Transaction Processing in a Service Oriented Architecture

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Overview

- **Fault tolerance**
- **Transaction fundamentals**
  - What is a transaction?
  - ACID properties
- **Distributed transactions**
- **The SOA effect on transactions**

Fault tolerance

- **Machines and software fail**
  - Fundamental universal law (entropy increases)
  - Things get better with each generation, but still statistically significant
- **Failures of centralized systems difficult to handle**
- **Failures of distributed systems are much more difficult**

Fault tolerance techniques

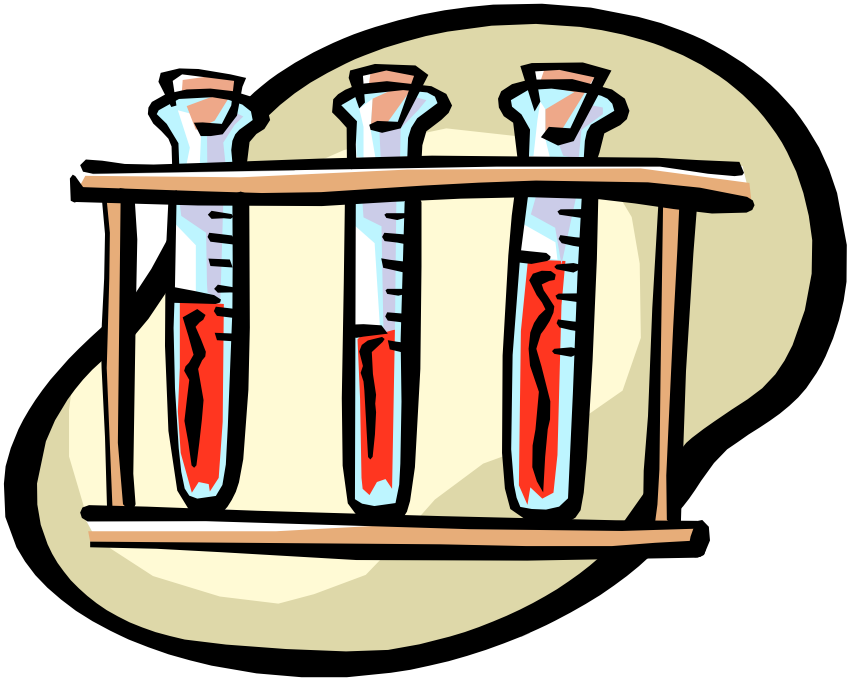
- **Replication of resources**
  - Increase availability
    - Probability is that a critical number of resources remain operational
    - “Guarantee” forward progress
  - Tolerate programmer errors by heterogeneous implementations
- **Spheres of control**
  - “Guarantee” no partial completion of work in the presence of failures
- **Often a duality**
  - *“Understanding the Role of Atomic Transactions and Group Communications in Implementing Persistent Replicated”,* Proceedings of the 8th International Workshop on Persistent Object Systems, California, USA,1998

What is a transaction?

- **Mechanistic aid to achieving correctness**
- **Provides an "all-or-nothing" property to work that is conducted within its scope**
  - Even in the presence of failures
- **Ensures that shared resources are protected from multiple users**
- **"Guarantees" the notion of shared global consensus**
  - Different parties in different locales have the same view of the transaction outcome

ACID Properties

- Atomicity
- Consistency
- Isolation
- Durability



Atomicity

- **within the scope of a transaction**
  - all changes occur together or no changes occur
- **atomicity is the responsibility of the transaction manager**
- **for example - a money transfer**
  - debit removes funds
  - credit add funds
  - no funds are lost!

Two-phase commit

- **Required when there are more than one resource managers (RM) in a transaction**
- **Managed by the transaction manager (TM)**
- **Uses a familiar, standard technique:**
  - marriage ceremony - Do you? I do. I now pronounce ..
  - It is only a consensus protocol
- **Two - phase process**
  - voting phase - can you do it?
    - Attempt to reach a common decision
  - action phase - if all vote yes, then do it.
    - Implement the decision

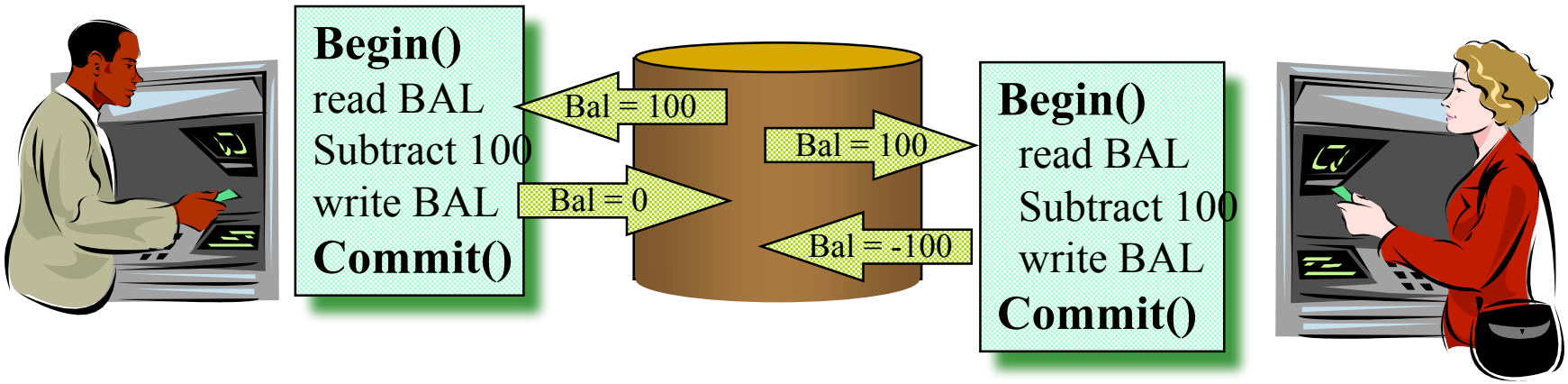
Consistency

- Transactions scope a set of operations
- Consistency can be violated within a transaction
  - Allowing a debit for an empty account
  - Debit without a credit during a Money Transfer
  - Delete old file before creating new file in a copy
- transaction must be correct according to application rules
- Begin and commit are points of consistency

- Consistency preservation is a property of a transaction, not of the TP system (unlike the A, I, and D of ACID)

Isolation

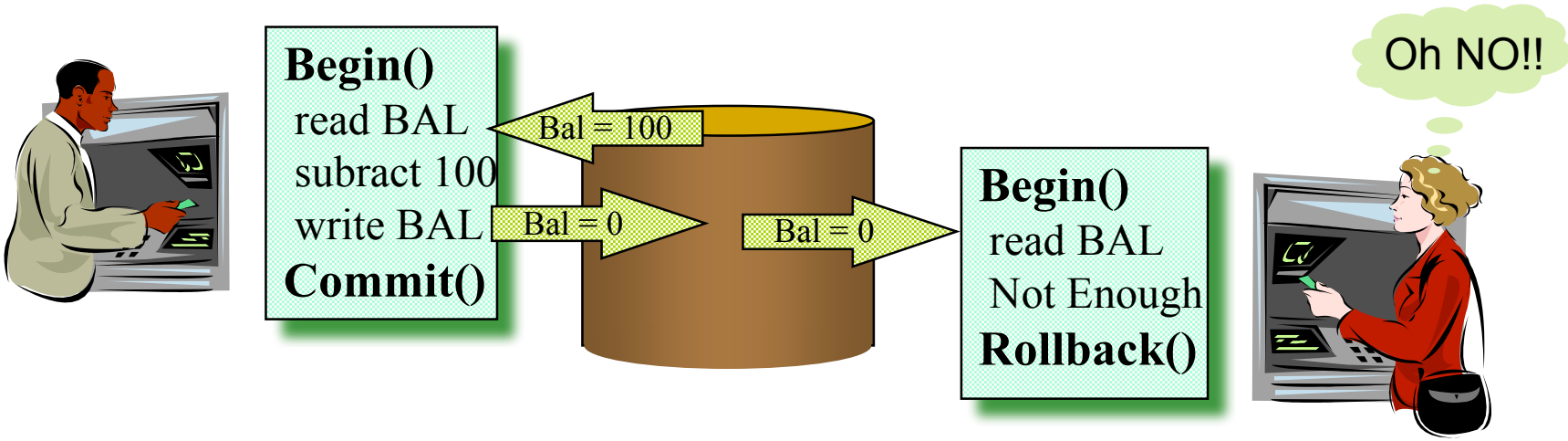
- **Running programs concurrently on same data can create concurrency anomalies**
  - the shared checking account example



Isolation

- **Transaction must operate as a black box to other transactions**
- **Multiple programs sharing data requires concurrency control**
- **When using transactions**
  - programs can be executed concurrently
  - BUT programs appear to execute serially

Isolation


Begin()
read BAL
subract 100
write BAL
Commit()
Bal = 100
Bal = 0
Bal = 0
Begin()
read BAL
Not Enough
Rollback()
Oh NO!!

Durability

- **When a transaction commits, its results must survive failures**
  - must be durably recorded prior to commit
  - system waits for disk ack before acking to user
- **If a transaction rolls back, changes must be undone**
  - before images recorded
  - undo processing after failure

Transactions for SOA

- **Business-to-business interactions may be complex**
  - involving many parties
  - spanning many different organisations
  - potentially lasting for hours or days
- **Cannot afford to lock resources on behalf of an individual indefinitely**
- **May need to undo only a subset of work**
- **So the search has been on, because …**

ACID-ic SOA?

- **ACID transactions implicitly assume**
  - Closely coupled environment
    - All entities involved in a transaction span a LAN, for example.
  - Short-duration activities
    - Must be able to cope with resources being locked for periods
- **Therefore, do not work well in**
  - Loosely coupled environments!
  - Long duration activities!

However …

- Web Services are as much about interoperability as they are about the Web
- In the short term Web Services transactions will be about interoperability between existing TP systems rather than running transactions over the Web

OASIS WS-TX Goals

- **4th attempt at standardising**
- **Support range of use cases**
- **“One-size does not fit all”**
  - “*Make each program do one thing well; to do a new job, build afresh rather than complicate old programs by adding new features”*, Doug McIlroy, inventory Unix pipes
  - Therefore a single protocol cannot cope with all requirements
- **Interoperability with existing transaction infrastructures**

ACID transaction model

- **Assume ACID transactions**
  - High degree of trust
  - Isolation for duration of transaction
  - Backward compensation techniques
  - Does not allow heuristic outcomes
- **Integration with existing transaction systems**
  - Important to leverage investments
- **Interoperability between transaction systems**

What characteristics are right?

- **Need to be able to relax the strict ACID properties**
- **Need to put control of some into hands of service developer**
  - Is consistency (or consensus) important?
- **May need a notion of a central coordinator**
  - But may not!
  - Or something with a fuzzy idea of what's going on
- ***"A comparison of Web services transaction protocols"*, IBM Developer Works, 2003.**

Relaxing isolation

- **Internal isolation or resources should be a decision for the service provider**
  - E.g., commit early and define compensation activities
  - However, it does impact applications
    - Some users may want to know a priori what isolation policies are used
- **Undo can be whatever is required**
  - Before and after image
  - Entirely new business processes

Relaxing atomicity

- **Sometimes it may be desirable to cancel some work without affecting the remainder**
  - E.g., prefer to get airline seat now even without travel insurance
- **Similar to nested transactions**
  - Work performed within scope of a nested transaction is provisional
  - Failure does not affect enclosing transaction
- **However, nested transactions may be too restrictive**

Structuring transactions

- **Could structure transactional applications from short-duration transactions**
  - Release locks early
  - Resulting application may still be required to appear to have “ACID” properties
    - May require application specific means to restore consistency
- **A transactional workflow system could be used to script the composition of these transactions**

Relaxation of consistency

- **ACID transactions (with two-phase commit) are all about strong global consistency**
  - All participants remain in lock-step
  - Same view of transaction outcome (atomic)
- **But that does not scale**
  - Replication researchers have known about this for years
    - Weak consistency replication protocols developed for large scale (number of replicas and physical deployment)
    - Merging of caching and replication protocols
      - Local domains of consistency
    - Cannot “stop the world” and enforce global consistency
  - Some transaction research into this, but industry pushing global consistency
    - Starting to see a change

Heisenberg's Uncertainty Principle

- **Cannot accurately measure both position and momentum of sub-atomic particles**
  - Can know one with certainty, but not the other
  - Non-deterministic measurements
- **Large-scale/loosely-coupled transactional applications suffer the same effect**
  - Can know that all services will eventually see same state, just not when
  - Or at known time can determine state within model/application specific degree of uncertainty
- **Or another way of thinking about it …**
  - No such thing as simultaneity in data space as there isn't in space-time
    - *"Data on the Outside vs. Data on the Inside", by Pat Helland*

No global consensus

- **Split transactions into domains of consistency**
  - Strong consistency within domains
  - Some level of (known) consistency between domains
    - See *"A method for combining replication and caching", Proceedings of International Workshop on Reliable Middleware Systems, October 1999*.
    - *OASIS WS-BusinessProcess specification*, part of OASIS WS-CAF, 2003.
  - Resolve inconsistencies at the business level
    - Don't try and run consensus protocols between domains
- **Consistency related to isolation**
  - Put into the control of the service and application developers

OASIS Business Process

- **All parties reside within *business domains***
  - Recursive structure is allowed
  - May represent a different transaction model
  - No required notion of consistency between domains
- **Business process is split into *business tasks***
  - Execute within domains
  - Compensatable units of work
    - Forward compensation during activity is allowed
      - Keep business process making forward progress
- **Consistency is application (service) dependent**
- **Atomicity (or lack thereof) in the “large” is taken for granted**

SOA or scale?

- **Problems with transactions pre-date SOA**
- **Current issues with database technologies are not SOA specific either**
- **Problems are two-fold**
  - Scalability (size and geographic distributed nature)
  - Control over the infrastructure/services
    - Trust comes into this too
- **Much research in the 1990's**
- **SOA (and Web Services) bring this to the foreground**
  - REST would be just as appropriate

Future directions

- **One size does not fit all!**
- **Business domains will impose different requirements on implementers**
  - Essentially construct domain-specific models
  - Real-time
- **The range and requirements for such extended models are not yet known**
  - Do not restrict implementations because we don't know what we want yet
- **Still a very active area of research and development**