Distributed Transaction Processing in the Escada Protocol

Alfrânio T. Correia Júnior

alfranio@lsd.di.uminho.pt.

Grupo de Sistemas Distribuídos

Departamento de Informática

Universidade do Minho

Scenario

- Dependable Databases are core components of our Information Society.
- Software based replication is an attractive solution to assure dependability.
- Problems arise when attempting to preserve the following:
  - Strong consistency (1SR).
  - Updates are carried through any replica.

Scenario (Problems)

- Traditional database replication protocols do not scale up well due to:
  - The high number of messages exchanged among the replicas.
  - The deadlock rate proportional to n^3, where n is the number of replicas, which is impractical.

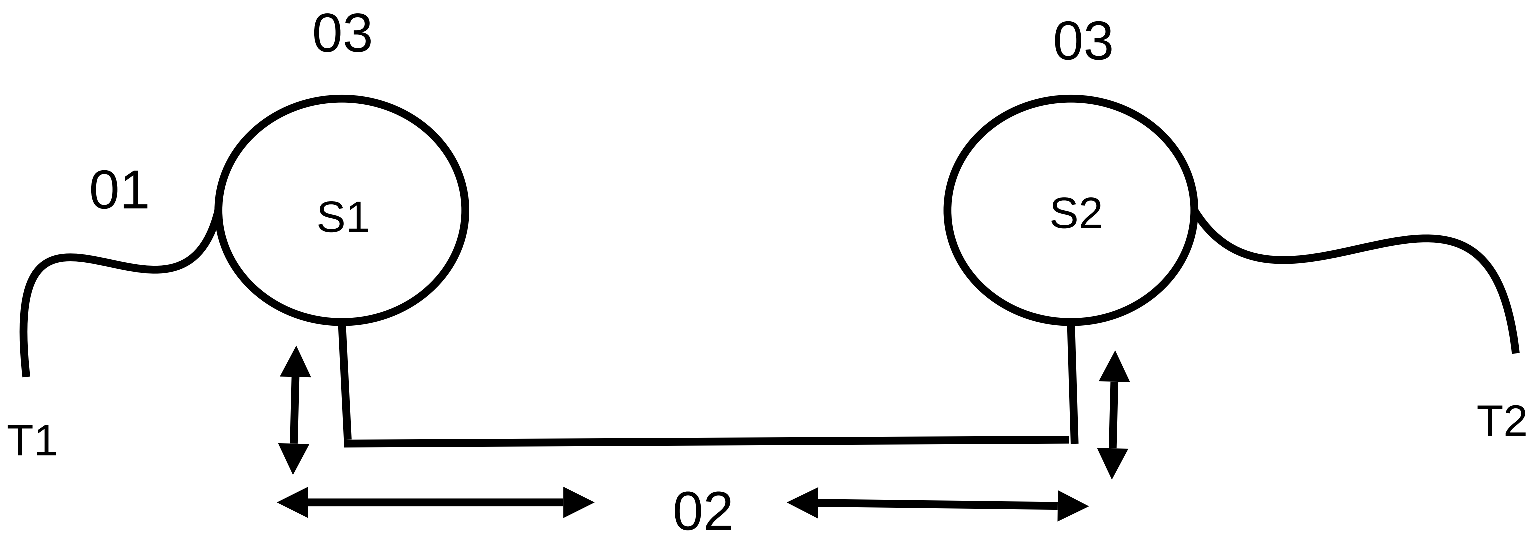
Scenario (Earlier Solutions)

- Lazy Replication relaxes the consistency criteria.
- Master/Slave chooses the replica that can receive the updates.

Escada Approach

- Pattern on the DBSM
- Replication based on group communication
- Update-everywhere and deferred updates
- Atomic broadcast to propagate the transaction's processing data
- Total order is combined with a conflict detection process to assure 1SR.

Protocol Overview



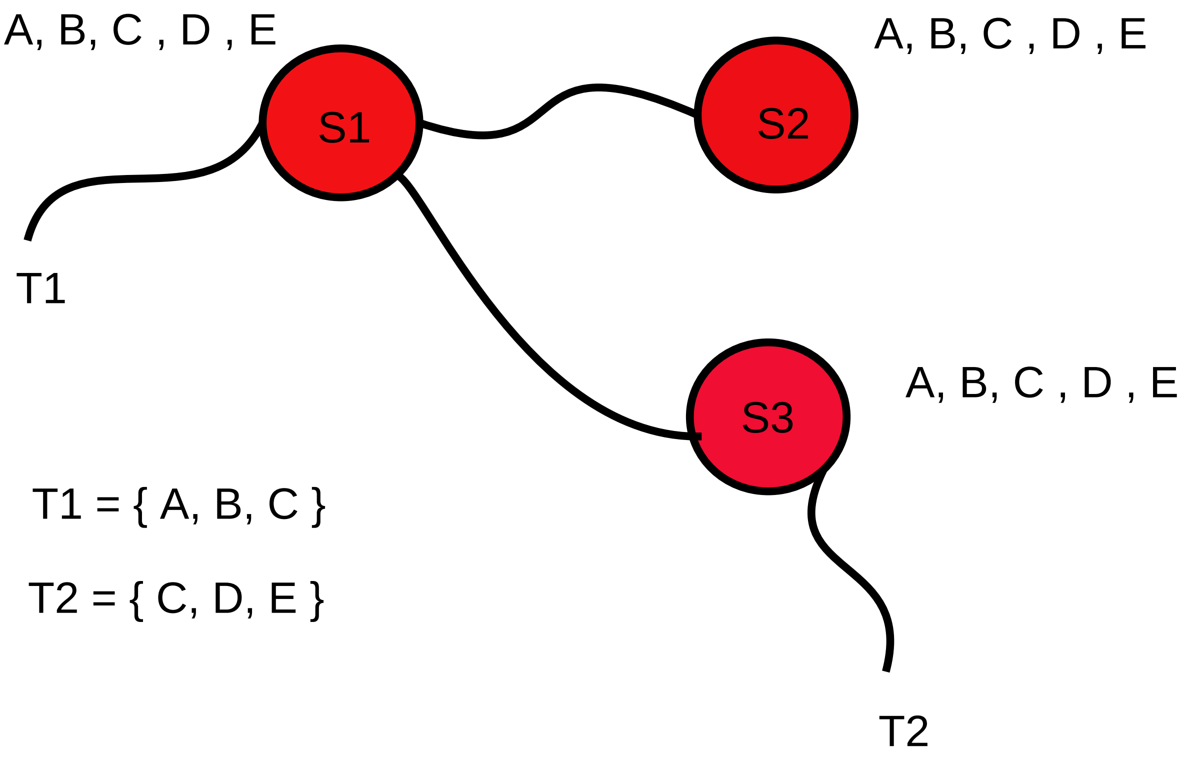
01 - Local Execution

02 - Atomic Multicast (RS, WS, WV)

03 - Certification

Termination Protocol

Protocol Overview



T1 = { A, B, C }

T2 = { C, D, E }

Escada Approach

- Target:
  - Large scale distributed systems.
  - Provides partial replication (Partial DBSM)
  - Reduces resource consumption exploiting application’s locality.

Motivation

How the Escada can be augmented to provide partial replication ?

Main Contributions

- Distributed Transaction Processing
- Semantic Caching
- Extensions to the PostgreSQL
- Evaluation Process (TPC-C and TPC-W)

Contribution

Distributed Transaction Processing

Partial DBSM

- Execution:
  - A site that handles a transaction may not be able to locally complete its execution.
  - It is possible that no single site can do it.
- Termination Protocol:
  - The distributed execution fragments the knowledge about conflicts.
  - How to decide if a transaction can commit or not ?

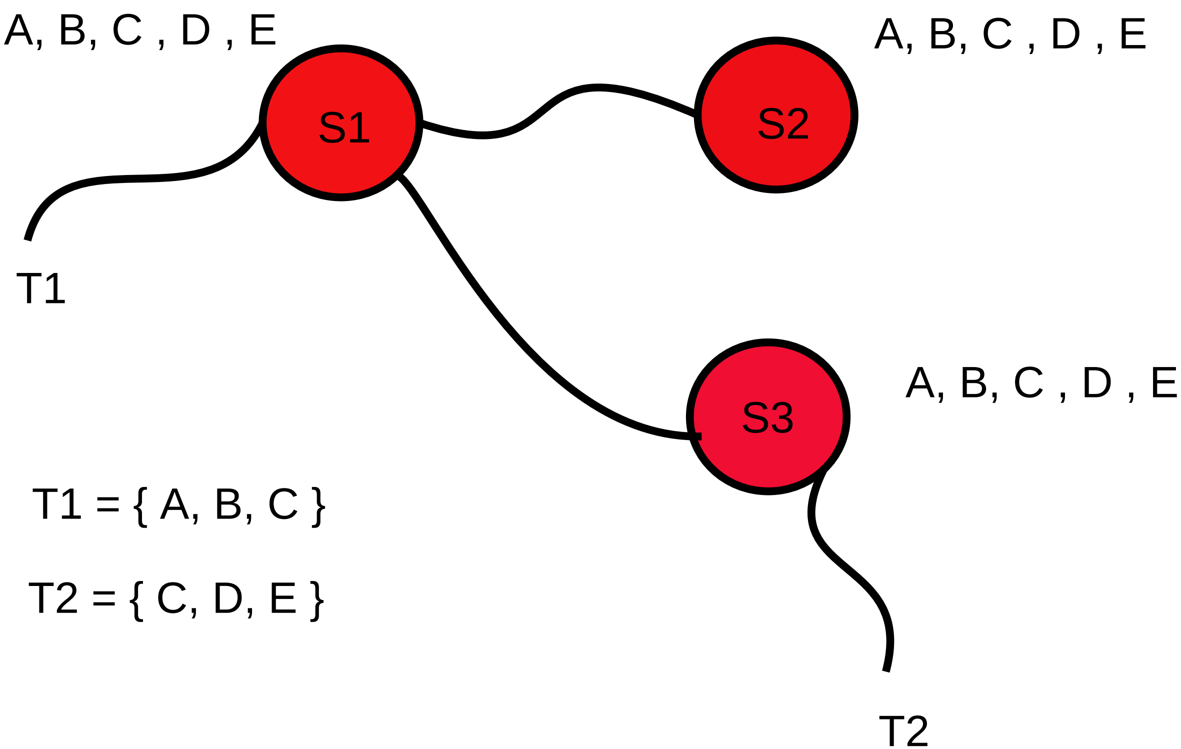
Execution

- Rewrites the queries mapping the original relations to the actual fragments.
- Sites are contacted according to the replicated fragments.

Termination Protocol

- The updated information is propagated to the pertinent replicas.
- What can we say about the read and write sets ?
  - They could be sent to all the replicas allowing a deterministic certification (non-voting).
  - They could be sent just to the pertinent replicas requiring a voting certification.

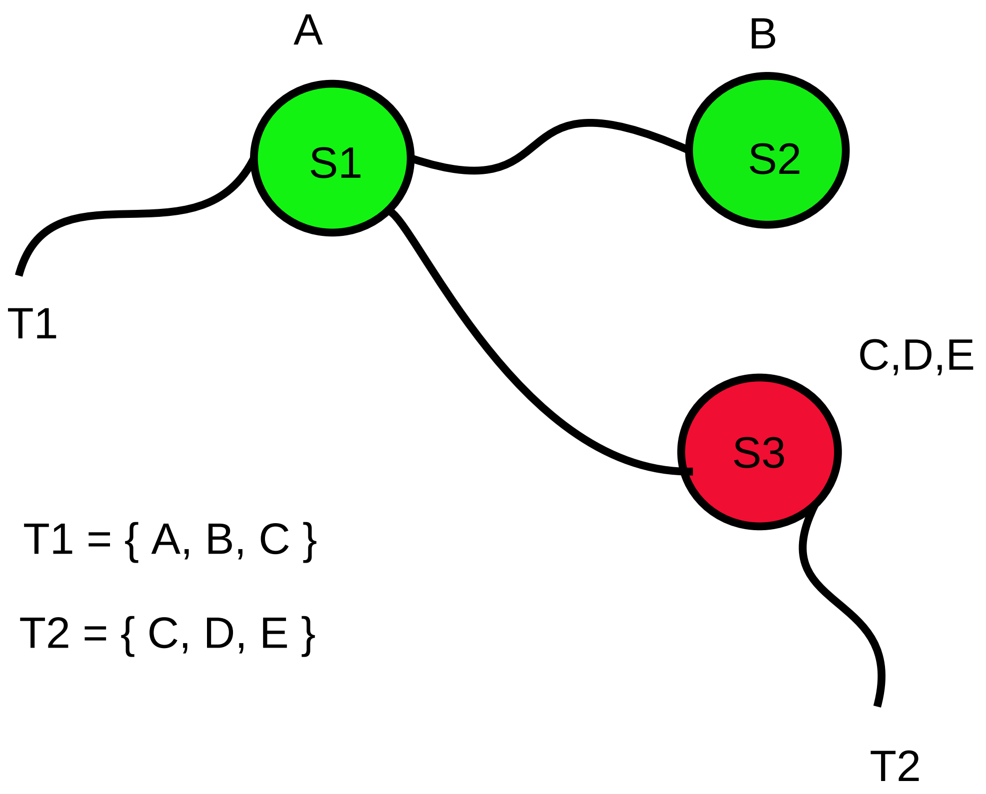
Non-Voting



T1 = { A, B, C }

T2 = { C, D, E }

Voting



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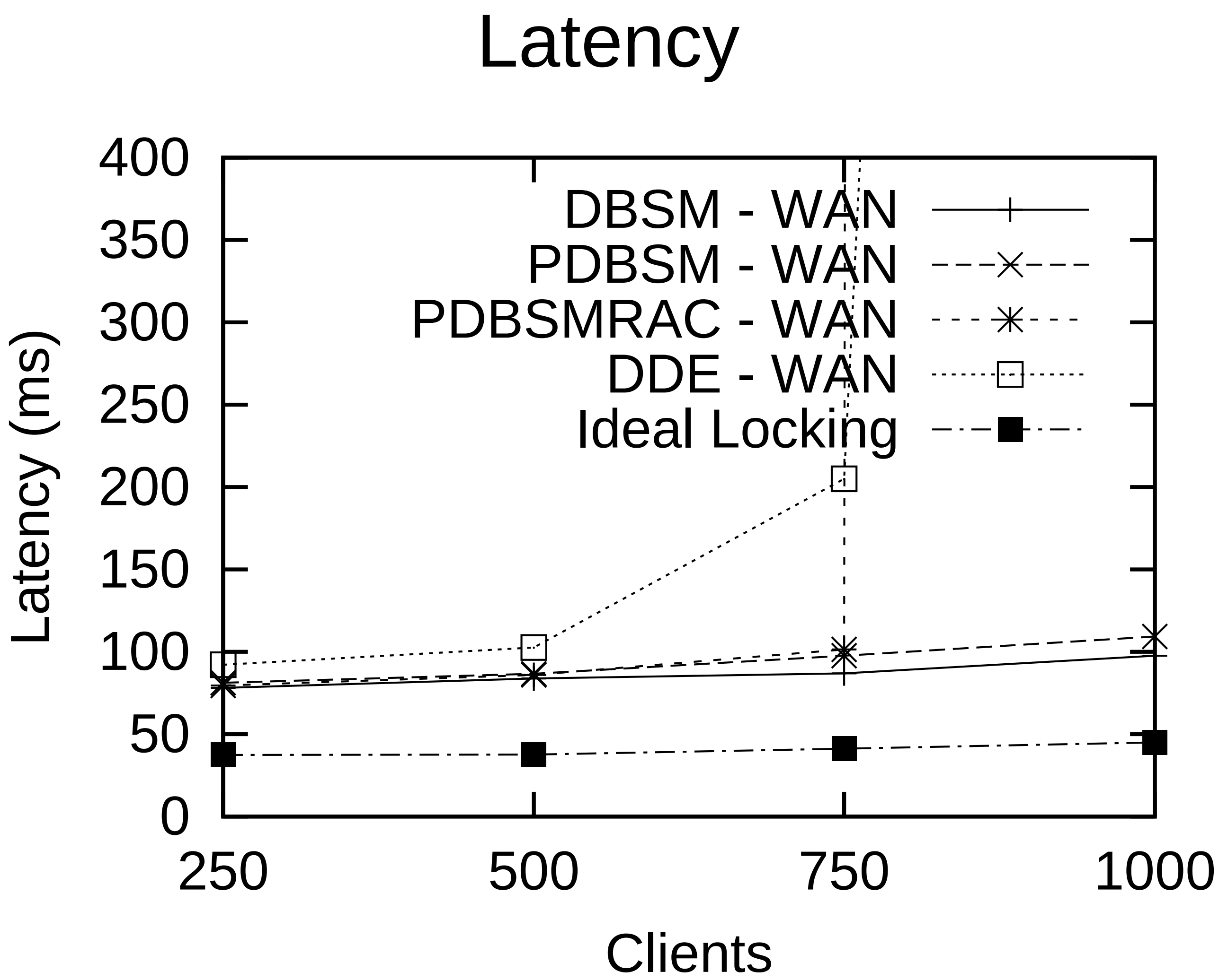
Experiments



Contribution

Semantic Caching

Semantic Caching

- Aims at reducing communication among distributed replicas.
- Exploits the broadcast to build the refresh mechanisms.
- Reduces the management overhead when compared to tuple and page-based solutions.
- Roughly, it caches the result sets and identifies them based on predicates.

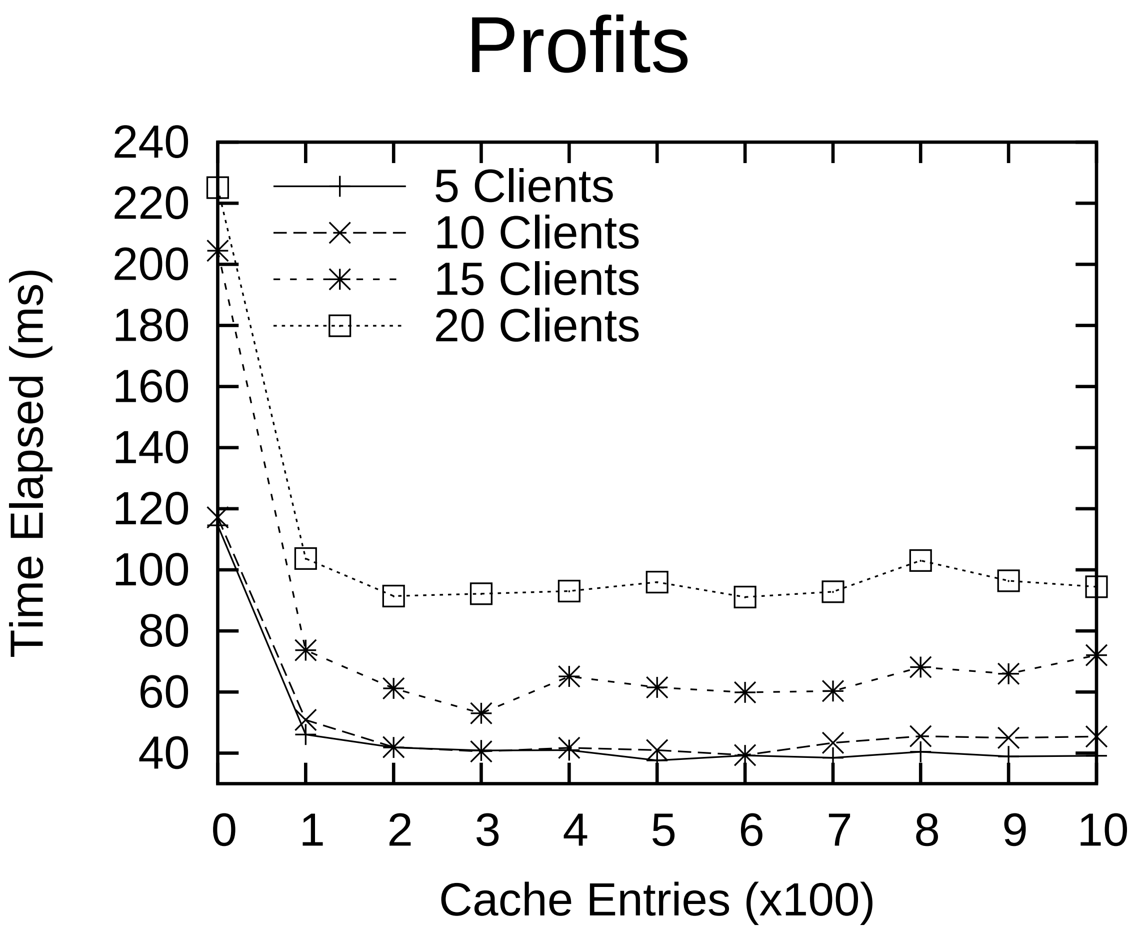
Semantic Caching

- The satisfiability background is behind this approach.
- Two predicates S and F are satisfiable if $S \wedge F$ is not a contradiction.
- The main idea: "upon receiving a query is possible to use a previous request ?".

Semantic Caching

- We use an important class of queries, called SPJ queries.
- However, other queries could be cached.

Experiments



Contribution

PostgreSQL

PostgreSQL

- We identified that the 1SR correctness criteria suggested by the DBSM is not achievable.
- We present an informal algorithm about how to exactly extract the read sets.
- Finally, we show how to extend the "rule mechanisms" of the PostgreSQL.

Contribution

Evaluation Process

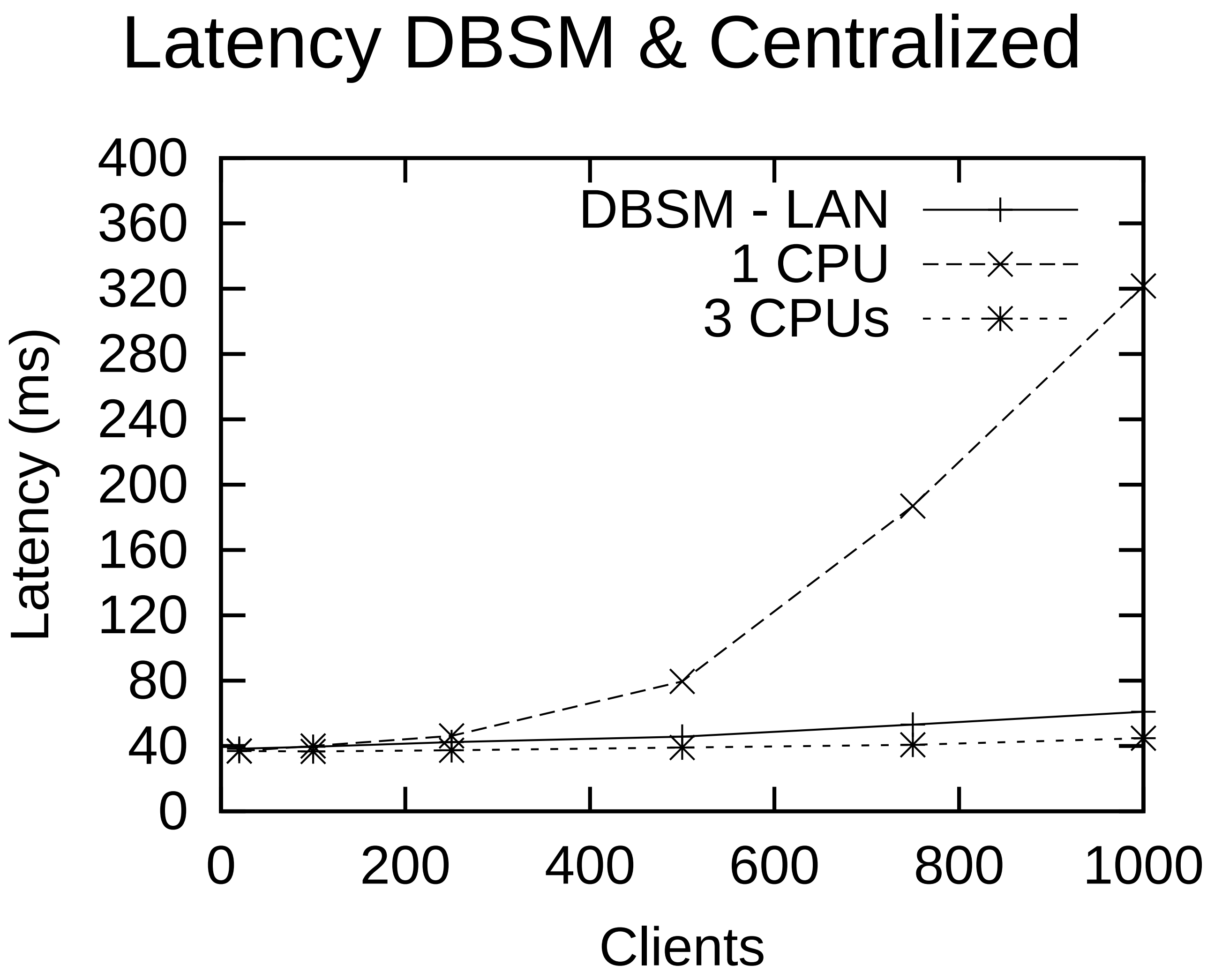
Evaluation Process

- We use a simulation tool that allows the combination of real and simulated code.
- The replication protocols, our main goal, are real implementations.
- This approach permits us to focus on our goal while at the same allows:
  - Variations on the network architecture, the workload, concurrency control policies.

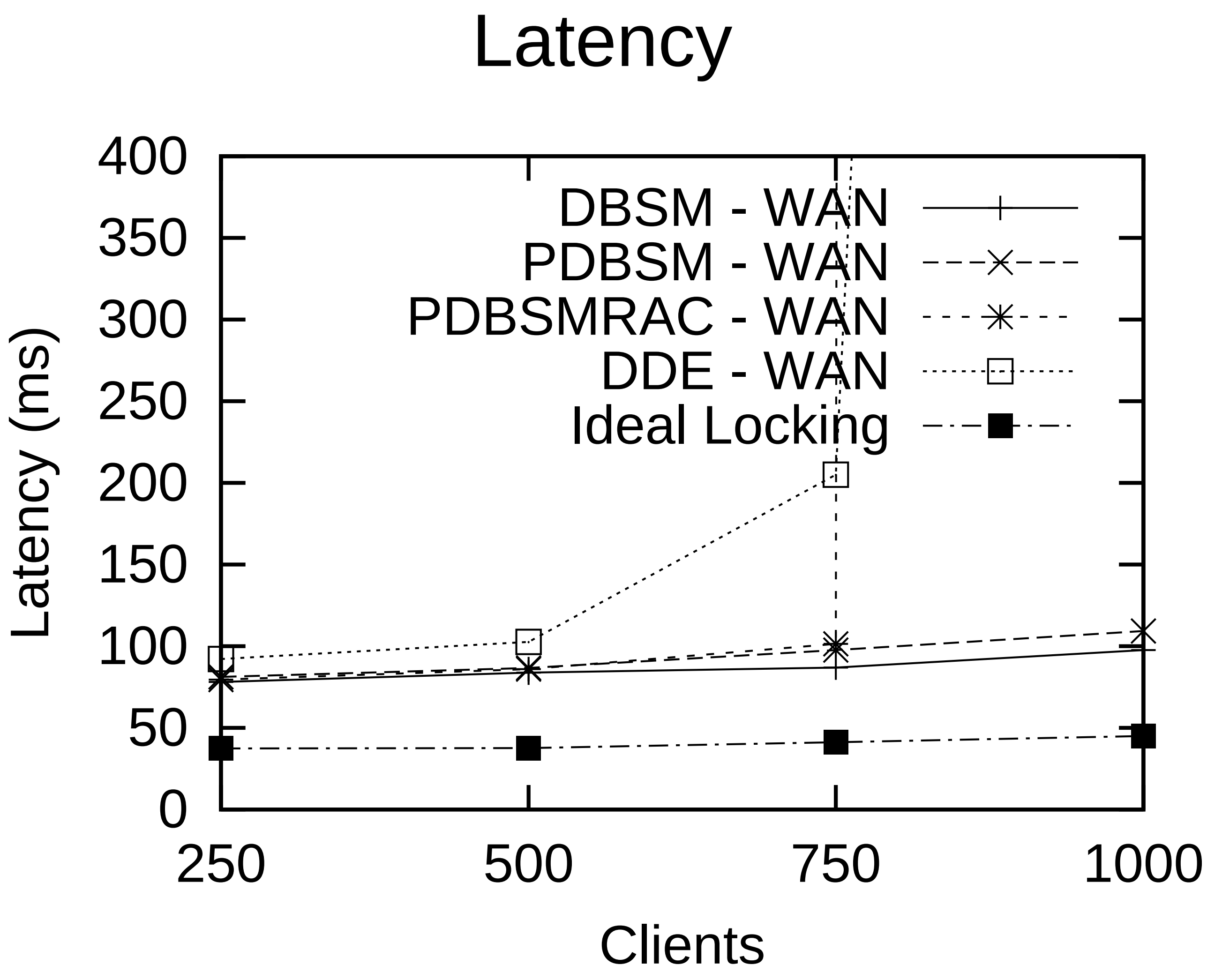
Evaluation Process

- TPC-W mimics an Internet commerce application.
- TPC-C mimics a wholesale supplier (OLTP).

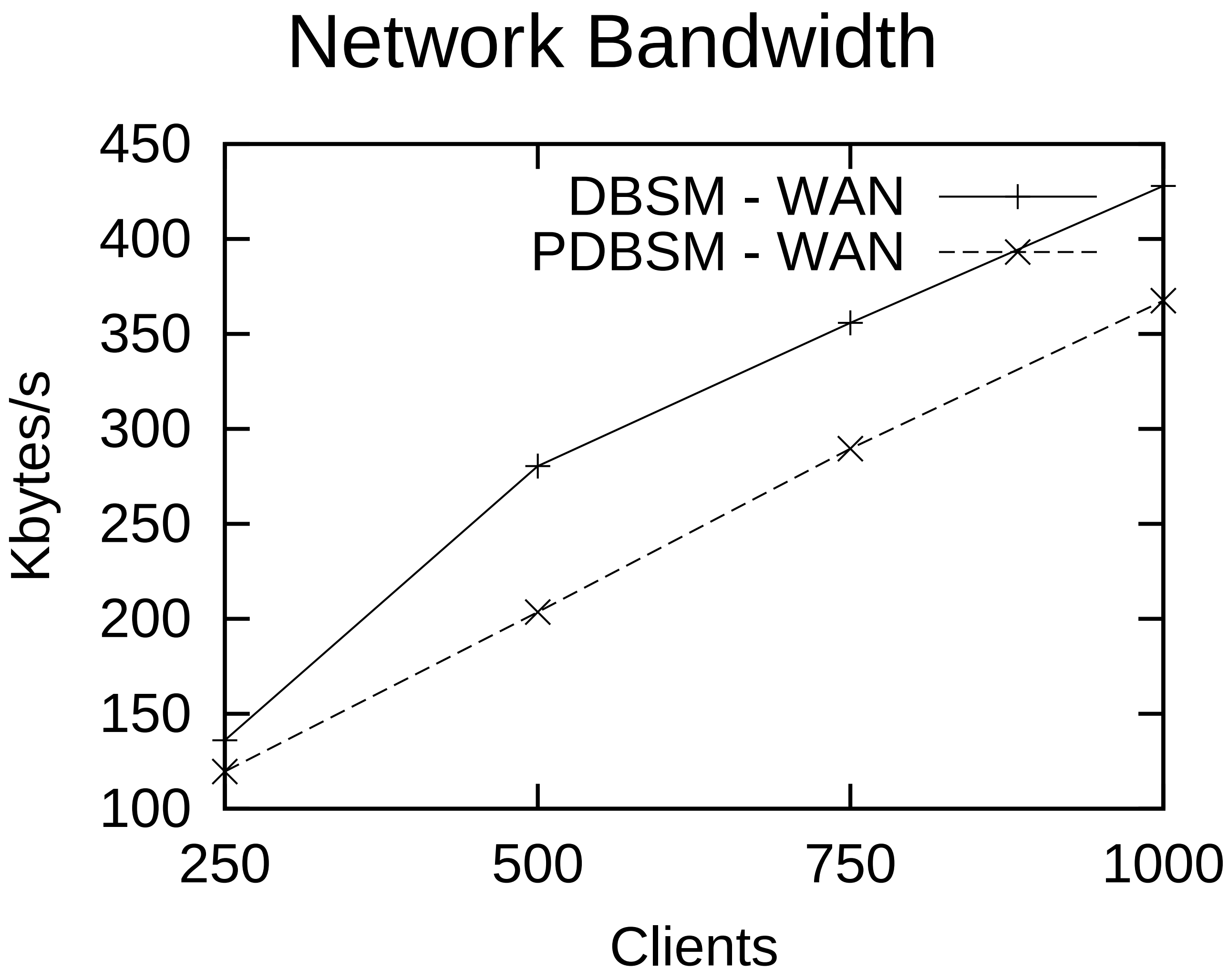
DBSM


Latency DBSM & Centralized
Latency (ms)
Clients
DBSM - LAN
1 CPU
3 CPUs
0
40
80
120
160
200
240
280
320
360
400
0
200
400
600
800
1000

Partial DBSM



Partial DBSM



Conclusion

- Database replication based on group communication is a feasible solution.
- The non-voting solution scales up better.
- The semantic caching reduces communication.
- Partial replication reduces resource consumption.

Future Work

- Improve our simulation tool: user friendly.
- Develop a version of our semantic caching to mobile elements.
- Revisit the Epsilon Serializability to Improve DBSM performance.

The End

Unfortunately, I don’t know how to the things that I need to do.
However, as a good start point I certainly know how I must not.
Sometimes, this knowledge avoids worthless efforts.

Sometimes, we simply need to go into the wrong direction to choose another path.