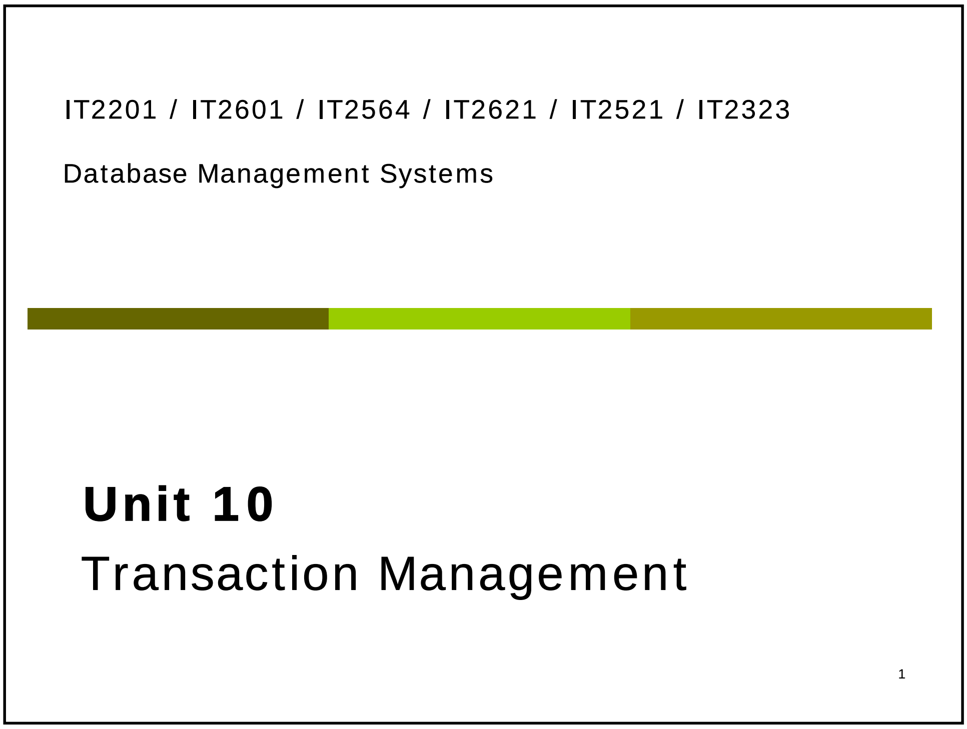

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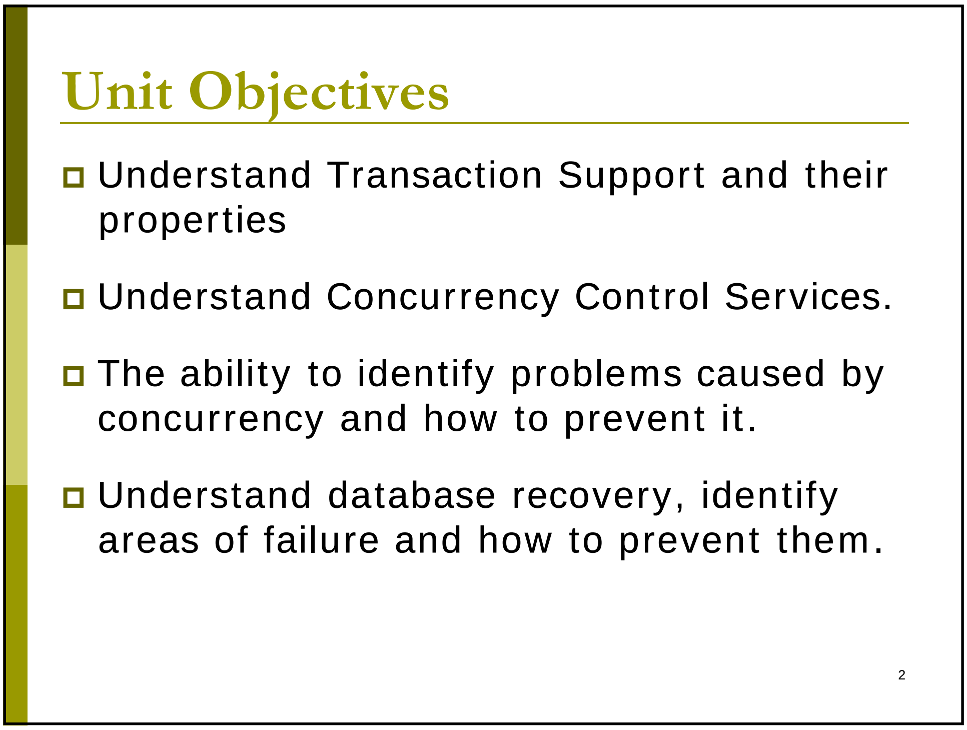
Database Management Systems

Unit 10
Transaction Management



Unit Objectives

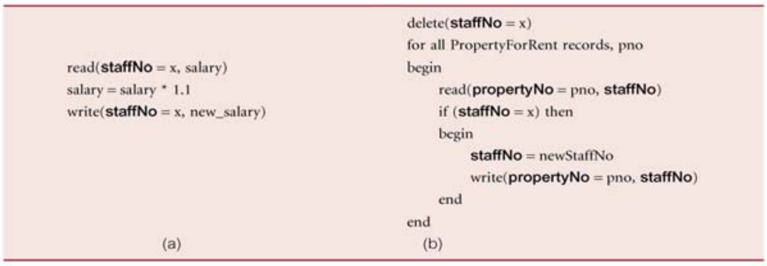
- Understand Transaction Support and their properties
- Understand Concurrency Control Services.
- The ability to identify problems caused by concurrency and how to prevent it.
- Understand database recovery, identify areas of failure and how to prevent them.

Transaction Support

- What is a Transaction
  - Action, or series of actions, carried out by user or application, which accesses or changes contents of database.
- A transaction is a logical unit of work on the database.
- A transaction transforms database from one consistent state to another.
- A transaction can have one of two outcomes:
  - commit
  - rollback

Example of a Transaction

- Transaction (a)
  - To update the salary of a particular member of staff given the staff number, x.
- Transaction (b)
  - To delete the member of staff with a given staff number x, and to reassign the properties managed by this staff to a different member of staff.

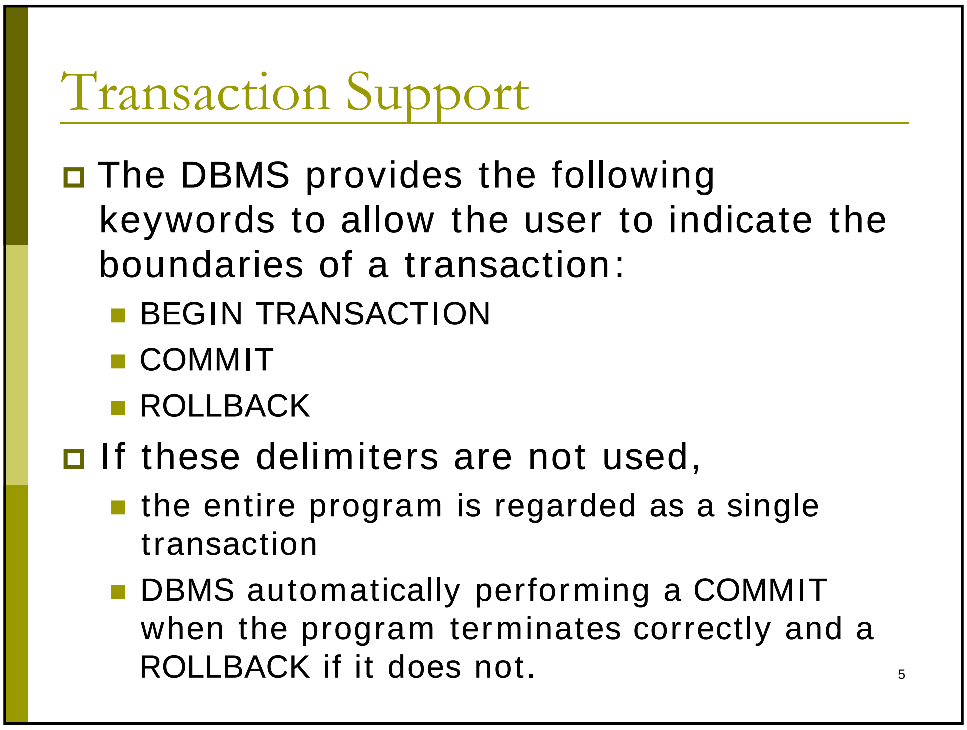


```
read(staffNo = x, salary)
salary = salary * 1.1
write(staffNo = x, new_salary)
```

(a)

```
delete(staffNo = x)
for all PropertyForRent records, pno
begin
    read(propertyNo = pno, staffNo)
    if (staffNo = x) then
    begin
        staffNo = newStaffNo
        write(propertyNo = pno, staffNo)
    end
end
```

(b)



Transaction Support

- The DBMS provides the following keywords to allow the user to indicate the boundaries of a transaction:
  - BEGIN TRANSACTION
  - COMMIT
  - ROLLBACK
- If these delimiters are not used,
  - the entire program is regarded as a single transaction
  - DBMS automatically performing a COMMIT when the program terminates correctly and a ROLLBACK if it does not.

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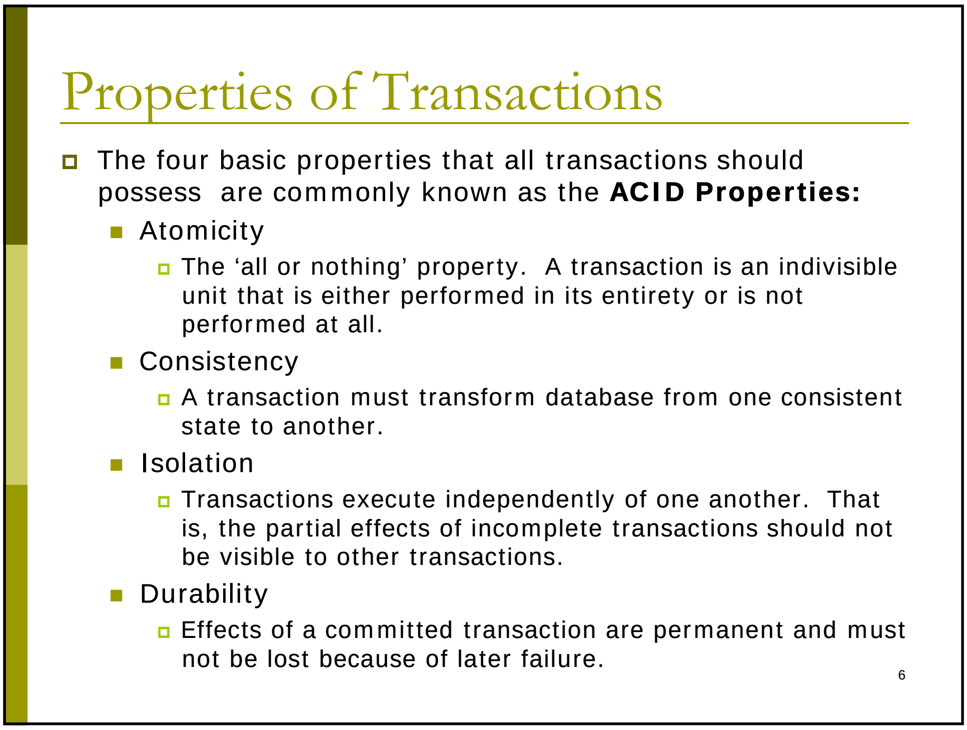

Properties of Transactions

- The four basic properties that all transactions should possess are commonly known as the **ACID Properties:**
  - Atomicity
    - The 'all or nothing' property. A transaction is an indivisible unit that is either performed in its entirety or is not performed at all.
  - Consistency
    - A transaction must transform database from one consistent state to another.
  - Isolation
    - Transactions execute independently of one another. That is, the partial effects of incomplete transactions should not be visible to other transactions.
  - Durability
    - Effects of a committed transaction are permanent and must not be lost because of later failure.

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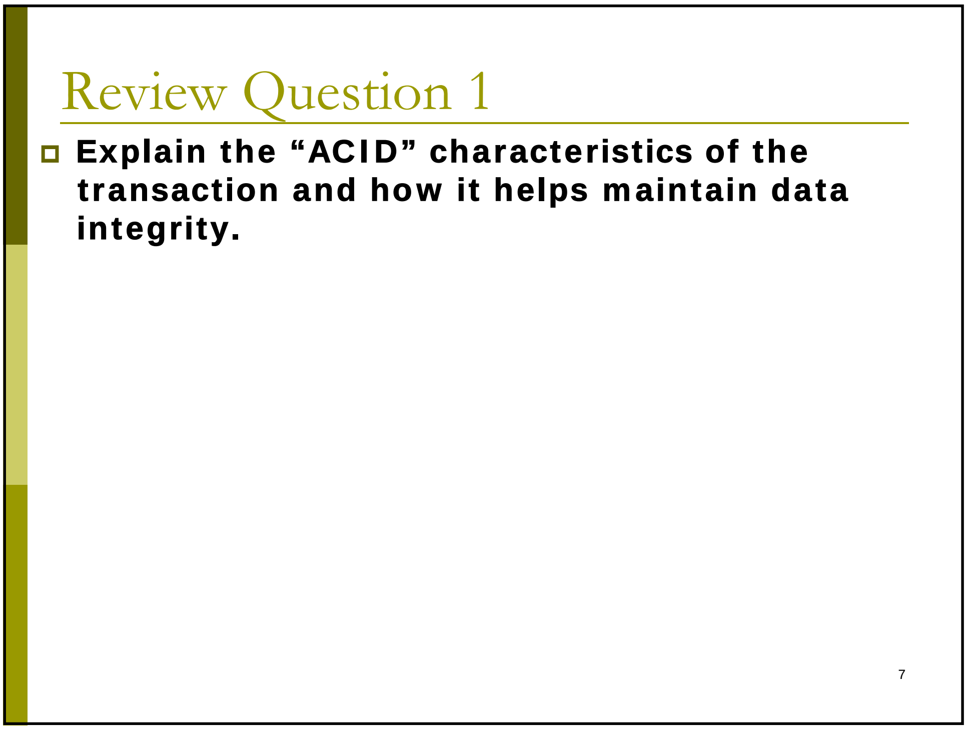

Review Question 1

- **Explain the "ACID" characteristics of the transaction and how it helps maintain data integrity.**

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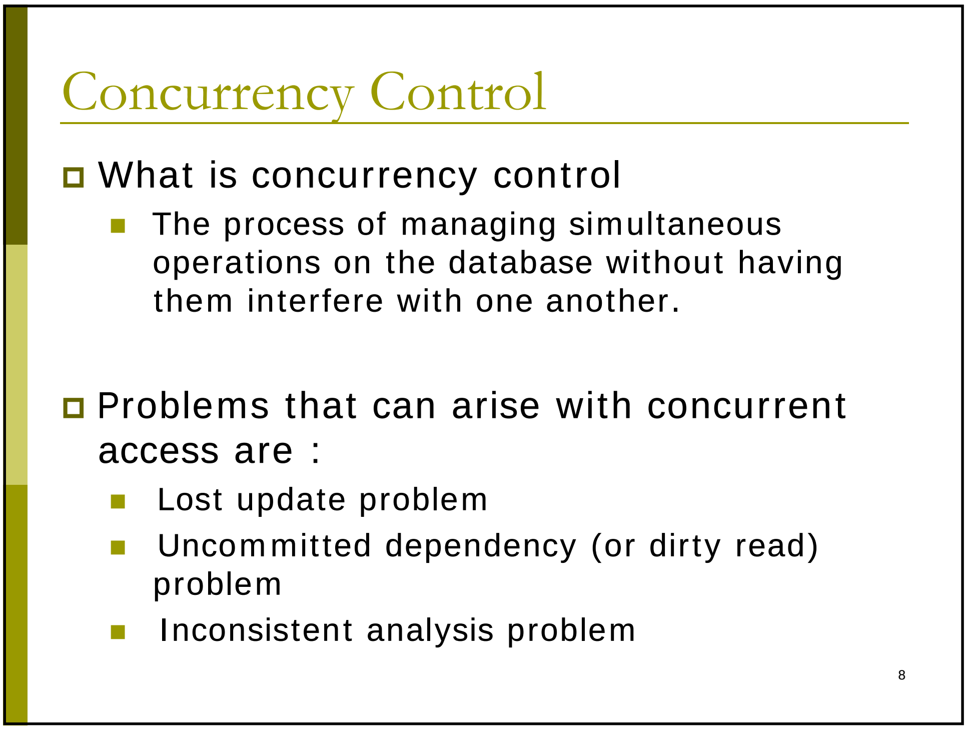

Concurrency Control

- What is concurrency control
  - The process of managing simultaneous operations on the database without having them interfere with one another.
- Problems that can arise with concurrent access are :
  - Lost update problem
  - Uncommitted dependency (or dirty read) problem
  - Inconsistent analysis problem

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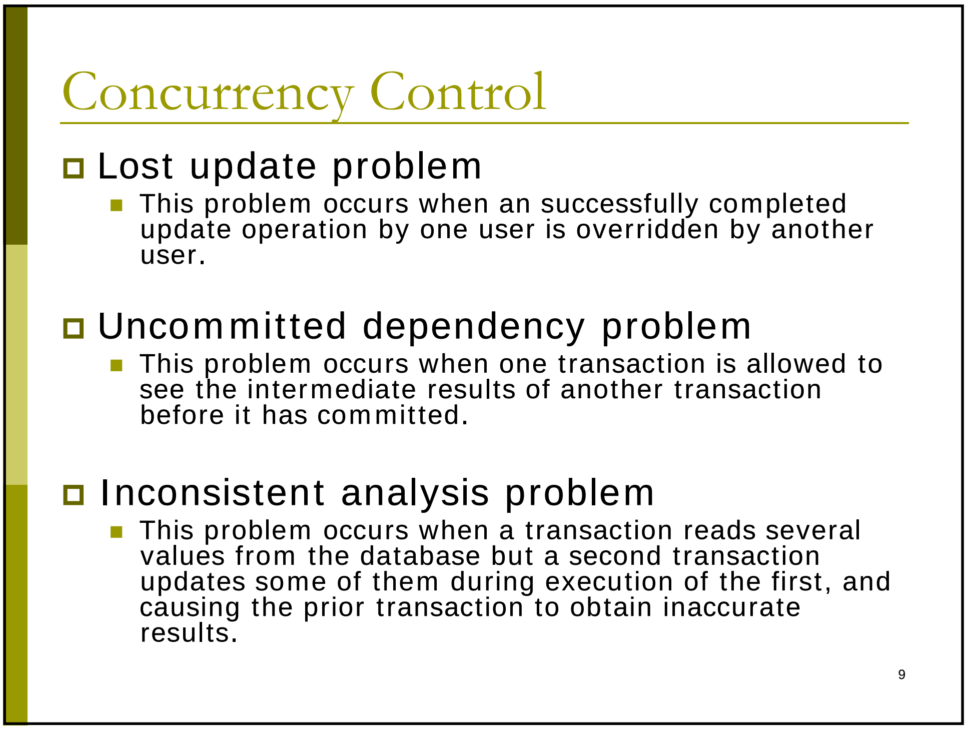
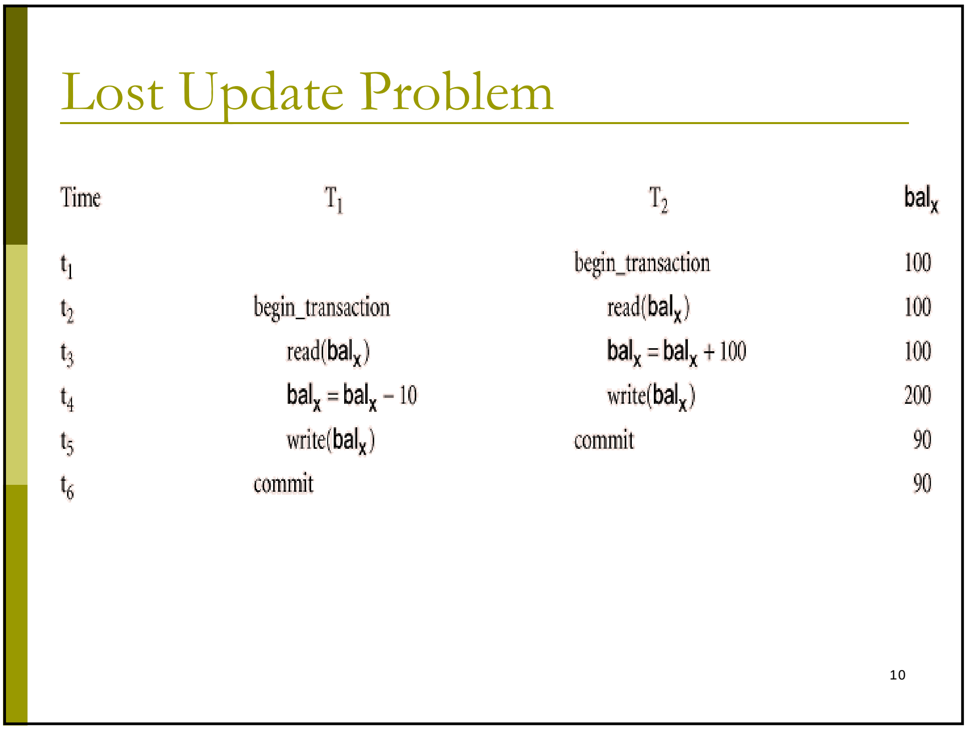


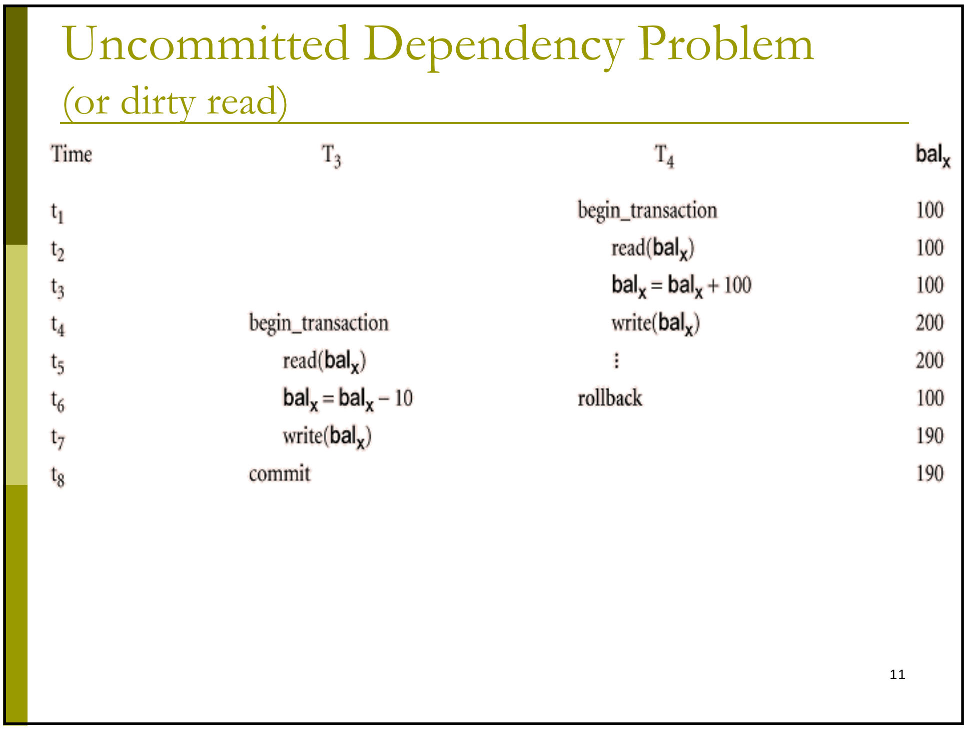
Concurrency Control

- Lost update problem
  - This problem occurs when an successfully completed update operation by one user is overridden by another user.
- Uncommitted dependency problem
  - This problem occurs when one transaction is allowed to see the intermediate results of another transaction before it has committed.
- Inconsistent analysis problem
  - This problem occurs when a transaction reads several values from the database but a second transaction updates some of them during execution of the first, and causing the prior transaction to obtain inaccurate results.



Lost Update Problem

Time	T_1	T_2	bal_x
t_1		begin_transaction	100
t_2	begin_transaction	read(bal_x)	100
t_3	read(bal_x)	$bal_x = bal_x + 100$	100
t_4	$bal_x = bal_x - 10$	write(bal_x)	200
t_5	write(bal_x)	commit	90
t_6	commit		90



Uncommitted Dependency Problem (or dirty read)

Time	T_3	T_4	bal_x
t_1		begin_transaction	100
t_2		read(bal_x)	100
t_3		$\text{bal}_x = \text{bal}_x + 100$	100
t_4	begin_transaction	write(bal_x)	200
t_5	read(bal_x)	⋮	200
t_6	$\text{bal}_x = \text{bal}_x - 10$	rollback	100
t_7	write(bal_x)		190
t_8	commit		190

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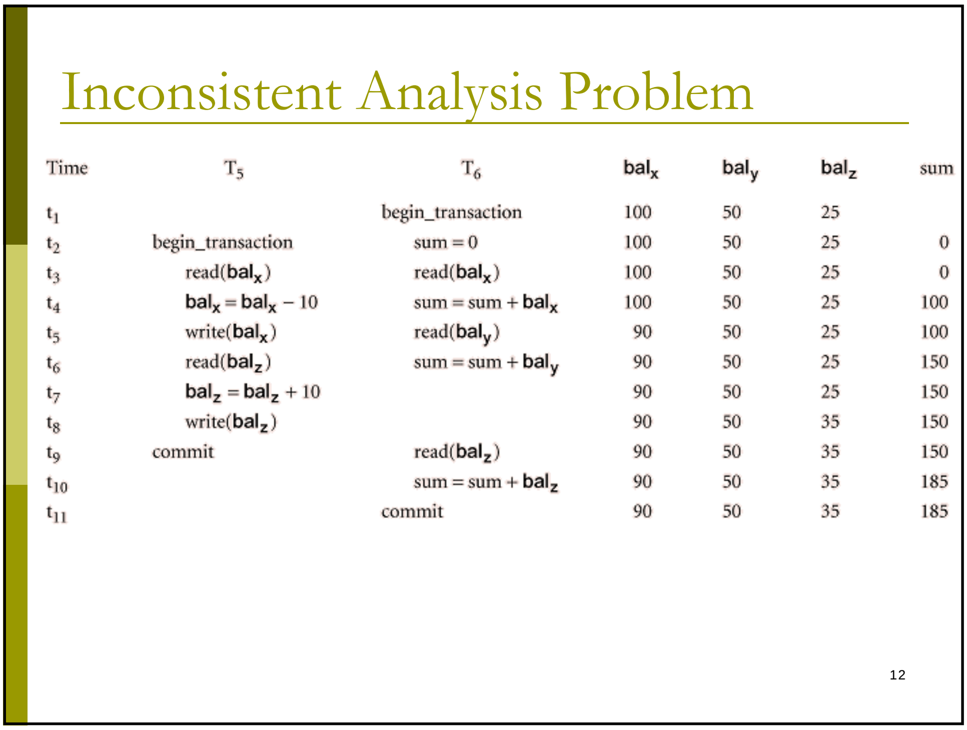

Inconsistent Analysis Problem

Time	T_5	T_6	bal_x	bal_y	bal_z	sum
t_1		begin_transaction	100	50	25	
t_2	begin_transaction	sum = 0	100	50	25	0
t_3	read(bal_x)	read(bal_x)	100	50	25	0
t_4	$\text{bal}_x = \text{bal}_x - 10$	sum = sum + bal_x	100	50	25	100
t_5	write(bal_x)	read(bal_y)	90	50	25	100
t_6	read(bal_z)	sum = sum + bal_y	90	50	25	150
t_7	$\text{bal}_z = \text{bal}_z + 10$		90	50	25	150
t_8	write(bal_z)		90	50	35	150
t_9	commit	read(bal_z)	90	50	35	150
t_{10}		sum = sum + bal_z	90	50	35	185
t_{11}		commit	90	50	35	185

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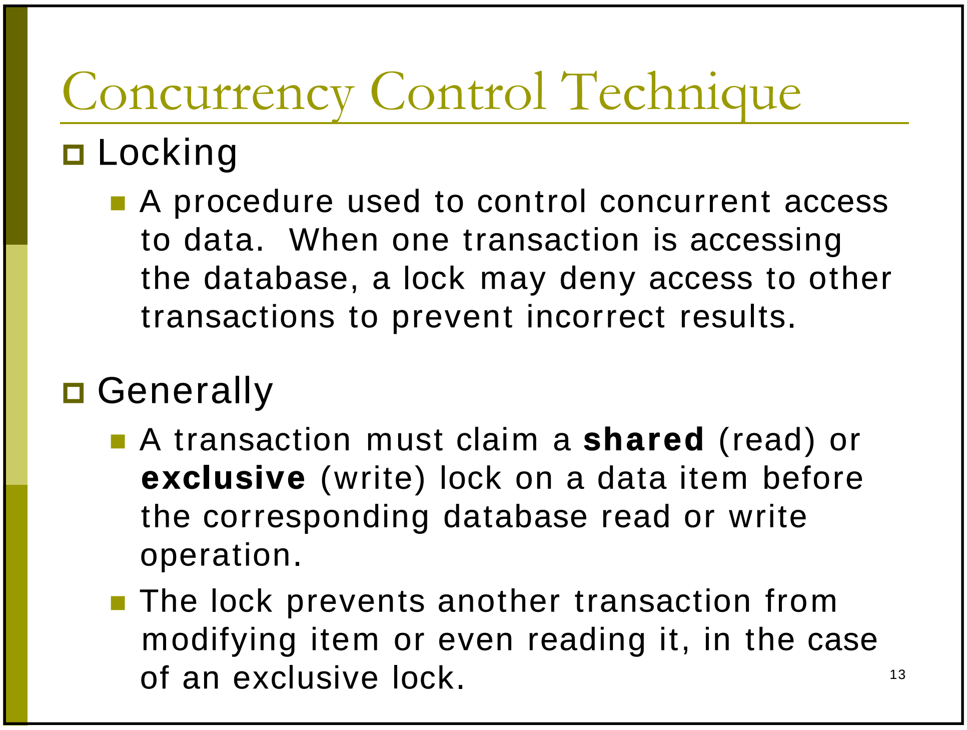

Concurrency Control Technique

- Locking
  - A procedure used to control concurrent access to data. When one transaction is accessing the database, a lock may deny access to other transactions to prevent incorrect results.
- Generally
  - A transaction must claim a **shared** (read) or **exclusive** (write) lock on a data item before the corresponding database read or write operation.
  - The lock prevents another transaction from modifying item or even reading it, in the case of an exclusive lock.

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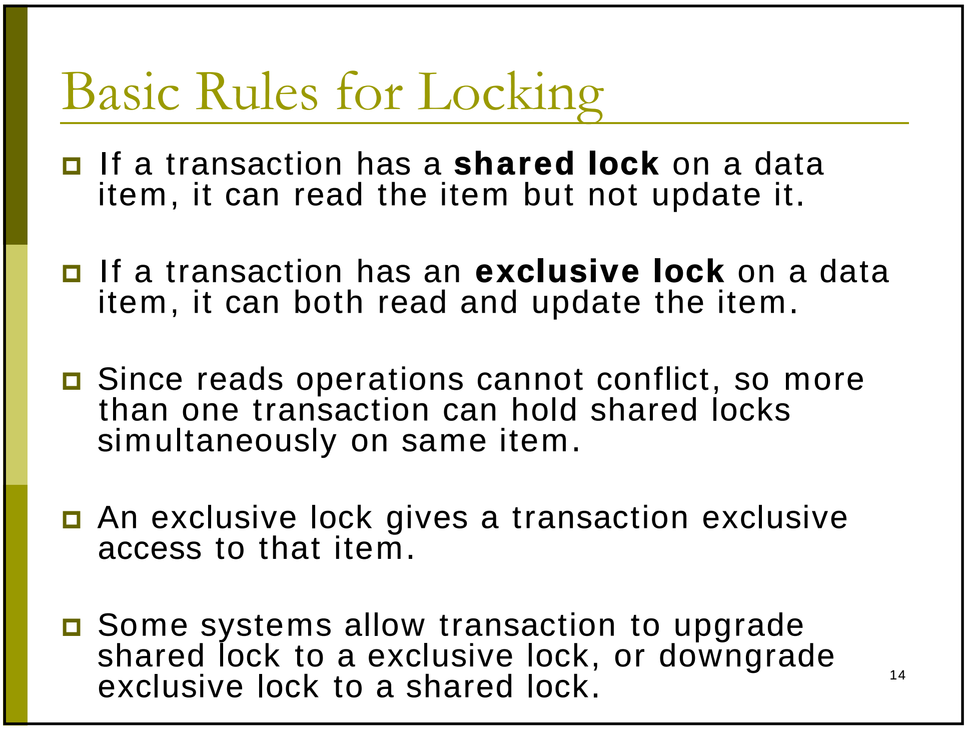

Basic Rules for Locking

- If a transaction has a **shared lock** on a data item, it can read the item but not update it.
- If a transaction has an **exclusive lock** on a data item, it can both read and update the item.
- Since reads operations cannot conflict, so more than one transaction can hold shared locks simultaneously on same item.
- An exclusive lock gives a transaction exclusive access to that item.
- Some systems allow transaction to upgrade shared lock to a exclusive lock, or downgrade exclusive lock to a shared lock.

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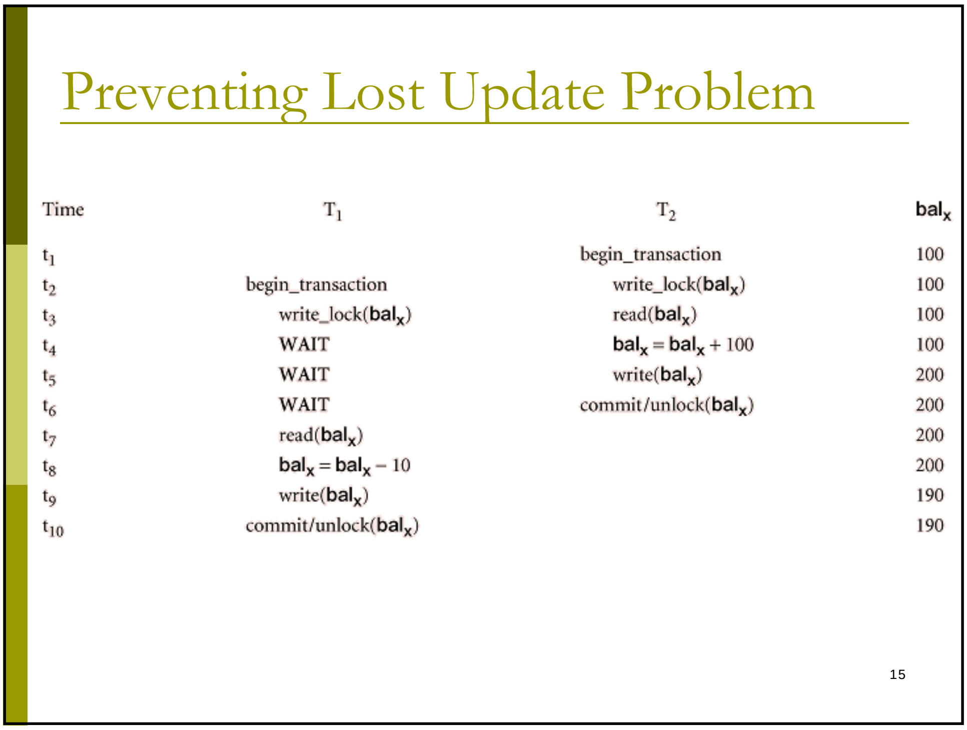

Preventing Lost Update Problem

Time	T_1	T_2	bal_x
t_1		begin_transaction	100
t_2	begin_transaction	write_lock(bal_x)	100
t_3	write_lock(bal_x)	read(bal_x)	100
t_4	WAIT	$bal_x = bal_x + 100$	100
t_5	WAIT	write(bal_x)	200
t_6	WAIT	commit/unlock(bal_x)	200
t_7	read(bal_x)		200
t_8	$bal_x = bal_x - 10$		200
t_9	write(bal_x)		190
t_{10}	commit/unlock(bal_x)		190

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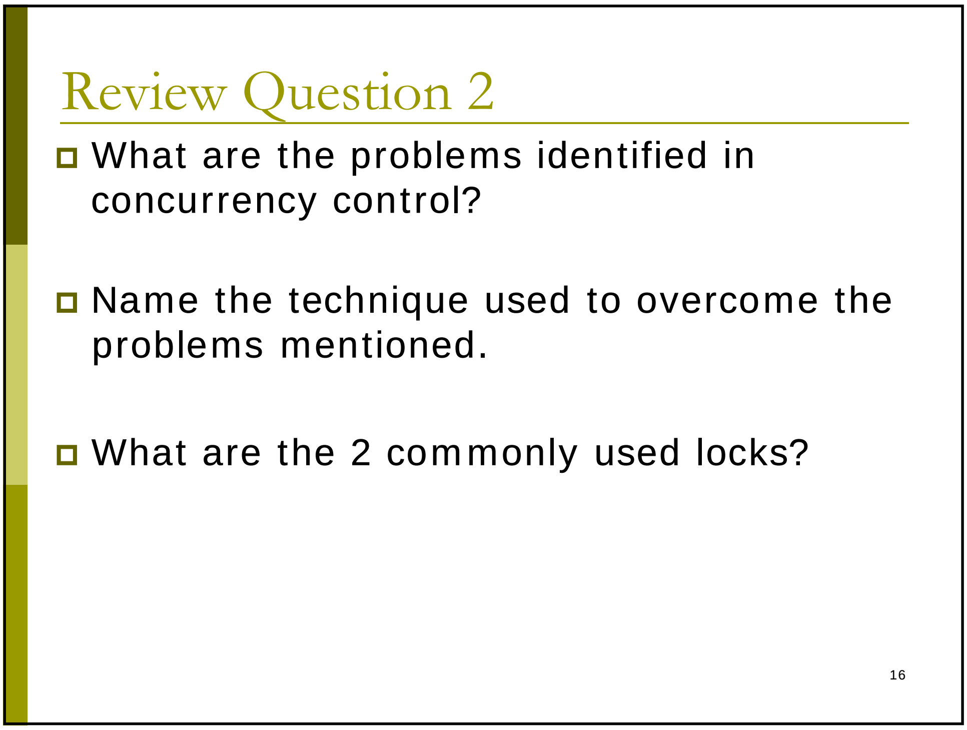

Review Question 2

- What are the problems identified in concurrency control?
- Name the technique used to overcome the problems mentioned.
- What are the 2 commonly used locks?

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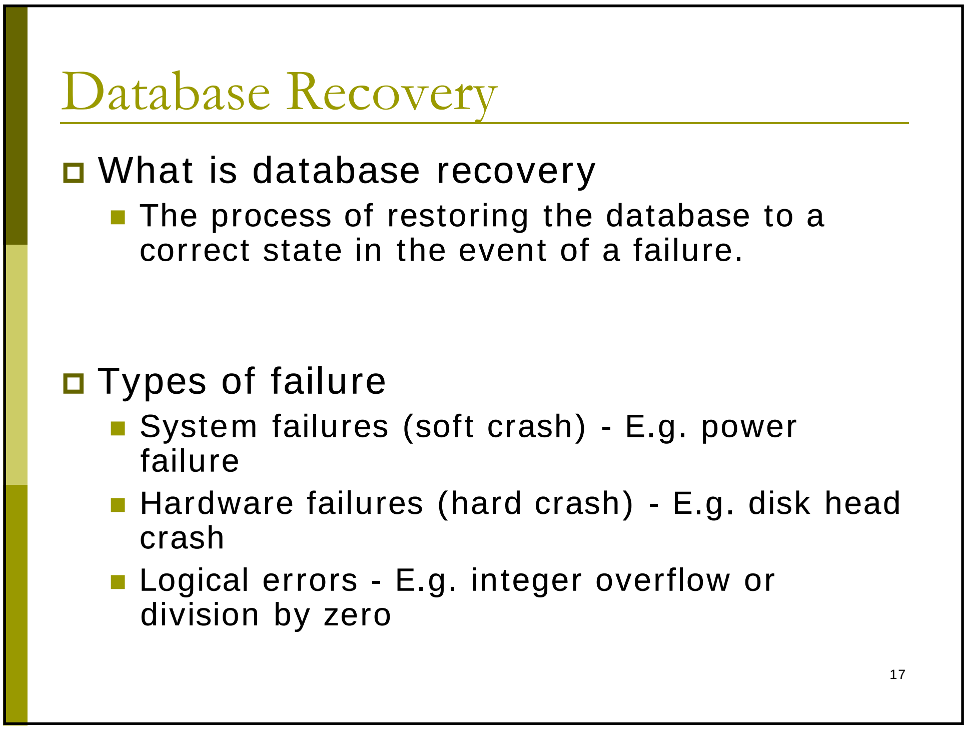
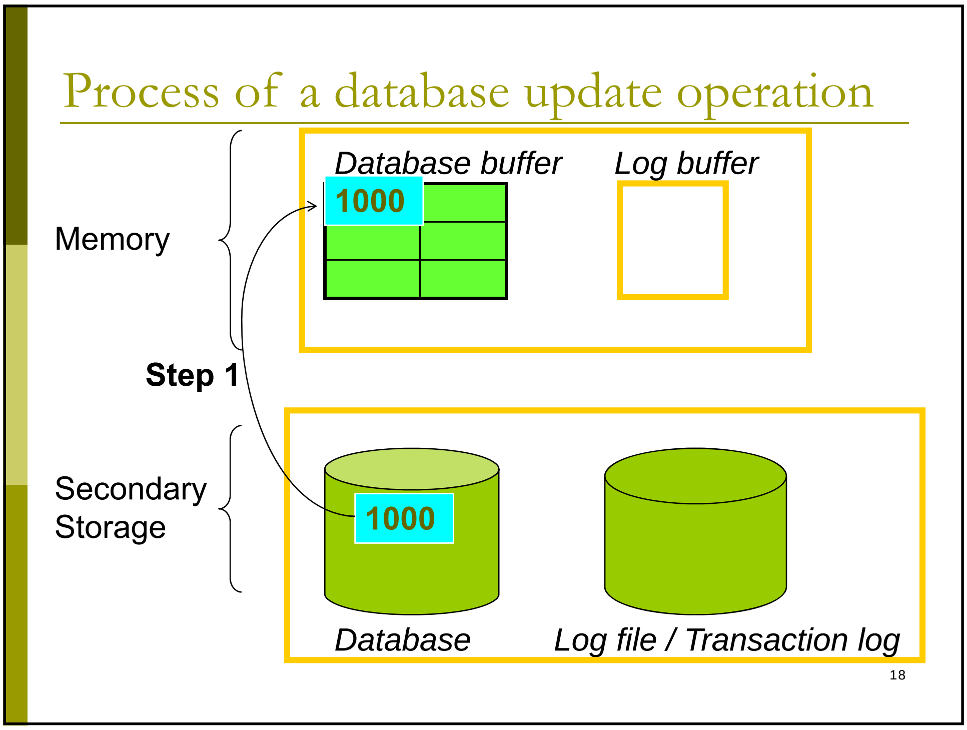


Database Recovery

- What is database recovery
  - The process of restoring the database to a correct state in the event of a failure.
- Types of failure
  - System failures (soft crash) - E.g. power failure
  - Hardware failures (hard crash) - E.g. disk head crash
  - Logical errors - E.g. integer overflow or division by zero



Process of a database update operation

Memory

Database buffer

1000

Log buffer

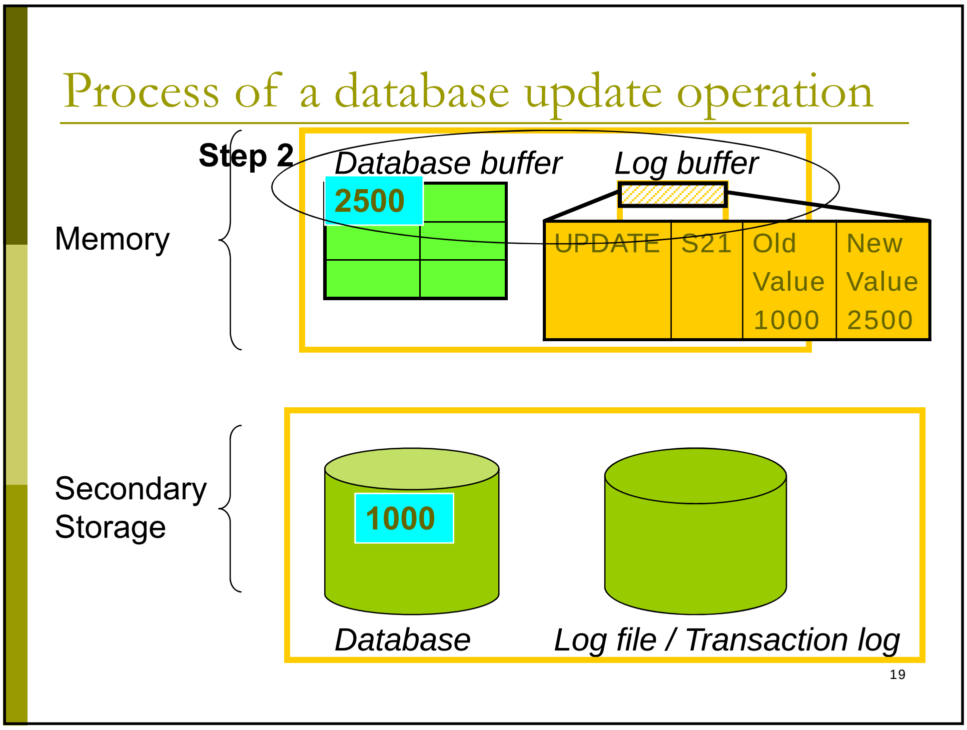
Step 1

Secondary Storage

1000

Database

Log file / Transaction log



Process of a database update operation

Step 2

Memory

Database buffer

2500

Log buffer

UPDATE	S21	Old Value 1000	New Value 2500

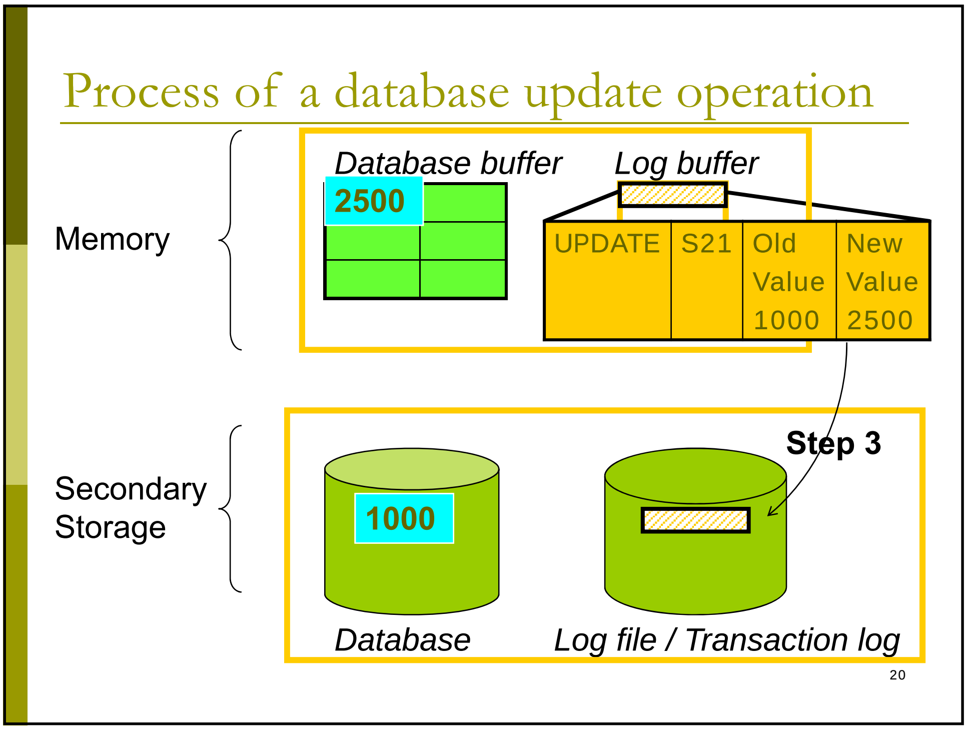
Secondary Storage

1000

Database

Log file / Transaction log

19



Process of a database update operation

Memory

Database buffer

2500

Log buffer

UPDATE	S21	Old Value 1000	New Value 2500

Step 3

Secondary Storage

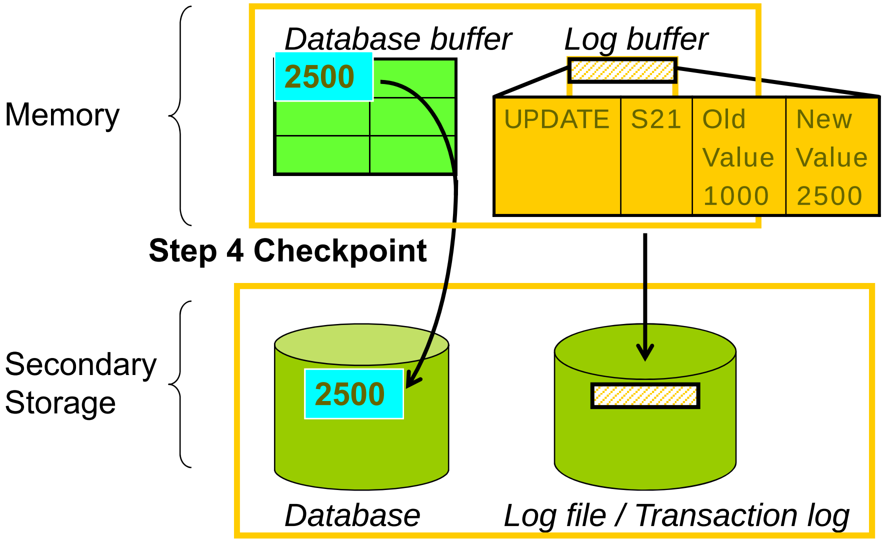
1000

Database

Log file / Transaction log

20

Process of a database update operation



Memory

Database buffer

Log buffer

2500

UPDATE	S21	Old Value 1000	New Value 2500

Step 4 Checkpoint

Secondary Storage

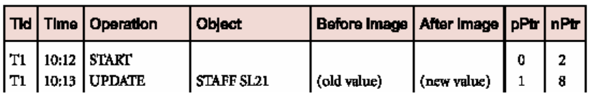
2500

Database

Log file / Transaction log

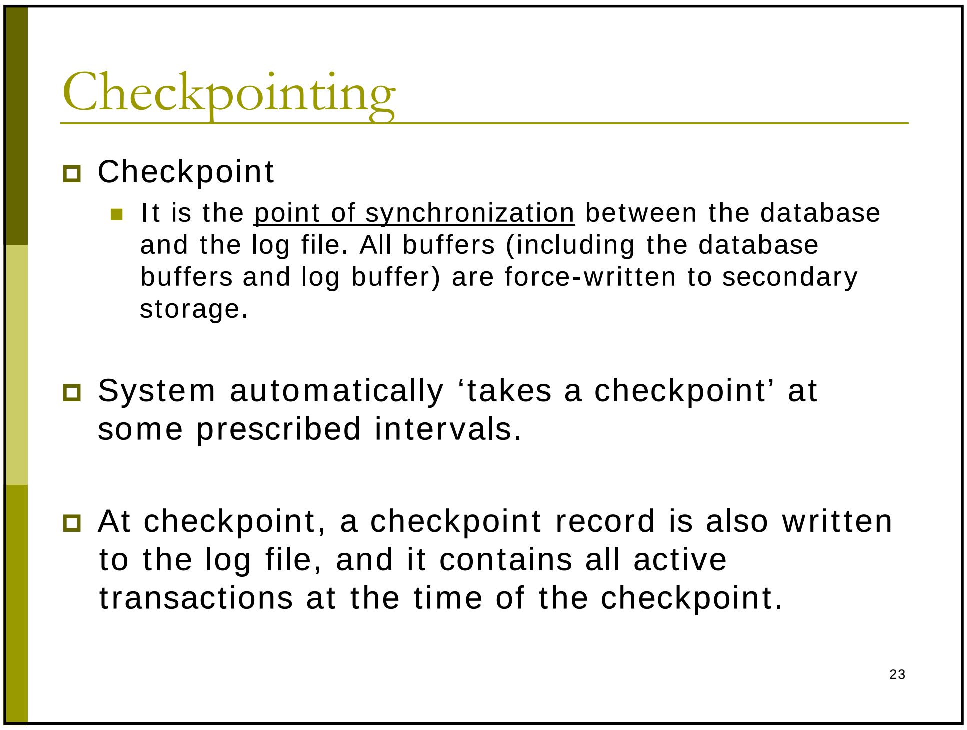
Log File

- A log file is a special file maintained by the DBMS, which contains information about all updates to database.
- E.g. of a update record in the log file :



Tid	Time	Operation	Object	Before Image	After Image	pPtr	nPtr
T1	10:12	START				0	2
T1	10:13	UPDATE	STAFF SL21	(old value)	(new value)	1	8

  - Note that Before-image and After-image of data item are stored in the log file.
- The log is used for purposes such as
  - Recovery
  - Performance monitoring
  - Auditing



Checkpointing

- Checkpoint
  - It is the point of synchronization between the database and the log file. All buffers (including the database buffers and log buffer) are force-written to secondary storage.
- System automatically 'takes a checkpoint' at some prescribed intervals.
- At checkpoint, a checkpoint record is also written to the log file, and it contains all active transactions at the time of the checkpoint.

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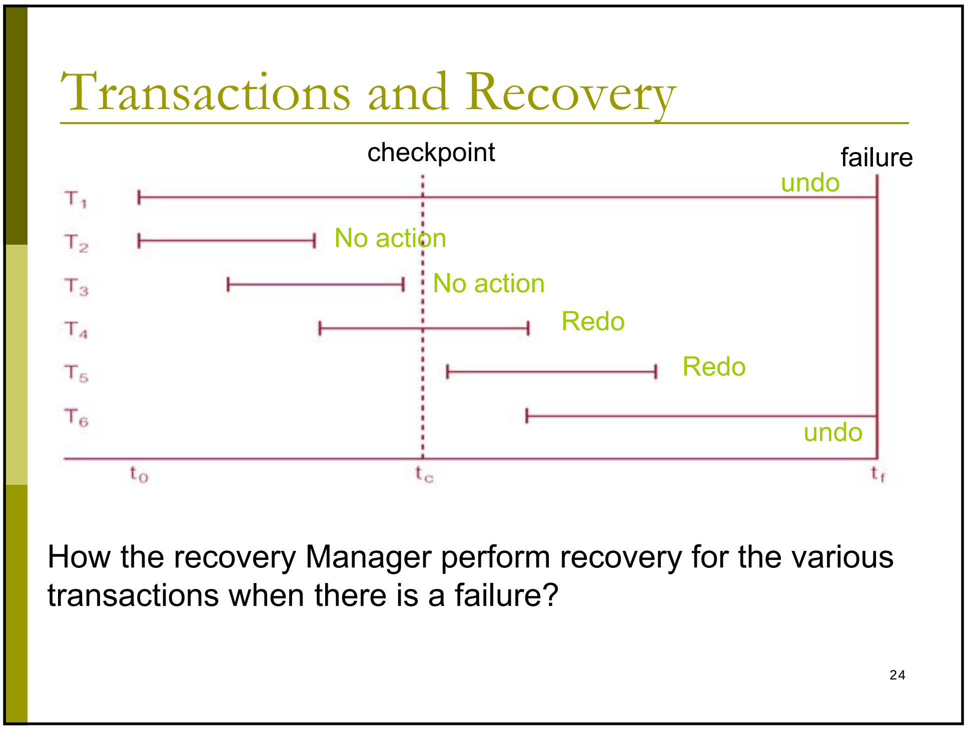

Transactions and Recovery

How the recovery Manager perform recovery for the various transactions when there is a failure?

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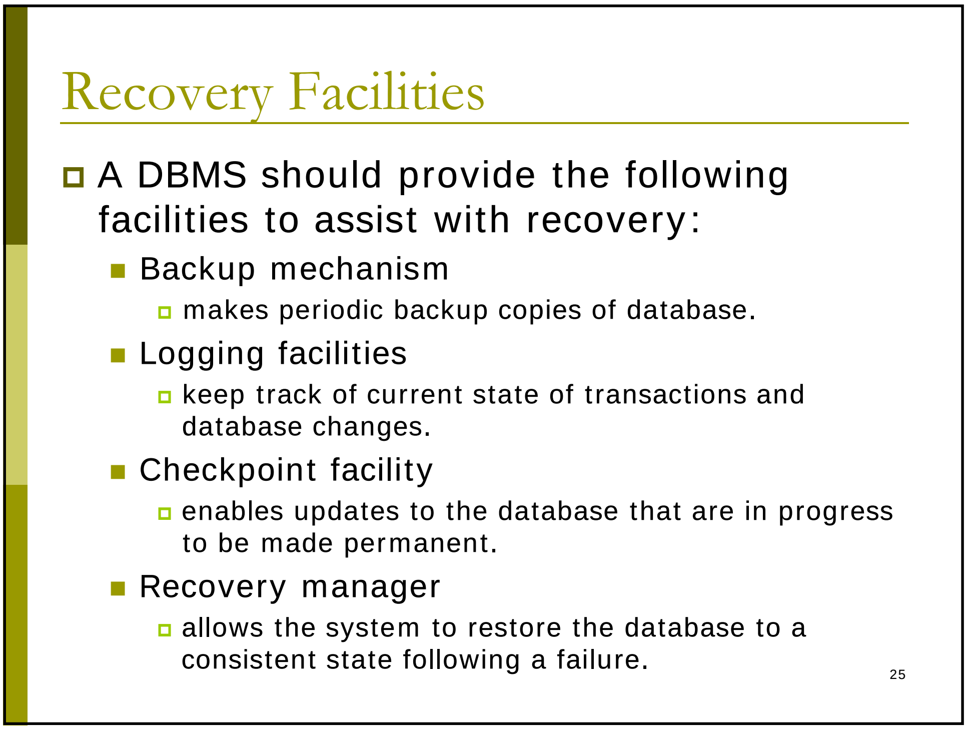
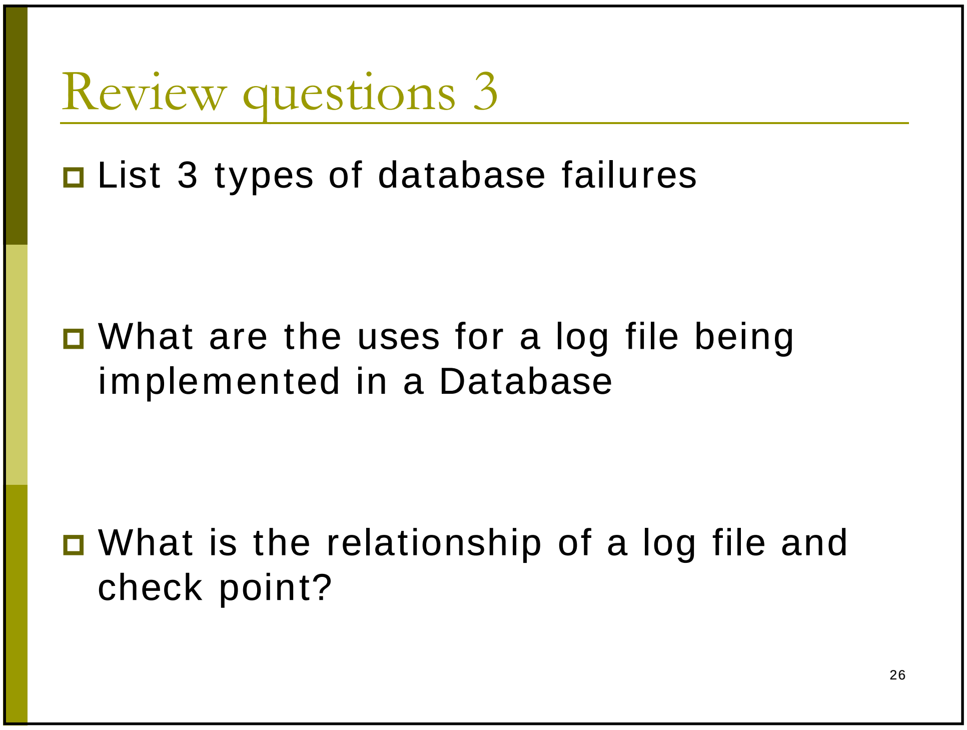


Recovery Facilities

- A DBMS should provide the following facilities to assist with recovery:
  - Backup mechanism
    - makes periodic backup copies of database.
  - Logging facilities
    - keep track of current state of transactions and database changes.
  - Checkpoint facility
    - enables updates to the database that are in progress to be made permanent.
  - Recovery manager
    - allows the system to restore the database to a consistent state following a failure.

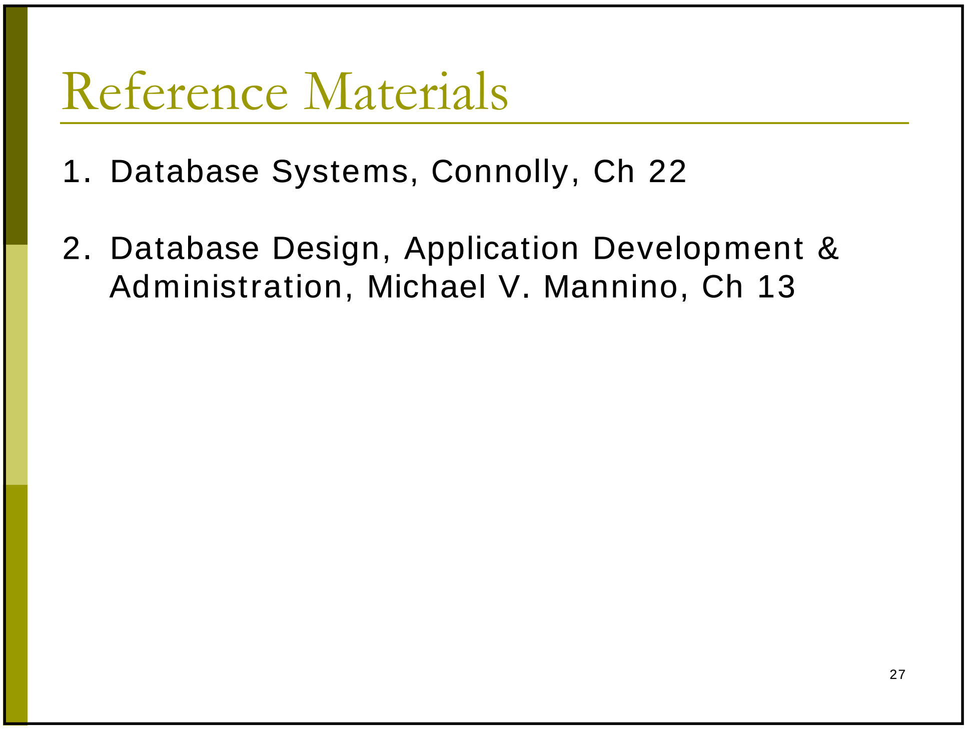


Review questions 3

- List 3 types of database failures

- What are the uses for a log file being implemented in a Database

- What is the relationship of a log file and check point?



Reference Materials

1. Database Systems, Connolly, Ch 22
2. Database Design, Application Development & Administration, Michael V. Mannino, Ch 13