Professional Development Program
Database Concepts

DATABASE ADMINISTRATION

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DATABASE ADMINISTRATION
Outline

- Transaction Processing
- Concurrency Problems
- Resource Locking
- Backup and Recovery

DATABASE ADMINISTRATION
Why?

- Programming with other applications
- Enforcement of referential integrity
- Many people using a system 24/7/365

- Information is important!
- CIA (Confidentiality Integrity Availability)


YOU HAVEN'T HEARD WHAT THE PROBLEM IS YET; HOW CAN YOU RECOMMEND BUILDING A DATABASE TO SOLVE IT??
S Adams
WE ALWAYS BUILD A DATABASE.
AND WE'LL NEED COFFEE MUGS FOR THE PROJECT TEAM.
© 1996 United Feature Syndicate, Inc. (NYC)
THE PROBLEM IS THAT WE HAVE POOR PROCESSES.
THAT COULD BE THE SLOGAN ON OUR MUGS!

DATABASE ADMINISTRATION
Transaction Processing - Intro

- What is a *transaction*?
  - Unit of interaction with a database system
  - Single logical operation on data (SQL)
  - Logical unit of work (LUW)

- Transaction Steps
  - Begin the transaction
  - Associated SQL queries execute
  - Commit the transaction

DATABASE ADMINISTRATION
Transaction Processing – ACID

- Atomicity
  - guarantees all parts of a transaction are complete
- Consistency
  - ensures that integrity constraints (rules) are maintained
- Isolation
  - transactions may not be seen in an intermediate state (by other operations)
- Durability
  - Once transaction has been verified by user (cannot be undone)

DATABASE ADMINISTRATION
Concurrency Problem 1

- Lost (Concurrent) Update
  - Row updates based on original value read

Checking (C) Balance Before $100		ATM $100 Deposit Transaction	ATM $20 Withdrawal Transaction
	T1	Read C = 100	Read C = 100
	T2		Write C 100–20 = 80
	T3		Commit
Checking (C) Balance After $200	T4	Write C 100+100 = 200	
	T5	Commit	

DATABASE ADMINISTRATION
Concurrency Problem 2

- Uncommitted Dependency (Dirty Read)
  - Transaction uses value based on another non-committed transaction

Checking (C) Balance Before $200

Checking (C) Balance After $280

	ATM $100 Deposit Transaction	ATM $20 Withdrawal Transaction
T1		Read = 200
T2		~~Write 200 – 20 = 180~~
T3	Read C = 180	~~Commit~~
T4	Write 180 + 100 = 280	
T5	Commit	

DATABASE ADMINISTRATION
Concurrency Problem 3

- Inconsistent Analysis (Non-Repeatable Read)
  - Data read by a transaction is different during multiple times based on another transaction

BEFORE
Checking (C)
$10
Savings (S)
$500

AFTER
Checking (C)
$110
Savings (S)
$400

	View S/C Account Balance Transaction	Transfer $100 from S to C Transaction
T1	Read C = 10	Read S = 500
T2		Write 500-100 = 400
T3		Read C = 10
T4		Write 10+100 = 110
T5		Commit
T6	Read S = 400	
T7	Commit	

DATABASE ADMINISTRATION
Concurrency Problem 4

- Phantom Read (Row)
  - Transaction rereads data and finds rows deleted/inserted by different transaction from a previous read

Deposit History (H) Before	
01/02/07	$100
02/05/07	$20

Deposit History (H) After	
01/02/07	$100
02/05/07	$20
02/31/07	$1000

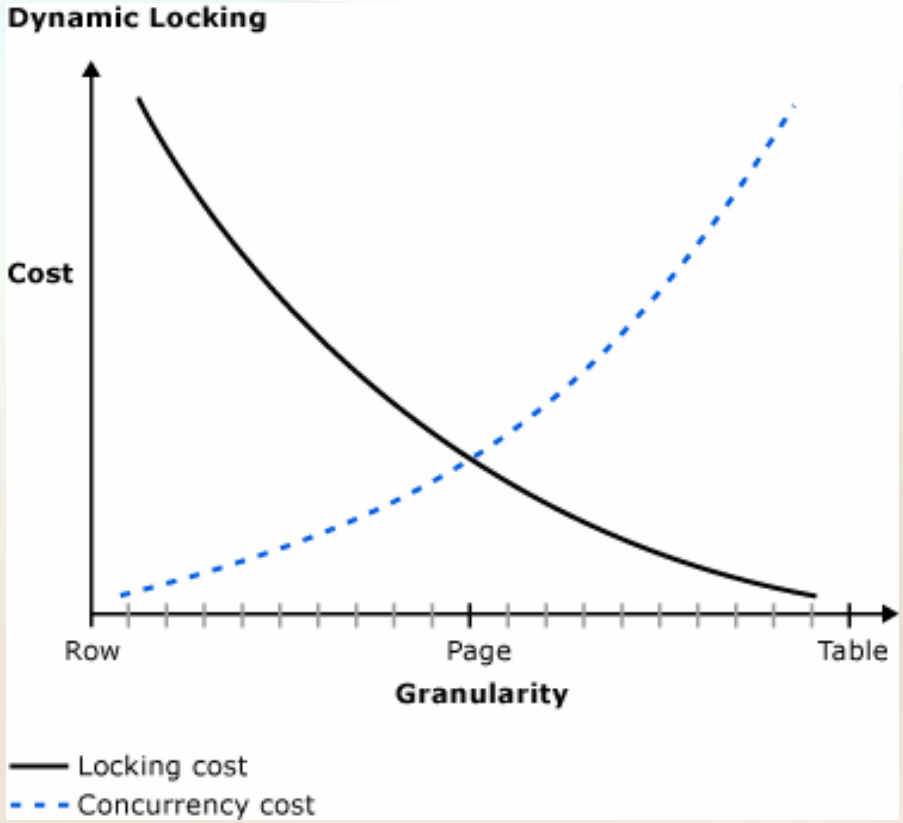
	ATM $1000 Deposit Transaction	Fraud Detection ≥$1000 Transaction
T1	Read C = 200	
T2	Write C 200+100 = 300	Read H(amt) ≥ $1000
T3	Write H 02/31/07 $1000	Write acct#
T4	Commit	Commit
T5		

DATABASE ADMINISTRATION
Resource Locking - Intro

- What is *resource locking*?
  - Prevents different transactions from obtaining copies of the same rows/table when being modified.
- Locks can be implemented by:
  - DBMS (Implicit Lock)
  - Program/Application (Explicit Lock)

DATABASE ADMINISTRATION
Resource Locking - Lock Granularity

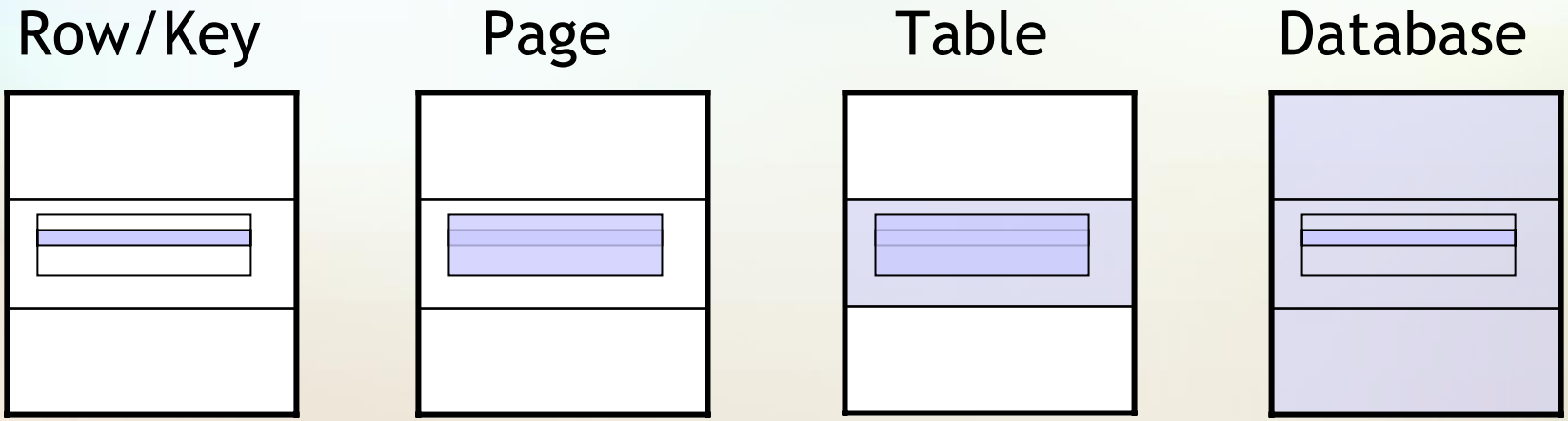
- **Larger**
  - –administration easy
  - –more conflicts
- **Smaller**
  - –administration hard
  - –less conflicts



Source: http://msdn2.microsoft.com/en-us/library/ms189286.aspx

DATABASE ADMINISTRATION
Resource Locking – Lock Granularity

- Granularity Options (most common)



DATABASE ADMINISTRATION
Resource Locking – Lock Types

- Exclusive
  - No other transactions can read/change data
- Shared
  - Data cannot be changed, but can be read
- And others depending on specific DBMS

DATABASE ADMINISTRATION
Transaction Processing – Isolation Levels

1. Read Uncommitted (Least Restrictive)
   - Shared locks are not issued when reading data
   - Physically corrupt data is not read
2. Read Committed
   - Use shared locks when reading data
   - Will not allow reading of uncommitted data
3. Repeatable Read
   - Locks placed on all data used in query (other transactions cannot update data)
4. Serializable (Most Restrictive)
   - Prevents updates or appending of new rows until transaction is complete.

DATABASE ADMINISTRATION
Transaction Processing – Isolation Levels

Problem	Isolation Level: Read Uncommitted	Read Committed	Repeatable Read	Serializable
Dirty Read	✓	✗	✗	✗
Nonrepeatable Read	✓	✓	✗	✗
Phantom Read	✓	✓	✓	✗

Source: Kroenke, D.M., & Auer, D.J. (2008). *Database Concepts.* 3rd ed. Upper Saddle River, NJ: Pearson Education Inc.

DATABASE ADMINISTRATION
Resource Locking – Locking Strategies

- "Overly Optimistic"
  - Assumes conflicts WILL NEVER occur
  - For single-user systems, read-only tables, or where records are guaranteed to only be accessed by one person at a time.
- Optimistic
  - Assumes conflict WILL GENERALLY NOT occur
  - Lock obtained after transaction processed
  - Better when lock granularity is large
- Pessimistic
  - Assumes conflict WILL GENERALLY occur
  - Lock obtained before transaction processing and released afterward
  - Better when lock granularity is small

DATABASE ADMINISTRATION
Resource Locking – Locking Strategies

Type of Data	Examples	Suggested Strategy
Live High-Volume	•Financial Accounts	1. Optimistic 2. Pessimistic
Live Low-Volume	•Personal Information •Insurance Policies	1. Pessimistic 2. Optimistic
Log (Append only)	•Access Logs •Account Histories •Transaction Records	Overly Optimistic
Lookup/Reference (Read Only)	•State •Payment Type	Overly Optimistic

Source: Ambler, S. (2003). Agile Database Techniques: Effective Strategies for the Agile Software Developer. Indianapolis, IN: Wiley Publishing, Inc.

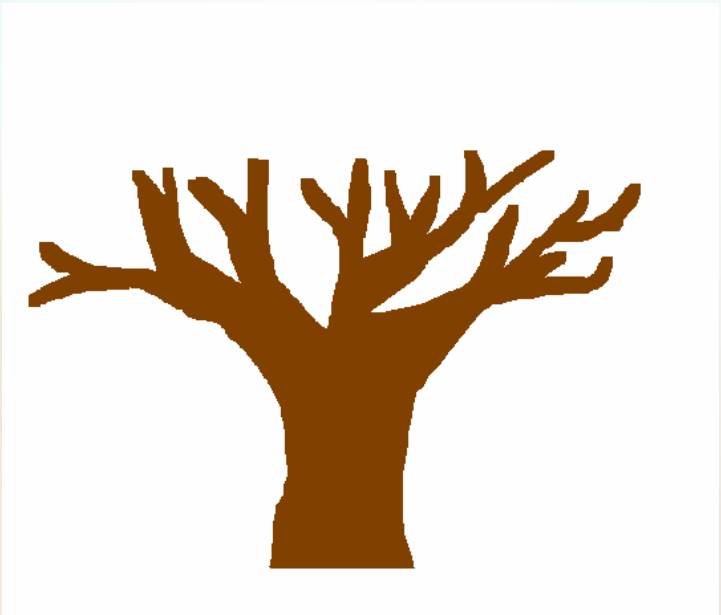
DATABASE ADMINISTRATION
Concurrency Problem 5

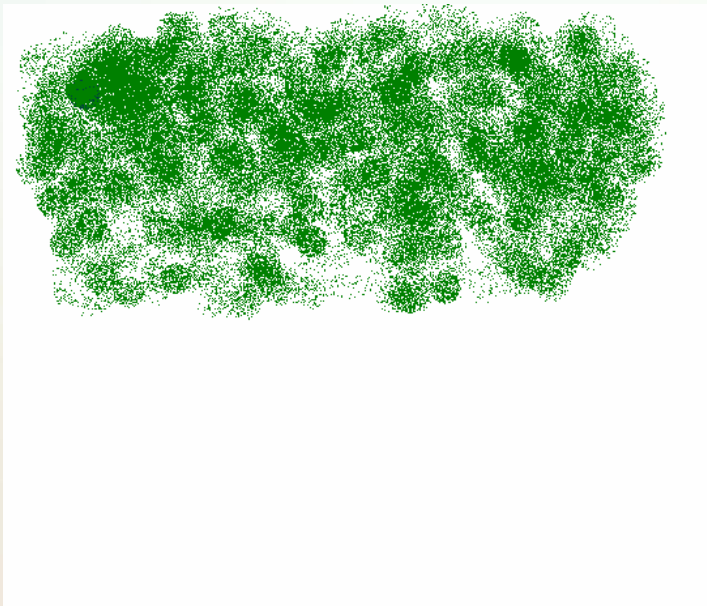
- Deadlock “Deadly Embrace” Problem
- Four “Coffman” Conditions

1. Mutual Exclusion
   - Resource assigned to one process or available
2. Hold-and-Wait
   - Processes already holding resources may request new resources
3. No Preemption
   - Only process holding resource can release it
4. Circular Wait
   - Two or more processes in a chain wait for resources that next process in chain has a lock

DATABASE ADMINISTRATION
Concurrency Problem 5 – Deadlock

- Crayon Example





DATABASE ADMINISTRATION
Concurrency Problem 5 – Deadlock

- Prevention
  - Only issue one lock request at a time (all resources needed should be locked prior)
  - Issue locks in same order
  - Avoid user interaction in transactions
  - User lower isolation levels
- Detection
  - DBMS Monitoring Tools

DATABASE ADMINISTRATION
Concurrency Problem 5 – Deadlock

- To deal with deadlock situation, need to stop at least one transaction.
- "Victim Selection"
  - Priority
  - Amount of locks held
  - Run time length
  - Time of transaction start

DATABASE ADMINISTRATION
Concurrency Problem 5 – Deadlock

- In instances of a distributed database, need *two-phase locking*.
- Phase 1
  - Each database will vote to commit or abort the transaction.
- Phase 2
  - Unanimous commit vote → Commit Transaction
  - Else → Rollback Transaction

DATABASE ADMINISTRATION

Backup and Recovery – Types of Failures

- System crashes
- Application errors
- Corruption of database
- Database (full/part) deletion
- Hardware failure
- Natural disasters, etc.

DATABASE ADMINISTRATION
Backup and Recovery - Transactions

- Reprocessing
  - Goes back to a known point and reprocesses workload after that point
  - Cons: Takes time and infeasible for high-volume systems & asynchronous
- Rollforward
  - Database restored using saved data
  - Valid transactions since save reapplied
- Rollback
  - Partially processed or bad transactions are undone

DATABASE ADMINISTRATION
Backup and Recovery – Log File

- Log File
  - Rollforward/Rollback use this function
- Contains:
  - Before-images
  - After-images
  - Time of actions
  - Operation types: begin, abort, commit, queries, database shutdown
  - Objected being acted upon (record type / identifier)
- When full should be saved on eternal storage media

DATABASE ADMINISTRATION
Backup and Recovery – Backups

- Backups
  - Should be on-site and on-site backups of important information
  - Should be routinely tested
  - May also be needed for audits/forensic investigations
- Generally, databases should be repaired ONLY when infeasible to restore it from a previous backup

DATABASE ADMINISTRATION
Backup and Recovery – Hybrid Strategy

- Restore, Repair and Merge
  - Used when have good backup but not all transaction logs created after backup
- Steps
  - Restore backup
  - Repair damaged copy of database (separately)
  - Merge data from repaired to restored database

DATABASE ADMINISTRATION
Summary

- Transaction Processing
- Concurrency Problems
- Resource Locking
- Backup and Recovery

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