18CSE07 & CLOUD COMPUTING

UNIT-II

CLOUD ENABLING TECHNOLOGIES

Data Center Technology – Virtualization Technology– Web Technology– Multitenant Technology– Service Technology– Case study : VM installation and deployment

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.
- Data centers exist as specialized IT infrastructure used to house centralized IT resources, such as servers, databases, networking and telecommunication devices, and software systems.
- It is where the cloud service provider (CSP) stores and processes vast amounts of data and runs various software applications and services.
- Data centers are typically comprised of the following technologies and components:
  - Virtualization
  - Standardization and Modularity
  - Automation
  - Remote Operation and Management
  - High Availability
  - Security-Aware Design, Operation, and Management
  - Facilities
  - Computing Hardware
  - Storage Hardware
  - Network Hardware
  - Other considerations

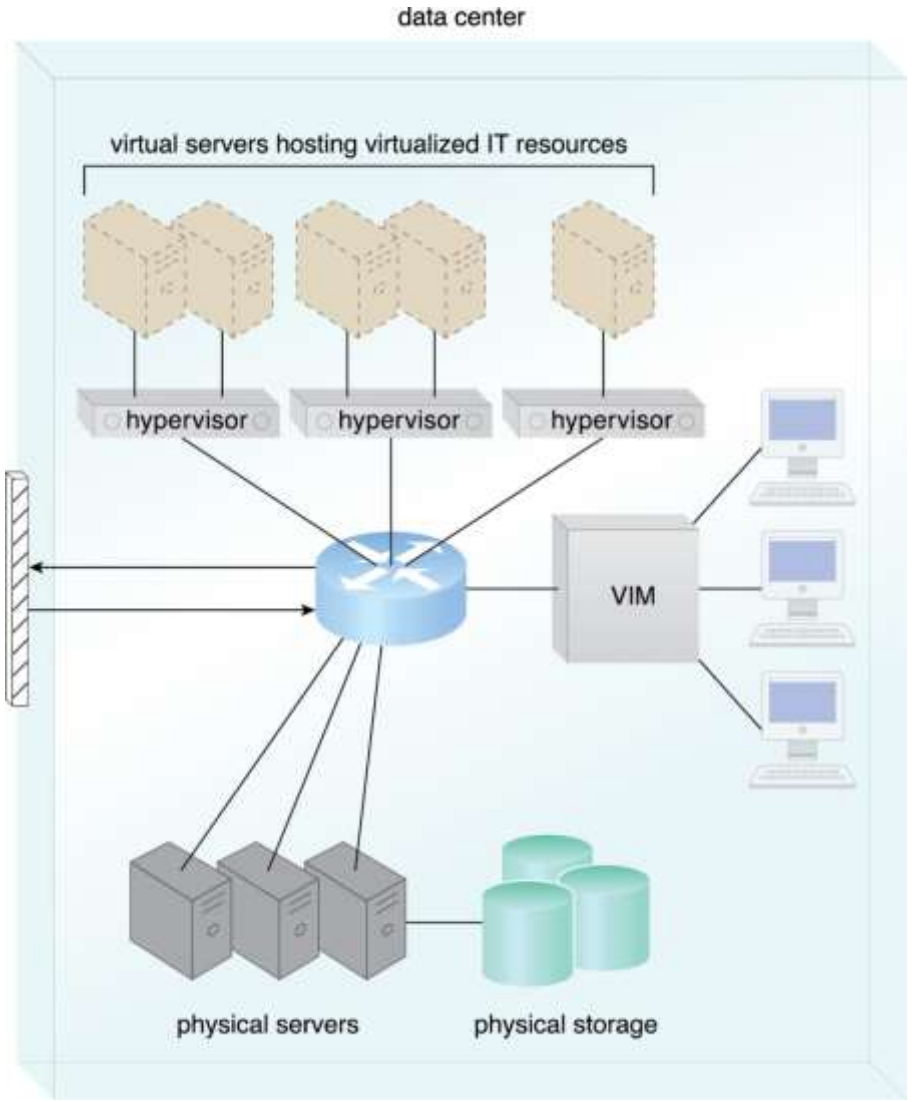
Virtualization

- Most important characteristics of cloud infrastructure
- Presents logical view of the original things
- In real time scenario where an user opens “my computer” icon, there appear some hard drive partitions say Local Disk (:C), (:D), (:E) and so on. The partition is the logical division of a hard disk drive to create user friendly view of multiple numbers of separate hard drives.
- Is there really multiple number of separate hard drives?
- It is an only single device. Hence Virtualization is a technique by which creation of logical view of actual things can be undertaken.
- In cloud computing environment, there are multiple number of servers connected through a network that makes an environment through virtualization technique that creates an interface on which user can access the data, and can deploy their applications but they don’t need to know the underlying process like our hard drive example.

Another example: virtual memory – Logically they are using main memory but actually they are using disk memory. User doesn’t know the underlying process

Virtualization

- Data centers consist of both physical and virtualized IT resources.
- Virtualized components that are easier to allocate, operate, release, monitor, and control.
- Data centers in cloud computing also employ virtualization technologies, which enable the efficient utilization of hardware resources by running multiple virtual machines (VMs) or containers on a single physical server.
- This consolidation of resources helps optimize performance, reduce costs, and enhance the overall efficiency of the data center.



The common components of a data center working together to provide virtualized IT resources

Standardization and Modularity

- Data centers are built upon standardized commodity hardware and designed with modular architectures, aggregating multiple identical building blocks of facility infrastructure and equipment to support scalability, growth, and speedy hardware replacements.
- Modularity and standardization are key requirements for reducing investment and operational costs as they enable economies of scale for the procurement, acquisition, deployment, operation, and maintenance processes.

- Consolidated IT resources can serve different systems and be shared among different cloud consumers.

Automation

- Data centers have specialized platforms that automate tasks like provisioning, configuration, patching, and monitoring without supervision.
- Advances in data center management platforms and tools leverage autonomic computing technologies to enable self-configuration and self-recovery.

Remote Operation and Management

- Most of the operational and administrative tasks of IT resources in data centers are commanded through the network's remote consoles and management systems.
- Technical personnel are not required to visit the dedicated rooms that house servers, except to perform highly specific tasks, such as equipment handling and cabling or hardware-level installation and maintenance.

High Availability

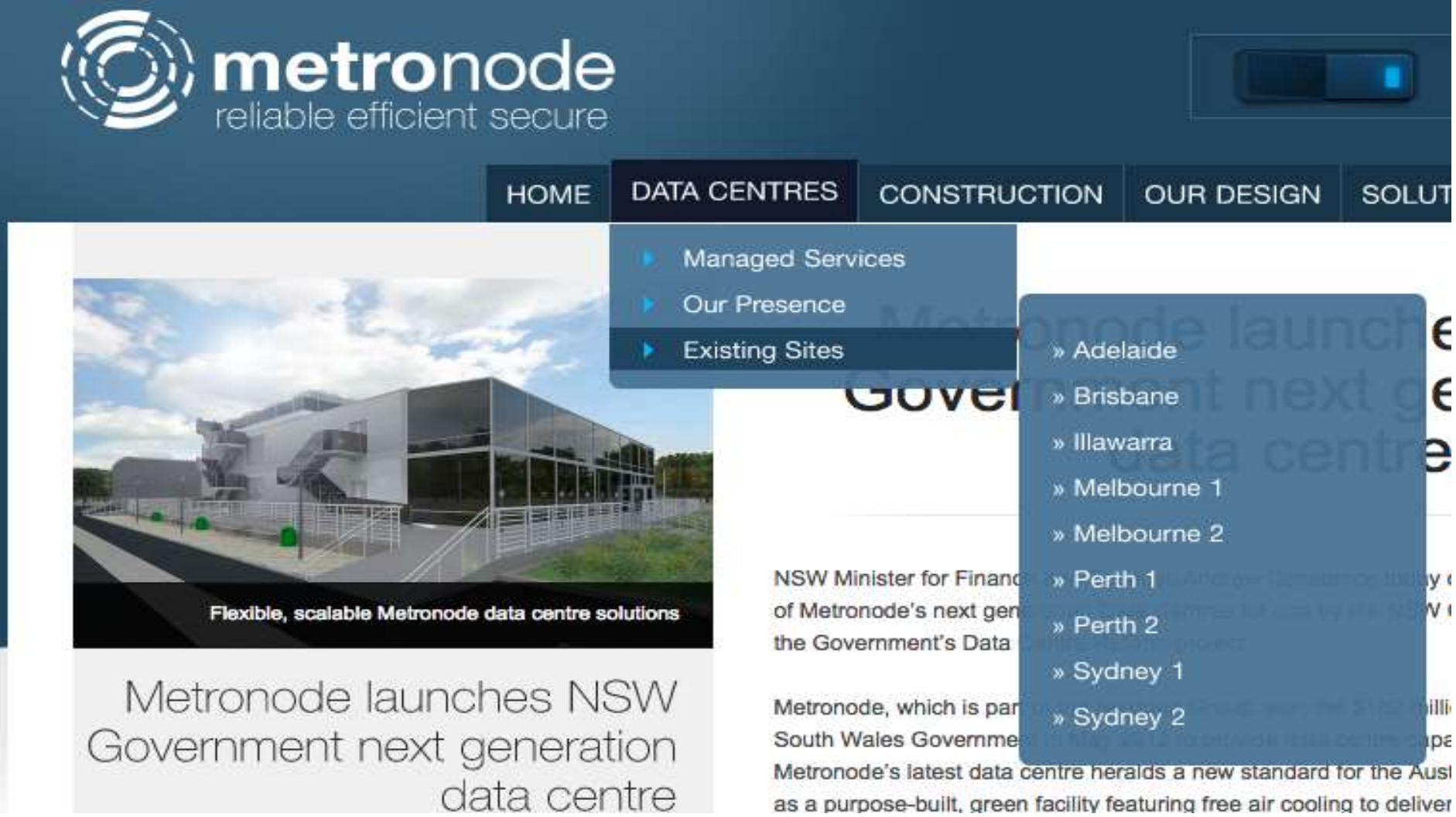
- Data center outage significantly impacts business continuity for the organizations that use their services, data centers are designed to operate with increasingly higher levels of redundancy to sustain availability.
- Data centers usually have redundant, uninterruptable power supplies, cabling, and environmental control subsystems in anticipation of system failure, along with communication links and clustered hardware for load balancing.

Security-Aware Design, Operation, and Management

- Physical and logical access controls and data recovery strategies, need to be thorough and comprehensive for data centers, since they are centralized structures that store and process business data.
- Outsourcing data center-based IT resources has been a common industry practice for decades.
- Outsourcing models often required long-term consumer commitment

Facilities

- Data center facilities are custom-designed locations that are outfitted with specialized computing, storage, and network equipment.
- Facilities have several functional layout areas, as well as various power supplies, cabling, and environmental control stations that regulate heating, ventilation, air conditioning, fire protection, and other related subsystems.



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Computing Hardware

- Much of heavy processing in Data centers is often executed by standardized commodity servers that have substantial computing power and storage capacity.
- Several computing hardware technologies are integrated into these modular servers such as:
  - rackmount form factor server design composed of standardized racks with interconnects for power, network, and internal cooling
  - support for different hardware processing architectures, such as x86-32bits, x86-64, and RISC
  - a power-efficient multi-core CPU architecture that houses hundreds of processing cores in a space as small as a single unit of standardized racks
  - redundant and hot-swappable components, such as hard disks, power supplies, network interfaces, and storage controller cards

Storage Hardware

- Data centers have specialized storage systems that maintain enormous amounts of digital information in order to fulfill considerable storage capacity needs.
- Storage systems are containers housing numerous hard disks that are organized into arrays.
- Networked storage devices - Categories
- *1. Storage Area Network (SAN)* - Physical data storage media are connected through a dedicated network and provide block-level data storage access using industry standard protocols, such as the Small Computer System Interface (SCSI).
- *2.Network-Attached Storage (NAS)* - Hard drive arrays are contained and managed by this dedicated device, which connects through a network and facilitates access to data using file-centric data access protocols like the Network File System (NFS) or Server Message Block (SMB).

NAS, SAN, and other more advanced storage system options provide fault tolerance in many components through controller redundancy, cooling redundancy, and hard disk arrays that use RAID storage technology

Storage Hardware

Storage systems usually involve the following technologies:

- *Hard Disk Arrays* - These arrays inherently divide and replicate data among multiple physical drives, and increase performance and redundancy by including spare disks. This technology is often implemented using redundant arrays of independent disks (RAID) schemes, which are typically realized through hardware disk array controllers.
- *I/O Caching – This is generally performed through hard disk array* controllers, which enhance disk access times and performance by data caching.
- *Hot-Swappable Hard Disks – These can be safely removed from arrays* without requiring prior powering down.
- *Storage Virtualization – This is realized through the use of virtualized hard* disks and storage sharing
- *Fast Data Replication Mechanisms – These include snapshotting, which is* saving a virtual machine's memory into a hypervisor-readable file for future reloading, and *volume cloning, which is copying virtual or physical* hard disk volumes and partitions.

Network Hardware

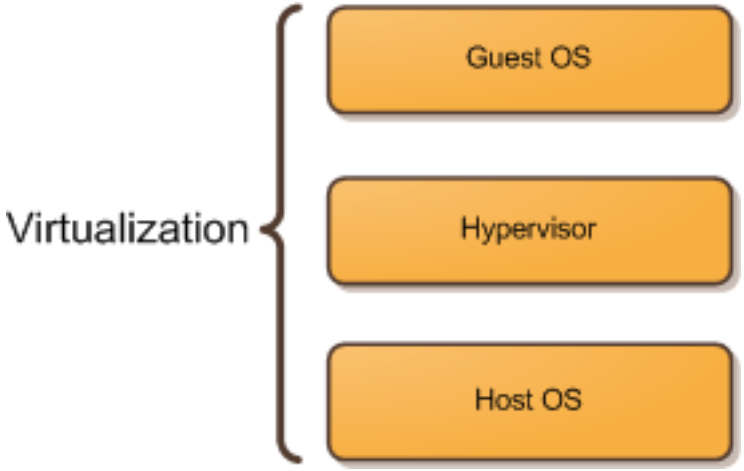
- Data centers require extensive network hardware in order to enable multiple levels of connectivity.
- Data center is broken down into five network subsystems:
  - Carrier and External Networks Interconnection
  - Web-Tier Load Balancing and Acceleration
  - LAN Fabric
  - SAN Fabric
  - NAS Gateways

Other Considerations

- IT hardware is subject to rapid technological obsolescence, with lifecycles that typically last between five to seven years.
- The on-going need to replace equipment frequently results in a mix of hardware whose heterogeneity can complicate the entire data center's operations and management (although this can be partially mitigated through virtualization).
- Security is another major issue when considering the role of the data center and the vast quantities of data contained within its doors.

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.



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Virtual Server

•The first step in creating a new virtual server through virtualization software is the allocation of physical IT resources, followed by the installation of an operating system.

•Virtual servers use their own guest operating systems, which are independent of the operating system in which they were created.

•Both the guest operating system and the application software running on the virtual server are unaware of the virtualization process, meaning these virtualized IT resources are installed and executed as if they were running on a separate physical server. (vital characteristic of virtualization)

•Guest operating systems typically require seamless usage of software products and applications that do not need to be customized, configured, or patched in order to run in a virtualized environment.

•Virtualization software runs on a physical server called a host or physical host, whose underlying hardware is made accessible by the virtualization software.

•The virtualization software functionality encompasses system services that are specifically related to virtual machine management and not normally found on standard operating systems.

•This is why this software is sometimes referred to as a virtual machine manager or a virtual machine monitor (VMM), but most commonly known as a hypervisor.

- Server virtualization - Server virtualization is the process of dividing a physical server into multiple unique and isolated virtual servers by means of a software application (virtualization software). Each virtual server can run its own operating systems independently.
- Three Kinds of Server Virtualization
- **Full Virtualization**
- **Para-Virtualization**
- **OS-Level Virtualization**

- **Full Virtualization:** Full virtualization uses a hypervisor, a type of software that directly communicates with a physical server's disk space and CPU. The hypervisor monitors the physical server's resources and keeps each virtual server independent and unaware of the other virtual servers. It also relays resources from the physical server to the correct virtual server as it runs applications. The biggest limitation of using full virtualization is that a hypervisor has its own processing needs. This can slow down applications and impact server performance.
- **Para-Virtualization:** Unlike full virtualization, para-virtualization involves the entire network working together as a cohesive unit. Since each operating system on the virtual servers is aware of one another in para-virtualization, the hypervisor does not need to use as much processing power to manage the operating systems.
- **OS-Level Virtualization:** Unlike full and para-virtualization, OS-level visualization does not use a hypervisor. Instead, the virtualization capability, which is part of the physical server operating system, performs all the tasks of a hypervisor. However, all the virtual servers must run that same operating system in this server virtualization method.

Why Server Virtualization?

- Server virtualization is a cost-effective way to provide web hosting services and effectively utilize existing resources in IT infrastructure.
- Without server virtualization, servers only use a small part of their processing power.
- This results in servers sitting idle because the workload is distributed to only a portion of the network's servers.
- Data centers become overcrowded with underutilized servers, causing a waste of resources and power.
- By having each physical server divided into multiple virtual servers, server virtualization allows each virtual server to act as a unique physical device.
- Each virtual server can run its own applications and operating system.
- This process increases the utilization of resources by making each virtual server act as a physical server and increases the capacity of each physical machine.

- 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.

Hardware Independence

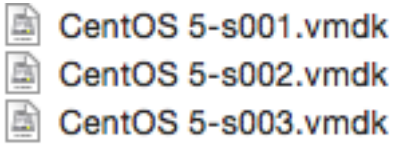
- Virtualization is a conversion process that translates unique IT hardware into emulated and standardized software-based copies.
- Virtual servers can easily be moved to another virtualization host, automatically resolving multiple hardware-software incompatibility issues.
- Cloning and manipulating virtual IT resources is much easier than duplicating physical hardware.

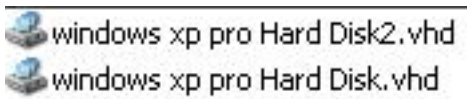
Server Consolidation

- The coordination function that is provided by the virtualization software allows multiple virtual servers to be simultaneously created in the same virtualization host.
- Enables different virtual servers to share one physical server.
- Is commonly used to increase hardware utilization, load balancing, and optimization of available IT resources.
- Is fundamental capability directly supports common cloud features, such as on-demand usage, resource pooling, elasticity, scalability, and resiliency.

Resource Replication

- Virtual servers are created as virtual disk images that contain binary file copies of hard disk content.
- Virtual **disk images** are accessible to the host's operating system, meaning simple file operations, such as copy, move, and paste, can be used to replicate, migrate, and back up the virtual server.





Operating System-Based Virtualization

- Operating system-based virtualization is the *installation of virtualization software in a pre-existing operating system*, which is called the *host operating system*
- For example, a user whose workstation is installed with a specific version of Windows wants to generate virtual servers and installs virtualization software into the host operating system like any other program.
- This user needs to use this application to generate and operate one or more
- virtual servers.
- The user needs to use virtualization software to enable direct access to any of the generated virtual servers.
- Since the host operating system can provide hardware devices with the necessary support, operating system virtualization can rectify hardware compatibility issues even if the hardware driver is not available to the virtualization software.

Operating System-Based Virtualization

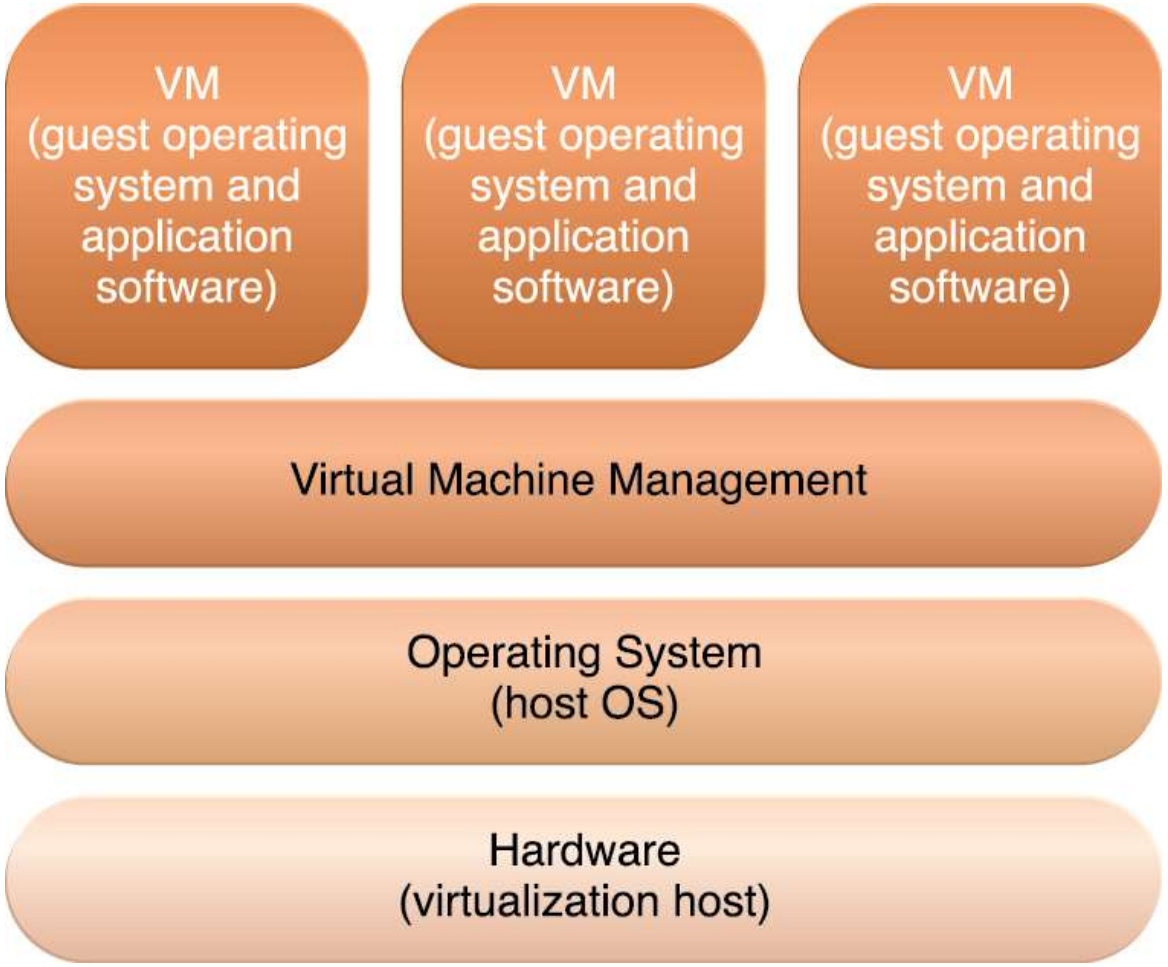
- Hardware independence that is enabled by virtualization allows hardware IT resources to be more flexibly used.
- Virtualization software translates hardware IT resources that require unique software for operation into virtualized IT resources that are compatible with a range of operating systems.
- Operating system-based virtualization can introduce demands and issues related to performance overhead such as:

✓ The host operating system consumes CPU, memory, and other hardware IT resources.

✓ Hardware-related calls from guest operating systems need to traverse several layers to and from the hardware, which decreases overall performance.

✓ Licenses are usually required for host operating systems, in addition to individual licenses for each of their guest operating systems.

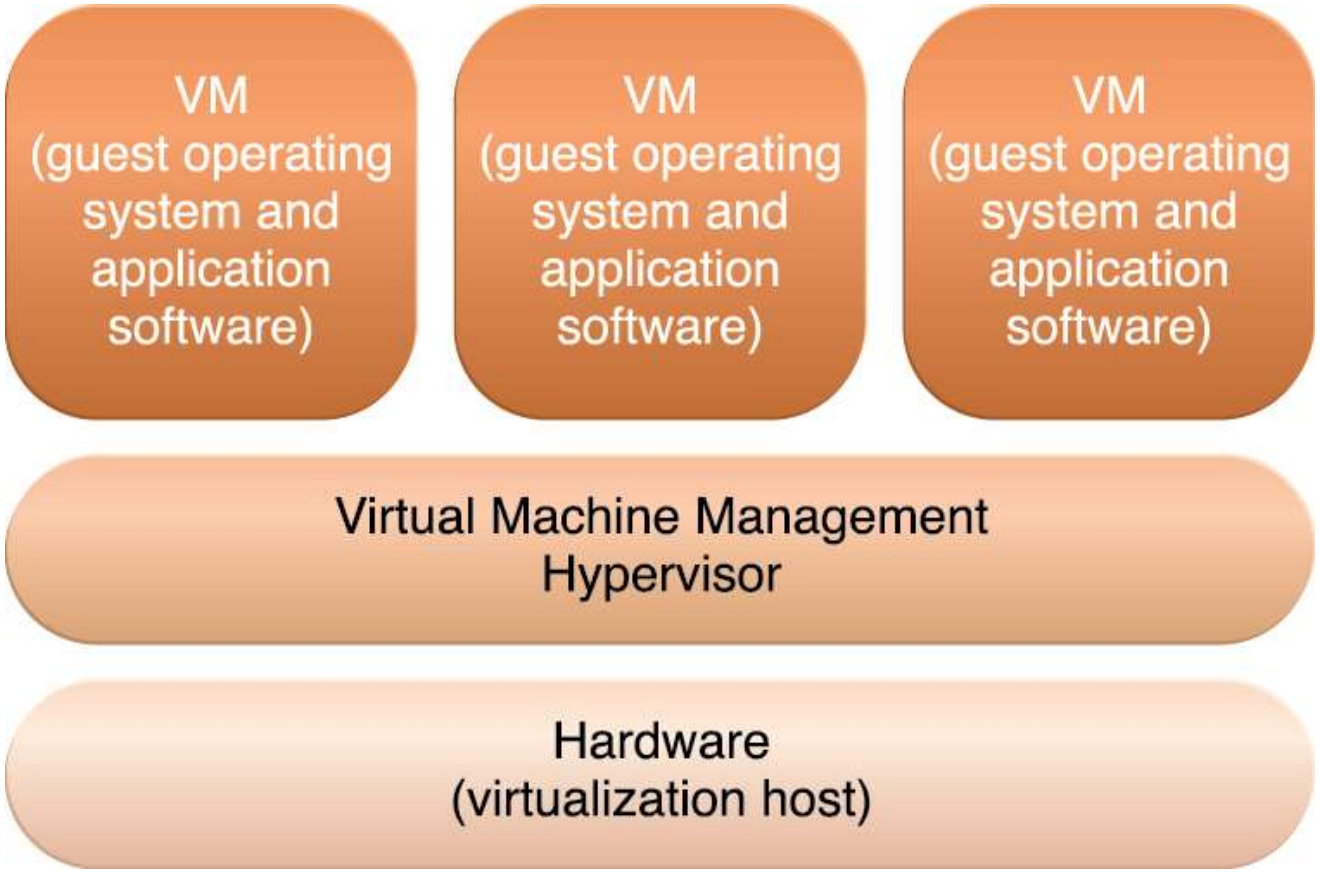
- So OS-based virtualization is the processing overhead required to run the virtualization software and host operating systems.
- Estimating, monitoring, and managing the resulting impact can be challenging because it requires expertise in system workloads, software and hardware environments, and sophisticated monitoring tools.



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.

Hardware-Based Virtualization

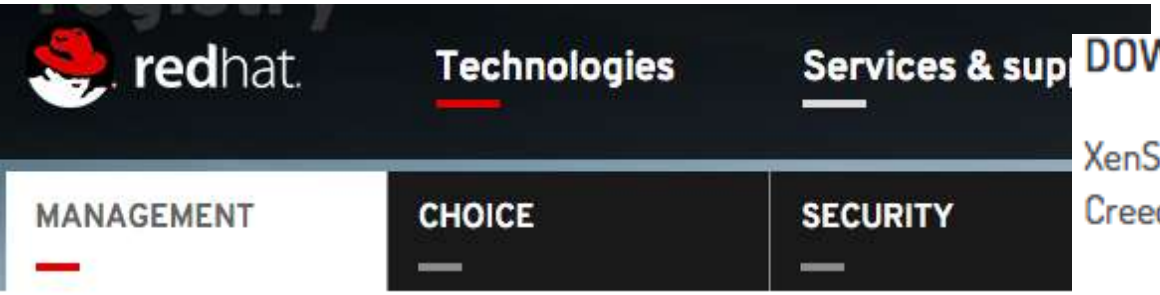
- Represents the *installation of virtualization software directly on the physical host hardware* so as to bypass the host operating system.
- Allowing the virtual servers to interact with hardware without requiring intermediary action from the host operating system generally makes hardware-based virtualization more efficient.
- *Virtualization software is typically referred to as a hypervisor for this type of processing*.
- A hypervisor has a simple user-interface that requires a negligible amount of storage space.
- It exists as a thin layer of software that handles hardware management functions to establish a virtualization management layer.
- This type of virtualization system is essentially used to optimize performance overhead inherent to the coordination that enables multiple virtual servers to interact with the same hardware platform.
- Main issues of hardware-based virtualization concerns compatibility with hardware devices.
- The virtualization layer is designed to communicate directly with the host hardware, meaning all of the associated device drivers and support software need to be compatible with the hypervisor.



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

Virtualization Management

- Modern virtualization software provides several advanced management functions that can automate administration tasks and reduce the overall operational burden on virtualized IT resources.
- Virtualized IT resource management is often supported by *virtualization infrastructure management (VIM)* tools that collectively manage virtual IT resources and rely on a centralized management module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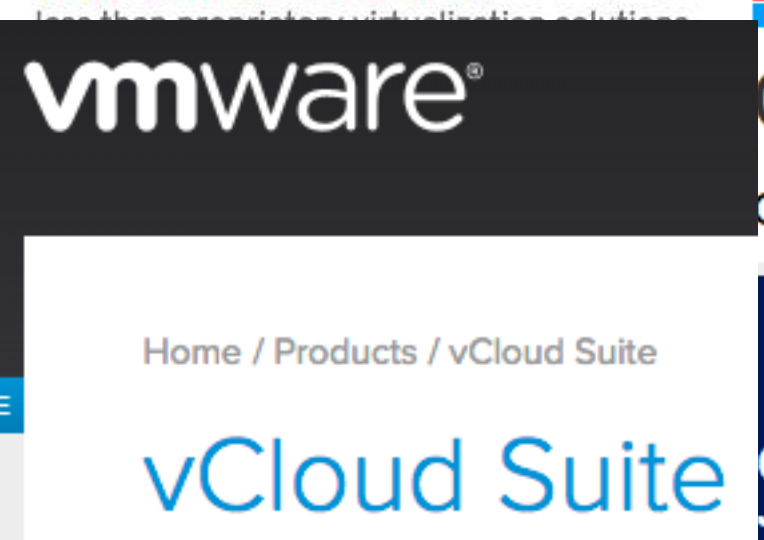
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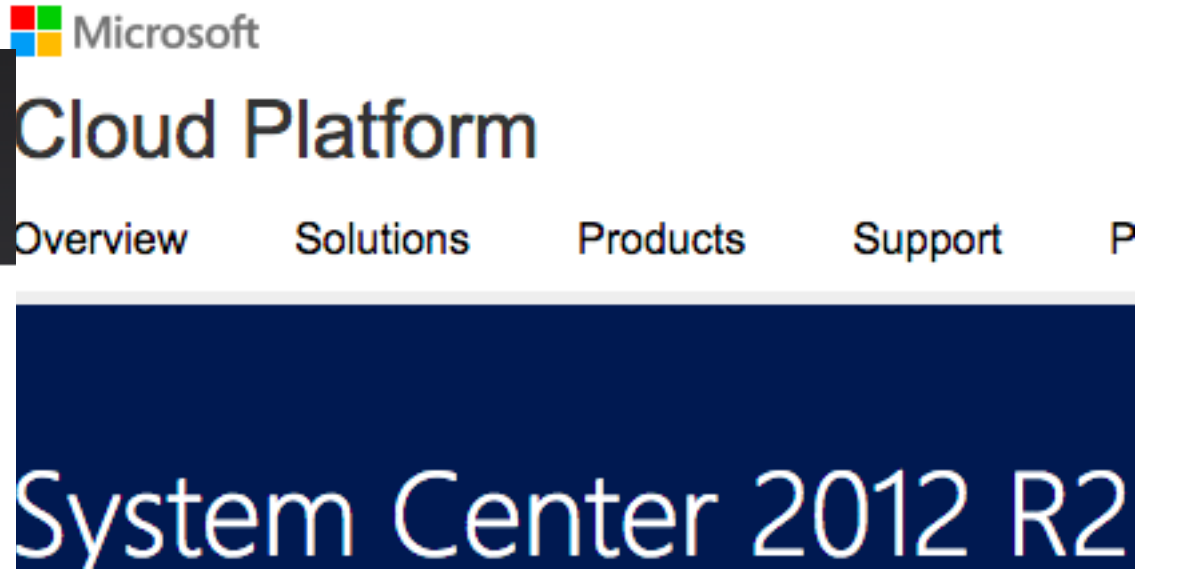
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Other Considerations

- *Performance Overhead* – Virtualization may not be ideal for complex systems that have high workloads with little use for resource sharing and replication. A poorly formulated virtualization plan can result in excessive performance overhead. A common strategy used to rectify the overhead issue is a technique called para-virtualization
- *Special Hardware Compatibility* – Many hardware vendors that distribute specialized hardware may not have device driver versions that are compatible with virtualization software. the software itself may be incompatible with recently released hardware versions.
- *Portability* – The programmatic and management interfaces that establish administration environments for a virtualization program to operate with various virtualization solutions can introduce portability gaps due to incompatibilities. Initiatives such as the Open Virtualization Format (OVF) for the standardization of virtual disk image formats are dedicated to alleviating this concern.

WEB TECHNOLOGY

- Web technology is generally used as both the implementation medium and the management interface for cloud services.
- Web technology is very commonly used for cloud service implementations and for front-ends used to remotely manage cloud based IT resources.
- Fundamental technologies of Web architecture include the URL, HTTP, HTML, and XML.

Basic Web Technology

✓ World Wide Web is a system of interlinked IT resources that are accessed through the Internet.

✓ The two basic components of the Web are the Web browser client and the Web server.

✓ Other components, such as proxies, caching services, gateways, and load balancers, are used to improve Web application characteristics such as scalability and security.

Basic Web Technology – 3 Fundamental Elements

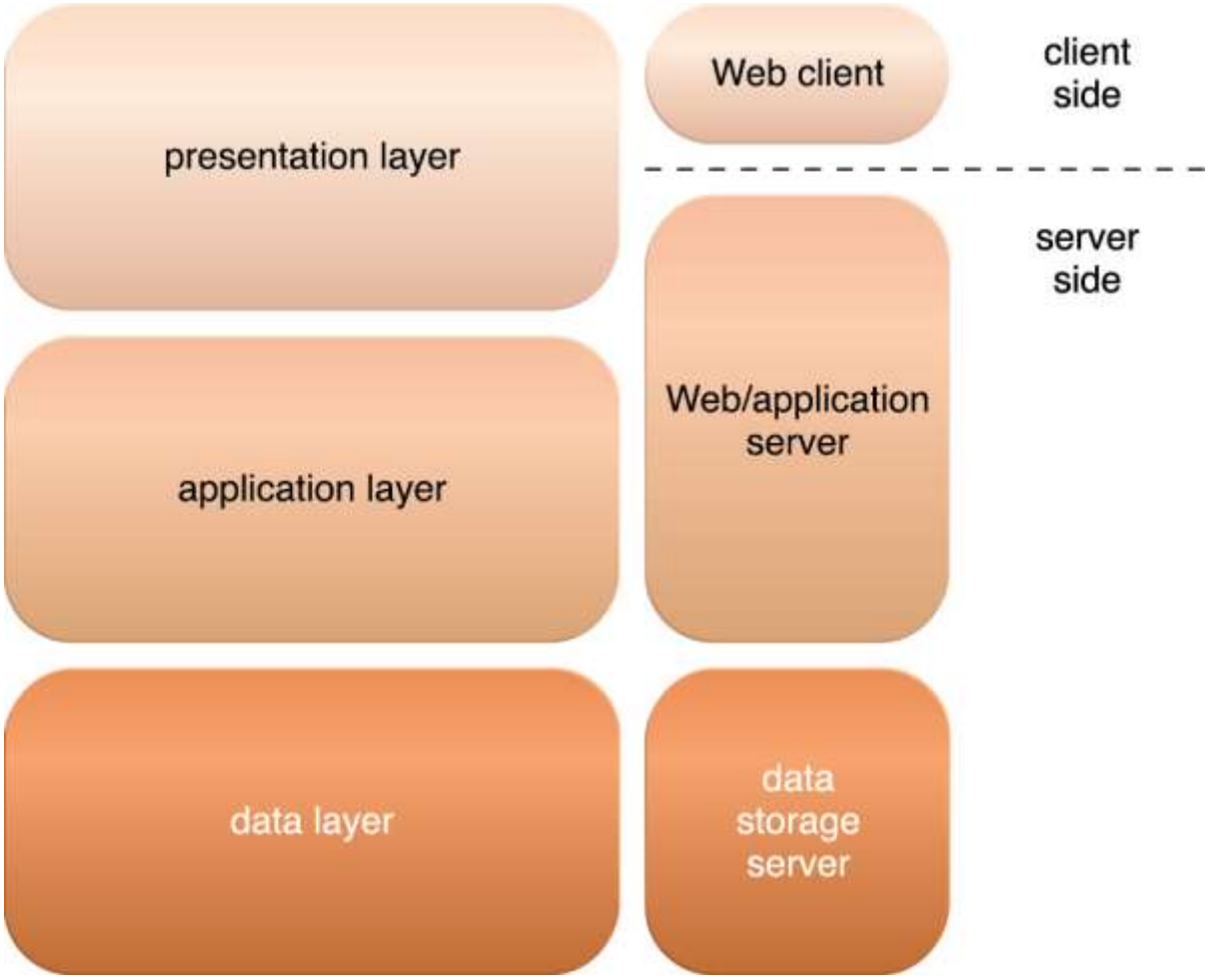
- *Uniform Resource Locator (URL)* – A standard syntax used for creating identifiers that point to Web-based resources, the URL is often structured using a logical network location.
- *Hypertext Transfer Protocol (HTTP)* – This is the primary communications protocol used to exchange content and data throughout the World Wide Web. URLs are typically transmitted via HTTP.
- *Markup Languages (HTML, XML)* – Markup languages provide a lightweight means of expressing Web-centric data and metadata. The two primary markup languages:
  - HTML: which is used to express the presentation of Web pages
  - XML: which allows for the definition of vocabularies used to associate meaning to Web-based data via metadata.

- For example, a Web browser can request to execute an action like read, write, update, or delete on a Web resource on the Internet, and proceed to identify and locate the Web resource through its URL.
- The request is sent using HTTP to the resource host, which is also identified by a URL.
- The Web server locates the Web resource and performs the requested operation, which is followed by a response being sent back to the client.
- The response may be comprised of content that includes HTML and XML statements.

Web Applications

- common architectural abstraction for Web applications - basic three-tier model.
- The first tier is called the *presentation layer, which represents the user-interface.*
- *The middle tier is the application layer that implements application logic*
- *The third tier is the data layer that* is comprised of persistent data stores.

Web Applications



The three basic architectural tiers of Web applications.

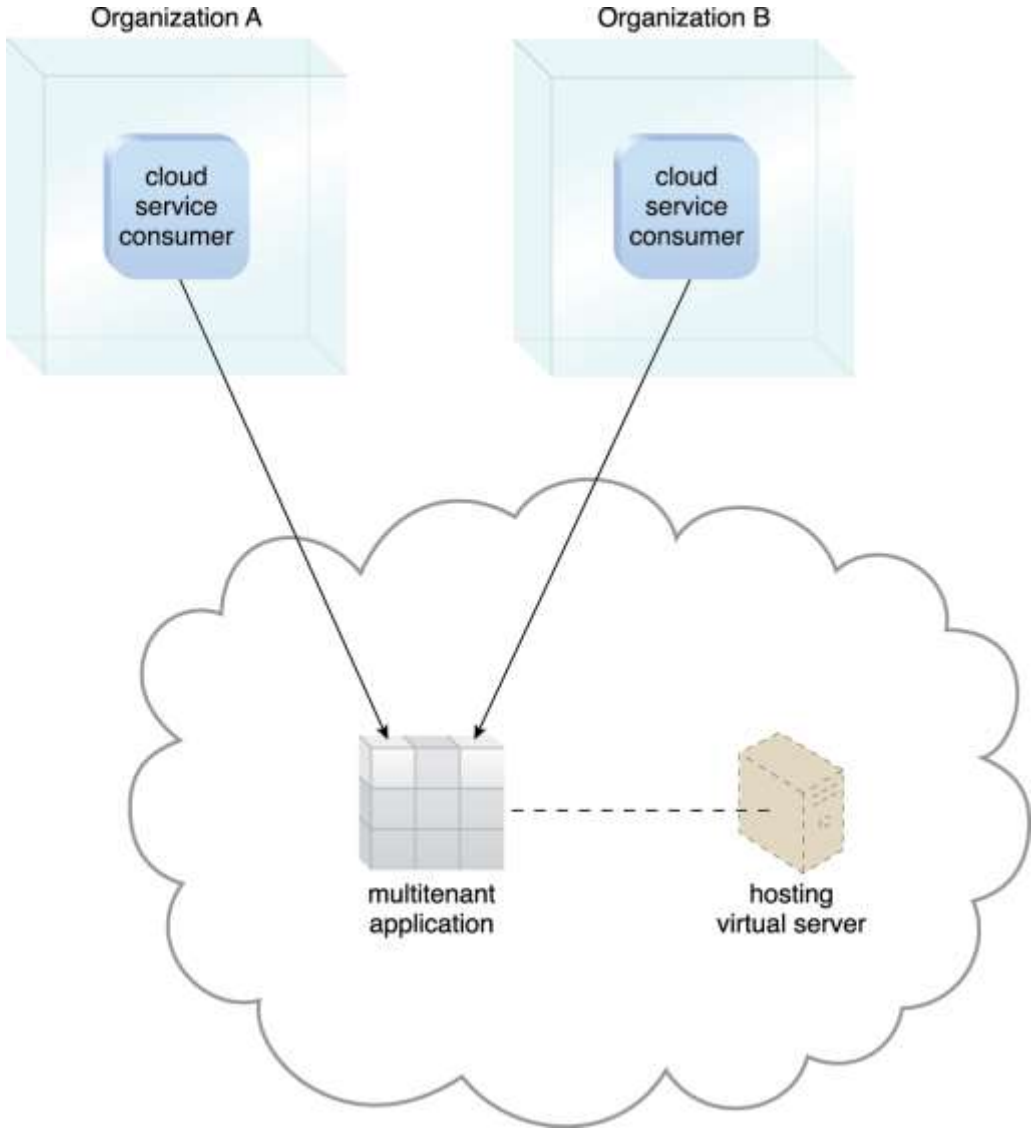
MULTITENANT TECHNOLOGY –

Example: SaaS application used by different users simultaneously

- The multitenant application design was created to enable multiple users (tenants) to access the same application logic simultaneously.
- Each tenant has its own view of the application that it uses, administers, and customizes as a dedicated instance of the software while remaining unaware of other tenants that are using the same application.
- Multitenant applications ensure that tenants do not have access to data and configuration information that is not their own.
- 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 groups.

Multitenant Technology (cont..)

- Multitenant application architecture is often significantly more complex than that of single-tenant applications.
- Common characteristics of multitenant applications include:
  - *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.
  - *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.
  - *Data Tier Isolation* – Tenants can have individual databases, tables, and/or schemas isolated from other tenants.



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

Multitenancy vs. Virtualization

- Multitenancy is sometimes mistaken for virtualization because the concept of multiple tenants is similar to the concept of virtualized instances.
- The differences lie in what is multiplied within a physical server acting as a host:
  - With virtualization: Multiple virtual copies of the server environment can be hosted by a single physical server. Each copy can be provided to different users, can be configured independently, and can contain its own operating systems and applications.
  - With multitenancy: A physical or virtual server hosting an application is designed to allow usage by multiple different users. Each user feels as though they have exclusive usage of the application.

SERVICE TECHNOLOGY

- Service technology is a keystone foundation of cloud computing that formed the basis of the “as-a-service” cloud delivery models.
- Core technologies behind Web Services are represented by following industry standards
  - *Web Service Description Language (WSDL)* – This markup language is used to create a WSDL definition that defines the application programming interface (API) of a Web service.
  - *XML Schema Definition Language (XML Schema)* – Messages exchanged by Web services must be expressed using XML.
  - *SOAP* – Formerly known as the Simple Object Access Protocol, this standard defines a common messaging format used for request and response messages exchanged by Web services.
  - *Universal Description, Discovery, and Integration (UDDI)* – This standard regulates service registries in which WSDL definitions can be published as part of a service catalog for discovery purposes.

REST Services

- REST services are designed according to a set of constraints that shape the service architecture to emulate the properties of the World Wide Web.
- REST services do not have individual technical interfaces but instead share a common technical interface that is known as the uniform contract, which is typically established via the use of HTTP methods.
- The six REST design constraints are:
  - Client-Server
  - Stateless
  - Cache
  - Interface/Uniform Contract
  - Layered System
  - Code-On-Demand

Service Agents

- Service agents are event-driven programs designed to intercept messages at runtime.
- There are active and passive service agents.
  - Active service agents perform an action upon intercepting and reading the contents of a message.
  - Passive service agents, on the other hand, do not change message contents..
- Cloud-based environments rely heavily on the use of system-level and custom service agents to perform much of the runtime monitoring and measuring required to ensure that features, such as elastic scaling and pay-for-use billing, can be carried out instantaneously.

Service Middleware

- Middleware platforms that evolved from messaging-oriented middleware (MOM) platforms used primarily to facilitate integration, to sophisticated service middleware platforms designed to accommodate complex service compositions.
- Two most common types of middleware platforms relevant to services computing are
  - Enterprise service bus (ESB): encompasses a range of intermediary processing features, including service brokerage, routing, and message queuing.
  - Orchestration platform: environments are designed to host and execute workflow logic that drives the runtime composition of services.