Yank: Enabling Green Data Centers to Pull the Plug

Rahul Singh, David Irwin, Prashant Shenoy
University of Massachusetts Amherst

K.K. Ramakrishnan
AT&T Research
Data Center Reliability

- Infrastructure designed to be highly available
  - Applications expect stable servers
    - Highly redundant power infrastructure
  - Availability is expensive

- Alternative approach
  - Relax strict stability assumption
  - Design low-cost HA techniques to compensate
Transient Servers

- Transiency Scenarios
  - Spot instances in Amazon Cloud
  - Server downtime due to power outage
  - Use of intermittent renewables

- **New abstraction**: Transient Server
  - Unpredictable availability
  - Receive advance warning of termination
Yank Problem Statement

How to maintain application availability while allowing data centers to transparently use transient servers?

- Introduce Transient Server Abstraction
- Design Yank: System Support for Transient Servers
- Apply Yank to Green Data Centers
Supporting Transient Servers

- **Two Ways of Using Transient Servers**
  - Modify Application
    - *Easy* – Batch Applications
    - *Hard* – Interactive (Web) Applications
  - System Support

- **Yank: System Support for Transiency**
  - Given warning, transfer transient VMs to stable server
  - Must complete transfer within warning time
Strawman Approaches

- **Live Migration**
  - Xen Live Migration [NSDI 2005]
  - *Pros:* Low Overhead
  - *Cons:* Large Warning Time (~70-100secs)

- **High Availability (HA) Solutions**
  - Remus [NSDI 2008]
  - *Pros:* Low Warning Time
  - *Cons:* High Overhead, High Hardware Cost

---

**HA**

- Low Warning Time
- High Overhead

**Live Migration**

- High Warning Time
- Low Overhead
Yank’s Approach

- Yank Covers Entire Spectrum of Warning Time
  - Low Warning Time -> Equivalent to HA
  - High Warning Time -> Equivalent to Live Migration

- Adapts to Warning Time
  - Overhead depends on the warning time
Yank High-Level Design

- Transient Server
  - Transient VM1
    - Snapshot Manager
  - Transient VM2
    - Snapshot Manager

- Backup Server
  - Backup Engine
    - In-Memory Queues
    - Snapshots on Disk

- Stable Server
  - Restoration Service

Warning

Warning
Limit on dirty state sent within warning time

One option: one threshold
- Send when \( \text{size of dirty state} < \text{limit} \)

Alternative: two thresholds
- Upper threshold -> Synchronous send with buffering
- Lower threshold -> Asynchronous send with no buffering
Backup Engine

- Per-VM in-memory queues for receiving updates
  - Enables fast acknowledgements
  - Write VM memory state to disk in background
- Highly multiplexed
  - Reduces extra hardware/power required for Yank
Restoration service on stable server

1. Receives in-memory queue+snapshot in parallel
2. Applies in-memory queue to snapshot
3. Restores VM using hypervisor’s restoration command
Transient Servers in Green Data Centers

On-Site Renewables

On-Site Renewables

Grid Energy

Grid Energy

ATS

ATS

UPS (Smaller Capacity)

UPS

Transient Servers

Stable Servers
Experimental Setup

- Implementation
  - *Snapshot Manager* – modification to Remus in Xen
  - *Backup Engine* – user level Python and C code
  - *Restoration Service* – C code

- Cluster of Blade Servers
  - 4GB RAM, 2.13 GHz Processor

- Benchmark Applications
  - *TPC-W*: Online bookstore

- Renewable Energy generation
  - Solar/Wind Generation Traces from UMass Deployment
Exploiting Warning Time

**TPC-W Data Transferred**

- **Pre-Warning**
- **Post-Warning**

5 Warning Time (secs)

- 70x reduction in data transferred

**TPC-W Response Time**

- 20x improvement in response time with just 5 second warning

- 4GB backup server supports 15 transient VMS
Solar Power Driven Transiency

- Yank masks applications from transiency due to changing power availability
Conclusions

- Transient Servers
  - Servers that terminate after a warning
  - Applicable to many scenarios

- Yank
  - System support for transient servers
  - Virtualization-layer solution

- Evaluation
  - Low overheads – performance, hardware, power
  - Hide transiency due to renewable power
  - Ongoing Work: Apply to Amazon spot instances
Questions?