Cloud-TM: Harnessing the Cloud with Distributed Transactional Memories

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Outline

1. Introduction
2. Programming models for the Cloud
3. Towards a Cloud-TM
4. Some Preliminary Results
5. FénixEDU
6. Conclusions
7. Bibliography

Motivation

- Development of programming models and tools that simplify the design and implementation of applications for the cloud.

D-STMs

Advocate the use of Distributed Software Transactional Memory (D-STM) in the context of cloud computing.

- Limitations of other models.
- Limitations of D-STMs.
- Current work and FénixEDU.

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MapReduce

- Program needs to be structured as a combination of *map* and *reduce* operations[DG08].
- Run-time automates:
  - Data partitioning.
  - Scheduling.
  - Failure recovery.
- However map-reduce programming model is unnatural for many applications.
  - Requires the use of a different programming paradigm.
  - Several extensions[ORS$^+$08].
  - Strong debate about the merits and drawbacks of the approach[Aba09, DSml].

PGAS

Partitioned Global Address Space

- Combines the DSM model with flavors from the message-passing (MPI-like) model[BCA+06].
  - Provides a global address space.
  - The programmer has explicitly control over data locality.
- Complex programming interface.
  - Targeted towards high-performance computing applications

D-STM

Distributed Software Transactional Memories

- Extends the TM abstraction across the boundaries of a single machine.
- Only recently the first systems have been implemented and reported[KAJ+08, BAC08, MMA06, CRCR09, AMS+07].
- Can D-STMs avoid the pitfalls of DSM systems?
    - Less synchronization points (only at commit time).
- Two-classes of systems:
    - Fully-replicated for small scale systems.
    - Partitioned address space for large-scale clusters.

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Research Challenges

Automatic parallelization

- Extremely hard ... but
- Transactional support makes easier to implement strategies based on the speculative execution of portions of code[HWO98, SCZM00, LTC+06].

Research Challenges

Fault-tolerance

- Only started to be considered by recent D-STMs.

Research Challenges

Coping with Workload Heterogeneity

- STM performance (even in the centralized case) is heavily dependent on the workload.
- Different algorithms exist, optimized for different workloads (the same applies to the underlying communication protocols).
- Autonomic adaptation.

Research Challenges

Automatic Resource Provisioning

- Algorithms to automatically perform the provisioning of the computing resources are required.
- There is now a reasonable amount of work from the autonomic computing that can be used in the D-STM context.

Research Challenges
ACI vs ACID

- Many STM works do not consider durability of data.
- In a general purpose environment, persistence needs to be addressed.
- Furthermore it may need integrated with the mechanisms required to transfer data among nodes.

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Some Preliminary Results

D^{2}STM

- Dependable Distributed STM[CRCR09] is a distributed fully replicated STM, that uses atomic broadcast to coordinate replicas. Bloom filters are used to control the size of messages.

Some Preliminary Results

Speculative Replication

- A technique that runs (potentially conflicting) transactions speculatively in different orders, to hide the inter-replica coordination latency.

Some Preliminary Results

Identifying and predicting the data access

- We are developing stochastic techniques for identifying and predicting the data access patterns of transactional applications[GCP09].
- Used for automatic partitioning and algorithm optimization.

Some Preliminary Results

Thread-level speculation techniques

- Aimed at achieving automatic, performance-effective parallelization of sequential programs [AC09].
- Current prototype is capable of automatically parallelizing Java code meant to be executed on a single multi-core machine (with very promising preliminary results).

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The FénixEDU system

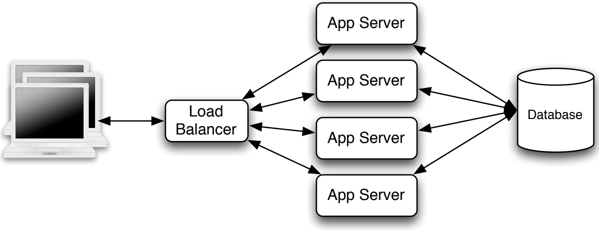
- Manages the on-line Campus activities
- Used in production by the Technical university of Lisbon
    - ... and being installed in other universities
- Processing between 1 000 000 and 4 500 000 transactions per day.

The FénixEDU system

- Web application
- Object-oriented domain model
- Relational DBMS to store data
- Object/relational mapping tool to store objects in the database
- Runs on a STM implementation

The FénixEDU system

- Application server is distributed to improve system throughput
- Database is used to synchronize replicas



The FénixEDU system requirements

- It could clearly be run in the cloud.
- Programmers use the object-oriented model they are familiar with.
- Resource requirements are variable (with short periods of hig peak loads).
- It has consistency constraints.

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Conclusions

- D-STM have many good properties that make them a promising technology to support distributed applications (with consistency requirements) in the Cloud.
- To fulfill this goal, many challenges need to be faced.
- There is already evidence that these challenges can be addressed.

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