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CS435 - Cloud Computing.

LEARNING MATERIALS

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- Essential Characteristics according to NIST definition:
  - Resource pooling
  - Rapid elasticity
  - On-demand self-service
  - Broad network access
  - Measured service

- Important Benefits of Cluster Computing:
  - Scalability
  - High availability and fault tolerance
  - Use of commodity computers (Widely available/affordable)

- Service Models according to NIST definition:
  - Software as a Service (SaaS)
  - Platform as a Service (PaaS)
  - Infrastructure as a Service (IaaS)

- Cloud Deployment Models according to NIST definition:
  - Private cloud
  - Community cloud
  - Public cloud
  - Hybrid cloud

- Servers are available in a variety of sizes and types:
  - Domain Name Server (DNS)
  - Web server
  - Database server

- Two common types of switched networks are:
  - Circuit-Switched Network
  - Packet-Switched Network

- TCP/IP Protocol Stack Layers:
  - Application

- Transport
- Network
- Data-link
- Physical

- Main protocols of Transport Layer are:
  - Transmission Control Protocol (TCP)
  - User Datagram Protocol (UDP)

- IP Addressing
  - IPv4 is a 32 bit universally unique address while IPv6 is the 128 bit universally unique address.
    - Total IPv4 addresses = 2^{32}
    - Total IPv6 addresses = 2^{128}

- Classification of IPv4 addresses:

	Bits For Network ID	**Total Networks**	**Network ID Starts With**	**First Byte**
Class A	8	2^7	'0' binary	0 to 127
Class B	16	2^{14}	'10' binary	128 to 191
Class C	24	2^{21}	'110' binary	192 to 223
Class D	Used for multicasting and No prefix or Network ID			224 to 239
Class E	Reserved for future use			240 to 255

- There are three categories of IPv6 addresses:
  - Unicast address
    - A unique address that identifies only one device or network. It's like a personal phone number that only rings on your phone.
  - Multicast address
    - A special address that sends data to multiple devices or networks at the same time. It's like a group phone number that rings on multiple phones at once.
  - Anycast address
    - A single address that can be used by multiple devices or networks, but data is only sent to the closest one. It's like a shared phone number that automatically connects you to the nearest available phone.

- Standard Ethernet types
  - Bridged
  - Switched
  - Full duplex switches

- Wired LAN vs. Wireless LAN

Wired LAN	Wireless LAN
Medium: Wires	Medium: Air
Physical connection to network	No physical connection to network
Broadcasting and multicasting possible when required	All devices are broadcasting
Hosts are connected through link layer switch	No link layer switch exists
Connection to other networks through router	Connected to other networks through access point (a device that connects a wireless and wired network)

- Advantages of Switch:
  - Connecting heterogeneous devices
  - Collision elimination

- Types of routing
  - Unicast routing
  - Multicast routing

  - Connectionless routing
  - Connection oriented routing

- Virtualization implementation levels:
  - Instruction Set Architecture (ISA) level
  - Hardware Abstraction level
  - Operating System Level
  - Library support level
  - Application level

- Classes of VM architectures
  - Hypervisor Architecture
  - Full-virtualization Architecture
  - Para-virtualization Architecture

- Reasons of virtualization:
  - Sharing of resources
  - Isolation of users of shared resource
  - Dynamic provisioning of virtual resources is easier than physical resources
  - Aggregation of smaller resources into a single big virtual resource
  - Easier management of virtual resources.

- A VM can be in any of the following states:
  - Powered-off
  - Suspended
  - Paused
  - Powered-on

- The following options are available for VM migration:
  - Cold migration
  - Warm migration
  - Live migration

- A VM is made of two basic components:
  - VM state (The processor and RAM contents)
  - Virtual hard disk (Residing on network storage or on host's hard disk)

- The data center owner has three major considerations:
  - Assuring Performance and QoS
  - Increase resource utilization
  - Saving costs

- Types of VPN:
  - Site-to-site VPN
  - Remote-access VPN:

- Business drivers lure the organizations to start using Cloud.
  - IT Capacity Planning
    - Lead Strategy
    - Lag Strategy
    - Match Strategy
  - Organizational Agility (Rapidly meet customer demands and expectations & Maintain a continuous competitive advantage)

- Cost Reduction

- Types of scaling:
  - Horizontal scaling
  - Vertical scaling

- Advantages of network storage (particularly of SAN) are:
  - Compatibility with common file systems and operating systems
  - Better performance than file server
  - Data reliability and reconstruction through replication
  - Best choice for backups

- Cloud based Database solutions:
  - Advantages
    - Cost effective scalability as per use
    - High availability of data due to replication of database
    - Reduced administration of database provided as service or as part of PaaS.
  - Disadvantages
    - Due to Internet based access, the Cloud based database is not as fast as a locally installed database
    - The user may not trust the cloud provider regarding sensitive data

- General Characteristics of Cloud according to NIST:
  - Network dependence
  - Workload locations are hidden from consumer
  - Security risks due to multi-tenency
  - IT skills required

- Common Characteristics of Multi-tenant Applications:
  - Scalability in terms of number of tenants
  - Usage isolation
  - Databases, tables and/or schema isolation for each user
  - Backup and restore is separate for each tenant
  - Data security

- Privacy issues of Cloud Computing:
  - Lack of user control

- Lack of training and expertise
- Possibility of secondary unauthorized use of consumer data
- Legal compliance

- Security issues of Cloud Computing:
  - Insufficient monitoring and audit
  - Lack of security policies
  - Unauthorized access
  - No trust of data deletion
  - Backup vulnerabilities

- Types of Cloud usage monitors:
  - Monitoring Agent
  - Resource Agent
  - Polling Agent

- The agreement has two parts:
  - Service Agreement
  - Service Level Agreement (SLA)

- Major goals of a Cloud platform can be:
  - Virtualization
  - Scalability
  - Efficiency
  - Reliability

- Configurations [Failover System]
  - Active-Active
  - Active-Passive

- Cluster Computing v/s Grid Computing

Cluster Computing	**Grid Computing**
Computers are located close to each other.	Computers may be located at a huge distance from one another.
Computers are connected by a high speed local area network bus.	Computers are connected using a low speed bus or the internet.
Computers are connected in a centralized network topology.	Computers are connected in a distributed or de-centralized network topology.

Whole system has a centralized resource manager.	Every node manages it's resources independently.
Whole system functions as a single system.	Each node behaves independently.

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- Common types of Resource Cluster Mechanism
  - Server Cluster
  - Database Cluster
  - Large Dataset Clusters

- Uses of remote administration console
  - Capacity planning
  - Provision and releasing IT resources for on-demand usage
  - Configure and setting cloud services
  - Managing user accounts, security credentials, authorization and access control
  - Monitor cloud service status, usage and performance

- A Cloud service may become disruptive/unavailable/down due to:
  - Over burden of processing load
  - Scheduled updates

- Cloud Balancing Architecture improves/increases the following features:
  - Load balancing
  - Performance and scalability of IT-resources
  - Availability and reliability of IT resources

- In Dynamic Failure Detection and Recovery Architecture, The resilient watchdog module performs the following five core functions:
  - Monitoring
  - Identifying an event
  - Executing the reactive routine/s
  - Reporting

- Dynamic Failure Detection and Recovery Architecture allows the implementation of an automated recovery policy consisting of predefined steps and may involve actions such as:
  - Running a script
  - Sending a message
  - Restarting services

- Following are the steps in Bare-Metal Provisioning Architecture:
  - Consumer connects to central software through self-service portal.
  - The available servers are shown.
  - The consumer choses the server and the OS to be installed.
  - The resource management system is used to install the required chosen OS.
  - The consumer starts using the provisioned server.

- Following are the steps in Rapid Provisioning Architecture:
  - A consumer chooses a VM package through self-service portal and submits the provisioning request.
  - The centralized provisioning module selects an available VM and initiates it through a suitable template.
  - Upon initiation, the baseline/s templates are applied.
  - The VM is ready to use now.

- **[Cloud Provider's Perspective]** The two basic IT resources of IaaS are:
  - VMs
  - Cloud storage
  - These are offered along with the:
    - CPU (virtual)
    - OS
    - RAM (virtual)
    - Storage (virtual)

- **[Cloud Consumer's Perspective]** The administrative rights of the IaaS consumer includes, controlling of:
  - Life cycle of VM (powering-On/Off and restarting)
  - Cloud storage attachment
  - Basic software installations (OS and pre-installed software)
  - Passwords and credentials
  - Costs

- **[Cloud Consumer's Perspective]** Typically, a PaaS consumer receives the following:

- Cloud emulation environment
- Class libraries
- Software libraries
- Frameworks
- Databases

- **[Cloud Consumer's Perspective]** The administrative rights of the PaaS consumer includes, controlling of:
  - Cloud storage device selection
  - Choosing the tools in case of ready-made environment
  - Deployment of automated scaling listener, load balancer and replication etc.
  - Login management of service/s developed/deployed using PaaS instance
  - IT-resource usage cost

- **[Cloud Consumer's Perspective]** A few runtime configurations can be controlled by SaaS consumers. These include:
  - Security related configurations
  - SLA monitoring
  - Usage cost control

- Inter-Cloud providers are of two types:
  - With extra resources
  - With resource shortage

- Business Cost Metrics:
  - Upfront Costs
  - On-going Costs

- Cost management can take place across the lifecycle phases of Cloud services. These phases may include:
  - Design & Development
  - Deployment
  - Service Contracting
  - Provisioning & Decommissioning

- The cost templates used by the providers depend upon:
  - Market competition
  - Overhead occurred during design, deployment and operations of the service

- Cost reduction considerations through increased sharing of IT resources

- A pricing model for Cloud services can be composed of:
  - Fixed and variable rates definitions
  - Negotiations by consumers
  - Cost customization possibilities
  - Discount offerings
  - Payment options

- Two common metrics related to service measuring resiliency are as follows:
  - Mean-Time System Recovery (MTSR) Metric
  - Mean-Time to Switchover (MTSO) Metric

- The key terminologies of privacy are:
  - Data subject
  - Data processor
  - Data controller

- Trust has two types:
  - Hard trust
  - Soft trust

  - Dynamic trust (short term)
  - Persistent trust (long term)

- Five primary functions of Cryptography:
  - Privacy
  - Integrity
  - Authentication
  - Non-repudiation (A mechanism to prove the originality of the sender)
  - Exchange of crypto keys which are the strings of bits used to change the format of the data

- Remedies for Denial of Service (DoS) attacks:
  - Contact ISP to clarify the reason of downgraded network performance
  - ISP can help in throttling malicious traffic
  - Using DoS detection tools

- Some prominent security protocols for wireless security are:
  - Wired Equivalent Privacy (WEP)
  - Wi-Fi Protected Access (WPA)
  - Wi-Fi Protected Access 2 (WPA2)

- Encryption helps in countering:
  - Insufficient authorization
  - Traffic eavesdropping
  - Malicious intermediary
  - Overlapping trust boundaries

- There are two basic types of encryption:
  - Symmetric Encryption
  - Asymmetric Encryption

- Identity and Access Management (IAM) Consist of four main components:
  - Authentication (verifies user identities)
  - Authorization (grants access to specific resources based on user roles and permissions)
  - User management (creates, updates, and deletes accounts as needed)
  - Credential management

- Several factors affect the Cloud reliability:
  - Network Dependence
  - Safety-Critical Processing

- The system requirements are of two types:
  - Functional (What the cloud service should do)
  - Non functional (How well the cloud service should perform)

- Cloud Solution Design Metrics:
  - Accessibility
  - Audit
  - Availability
  - Maintainability
  - Backup

- In Cloud Resource Scheduling, There are two main steps:
  - Resource provisioning
  - Resource scheduling

- Effective resource scheduling reduces:
  - Energy consumption
  - Execution time
  - Execution cost

- Cloud Resource Scheduling Fulfills following QoS requirements:
  - Security
  - Availability
  - Reliability
  - Scalability

- Types of computational offloading:
  - Static
  - Dynamic

- Generic characteristics of big data:
  - Data volume is huge
  - The data is generated, captured and processed at high speed.
  - Data may not be categorized into regular relational databases

- The characteristics of big data can be represented by 4vs:
  - Value
  - Volume
  - Velocity
  - Variety

- popular models for big data:
  - Distributed Map Reduce model (popularized by Hadoop)
  - NoSQL model (used for non-relational, non-tabular storage)
  - SQL RDBMS model (for relational tabular storage of structured data)

- Software Defined Networking (SDN) has four characteristics:
  - Standardized APIs

- Centralization of control plane
- Programmable control plane
- Separation of control and data planes

- Online gaming consists of four basic building blocks:
  - Networking module
  - Input module
  - Rendering module
  - Game logic module

- Load Balanced Virtual Server (VM) Instances Architecture Implements a capacity watchdog/monitor system consisting of:
  - Cloud usage monitor
  - Capacity planner
  - Live VM migration module

- The rapid provisioning architecture has a (centralized) control module complemented by:
  - Server templates
  - Server images
  - OS and Application baselines
  - Applications and PaaS packages
  - Customized scripts and management modules for smooth procedures

- The United States Computer Emergency Readiness Team (US-CERT) defines the following symptoms in Denial of Service (DoS) Attacks:
  - Higher than usual volumes of spam email
  - Degradation in network performance
  - Inability to reach a website

- Remedies for Denial of Service (DoS) Attacks:
  - Using DoS detection tools
  - Contact ISP to clarify the reason of downgraded network performance
  - ISP can help in throttling malicious traffic

- Regarding the IT governance requirements, the following are important points:
  - Describe the access control policies for various users
  - Identify the controls needed within and outside the Cloud based solution so that the application can work correctly.

- Identify how to align the Cloud solution with company's business strategy
- Describe how the Cloud provider logs the errors and system events and how to access the log and performance monitoring tools made available to the consumer

- Cloud Computing vs Mobile Cloud Computing
  - Devices Used:
    - **Cloud Computing:** Typically uses computers, servers, and other non-mobile devices.
    - **Mobile Cloud Computing:** Primarily uses smartphones and tablets to access cloud services.
  - Location of Use:
    - **Cloud Computing:** Often used in fixed locations like offices or homes with stable internet.
    - **Mobile Cloud Computing:** Designed to be used on the go, anywhere with mobile internet access.
  - Resource Demands:
    - **Cloud Computing:** Requires more powerful hardware and higher internet bandwidth.
    - **Mobile Cloud Computing:** Optimized for devices with limited processing power and lower bandwidth.

- Popular platforms for Big Data processing are:
  - Spark
  - Hadoop
    - MapReduce programming framework
    - Hadoop Distributed File System (HDFS)

- High speed communication links are used to connect the clustered IT resources for:
  - Task scheduling
  - Data sharing
  - Workload distribution
  - System synchronization

- Disadvantages of Lack of user control:
  - No Ownership and control of infrastructure
  - No Control over data lifecycle
  - Uncertainty of Data Access and Unauthorized Detection
  - Unclear Responsibility for Unauthorized Access
  - Challenges in Retrieving and Deleting Data from a Previous Provider