Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Ganymed/Satellites/DBFarm

Seminar in Distributed Computing

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Motivation

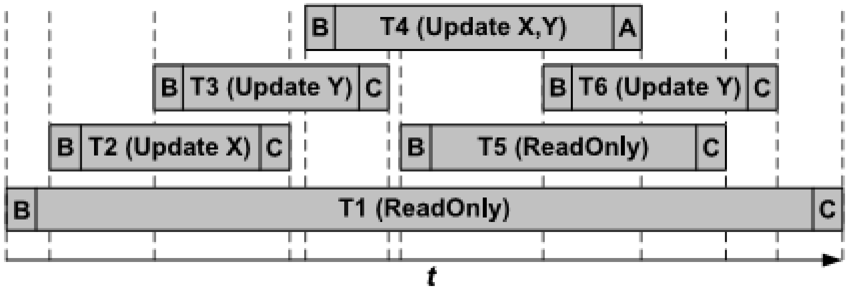
- Data grids, large scale web applications etc. overcharge DB engines
- Replication is the solution to scalability issues
- Existing solutions do not behave like a single database
  - Asynchronous (lazy) replication
  - Consistency is abandoned in favour of scalability

RSI-PC

- **R**eplicated **S**napshot **I**solation with **P**rimary **C**opy
  - Scheduling algorithm
  - One primary copy as *master*
  - Arbitrary number of replicated *slaves*

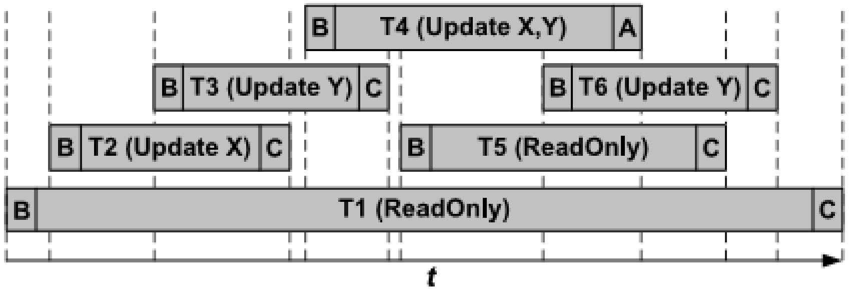
- Implemented as transaction scheduler
  - Scheduler distinguishes *read-only* and *update*

Snapshot Isolation (SI)



- Every transaction sees a consistent data state
- Conflicting updates are resolved by the *first-committer-wins* rule

First-committer-wins



- T4 is aborted since start(T4) < end(T3) and T3 and T4 both update Y
- No other conflicts here

Isolation levels

- SERIALIZABLE
  - Uses row level write locks
  - Only sees updates commited before transaction start
  - Transaction that commits later is aborted
  - Potential deadlocks, resolved by the database

- READ COMMITTED
  - Sees all commited updates
  - No aborting
  - Fuzzy reads possible
  - Default in Oracle and PostgreSQL

RSI-PC *updates*

- All updates are handled by the master

- After a successful commit the master extracts the *writeset* of the transaction
- The *writesets* are sent to all slaves in the same order
- *Writesets* are tagged with a global database version number

Writeset

- Optimization of the *update-everywhere* approach
- Propagtion of database changes instead of SQL-statements

RSI-PC *reads*

- The scheduler distributes reads to the slaves
- Round robin
- If the slave has not yet applied all commited updates, the read is delayed

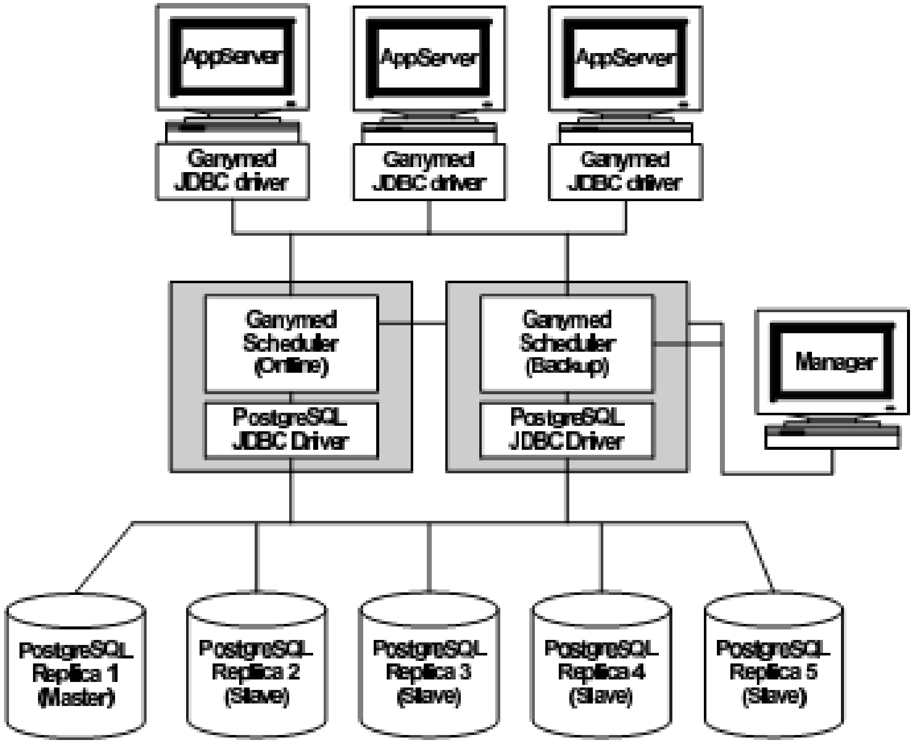
- Client is able to define a staleness threshold to shorten the delay

RSI-PC

- No SQL statement parsing
- No concurrency control operations
- No locking at scheduler level

- -> Very fast and „thin“ middleware

Ganymed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Ganymed JDBC driver
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Ganymed Scheduler (Online)
PostgreSQL JDBC Driver
Ganymed Scheduler (Backup)
PostgreSQL JDBC Driver
Manager
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PostgreSQL Replica 2 (Slave)
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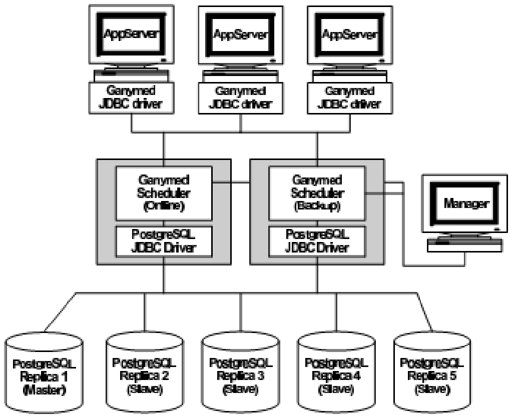
PostgreSQL Replica 5 (Slave)

Ganymed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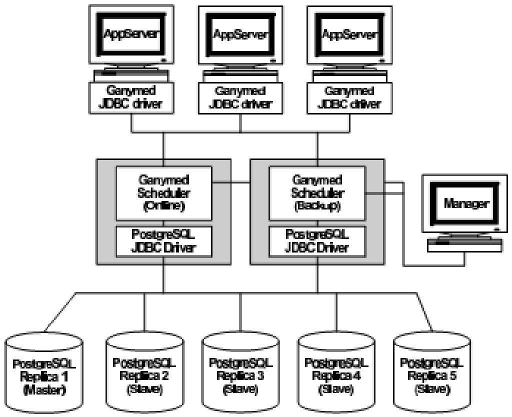
- Scheduler
  - Implements RSI-PC
  - JDBC driver
  - Behaves like a single SI based database
  - Distributes transactions over master and slaves

- Manager component
  - System monitoring
  - Configuration
  - Graphical interface

Ganymed scheduler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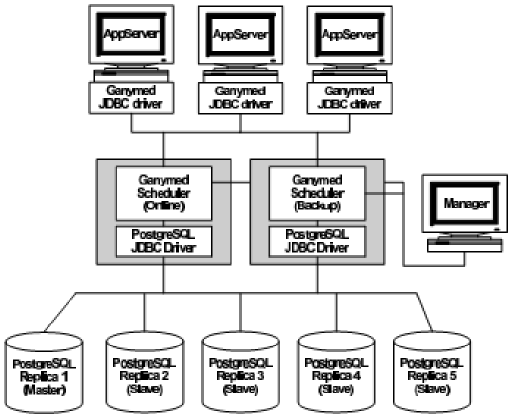
- JDBC Driver
  - Standard interface
  - Easy integration
  - Easy migration from centralized systems
  - Client application has to mark read-only transactions
    - By *Connection.setReadonly();*
  - No support for writeset extraction
    - Has to be done in the database

- Behaves like a single database
  - Transparent to clients

Ganymed scheduler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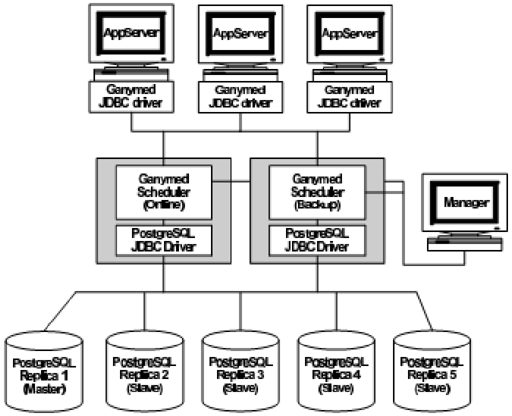
- Implements RSI-PC algorithm
  - No support for loose consistency models
  - Read-only transactions always assigned to a slave
    - Even if the master replica has free capacity
  - A FIFO queue for each replica is used to distribute writesets

- Supports PostgreSQL and Oracle replicas
- Heterogenous environment (also OS-wise)
- Dynamic management of replicas

Ganymed manager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- System monitoring
  - Replica loads
  - Component failures
    - Replica failure is handled by the scheduler
    - On scheduler failure, the manager tries to start a backup scheduler
- Configuration
  - Adding and removing of replicas
  - System startup
    - Choice of master replica

Ganymed evaluation

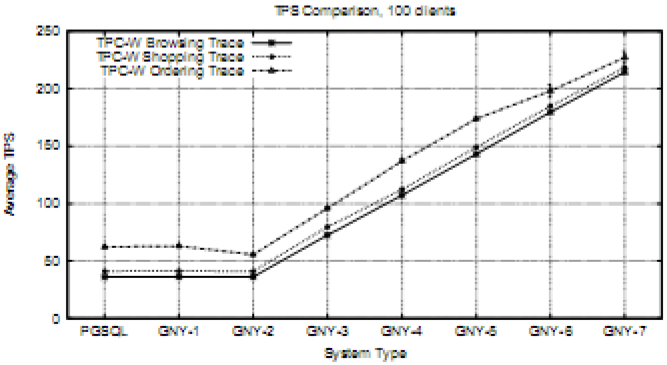
- Different Ganymed configurations tested against single PostgreSQL DB
  - Load generator simulating TPC-W application server

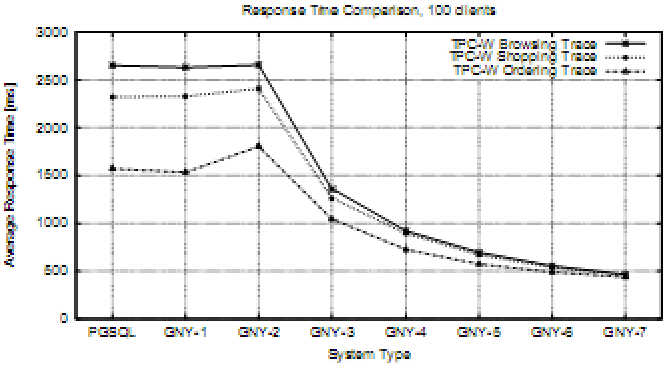
- Testing of component failure

TPC-W benchmark

- **T**ransactional **P**rocessing **C**ouncil
- Simulates real world transactional web applications
- Three different types of workload
  - WIPS: shopping
    - 80% read-only
  - WIPSb: browsing
    - 95% read-only
  - WIPSo: ordering
    - 50% read-only

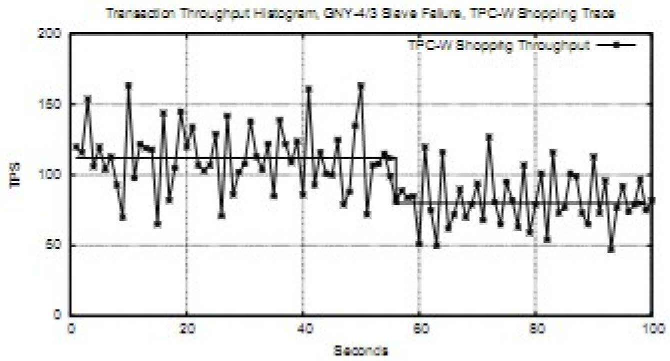
Performance and scalability

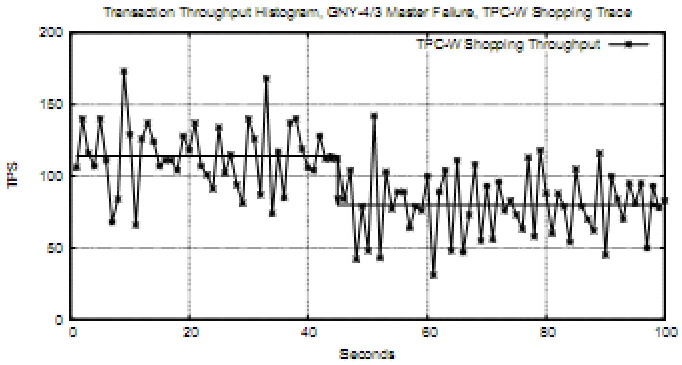




- Throughput and response time measurements

Component failure

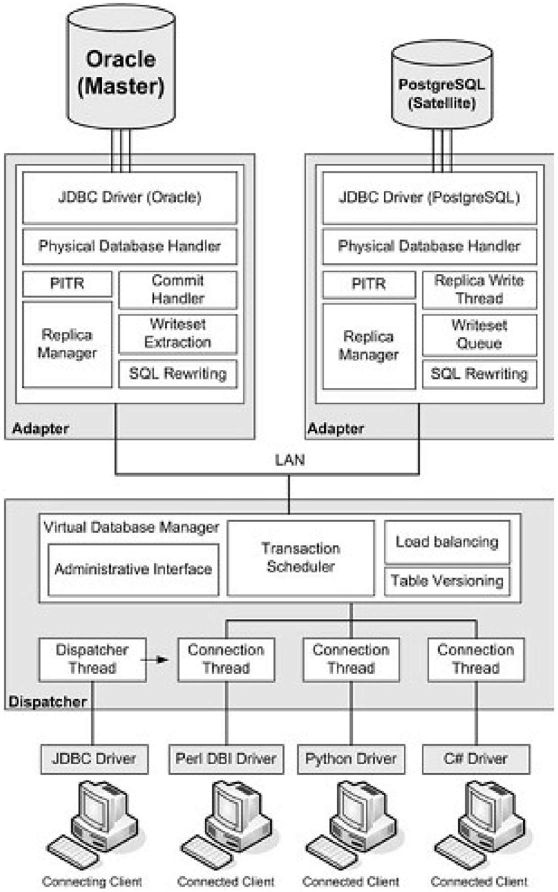




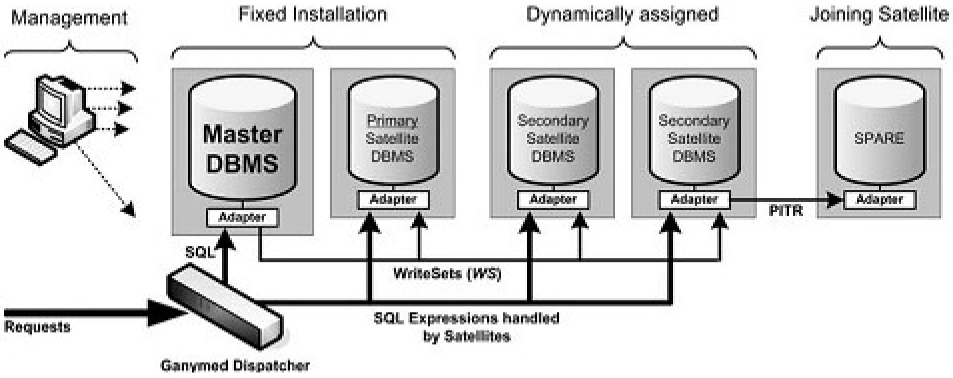
- Reaction to slave and master failure

Extending DBMSs with satellite databases

- Extension of Ganymed
- Dynamically create satellites
- Satellites can add fuctionality



Satellites



- Primary satellites are used to create secondary satellites without bothering the master
- Different load distribution policies can now be selected: *round-robin*, *least-pending-requests-first*, *least-loaded*

Satellites

- Several isolation levels are now supported on the master
  - Slaves respond to queries always using SI
- Satellites can appear and disappear without causing any loss of data
- SQL parsing is done in case of single queries to optimize routing
  - Slaves with only part of the tables can be used

Dynamic creation of satellites

- **Copy (used in Ganymed)**
  - Just copy a snapshot from the master or a ready satellite and start applying writesets
- Writeset replay
  - If a history of writesets has been kept, they can be applied to an old copy of the system
  - Especially useful if a satellite has left the setup and is then reentering
- Hybrid
  - Decide for each object (table) whether to copy or to replay its writesets

Dynamic creation of satellites

- **Physical copy (used in Ganymed)**
  - Directly transferring DBMS table space files
- Logical copy
  - Extracting and importing data using queries

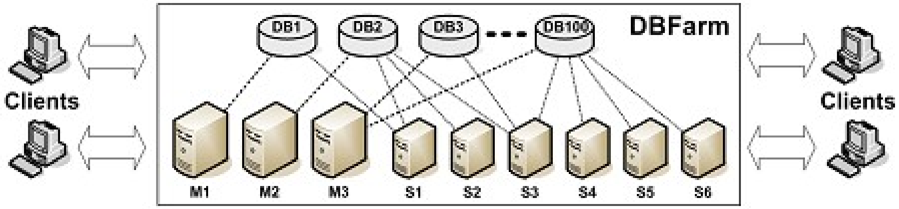
The PITR approach (point-in-time-recovery)

- Take a copy of the primary satellite
- Submit a marker transaction
- Copy the REDO logs
- Apply all transactions that occurred after the first step (get writesets from primary satellite)
- Apply all writesets received since activation of the queue

DBFarm: A Scalable Cluster for Multiple DBs

- Primary copy, read-only satellites scenario with multiple DB instances
- For use on clusters
- Potential use as a service provider
  - Clients see a single consistent image

DBFarm



- Scalability up to several hundred DB instances
- Again, load distribution is done by having one master for updates and read-only slaves
- Later versions use Ganymed as single SI database

Summary

- Idea is the same in all three papers
  - Write one, read many
  - Thin middleware-layer for load distribution

Thank you. Questions?