish times to minutes
        int startMinutes = convertToMinutes(startTime);
        int finishMinutes = convertToMinutes(finishTime);

        // If the finish time is less than the start time, it means the finish time is on the next day
        if (startMinutes > finishMinutes) {
            finishMinutes += 24 * 60; // Add 24 hours in minutes to the finish time
        }

        // Rounds start time to the next quarter hour if not already rounded
        startMinutes = (startMinutes + 14) / 15 * 15;
        // Rounds finish time down to the previous quarter hour
        finishMinutes = finishMinutes / 15 * 15;

        // Calculate the difference in the number of quarter hours played
        // and ensure the result is not negative
        return max(0, (finishMinutes - startMinutes) / 15);
    }

private:
    // Helper function to convert time in "HH:MM" format to total number of minutes
    int convertToMinutes(const string& time) {
        int hours, minutes;
        sscanf(time.c_str(), "%d:%d", &hours, &minutes); // Parse the string for hours and minutes
        return hours * 60 + minutes; // Convert time to minutes
    }
};
```

Typescript Solution

```typescript
/**
 * Helper function to convert a time string to its equivalent total minutes.
 * @param {string} time - Time in the format of "HH:MM".
 * @returns {number} Numeric representation of time in minutes.
 */
function toMinutes(time: string): number {
    // Split the time string into hours and minutes and convert them into numbers
    const [hours, minutes] = time.split(':').map(Number);
    // Calculate the total minutes
    return hours * 60 + minutes;
}

/**
 * Calculates the number of full 15-minute rounds that can be played
 * between a start time and a finish time.
 * @param {string} startTime - Start time in the format of "HH:MM".
 * @param {string} finishTime - Finish time in the format of "HH:MM".
 * @returns {number} The number of full 15-minute rounds that can be played.
 */
function numberOfRounds(startTime: string, finishTime: string): number {
    // Convert start and finish times to minutes
    let startMinutes = toMinutes(startTime),
        finishMinutes = toMinutes(finishTime);

    // If the start time is after finish time, add 24 hours to finish time
    if (startMinutes > finishMinutes) {
        finishMinutes += 24 * 60; // Add one full day in minutes
    }

    // Calculate the number of full 15-minute rounds
    const rounds = Math.floor(finishMinutes / 15) - Math.ceil(startMinutes / 15);

    // Return positive number of full rounds or 0 if the result is negative
    return rounds > 0 ? rounds : 0;
}
```

Time and Space Complexity

Time Complexity

The time complexity of the `numberOfRounds` function is `O(1)`. This is because the function consists of a few arithmetic operations and conditional checks, which are all constant time operations. The function calculates the minutes for the start and finish times, then computes the rounds by dividing by 15. The constants do not scale with the size of the input, as the input is always a time in `HH:MM` format.

Space Complexity

The space complexity of the `numberOfRounds` function is also `O(1)`. This function uses only a fixed number of integer variables to store the start and finish times, and for the intermediate calculations. It does not allocate any additional space that grows with the input size, resulting in constant space complexity.