Who Decides Migration?
A Migration Lock Mechanism for Virtual Machines

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SVM’13, 18 October 2013, Zurich
Agenda

- Why migration lock?
- Design of migration lock mechanism
- Implementation
- How to use migration lock?
- Conclusion
Why migration lock?

- Migration is a powerful management feature
  - Migrate virtual machines to different hosts help to
    - Improve resource utilization and save energy
    - Achieve load balance and better QoS
    - React in advance of failure or maintenance
    - ......
Why migration lock?

- Defects of virtual machine migration
  - May slow down the performance of VM during migration
    - Network and disk I/O
    - Memory access
  - Destination host may lack of some hardware resources
    - SR-IVO NIC
    - General Purpose GPU
  - Co-running with different VMs on the same host
Why migration lock?

- Scenarios in which migration will cause significant performance degradation or even system failure
  - The application is running some critical code and does not want to be affected by migration of the virtual machine;
  - The application is performing some critical operation, migration will fail the operation;
  - Some special optimizations, such as optimizing communication between virtual machines sharing the physical host, requires that several virtual machines run on the same physical machine at the same time;
  - Dependence on special hardware resource
Why migration lock?

- Migration lock
  - Enable the VMM learn about whether a VM can be migrated.
  - Enable applications in a VM tell the VMM do not migrate the enclosing VM.
Design of migration lock mechanism

- A status flag added to the virtual machine.
  - VMM must check the flag before migrating a virtual machine.

- Static migration lock
  - Set the lock in configuration file or in the command line of creating the VM.

- Dynamic migration lock
  - Set or clear the lock while the VM is running.
Design of migration lock mechanism

Set Migration Lock Dynamically

1: Create a virtual machine and set it cannot be migrated.
2: Fail to migrate the virtual machine.
3: Set the virtual machine to be migratory during its running period.
4: Migrate the virtual machine successfully.
Implementation

- Implemented the migration locking mechanism on Xen-3.31, which involves change in:
  - Xen hypervisor
  - Guest OS of DomU
  - Application in DomU
  - Xen tools
Implementation in Xen hypervisor

- The the structure `domain`
  - `bool_t is_migratory`
  - Setting or clearing migration lock reflect finally on it
  - Checking it before invoking migration

- A new hypercall
  - Hypercall number: `__HYPervisor_set_migration_flag`
  - Hypercall handler function: `do_set_migration_flag`
  - With parameter 1 for setting and 0 for clearing
Implementation in Guest OS of Domain U

- To transfer the command of setting migration lock from the application level to the Xen hypervisor

- Different implementation for
  - Para-virtualized guest OS – Linux
    - System call
  - Full-virtualized guest OS – Windows
    - A special device driver
Implementation in Guest OS of Domain U

- Para-virtualized guest OS – Linux
  - 64bit Linux, kernel version 2.6.18
  - System call with number 235
  - Handler function - \texttt{sys\_set\_migration\_flag}
    - Which will call \texttt{\_\_\_\_HYPERVERISOR\_set\_migraton\_flag}
Implementation in Guest OS of Domain U

- Full-virtualized guest OS – Windows
  - In the special device driver
    - Firstly, obtain the number of hypercall pages of Xen Hypervisor via CPUID instruction
    - Then, allocate a block memory with the same size as the hypercall pages for setting new hypercall pages for Windows Operating System by using WRMSR instruction.
    - Finally, invoke the hypercall from the handling function of MldDDKDeviceIOCotrol
Implementation in Application in Domain U

- An application tools (*set_migration_flag*) for users in Guest OS to set migration lock
  - On Para-virtualized guest OS – Linux
    - The tool invoke the system call to set migration lock
  - On Full-virtualized guest OS – Windows
    - The tool invoke the I/O control operation to set migration lock
  - CMD: *set_migration_flag flag* (flag =1 or 0)

- Users can also call invoke the system call on Linux or invoke the I/O control operation on Windows in their applications to set migration lock.
Implementation in Xen tools

In the Process of Creating Domain U

CMD:

```
xm create config_file -migration=yes|no
```

Configuration file:

```
migration = yes|no
```
Implementation in Xen tools

In the Process of Migrating Do

Checking the lock in two functions:

   domain_migrate
   xc_domain_save
How to use migration lock?

- With migration locking mechanism
  - Virtual machine may prevent itself from migration on its own initiative.
  - Current migration strategies should take migration lock into consideration.

- Two problems to be solved:
  - How to prevent a virtual machine from using migration lock arbitrarily?
  - How to make a migration schedule without knowing in advance whether or not a virtual machine can be migrated?
Ideas about how to use migration lock

- **To avoid using migration lock arbitrarily**
  - Specify in the SLA whether or not a virtual machine may set migration lock.
    - Only allowed virtual machines may set migration lock; or some forbidden virtual machines are disable to set migration lock.
  - **Tax on setting migration lock according to historical working load.**
    - To force user to use migration lock properly. To punish those selfish users.
  - **Define a constant time slice as the maximum time that a migration lock may persist.**
    - Prevent a virtual machine hold the migration lock too long. Recover from application failures without releasing migration lock.
  - **Provide *trylock* mechanism on migration lock for application.**
    - Application may have opportunity to avoid doing critical actions or binding to unpopular hardware resources when migration lock is unavailable. (for example, a virtual machine currently in migrating).
  - **Atomic and consistent operation to set and check migration lock.**
    - Avoid data racing, consistent view of migration lock in both VMM and VM.
Ideas about how to use migration lock

- To make good migration schedules with migration lock
  - Fail and retry strategies
    Make migration schedules only on those virtual machines that can be migrated.
    When a scheduled VM becomes locked, discard old schedules and try make new ones.
  - Probabilities model
    With historical information data mining, make migration schedules considering the probabilities of a VM changing from unlocked to locked and vice versa.
  - Wait and retry strategies
    With the help of maximum lock slice, wait for the lock to be released when a scheduled VM is locked when try to migrate it.
Conclusion

- Scenarios in which migration will cause significant performance degradation or even system failure
- Migration Lock mechanism can work.
- Do we need Migration Lock?
- How to use migration lock?
- How migration management work together with migration lock?
Thanks!

Q & A