Content from different reference book suggested "Cloud Computing Black book [Kailash Jayaswal,Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah & Kogent Learning Solutions Inc.]" by Prof. Sujata Mam and mentioned in CC Syllabus file, Presentations, Notes provided in 2023

Here's a cheatsheet summarizing the key points from your notes on "Introduction to Cloud Computing" and "Virtualization":

Introduction to Cloud Computing

- Cloud computing is a transformative technology driven by the growth of applications across various domains.

- It addresses challenges of exponential growth in compute capabilities, digital content, and consumption.

- Key characteristics: On-Demand Self-Service, Ubiquitous Network Access, Resource Pooling, Rapid Elasticity, Pay-as-You-Go.

- Service models: SaaS, PaaS, IaaS.

- Deployment models: Public Cloud, Private Cloud, Hybrid Cloud.

- Advantages: On-demand provisioning, scalability, cost savings, rapid deployment, global accessibility.

- Disadvantages: Internet dependency, limited control, security concerns, vendor lock-in, data transfer costs.

Virtualization

- Virtualization abstracts and manages computer resources efficiently.

- It allows multiple virtual instances on a single physical server, enhancing flexibility and utilization.

- Virtualization layers: Hypervisor, Virtual Machine, Guest OS.

- Types of Hypervisors: Type 1 (Bare-Metal) and Type 2 (Hosted).

- Benefits of virtualization: Maximizes resource sharing, reduces hardware costs, enhances security, disaster management, and portability.

- Virtualization categories: Platform Virtualization and Resource Virtualization.

- Platform Virtualization techniques: Emulation, Full Virtualization, Paravirtualization, Operating System-Level Virtualization, Library-Level Virtualization, Application-Level Virtualization.

- Full Virtualization vs. Paravirtualization: Differences in instruction emulation and OS modification.

- Multi-core virtualization: Virtual Cores (VCPUs), benefits in resource management.

Cloud Computing Services

- Cloud computing involves accessing applications and services via the internet.

- Service models: SaaS (End Users), PaaS (Application Developers), IaaS (Network Architects).

- Delivery models: SaaS mature, PaaS/IaaS evolving.

- Pros and Cons of SaaS, PaaS, IaaS.

- Key cloud service providers: Amazon, Google, Microsoft, Salesforce.

- Database as a Service (DBaaS) shift and challenges.

- Cloud storage comparison.

- Cloud provider rankings and adoption modes.

Key Players in Cloud Computing Platforms

- Amazon AWS, Microsoft Azure, Google App Engine, IBM, Salesforce.com.

Conclusion

- AWS leads, Azure catching up, Google Cloud facing adoption challenges.

- Cloud services continue to evolve and impact various industries.

Feel free to use this cheatsheet as a quick reference for your notes on cloud computing and virtualization.

Introduction to Cloud Computing

In recent years, the world has undergone a transformative change driven by the rapid growth of applications across various domains. The surge in applications, ranging from biomedical informatics to space exploration, from business analytics to social networking platforms like YouTube and Facebook, has reshaped the digital landscape. This explosive growth has been fueled by the proliferation of digital content and the ever-increasing demand for digital consumption.

Cloud computing has emerged as a pivotal solution in this dynamic environment. It addresses the challenges posed by the exponential growth in compute capabilities, digital content generation, and consumption. The traditional IT infrastructure, characterized by manual provisioning, dedicated hardware, fixed capacity, and significant capital and operational expenses, struggles to cope with the complexities of this evolving landscape.

Cloud Computing Defined

At its core, cloud computing is a revolutionary concept that enables convenient, on-demand network access to a shared pool of configurable computing resources. These resources encompass networks, servers, storage, applications, and services. Cloud computing operates over the Internet, providing users with hardware, software, and networking services seamlessly.

This model of computing hides the intricate details of underlying infrastructure from both users and applications, offering a simplified interface or API for interaction. Cloud computing can be understood as a natural progression from utility computing, offering a platform that supports diverse requirements and applications.

Key Characteristics of Cloud Computing

Cloud computing is defined by five essential characteristics:

1. On-Demand Self-Service: Users can access resources and services as needed without requiring human intervention.

2. Ubiquitous Network Access: Users can access cloud services anytime, anywhere, using any device with an internet connection.

3. Resource Pooling: Computing resources are pooled to serve multiple clients, promoting efficient utilization and scalability.

4. Rapid Elasticity: Cloud resources can be quickly scaled up or down based on demand, allowing for efficient resource allocation.

5. Pay-as-You-Go: Users are charged based on their actual usage of resources, mirroring the utility pricing model.

Cloud Service Models

Cloud computing offers three primary service models:

1. Software as a Service (SaaS): End-users can access applications and services hosted in the cloud, without the need for local installations or maintenance. Examples include web-based email services like Gmail and collaboration tools like Google Docs.

2. Platform as a Service (PaaS): Developers can build, deploy, and manage applications without concerning themselves with the underlying infrastructure. PaaS provides a development environment and runtime platform for creating software. Examples include Microsoft Azure and Salesforce's PaaS offerings.

3. Infrastructure as a Service (IaaS): Users can provision and manage virtualized computing resources such as virtual machines, storage, and networks. IaaS offers greater control over the infrastructure while abstracting hardware details. Notable IaaS providers include Amazon Web Services (AWS) and Google Cloud Platform (GCP).

Deployment Models of Cloud

Cloud computing deployment models include:

1. Public Cloud: Cloud infrastructure is owned and operated by third-party providers, offering services to multiple organizations over the internet. Examples include AWS, GCP, and Microsoft Azure.

2. Private Cloud: Cloud infrastructure is dedicated to a single organization and may be hosted internally or externally. Private clouds provide greater control and security, making them suitable for sensitive data and applications.

3. Hybrid Cloud: Combines elements of both public and private clouds, allowing data and applications to be shared between them. Hybrid clouds offer flexibility and efficiency, enabling organizations to leverage the benefits of both models.

Advantages and Disadvantages of Cloud Computing

Advantages:
- On-demand resource provisioning.
- Scalability and flexibility.
- Reduced operational and maintenance costs.
- Rapid development and deployment.
- Global accessibility and collaboration.

Disadvantages:
- Dependency on internet connectivity.
- Limited control over infrastructure.
- Security and privacy concerns.
- Vendor lock-in risks.
- Potential data transfer costs.

In conclusion, cloud computing has revolutionized the IT landscape, offering unprecedented scalability, accessibility, and cost-efficiency. With its various service models and deployment options, cloud computing has transformed the way organizations deliver and consume technology services, enabling innovation and growth in an increasingly digital world.

Virtualization Notes:

Definition:
- Virtualization is the abstraction of computer resources.
- It hides the physical characteristics of resources from how other systems, applications, or users interact with them.
- It can involve making a single physical resource appear as multiple logical resources or vice versa.

Virtualization Overview:
- A hardware-reducing, cost-saving, and energy-saving technology.
- Transforms IT landscape and changes computing methodologies.
- Increases efficiency, utilization, and flexibility of existing hardware.

- Allows running multiple OSes and applications on the same server concurrently.

Virtualization Layers:
- Virtual Machine Monitor (VMM) or Hypervisor: Middleware between hardware and virtual machines.
- Virtual Machine (VM): Represents isolated environments running OSes and applications.
- Guest Operating System: OS running inside a virtual machine.

Hypervisor:
- Allows multiple OSes to share a single hardware host.
- Controls host resources and allocates them to guest OSes.
- Ensures guest OSes cannot disrupt each other.

Types of Hypervisors:
1. Type 1 (Bare-Metal Hypervisor): Directly on hardware, guest OSes on top.
2. Type 2 (Hosted Hypervisor): Over host OS, guest OSes on top.

Virtualization Benefits:
- Maximizes resource sharing, reduces hardware costs.
- Minimizes maintenance needs.
- Utilizes OS services, isolates multiple systems.
- Tests beta software, maintains legacy applications.
- Enhances system security, enables disaster management.
- Provides encapsulation and portability.
- Offers hardware independence.

Virtualization Categories:
1. Platform Virtualization: Simulates virtual machines.
2. Resource Virtualization: Simulates combined or simplified resources.

Platform Virtualization Techniques:
- Emulation: Complete hardware simulation for different CPU architectures.
- Full Virtualization: Simulates enough hardware for unmodified guest OS to run.
- Paravirtualization: Offers special APIs for modifying guest OS.
- Operating System-Level Virtualization: Creates isolated containers on a single physical server.
- Library-Level Virtualization: Creates execution environments for running alien programs.
- Application-Level Virtualization: Virtualizes an application as a VM.

Full Virtualization vs. Paravirtualization:
- Full Virtualization: Emulates instructions via binary translation, no OS modification.
- Paravirtualization: Requires guest OS modification, uses hypercalls for non-virtualizable instructions.

Multi-Core Virtualization:
- Virtual Cores (VCPUs): Can exceed the number of physical cores.
- Easier resource management and design when hardware assists in dynamic resource utilization.
- Supports better resource management and helps with complex software scenarios.

These notes cover the concept of virtualization, its types, benefits, and various virtualization techniques, including full virtualization, paravirtualization, and different levels of virtualization. It also touches on multi-core virtualization and the advantages of hardware assistance in managing virtual cores.

Virtualization

Virtualization is a concept in computing that involves abstracting and managing computer resources, allowing them to be used more efficiently and flexibly. It encompasses the creation of virtual versions of physical resources like servers, operating systems, applications, and storage devices, enabling multiple instances to run independently while sharing the same physical hardware.

What is Virtualization

Virtualization is a technology that reduces hardware costs, saves energy, and transforms IT operations. It enables running multiple operating systems and applications on a single physical server, thus increasing hardware utilization and flexibility. Virtualization offers benefits like reduced IT costs, increased efficiency, utilization, and flexibility of existing hardware, and the ability to isolate and manage operating systems and applications as single units.

Virtual Machine, Guest Operating System, and VMM (Virtual Machine Monitor)

The virtualization layer, also known as the Virtual Machine Monitor (VMM) or hypervisor, acts as middleware between the underlying hardware and the virtual machines in the system. A hypervisor allows multiple operating systems (guests) to share the same hardware host, ensuring resource allocation and isolation between guests to prevent disruptions.

Difference between Traditional Computers and Virtual Machines

Before Virtualization:
- Single OS image per machine
- Tight coupling of software and hardware
- Running multiple applications on the same machine can cause conflicts
- Inflexible and costly infrastructure

After Virtualization:
- Hardware-independent OS and applications
- Virtual machines can be provisioned to any system
- OS and applications can be managed as a single unit through encapsulation
- Improved flexibility and reduced infrastructure costs

Virtualization Benefits

Virtualization offers various benefits, including:
- Maximizing resource sharing
- Reducing hardware costs
- Minimizing maintenance requirements
- Utilizing OS services efficiently

- Isolating multiple systems
- Testing beta software and maintaining legacy applications
- Enhancing system security
- Disaster management
- Encapsulation for portability and hardware independence

Virtualization Categories

Virtualization is divided into two main categories:
1. Platform Virtualization: Involves simulating virtual machines, creating a virtual environment for guest software to run.
2. Resource Virtualization: Simulates fragmented or simplified resources, optimizing resource utilization.

Platform Virtualization

Platform virtualization involves creating virtual machines using a combination of hardware and software. These virtual machines are managed by a host software, creating simulated computer environments for guest software. Different approaches to platform virtualization include:
- Emulation or simulation
- Native virtualization and full virtualization
- Partial virtualization
- Paravirtualization
- Operating system-level virtualization
- Application virtualization

Hypervisor

A hypervisor, also known as a Virtual Machine Monitor (VMM), manages multiple guest operating systems on a single hardware host. There are two types of hypervisors:
1. Type 1 (Bare Metal) Hypervisor: Operates directly on hardware, managing guest OSs on top of it.
2. Type 2 (Hosted) Hypervisor: Runs on a host operating system and manages guest OSs on top of the host.

Major VMM and Hypervisor Providers

Some major providers of virtualization solutions include Xen, VMware, and KVM. These solutions offer different approaches to virtualization, such as full virtualization, para-virtualization, and hardware-assisted virtualization.

Conclusion

Virtualization is a crucial technology that optimizes hardware utilization, reduces costs, and enhances flexibility in IT environments. It enables the creation of virtual instances of various resources and offers different levels of virtualization, from instruction set architecture level to application level, each with its advantages and limitations. Hypervisors play a key role in managing and orchestrating virtual machines, enabling efficient sharing of physical hardware resources among multiple guest operating systems.

Cloud Computing Services

What is Cloud Computing?
- Cloud computing involves accessing online applications stored on the cloud and running them through a web browser on a user's machine.
- It's using the internet to access software hosted on remote servers with the associated hardware and infrastructure.
- Cloud services include Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Cloud Computing Service Models:
1. Software as a Service (SaaS) - End Users:
   - Provides applications that can be accessed via the internet from anywhere.
   - Examples: Gmail, Yahoo Mail.
   - No need for additional hardware or software on the user's end.
   - Offers security features like SSL encryption.

2. Platform as a Service (PaaS) - Application Developers:
   - Delivers a computing platform and solution stack.
   - Developers can build their own applications using provided tools and resources.
   - Enables rapid development at a lower cost.
   - Examples: Salesforce, Windows Azure.

3. Infrastructure as a Service (IaaS) - Network Architects:
   - Provides computing power that can be rented for a limited time.
   - Allows existing applications to run on cloud provider's hardware.
   - Offers virtual machines, storage, firewalls, load balancers, and more.
   - Examples: Amazon Web Services (AWS), Google Cloud, Microsoft Azure.

Delivery Models:
- Cloud-based software services are maturing, while cloud platform and infrastructure offerings are still developing.
- Three main service models: SaaS, PaaS, and IaaS.

SaaS Pros and Cons:
- Pros: Accessible from any computer, facilitates collaboration.
- Cons: Generic applications may not suit all business needs.

PaaS Pros and Cons:
- Pros: Rapid development at a low cost, private or public deployment.
- Cons: Limited to provider's language and tools.

IaaS Pros and Cons:
- Pros: Dynamically choose resources, access vast computing power, eliminate IT hardware investment.
- Cons: Risk of data access by vendor, dependency on Internet availability.

Cloud Service Providers:

- Amazon, Google, Microsoft, Salesforce are examples of major providers for SaaS, PaaS, and IaaS.

Cloud Platform Providers:
1. Google Cloud Platform: Offers scalable and manageable apps with infrastructure similar to Google's applications.
2. Microsoft Azure: Provides a platform for web app creation, deployment, and management.
3. Salesforce: Empowers enterprise app development with ease and productivity.
4. Engine Yard: Offers rapid application innovation with powerful infrastructure orchestration.
5. AWS Elastic Beanstalk: Simplifies application deployment and management in AWS.
6. LongJump: Provides customizable web applications for business management.
7. OpenShift: Red Hat's PaaS for various programming languages.
8. Cloud Foundry: An open PaaS with cloud and developer framework choices.

Database as a Service (DBaaS):
- A shift from traditional, dedicated, on-premise databases to cloud-hosted, shared resources.
- Challenges include availability, elasticity, manageability, and cost.

Cloud Storage Comparison:
- Storage service comparison across providers like Amazon, Apple iCloud, and Box.

Cloud Computing Market Leaders:
- Amazon is a market leader for Mode 2 users and a thought leader with rich IaaS and PaaS features.
- Microsoft Azure appeals to both Mode 1 and Mode 2 users with integration and existing investments.

Google Cloud Platform and Microsoft Azure:
- AWS remains the leader, but Microsoft Azure is catching up and gaining market share.
- Google Cloud Platform is innovative but faces adoption concerns due to privacy.

These notes cover the basics of cloud computing, service models (SaaS, PaaS, IaaS), delivery models, pros and cons, key players, and challenges in database services and cloud adoption.

Cloud Computing Services: Detailed Notes

What is Cloud Computing?
- Cloud computing refers to the practice of using the internet to access and utilize remote resources, such as software, hardware, and storage, delivered as services over the network.
- Users can create an environment on their local machines by accessing online applications hosted on the cloud and running them through web browsers.
- It involves accessing someone else's software on someone else's hardware in data centers via the internet.

Cloud Computing Services
1. Software as a Service (SaaS): Targeted at End Users
   - Provides ready-to-use applications accessible over the internet.
   - Users access cloud-hosted applications without needing additional hardware or software.
   - Examples: Gmail, Yahoo Mail, Hotmail.
   - Offers security features like SSL encryption.

- Pros: Accessibility, collaborative working; Cons: Generic applications not always suitable for business use.

2. Platform as a Service (PaaS): Aimed at Application Developers
- Offers a computing platform for developers to build and deploy their own applications.
- Includes OS, programming language environment, database, and web server.
- Enables rapid development at lower cost.
- Examples: Salesforce.com, Windows Azure.
- Pros: Rapid development, deployment flexibility; Cons: Limited to provider's tools.

3. Infrastructure as a Service (IaaS): Intended for Network Architects
- Provides virtualized computing resources over the internet.
- Offers virtual machines, storage, networks, and other resources.
- Allows running existing applications on cloud provider's hardware.
- Examples: Amazon Web Services (AWS), Google Cloud, Microsoft Azure.
- Pros: Dynamically choose resources, eliminates need for physical hardware; Cons: Vendor dependence, internet availability dependency.

Delivery Models
- While software services are mature, platform and infrastructure offerings are still evolving.
- SaaS, PaaS, IaaS form a hierarchy of cloud services, with increasing levels of control over resources.

SaaS Pros and Cons
- Pros: Free or subscription-based, accessible from any computer, promotes collaboration.
- Cons: May not be suitable for all business needs.

PaaS Pros and Cons
- Pros: Enables rapid development, private/public deployment.
- Cons: Limited to provider's tools and languages.

IaaS Pros and Cons
- Pros: Flexible resource configuration, vast computing power, reduced IT hardware investment.
- Cons: Data security risks, dependency on internet availability, limited privacy and customization.

Parameter Comparison - SaaS vs. PaaS vs. IaaS
- Control of Application: No (SaaS), Yes (PaaS/IaaS)
- Control of Operating System: No (SaaS/PaaS), Yes (IaaS)
- Networking Control: No (SaaS/PaaS), Yes (IaaS)
- Control of Hardware: No (SaaS/PaaS/IaaS)
- Programming Building Blocks: No (SaaS), Yes (PaaS), No (IaaS, typically)

Platform as a Service (PaaS) Providers
- Google's App Engine, Microsoft's Azure, Salesforce.com, Engine Yard, AWS Elastic Beanstalk, LongJump, OpenShift, Cloud Foundry.

Database as a Service (DBaaS)
- Shift from traditional dedicated databases to cloud-hosted, shared databases.

- Challenges: Availability, scalability, manageability, cost.

Database on Cloud - Paradigm Shift
- Cloud: Availability, stateless, limited control, expectations of reduced costs.
- Traditional Database: Mission-critical, stateful, usage patterns.

Database Challenges and Solutions
- Availability: Amazon RDS Multi Zone, Xeround.
- Scalability: Scale up vs. scale out, shared everything vs. shared nothing, Xeround, ScaleBase/dbShards, MySQL Cluster.
- Elasticity: Scaling up/down and in/out.
- Manageability: DBaaS features, self-serve, APIs.
- Cost: Achieving pay-per-use, resource sharing.

Cloud Storage Comparison
- Comparison of storage services based on provider and pricing tiers.

Key Players in Cloud Computing Platforms
- Amazon AWS, Microsoft Azure, Google App Engine, IBM, Salesforce.com.

Cloud Provider Rankings
- Amazon leads with a strong market presence, followed by Microsoft catching up.
- IBM's execution ability has fallen.
- Mode 1 vs. Mode 2 cloud adoption.

Amazon Web Services (AWS)
- Started as PaaS, moved to IaaS in 2013.
- Holds second place in market share.
- Microsoft Azure gaining traction.
- Partner ecosystem still developing.

Google Cloud Platform
- AWS still a market leader.
- Microsoft catching up and leading in the UK.
- Google's issue of "knows too much" syndrome affecting adoption.

Microsoft Azure
- Making progress, appeals to both Mode 1 and Mode 2 users.
- Integration with Microsoft technologies, leveraging existing investments.

Conclusion
- AWS remains the leader, Microsoft Azure is catching up.
- Google Cloud making strides but facing adoption issues.
- Cloud services continue to evolve and impact various industries.