CSSE 332 -- OPERATING SYSTEMS

The Readers/Writer Problem

Name: SOLUTION KEY

Question 1. (5 points) For the readers/writers problem initially presented, describe the state of the world (or the concurrency state). Make sure to provide a description of each state variable as well as its type and **default value.**

> **Solution:** Initially, we only care about the number of readers present and the number of writers in the critical section. The number of readers in the critical section can be arbitrary while the number of writers in the critical section can only be 0 or 1.

Question 2. (5 points) Based on your answer to the first question, write down the *waiting conditions* for each of the readers and the writers threads. Feel free to write it in pseudo-code to avoid unnecessary clutter due to `pthreads` syntax.

Waiting conditions for the readers thread:

> **Solution:** The readers will wait only when there is a writer in the critical section. They will be awakened from their waiting state only when that writer leaves the critical section.

Waiting conditions for the writers thread:

> **Solution:** The writer will wait when either there's another writer in the critical section or when there are any readers in the critical section. They will be awakened from their state by a leaving writer or by **the last reader** leaving the critical section.

Question 3. (5 points) Briefly describe the main problem with the first implementation of the readers/writers problem we discussed in class.

> **Solution:** We encounter a problem where the writers can starve since we already have many readers and the number of readers in the critical section might never reach 0, so writers will never wake up from their waiting state.

Question 4. (5 points) Briefly explain the changes that would need to be made to address the writers' starvation problem discussed in the previous question. Make sure to mention relevant changes to the concurrency state and/or the waiting conditions.

Solution to the starvation problem:

> **Solution:** We need to give writers a priority over the readers when they arrive at the critical section, so we will stop new readers from entering the critical section when a writer arrives and is waiting.

Updates to the state of the world:

> **Solution:** We now also need to keep track of the number of writer waiting.

Updates to the waiting conditions:

> **Solution:** For the writer threads, not much changes.
>
> For the reader threads, we now also have to wait when there is a writer waiting. We will be awakened by writer leaving the critical section. Note that the last reader leaving the critical section need not awaken other readers. That is because of the following:
>
> 1. If there is a writer waiting, then that writer gets priority, so we only need to wake up that writer.
>
> 2. If there is no writer waiting, then there cannot be readers waiting (since this is the last one leaving), so no need to worry about signaling in this case.