Cloud Computing – SWE 2022 [~KShawki]

***Chapter 2. Cloud Computing Principles and Paradigms***

***Mainframe Verses Cloud Computing***

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|  | **Mainframe** | **Cloud Computing** |
| **Differences** | Offers finite computing power | Provides almost infinite power and capacity |
| Dummy terminals as user interface devices | PCs can provide local computing and cashing |
| **Similarity** | Cloud is a return to mainframe computing | |

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**History of The Internet Revolution**

* The Internet has gone through four revolutions since its inception.
* Every revolution takes about ten years to be internalized.
* Cloud Computing is a major part of the *fifth revolution*.

***Cloud Computing***

***Definitions:***

* *It is a computational environment that provides transparent access to a shared pool of computing resources matching the user's needs,*
  + e.g., processing power, Storage, Applications, and Components.
* *[Egypt's Cloud Computing Strategic Plan-2011]*

***National Institute of Standards and Technology [NIST] Definitions***

* *It’s a Computing model for enabling everywhere, convenient, on-demand network access to a shared pool of configurable computing resources*
  + e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction
* *NIST Definition of Cloud Computing.*
* Cloud Model promotes *availability* and is composed of *five essential characteristics, three service models*, and *four deployment models*.

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| **Five Essential Characteristics** | **Three Service** | **Four Deployment models** |
| On Demand Service | Software as a Service (SaaS) | Private Cloud |
| Network Access Everywhere | Platform as a Service (PaaS) | Community Cloud |
| Resource Pooling | Infrastructure as a Service (IaaS) | Public Cloud |
| Rapid Elasticity | Hybrid Cloud |
| Measured Service |

* **Essential Characteristics:** 
  + **On-demand Self-Service:**

A consumer can provision computing capabilities (e.g., server time, network, and storage) as needed automatically without requiring human interaction with each service provider.

* + **Broad Network Access**

Capabilities available over network and accessed through standard mechanisms using heterogeneous client platforms (e.g., mobile phones, tablets, laptops, and workstations).

* + **Resource Pooling**

Computing resources are pooled to serve multiple consumers according to their demand.

* + **Rapid Elasticity**

Capabilities can elastically provision and released, in some cases automatically, to scale up and down according to consuming rate.

* + **Measured Service**

Resource usage can monitor, control, and report, providing transparency for both provider and consumer of the utilized service.

* **Service Models:** 
  + **Software as a Service (SaaS)**

The computing capability Provided to consumer (External user) with provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through web browser

* + (e.g., web-based email), or a program interface.
  + **Platform as a Service (PaaS):**

The capability provided to the consumer (developer) by needed platform environment to develop his application using programming languages, libraries, services, and tools supported by the provider.

* + - The consumer *doesn’t manage or control* underlying cloud infrastructure but has control over deployed applications and possibly configuration settings for the application-hosting environment.
  + **Infrastructure as a Service (laaS)**

The capability provided to the consumer (organizations) to provision processing, storage, networks, and other fundamental computing resources where the consumer able to deploy and run arbitrary software.

* + - The consumer does not manage or control underlying cloud infrastructure, but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).
* **Deployment Types:** 
  + **Private Cloud**

Cloud infrastructure provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units).

* + - It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.
  + **Public Cloud**

Cloud infrastructure is provisioned for open use by the general public.

* + - It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.
    - It exists on the premises of the cloud provider (i.e., Data Centers).
  + **Community Cloud**

It’s provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations).

* + - It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
  + **Hybrid Cloud**

it’s a composition of two or more distinct cloud infrastructures (private, community, or public) bound together by standardized or proprietary technology that enables data and application portability.

* + - A cloud computing environment uses a mix of on-premises, private cloud and third-party, public cloud services with orchestration between their platforms.
    - Companies can run critical workloads or sensitive applications on the private cloud and use the public cloud to handle bursts or spikes in demand.

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***Multi-Cloud***

* It refers to the presence of more than one cloud deployment of the *same type* (Public or Private or Hybrid), sourced from different vendors.
* It refers to the presence of more than one cloud deployment of the same type (Public or Private or Hybrid), sourced from different vendors.
* A multi-Cloud strategy is an approach that operates any combination of Private, Public, and Hybrid clouds sourced from different vendors.
* An organization may have multiple Public and Private clouds or multiple Hybrid clouds, all either connected together or not.

***Multi-Clouds Verses Hybrid Cloud***

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| **Compression** | **Hybrid Cloud** | **Multi-Cloud** |
| **Differences** | An amalgamation of a private cloud with one or more public cloud. | An amalgamation of two or more public/hybrid cloud under centralized management |
| It can be any combination of SaaS, laaS, PaaS and any other as-a-service | A multi-cloud strategy offers the ability to select different cloud services from different providers |
| It is a singular entity (ie., the cloud components are integrated to form singular entity) | It isn't single entity "individual clouds may not be integrated together" |
| a hybrid cloud could be part of a multi-cloud deployment. | Enables organizations to locate IT resources closely to end users to achieve optimal performance and minimal latency |
| **Similarity** | Multi-cloud and hybrid cloud computing are similar, but different IT infrastructure model. | |

***Cloud Benefits:***

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   Description automatically generated**No up-front investment [Capital Expense (CapEx)]**
   * Pay-as you-go pricing model.
   * No need to invest in the infrastructure.
   * Resources are rented according to needs.
2. **Lowering operating cost [Operational Expense (OpEx)]**
   * Resources are allocated and de-allocated on demand.
   * No need to provide capacities according to peak load.
   * Resources can be released to save on operating costs when service demand is low.
3. **Highly scalable**
   * **Infrastructure providers:** provide pool large amount of resources from data centers and make them easily accessible.
   * **Service providers:** can easily expand its service to large scales to handle rapid increase in service demands.
4. **Easy access**
   * Services hosted in the cloud are generally web-based.
   * Accessible through devices with Internet connections.
   * Devices: desktop, laptop, cell phones and PDAs.
5. **Reducing business risks and maintenance expenses (OpEx):**
   * Outsource the service infrastructure to the cloud.
   * ***Service providers*** shift business risks (such as hardware failures) to ***infrastructure providers.***
   * ***Infrastructure providers*** often have better expertise and are better equipped for managing these risks.
   * A ***service provider*** can cut down the hardware maintenance and the staff training cost.
6. **Elasticity**

Degree to which a system can adapt to workload changes by provisioning and deprovisioning resources in an autonomic manner.

* + such that at each point in time the available resources match the current demand as closely as possible to avoid *Over- Provisioning* or *Under-Provisioning.*
  + *Over-Provisioning:* Allocating more resources than required.
  + *Under-Provisioning:* Allocating fewer resources than required.

1. **Energy Savings**

Energy efficiency benefits of cloud computing are substantial, and growth in the market will have important implications for both energy consumption and Green House Gas [GHG] emissions.

***Advantages of Cloud:***

|  |  |
| --- | --- |
| * Lower computer costs * Improved performance * Reduced software costs * Instant software updates * Unlimited storage capacity | * Increased data reliability * Universal document access * Latest version availability * Easier group collaboration * Device independence |

***Disadvantages of Cloud:***

* *Requires a constant Internet connection:* Doesn’t work well with low-speed connections.
* *Features might be limited:* Can be slow, Stored data can be lost, Stored data might not be secure

***Cloud Computing Services***

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|  | **Who Uses it** | **What Services are available** | **Why use it?** |
| **SaaS** | Business Users | Email, Office, CRM, Blogs. | To complete business tasks. |
| **PaaS** | Developers | Services and Applications test, development, integrations and deployment environment. | Create and deploy service for users |
| **IaaS** | System Manager | Virtual Machines, Operations Systems, Massaging Queue, Networks, Storage, CPU, Memory backup. Services. | Create platforms for services and applications test, development, integration and deployment |

***Cloud Computing Hierarchy***

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1. **Application Layer:** 
   * Highest level of the hierarchy
   * Consists of the actual cloud applications
   * Cloud applications can better affect the automatic-scaling feature to achieve better performance, availability, and lower operating cost.
2. **Platform Layer**
   * Built on top of the infrastructure layer.
   * Consists of OSs and application frameworks by providing Virtual Machines with specific configuration.
   * Minimize the burden of deploying applications directly into VM containers.
   * E.g., Google App Engine provides API support for implementing storage, database, and business logic.
3. **Infrastructure Layer *(aka: Virtualization Layer)***
   * Creates a pool of storage and computing resources by partitioning the physical resources into instants using virtualization technologies such as Xen, KVM, and VMware.
   * An essential component of cloud computing, since many key features, such as dynamic resource assignment, are only made available through virtualization technologies.
4. **Hardware Layer:** 
   * Typically implemented in data centers
   * Responsible for ***managing physical resources of the cloud:***
     + Physical servers, routers, switches, power cooling systems.
   * Typical issues at hardware layer include:
     + Hardware configuration, Fault tolerance, Traffic and resource management.

Diagram

Description automatically generated***Cloud Computing Providers***

* laaS and PaaS providers are often   
  parts of the same organization.
* PaaS and laaS providers are often   
  called the infrastructure providers   
  or cloud providers.

***Some Commercial Cloud***

* **Windows Azure (PaaS):** Hosting service for .NET applications and database.
* **Google App Engine [GAE] (PaaS):** Automatic scaling and reliability at the price of a highly constrained application structure (3-tier Web application).
* **BlueMix (PaaS):** Provides a *dashboard to create, view, and manage applications* and services, as well as monitor application's resource usage.
* **Amazon Web Services (laaS):**
  + includes Scalable Storage Service (S3), Elastic Computing Cloud (EC2), Elastic Block Store (EBS)
  + Comes with many secondary tools: e-commerce, Content- Distribution Network (CDN), etc.

***Cloud Computing Challenges:***

* **Performance**
  + Data-intensive applications.
  + Latency and delays for users far from cloud providers.
* **Security and Privacy**
  + Companies are still concerned about security.
  + Customers are worried about vulnerability to attacks.
* **Control**
  + Providers have control of platforms.
  + No platforms for specific users &their business practices.
* **Bandwidth Costs**
  + Low for smaller Internet-based applications.
  + Significantly grow for data-intensive applications.
* **Reliability**
  + Not always offer round-the-clock reliability

***Service Level Agreement (SLA):*** A contract between the user and the Provider.

* **SLA** contains terms and conditions to ensure the rights of the users, as well as the providers.
* Its role is identifying the user’s needs and creates a relationship between the user and the service provider.
  + *User Needs:* Guarantee the resources availability, reliability, and QoS.
  + *Provider needs:* Guarantee the resource utilization and revenue.
* SLA describes a set of non-functional requirements of the service the customer is rending.

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***Service Level Agreement Metrics***

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