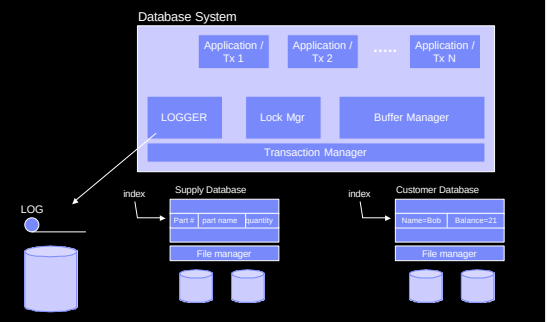
IBM Systems Group

Transaction Manager Concepts

Dr. Nick Bowen,
VP UNIX and xSeries SW Development
October 17, 2003

Agenda

- Database Concepts
- Transaction Manager Overview
- Logging, REDO and UNDO
- Two Phase Commit
- Distributed Transaction Processing



ACID

Atomicity	"All or nothing" undo aborted redo committed coordinate with distributed "A correct transformation of the source"
Consistency	Aborting any transactions that fail to pass R.M. consistency tests "Once done, it is done"
Durability	Forcing all log records of committed transactions to durable memory Redoing any recently committed work at restart
Isolation	Individual transactions do not bump into one another

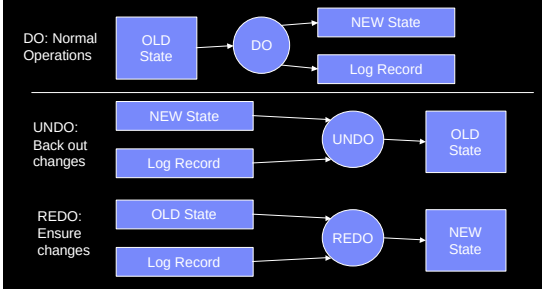
DB101

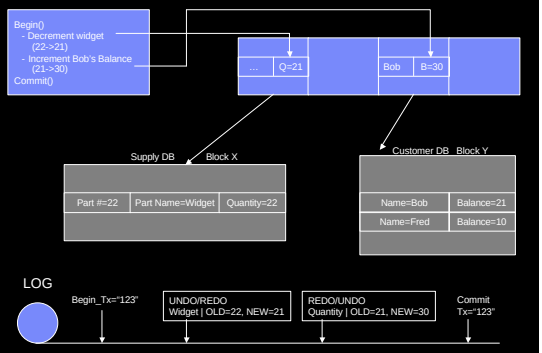
- Application: DBM – eCommerce
  - Supply DB (inventory) – decrement
  - Billing - create bill
  - Shipping - create order for factory for ship
- Failure reasons (3)
  - Normally just overhead – it all works
  - Programming style error, e.g. abort changes
  - System crashes, credit card authorized failure, DB crashes

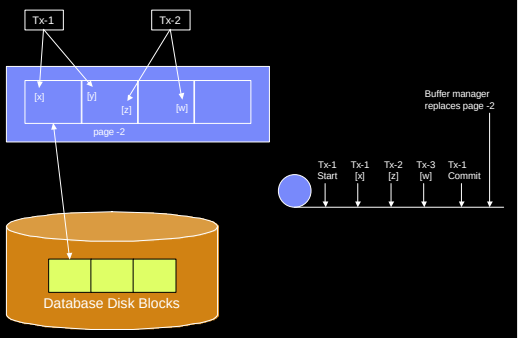
DO-UNDO-REDO Protocol

- Programming style for resource managers
- Structure each operation ("DO") so it can be undone or redone
- Any operation should perform
  - The actual operation ("DO")
  - A log record
  - An "UNDO" program
  - A "REDO" program

DO-UNDO-REDO Protocol

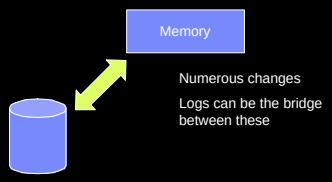






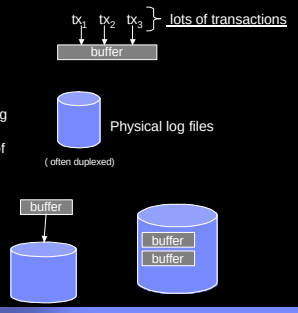
Log is a critical component

- Very asynchronous – lots of I/O must occur concurrently
- Allows regular I/O to be asynchronous or deferred
- Buffer manager

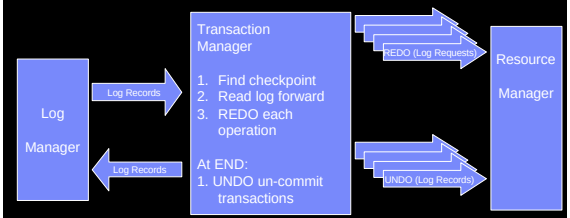


Logs (continued)

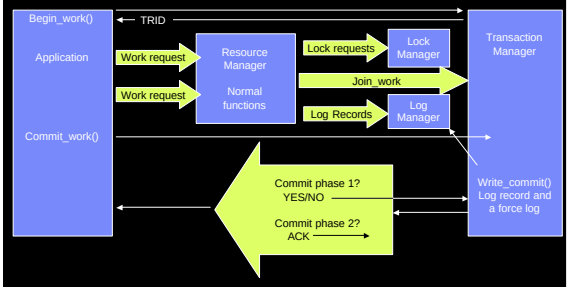
- Log force at every Tx would be a serial bottleneck
- If lots of Tx's are concurrently committing (approximately) a log force can handle lots of Tx's
- WADS concept



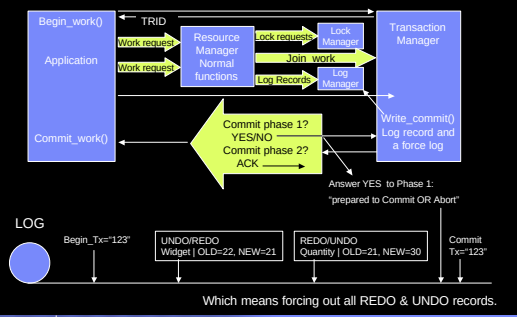
Data Flow in a System Restart



Normal (no failure) execution of an application interacting with a resource manager



The Heart of the Issue: Force Log of Prepare & Commit



Which means forcing out all REDO & UNDO records.

Two Phase Commit

- We have shown two phase for one system, one RM
- Can be extended:
  - Multiple RM's on a single system
  - Multiple RM's on distributed systems

Two phase commit: Making computations atomic

- Tx Manager asks RM's to commit
  - Can be multiple ones
  - Can be on different systems
- Each Vote YES or NO
  - Vote YES means "Prepared to commit or Abort"
- Tx Manager proceeds to commit if all YES
  - Forces "End Phase 1" log record
  - This is the "atomic instance"

For example…

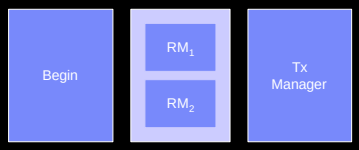
- Application wants to commit Tx TRID=555
  1. Application must begin a Tx
  2. RM's must tell Tx Manager they want to join a transaction.
  3. Major Stages:

Phase 1	Prepare	Ask each RM to vote: YES/NO
	Decide	Tx mgr logs a commit record (if all yes) to durable storage. This is a precise commit point, when the bits hit the disk.
Phase 2	Commit	Tx tells RM's about decision
	Complete	Once all RM's "ACK" commit, write a completion record

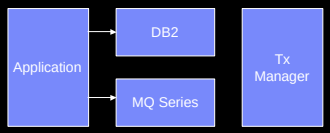
Restart Processing

- Transaction manager – finds all
  - Begin_work with no commit record => Transactions to abort
  - Begin_work with commit => RM's must be told with no complete about Tx's
  - Begin_work + commit + complete => Ignore
- RM Restart
  - Must find work either process an abort (UNDO) or ensure everything is done (REDO)

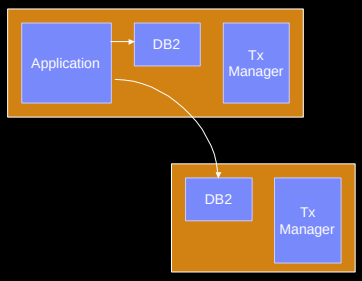
Why is this complicated?



…between two products

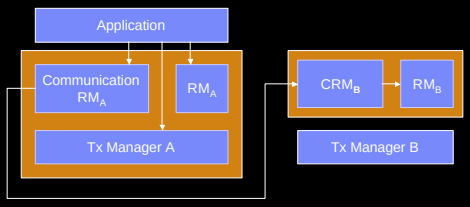


…between distributed systems

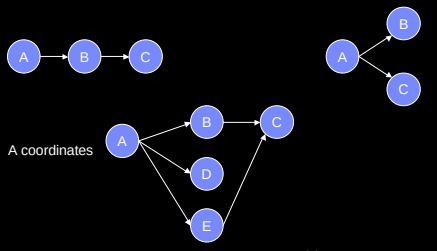


Distributed Transactions

- Root Tx's manager – where application performs original begin_work



Can get complicated…



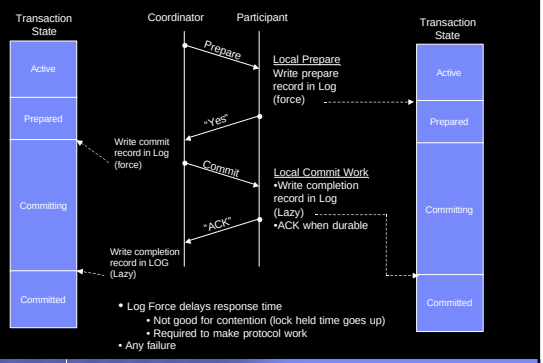
B, D, E participate with A

B coordinates for C

Distributed Two Phase

O_1	Local prepare – call local RM's Distributed prepare – send prepares on each outgoing session
Commit!!!	Decide – all local RM's vote YES & outgoing sessions vote YES
O_2	Commit – tell RM's & outgoing session Complete - same

- Prepare now has a time-out
- Commit record has names of distributed RM's who need to know about phase 2 commit
- "In doubt" of CRM – voted YES, but does not know. Must poll upstream Tx Mgr
- Presumed abort protocol (optimization: coordinator is queried on Tx that is not active, prepared, or committed, then assume aborted)
  - presumption that no record found == abort
  - participant sends ACK only when the completion state is durable
  - coordinator only sends records the completion log when all commit messages have been acknowledged



Putting it All Together

- Basic transaction & database concepts
- Normal commit processing
- Importance of the LOG
- Two Phase Commit
- Extending for Distributed Processing
- Further Reading "Transaction Processing: Concepts and Techniques," Jim Gray and Andreas Reuter.
  - Chapter 10 "Transaction Manager Concepts" pages 529-582
  - Note - - 1000 other pages!!!!