



# Table of Contents

<b>Introduction .....</b>	<b>xxi</b>
<b>Chapter 1: Era of Cloud Computing .....</b>	<b>1</b>
Getting to Know the Cloud .....	2
Cloud and Other Similar Configurations .....	3
Peer-To-Peer, Client-Server, and Grid Computing .....	4
Cloud Computing Versus Peer-to-Peer Architecture .....	5
Cloud Computing Versus Client-Server Architecture .....	5
Cloud Computing Versus Grid Computing.....	6
How We Got to the Cloud .....	6
Concept Phase.....	7
Pre-Cloud Phase .....	10
Cloud Phase .....	11
Server Virtualization Versus Cloud Computing.....	13
Components of Cloud Computing.....	14
Cloud Types—Private, Public, and Hybrid.....	16
The Public Clouds .....	16
The Private Clouds .....	16
The Community Clouds.....	17
The Hybrid Cloud .....	18
Impact of Cloud Computing on Businesses .....	18

**Table of Contents**

---

Organizations that Could Benefit from Public or Private Clouds.....	20
The Cloud is not for Everyone - When you Might not Benefit from the Cloud.....	21
Cloud Computing Service Delivery Models .....	23
Points to Remember .....	25
<b>Chapter 2: Introducing Virtualization .....</b>	<b>27</b>
Introducing Virtualization and its Benefits .....	28
Benefits.....	29
Implementation Levels of Virtualization.....	30
Comparison between the Implementation Levels of Virtualization .....	34
Virtualization Design Requirements.....	34
Virtualization Providers.....	35
Virtualization at the OS Level .....	37
Virtualization Structure .....	38
Hosted Structure.....	38
Bare-Metal Structure .....	40
Virtualization Mechanisms.....	41
Open Source Virtualization Technology.....	42
KVM versus the Xen Hypervisor .....	43
Xen Virtualization Architecture .....	43
Binary Translation with Full Virtualization .....	44
Paravirtualization with Compiler Support.....	45
Virtualization of CPU, Memory, and I/O Devices .....	46
Hardware Support for Virtualization in Intex x86 Processor.....	48
CPU Virtualization.....	49
Memory Virtualization.....	50
Device and I/O Virtualization.....	51
Virtualization in Multicore Processors .....	52
Points to Remember .....	53
<b>Chapter 3: Cloud Computing Services .....</b>	<b>55</b>
Infrastructure as a Service (IaaS).....	57
Platform as a Service (PaaS).....	58

Leveraging PaaS for Productivity .....	61
Guidelines for Selecting a <i>PaaS</i> Provider.....	63
Concerns with PaaS.....	63
Language and <i>PaaS</i> .....	64
Software as a Service (SaaS).....	64
Database as a Service (DBaaS).....	70
Specialized Cloud Services .....	71
Points to Remember .....	72
<b>Chapter 4: Cloud Computing and Business Value.....</b>	<b>73</b>
Key Drivers for Cloud Computing .....	74
Cloud Computing and Outsourcing.....	75
Types of Scalability .....	77
Use of Load Balancers to Enhance Scalability .....	77
Variable Operating Costs Using Cloud Computing.....	78
Time-to-market Benefits of Cloud Computing .....	78
Distribution Over the Internet.....	79
Levels of Business Value from Cloud Computing.....	79
Points to Remember .....	80
<b>Chapter 5: Demystifying Cloud Computing .....</b>	<b>81</b>
Myths and Truths.....	82
Points to Remember .....	86
<b>Chapter 6: Cloud Types and Models .....</b>	<b>87</b>
Private Cloud.....	88
Components of a Private Cloud .....	90
Implementation Phases of a Private Cloud.....	91
Hardening a Private Cloud.....	93
What is Not a Private Cloud.....	94
Use Cases of a Private Cloud.....	95
Case Study: Private Cloud for Central and State Governments.....	96
Case Study: Private Cloud for College to Create a Virtual Computing Lab.....	97

## Table of Contents

---

Community Cloud .....	98
Public Cloud .....	99
When to Avoid Public Clouds .....	102
Public Versus Community Cloud.....	104
Cloud APIs.....	105
Case Study: Weather Forecasting Using a Public Cloud .....	107
Case Study: Software Development and Testing in a Public Cloud .....	107
Hybrid Clouds.....	109
Private Versus Hybrid Cloud .....	110
Points to Remember .....	111
<b>Chapter 7: Open Source Cloud Implementation and Administration .....</b>	<b>113</b>
Open-Source Eucalyptus Cloud Architecture .....	114
Features of Eucalyptus.....	114
Components of Eucalyptus.....	116
Modes of Operation.....	118
Installation and Configuration Process.....	121
Open-Source OpenStack Cloud Architecture.....	129
Features of OpenStack.....	131
Components of OpenStack .....	132
Modes of Operation.....	136
Installation and Configuration Process.....	136
Cloud Administration and Management .....	141
OpenStack Web-Based Interface Dashboard .....	141
Eucalyptus Web-Based Interface.....	143
Starting and Shutting Down the Cloud Controller and Cluster Controller .....	145
Bundling or Uploading Virtual Machine Images on the Cloud Controller.....	146
Bundling and Uploading Bootable Image File .....	146
Bundling and Uploading the Kernel, initrd, and root Partition Separately .....	146
Launching Instances through PHP-Based Web Interface .....	148
Connecting to the Instances through PHP-Based Web Interface .....	148
GUI Access to VM Instances over SSH.....	148
Points to Remember .....	149

---

<b>Chapter 8: Cloud Deployment Techniques .....</b>	<b>151</b>
Potential Network Problems and their Mitigation.....	153
Cloud Network Topologies .....	153
Automation for Cloud Deployments .....	154
Self-Service Features in a Cloud Deployment.....	155
Federated Cloud Deployments .....	156
Cloud Performance .....	156
Cloud Performance Monitoring and Tuning.....	157
Impact of Memory on Cloud Performance.....	157
Improving Cloud Database Performance.....	158
Cloud Services Brokerage (CSB) .....	158
Points to Remember .....	159
<b>Chapter 9: Recent Trends in Cloud Computing and Standards .....</b>	<b>161</b>
Recent Trends: Conflict of Interest for Public Cloud and IT Product Providers.....	162
Recent Trends in Cloud Compliance .....	163
Recent Trends in Security: BYOD and Encryption Exposures .....	163
Recent Trends in Cloud Standards .....	164
Approaches to Implement Interoperability between Clouds.....	167
Recent Changes in Professional Certifications .....	168
Cloud Ratings.....	169
Cloud Computing Trends that are Accelerating Adoption.....	170
Points to Remember .....	171
<b>Chapter 10: Host Security in the Cloud .....</b>	<b>173</b>
Security for the Virtualization Product.....	174
Host Security for SaaS.....	175
Host Security for PaaS.....	176
Host Security for IaaS.....	177
Points to Remember .....	178

<b>Chapter 11: Data Security in the Cloud.....</b>	<b>179</b>
Challenges with Cloud Data.....	181
Challenges with Data Redundancy.....	181
Challenges with Disaster Recovery.....	181
Challenges with Data Backup.....	182
Challenges with Data Replication.....	182
Challenges with Data Residency or Location.....	182
Challenges with Data Reliability.....	183
Challenges with Data Fragmentation.....	183
Challenges with Data Integration.....	183
Challenges with Data Transformation.....	184
Challenges with Data Migration.....	184
Challenges with Data Security.....	184
Data Confidentiality and Encryption.....	186
Key Protection.....	187
Key Length.....	189
Backup Data.....	190
Data Availability.....	191
Data Integrity.....	193
Cloud Data Management Interface.....	194
Cloud Storage Gateways (CSGs).....	195
Advantages of Using a CSG.....	197
Cloud Firewall.....	198
Virtual Firewall.....	198
Points to Remember.....	198
<b>Chapter 12: Application Architecture for Cloud.....</b>	<b>201</b>
Cloud Application Requirements.....	202
Architecture for Traditional Versus Cloud Applications.....	204
Assumptions for Traditional and Cloud Applications.....	204
Recommendations for Cloud Application Architecture.....	205
Fundamental Requirements for Cloud Application Architecture.....	207

Relevance and Use of Client-server Architecture for Cloud Applications.....	210
Addressing Cloud Application Performance and Scalability .....	211
Service-Oriented Architecture (SOA) for Cloud Applications.....	212
Parallelization within Cloud Applications.....	215
Leveraging In-memory Operations for Cloud Applications.....	216
Points to Remember .....	216
<b>Chapter 13: Cloud Programming .....</b>	<b>219</b>
Programming Support for Google Apps Engine .....	220
Google File System .....	221
BigTable as Google’s NoSQL System.....	223
Chubby as Google Distributed Lock Service.....	226
Programming Support for Amazon EC2.....	229
Amazon S3 .....	229
Elastic Block Store (ESB) .....	231
Amazon SimpleDB.....	233
Points to Remember .....	235
<b>Chapter 14: Adoption and Use of Cloud by Small and                   Medium Businesses (SMBs).....</b>	<b>237</b>
Pace of Adoption of Public Cloud by SMBs .....	238
Public Cloud Benefits for SMBs.....	239
Public Cloud Adoption Phases for SMBs .....	241
Cloud Vendor Roles and Responsibilities Towards SMBs.....	243
Vendor Selection Phases.....	244
Cloud Provider Liability.....	245
Cloud Provider Capabilities.....	245
Infrastructure Management Capabilities .....	245
Service Management Capabilities .....	246
Financial Management Capabilities .....	246
Risk Management Capabilities.....	247
Success Factors for Cloud Consumers .....	248

**Table of Contents**

---

Issues with SMBs Using Public Cloud Services .....	251
Points to Remember .....	251
<b>Chapter 15: Adoption and Use of Cloud by Enterprises .....</b>	<b>253</b>
Questions that Enterprises Must Ask Cloud Vendors.....	255
Points to Remember .....	268
<b>Chapter 16: Migrating Applications to the Cloud .....</b>	<b>269</b>
Key Aspects That Will Migrate Users to Cloud Applications.....	270
Cloud Migration Techniques.....	270
Phases During the Migration of an Application to the Cloud.....	273
Cloud Emulators and Its Use for Application Testing and Migration .....	275
Points to Remember .....	275
<b>Chapter 17: IT Service Management for Cloud Computing.....</b>	<b>277</b>
ITIL-Based Service Management.....	278
Service Strategy .....	280
Strategy Management for IT Services .....	280
Service Portfolio Management.....	281
Financial Management of IT Services.....	281
Demand Management.....	282
Business Relationship Management.....	282
Service Design .....	282
Design Coordination .....	283
Service Catalog .....	283
Service Level Management .....	284
Availability Management .....	284
Capacity Management .....	284
IT Service Continuity Management (ITSCM) .....	285
Information Security Management System (ISMS) .....	286
Supplier Management.....	286



Service Transition.....	287
Transition Planning and Support (or Project Management Phase).....	288
Change Management .....	288
Service Asset and Configuration Management (SACM) .....	289
Release and Deployment Management .....	290
Service Validation and Testing.....	290
Change Evaluation .....	290
Knowledge Management.....	291
Service Operations .....	291
IT Operations Management.....	292
Service Helpdesk.....	292
Event Management.....	292
Incident Management .....	293
Request Fulfillment .....	293
Problem Management.....	294
Access Management.....	294
Technical Management .....	295
Application Management .....	295
Continual Service Improvement .....	295
Points to Remember .....	297
<b>Chapter 18: SLA with Cloud Service Providers .....</b>	<b>299</b>
The Concept of an SLA .....	301
SLA Aspects and Requirements.....	302
Service Availability .....	305
Cloud Outages.....	305
Credit Calculation for SLA Breaches .....	306
Sample SLA 1: Amazon S3 SLA .....	306
Sample SLA 2: The Rackspace Cloud Server SLA.....	309
Sample SLA 3: Google Apps SLA .....	311
Sample SLA 4: HP Cloud Compute SLA.....	312
Points to Remember .....	315

**Chapter 19: Risks, Consequences, and Costs for Cloud Computing.....317**

Introducing Risks in Cloud Computing ..... 318

Risk Assessment and Management..... 320

Risk of Vendor Lock-in ..... 320

Risk of Loss of Control..... 321

Risk of Not Meeting Regulatory Compliances ..... 321

Risk of Resource Scarcity or Poor Provisioning ..... 321

Risk in a Multi-Tenant Environment ..... 322

Risk of Failure..... 322

Risk of Failure of Supply Chain ..... 322

Risk of Inadequate SLA ..... 323

Risks of Malware and Internet Attacks..... 323

Risk of Management of Cloud Resources..... 323

Risk of Network Outages..... 324

Risks in the Physical Infrastructure ..... 324

Legal Risk Due to Legislation..... 324

Risks with Software and Application Licensing ..... 325

Security and Compliance Requirements in a Public Cloud ..... 326

Calculating Total Cost of Ownership (TCO) for Cloud Computing..... 327

Direct and Indirect Cloud Costs..... 327

Costs Allocations in a Cloud ..... 328

Chargeback Models for Allocation of Direct and Indirect Cost..... 329

Chargeback Methodology ..... 330

    Cost..... 331

Billable Items ..... 331

    Atomic Units..... 332

    Pricing Model ..... 332

    Chargeback Tools and Solution..... 333

Maintaining Strategic Flexibility in a Cloud..... 334

Points to Remember ..... 335

**Chapter 20: AAA Administration for Clouds .....337**

The AAA Model..... 338

    Authentication..... 338

---

Authorization.....	338
Accounting of Cloud Resource Utilization.....	339
Single Sign-On for Clouds.....	340
Case Study: Secure SSO for Migration to the Cloud for Southern Shipyards.....	342
Industry Implementations for AAA.....	343
Authentication Management in the Cloud.....	344
Standards for Controlling Access.....	345
SAML.....	346
Authorization Management in the Cloud.....	349
Accounting for Resource Utilization.....	350
Points to Remember.....	350
<b>Chapter 21: Regulatory and Compliance Requirements for Clouds.....</b>	<b>351</b>
Regulations for Clouds.....	352
GLBA.....	355
HIPAA: Health Insurance Portability and Accountability Act of 1996.....	356
HITECH: Health Information Technology for Economic and Clinical Health Act.....	357
PCI-DSS: Payment Card Industry-Data Security Standards.....	358
SOX: Sarbanes-Oxley Act.....	359
ECPA: Electronics Communication Privacy Act.....	360
How to Evaluate Compliance within a Cloud.....	361
Understand Compliance Requirements and Work with Your Cloud Service Provider.....	361
Select a Cloud Provider with a History of Transparency in Security and Policies.....	362
Separate Your and Your Cloud Provider’s Responsibilities.....	362
Understand Your Application and Data Requirements.....	363
Know About the Certifications and Compliance of Your Cloud Provider.....	363
Points to Remember.....	363
<b>Chapter 22: Security As A Service.....</b>	<b>365</b>
What Can Security-as-a-Service Offer?.....	366
Benefits of Security-as-a-Service.....	368
Concerns with Security-as-a-Service.....	370
Security Service Providers.....	371

**Table of Contents**

---

Identity Management as a Service (IdMaaS).....	373
Attributes of IdMaaS Providers.....	376
Leading IdMaaS Providers .....	377
Points to Remember .....	377
<b>Chapter 23: Cloud Certifications and Audits .....</b>	<b>379</b>
Certifications.....	380
ISO 9000 Family of Certifications .....	380
ISO 27000 and ISMS Family of Certifications .....	380
CMMI Certifications.....	381
Cloud Audit Framework.....	383
SysTrust.....	383
WebTrust.....	384
SAS 70.....	385
Cloud Auditing Requirements.....	386
Internal Audit Requirements.....	386
Customer Audit Requirements.....	386
Government Audit Requirements.....	387
Points to Remember .....	387
<b>Chapter 24: Application Development for Cloud.....</b>	<b>389</b>
Developing On-Premise Versus Cloud Applications .....	390
Modifying Traditional Applications for Deployment in the Cloud.....	391
Stages During the Development Process of Cloud Application .....	392
Managing a Cloud Application.....	393
Using Agile Software Development for Cloud Applications.....	394
Cloud Applications: What NOT To Do .....	396
Static Code Analysis for Cloud Applications.....	396
Developing Synchronous and Asynchronous Cloud Applications.....	397
Case Study: Software Product Development and Testing in a Public Cloud.....	397
The ISV selects two cloud providers .....	398
Points to Remember .....	399

<b>Chapter 25: Application Security in the Cloud .....</b>	<b>401</b>
Cloud Application Software Development Lifecycle (SDLC) .....	403
Cloud Service Reports by Providers .....	404
Application Security in an IaaS Environment .....	405
Application Security in a PaaS Environment .....	408
Security Challenges in a PaaS .....	409
Protecting a PaaS .....	410
Application Security in a SaaS Environment .....	411
Points to Remember .....	413
<b>Chapter 26: Cloud Computing: The Road Ahead .....</b>	<b>415</b>
The Road Ahead for Revenue for Cloud Providers .....	416
The Road Ahead for Enterprise Customers .....	417
The Road Ahead for Corporate IT Administrators .....	417
The Road Ahead for Corporate IT Departments .....	418
Change in IT Team Structure .....	418
Lower Operational Expenses .....	419
Open Systems .....	419
The Road Ahead for Cloud Developers .....	419
The Road Ahead for Standards .....	420
The Road Ahead for System Integrators and Managed Service Providers .....	421
The Road Ahead for Cloud Service Brokerages .....	423
iPaaS - “Embedded” Feature of Cloud Services .....	424
The Road Ahead for Cloud Security .....	426
The Road Ahead for Cloud SLAs .....	428
The Road Ahead for Identity Management .....	428
The Road Ahead for Cloud Consumers .....	429
Points to Remember .....	431
<b>Chapter 27: Mobile Cloud Computing .....</b>	<b>433</b>
Definition of Mobile Cloud Computing .....	434
Architecture of Mobile Cloud Computing .....	436
Benefits of Mobile Cloud Computing .....	438

**Table of Contents**

---

Extended Lifetime of the Battery.....	439
Improved Data Storage Capacity and Processing Power .....	439
Improved Reliability .....	440
Mobile Cloud Computing Challenges .....	440
Challenges at Cloud End .....	442
Points to Remember .....	445
<b>Glossary .....</b>	<b>447</b>
<b>Index .....</b>	<b>455</b>