WICE - A Pragmatic Protocol for Database Replication in Interconnected Clusters

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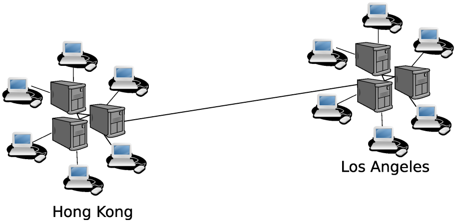
Setting

- Database replication among clusters
- WAN-setting
- Goals:
  - Maximize fault tolerance
  - Reduce query latency
- Full replication: Each server holds a complete copy of the database



Our focus: Concurrency control

- Servers receive *transaction requests*. Example:

  T = r(x) r(y) w(y)

- Each server can receive any type of request
- Transactions may execute concurrently, but we require a total, logical order: Execution should be reproducible in a non-replicated database

Replication strategies

- Primary backup: One node executes all update transactions
- Deterministic execution: Execute all transactions at all sites in the same order
- Distributed coordination: Execute at any site, only updates are distributed. Requires coordination before commit.
- Our interest is in protocols using distributed coordination

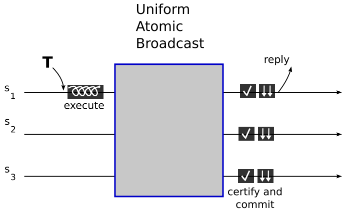
Coordination through atomic broadcast

- Basic principle:
  - First, all operations are executed at receiving server
  - Then, updates are distributed to all servers by an *atomic broadcast*, provided by a group-communication service
- Atomic broadcast provides total order
- This order is basis for validation:

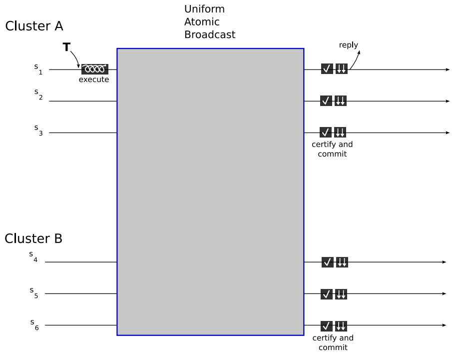
  A transaction can commit if and only if all read-operations read the most recently written value according to the total order.

DBSM

- Message contains updates, read-set and version of reads
- Deterministic certification: If one site successfully certifies transaction, all sites will
- Atomic broadcast must be *uniform* to provide failover
- The delay between an update is initated until it is applied at remote site determine the abort rate



DBSM with interconnected clusters



- Generic group-communication software in WAN is troublesome
- Using a black-box primitive for uniform atomic broadcast may block application-specific optimizations

Example: Cost of uniformity

- T1: x := x + 4, T2: x := x - 4
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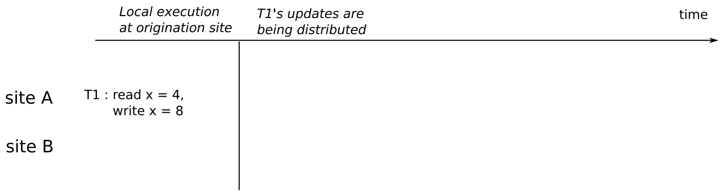

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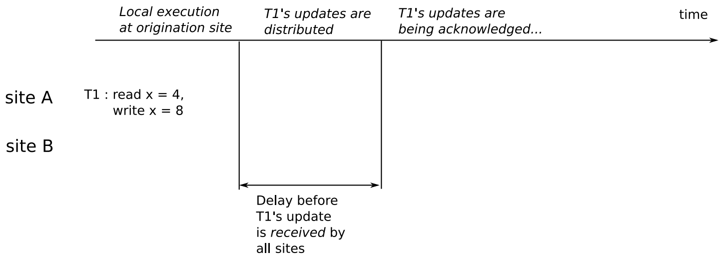

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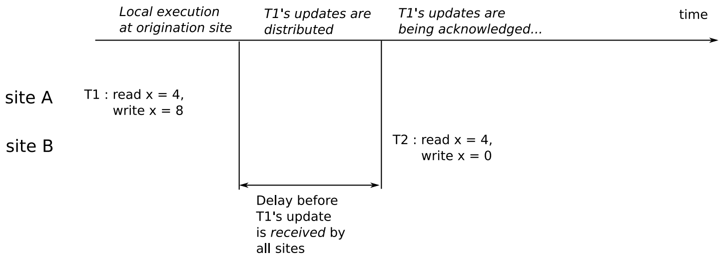

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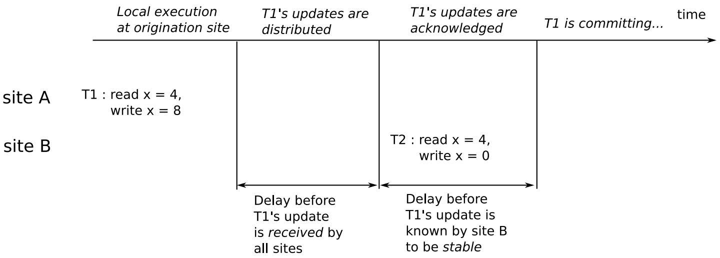

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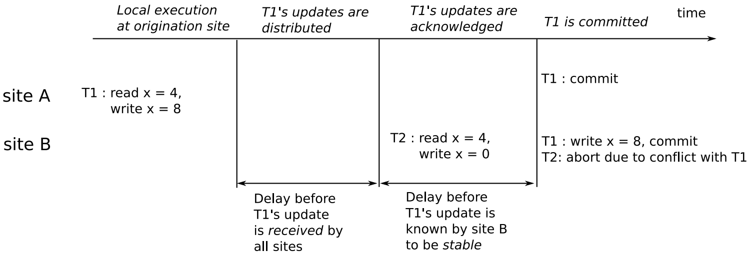

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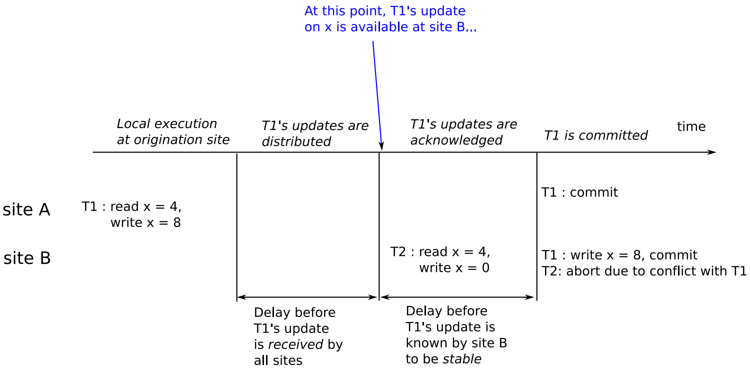

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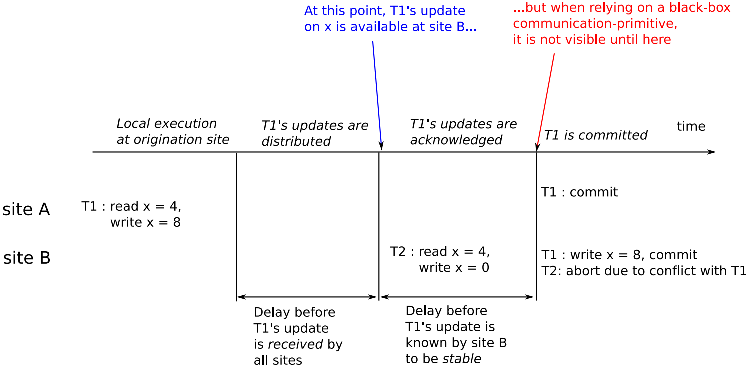


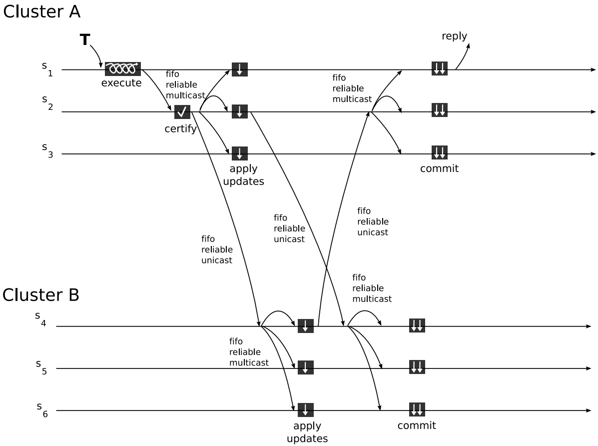
Our proposal: WICE

We want to reduce abort rate and simplify deployment by:

- Opening the communication-primitive: Group communication only within clusters – all inter-cluster messaging sent by unicast
- Exploiting tight integration with database system: Remote updates should be available before uniformity
- Perform certification at one central site: Allows explicit certifier placement

Disadvantage: Failure-handling part of the protocol

WICE: Communication pattern



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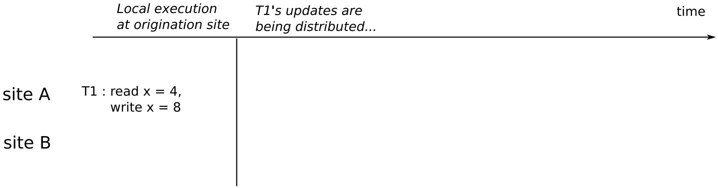

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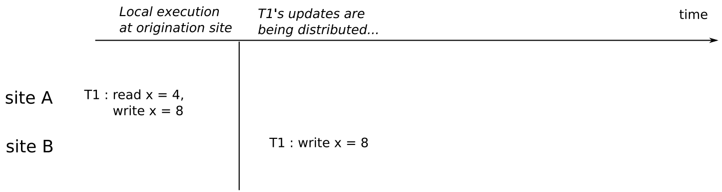

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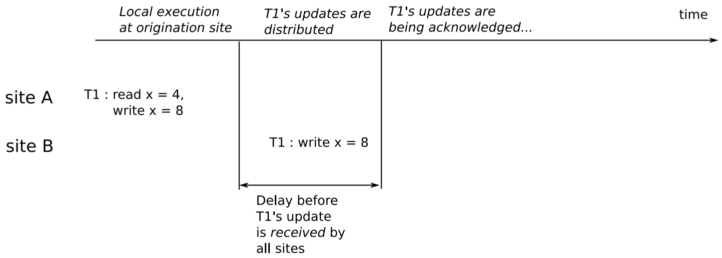

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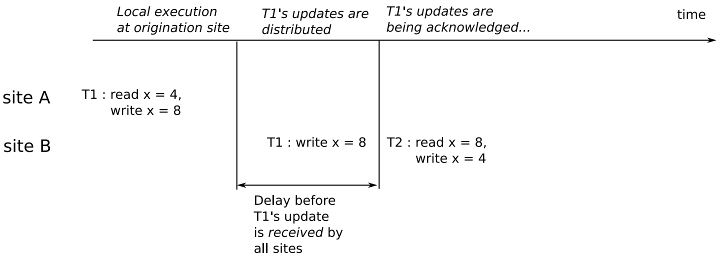

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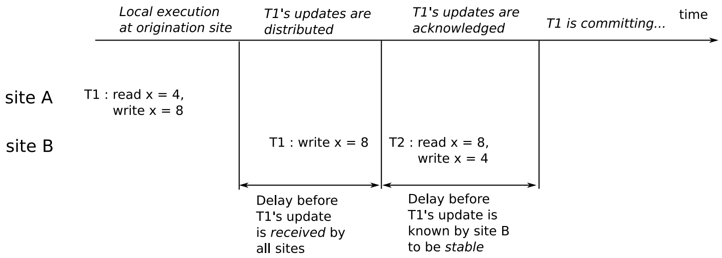

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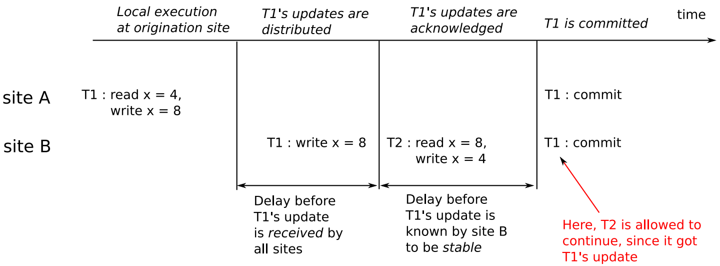
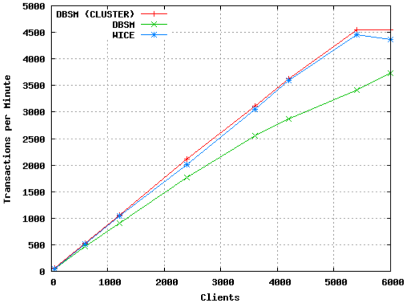


Experiments

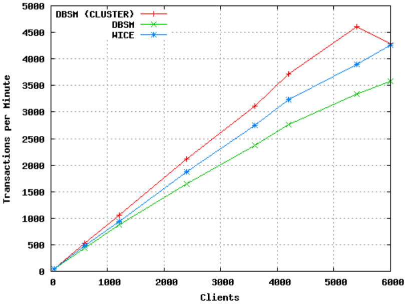
- WICE was simulated along with DBSM.
- Two clusters, each with 3 servers:
  - negligible intra-cluster latency
  - 200 ms inter-cluster latency
  - Unrestricted bandwidth
- 92% of transactions update some objects
- From 60 to 6000 simultaneous clients

Throughput

Cluster A



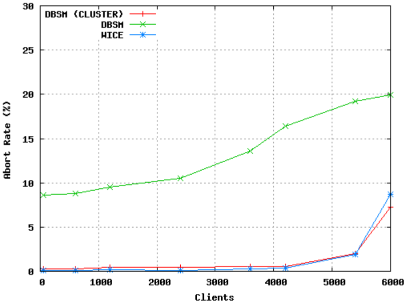
Cluster B



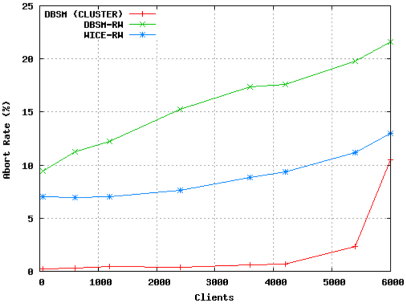
Number of transactions committed per minute

Abort rate

Cluster A

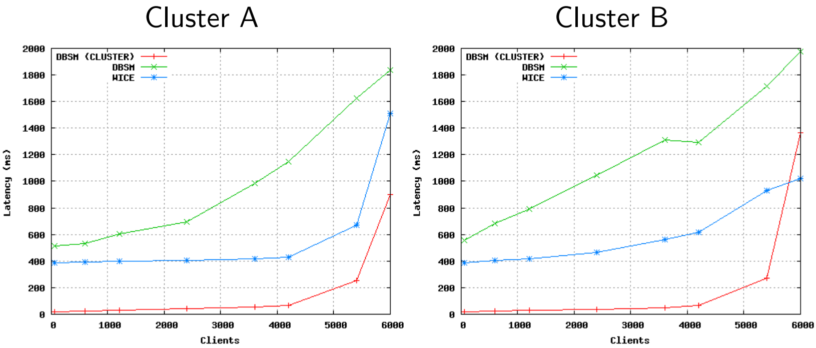


Cluster B



Fraction of submitted transactions that eventually aborts

Latency



Elapsed time from submit until reply is received

Conclusion

- We have shown one strategy to extend the ideas of group-communication based replication protocols to a WAN-environment
- Our most important point is that updates must be exposed before the transaction is stable
- Further work:
  - Implementation in real system
  - Weaker assumptions on replication degree and stability requirements

Thank you!

Questions?

- The GORDA-project: `http://gorda.di.uminho.pt`
- My email: `jongr@ifi.uio.no`