Case Study: Banking System – SafeBank Ltd.

Scenario:

SafeBank Ltd. is a medium-sized commercial bank that allows its customers to perform online banking operations such as money transfers, deposits, and withdrawals. The database system must ensure data integrity, concurrent access control, and data recovery in case of system failure.
Two users, Alice and Bob, are performing transactions simultaneously:
Alice is transferring ₹5000 from her Savings account to her Checking account.
Bob is depositing ₹3000 into his Savings account.
Meanwhile, a power failure occurs after Alice's transaction is half-completed.

SafeBank uses a log-based recovery system and strict two-phase locking (2PL) with Shared (S) and Exclusive (X) locks to manage concurrency.

1. **Which of the following is not an ACID property?**
   a) Atomicity
   b) Consistency
   c) Durability
   d) Availability
   Answer: d) Availability
2. **What ensures that transactions do not interfere with each other in a concurrent environment?**
   a) Redundancy
   b) Two-phase locking
   c) RAID
   d) Indexing
   Answer: b) Two-phase locking
3. **Atomicity in a transaction ensures that:**
   a) The transaction does not conflict with other transactions
   b) All operations of the transaction are completed or none are
   c) The data remains consistent
   d) The results are stored permanently
   Answer: b) All operations of the transaction are completed or none are

4. **What type of lock must be acquired by Alice to deduct ₹5000 from her Savings account?**
   a) Shared Lock
   b) Exclusive Lock
   c) Intent Shared Lock
   d) Intent Exclusive Lock
   Answer: b) Exclusive Lock
5. **Which type of lock allows multiple transactions to read but not write the data?**
   a) Shared Lock
   b) Exclusive Lock
   c) Write Lock
   d) Read-Write Lock
   Answer: a) Shared Lock
6. **In strict 2PL, locks are released:**
   a) As soon as the operation is completed
   b) After each phase
   c) Only after the transaction commits or aborts
   d) After the read operation
   Answer: c) Only after the transaction commits or aborts
7. **If Bob wants to deposit ₹3000 in his Savings account, which lock will he need on that account?**
   a) No lock

b) Shared lock
c) Exclusive lock
d) Either shared or exclusive
Answer: c) Exclusive lock

8. **What would happen if Alice tries to access a record already locked in exclusive mode by Bob?**
a) She will overwrite the data
b) She will be granted shared access
c) Her transaction will wait (block)
d) Her transaction will abort immediately
Answer: c) Her transaction will wait (block)

9. **What type of logging does SafeBank use for recovery?**
a) Shadow paging
b) Log-based recovery
c) Backup and restore
d) Differential logging
Answer: b) Log-based recovery

10. **In log-based recovery, which information is typically recorded in the log?**
a) Only the new value
b) Only the old value
c) Both old and new values
d) None of the above
Answer: c) Both old and new values

11. **If a failure occurs mid-transaction, what technique is used to undo its effects?**
a) Roll-forward
b) Rollback
c) Deadlock detection
d) Transaction flushing
Answer: b) Rollback

12. **In log-based recovery, what does the system do during the REDO phase?**
a) Reverts uncommitted transactions
b) Re-applies the effects of committed transactions
c) Deletes old logs
d) Acquires new locks
Answer: b) Re-applies the effects of committed transactions

13. **If Alice's transaction is half-completed during a power failure, what happens during recovery?**
a) The changes are applied
b) The transaction is rolled back
c) The transaction is committed
d) Nothing happens
Answer: b) The transaction is rolled back

14. **Which property ensures that once a transaction is committed, its changes persist despite failure?**
a) Atomicity
b) Consistency
c) Durability
d) Isolation
Answer: c) Durability

15. **Which action should the recovery manager take for Bob's completed deposit transaction?**
a) Undo the transaction
b) Ignore the transaction
c) Redo the transaction
d) Abort the transaction
Answer: c) Redo the transaction

16. **If Alice and Bob are waiting on each other's locks, what situation can arise?**
    a) Concurrency
    b) Starvation
    c) Deadlock
    d) Consistency
    Answer: c) Deadlock
17. **Which isolation level is implied by strict 2PL?**
    a) Read Uncommitted
    b) Read Committed
    c) Repeatable Read
    d) Serializable
    Answer: d) Serializable
18. **How can deadlocks be prevented in a strict 2PL system?**
    a) By using timeouts or wait-die schemes
    b) By aborting all transactions
    c) By disabling locks
    d) By using non-locking protocols
    Answer: a) By using timeouts or wait-die schemes

19. **Which of the following is a correct pair of actions for transaction control?**
    a) LOCK and FLUSH
    b) BEGIN and KILL
    c) COMMIT and ROLLBACK
    d) READ and WRITE
    Answer: c) COMMIT and ROLLBACK
20. **Which component is responsible for maintaining logs and recovering from crashes?**
    a) Scheduler
    b) Lock manager
    c) Recovery manager
    d) Transaction manager
    Answer: c) Recovery manager

II. Case Study: FastLoan – Automated Loan Processing System Scenario:

FastLoan is an automated loan processing system used by FinTrust Bank. It processes personal loan applications, checks credit history, verifies account balances, and then disburses funds. Several departments access shared databases concurrently to:

- Verify eligibility (credit score and employment),
- Check account balance, and
- Transfer approved loan funds to the applicant's account.

Two loan officers, Officer A and Officer B, are handling applications for two customers at the same time. Officer A is processing a loan for Customer X, and Officer B is processing a loan for Customer Y.

Mid-process, a system crash occurs. The system uses Shadow Paging for recovery and Basic 2PL (Two-Phase Locking) to manage concurrency.

1. What is the primary role of Basic Two-Phase Locking (2PL) in the FastLoan system?

A. Backup data to external storage
B. Ensure serializability during concurrent transactions
C. Reduce transaction latency
D. Automatically rollback transactions

Correct Answer: B

2. In the event of a system crash, how does shadow paging help in recovery?

A. By logging each transaction's steps
B. By maintaining a backup database
C. By using a copy-on-write strategy that preserves the original pages
D. By encrypting data before storage

Correct Answer: C

3. During the crash, Officer A was updating Customer X's account. Which part of 2PL ensures that the account balance is not inconsistently updated?

A. Read phase
B. Commit phase
C. Locking phase
D. Shrinking phase

Correct Answer: C

4. What could happen if Basic 2PL is not followed during loan processing?

A. Reduced disk usage
B. Faster transaction processing
C. Dirty reads and lost updates
D. Improved customer service

Correct Answer: C

5. What happens to the changes made during a transaction that did not reach the commit point when the crash occurred?

A. They are written to the shadow copy
B. They are permanently stored
C. They are lost and ignored during recovery
D. They are retried automatically

Correct Answer: C

6. When both Officer A and Officer B try to access the same customer account, what mechanism ensures that there are no conflicts?

A. Shadow Copying
B. Write-Ahead Logging

C. Locking in 2PL
D. Replication

Correct Answer: C

7. Which of the following best describes the "shrinking phase" in Basic 2PL?

A. Releasing all acquired locks
B. Locking more resources
C. Writing data to disk
D. Starting the transaction

Correct Answer: A

8. Why is shadow paging considered a recovery mechanism rather than a concurrency control mechanism?

A. It prevents deadlocks
B. It avoids the need for locks
C. It ensures data integrity after failures
D. It handles multi-user access

Correct Answer: C

9. After recovery, which version of the data does shadow paging use?

A. Latest in-memory version
B. Intermediate pages before failure
C. Committed and stable shadow pages
D. Random pages from the cache

Correct Answer: C

10. Which scenario would lead to a deadlock in the FastLoan system?

A. Two officers reading different accounts
B. An officer waiting for a lock held by another officer who is also waiting on a lock
C. An officer writing to a single account
D. System reboot due to crash

Correct Answer: B