Fail safe Virtual Machine Migration

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Abstract— **This term paper furnishes a survey on fail safe virtual machine migration. In last few decades virtualization technology effectively handling the growing demand of computing, communication and storage resources in big Cloud Data Centers. Virtualization creates abstract form of resources such as server, storage, network, virtual computer hardware platform etc.**
In a large-scale cloud-based data centers, many Physical Machines hosts dozens of Virtual Machines which are used by various users and running different applications. Virtual Machine load measured according to use of various applications and resources used by Clint and traffic. Sometimes this load due to high traffic, overloading the Virtual Machine`s resources. Since, the Physical Machines which is hosts the Virtual Machines have limited resources and if they overload, they might fail or their performance may decrease. In this situation we need to migrate the heavily the heavily overloaded Physical Machine to a underloaded Physical Machine in order to handle the load and traffic in data centers. This migration needs a clear mechanism to control user traffic and load on both source and destination Physical Machines in order to provide a dedicated bandwidth that needed for VM migration. Virtual Machine Migration needs intelligent approaches to avoid saturating bandwidth problem and minimize the server downtime, because it is a very resource intensive process.
Hence this migration process adversely affects the efficiency of data centers and reduce the performance of running applications, especially when critical business objectives and Service Level Arguments are to be met.
As every coin has two faces Virtual Machine Migration also has its pros which is drastically increasing the capabilities of cloud data centers to handle robust situations.
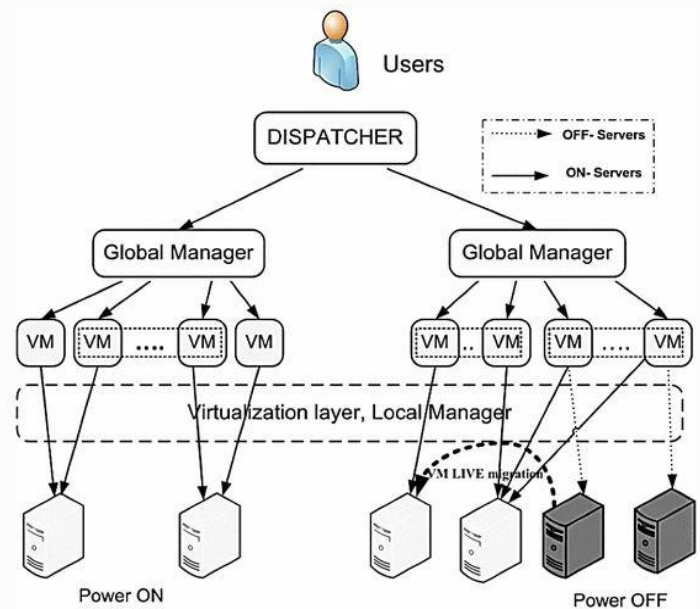**This process helps to achieve different resource management goals such as power management, load balancing, online system maintenance, proactive fault tolerance and resource sharing etc.**

I. INTRODUCTION

Virtual Machine Migration is similar to the process of Teleportation because in simple words it is the task of moving a Virtual Machine from one Physical Machine`s environment to another Physical Machine`s environment with its state and all resources. In this way it is a part of hardware virtualization systems.

Due to vast and elastic capabilities Cloud Computing has revolutionized the IT world and its resources become simple to use and powerful in terms of processing capability, storage capacity and time efficiency which attracts the clients and developers to use its resources.

Due to this increasing demand of IT resources, draw the attention of Service Providers and Researchers to share these resources among clients and end users in order to efficient resource utilization for maximizing the profit. In Cloud based environments services are delivered in the form of platforms, hardware resources, software, database, infrastructure and much more information using IBM smart cloud, Microsoft Azure, Amazon`s EC2, Google App Engine etc.

Virtualization technology was developed in 1960 by IBM in order to maximize the hardware resource utilization of powerful and expensive mainframe computers. It is provided by a Virtual Machine Monitor or Hypervisor which is a thin layer of software running between operating system (OS) and systems hardware that control, manage and maps multifarious Virtual Machines on a unit platform. It is also a complete hardware and software stack which is fulfilling the incoming request or provide services to the users.
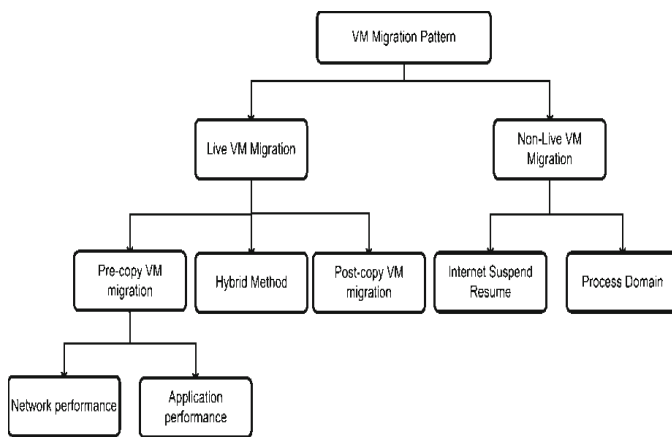
The role of Virtual Machine Migration is binary, first is to improve the resource utilization and second is to increase the Service Provider`s profit.

This term paper starts with a brief discussion of Virtualization, Virtual Machine Migration, its benefits, background and then a detailed discussion on Virtual Machine Migration Schemes, threats, Error and failure cause in Virtual Machine Migration and finally, a conclusion, future work and references.

II. VM Migration Schemes
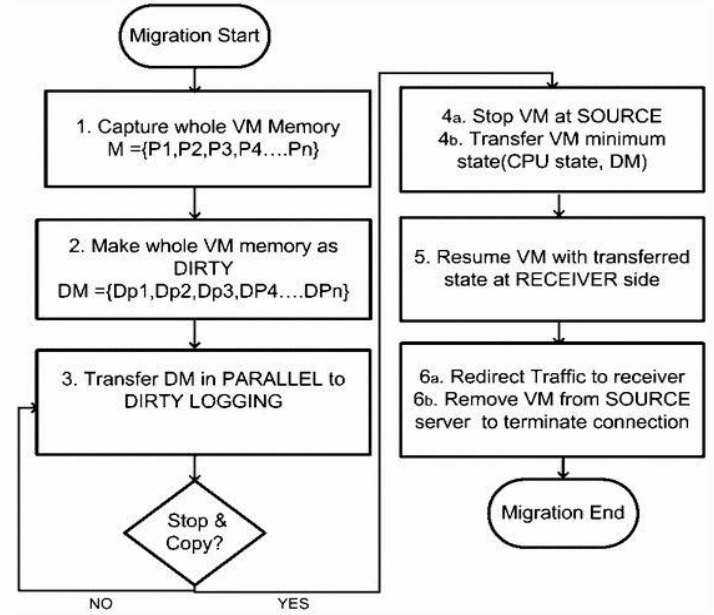
LIVE VM Migration

Live Virtual Machine Migration is an important Virtualisation feature in which a running Virtual Machine is moved between various Physical host machines with scurce Virtual Machine`s CPU state, storage, memory, and network resource completely moved to the target host without disturbing the clint and running applicatons. However, this migration can consume significant bandwidth of 500 Mb/s for 10 seconds for a trivial server, therefore these non-negotiable aspects need to be concider when scheduling migration. Hgher trafic and workload in order to network bandwidth intensive migration can cause network congestion.

Live Migration method services the running applications un-interruptedly during the elapsed Virtual Machine Migration time. The goal of live migration method includes the optimization of application performance during migration process, increasing the bandwidth utilizing efficiency and minimize downtime. The bandwidth optimization process augments the application`s QoS when putting extra load on system`s resources such as CPU cycles.
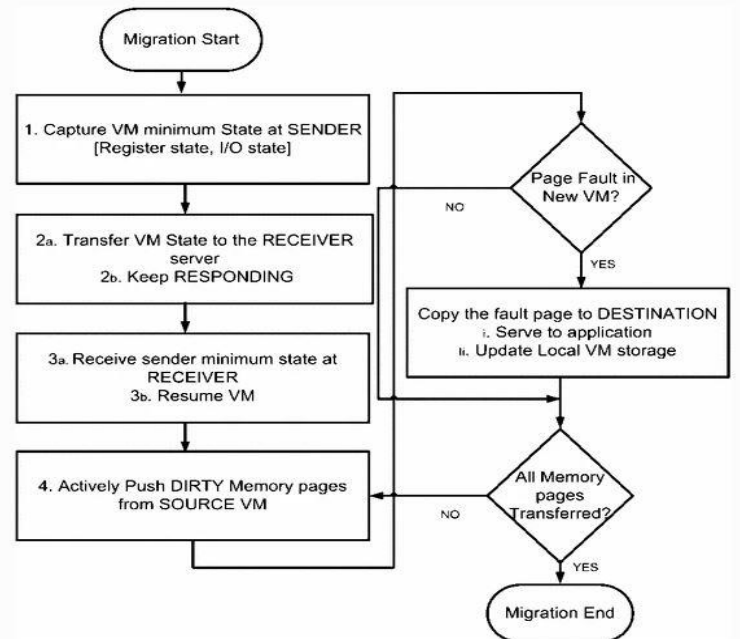
I.   Pre-copy Virtual Machine Migration

A pre-copy Virtual Machine migration pattern iteratively copies intra-servers Virtual Machine`s memory pages until the termination condition is met. In this migration technique relatively total migration time is higher, to transfer dirty pages subsequently network and system resource remains copied for longer time. The whole process consists of several rounds whereas dirty memory pages proactively uploaded on receiver server when dirty pages pushed from source server. Due to fast memory dirtying rate of memory intensive applications relative to available network bandwidth which challenges the pre-copy live migration scheme. An abstract overview process of pre-copy Migration given in figure as follows.
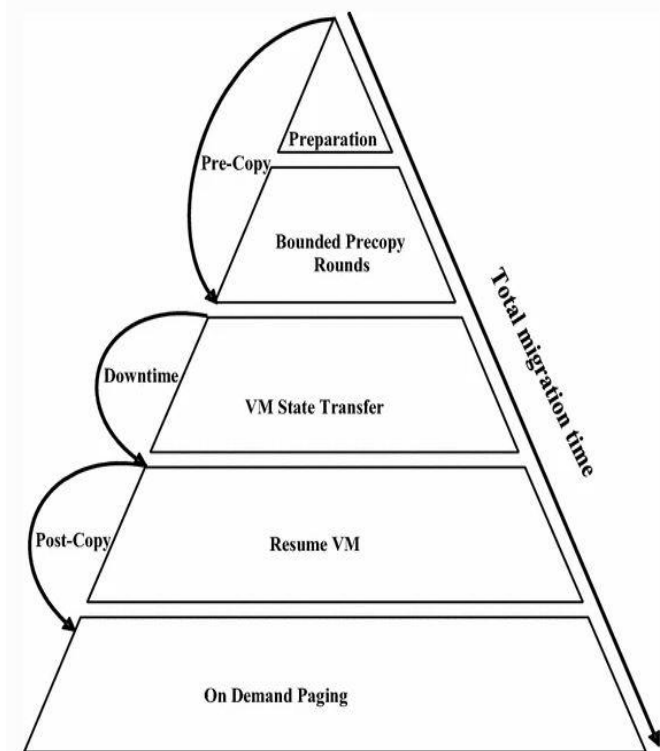

II.   Post-copy Virtual Machine Migration

This migration process is initiated by suspending the Virtual Machine execution at the source server and during suspension stage, the minimum state of Virtual Machine i.e. non-pageable memory, registers, CPU state etc. are captured. After this, the complete Virtual Machine Migration process is divided in three phases. In first phase the captured minimum state is transferred to the target server and during second phase Virtual Machine is resumed with transferred Virtual Machine state at target server. In third phase it fetches memory pages from source server based on read/write request made by migrant application. It is the highest time-consuming stem among three steps and during this phase Virtual Machine service is temporarily suspended until required memory pages are fetched from the source server, based on read/write request of migrant application.
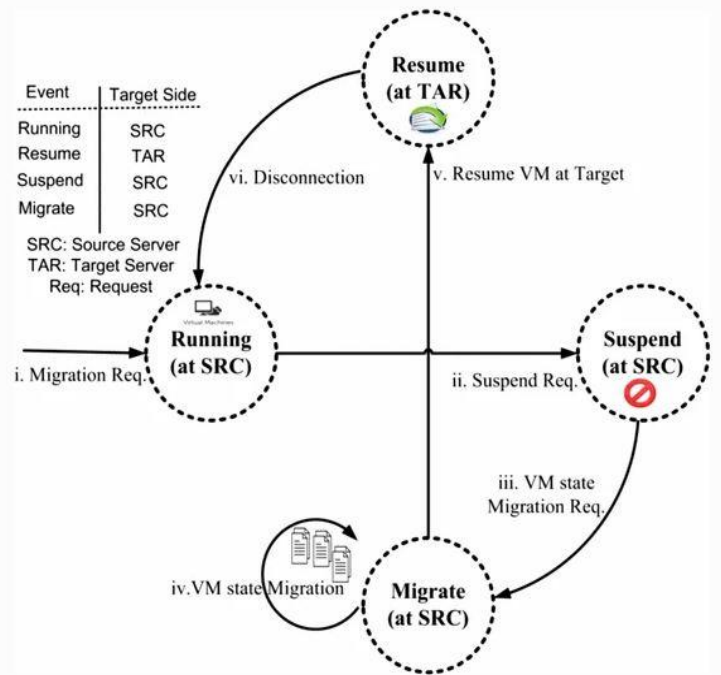
III.   Hybrid Methods

This migration scheme as name suggest combines the properties of both post-copy and pre-copy Virtual Machine Migration schemes to improve migration performance. If we compare this process with post-copy migration pattern, the hybrid scheme exploits bounded pre-copy rounds to transfer and identify Virtual Machine working set to reduce the network I/O page fault rate. After the completion of bounded pre-copy rounds post-copy method captures and transfers the minimum state to target server to resume Virtual Machine. Hybrid migration process completed in five phases which are preparation, bounded pre-copy rounds, Virtual Machine state transfer, resumption and on demand paging.
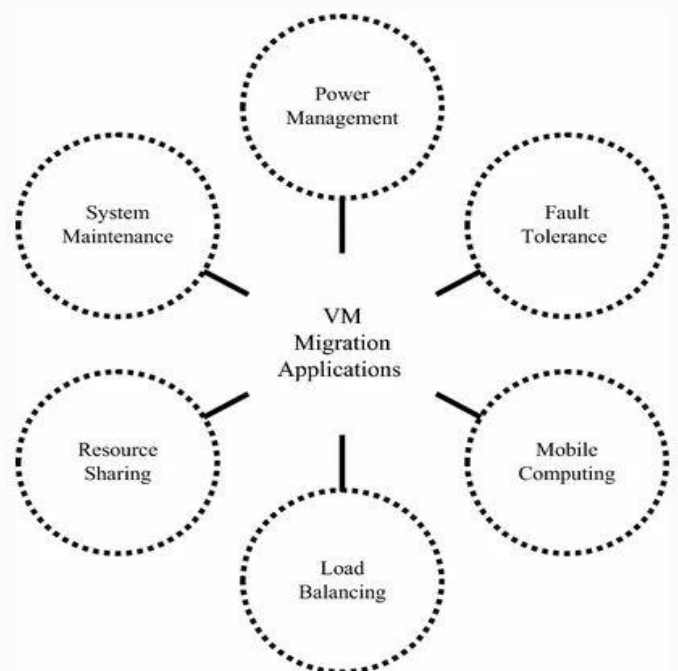
An abstract view of Non-live VM Migration is in fig as follows.

Virtual Machine suspends a running application when it receives a migration request and during the suspend state the hypervisor estimates and reserves required system resources for the Virtual Machine at the receiver end. The source server`s hypervisor, migrates Virtual Machine`s memory until all memory pages reaches the receiver server. Virtual Machine enters into the resume state when complete memory is transferred, to restart Virtual Machine at the receiver end. When Virtual Machine is resumed, the connection with the source is demolished.

Applications of VM Migration

Live Virtual Machine migration is required to full fill the running application resource demand.

Non-live Virtual Machine Migration

In Non-live migration process, the application execution discontinues while migrating the memory stare from source to destination server. It doesn`t resume the Virtual Machine at target server until complete Virtual machine is transferred. The Process migration leads to the foundation for non-live Virtual Machine migration pattern i.e. in non-live migration pattern as compared to Process migration migrate application along with all its execution states to remove the issue of residual dependency. Due to server disconnection during migration process in Non-Live migration schemes such as Process Domain and Internet Suspend Resume lead to the degradation of application QoS, specially for interactive web applications. Coming to advantages it offers guarantee that memory pages are transferred exactly once and predictable migration time during the migration process.

Threats in live Virtual Machine migration

As the popularity of cloud computing increases, hackers also put their attention towards this by finding new ways to attack on consumer`s data or on cloud services, who may range from Denial-of-Service (DoS) to Man-In-The-Middle (MITM) attackers. It is one of the critical factors that needs to be more examination when Virtual Machine migration is being considered because, it discourages many sectors like medical, financial and government to take service of live migration. When the migration is under-process, here can be many active and passive attacks possible. Few of them are listed below:

I. Bandwidth Stealing: Hacker may steal the network bandwidth by hacking the source Virtual Machine and migrate it to the destination.

II. Active manipulation: Hackers can modify the data which is travelling from server to server.

III. Falsely advertising: The hackers may advertise false information of resources over network and that can attract others for migrating their Virtual Machines towards hacker`s end.

For preventing and detecting such hacks, there are several cryptographic algorithms available which are used for encryption and decryption of data. There are some precautions must be taken when migration process is initiated, at the both source and target end:

1. The authenticated person only should initiate the migration process.
2. The entire migration information must be kept confidential.

3. Security among various entities at every step must be preserved.

4. There can be intelligent fraud detection system.

Fail and Error in VM Migration

1. Cannot migrate a virtual machine.
2. Migrating a virtual machine fails
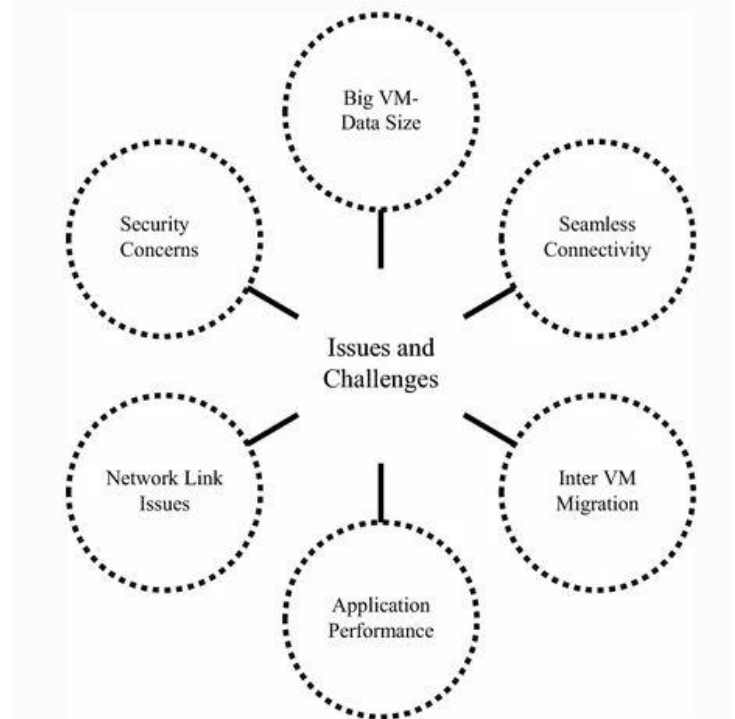3. You will see the error of the form:

```
The VM failed to resume on the
destination during early power on: Cause
```

The Cause `can be one` of the following:

1. Cannot allocate memory.
2. No such device.
3. The file specified is not a virtual disk.
4. Insufficient permission to access file.
5. The destination file system does not support large files.
6. Failed to lock the file.
7. Could not open/create change tracking file.

Research issues and Challenges

In this section we will discusses the challenges and research issues in Virtual Machine migration. The significant domains required in developing optimal Virtual Machine migration schemes for cloud computing are shown in figure below:

Live migration migrates the Virtual Machine without disconnecting with the client. Accuracy and Performance of live Virtual Machine migration must be very high and migration process must be seamless for providing the continuous services. Preset techniques face many challenges when migrating the data intensive applications and memory such as consumption of bandwidth, cloud resources overloading and network faults. Some common and basic challenges that hamper live migration are: transfer rate, page re-send problem, missing page problem, migration over WAN network, migration of VM with the larger application, resources availability problem and address-wrapping problems.

CONCLUSION

In this paper we have discussed the concept of virtualization and Virtual Machine Migration, importance of Cloud Computing in IT industry, Virtual Machine Migration scheme, errors, fail and challenges in live Virtual Machine Migration scheme.

Virtual Machine migration process is very expensive and leads to adequate system resource required to handle the unpredictable traffic, workload, large virtual machines, possibility of violation of Service Level Agreements (SLA) and specially the performance of co-resident applications that are adversely affected in case of inappropriate virtual machine migration process management. Due to this many optimization techniques have been proposed to assist data centers operators with optimizing resource utilization technologies to reduce virtual machine migration errors. The pre-copy migration scheme improves application performance by optimizing the stop-and-copy phase during iterative memory transfer rounds whereas, the post-copy-based migration patterns improves application performance by pre-fetching memory pages to the receiver end to reduce network I/O page faults. Both the migration schemes pre-copy and post-copy perform well when hosting read and write intensive application respectively. The migration over WAN links suffers on account of limited shared bandwidth and a need for network connection redirection and storage migration.

The challenges faced by Virtual Machine migration schemes are very dynamic like system workload, memory size, degree of SLA violation, Cloud resource heterogeneity, unpredictable workload nature and computationally expensive migration schemes etc. The sized Virtual Machine memory increases the migration time and service downtime. Including optimization methods like fine granular deduplication, memory contents compression and dynamic write throttling instrumentation improves application performance at the cost of required system resources. Security is another major threat to the Virtual Machine migration process and it can be safeguarded by preventing compromised entities' access, isolating Virtual Machine`s boundaries and securing the network connections.

Future Work

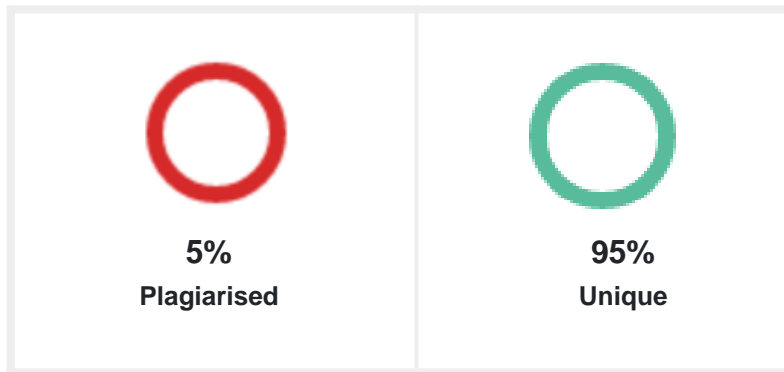There is no doubt that the future of Cloud Computing is bright, productive and full of aspirations.

In future work, in Virtual Machine migration, we will propose a novel approach which would be able to reduce service downtime and total migration time. We will also optimize the migration techniques in the hypervisor to improve the performance, security and reduce error of the live Virtual Machine migration.

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Abstract— This term paper furnishes a survey on fail safe virtual machine migration. In last few decades virtualization technology effectively handling the growing demand of computing, communication and storage resources in big Cloud Data Centers. Virtualization creates abstract form of resources such as server, storage, network, virtual computer hardware platform etc. In a large-scale cloud-based data centers, many Physical Machines hosts dozens of Virtual Machines which are used by various users and running different applications. Virtual Machine load measured according to use of various applications and resources used by Clint and traffic. Sometimes this load due to high traffic, overloading the Virtual Machine`s resources. Since, the Physical Machines which is hosts the Virtual Machines have limited resources and if they overload, they might fail or their performance may decrease. In this situation we need to migrate the heavily the heavily overloaded Physical Machine to a underloaded Physical Machine in order to handle the load and traffic in data centers. This migration needs a clear mechanism to control user traffic and load on both source and destination Physical Machines in order to provide a dedicated bandwidth that needed for VM migration. Virtual Machine Migration needs intelligent approaches to avoid saturating bandwidth problem and minimize the server downtime, because it is a very resource intensive process. Hence this migration process adversely affects the efficiency of data centers and reduce the performance of running applications, especially when critical business objectives and Service Level Arguments are to be met. As every coin has two faces Virtual Machine Migration also has its pros which is drastically increasing the capabilities of cloud data centers to handle robust situations. This process helps to achieve different resource management goals such as power management, load balancing, online system maintenance, proactive fault tolerance and resource sharing etc. I. INTRODUCTION Virtual Machine Migration is similar to the process of Teleportation because in simple words it is the task of moving a Virtual Machine from one Physical Machine`s environment to another Physical Machine`s environment with its state and all resources. In this way it is a part of hardware virtualization systems. Due to vast and elastic capabilities Cloud Computing has revolutionized the IT world and its resources become simple to use and powerful in terms of processing capability, storage capacity and time efficiency which attracts the clients and developers to use its resources. Due to this increasing demand of IT resources, draw the attention of Service Providers and Researchers to share these resources among clients and end users in order to efficient resource utilization for maximizing the profit. In Cloud based environments services are delivered in the form of platforms, hardware resources, software, database, infrastructure and much more information using IBM smart cloud, Microsoft Azure, Amazon`s EC2, Google App Engine etc. Virtualization technology was developed in 1960 by IBM in order to maximize the hardware resource utilization of powerful and expensive mainframe computers. It is provided by a Virtual Machine Monitor or Hypervisor which is a thin layer of software running between operating system (OS) and systems hardware that control, manage and maps multifarious Virtual Machines on a unit platform. It is also a complete hardware and software stack which is fulfilling the incoming request or provide services to the users. The role of Virtual Machine Migration is binary, first is to improve the resource utilization and second is to increase the Service Provider`s profit. This term paper starts with a brief discussion of Virtualization, Virtual Machine Migration, its benefits, background and then a detailed discussion on Virtual Machine Migration Schemes, threats, Error and failure cause in Virtual Machine Migration and finally, a conclusion, future work and references. II. VM Migration Schemes LIVE VM Migration Live Virtual Machine Migration is an important Virtualisation feature in which a running Virtual Machine is moved between various Physical host machines with scurce Virtual Machine`s CPU state, storage, memory, and network resource completely moved to the target host without disturbing the clint and running applicatons. However, this migration can consume significant bandwidth of 500 Mb/s for 10 seconds for a trivial server, therefore these non-negotiable aspects need to be concider when scheduling migration. Hgher trafic and workload in order to network bandwidth intensive migration can cause network

congestion. Live Migration method services the running applications un-interruptedly during the elapsed Virtual Machine Migration time. The goal of live migration method includes the optimization of application performance during migration process, increasing the bandwidth utilizing efficiency and minimize downtime. The bandwidth optimization process augments the application`s QoS when putting extra load on system`s resources such as CPU cycles. I. Pre-copy Virtual Machine Migration A pre-copy Virtual Machine migration pattern iteratively copies intra-servers Virtual Machine`s memory pages until the termination condition is met. In this migration technique relatively total migration time is higher, to transfer dirty pages subsequently network and system resource remains copied for longer time. The whole process consists of several rounds whereas dirty memory pages proactively uploaded on receiver server when dirty pages pushed from source server. Due to fast memory dirtying rate of memory intensive applications relative to available network bandwidth which challenges the pre-copy live migration scheme. An abstract overview process of pre-copy Migration given in figure as follows. II. Post-copy Virtual Machine Migration This migration process is initiated by suspending the Virtual Machine execution at the source server and during suspension stage, the minimum state of Virtual Machine i.e. non-pageable memory, registers, CPU state etc. are captured. After this, the complete Virtual Machine Migration process is divided in three phases. In first phase the captured minimum state is transferred to the target server and during second phase Virtual Machine is resumed with transferred Virtual Machine state at target server. In third phase it fetches memory pages from source server based on read/write request made by migrant application. It is the highest time-consuming stem among three steps and during this phase Virtual Machine service is temporarily suspended until required memory pages are fetched from the source server, based on read/write request of migrant application.

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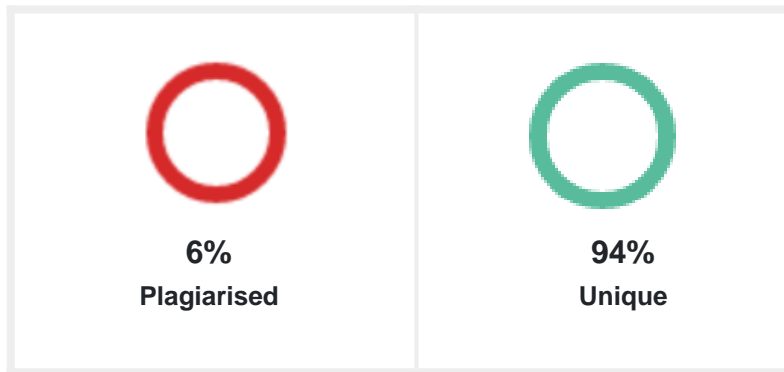https://link.springer.com/article/10.1186/s13677-017-0092-1

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III. Hybrid Methods This migration scheme as name suggest combines the properties of both post-copy and pre-copy Virtual Machine Migration schemes to improve migration performance. If we compare this process with post-copy migration pattern, the hybrid scheme exploits bounded pre-copy rounds to transfer and identify Virtual Machine working set to reduce the network I/O page fault rate. After the completion of bounded pre-copy rounds post-copy method captures and transfers the minimum state to target server to resume Virtual Machine. Hybrid migration process completed in five phases which are preparation, bounded pre-copy rounds, Virtual Machine state transfer, resumption and on demand paging. Non-live Virtual Machine Migration In Non-live migration process, the application execution discontinues while migrating the memory stare from source to destination server. It doesn`t resume the Virtual Machine at target server until complete Virtual machine is transferred. The Process migration leads to the foundation for non-live Virtual Machine migration pattern i.e. in non-live migration pattern as compared to Process migration migrate application along with all its execution states to remove the issue of residual dependency. Due to server disconnection during migration process in Non-Live migration schemes such as Process Domain and Internet Suspend Resume lead to the degradation of application QoS, specially for interactive web applications. Coming to advantages it offers guarantee that memory pages are transferred exactly once and predictable migration time during the migration process. An abstract view of Non-live VM Migration is in fig as follows. Virtual Machine suspends a running application when it receives a migration request and during the suspend state the hypervisor estimates and reserves required system resources for the Virtual Machine at the receiver end. The source server`s hypervisor, migrates Virtual Machine`s memory until all memory pages reaches the receiver server. Virtual Machine enters into the resume state when complete memory is transferred, to restart Virtual Machine at the receiver end. When Virtual Machine is resumed, the connection with the source is demolished. Applications of VM Migration Live Virtual Machine migration is required to full fill the running application resource demand. Threats in live Virtual Machine migration As the popularity of cloud computing increases, hackers also put their attention towards this by finding new ways to attack on consumer`s data or on cloud services, who may range from Denial-of-Service (DoS) to Man-In-The-Middle (MITM) attackers. It is one of the critical factors that needs to be more examination when Virtual Machine migration is being considered because, it discourages many sectors like medical, financial and government to take service of live migration. When the migration is under-process, here can be many active and passive attacks possible. Few of them are listed below: I. Bandwidth Stealing: Hacker may steal the network bandwidth by hacking the source Virtual Machine and migrate it to the destination. II. Active manipulation: Hackers can modify the data which is travelling from server to server. III. Falsely advertising: The hackers may advertise false information of resources over network and that can attract others for migrating their Virtual Machines towards hacker`s end. For preventing and detecting such hacks, there are several cryptographic algorithms available which are used for encryption and decryption of data. There are some precautions must be taken when migration process is initiated, at the both source and target end: 1. The authenticated person only should initiate the migration process. 2. The entire migration information must be kept confidential. 3. Security among various entities at every step must be preserved. 4. There can be intelligent fraud detection system. Fail and Error in VM Migration 1. Cannot migrate a virtual machine. 2. Migrating a virtual machine fails 3. You will see the error of the form: The VM failed to resume on the destination during early power on: Cause The Cause can be one of the following: 1. Cannot allocate memory. 2. No such device. 3. The file specified is not a virtual disk. 4. Insufficient permission to access file. 5. The destination file system does not support large files. 6. Failed to lock the file. 7. Could not open/create change tracking file. Research issues and Challenges In this section we will discusses the challenges and research issues in Virtual Machine migration. The significant domains required in developing optimal Virtual Machine migration schemes for cloud computing are shown in figure

below: Live migration migrates the Virtual Machine without disconnecting with the client. Accuracy and Performance of live Virtual Machine migration must be very high and migration process must be seamless for providing the continuous services. Preset techniques face many challenges when migrating the data intensive applications and memory such as consumption of bandwidth, cloud resources overloading and network faults. Some common and basic challenges that hamper live migration are: transfer rate, page re-send problem, missing page problem, migration over WAN network, migration of VM with the larger application, resources availability problem and address-wrapping problems.

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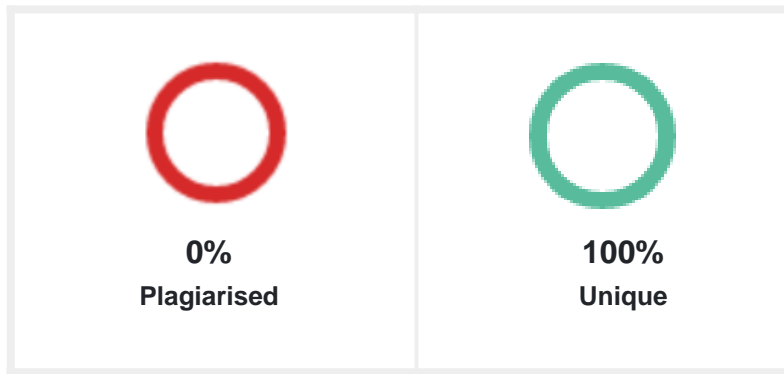... troubleshooting OSPF is no different than troubleshooting any other routing protocol. The cause can be one of the following: ? Missing routing information ...

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