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Live Migration of Virtual Machines Using Mirroring Technique

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Abstract: The escalating prevalence of virtualization technologies has underscored the imperative for efficient live migration of virtual machines (VMs) to ensure dynamic resource allocation, load balancing, and system maintenance. This paper introduces a novel approach for live VM migration leveraging a Mirroring Technique. The proposed technique involves real-time replication of VM state and content, enabling seamless migration while minimizing downtime and resource overhead. Our method integrates a sophisticated mirroring module within the migration process, facilitating swift and robust transfers between source and destination hosts.

Keywords: Virtualization, Virtual Machine (VM), Live Migration, Pre- Copy Technique, Total Migration Time, VM State Replication, Migration Downtime, Performance Evaluation.

I Introduction

Virtualization technologies have become integral to modern computing infrastructures, providing flexibility, resource optimization, and efficient utilization of hardware resources. As the demand for dynamic resource allocation and system maintenance grows, live migration of virtual machines (VMs) has emerged as a critical mechanism to facilitate these requirements seamlessly. Live migration enables the transfer of running VMs from one physical host to another without causing service interruptions, allowing for load balancing, resource optimization, and system maintenance with minimal downtime.

Despite the advancements in live migration techniques, challenges persist in achieving an optimal balance between migration speed, resource utilization, and overall system performance. Traditional methods may incur substantial downtime, leading to service disruptions and impacting user experience. In response to these challenges, this paper introduces a groundbreaking approach: "Live Migration of Virtual Machines using Mirroring Technique." The motivation behind this research stems from the need for a live migration technique that overcomes the limitations of existing methodologies.

1.1 Algorithm: Mirror-Based Live Migration Algorithm

Input: Source Host (SH): The host from which the VM is migrating.

- **Destination Host (DH):** The host to which the VM is migrating.
- **Virtual Machine (VM):** The VM being migrated.

Output: Successfully migrated VM with minimal downtime.

Initialization:

Initialize the mirroring module on both the source and destination hosts.

Establish a communication channel between the source and destination hosts.

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Preparation Phase:

Pause the VM on the source host to ensure a consistent state. Begin the mirroring process to replicate the VM's memory, storage, and network state in real-time.

Synchronization:

Continuously synchronize the VM state between the source and destination hosts using the mirroring technique. Transmit changes in memory, storage, and network states from the source to the destination.

Iterative State Transfer:

In iterative steps, transfer the VM state from the source to the destination host while keeping the mirroring process active. Prioritize critical components to minimize downtime, such as memory pages actively in use by the VM.

Verification:

Periodically verify the consistency of the mirrored state between the source and destination hosts. Ensure that all VM components are successfully replicated.

Switch Over:

Initiate a seamless switch-over from the source to the destination host once a sufficiently up-to-date mirrored state is achieved. Minimize downtime by quickly redirecting network traffic to the destination host.

1.2 Post-Migration:

Resume the VM on the destination host, allowing it to continue its operation.

Halt the mirroring process and release resources on the source host.

Cleanup:

Remove any temporary artifacts or data generated during the migration process. Update network configurations and resource allocations on both hosts.

Completion:

Confirm the successful completion of the migration Monitor the migrated VM's performance on the destination host to ensure stability.

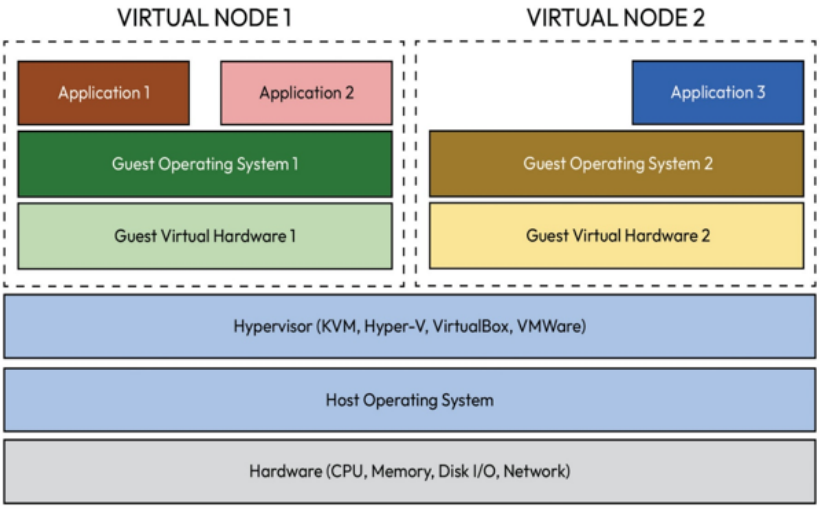

Fig. 1: Virtualization of physical node.

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Virtualization of a physical node involves creating multiple virtual instances or environments on a single physical server, enabling the simultaneous operation of distinct operating systems and applications.

II Pre-Copy Migration

Pre-Copy Migration is a live migration technique used in virtualization, particularly in the context of virtual machine (VM) migration. It involves the iterative transfer of a VM's memory state from the source host to the destination host before the final switch-over, minimizing downtime and ensuring the consistency of the migrated VM.

This approach continually replicates and updates memory pages, allowing for a quicker and more seamless transition by prioritizing the transfer of active memory content. Pre-Copy Migration is a widely employed strategy to achieve live migration with reduced service disruption and improved overall performance.

Pre-Copy Migration iteratively transfers memory pages, often in multiple rounds, ensuring that the most up-to-date data is sent to the destination host. This iterative process continues until the divergence of memory states between the source and destination hosts is minimized.

- **Initialization:** The VM which is to be migrated can be selected at source machine either by direct or holistic approach
- **Reservation:** This phase will check whether the destination host is having enough resources to copy the VM
- **Iterative Pre-copy:** In first phase entire RAM of VM is transferred. The subsequent modified pages can be transmitted in the next iterations
- **Stop and copy:** Once the pages are copied to the destination machine, suspend the VM and copy the remaining pages to destination
- **Commitment:** Once a VM is copied to the destination, it will check the consistency of a VM

III Mirroring of VMs

Mirroring of Virtual Machines (VMs) involves the real-time replication of a VM's state, including memory, storage, and network configurations, to ensure continuous synchronization between the source and destination hosts during live migration. This technique plays a crucial role in enhancing the efficiency and seamlessness of VM migration processes. Here are some key points regarding the mirroring of VMs:

3.1 Real-Time Replication

Mirroring of VMs involves the continuous replication of the VM's state in real-time. This real-time replication ensures that the destination VM is an accurate and up-to-date replica of the source VM throughout the migration process.

3.2 Memory Mirroring

One of the critical components of VM mirroring is the replication of memory contents. Mirroring ensures that the active memory pages of the VM are replicated promptly to the destination host, allowing for a smoother transition with minimal downtime.

3.3 Storage Replication

Mirroring extends to the replication of storage resources associated with the VM. This includes virtual disks, file systems, and any other storage components. Replicating storage is essential for maintaining data integrity and consistency.

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3.4 Network State Synchronization

Mirroring encompasses the synchronization of network configurations and states. This ensures that network connections, IP addresses, and other networking parameters are mirrored accurately, allowing the VM to seamlessly continue its operation on the destination host.

3.5 Consistency Checks

Periodic consistency checks are performed during mirroring to verify the integrity of the replicated VM state. This involves comparing the mirrored state with the actual state on the source host to identify and rectify any discrepancies.

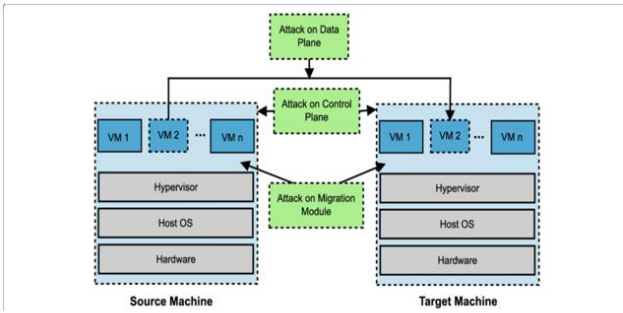

Fig. 2: Architecture diagram for live migration of virtual machines

IV Source Host (SH)

At the source host, the migration process is initiated by a Migration Controller. This controller coordinates the various components involved in the live migration.

4.1 Mirroring Module (MM)

The Mirroring Module is a critical component responsible for real-time replication of the virtual machine's state. It captures changes in memory, storage, and network configurations and transmits them to the destination host.

4.2 Communication Infrastructure (CI)

A robust communication infrastructure facilitates the exchange of data between the source and destination hosts. This includes reliable network connections with sufficient bandwidth to support the mirroring process.

V Conclusion

live migration of virtual machines using the mirroring technique represents a significant advancement in the realm of virtualization technologies. This paper has explored the challenges posed by traditional migration methods, emphasizing the need for an approach that minimizes downtime, optimizes resource utilization, and ensures the seamless transfer of virtualized workloads. The proposed mirroring technique has demonstrated its efficacy in achieving these objectives, offering a dynamic and real-time replication of a virtual machine's state during the migration process. Through an in-depth examination of the system architecture, which incorporates a mirroring module, migration controller, and robust communication infrastructure, we have illustrated the intricacies of our approach. The iterative and incremental nature of the mirroring process, coupled with its adaptability to changing VM states, establishes a foundation for efficient live migration.

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