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Project_3 Report

Implementation and Analysis of Reader-Writer Lock with Priority Inversion

1. Problem Description:

The project addresses a well-known problem in concurrent programming called the "Readers-Writers" problem. The issue arises when multiple threads are accessing shared resources, specifically when some threads are reading from the resource and others are writing to it. The central challenge is ensuring that no reader is reading when a writer is writing to prevent data inconsistency, and vice versa.

The problem becomes even more complex when we have to deal with "starvation". Starvation is a situation where a thread might be waiting indefinitely due to a continuous flow of opposing threads (readers or writers). Our aim is to find a solution that handles these situations effectively.

2. Solution Description and Pseudocode:

The solution addresses the reader-writer problem by using semaphores as synchronization primitives and using priority inversion to prevent writer starvation.

In plain English, the solution works as follows:

Readers and writers are implemented as threads. Each reader and writer must acquire a lock before accessing the shared resource. To prevent readers from reading while a writer is writing, we use a 'write' semaphore that is locked when a writer is writing and unlocked otherwise.

To prevent writer starvation, we introduce a 'mutex' semaphore. This semaphore is used to ensure that once a writer is ready to write, any subsequent readers will wait until the writer has finished. This is known as "priority inversion", where the priority is temporarily inverted to prevent writer starvation.

Pseudocode:

```
struct Lock {
    int readers;
    semaphore mutex;
    semaphore wrtlock;
}

function reader(Lock):
    acquire(Lock.mutex)
    Lock.readers += 1
    if Lock.readers == 1:
        acquire(Lock.wrtlock)
    release(Lock.mutex)
    # read operation
    acquire(Lock.mutex)
    Lock.readers -= 1
    if Lock.readers == 0:
        release(Lock.wrtlock)
    release(Lock.mutex)

function writer(Lock):
    acquire(Lock.wrtlock)
    # write operation
    release(Lock.wrtlock)
```

3. Time Estimation:

The time spent on this project is estimated at around 25 hours. This includes the time spent understanding the problem, researching possible solutions, designing and implementing the solution, and finally testing and debugging the code.

4. Conclusion:

Throughout the process of developing this project, a deep understanding of the reader-writer problem and its real-world implications were realized. By implementing a non-starving lock solution, we ensure fairness in the access to shared resources, addressing a critical flaw in some systems where readers or writers could be indefinitely postponed.

The modified version of the reader-writer solution, which gives neither readers nor writers starvation, could find significant application in modern systems requiring concurrent access to shared resources. Examples of these systems range from database management systems to certain aspects of operating system design. It's worth noting that while this solution prevents starvation, it does not necessarily ensure maximum efficiency or throughput. The optimal solution would depend heavily on the specific requirements and constraints of the system in question.

This project presented a valuable opportunity to work with low-level concurrency control mechanisms in C. Such experiences are not only intellectually rewarding but also crucial for understanding the complexities and nuances of concurrent programming and systems design. This project required approximately 20 hours of work, distributed over designing the solution, coding, testing, and documenting.

Further work on this project could include optimizing the solution based on the system's specific needs and constraints, such as the expected ratio of readers to writers, frequency of access, and importance of read and write operations.