

**UNIT I**

<b>Chapter 1 : Fundamentals of Cloud Computing</b>	<b>1-1 to 1-38</b>
<b>1.1 Introduction to Cloud Computing</b>	<b>1-1</b>
1.1.1 Concept Building : Consuming Services Vs Owning Products	1-1
1.1.2 What is Cloud Computing ?	1-2
1.1.3 Goals of Cloud Computing	1-3
1.1.4 Advantages of Cloud Computing	1-4
1.1.5 Disadvantages of Cloud Computing	1-5
<b>1.2 Origins and Influences</b>	<b>1-5</b>
<b>1.3 Basic Concepts and Terminologies</b>	<b>1-6</b>
<b>1.4 Risks and Challenges in Cloud Computing</b>	<b>1-8</b>
1.4.1 Concept Building : Shared Responsibility Model	1-9
<b>1.5 Cloud Security Risks and Countermeasures</b>	<b>1-9</b>
1.5.1 Loss of Governance	1-10
1.5.1(A) Countermeasures for Loss of Governance	1-10
1.5.2 Lock-In	1-12
1.5.2(A) Countermeasures for Lock-In	1-13
1.5.3 Isolation Failure	1-13
1.5.3(A) Countermeasures for Isolation Failure	1-13
1.5.4 Proving Compliance	1-13
1.5.4(A) Countermeasures for Proving Compliance	1-14
1.5.5 Data Exposure	1-14
1.5.5(A) Countermeasures for Data Exposure	1-14
1.5.6 Malicious Insider	1-15
1.5.6(A) Countermeasures for Malicious Insiders	1-15
1.5.7 Insufficient IAM (Identity and Access Management) Controls	1-15
1.5.7(A) Countermeasures for Insufficient IAM Controls	1-16
1.5.8 Insecure Interfaces and APIs	1-17
1.5.8(A) Countermeasures for Insecure Interfaces and APIs	1-17
<b>1.6 Roles in Cloud Computing</b>	<b>1-17</b>
<b>1.7 Boundaries in Cloud Computing</b>	<b>1-18</b>
<b>1.8 Cloud Characteristics</b>	<b>1-19</b>
1.8.1 On-Demand Self-Service	1-19
1.8.2 Broad Network Access	1-20
1.8.3 Resource Pooling	1-20
1.8.4 Rapid Elasticity	1-21
1.8.5 Measured Service	1-21
<b>1.9 Cloud Delivery (Service) Models</b>	<b>1-22</b>
1.9.1 Concept Building – Service Delivery Models	1-22

1.9.2	Cloud Service Models .....	1-23
1.9.2(A)	Software as a Service (SaaS) .....	1-23
1.9.2(B)	Platform as a Service (PaaS) .....	1-25
1.9.2(C)	Infrastructure as a Service (IaaS) .....	1-27
1.9.3	Comparison between SaaS, PaaS, IaaS.....	1-29
1.9.4	Cloud Pyramid .....	1-30
<b>1.10</b>	<b>Cloud Deployment Models .....</b>	<b>1-30</b>
1.10.1	Private Cloud .....	1-31
1.10.1(A)	Advantages of Private Cloud .....	1-31
1.10.1(B)	Disadvantages of Private Cloud .....	1-32
1.10.2	Public Cloud .....	1-32
1.10.2(A)	Advantages of Public Cloud .....	1-32
1.10.2(B)	Disadvantages of Public Cloud .....	1-33
1.10.3	Community Cloud.....	1-33
1.10.3(A)	Advantages of Community Cloud.....	1-33
1.10.3(B)	Disadvantages of Community Cloud.....	1-34
1.10.4	Hybrid Cloud .....	1-34
1.10.4(A)	Advantages of Hybrid Cloud.....	1-34
1.10.4(B)	Disadvantages of Hybrid Cloud .....	1-34
1.10.5	Comparison of Cloud Deployment Models .....	1-35
1.10.6	Summary of Cloud Characteristics, Service Model, and Deployment Model.....	1-35
<b>1.11</b>	<b>Types of Cloud .....</b>	<b>1-36</b>
1.11.1	Intercloud or Federated Cloud.....	1-36
1.11.1(A)	Advantages of Federation.....	1-36

**UNIT II**

<b>Chapter 2 :</b>	<b>Cloud-Enabling Technology and Virtualization</b>	<b>2-1 to 2-48</b>
<b>2.1</b>	<b>Cloud Enabling Technologies.....</b>	<b>2-1</b>
2.1.1	Broadband Networks and Internet Architecture .....	2-2
2.1.2	Datacentre Technology.....	2-3
2.1.3	Virtualization Technology.....	2-4
2.1.4	Web Technology .....	2-5
2.1.5	Multi-tenant Technology .....	2-7
2.1.5(A)	Advantages of Multi-tenancy .....	2-7
2.1.5(B)	Disadvantages of Multi-tenancy .....	2-7
2.1.5(C)	Comparison between Single-tenant and Multi-tenant Applications .....	2-8
2.1.6	Service Technology or Service Oriented Architecture (SOA) .....	2-8
2.1.6(A)	Characteristics of a Service.....	2-9
2.1.6(B)	Core Elements of the Service Technology.....	2-9
<b>2.2</b>	<b>Introduction to Virtualization.....</b>	<b>2-9</b>

<b>2.3</b>	<b>Core Components of Virtualization .....</b>	<b>2-10</b>
2.3.1	Physical Server / Hardware .....	2-10
2.3.2	Virtualization Layer .....	2-10
2.3.3	Virtual Machines (VM) .....	2-12
2.3.4	Guest Operating System (OS) .....	2-14
2.3.5	Applications (App).....	2-15
2.3.6	Summary of Mapping Virtualization Components to Cloud Computing .....	2-16
<b>2.4</b>	<b>Advantages / Needs / Applications / Goals of Virtualization .....</b>	<b>2-16</b>
2.4.1	Server Consolidation and Resource Optimisation .....	2-17
2.4.2	Improved Productivity and Operational Efficiency.....	2-17
2.4.3	Cost Savings .....	2-18
2.4.4	Improved Security .....	2-18
2.4.5	Improved Resiliency .....	2-19
<b>2.5</b>	<b>Challenges / Limitations of Virtualization.....</b>	<b>2-20</b>
2.5.1	Could be a Single Point of Failure .....	2-20
2.5.2	Not Everything can be Virtualized .....	2-20
2.5.3	Requires Skilled Staff.....	2-21
2.5.4	Virtual Machine Sprawl.....	2-21
2.5.5	Capacity Planning is Hard .....	2-21
2.5.6	Managing Licenses.....	2-22
<b>2.6</b>	<b>Implementation Levels of Virtualization .....</b>	<b>2-22</b>
2.6.1	Instruction Set Architecture (ISA) Level Virtualization .....	2-22
2.6.2	Hardware Abstraction Layer (HAL) Level Virtualization.....	2-23
2.6.3	Operating System Level Virtualization .....	2-23
2.6.4	Library Level Virtualization .....	2-25
2.6.5	Application Level Virtualization.....	2-26
2.6.6	Comparison between various Implementation Levels of Virtualization.....	2-27
<b>2.7</b>	<b>Virtualization Structures / Tools and Mechanisms.....</b>	<b>2-27</b>
2.7.1	Types of Hypervisors.....	2-27
2.7.1(A)	Type 1 : Baremetal Hypervisor .....	2-27
2.7.1 (B)	Type 2 : Hosted Hypervisor.....	2-30
2.7.1(C)	Comparison between Type 1 and Type 2 Hypervisor.....	2-30
2.7.2	Types of Hardware-Level Virtualization .....	2-31
2.7.2(A)	Full Virtualization using Binary Translation.....	2-32
2.7.2(B)	OS Assisted Virtualization or Paravirtualization.....	2-33
2.7.2(C)	Hardware-Assisted Virtualization.....	2-33
2.7.2(D)	Comparison between Types of Hardware-Level Virtualization .....	2-34
<b>2.8</b>	<b>Virtualization of CPU, Memory and I/O Devices .....</b>	<b>2-35</b>
2.8.1	CPU Virtualization.....	2-35
2.8.2	Memory Virtualization.....	2-35
2.8.3	I/O Device Virtualization.....	2-36

<b>2.9</b>	<b>Virtual Clusters and Resource Management.....</b>	<b>2-36</b>
2.9.1	Virtual Clusters.....	2-37
2.9.2	Characteristics of Virtual Clusters.....	2-38
2.9.3	Live VM Migration.....	2-38
2.9.3(A)	Advantages of Live VM Migration.....	2-39
2.9.3(B)	Live VM Migration Steps.....	2-39
<b>2.10</b>	<b>Virtualization for Datacentre Automation .....</b>	<b>2-41</b>
2.10.1	Nimbus .....	2-41
2.10.2	Eucalyptus .....	2-42
2.10.3	OpenNebula .....	2-43
2.10.4	OpenStack.....	2-44
2.10.5	VMware vSphere .....	2-45

**UNIT III**

---

**Chapter 3 : Common Standards and Cloud Platforms** **3-1 to 3-66**

---

<b>3.1</b>	<b>Common Standards .....</b>	<b>3-1</b>
3.1.1	The Open Cloud Consortium / The Open Commons Consortium (OCC).....	3-2
3.1.2	Open Virtualization Format (OVF).....	3-2
3.1.2(A)	Characteristics of OVF.....	3-3
3.1.2(B)	Lifecycle of an OVF based Virtual System.....	3-3
3.1.3	AJAX.....	3-4
3.1.4	XML.....	3-4
3.1.5	JSON.....	3-5
3.1.5(A)	Comparison between JSON and XML.....	3-6
3.1.6	Solution Stack - LAMP and LAPP.....	3-6
3.1.7	Syndication.....	3-7
3.1.7(A)	Really Simple Syndication (RSS).....	3-9
3.1.7(B)	Atom.....	3-10
<b>3.2</b>	<b>Standards for Security.....</b>	<b>3-12</b>
3.2.1	Transport Layer Security (TLS).....	3-12
3.2.2	Identity Federation.....	3-13
3.3	Services Offered by Amazon Web Services (AWS).....	3-13
3.3.1	Amazon EC2.....	3-15
3.3.1(A)	Characteristics and Features of EC2.....	3-15
3.3.1(B)	Creating an EC2 Instance.....	3-16
3.3.2	Amazon Virtual Private Cloud (VPC).....	3-22
3.3.2(A)	Characteristics of Amazon VPC.....	3-23
3.3.2(B)	Creating a VPC .....	3-26
<b>3.4</b>	<b>AWS Storage and Content Delivery .....</b>	<b>3-27</b>
3.4.1	Amazon S3.....	3-27

3.4.1(A)	Characteristics and Features of S3 .....	3-27
3.4.1(B)	Creating an Amazon S3 Bucket.....	3-28
3.4.1(C)	Managing Objects in S3.....	3-34
3.4.2	Amazon EBS.....	3-41
3.4.2(A)	Characteristics and Features of Amazon EBS .....	3-42
3.4.2(B)	Creating and Attaching an EBS Volume to an EC2 Instance .....	3-42
3.4.2(C)	Amazon EBS Snapshots .....	3-45
3.4.3	Amazon EFS .....	3-47
3.4.3(A)	Characteristics and Features of Amazon EFS.....	3-47
<b>3.5</b>	<b>Amazon CloudFront.....</b>	<b>3-47</b>
3.5.1	Characteristics and Features of Amazon CloudFront.....	3-49
<b>3.6</b>	<b>Amazon Elastic Load Balancing Service.....</b>	<b>3-50</b>
3.6.1	Introduction to Load Balancers.....	3-50
3.6.1(A)	Load Balancer Algorithms (Method, Schemes, Techniques).....	3-50
3.6.1(B)	Performance Benefits of using a Load Balancer .....	3-51
3.6.2	Introduction to Amazon ELB .....	3-52
3.6.2(A)	Characteristics and Features of Amazon ELB .....	3-53
3.6.2(B)	Comparison between Types of ELB.....	3-53
3.6.2(C)	Creating and Verifying ELB.....	3-53
<b>3.7</b>	<b>Google Cloud .....</b>	<b>3-59</b>
<b>3.8</b>	<b>Google App Engine .....</b>	<b>3-60</b>
3.8.1	Characteristics and Features of Google App Engine .....	3-61
<b>3.9</b>	<b>Cost Model.....</b>	<b>3-61</b>
<b>3.10</b>	<b>Microsoft Azure.....</b>	<b>3-62</b>
3.10.1	Azure Virtual Machines (Azure VM).....	3-62
3.10.2	Blob Storage.....	3-63
3.10.3	Database Services .....	3-63
3.10.4	Azure Monitor.....	3-64

## UNIT IV

<b>Chapter 4 :</b>	<b>Data Storage and Security in Cloud</b>	<b>4-1 to 4-26</b>
<b>4.1</b>	<b>Cloud File Systems .....</b>	<b>4-1</b>
4.1.1	General Architecture of Cloud File Systems.....	4-2
4.1.1(A)	Client-Server Architecture .....	4-2
4.1.1(B)	Cluster-based Architecture.....	4-2
<b>4.2</b>	<b>Google File System (GFS) .....</b>	<b>4-3</b>
4.2.1	Characteristics and Features of GFS.....	4-3
4.2.2	Architecture of GFS.....	4-4
<b>4.3</b>	<b>Hadoop Distributed File System (HDFS) .....</b>	<b>4-4</b>
4.3.1	Characteristics and Features of HDFS .....	4-4

4.3.2	Architecture of HDFS.....	4-5
<b>4.4</b>	<b>Bigtable.....</b>	<b>4-5</b>
4.4.1	Characteristics and Features of Bigtable.....	4-6
4.4.2	Architecture of Bigtable.....	4-6
<b>4.5</b>	<b>HBase.....</b>	<b>4-8</b>
4.5.1	Characteristics and Features of HBase.....	4-8
4.5.2	Architecture of HBase.....	4-8
<b>4.6</b>	<b>Dynamo.....</b>	<b>4-9</b>
4.6.1	Characteristics and Features of Dynamo.....	4-10
4.6.2	Architecture of Dynamo.....	4-10
<b>4.7</b>	<b>Cloud Data Stores.....</b>	<b>4-11</b>
4.7.1	Google Cloud Datastore.....	4-11
4.7.1(A)	Comparison Between Cloud Datastore and Relational Database.....	4-11
4.7.1(B)	How Google Cloud Datastore Works.....	4-12
4.7.2	Amazon SimpleDB.....	4-12
4.7.2(A)	How Amazon SimpleDB Works.....	4-13
4.7.3	Cloud Storage (Overview and Providers).....	4-13
<b>4.8</b>	<b>Securing the Cloud.....</b>	<b>4-14</b>
4.8.1	Security Advantages of Cloud-Based Solutions.....	4-14
4.8.1(A)	Cloud Based Benefits.....	4-14
4.8.1(B)	Staffing and Expertise.....	4-15
4.8.1(C)	Cross Pollination.....	4-15
4.8.2	Business Continuity and Disaster Recovery.....	4-15
4.8.2(A)	Benefits of Business Continuity Planning.....	4-16
4.8.2(B)	Types of Disruptive Events (or Threats).....	4-16
4.8.2(C)	Business Continuity Planning Process.....	4-18
4.8.2(D)	Business Continuity in the Cloud Era.....	4-23

**UNIT V**

<b>Chapter 5 :</b>	<b>Ubiquitous Clouds and The Internet of Things</b>	<b>5-1 to 5-26</b>
<b>5.1</b>	<b>Cloud Trends in Supporting Ubiquitous Computing.....</b>	<b>5-1</b>
5.1.1	Cloud Mashup.....	5-2
5.1.1(A)	Advantages of Cloud Mashup.....	5-3
5.1.1(B)	Disadvantages of Cloud Mashup.....	5-3
5.1.2	Mobile Cloud Computing.....	5-3
5.1.3	Comparison between Cloudlet and Cloud.....	5-4
<b>5.2</b>	<b>Performance of Distributed Systems and the Cloud.....</b>	<b>5-5</b>
<b>5.3</b>	<b>Enabling Technologies for the Internet of Things.....</b>	<b>5-6</b>
5.3.1	Architecture of IoT.....	5-6
<b>5.4</b>	<b>Radio-Frequency Identification (RFID).....</b>	<b>5-8</b>

5.4.1	How RFID Works ? .....	5-9
5.4.2	Application of RFID in IoT .....	5-9
5.4.3	Advantages of RFID .....	5-10
5.4.4	Disadvantages of RFID .....	5-10
<b>5.5</b>	<b>Wireless Sensor Networks (WSN) .....</b>	<b>5-10</b>
<b>5.6</b>	<b>ZigBee Technology .....</b>	<b>5-11</b>
5.6.1	Benefits of ZigBee .....	5-11
5.6.2	ZigBee Technical Specifications .....	5-11
5.6.3	ZigBee Architecture .....	5-12
<b>5.7</b>	<b>Global Positioning System (GPS) .....</b>	<b>5-13</b>
5.7.1	How GPS Works ? .....	5-14
5.7.2	IoT with GPS .....	5-14
<b>5.8</b>	<b>Benefits of using Wireless Network for Ubiquitous Computing .....</b>	<b>5-15</b>
<b>5.9</b>	<b>Challenges and Outlook of Ubiquitous Systems .....</b>	<b>5-15</b>
<b>5.10</b>	<b>Innovative Applications of the Internet of Things .....</b>	<b>5-16</b>
5.10.1	Smart Buildings .....	5-16
5.10.2	Smart Power Grid .....	5-17
5.10.2(A)	Characteristics of Smart Power Grid .....	5-18
5.10.2(B)	Applications of Smart Power Grid .....	5-19
5.10.3	Retailing and Supply Chain Management .....	5-19
5.10.4	Cyber Physical System (CPS) .....	5-20
5.10.4(A)	Architecture of CPS .....	5-21
5.10.4(B)	Relation between IoT and CPS .....	5-21
<b>5.11</b>	<b>Online Social and Professional Networking .....</b>	<b>5-22</b>
5.11.1	Facebook .....	5-22
5.11.1(A)	Architecture of Facebook .....	5-22
5.11.2	Twitter .....	5-23
5.11.2(A)	Architecture of Twitter .....	5-24

**UNIT VI**

<b>Chapter 6 :</b>	<b>Future of Cloud Computing</b>	<b>6-1 to 6-23</b>
<b>6.1</b>	<b>How the Cloud Will Change Operating Systems .....</b>	<b>6-1</b>
<b>6.2</b>	<b>Location-Aware Applications .....</b>	<b>6-2</b>
<b>6.3</b>	<b>Intelligent Fabrics .....</b>	<b>6-4</b>
<b>6.4</b>	<b>Intelligent Paint .....</b>	<b>6-5</b>
<b>6.5</b>	<b>The Future of Cloud TV .....</b>	<b>6-5</b>
<b>6.6</b>	<b>Future of Cloud-Based Smart Devices .....</b>	<b>6-7</b>
<b>6.7</b>	<b>Faster Time to Market for Software Applications .....</b>	<b>6-7</b>
<b>6.8</b>	<b>Home-Based Cloud Computing .....</b>	<b>6-9</b>
<b>6.9</b>	<b>Mobile Cloud .....</b>	<b>6-9</b>

---

<b>6.10</b>	<b>Autonomic Cloud Engine</b> .....	<b>6-9</b>
<b>6.11</b>	<b>Multimedia Cloud</b> .....	<b>6-11</b>
<b>6.12</b>	<b>Energy Aware Cloud Computing</b> .....	<b>6-12</b>
<b>6.13</b>	<b>Jungle Computing</b> .....	<b>6-13</b>
<b>6.14</b>	<b>Docker at a Glance</b> .....	<b>6-14</b>
6.14.1	Architecture of Docker.....	6-15
6.14.2	Building a Docker Image.....	6-15
6.14.3	Docker Workflow .....	6-16
6.14.4	Process Simplification.....	6-18
6.14.5	Broad Support and Adoption.....	6-19
6.14.6	Getting the Most from Docker .....	6-21
6.14.7	Comparison between VMs and Containers .....	6-22

---