A Transactional In-Memory Data Grid

Kim-Thomas Möller, Marc-Florian Müller, Michael Sonnenfroh, Michael Schöttner

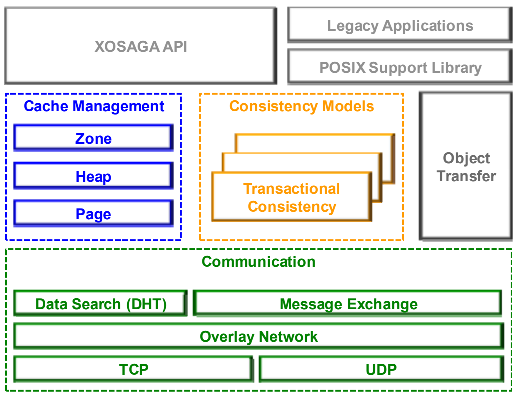
Abteilung Betriebssysteme, Heinrich-Heine-Universität Düsseldorf

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Problem & Solution

- **Problem: grid systems offer only message passing → data exchange and consistency management is difficult**
  - No transparent data access
  - Large object structures are repeatedly passed by value
  - Need hand-written code to maintain consistency of cached data
- **Solution: complement message passing by transparent remote data/object access**
  - Automatic multi-consistency management
  - Peer-to-peer technologies for scalability & reliability
  - Adaptive replica control for performance and fault tolerance
  - Kaffe-based version for pointer sharing in heterogeneous setups

Object Sharing Service (OSS) - Architecture



Object Allocation & Replication

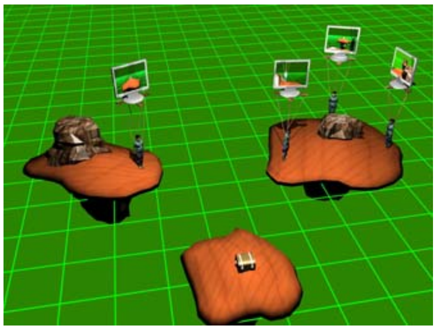
- **Object Allocation:**
  - Meta data stored in shared space
  - Object-based access detection
    - Allocating each object on a separate logical page
    - Several pages are mapped onto one page frame
  - Supports restartable object allocation within transactions
- **Adaptive Replica Management:**
  - Monitoring of access patterns to place replicas near accessing peers
  - And also geographically scattered for fault tolerance reasons.

Consistency Management

- **Different consistency models/domains:**
  - Weak and strong consistency models (within one application)
  - Stronger models can be decoupled by consistency domains
- **Speculative transactions (TAs):**
  - Avoiding complicated lock management and deadlocks
  - TAs are automatically restarted if a conflict is detected
  - Overlay-based commit protocols used for scalability
  - Pipelined transactions for masking commit latency
  - Transactions can call third party code

Target Applications

- **Distributed Interactive Applications:**
  - For example the multi-user virtual world Wissenheim
  - Scene graph and avatars shared using OSS
  - Game state managed using speculative transactions and weak consistency

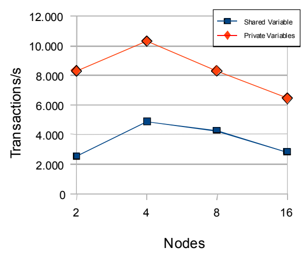


- **Number Crunching:**
  - For example map & reduce
  - For cluster federations
  - Distributed caching for fast data access

Preliminary Evaluation

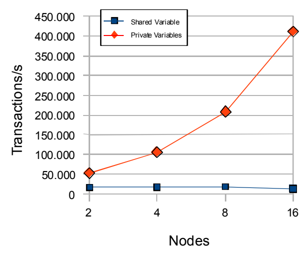
- **Test Applications:**
  - Synthetic speculative transactions
  - Worst case: all nodes incrementing one shared variable
  - Best case: all nodes incrementing private variables, only
- **Testbed**:
  - Cluster with 16 nodes each with two AMD Opteron Dual Core 1,8 GHz, 2 GB RAM and Debian Linux 64 (Kernel 2.6.24.3)
  - Switched Gigabit Ethernet network
  - Average token request time 443µs
  - Average page request time 302µs

Global Commit



- Each commit synchronized globally over network

Mixed Commit



- Global and local commits

Future Work

- Large-scale measurements using XtreemOS testbed and Grid 5000
- Wissenheim experiments with students joining from home
- Heterogeneity addressed by a modified Kaffe version
- Optimization of scalability and fault tolerance

XtreemOS Enabling Linux for the Grid

This work is part of the XtreemOS project.
More information at: http://www.xtreemos.eu

Software based on Mandriva packages:
http://www.xtreemos.eu/software/downloading

XtreemOS is supported by IST FP6-033576

Information Society Technologies

OpenGridForum

XtreemOS is a member of the Open Grid Forum