

Part B: Reader-Writer Locks

Consider an application where multiple threads of a process wish to read and write data shared between them. Some threads only want to read (let's call them "readers"), while others want to update the shared data ("writers"). In this scenario, it is perfectly safe for multiple readers to concurrently access the shared data, as long as no other writer is updating it. However, a writer must still require mutual exclusion, and must not access the data concurrently with any other thread, whether a reader or a writer. A reader-writer lock is a special kind of a lock, where the acquiring thread can specify whether it wishes to acquire the lock for reading or writing. That is, this lock will expose two separate locking functions, say, `ReaderLock()` and `WriterLock()`, and analogous unlock functions. If a lock is acquired for reading, other threads that wish to read may also be permitted to acquire the lock at the same time, leading to improved concurrency over traditional locks.

There are two flavours of the reader-writer lock, which we will illustrate with an example. Suppose a reader thread R1 has acquired a reader-writer lock for reading. While R1 holds this lock, a writer thread W and another reader thread R2 have both requested the lock. Now, it is fine to allow R2 also to simultaneously acquire the lock with R1, because both are only reading shared data. However, allowing R2 to acquire the lock may prolong the waiting time of the writer thread W, because W has to now wait for both R1 and R2 to release the lock. So, whether we wish to permit more readers to acquire the lock when a writer is waiting is a design decision in the implementation of the lock. When a reader-writer lock is implemented with **reader preference**, additional readers are allowed to concurrently hold the lock with previous readers, even if a writer thread is waiting for the lock. In contrast, when a reader-writer lock is implemented with **writer preference**, additional readers are not granted the lock when a writer is already waiting. That is, we do not prolong the waiting time of a writer any more than required.

In this part of the lab, you must implement both flavours of the reader-writer lock. You must complete the definition of the structure that captures the reader-writer lock in `rwlock.h`. The following functions to be supported by this lock are also defined in the header file:

- The function `InitializeReadWriteLock()` must initialize the lock suitably.
- The function `ReaderLock()` is invoked by a reader thread before entering a read-only critical section, and the function `ReaderUnlock()` is invoked by the reader when exiting the critical section.
- The function `WriterLock()` is invoked by a writer thread before entering a critical section with shared data updates, and the function `WriterUnlock()` is invoked by the writer when exiting the critical section.

You must write the code to implement these functions. You must write code that implements reader-writer locks with reader preference in `rwlock-reader-pref.c`. Similarly, you must

implement reader-writer locks with writer preference in `rwlock-writer-pref.c`. Note that both implementations of the lock must share the same header file, including the definition of the reader-writer lock structure. Therefore, your lock structure may have some fields that are only used in one version of the code and not the other.

You are given two tester programs that test each variant of your reader-writer lock. The tester program takes two command line arguments, say `R` and `W`. The program then spawns `R` reader threads, followed by `W` writer threads, followed by `R` additional reader threads. Each thread, upon creation, tries to acquire the same reader-writer lock as a reader or writer (as the case may be), holds the lock for a long period of time, and finally releases the lock. The program judges the correctness of your implementation by observing the relative ordering of the acquisitions and releases of these locks. By invoking this tester with different values of `R` and `W`, one can test the reader-writer lock code reasonably thoroughly. Of course, you are encouraged to write your own test programs that use the reader-writer lock as well.

Submission Instructions

You must submit `rwlock.h`, `rwlock-reader-pref.c`, and `rwlock-writer-pref.c`. You need not submit the testing code.

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