# Virtual Clusters and Resource Management : Live Migration Of VMs

Y. V. Lokeswari AP/ CSE

SSN College of Engineering

Reference: Distributed and Cloud Computing

K. Hwang, G. Fox and J. Dongarra

# Design Issues of Virtual Cluster

- Live Migration Of VMs
- Memory and File Migration
- Dynamic Deployment of Virtual Clusters

# Outline

- Physical and Virtual Cluster
- Green Computing
- Managing Virtual Cluster
- Requirements of VM live Migration
- States of VM
- Live Migration Of VMs
- Performance of Live Migration of VMs.

# Physical Cluster Vs Virtual Cluster

- **Physical Cluster**: Collection of **Physical machines** interconnected by physical network such as **LAN**.
- **Virtual Cluster**: VMs installed at **distributed** servers form one or more **physical clusters**.
- VMs in **Virtual Cluster** are interconnected by **Virtual Network**.

# Virtual Cluster Characteristics

- The virtual cluster nodes can be either **physical** or **virtual** machines. Multiple VMs running with **different OSs** can be deployed on the **same physical** node.
- A VM runs with a **guest OS**, which is often **different** from the **host OS**, that manages the **resources** in the **physical machine**, where the VM is implemented.
- The purpose of using VMs is to **consolidate multiple** functionalities on the same **server**. This will greatly enhance the **server utilization** and **application flexibility**.
- **VMs** can be colonized (**replicated**) in multiple servers for the purpose of promoting **distributed parallelism**, **fault tolerance**, and **disaster recovery**.
- The size (number of nodes) of a **virtual cluster** can **grow** or **shrink** dynamically, similarly to the way an **overlay network** varies in size in a P2P network.
- The **failure** of any **physical** nodes may **disable** some **VMs** installed on the failing nodes. But the **failure** of **VMs** will **not** pull **down** the **host** system.

# Virtual Clusters vs. Physical Clusters

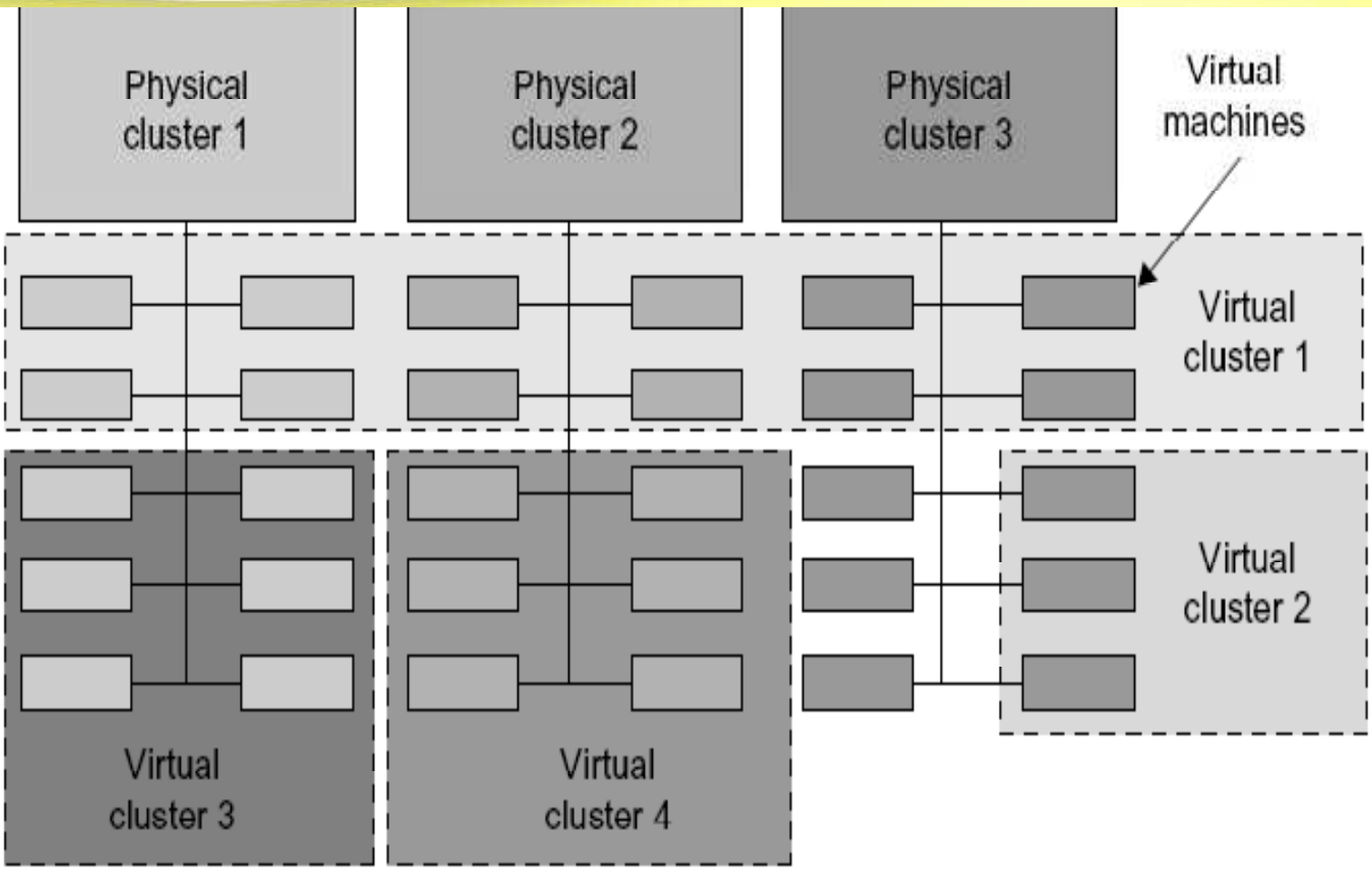


**FIGURE 3.18**

A cloud platform with 4 virtual clusters over 3 physical clusters shaded differently.

# Virtual Cluster

- Large number of VM images might be present, the most important thing is to determine **how** to **store** those **images** in the system efficiently.
- There are **common installations** for most users or applications, such as **operating systems** or user-level **programming libraries**.
- These software packages can be **preinstalled** as **templates** (called **template VMs**).
- With these templates, users can build their own **software stacks**.
- **New OS instances** can be **copied** from the **template** VM.
- User-specific components such as **programming libraries** and **applications** can be **installed** to those **instances**.

# Virtual Clusters vs. Physical Clusters

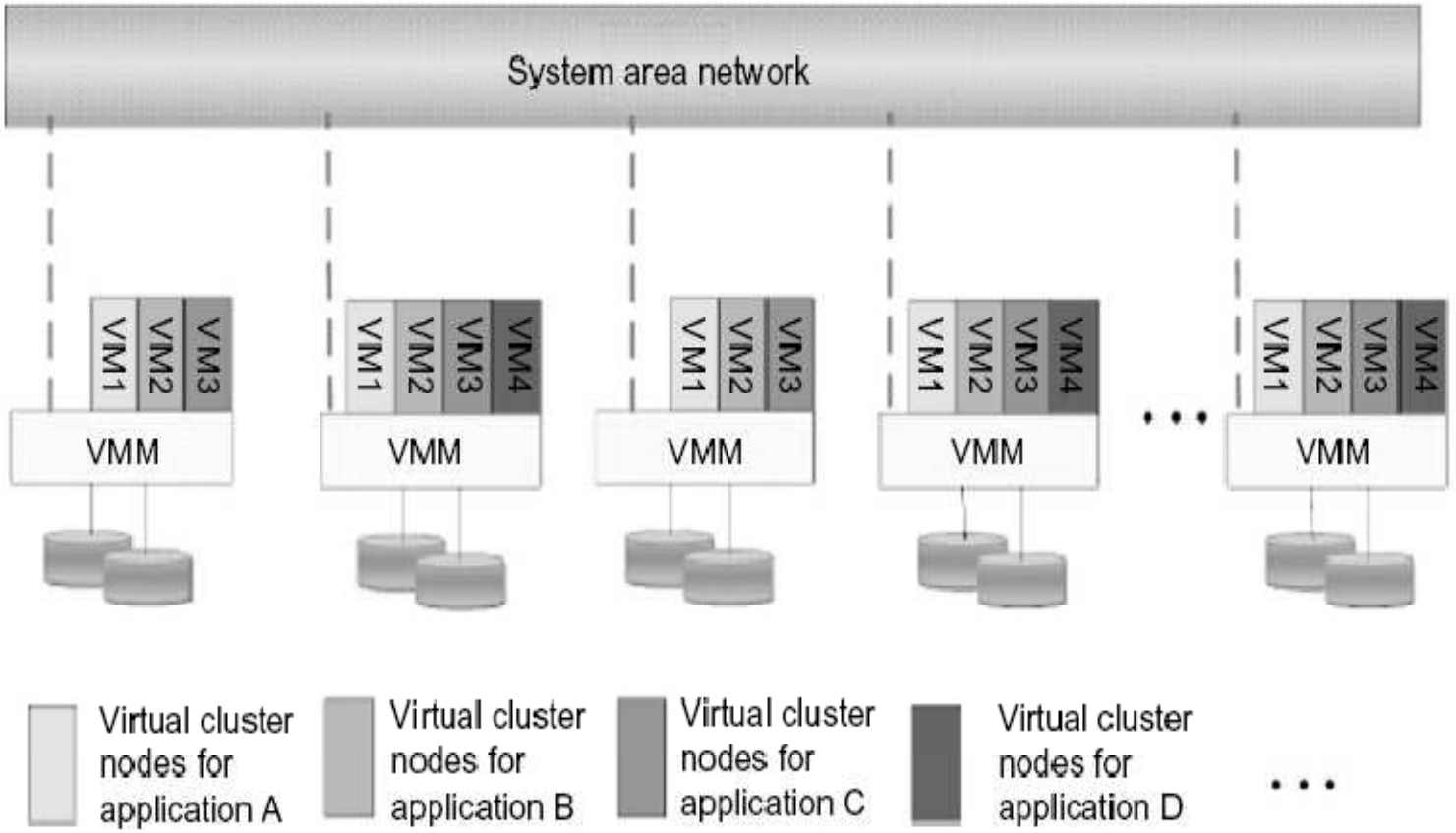


**FIGURE 3.19**

The concept of a virtual cluster based on application partitioning.

*(Courtesy of Kang, Chen, Tsinghua University 2008)*

# Fast Deployment and Effective Scheduling

- **Physical machines** are called as **Host systems**
- **VMs** are called as **Guest systems**.

- **Deployment Involves**: **construct** and **distribute software stacks** (OS, libraries, applications) to a physical node inside clusters as fast as possible

- If one user finishes using his system, the corresponding virtual cluster should **shut down** or **suspend** quickly to **save** the **resources** to **run** other **VMs** for other users.

# Concept of “Green Computing"

- **Green Computing** says **saving energy** cost of components **without affecting performance**.
- saving the energy cost of components in a **single workstation** without a global vision.
- **Cluster-wide** energy-efficient **techniques** can only be applied to **homogeneous workstations** and specific applications.
- The **live migration** of VMs allows workloads of **one node** to transfer to **another node**.
- the challenge is to determine how to **design migration strategies** to implement **green computing without** influencing the **performance** of clusters

# Concept of “Green Computing"

- **Load balancing** of applications in a **virtual cluster**.
- Load balancing can be achieved using the **load index** and **frequency** of **user logins**.
- The **automatic scale-up** and **scale-down** mechanism of a virtual cluster can be implemented based on this model.
- Consequently, we can increase the **resource utilization** of nodes and **shorten** the **response time** of systems

# High-Performance Virtual Storage

- **Storage architecture design** can be applied to **reduce duplicated blocks** in a distributed file system of **virtual clusters**.
- **Hash values** are used to **compare** the **contents** of **data blocks**
- Users store the **identification** of the **data blocks** for corresponding VMs in a user-specific virtual cluster.
- **New blocks** are created when users **modify** the **corresponding data**.
- **Newly** created **blocks** are identified in the **users' profiles**.

# High-Performance Virtual Storage

- Four steps to deploy a group of VMs onto a target cluster: **preparing the disk image, configuring the VMs, choosing the destination nodes, and executing the VM deployment command on every host**
- Use templates to simplify the disk image preparation process.
- A **template** is a **disk image** that includes a **preinstalled operating system** with or without certain application software.
- **Templates** could implement the **COW** (Copy on Write) format.
- A **new COW backup** file is very **small** and **easy** to **create** and **transfer**.
- It definitely **reduces disk space** consumption.

# A Virtual Cluster

- A **cluster** is built with mixed **nodes** of **host** and **guest systems.**
- When a **VM fails**, its role could be **replaced** by **another VM** on a different node, as long as they both run with the **same guest OS**.
- When **Host** system **fails**, move all **VMs** from **one host** to **another**.
- The **advantage** is enhanced **failover flexibility**.
- The potential drawback is that a **VM** must **stop** playing its **role** if its residing host node fails.
- Four ways to manage a virtual cluster- 1. **guest-based manager**, 2. **host-based manager**, 3. **independent cluster manager** on **both** the **host** and **guest** systems, 4. **integrated cluster** on the **guest** and **host** systems

# Managing Virtual Cluster

- Manage a virtual cluster- **Guest-based manager : The** cluster manager **resides** on a **guest system**. In this case, multiple VMs form a virtual cluster.
- Manage a virtual cluster- **Host-based manager :** The cluster manager **resides** on **Host system**. It supervises the **guest systems** and can **restart** the guest system on another physical machine.
- Manage a virtual cluster- **independent cluster manager on both the host and guest systems :** Complex
- Manage a virtual cluster- **integrated cluster on the guest and host systems :** manager must be designed to distinguish between **virtualized resources** and **physical resources**

# VMM Design Requirements

- First, a VMM should provide an environment for programs which is essentially identical to the original machine.
- Second, programs run in this environment should show, at worst, only minor decreases in speed.
- Third, a VMM should be in complete control of the system resources
  - The VMM is responsible for allocating hardware resources for programs.
  - It is not possible for a program to access any resource not explicitly allocated to it.
  - It is possible under certain circumstances for a VMM to regain control of resources already allocated.

Not all processors satisfy these requirements for a VMM. A VMM is tightly related to the architectures of processors. It is difficult to implement a VMM for some types of processors, such as the x86.

# Requirements of Live Migration

- The motivation is to **design** a **live VM migration** scheme with
  - **negligible downtime**
  - **the lowest network bandwidth consumption possible**
  - **a reasonable total migration time**
  - **Migration does not disrupt other active services residing in same host**

# States of VM

- A VM can be in one of below 4 states,
  - **Inactive**
  - **Active**
  - **Paused**
  - **Suspended**

# States of VM

- **Inactive State:** VM is **not enabled**.
- **Active State:** VM that has been **instantiated** at the virtualization platform to **perform** a real **task**
- **Paused State:** VM that has been **instantiated** but **disabled** to **process** a **task** or **paused** in a **waiting state**
- **Suspended State:** A VM enters the **suspended** state if its machine **file** and **virtual resources** are **stored** back to the **disk**

# Live Migration of Virtual Machines

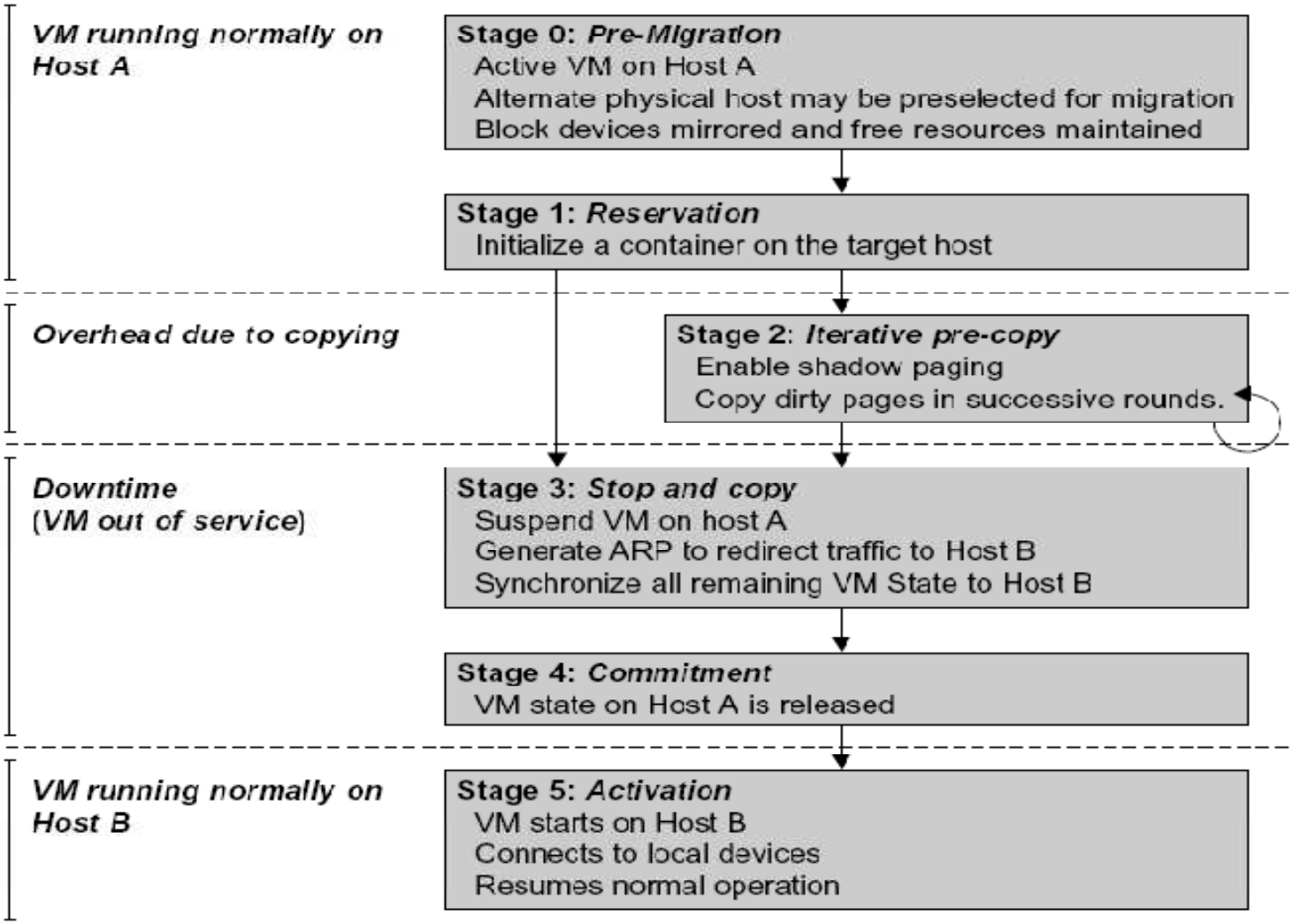


**FIGURE 3.20**

Live migration process of a VM from one host to another.

(*Courtesy of C. Clark, et al. [14]*)

# Performance of Live Migration of VMs

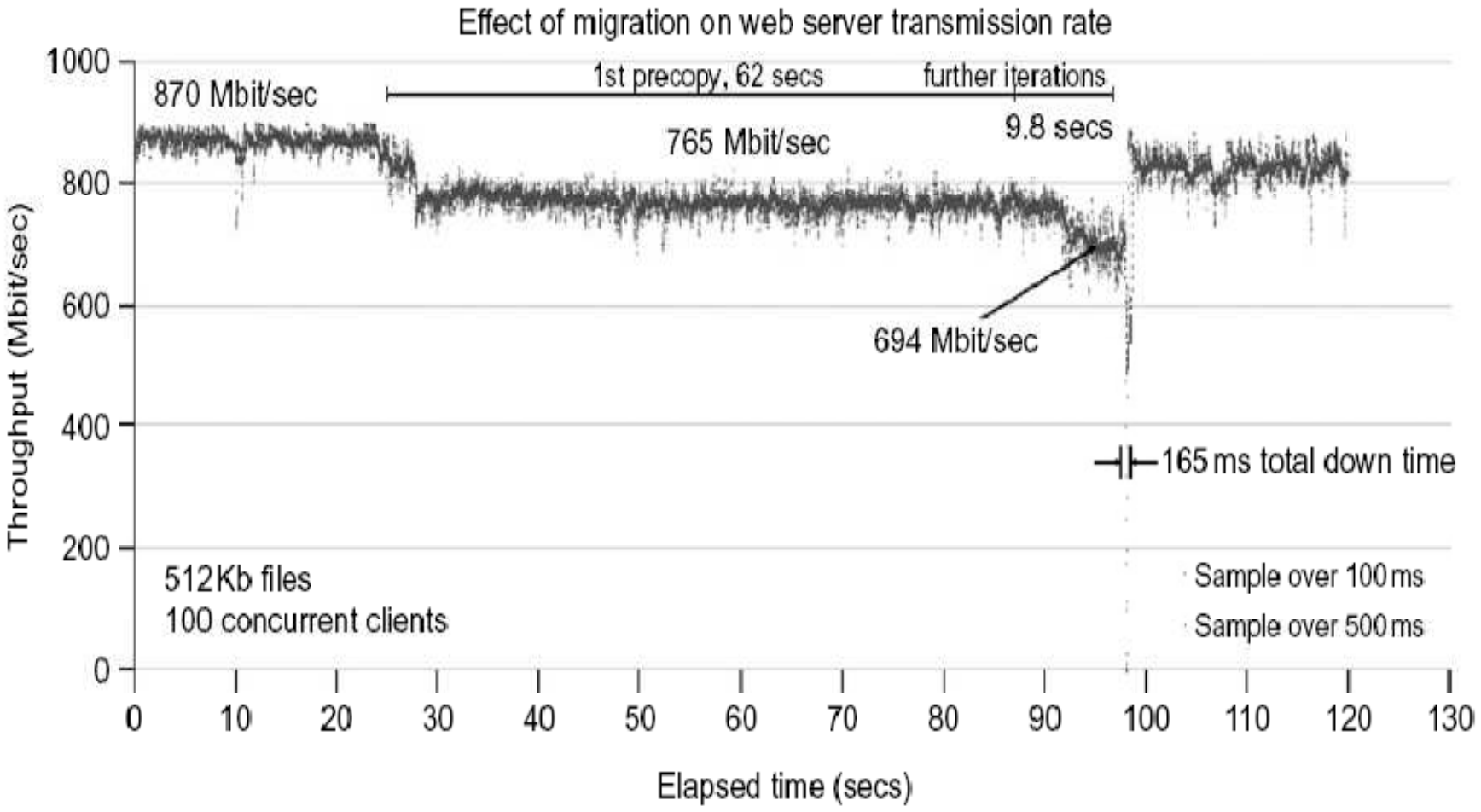


**FIGURE 3.21**

Effect on data transmission rate of a VM migrated from one failing web server to another.

*(Courtesy of C. Clark, et al. [14])*

# Summary

- Physical and Virtual Cluster
- Green Computing
- Managing Virtual Cluster
- Requirements of VM live Migration
- States of VM
- Live Migration Of VMs
- Performance of Live Migration of VMs.

***Thank You***