

5 Concurrent and Distributed Systems (mk428)

In a bank’s database, let a *payment* from one account (the *source*) to another (the *destination*) be a transaction that first reads the balance of both accounts, aborting if the payment amount is greater than the source account balance. If not aborted, the transaction updates the source account balance to be the balance it previously read minus the payment amount, updates the destination account balance to be the previously read balance plus the payment amount, and then commits.

- (a) What is the purpose of strict two-phase locking (2PL) in a database, and how does it work? [3 marks]
- (b) Assume the database uses strict 2PL with a multi-reader single-writer lock for each account, which is acquired when the account is first accessed in a transaction. Which problem could occur if there is a payment from account *A* to account *B*, and concurrently another payment from account *B* to account *A*? Draw a state machine diagram showing all the possible executions of these two payments, assuming that each account balance read or update is an atomic operation. [6 marks]
- (c) Your colleague suggests changing the payment transaction as follows. Instead of accessing first the source and then the destination account, a payment transaction should first read the balance of the account with the lower account number, then read the balance of the account with the higher account number, then update the lower-numbered account, and finally update the higher-numbered account. Does this prevent the problem from Part (b)? Justify your answer. [4 marks]
- (d) As a consistency check, the bank wants to periodically read the balance of all accounts and confirm that their sum equals the bank’s total holdings. Explain what problems might occur in a database that uses strict 2PL. [2 marks]
- (e) The bank is considering moving to a database that uses optimistic concurrency control instead of 2PL. Explain what impact this is likely to have on the scenarios from Parts (b), (c), and (d). What new problems might this introduce that do not occur with 2PL? [5 marks]