



SINGAPORE UNIVERSITY OF
TECHNOLOGY AND DESIGN

50.043 Database Lab 3 Report

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50.043 Database System and Big Data ~ Lab 3

Summary and Design decisions

Exercise 1, 2 & 5 ~ Lock acquisition and release in Bufferpool

In `bufferpool.java`, `GetPage()` function was modified to acquire a lock from lock manager before returning pages to ensure all page access goes through proper lock acquisition and proper permissions checking. `UnsafeReleasePage()` was implemented to release both read and write lock. The two-phase locking protocol is implemented through shared and exclusive locks along with a deadlock detection mechanism.

Exercise 3 ~ NO STEAL Buffer management

The NO STEAL policy was implemented by modifying `evictPage()` to iterate through the bufferpool pages, only evicting clean pages. In the case that no clean pages are found, a `DbException` is thrown to prevent the eviction of dirty pages from uncommitted transactions. Uses first-found clean page selection for eviction.

Exercise 4 ~ Transaction Completion

`TransactionComplete()` was implemented with commit/abort logic; On commit, the function calls `flushPages(tid)` to write all transaction's dirty pages to disk. On abort, it restores pages to before-image state by replacing dirty pages in bufferpool. And always releases all transaction locks in finally block regardless of commit/abort outcome to guarantee lock cleanup, preventing deadlock from unreleased locks

Deadlock Detection and Prevention

Created a separate `LockManager` class that manages lock state using a `concurrentHashMap` data structure. `LockManager` uses four main data structures;

1. `PageLocks` maps `PageId` to sets of lock objects
2. `TransactionLocks` maps `TransactionId` to sets of Locks held
3. `WaitingQueue` maintains FIFO queues of lock requests per page
4. `WaitForGraph` tracks transaction dependencies for deadlock detection

The implemented data structures provide efficient lookup and maintenance operations and ensures thread safety through synchronized blocks. The design checks if the lock can be granted immediately, otherwise it adds the transaction to the wait-for graph, performing cycle detection, and enqueues the request.

The cycle detection is done using a depth-first search algorithm with recursion stack to detect cycles in the wait for graph. This method provides more precise detection when

detecting a deadlock as it only aborts transactions when actual deadlocks exists, minimizing rollbacks. The FIFO queue ensures transactions acquire locks in request order, preventing starvation.

However, the cost to maintain the graph is high, as the graph must update wait-for relationships after every lock release, requiring iteration through waiting queues. The deadlock detection maintain many data structures to function, causing memory overhead that grows with transaction count.

Missing/Incomplete Elements Of Our Code/Changes Made To The API

All Lab 1, 2 and 3 code have been implemented. No Changes made to the API