CS 4037
Introduction to Cloud Computing
Lecture 5

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Cloud Enabling Technologies

Lecture's Agenda

- **Broadband Networks and Internet Architecture**
- Data Center Technology
- Virtualization Technology
- Multitenant Technology

Internet Service Providers (ISPs)

- All clouds must be connected to a network. This inevitable requirement forms an inherent dependency on internetworking.

- Cloud consumers have the option of accessing the cloud using only private and dedicated network links in LANs, although most clouds are Internet-enabled.

- Established and deployed by ISPs, the Internet's largest backbone networks are strategically interconnected by core routers that connect the world's multinational networks.

Internet Service Providers (Cont.)

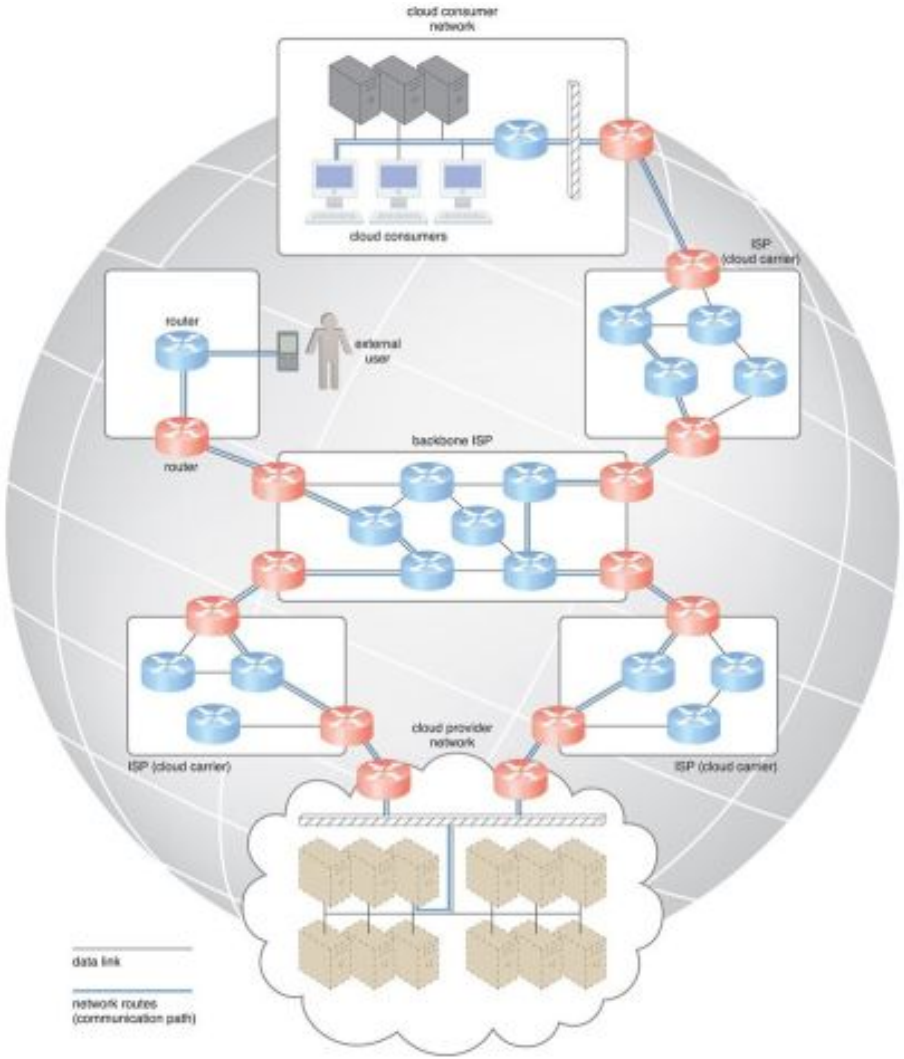

Figure 5.1. Messages travel over dynamic network routes in this ISP internetworking configuration.

Internet Reference Model and Protocol Stack

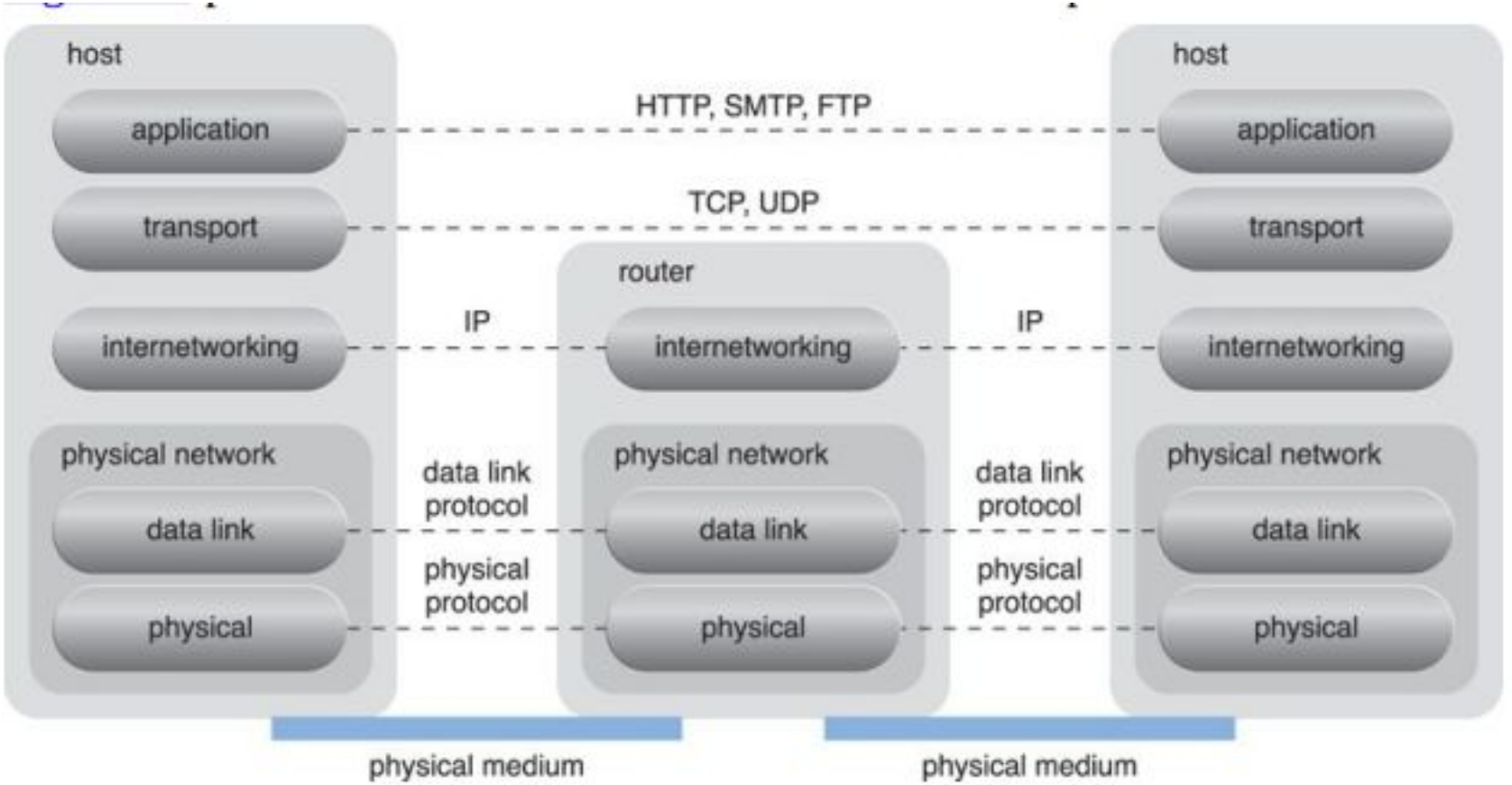

Figure 5.4. A generic view of the Internet reference model and protocol stack.

Broadband Networks and Internet Architecture – Key Points

- Cloud consumers and cloud providers typically use the Internet to communicate, which is based on a decentralized provisioning and management model and is not controlled by any centralized entities.

- The main components of internetworking architecture are connectionless packet switching and router-based interconnectivity, which use network routers and switches.

- Network bandwidth and latency are characteristics that influence QoS, which is heavily impacted by network congestion.

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Data Center Technology

- Grouping IT resources in close proximity with one another, rather than having them geographically dispersed, allows for power sharing, higher efficiency in shared IT resource usage, and improved accessibility for IT personnel.

- These are the advantages that naturally popularized the data center concept.

- Modern data centers exist as specialized IT infrastructure used to house centralized IT resources, such as servers, databases, networking and telecommunication devices, and software systems.

Data Center Technology (Cont.)

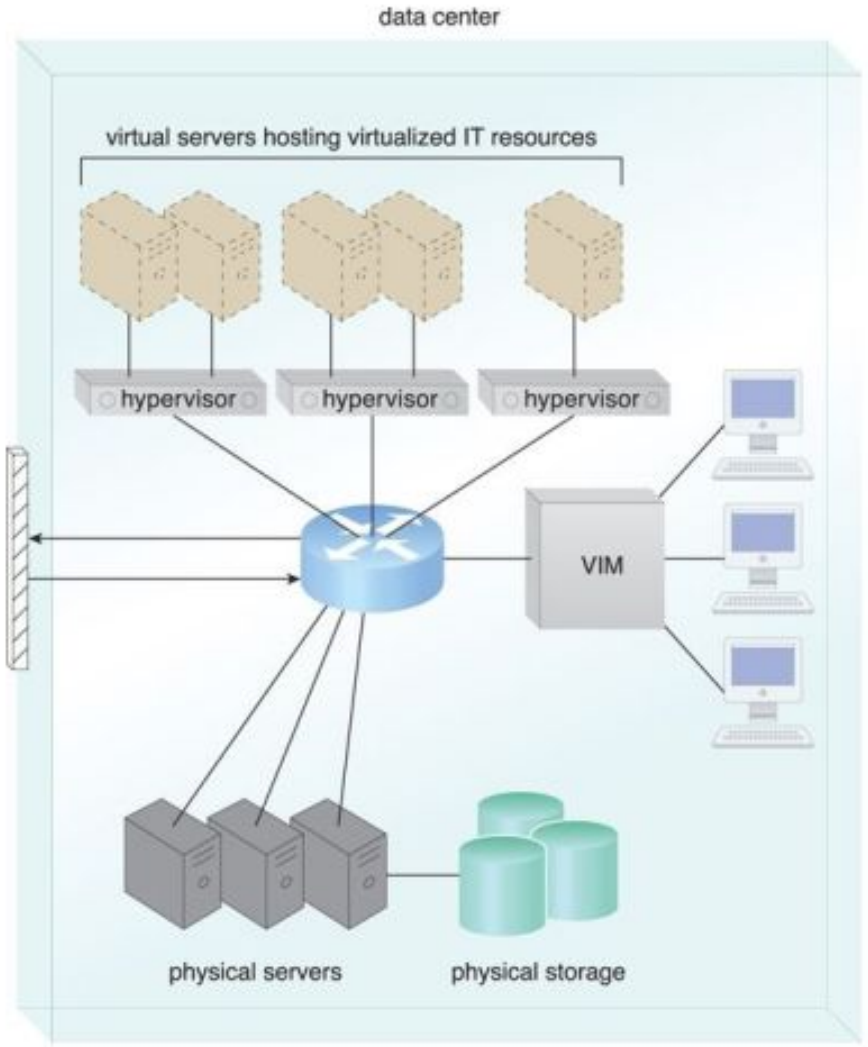
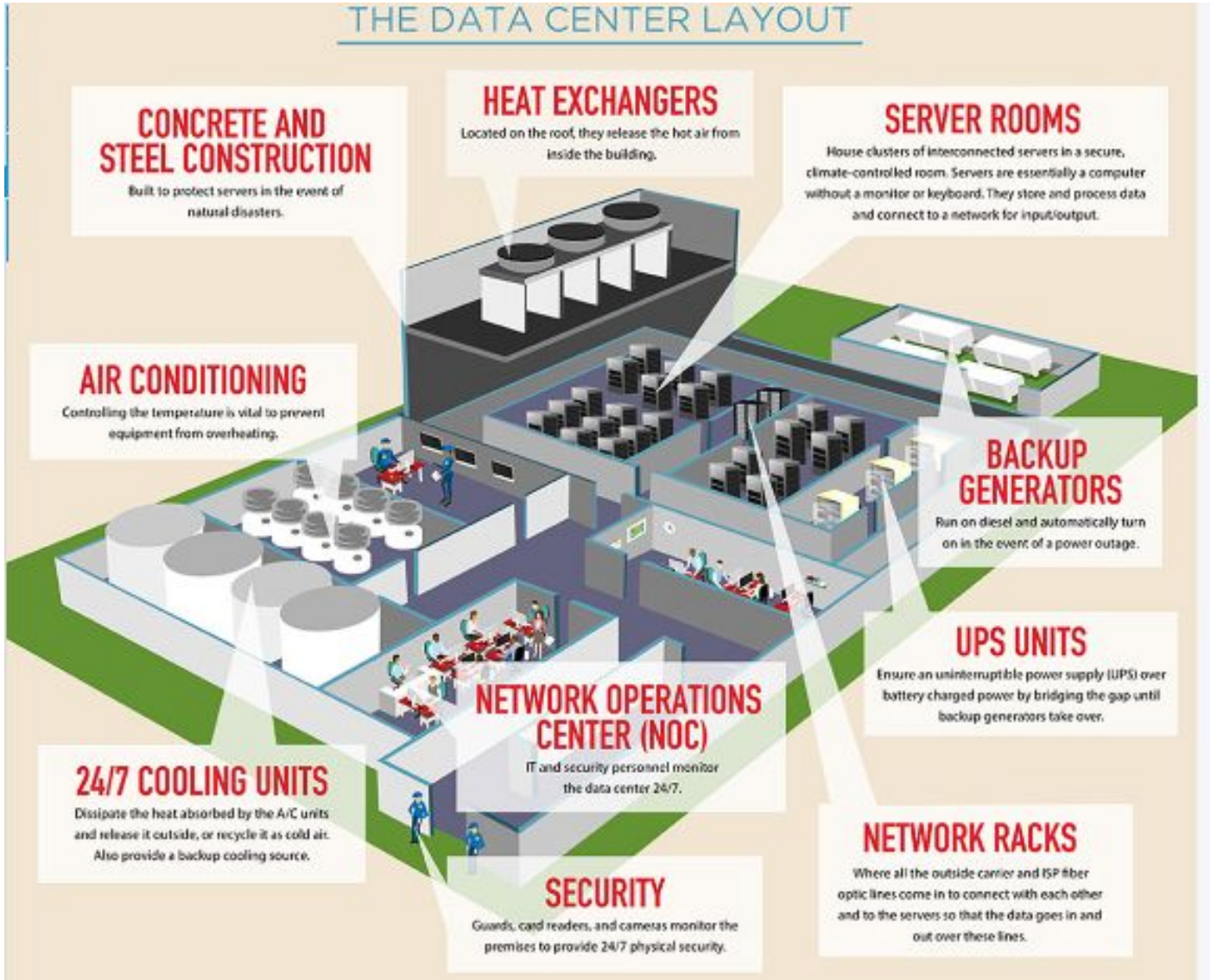


Figure 5.7. The common components of a data center working together to provide virtualized IT resources supported by physical IT resources.

Data Center Technology (Cont.)



Data Center Technology – Key Points

- A data center is a specialized IT infrastructure that houses centralized IT resources, such as servers, databases, and software systems.

- Data center IT hardware is comprised of standardized commodity servers of increased computing power and storage capacity, while storage system technologies include disk arrays and storage virtualization.

Data Center Technology – Key Points

- Technologies used to increase storage capacity include Direct Attached Storage (DAS), Storage Area Network (SAN), and Network Attached Storage (NAS).

- Computing hardware technologies include rack-mounted server arrays and multi-core CPU architectures, while specialized high-capacity network hardware and technology, such as content-aware routing, LAN and SAN fabrics, and NAS gateways, are used to improve network connectivity.

- Reading Assignment: DAS, SAN and NAS.

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Virtualization Technology

- Virtualization is the process of converting a physical IT resource into a virtual IT resource.
- Most types of IT resources can be virtualized, including:
  - Servers – A physical server can be abstracted into a virtual server.
  - Storage – A physical storage device can be abstracted into a virtual storage device or a virtual disk.
  - Network – Physical routers and switches can be abstracted into logical network fabrics, such as VLANs.
  - Power – A physical UPS and power distribution units can be abstracted into what are commonly referred to as virtual UPSs.
- Virtual servers are created as virtual disk images that contain binary file copies of hard disk content.

Hardware Based Virtualization

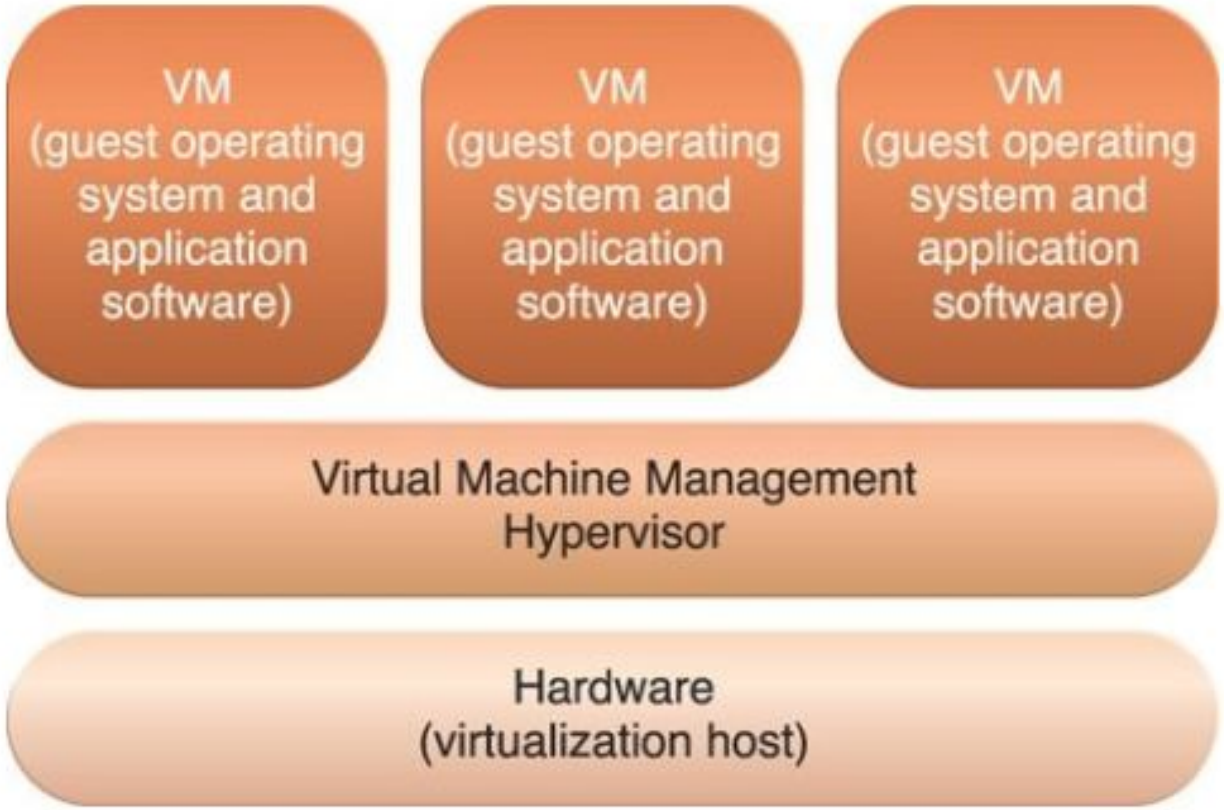

Figure 5.9. The different logical layers of hardware-based virtualization, which does not require another host operating system.

Operating System Based Virtualization

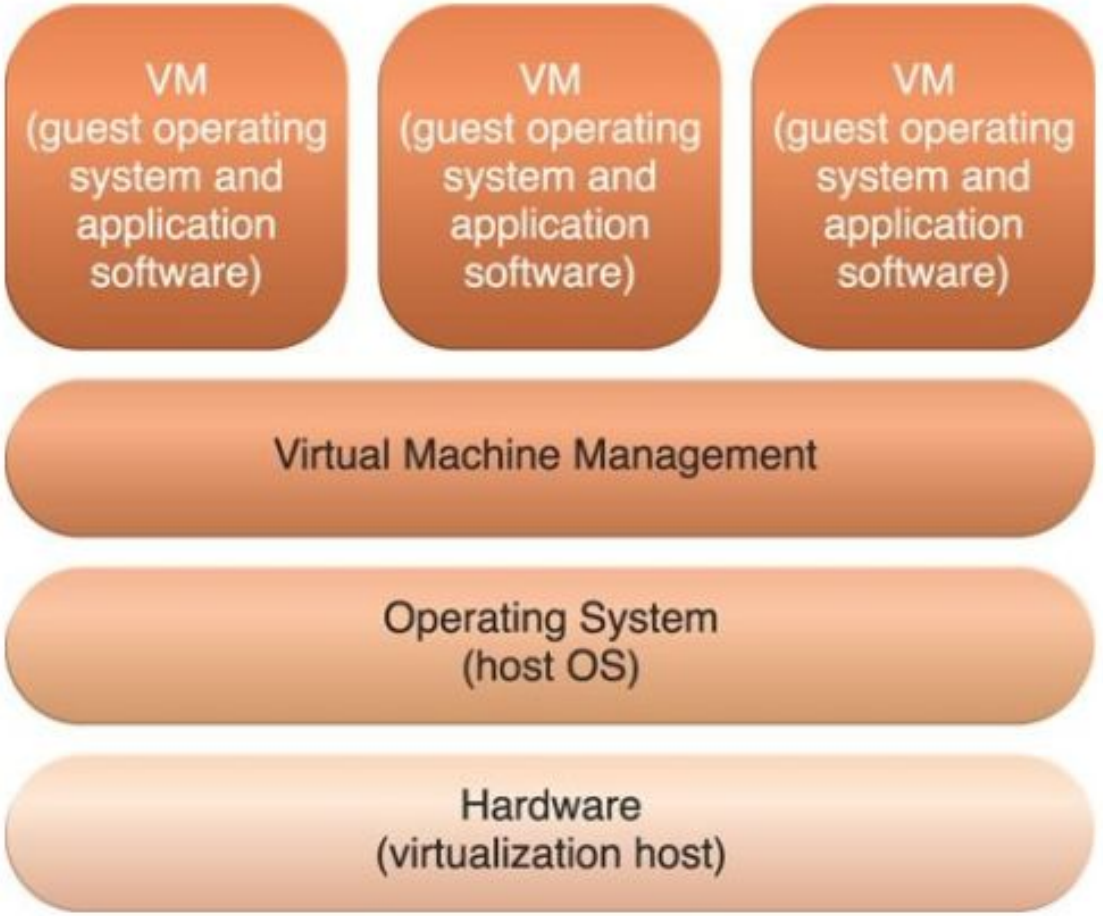

Figure 5.8. The different logical layers of operating system-based virtualization, in which the VM is first installed into a full host operating system and subsequently used to generate virtual machines.

Virtualization Technology – Key Points

- Server virtualization is the process of abstracting IT hardware into virtual servers using virtualization software.

- Virtualization provides hardware independence, server consolidation, and resource replication, and further supports resource pooling and elastic scalability.

- Virtual servers are realized through either operating system-based or hardware-based virtualization.

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Multitenant Technology

- **With multitenant technology, tenants can individually customize features of the application, such as:**
  - **User Interface – Tenants can define a specialized "look and feel" for their application interface.**
  - **Business Process – Tenants can customize the rules, logic, and workflows of the business processes that are implemented in the application.**
  - **Data Model – Tenants can extend the data schema of the application to include, exclude, or rename fields in the application data structures.**
  - **Access Control – Tenants can independently control the access rights for users and group**

Characteristics of Multitenant Applications

Usage Isolation:

- The usage behavior of one tenant does not affect the application availability and performance of other tenants.

Data Security:

- Tenants cannot access data that belongs to other tenants.

Recovery:

- Backup and restore procedures are separately executed for the data of each tenant.

Characteristics of Multitenant Applications (Cont.)

Application Upgrades:

- Tenants are not negatively affected by the synchronous upgrading of shared software artifacts.

Scalability:

- The application can scale to accommodate increases in usage by existing tenants and/or increases in the number of tenants.

Metered Usage:

- Tenants are charged only for the application processing and features that are actually consumed.

Multitenant Technology

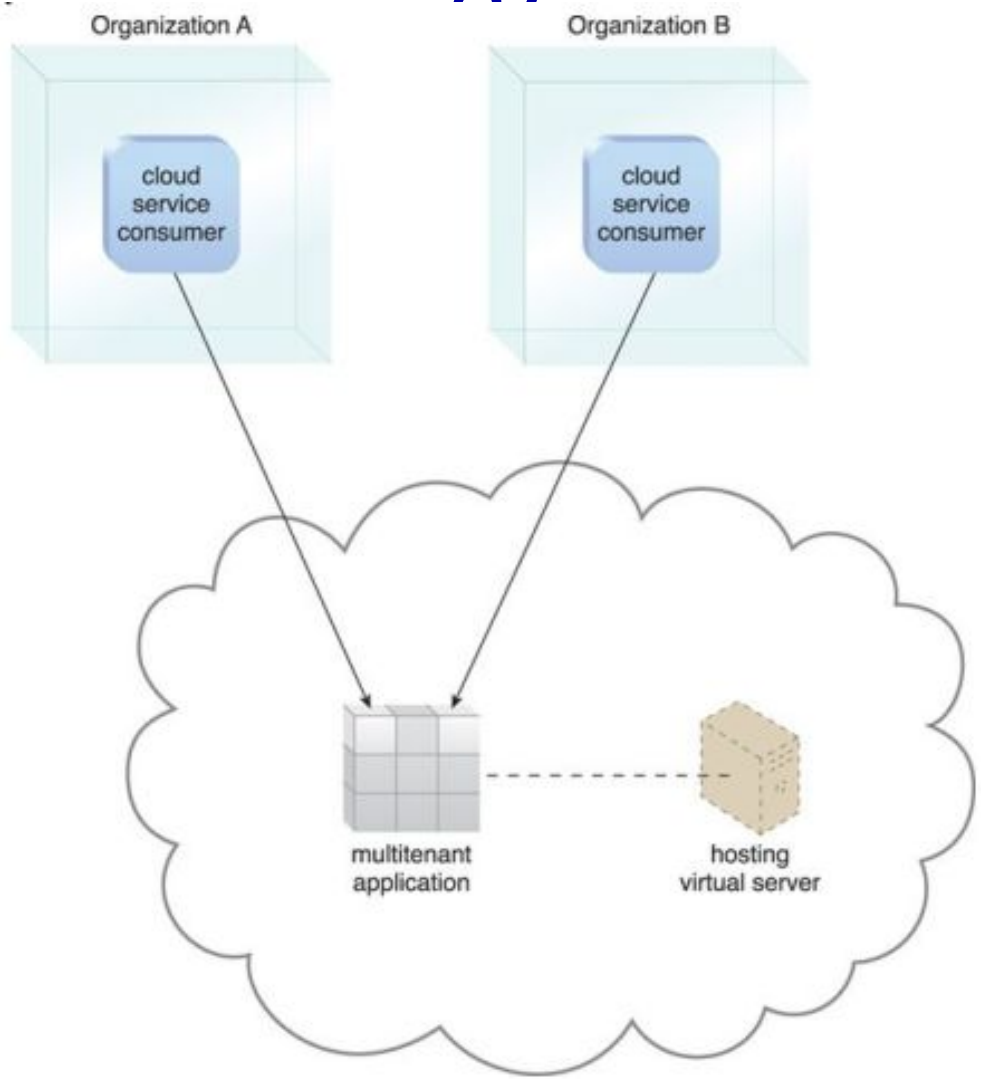

Figure 5.11. A multitenant application that is serving multiple cloud service consumers simultaneously.

Reading Assignment

- **Book Reading Assignment**

  - **5.7 Case Study Example**

Additional Resources

- **Cloud Computing – Concepts, Technology, and Architecture by Thomas Erl, Zaigham Mahmood, and Ricardo Puttini**

  - **Chapter 5: Cloud Enabling Technologies**

Questions?