Starve-Free Readers Writers Problem

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Code description:

r_active is the number of active readers (readers in critical section, r_waiting is the number of readers waiting to go into the critical section. r_sem is the semaphore that waiting readers sleep on. The writers have analogous variables. lock is a mutex semaphore used by both readers and writers.

Here is an intuition of how the algorithm behaves. You have a room, maybe it has windows so you can look inside. Just outside this room, there are two benches. One for readers, one for writers. Suppose you are a writer, and are coming in. You look inside the room. If there are readers in the room, you sit on the bench. If there are writers in the room, but there are readers sitting on the bench to go in, you will sit on a bench. Basically, this will prevent starvation. You will be polite and allow the reader to have a chance to go in. If you a writer waiting to enter, and there are writers in the room as well as readers on the bench, then the last writer to exit will let all waiting readers into the room. Then, the last reader to exit will let all the writers in. Some invariants that hold:

- Safety conditions: Readers and writers can not be active at the same time.

  $nr\_active > 0 \;-> nw\_active == 0$

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- Other conditions.

  $nr\_active > 0 \;\&\; nr\_waiting > 0 \;-> nw\_waiting > 0$

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- Readers can't be both active and waiting unless a writer is waiting.

So, basically, if a writer is waiting, then either readers are in the room, and the last reader will let the writer in, or writers are in the room, in which case we waited because readers were waiting, and thus the last writer will let in the readers, and the last reader will let us in.

The last writer will check if there are any readers waiting, and if so, let all readers in. So, as the writers are in the room, if there are more readers and writers coming in, then all the readers that are on the bench as the last writer leaves are the ones sent in the room.