Kemari: Virtual Machine Synchronization for Fault Tolerance using DomT

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Outline

- Our goal
- Design
- Architecture overview
- Implementation
- Evaluation
- Conclusion

Brush up on Xen Summit 2007
What is Kemari?

Kemari is a football game that players keep a ball in the air.

Don’t drop the ball!
Our goal

Don’t drop the ball! Don’t drop the VMs!

Kemari: Virtual Machine Synchronization
What needs to be done?

- Virtual Machine Synchronization
  - Primary VM and Secondary VM must be identical
- Detection of failure
- Failover mechanism

Extension of existing techniques
How to synchronize VMs?

- Need to make the overhead of sync smaller
  - Make sync time shorter
  - Only transfer updated data
  - Sync VMs less often
    - Secondary must be able to continue transparently

Sync VMs before sending or receiving Events
- Events: Storage, network, console
What happens if synced on specific intervals?

- Primary VM
- Primary VMM
- Storage
- Secondary VMM
- Secondary VM

1. Sync VM
2. Update Secondary
3. Sync completed
4. Read request
5. Reply
6. Write request
7. Reply
8. Failover to Secondary VM after detecting HW failure
9. Read request

$V_i$: VM’s state
$S_j$: Storage’s state

- Secondary VM won’t be able to continue transparently

The state between VM and storage isn’t consistent
Sync on events from VM to storage

1. Read / Write request
2. Sync VM and event
3. Update Secondary
4. Sync completed
5. Resume Read / Write
6. Reply

Resume point:
Just before operating storage

Secondary will redo the same operation as Primary
Secondary will receive the same reply as Primary

$V_i$: VM’s state
$S_j$: Storage’s state
Guest VM is running on Kemari
- Guest is running VNC server, and the client accesses via VNC client
- xclock is launched from the client
- See what happens to the clock when the primary physical server is shut downed from HP iLO2 management console
The core of the synchronization mechanism resides in hypervisor to synchronize virtual machines efficiently.

- LOC ≅ 3000 (hypervisor: 1000, Dom0+Tools: 2000)
What is DomT?

- Para-virtualized domain which uses shadow page table (auto-translated-mode)
- Don't have to translate the page tables on transferring
- DomT patch set for xen-3.0.4 was written by Michael A Fetterman from University of Cambridge
Implementation of Kemari

- Event Channel tapping
- Transferring DomT
- Restoring para-virtualized devices
Event Channel tapping

- Simple but the key component of Kemari
- Monitors IN/OUT or Both
- Registered function is called on specific events
- Dynamically attachable
  - May be useful for measurements
Transferring DomT

1. Pauses DomT and locks the grant tables. **No need to suspend!**  
   - Grant tables are mapped at the last 4 pages of DomT region
2. Extracts dirtied pfns from the bitmap, copies pfns and the vcpu to the shared buffer, and notifies Tools via event channel
3. Maps dirtied pages, transfers pages and vcpu to the secondary
4. Secondary prepares temp buffers to rollback when failure is detected during transfer
Restoring para-virtualized devices

1. Device Channel is stored in DomT region

2. Attach the Back-end to the Device Channel using BACK_RING_ATTACH macro

3. Adjust producer and consumer indexes of the Back-end appropriately
Evaluation

Evaluation items
- Performance of the Primary VM (Network and File I/O) using netperf and iozone

Test machines
- Hardware spec
  - CPU: Intel Xeon 3GHz X 2
  - Memory: 4GB
  - Network: Gigabit Ethernet, InfiniBand
  - SAN: FC Disk Array

- VM spec
  - VMM: Xen 3.0.4 with DomT support
  - Guest OS: Debian Etch
  - Memory: 512MB
Performance of Primary VM

- InfiniBand boosted the performance of Network and Buffered + fsync, both of which dirties many pages
- All benchmarks continued transparently when the primary server was shut downed from the HP iLO 2 management console
Conclusion

- Kemari is a Virtual Machine synchronization mechanism to achieve Fault Tolerance

- Don't drop the ball! Don't drop the VMs!

- Implemented Kemari using Xen and DomT
  - Thanks to Michael from University of Cambridge

- Demonstrated Kemari achieved acceptable performance
Future work

- Demonstrate the range of applications Kemari can manage to run transparently
- Improve the performance of I/O intensive applications that send numbers of events
- Hosting HVM domains with PV drivers
- Hosting multiple domains simultaneously
- Functions to implement for practical use such as detection of HW failure and failover mechanism