Announcement

- Deadline for forming group:
- ✓ 5 PM. Friday 22nd March 2019
- ✓ Form a group then send the name of the group members with SID and their emails.
- ✓ Do not forget to mention group leader name

SIT706
Cloud Computing Technologies

Week 3

Cloud Technologies

Chapter 5
Cloud-Enabling Technology

Chapter 5 - Cloud-Enabling Technology

1. Broadband Networks and Internet Architecture
2. Data Centre Technology
3. Virtualisation Technology
4. ~~Web Technology~~
5. Multitenant Technology
6. ~~Service Technology~~

Broadband Networks and Internet Architecture

1. Internetworks
2. Internet Service Providers (ISPs)
3. The Internet…
4. Connectionless Packet Switching
5. Router-based Interconnectivity
6. Physical Network
7. Transport Layer Protocol
8. Application Layer Protocol
9. Technical and Business Considerations

Broadband Networks and Internet Architecture

1. **Internetworks**, e.g., the Internet allow for the remote provisioning of IT resources and support ubiquitous network access
   - The potential of cloud platforms therefore generally grow in parallel with advancements in Internet connectivity and service quality

Broadband Networks and Internet Architecture

2. <u>Internet Service Providers (ISPs)</u>

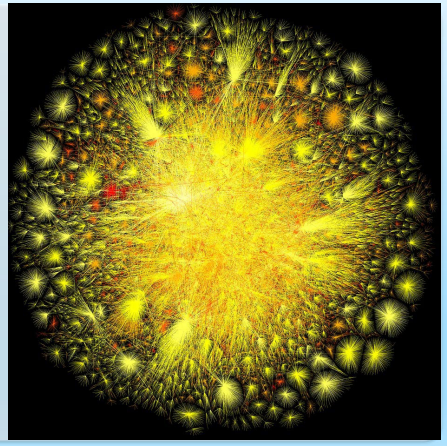
- Internet's largest backbone networks are established and deployed by ISPs
- Worldwide connectivity is achieved through a hierarchical topology composed of three tiers:

Broadband Networks and Internet Architecture

1. Tier 1: large-scale, international providers that oversee massive interconnected global networks
2. Tier 2: regional providers
3. Tier 3: local providers

Broadband Networks and Internet Architecture

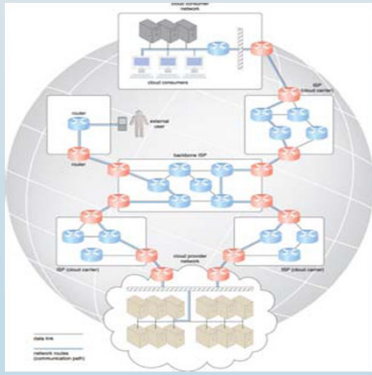
3. The Internet…



Source:
The Opte Project / Barrett Lyon
www.opte.org
February 2015

Broadband Networks and Internet Architecture

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



Broadband Networks and Internet Architecture

4. **Connectionless Packet Switching**
   - End-to-end data flows divided into small packets of data that are delivered forwarded independently to the destination

https://www.google.com.au/search?q=What+is+Connectionless+Packet+Switching&tbm=isch&source=iu&ictx=1&fir=BWeDclDvdjyhxM%253A%252CjFIRcxvudS7y4M%252C_&vet=1&usg=AI4_-kQZ_cK3OUFq8CXGG_meX2OxlTmg1Q&sa=X&ved=2ahUKEwjQy7WC1oDhAhVHfisKHREWDhsQ9QEwAHoECAUQBg#imgrc=BWeDclDvdjyhxM:&vet=1

Broadband Networks and Internet Architecture

5. **Router-based Interconnectivity**
   - A device connected to multiple networks which forwards packets
6. **Physical Network**
   - Comprise a data link layer controlling data transfer and a physical layer transmitting bits through wired/wireless media, e.g., Ethernet, ATM network, 3G mobile HSDPA, 4G (LTE-A, WiMax), 5G mobile data.

Broadband Networks and Internet Architecture

WaveBand

Band Designation	Nominal Frequency Range	Specific Bands
HF	3-30 MHz0	--
VHF	30-300 MHz	138-144 MHz 216-225 MHz
UHF	300-1000MHz	420-450 MHz 890-942 MHz
L	1-2 GHz	1.215-1.4 GHz
S	2-4 GHz	2.3-2.5 GHz 2.7-3.7 GHz
C	4-8 GHz	5.25-5.925 GHz
X	8-12 GHz	8.5-10.68 GHz
Ku	12-18 GHz	13.4-14.0 GHz 15.7-17.7 GHz
K	18-27 GHz	24.05-24.25 GHz
Ka	27-40 GHz	33.4-36.0 GHz
V	40-75 GHz	59-64 GHz
W	75-110 GHz	76-81 GHz 92-100 GHz
millimeter	110-300 GHz	--

Broadband Networks and Internet Architecture

mmWaveBand

Millimeter wave band	Frequency range
Q band	30 to 50 GHz
U band	40 to 60 GHz
V band	50 to 75 GHz
E band	60 to 90 GHz
W band	75 to 110 GHz
F band	90 to 140 GHz
D band	110 to 170 GHz
G band	110 to 300 GHz

Also know as extremely high frequency (EHF)

Broadband Networks and Internet Architecture

7. Transport Layer Protocol

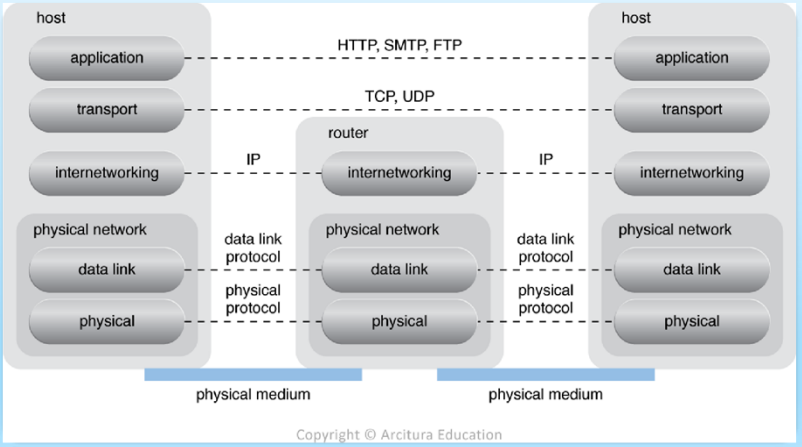
– Use the Internet Protocol to provide standardised, end-to-end communication, e.g., Transmission Control Protocol (TCP) and User Datagram Protocol (UDP)

Broadband Networks and Internet Architecture

8. Application Layer Protocol

– Use transport layer protocols to standardise and enable specific data packet transferring methods, e.g., HTTP, SMTP for e-mail, BitTorrent for P2P, and SIP (Session Initiation Protocol) for IP telephony

Broadband Networks and Internet Architecture



Broadband Networks and Internet Architecture

9. <u>Technical and Business Considerations</u>

– Connectivity Issues:

1. TCP/IP allows access to IT resources either on the local corporate network or remote resources, e.g., cloud-based IT resources

Broadband Networks and Internet Architecture

- Connectivity Issues:
  2. Traditional on-premise deployment models provide organisations with complete control over network traffic and can safeguard their corporate networks using firewalls and monitoring software
     - Same control may not be possible when using cloud

Broadband Networks and Internet Architecture

- Connectivity Issues:
  3. Major cloud providers offer Internet connectivity that is superior to the connectivity of individual organisations, resulting in additional network usage charges as part of their pricing model

Broadband Networks and Internet Architecture

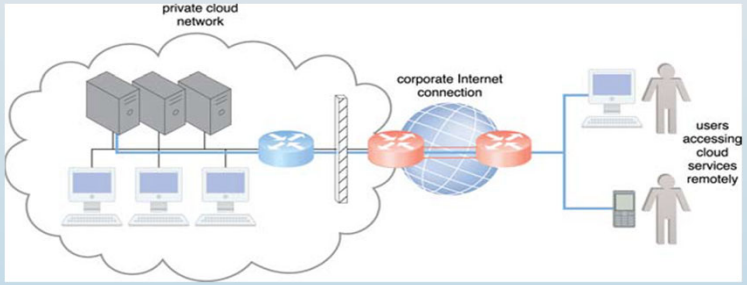
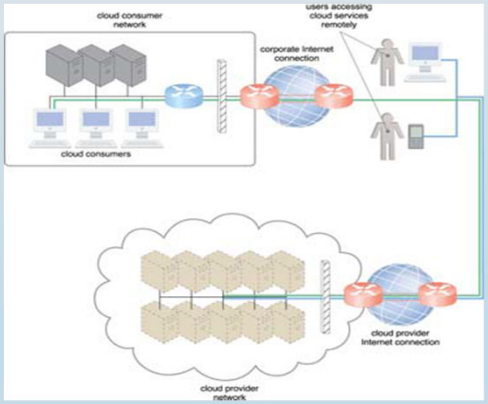


Figure 5.5 The internetworking architecture of a private cloud. The physical IT resources that constitute the cloud are located and managed within the organization.

Broadband Networks and Internet Architecture

Figure 5.6 The internetworking architecture of an Internet-based cloud deployment model. The Internet is the connecting agent between non-proximate cloud consumers, roaming end-users, and the cloud provider's own network.



Broadband Networks and Internet Architecture

On-Premise IT Resources	Cloud-Based IT Resources
Internal end-user devices access corporate IT services through the corporate network	Internal end-user devices access corporate IT services through an Internet connection
Internal users access corporate IT services through the corporate Internet connection while roaming in external networks	Internal users access corporate IT services while roaming in external networks through the cloud provider's Internet connection
External users access corporate IT services through the corporate Internet connection	External users access corporate IT services through the cloud provider's Internet connection

Broadband Networks and Internet Architecture

9. <u>Technical and Business Considerations (Cont.)</u>

– Network Bandwidth and Latency Issues:

- Overall bandwidth to cloud-based services (end-to-end bandwidth) is affected not only by ISP connections but also by all intermediary nodes

Broadband Networks and Internet Architecture

- Network Bandwidth and Latency Issues:
  - Latency (also known as time delay) also increases with every intermediary node on the data packet's path
  - "Best effort" semantics on the Internet can also result in bandwidth reductions, latency increases, or even packet loss

Broadband Networks and Internet Architecture

9. <u>Technical and Business Considerations(Cont.)</u>

- Cloud Carrier and Cloud Provider Selection:
  - Cloud consumers and cloud providers may need to use multiple cloud carriers to achieve adequate connectivity and reliability for cloud applications (additional cost)
    - Imagine if your business relies on cloud-based services to operate and your ISP experiences an outage!

Data Centre Technology

- What is the difference between Cloud computing and Data centre?

Data Centre Technology

- The key difference between Cloud computing and Data centre:
  i. Cloud computing is working in off-premise
  ii. It is a form of computing in which users storage their data on internet.
- Data centre is working in *on premise*
  i. Users data are stored in the hardware devices within a company on local network.

Data Centre Technology

- Cloud computing resources is delivering system resources for examples RAM, memory, network bandwidth, processor.
- These are stored in any data centre but that resources are providing by any authorize cloud provider.
- The authorize cloud provider take cares all updates and ongoing maintenance and data centre are usually run by an building.

Data Centre Technology

1. Modern Data Centres
2. Technologies and Components

Data Centre Technology

1. **Modern Data Centres**
   - specialised IT infrastructure housing servers, databases, networking, telecommunication devices, and software systems
     - Grouping of IT resources enables power sharing, higher efficiency in shared IT resource usage, and improved accessibility for IT personnel

Data Centre Technology

2. **Technologies and Components**
   - **Virtualization**: rather than direct usage of physical IT resources, virtualization platforms present an abstraction of physical resources that are easier to allocate, operate, release, monitor, and control.
   - **Standardisation and Modularity**: use of commodity hardware and modular architectures as building blocks supports scalability, growth, and speedy hardware replacements.

Data Centre Technology

2. **Technologies and Components**
   - **Automation:** specialised platforms automating tasks including provisioning, configuration, patching, and monitoring without the supervision.
   - **Remote Operation and Management:** most tasks can be completed through network-based remote consoles and management systems.

Data Centre Technology

2. **Technologies and Components**
   - **High Availability**: increased redundancy used to sustain availability, e.g., redundant UPS, cabling, environmental control (air conditioning, fire control, etc.), communication links, and clustered hardware for load balancing.
   - **Security-Aware Design, Operation, and Management**: physical and logical access control and data recovery strategies

Data Centre Technology

2. **Technologies and Components**
   - **Facilities**: custom-designed facilities outfitted with specialised computing, storage, and network equipment, including several functional areas, power supplies, cabling, environmental control stations, etc.

Data Centre Technology

2. **Technologies and Components**
   - **Computing Hardware:** standardised commodity servers with substantial computing power and storage capacity
     - Rackmount form factor supporting standardised racks with interconnects for power, network, and internal cooling
     - Support for different hardware processing architecture, e.g., x86-32, x86-64, RISC (reduced instruction set computer) can operate on MIPS (millions of instructions per second)

Data Centre Technology

– Computing Hardware:
  - Power-efficient multi-core CPU architectures
    - A **multi-core processor** is a single computing component with two or more independent processing units called **cores**, which read and execute program instructions.

Data Centre Technology

– Computing Hardware:
  - Redundant and hot-swappable components, e.g., hard disks, power supplies, network interfaces, storage cards
  - **Blade server** architectures for improved interconnection and reduced physical space/power requirements

Data Centre Technology

Blade server architectures

Data Centre Technology

– Storage Hardware:

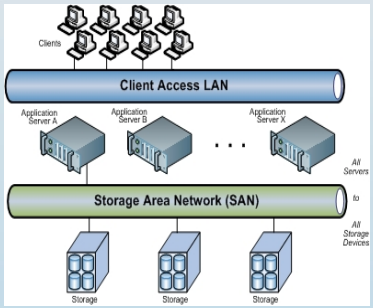
- **Hot-Swappable Hard Disks**: can removed/replace disks in arrays without requiring powering down
- **Storage Virtualization:** using virtualized hard disks and storage sharing
- **Fast Data Replication Mechanisms**: **Data Replication** is the process of **storing data in more than one site or node.** **S**napshotting and volume cloning

Data Centre Technology

– Storage Hardware:

- **Storage Area Networks (SANs):** physical data storage media of multiple storage devices connected through a dedicated local network which operate on disk blocks
- **Network-Attached Storage (NASs):** is a **single storage** device which operates on data files. It manages hard drive arrays which connecting to a network.

Data Centre Technology



SAN

NAS

Data Centre Technology

	NAS	SAN
Fabric	Uses TCP/IP networks, most commonly Ethernet	Runs on high speed Fibre Channel networks
Data processing	Processes file-based data	Processes block data
Protocols	Connects directly to an Ethernet network Can use several protocols to connect with servers including NFS, SMB/CIFS, and HTTP	Uses SCSI protocol to communicate with servers
Performance	Generally has lower throughput and higher latency because of its slower file system layer	A higher performer for environments that need high-speed traffic
Scalability	Entry level and NAS devices are not highly scalable, High-end NAS systems scale to petabytes using clusters or scale-out nodes	Scalability is a major driver: its network architecture enables admins to scale performance and capacity in scale-up or scale-out configurations
Ease of management	Easier to manage: device easily plugs into the LAN and offers a simplified management interface	Requires more administration time than NAS
Price	In general NAS is less expensive to purchase and maintain, although a high-end NAS will cost more than an entry-level SAN	SANs are more complex to manage with FC SANs on top of the complexity heap

Data Centre Technology

2. <u>Technologies and Components</u>

– **Network Hardware:** extensive networks to provide multiple levels of connectivity

- **Carrier and External Networks Interconnection**: connectivity between external WAN and data centre's LAN, firewalls, VPNs, etc.
- **Web-Tier Load Balancing and Acceleration**: pre-processors, encryption/decryption appliances.

Data Centre Technology

– Network Hardware:

- **LAN Fabric:** high performance and redundant connectivity for all data centre IT resources (usually 10Gbps+)
- **SAN Fabric:** used in SANs, usually Fibre Channel (FC), Fibre Channel over Ethernet (FCoE), or InfiniBand
- **NAS Gateways:** attachment points for NAS devices and facilitates data transmission between SAN and NAS devices

Data Centre Technology

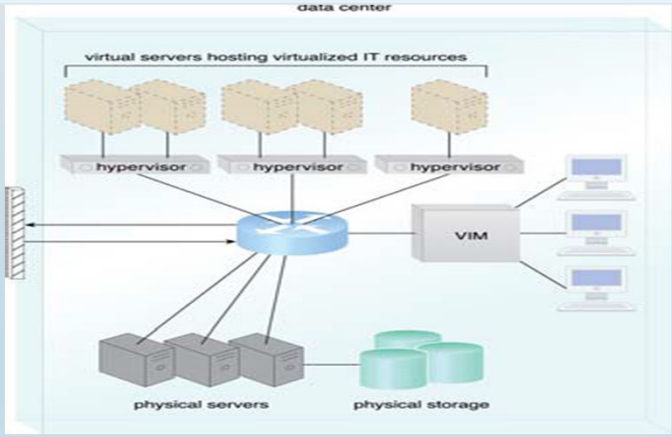


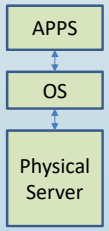
Figure 5.7 The common components of a data center working together to provide virtualized IT resources supported by physical IT resources.

Virtualisation Technology

1. Virtualization
2. Steps for creating a virtual server
3. Virtualization software
4. Hardware Independence
5. Server Consolidation
6. Resource Replication
7. Operating System-Based vs Hardware-Based Virtualization
8. Virtualization Management
9. Other Considerations

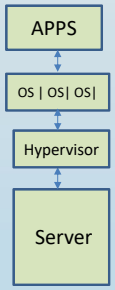
Virtualisation Technology

- **Concepts of Virtualisation**



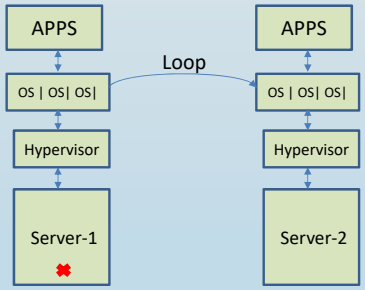
Virtualisation Technology

Virtualisation:
Allows users to run various guest operating systems within their own applications(windows).



Virtualisation Technology

- Concepts of Virtualisation



Virtualisation Technology

1. **Virtualization**
   - is the process of converting a physical IT resource into a virtual IT resource, including
     - Servers → Virtual Server (or Virtual Machine)
     - Storage → Virtual storage device / virtual disk
     - Network → Logical network fabrics, e.g., VLANs
     - Power → Virtual UPSs

Virtualisation Technology

2. **Steps for creating a virtual server**
   - Allocate physical IT resources
   - Install an operating system (a "guest" OS)
     - Usually unaware of virtualization, as if running on physical server

Virtualisation Technology

3. **Virtualization software**
   - It is a process that separates a computer's operating system and applications from the underlying physical hardware.
   - Usually done as software although embedded hypervisors can be created for things like mobile devices
   - runs on a physical server called a host or physical host
     - Manages the physical server resources
     - Usually referred to as a hypervisor, but sometimes referred to as a virtual machine manager or virtual machine monitor (VMM)

Virtualisation Technology

4. **Hardware Independence**
   - Operating system and application software have dependencies on underlying hardware (device drivers, paths, etc.)
   - Virtualization converts unique IT hardware into emulated and standardised software-based copies, allowing:
     - Virtual servers to be moved between virtual hosts
     - Cloning and manipulation of virtual IT resources

Virtualisation Technology

5. **Server Consolidation**
   - Multiple virtual servers can exist on a single virtualization host, allowing:
     - Increased hardware utilization
     - Load balancing
     - Optimization of available resources
     - Different guest operating systems on the same host

Virtualisation Technology

5. **Server Consolidation**
   - Directly supports common cloud features such as on-demand usage, resource pooling, elasticity, scalability, and resiliency

Virtualisation Technology

6. **Resource Replication**
   - Virtual servers are created as virtual disk images containing binary copies of hard disk content
   - Host operating system can copy, move, paste, etc. to replicate, migrate, and back up the virtual server

Virtualisation Technology

6. **Resource Replication**
   - Enables
     - Creation of standardized virtual machine images: operating system, applications software, etc.
     - Increased agility in migration and deployment of new VMs for rapid scale out/up

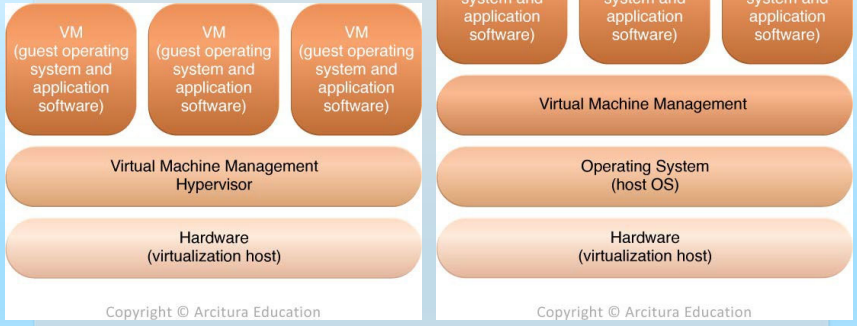
Virtualisation Technology

6. **Resource Replication**
   - Enables
     - Ability to roll back through use of VM snapshots saving state of VM memory and hard disk
     - Support for business continuity with efficient backup and restoration procedures, multiple instances of critical IT resources and applications

Virtualisation Technology

7. **Operating System-Based vs Hardware-Based Virtualization**
   - So far our discussions have focused on hardware-based virtualization
   - It is also possible to install virtualization software in a pre-existing operating system

Virtualisation Technology



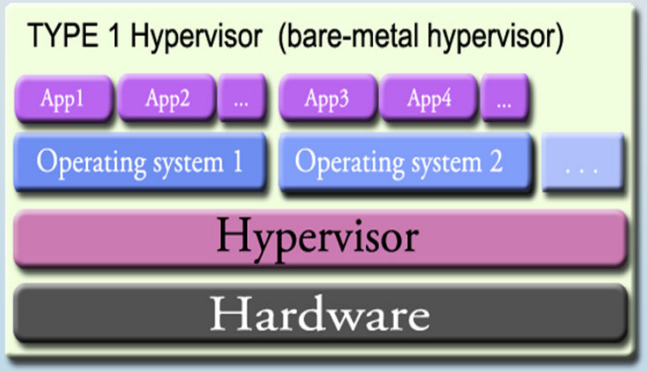
Virtualisation Technology

7. **Operating System-Based vs Hardware-Based Virtualization**
   - **Type 1 Hypervisor** (Hardware-Based also called bare metal hypervisor):
     - Type1 hypervisor or virtual machine monitor (VMM) is installed on directly on physical host server hardware
     - Virtualization software runs directly on hardware
     - VMM communicates directly with system hardware rather than relying on a host operating system

Virtualisation Technology

– **Type 1 Hypervisor (Hardware-Based):**
  - Hypervisor has simple user-interface and requires negligible storage (versus a full-service operating system)
  - Can have compatibility issues (usually support less devices than a full-service operating system)
  - Examples: VMWARE ESX, VMWARE ESXi, Microsoft Hyper-V,

Virtualisation Technology



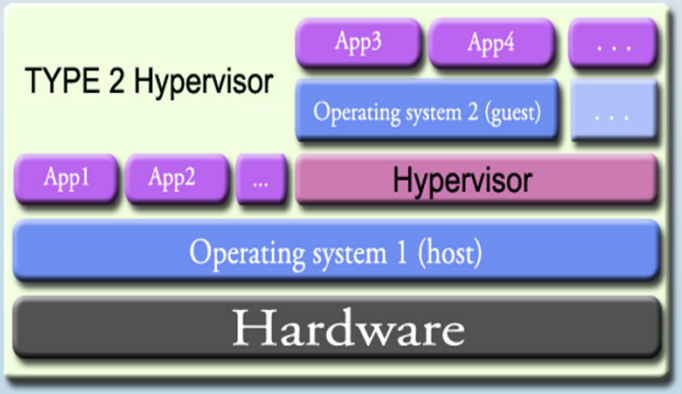
Virtualisation Technology

- **Type 2 Hypervisor (Operating System-Based):**
  - Virtualization software runs inside host operating system
  - Most/all virtual hardware provided through emulation
  - Allows hardware IT resources to be more flexibly used

Virtualisation Technology

- **Type 2 Hypervisor (Operating System-Based):**
  - Generally higher overheads
    - Host operating system consumes CPU, memory, other resources
    - Hardware-related calls need to traverse several layers to/from hardware
    - Licenses required for host operating systems in addition to guest operating system

Virtualisation Technology



Virtualisation Technology

8. **Virtualization Management**
   - Many tasks can be performed more easily using virtual servers rather than physical servers
   - Virtual IT resource management often supported by virtualisation infrastructure management (VIM) tools
     - Collectively manage virtual IT resources via a centralised management module (a controller)

Virtualisation Technology

9. **Other Considerations**
   - **Performance Overhead:** virtualisation may not be ideal in some cases, e.g., systems with high workloads
   - **Special Hardware Compatibility:** device drivers may not be available for hardware-based virtualisation software

Virtualisation Technology

9. **Other Considerations**
   - **Portability:** programmatic/management interfaces for virtualisation may cause portability gaps
     - Initiatives such as Open Virtualisation Format (OVF) for standardised virtual disk image formats aim to alleviate this

Web Technology

1. Basic Web Technology
2. Web Applications

Multitenant Technology

1. Multitenant Technology
2. Common Characteristics

Multitenant Technology

1. **Multitenant Technology**
   - Enables multiple users (tenants) to access the same application logic simultaneously
   - Each tenant has own view of the application it uses, administers, and customises
   - Tenants do not have access to data and configuration information that is not their own
   - Sometimes mistaken for virtualisation as multiple tenant concept is similar to virtualised instances

Multitenant Technology

2. **Common Characteristics**
   - **Usage isolation:** behaviour of one tenant does not affect others
   - **Data security:** tenants cannot access data of other tenants
   - **Recover:** backup and restore occurs separately for each tenant

Multitenant Technology

2. **Common Characteristics**
   - **Application Upgrades:** tenants are not negatively affected by upgrading of shared software artefacts
   - **Scalability:** can scale to accommodate increase in usage by tenants/number of tenants
   - **Metered usage:** tenants are charged only for processing/features used

Multitenant Technology

2. **Common Characteristics**
   - **Data Tier Isolation:** tenants can have individual databases, tables, and/or schemas isolated from other tenants

Week 3 Summary

- Cloud Technologies
  - Broadband Networks and Internet Architecture
  - Data Centre Technology
  - Virtualisation Technology
  - Multitenant Technology

Video

- Please watch this video:

https://www.youtube.com/watch?v=zLJbP6vBk2M

For Virtualisation Concepts