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Student Name	Nguyen Anh Nhan	**Student ID**	GCH190414
Class	GCH0801	**Assessor name**	Do Quoc Binh

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I certify that the assignment submission is entirely my own work and I fully understand the consequences of plagiarism. I understand that making a false declaration is a form of malpractice.

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Introduction

Cloud computing is expanding the reach of the IT landscape. Driven by a number of converging and complementary factors, cloud computing is evolving as a viable model of IT service delivery at an amazing rate. In the following report we will describe the definition of cloud computing, the models that are being provided by service providers, and exploit the variety of IT services. Cloud computing offers a number of benefits over traditional on-premises computing models, including reduced costs and increased agility and flexibility. Its transformation potential is enormous and impressive, and as a result, cloud computing is being adopted by individual users, businesses, educational institutions, governments, and community organizations.

1. Overview cloud computing

According to (Chandrasekaran, 2014), The formal definition of cloud computing comes from the National Institute of Standards and Technology (NIST): "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources such as networks, servers, storage, applications, and services, that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.

That means a computing resource or infrastructure including server hardware, storage, networking, or application software is all available from your cloud provider or your website / facility. The provider can be accessed over the Internet from any remote location and with any local computing device. In addition, usage or accessibility is usage-only for customers based on their needs and needs, also known as the pay-as-you-go or pay-per-use model.

2. Client – Server

According to (Moltchanov, 2013), in the client/server model, all end systems are divided into clients and servers each designed for specific purposes.

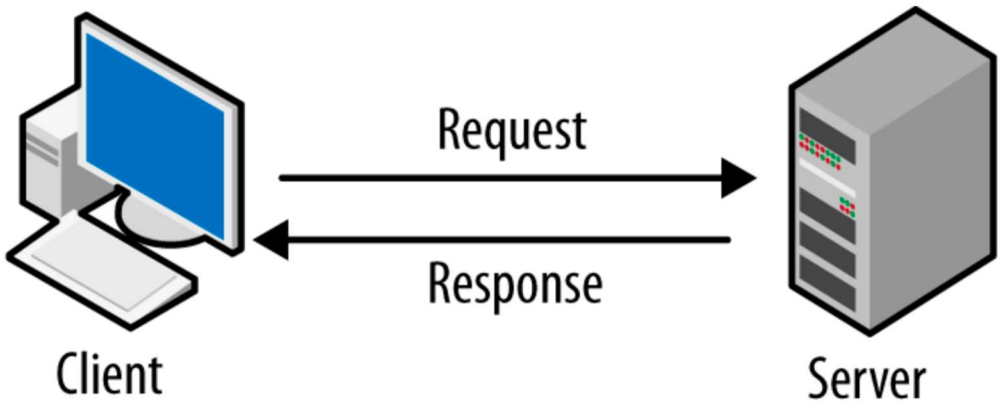


Figure 1. Client - Server Relationship

2.1 Client

According to (Moltchanov, 2013), the client takes an active role and initiates the communication session by sending a request to the server.

- At this point, the client must have knowledge of the available servers and the services they provide
- However, the client can only communicate with the server; they cannot see each other.

Clients are devices/programs that request services from servers. Clients can be distinguished according to the functionality they provide and the amount of processing load they carry.

There are 2 types of client:

Fat client

Fat clients are devices/programs that are powerful enough and operate with limited dependence on their server counterparts.

- Fat clients as devices – a user workstation that is powerful and fully-featured in its own right.

For example, a desktop PC, a laptop, a netbook

- Fat clients as programs – a client carries a relatively large the proportion of the processing load.

  For example, the Lineage II gaming client (more than 2 GB in size).

Thin client

Thin clients are devices/programs that have very limited functionality and depend heavily on their server counterparts.

- Thin clients as devices – a user workstation that contains a minimal operating system and little or no data storage

For example, Sun Ray thin clients in Lintula, room TC215 (Moltchanov, 2013).

- Thin clients as programs – a client mainly provides a user interface, while the bulk of processing occurs in the server

For example, the OnLive gaming client (about 10 MB in size) (Moltchanov, 2013).

2.2 Server

According to (Moltchanov, 2013), servers have a passive role and respond to their clients by acting on each request and returning results

- One server generally supports numerous clients.

The purpose of servers is to provide some predefined services for clients

There are 2 types of servers:

Iterative server

Iterative design is quite simple and is most suitable for short-duration services that exhibit relatively little variation in their execution time.

It means if the time to handle a client can be long, the waiting time experienced by subsequent clients may be unacceptable. Examples of Internet services deployed as repeat servers like echo (RFC 862) and daytime (RFC 867)

Iterative servers iterate through the following steps:

Step 1: Wait for a client request to arrive

Step 2: Process the request and send the response back to the client

Step 3: Go back to Step 1

So, iterative servers handle clients sequentially, finishing with one client before servicing the next.

Concurrent server

Concurrent design is more complex but yields better performance. It allows to improve responsiveness and reduce latency when the rate at which requests are processed is less than the rate at which requests arrive at the server. Internet services like HTTP, telnet, and FTP are commonly implemented as concurrent servers.

Concurrent servers perform the following steps:

- Step 1: Wait for a client request to arrive
- Step 2: Use a new process/task/thread to handle the request
- Step 3: Go back to Step 1

Thus, concurrent servers handle client requests in parallel.

2.3. Relation between Client and Server

Below are some of the characteristics to distinguish between client and server.

Hardware role: The terms "client" and "server" generally refer to the key roles performed by networked hardware.

- A "client" is usually something like a PC used by an individual and essentially initiates the conversation by sending a request.
- A "server" is usually a powerful machine dedicated to responding to customer requests, sitting in a server room somewhere that no one other than its administrator has ever seen.

Software roles: TCP/IP uses different pieces of software for many protocols to implement "client" and "server" roles.

- Client software is usually found on client hardware and server software on server hardware, but not always.
- Some devices may run both client and server software.

Web clients: Mozilla Firefox, Internet Explorer, Google Chrome, . . .

For example, "Web Statistics" by W3Schools

Web servers: Apache, Microsoft IIS, GWS, . . .

For example, "Web Server Survey" by Netcraft Ltd.

Transaction role: During communication processes, the customer is the entity that initiates the communication or sends a query; The server responds, often providing information. Usually, the client software on the client will initiate a transaction, but this does not always happen.

For example, when two SMTP servers communicate for email exchange, both are server programs running on the server hardware. However, in the process of exchanging information one device acts as a client, while the other acts as a server.

3. Peer-to-peer (P2P)

According to (Chandrasekaran, 2014), in the P2P model, all end systems have equivalent capabilities and responsibilities and either party can initiate a communication session.

The participants share a part of their own hardware resources, For example, storage capacity, link capacity, CPU power. These shared resources are necessary to provide the service or content offered by the P2P network.

Thus, the participants are both resource providers and resource requestors and use similar networking programs to connect with each other.

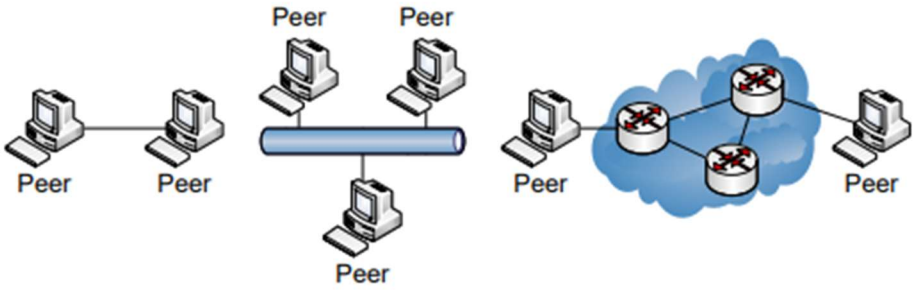


Figure 2: P2P model

Downlink and uplink data flow tend to be (but not necessarily) symmetric in P2P networks. This is because each connected host simultaneously operates as both client and server, thus receiving and transmitting on average the same amount of data.

The P2P paradigm does not have the notion of clients or servers, but rather equivalent peers, that act simultaneously as both clients and servers. However, with every contact session, we can always differentiate between requesting peers as "clients" and reacting peers as "servers".

Again, this model is relevant to end systems only, regardless of how the end systems are connected to each other.

Below is a table of advantages and disadvantages of P2P:

Advantage	Disadvantage
Improved scalability and reliability.	Lack of centralized control.
No need for a dedicated application and database server	Computers that have shared resources may suffer sluggish performance.
	Low security.

Table 1: Advantage and Disadvantage of P2P

P2P Example

An example that quite famous is game stations. Years ago, when Internet is not popular and people used to connect to the network by Broadband connection, P2P is the main method of connection in workplace and the only choice for devices to connect to each other in small area.

The game industry was rapidly grown in 1990s with many popular devices. Here is one example with two game controllers connected to a single game station.

Nowadays, a famous P2P connection is Bluetooth. However, people can establish a P2P connection using Wi-Fi or other kind of wired or wireless connection.

4. High Performance Computing

4.1. Definition

4.1.1. Parallel

According to (Chandrasekaran, 2014), Parallel computing is also one of the facets of HPC. Here, a set of processors work cooperatively to solve a computational problem. These processor machines or CPUs are mostly of homogeneous type. Therefore, this definition is the same as that of HPC and is broad enough to include supercomputers that have hundreds or thousands of processors interconnected with other resources.

One can distinguish between conventional computers and parallel computers in the way the applications are executed. In parallel computing, since there is the simultaneous use of multiple processor machines, the following apply:

- It is run using multiple processors (multiple CPUs).
- A problem is broken down into discrete parts that can be solved concurrently.
- Each part is further broken down into a series of instructions.
- Instructions from each part are executed simultaneously on different processors.
- An overall control/coordination mechanism is employed.

4.1.2. Cluster

According to (Chandrasekaran, 2014), A cluster computing system consists of a set of the same or similar type of processor machines connected using dedicated network infrastructure. All processor machines share resources such as a common home directory and have software such as a message passing interface (MPI) implementation installed to allow programs to be run across all nodes simultaneously. This is also a kind of HPC category. The individual computers in a cluster can be referred to as nodes.

If we have processor machines of heterogeneous types in a cluster, this kind of clusters become a subtype and still mostly are in the experimental or research stage.

4.1.3. Distributed

According to (Chandrasekaran, 2014), distributed computing is also a computing system that consists of multiple computers or processor machines connected through a network, which can be homogeneous or heterogeneous, but run as a single system.

Connectivity can be so that the CPUs in a distributed system can be physically close together and linked to a local network, or they can be geographically isolated and connected to a wide area network. Any number of potential configurations on processor devices, such as mainframes, PCs, workstations, and minicomputers, support heterogeneity in a distributed framework. The aim of distributed computing is to make such a network operate like a single computer.

Distributed computing systems are advantageous over centralized systems, because there is support for the following characteristic features:

- Scalability: It is the ability of the system to be easily expanded by adding more machines as needed, and vice versa, without affecting the existing setup.
- Redundancy or replication: Here, several machines can provide the same services, so that even if one is unavailable (or failed), work does not stop because other similar computing supports will be available.

4.2. Example

In real life, there's several uses of HPC. Actually, HPC is not so common in daily life since its specific purposes. According to its power, it's suitable for tasks that requires a fast, reliable and stable performance. An example that can be mentioned here is Deep Learning. With a high power of computing, calculations can be done way much faster and the data can be analyzed rapidly.

As in IBM (United States), two supercomputers (which are fastest on the world) was built for Machine Learning purpose.

Figure 3. IBM Supercomputers

5. Deployment Models

A cloud deployment model represents a specific type of cloud environment, primarily distinguished by ownership, size, and access.

There are four common cloud deployment models:

- Public cloud.
- Community cloud.
- Private cloud.
- Hybrid cloud.

5.1. Public Deployment

According to (Chandrasekaran, 2014), a public cloud is a publicly accessible cloud environment owned by a third-party cloud provider. The IT resources on public clouds are usually provisioned via the previously described cloud delivery models and are generally offered to cloud consumers at a cost or are commercialized via other avenues such as an advertisement.

According to NIST, the public cloud is the cloud infrastructure that 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.

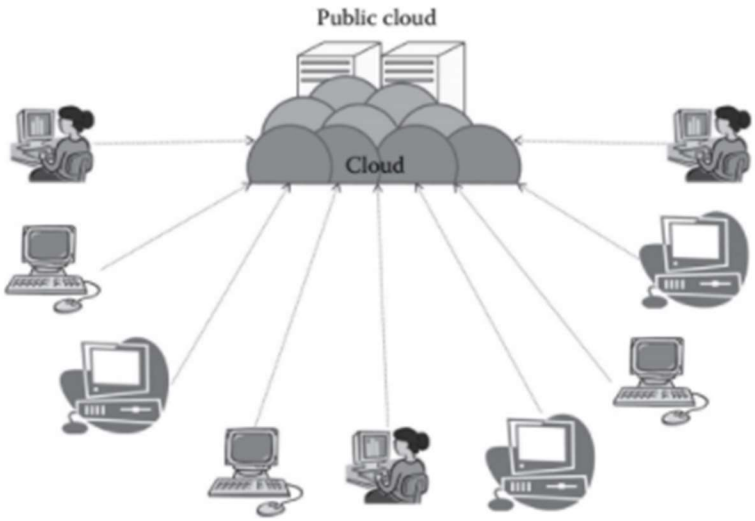


Figure 4. Public Deployment

There are several advantages and disadvantages of a public cloud.

Advantage	Disadvantage
There is no need for maintaining the cloud.	Security is an issue.
There is no limit for the number of users	Privacy and organizational autonomy are not possible.
The public cloud is highly scalable.	
There is no need of establishing infrastructure for setting up a cloud.	
They are comparatively less costly than other cloud models.	
Strict SLAs are followed.	

Table 2: Advantages and disadvantages of a public cloud

Real Example

In reality, Hpublic cloud is frequently used in small businesses and systems. As provided above about some advantages of using Public Deployment, the scalability and the requirements for maintenance is the main points which make thing more flexible when using this kind of deployment. Furthermore, the low cost also very important that's efficient in small businesses.

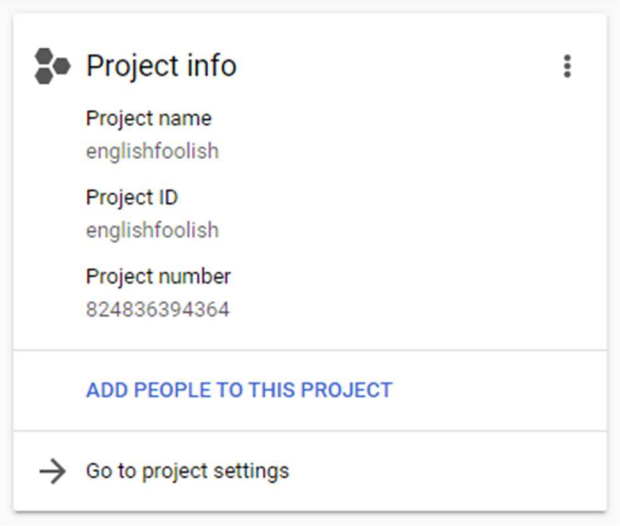
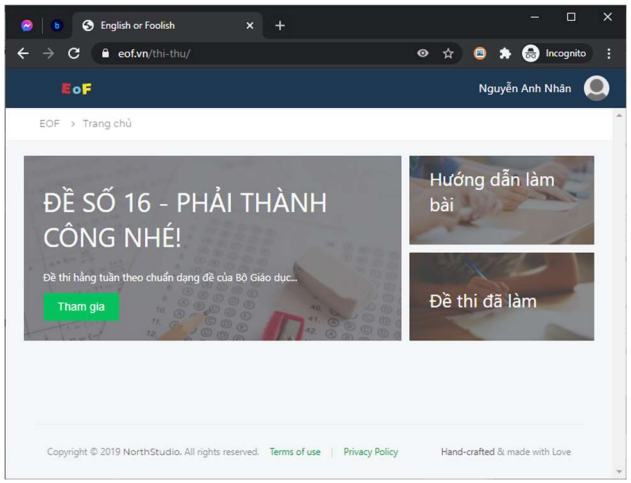


Figure 5. A Project deployed onto Google Cloud Platform

In real life, the author has experienced in some projects that used Public Cloud Service as the Deployment Service for the whole project. To be specific, an "instance" was deployed through Google Cloud Engine - GCE (of Google Cloud Platform - GCP).

About the experience, GCP – GCE provides a flexible way to deploy an instance and makes things much easier to do. With some steps interacting with a friendly web panel interface, the author has successfully to deploy a Cloud Instance which stands for providing a website including an online messaging service.



The stability of the public deployment is also very good as its uptime is nearly always. The deployment process is quite simple since it depends on a famous "version control service - VCS" – Git.

The result of the process is a website: https://eof.vn and a Messaging bot for English self-learning Chatbot: https://m.me/EnglishOrFoolish.

Figure 6. Self-made Example Project

5.2. Private Deployment

According to the National Institute of Standards and Technology (NIST), a private cloud can be defined as the cloud infrastructure that is provisioned for exclusive use by a single organization comprising multiple consumers. 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.

The private cloud in simple terms is the cloud environment created for a single organization. It is usually private to the organization but can be managed by the organization or any other third party. A private cloud can be deployed using Open-source tools such as OpenStack, Eucalyptus. The private cloud is small in size as compared to other cloud models. Here the cloud is deployed and maintained by the organizations themselves (Chandrasekaran, 2014).

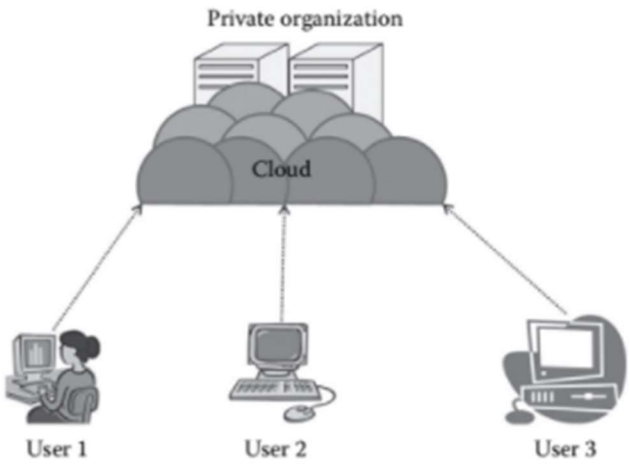


Figure 7: On-premise private cloud.

There are several advantages and disadvantages of a private cloud.

Advantage	**Disadvantage**
It is controlled by the organization.	For the private cloud, budget is a constraint.
It provides a high level of security and privacy to the user.	The private clouds have loose SLAs.
The cloud is small in size and is easy to maintain.	

Table 3: Advantage and disadvantage of private cloud

Real Example

Private cloud is much more complicated in deployment and maintenance, that's why it's often be used in large businesses or big projects with higher customization and optimization deep down in the system infrastructure.

The private cloud not only allows the company to keep everything quarantined from outside but also enables the system administrators control the whole system better. The pros point when comparing to Public Deployment is that it doesn't rely on a third-party stakeholder. By managing the whole system, the company has better level of security while the size of the cloud is smaller.

In reality, the author has also experienced in working with small and private cloud. The circumstance is that the company which author worked with was working on a project that has a large amount of customer. They used to deploy things on Google Cloud Platform, however, due to the rapid growth of the number of users, the billing seems to raise uncontrollable. After few months, the company decided to move to private cloud with self-maintained environment.

Servers are placed on a floor of the building and being controlled by a "Central Server".

From a system on Central Server, the System Administrator able to deploy instances with custom specs.

The biggest advantages the author can see while using Private Cloud Instances is that the scalability is "manually" and keep things behind firewall.

Figure 8. Physical Private Cloud Instances

By saying it manually, it seems to be very complex while the “System Admin” must have a lot of knowledge in managing & maintaining servers to modify the whole system. But, it’s a lot cheaper and easier to re-scale the system when it’s required to do so.

Since it’s an enterprise product, deploying with private cloud keeps customer’s information absolutely safe in company procedure (which highly important in protecting data).

5.3. Community Cloud

According to NIST, the community cloud is the cloud infrastructure that is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns such as 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 (Chandrasekaran, 2014).

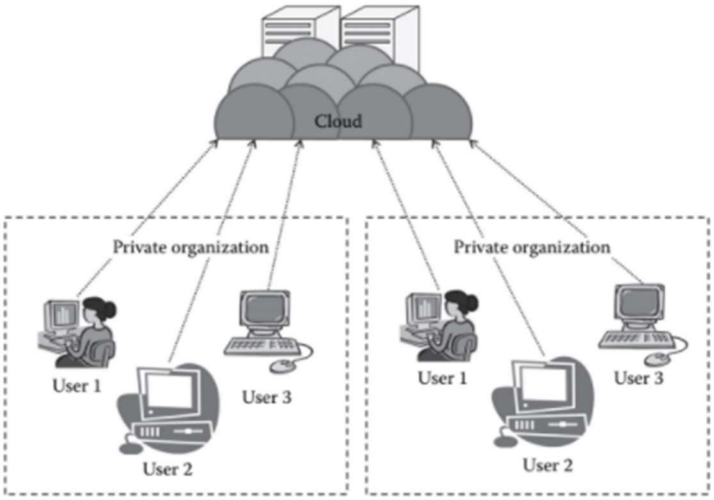


Figure 9. Community cloud

There are some several advantage and disadvantages of community cloud:

Advantage	**Disadvantage**
Allows establishing a low-cost private cloud.	Autonomy of an organization is lost.
Better security than the public cloud.	Security features are not as good as the private cloud.
Allows collaborative work on the cloud.	It is not suitable if there is no collaboration.
Allows sharing of responsibilities among the organization.	

Table 4. Advantage and disadvantages of community cloud

Real Example

"The cheapest in cost, based on trust, honesty."

In the author's opinion, the community cloud's security level is not persistent. While it's used and managed by different businesses, it shares the security issues and harder to keep things private indeed.

Since information & traffic is shared (and used) in a same streamline, the community cloud is not being used by "fully different businesses". It means that among businesses used this kind of deployment, there're always similarities (or in a group of companies).

Because of that, a real example for this kind of deployment is the government cloud instances. In the U.S, federal agencies' cloud system is provided by IBM SoftLayer. According to (IBM, 2015):

> *"Only governmental entities sharing common characteristics like security, auditability and privacy concerns/requirements can use this platform (IBM SoftLayer). Such an approach gives much more confidence in the platform, which cloud consumers will use to deploy their sensitive workloads."*

In Vietnam, the government also uses Community Cloud to secure internal information transport. The biggest pros when using this kind of deployment is that the confidence in security (of the community) keeps thing easier in management. However, the confidence relies in trust.

One another famous community cloud is Salesforce's System.

It's the combination of many different cloud instances that serve different purposes.

The isolation of instances makes it easier to maintain and scale while grouping them into a "community cloud" keeps it easy to handle.

5.4. Hybrid Cloud

According to NIST, the hybrid cloud can be defined as the cloud infrastructure that is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability. The usual method of using the hybrid cloud is to have a private cloud initially, and then for additional resources, the public cloud is used (Chandrasekaran, 2014).

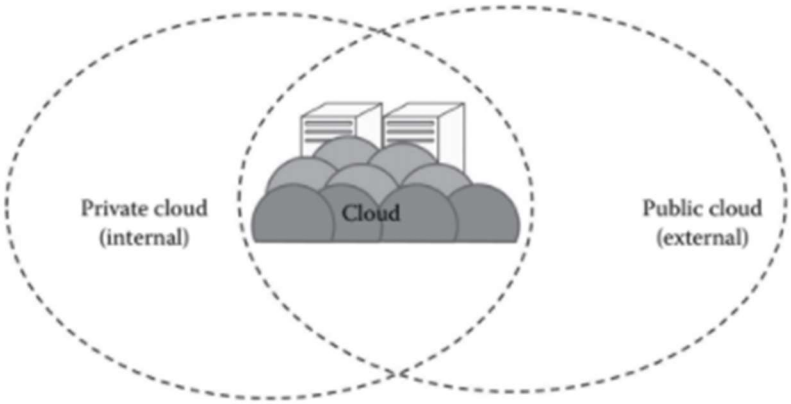


Figure 10. Hybrid cloud

There is several advantages and disadvantage of hybrid cloud:

Advantage	**Disadvantage**
Having power of both the private and public clouds.	The security features are not as good as the public cloud.
Better security than the public cloud.	Managing a hybrid cloud is complex.
Highly scalable.	It has stringent SLAs.

Table 5: Advantages and disadvantage of hybrid cloud

Real Example

Hybrid Cloud is the combination of Public Cloud and Private Cloud.

A big real example is Amazon Web Services (AWS). According to its front page:

> *"Amazon Web Services is a subsidiary of Amazon providing on-demand cloud computing platforms and APIs to individuals, companies, and governments, on a metered pay-as-you-go basis."* - (AWS, 2021)

Although AWS is widely known for its public cloud platform services, it also provides Hybrid cloud for businesses that need on-premise installation.

The purpose of using Hybrid Cloud on AWS is the extendibility on existing server. For example, if a company requires to up scale the data center (data warehouse), a "Data center extension" is integrated into existing service (on-premises) and create a single enterprise environment that is a combination of both cloud service (existing service & AWS).

One other use-case that's useful is Storage. Basically, when a system is being backup, it will save a copy of the system on same instance which makes the free storage of the server always has to be "at least" double time than the used storage. Further, when syncing data, it requires us to open a connection between two servers that's can be vulnerable.

By using AWS and use Hybrid Cloud, it will reduce the workload and make use of strength of AWS instead of rely so much on existing cloud server.

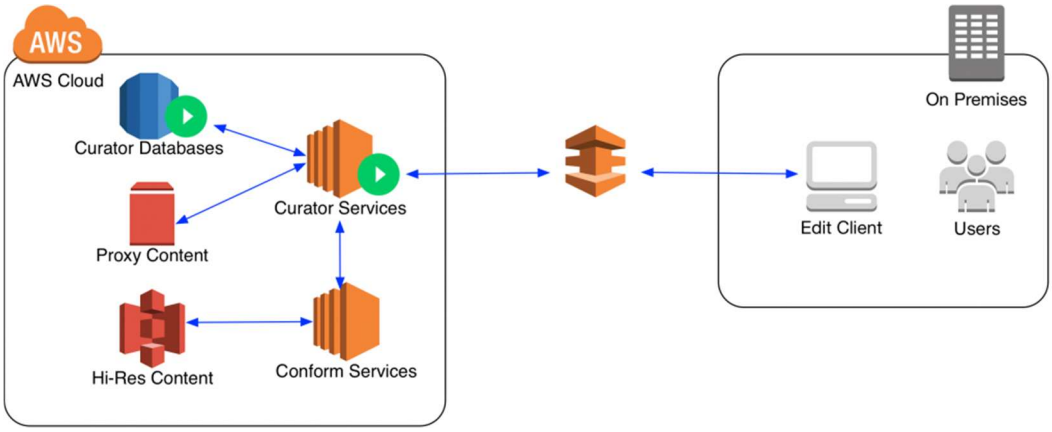


Figure 11. Example of using AWS in Cloud on-premise

6. Cloud Service Models

6.1 Infrastructure as a Service

According to (Chandrasekaran, 2014), IaaS changes the way that the compute, storage and networking resources are consumed. It means IaaS changes the computing from a physical infrastructure to a virtual infrastructure. IaaS provides virtual computing, storage, and network resources by abstracting the physical resources. Technology virtualization is used to provide virtual resources. All the virtual resources are given to the virtual machines (VMs) that are configured by the service provider. The end-users or IT architects will use the infrastructure resources in the form of VMs.

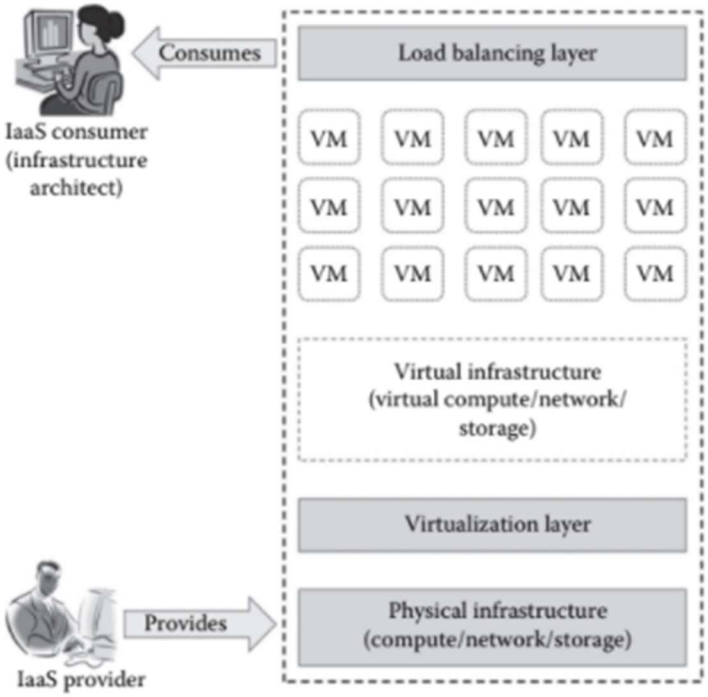


Figure 12. Overview IaaS

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources on a pay-per-use basis where he or she is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications and possibly limited control of select networking components.

There is several advantages and disadvantage of IaaS:

Advantage	Disadvantage
Pay-as-you-use model: This ensures that the customers are required to pay for what they have used. This model eliminates unnecessary spending on buying hardware.	Security issues: There are many attacks that target the hypervisors to compromise it. If hypervisors get compromised, then any VMs can be attacked easily.
Reduced TCO: The IT users can rent the IT infrastructure rather than buy it by spending a large amount. IaaS reduces the need for buying hardware resources and thus reduces the TCO.	Interoperability issues: Occasionally, a customer may face carrier lockout when switching between service providers.
Elastic resources: IT users can scale up or scale down the resources whenever they want.	Performance issues: The latency of the network plays an important role in deciding the performance.
Better resource utilization: IaaS ensures better resource utilization and provides high ROI for IaaS providers.	
Supports Green IT: In IaaS, the need of buying dedicated servers is eliminated single infrastructure is shared between multiple customers, thus reducing the number of servers to be purchased and hence the power consumption that results in Green IT.	

6.2 Platform as a Service

According to (Chandrasekaran, 2014), PaaS changes the way that the software is developed and deployed. Most of the applications developed by traditional development platforms result in licensing-based software, whereas PaaS changes the application development from local machine to online. PaaS providers provide the development. PaaS from the data center. The developers can consume the services over the Internet.

There are some several advantages and disadvantages of PaaS:

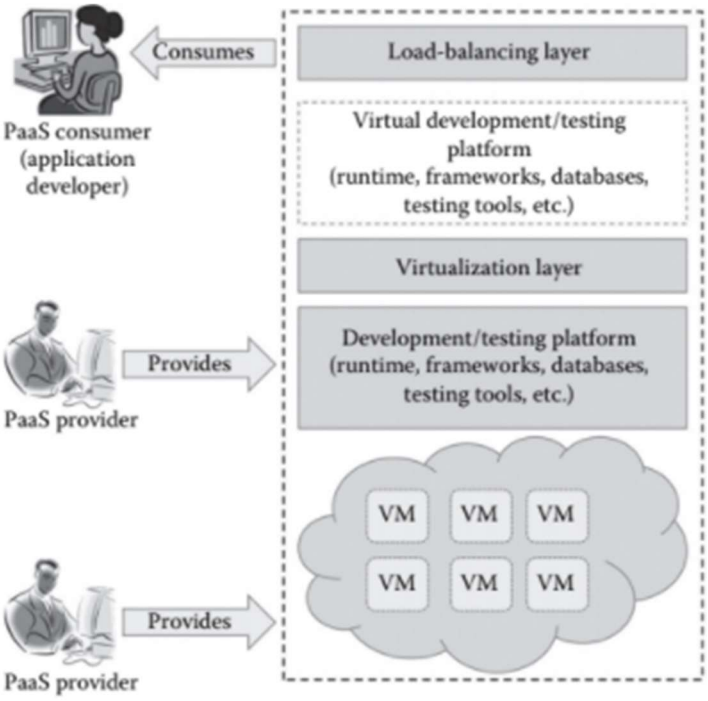


Figure 13. Overview PaaS

Advantage	Disadvantage
Quick development and deployment: Most of the PaaS services automate the testing and deployment process as soon as the developer completes the development.	Vendor lock-in: The vendor lock-in problem of PaaS services does not allow the applications to be migrated from one PaaS provider to the other.
Reduces TCO: PaaS allows the developers to rent the software, development platforms, and testing tools to develop, build, and deploy the application.	Security issues: Since data are stored in off-premise third-party servers, many developers are afraid to go for PaaS services.
Supports agile software development: PaaS services support agile methodologies that the ISVs and other development companies are looking for.	Less flexibility: PaaS providers do not give much freedom for the developers to define their own application stack. Most of the PaaS providers

	provide many programming languages, databases, and other development tools.
Different teams can work together: PaaS services support developers from different places to work together on the same project.	Depends on Internet connection: Since the PaaS services are delivered over the Internet, the developers should depend on Internet connectivity for developing the application.
Ease of use: PaaS provides a wide variety of client tools such as CLI, web CLI, web UI, APIs, and IDEs. The developers are free to choose any client tools of their choice.	
Less maintenance costs: The portion of administrator recruitment costs is eliminated by the PaaS services because the underlying infrastructure is maintained by the infrastructure vendors.	

Table 6: Advantages and disadvantages of PaaS

6.3 Software as a Service

According to (Chandrasekaran, 2014), SaaS changes the way software is delivered to customers. In the traditional software model, software delivered as a license-based product needs to be installed in the end user device. Since SaaS is provided as an on-demand service over the Internet, there is no need to install software on the end user's device. SaaS services can be accessed or disconnected at any time based on end user needs. SaaS service can be accessed from any lightweight web browser on any device such as laptop, tablet, and smartphone. Some SaaS services can be accessed from a thin client, do not contain as much storage space, and cannot run as much software as a traditional desktop computer.

Figure 14. Services provided by SaaS Providers.

There are several advantages and disadvantage of SaaS:

Advantage	Disadvantage
Cost savings: Since SaaS services follow a utility-based or on-demand payment method, it requires end users to pay for what they used.	Security: Since the SaaS application is shared between many end users, there is a possibility of data leakage.
Ease of access: SaaS services can be accessed from any devices if it is connected to the Internet.	Connectivity requirements: The dependency on high-speed Internet connection is a major problem in SaaS applications.
No client-side installation: The end users can access the services directly from the service provider data center without any installation. There is no need of high-end hardware to consume SaaS services	Loss of control: The degree of control over the SaaS application and data is lesser than the on-premise application.

Dynamic scaling: The SaaS services leverage elastic resources provided by cloud computing; it can handle any type of varying loads without disrupting the normal behavior of the application.	
Disaster recovery: The replicas are distributed across many servers. If any server fails, the end-user can access the SaaS from other servers. It also ensures the high availability of the application.	
Multitenancy: Multitenancy increases resource utilization from the service provider side	

Table 7: Advantages and disadvantage of SaaS

6.4 Comparing Service Models

Based on the above service model, we build a table comparing the characteristics of the service models.

	SaaS Model	PaaS Model	IaaS Model
Characteristics	- User are provided with applications that are accessible anytime from anywhere, these applications are provided in one-to-many mechanism. - Access via web to commercial software. - User does not need to manage the software such as upgrade and patches. - Application programing interfaces is giving the ability the different pieces of software to integrated. SLAs. - UI powered by "thin client" application. - Stateless and loosely coupled. - Modular. - Semantic interoperability. - Centralized Hosting / Delivery. - Open Collaboration/ Sharing.	- Users are providing with platform for applications hosted in the Cloud. - Services to develop and deploy host and maintain application in the same developer environment. - Web base user interface creation tools help modify, create, deploy, and test different UI scenarios. - Same development application cloud could be utilized by many users. - Web service and database are integrating with PaaS via common standards. - Support for development team collaboration. - Tool averrable to handle billing and subscription management. - User interface is - Customizable/Programmable. - Database customization is unlimited. - Solid workflow engine/capabilities. - Flexible services-enable integration model. - It is consuming cloud infrastructures.	- Users are provided with virtualized hardware and storage on top of which they can build their infrastructure. - Allows for dynamic/self-scaling. - It has alterable cost, utility pricing model. - Ability to provide single hardware to many users. - Supported OS and Platform independent. - The costs less due to the share of infrastructure. SLA - Pay as you go. - Application / frameworks
Typical level of control granted to could consumer	Usage and usage-related configuration.	Limited administrative	Full administrative

Consumer activities	User and configures cloud service	Test, develop, manage and deploy cloud-based solutions and cloud services.	Configure and setup bare infrastructure, install, manage and monitor and required software.
Provider activities	Manage, maintain and implement cloud service monitor usage by consumer of cloud	Pre-config platform and provision underlying infrastructure, middleware, and other requires IT resources as requisite monitor usage by consumer of cloud.	Manage and provision to storage, physical processing, hosting and networking the requires monitor usage by the consumer of cloud.
Service	Email, CRM, website testing, Virtual desktop, wiki, blog, automation	Service and application test, development, integration and deployment.	Virtual machine, operation system, message queue, network, storage, CPU, memory, Backup service
Venders	Saleforce.com, Google document, project management, Facebook.com, Gmail, Hotmail, etc.	Google AppEngine, Microsoft, Azure, Yahoo developer Network, MSFT, Heroku, Engine Yard, etc.	Amazon EC2 and S3, Gogrid, IBM BlueHouse, Linode, VMWare

Table 8: Comparing the service models

7. Characteristic of Cloud

Cloud computing has five essential characteristics. Without any of these characteristics, it's not cloud computing.

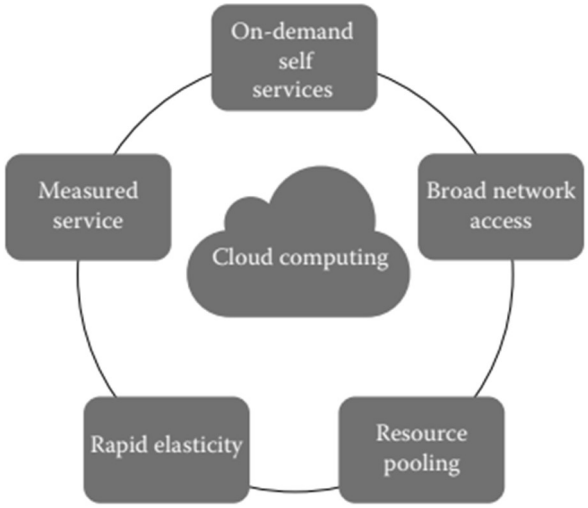


Figure 15. The essential characteristics of cloud computing.

On-demand self-service: A consumer can unilaterally provision com- putting capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

Broad network access: Capabilities are available over the network and accessed through standard mechanisms that promote use by hetero- generous thin or thick client platforms, for example mobile phones, laptops, and personal digital assistants.

Elastic resource pooling: The provider's computing resources are pooled to serve multiple consumers using a multitenant model.

Rapid elasticity: Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in.

Measured service: Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service.

8. Virtualization and Multicore

8.1 Virtualization

According to (Chandrasekaran, 2014), Virtualization is the fundamental core technology of cloud computing. It helps create a multi-object model for a cloud environment by optimizing resource usage through sharing. With benefits such as lower cost and extended technology life, this has made it a popular choice with SMEs. Using virtualization, the service provider-owned physical infrastructure is shared among many users, increasing resource utilization.

Virtualization is not only limited to the hardware, it can take many forms such as memory, processor, I/O, network, OS, data, and application It helps to improve scalability and resource utilization of the underlying infrastructure. It also enables the IT personnel to perform the administration task easier.

Many approaches have been adopted in implementing virtualization technology. Some of the important approaches are discussed in the following list:

- Full Virtualization
- Paravirtualization
- Hardware-Assisted Virtualization

The advantage and disadvantage of Virtualization are following that table:

Advantage	Disadvantage
• Better resource utilization. • Dynamic data center. • Eases to control system and administration. • Increases ROI. • Improves disaster recovery.	• Single point of failure • Demands high-end and powerful infrastructure. • May lead to lower performance. • Requires specialized skill set.

Table 9. Advantage and disadvantage of Virtualization

8.2 Multicore

According to (Chandrasekaran, 2014), for multi-core technology, two or more CPUs operate on the same chip. In this architecture, a single physical processor contains the core logic of two or more processors. These microprocessors are packaged into a single integrated circuit (IC). These single ICs are called a die. Multi-core technology can also refer to multiple molds packaged together. This technology allows the system to perform more tasks with higher system-wide efficiency. It also reduces power consumption and achieves more efficiency, handling multiple tasks simultaneously. Multi-core technology can be used in desktops, mobile personal computers (PCs), servers and workstations.

This multi-core technology is used to speed up processing in a multi-object cloud environment. Multi-core architecture has become a trend for high-performance processors recently, and the results of different theory and case studies illustrate that multi-core architectures are scalable with number of cores. There are two types of multi-core:

- Multi-core processor and virtual machine scalability
- Multi-factor technology and parallelism in the cloud

9. Solution for ATN

9.1. Overview Scenario

ATN is a Vietnamese company which is selling toys to teenagers in many provinces all over Vietnam. The company has a revenue of over 700.000 dollars/year. Currently, each shop has its own database to store transactions for that shop only. Each shop has to send the sale data to the board director monthly and the board director needs lots of time to summarize the data collected from all the shops. Besides, the board can't see the stock information update in real-time.

9.2 Overview Solution

Based on the above scenario shows that ATN company has large revenue, huge data system. Currently each store has a database to store transactions from each year, the store must send data to the director. Management took a lot of time to summarize the data gathered. Based on this scenario, ATN should use cloud computing service because of the following reasons:

Firstly, using cloud computing, managers can manage all of the branch stores data anywhere, as long as the manager needs and has internet connection. Another advantage is the flexibility and mobility of cloud computing. The corporate chain can be active at any time, which can reduce the number of corporate workstations. Furthermore, cloud computing allows company executives to efficiently monitor company activities.

Secondly, stored data in the traditional server, businesses will have to buy and install hardware and software for all machines in the company to be compatible with each other. Each new purchase or upgrade will have to repeat this process once. This is too costly human and material resources for a large-scale company like ATN. However, if the ATN company uses the cloud, it only needs to pay for the services they buy. With cloud computing, IT will not need to spend a lot of time installing new hardware, software and reconfiguring devices. Do not waste time searching and always transfer data in the company. It provides everyone with the same technology platform, helping everyone to operate on the same platform. Furthermore, service charges are based on storage capacity, storage and number of users, time and storage. Therefore, ATN can easily choose its budget to save costs. If your data gets overwhelmed, you can easily get more storage and

upgrade your storage plan in minutes instead of the traditional way of adding servers, setting up settings and licenses.

Then, this cloud model makes it easy for users to access. Since it allows managers and employees in stores to access a particular vendor's technology service in the cloud without any knowledge or experience with that technology, regardless infrastructure to service that technology. Cloud computing eliminates redundant or repetitive tasks like data recovery. It's also a great choice for companies to improve performance, so team stores can easily share data anytime and at any time.

Last but not least, in ATN's business activities, or in any industry, information security is always a very important issue, indispensable for businesses. Should calculate the security of virtual Cloud Server is always at the best level and upgraded many times higher than conventional servers. In addition, the company does not have to worry about data backup plans. Data will always be available as long as the company uses the internet. Using corporate cloud computing will solve all data loss problems and disaster plans.

9.2. Deployment Model

Each of these types of clouds brings the benefits of efficiency and business boost to the company. But for the needs of users, we recommend the company to choose public cloud. There are several reasons why we choose public cloud:

Firstly, ATN is a medium company with annual income of 700,000 USD / year. So the company needs a small and medium model at a low cost. The public cloud model is a low-cost, even free, implementation model. The extremely flexible pricing structure is one of the top benefits of the public cloud. Most public cloud providers offer businesses the flexibility of hourly billing. ATN only pays for infrastructure based on the needs of its users. Besides it is possible to run their web applications without any fixed cost commitment for server, software, setup or maintenance.

Secondly, public cloud is a service model based on cloud computing platform, provided by a third party to users over the public internet. The important thing is that the public cloud is not limited to using the service, that all employees from branch stores, and managers can use the service. Besides, the community cloud

service is not tied in terms of location and location. As a result, all of the company's affiliated stores can use the service as long as an internet connection is required.

Thirdly, the corporate side can set up their public cloud within hours. The company can purchase service packs and be remotely deployed and configured through the cloud provider's website. The corporate IT team can easily configure and manage the remote setup of their store branches with just an internet connection.

Other, the cloud provider is responsible for maintaining the hardware, software, and networks in the cloud. Therefore, the corporate side doesn't need to worry about updating their infrastructure or worrying about aspects like security and upgrades.

Small and medium businesses often don't want to sign long-term contracts and commitments about storage capacity. And so is ATN company, their data capacity varies from month to month, every year. Therefore, they do not want to commit to a long-term service and commitment to capacity. In such situations, the public cloud storage service works very well because it doesn't require a commitment or a long term investment. Cloud providers often offer pay-on-use models that make overall interaction incredibly easy and hassle-free. That is, ATN Company uses public model, they can expand, exploit more resources whenever they need. Then, with the public cloud, the company will experience simplified internal operations, better distribution, better collaboration, faster deployment of new.

Last but not least, almost all public cloud providers guarantee over 99% uptime and no risk of failure. Since the overall cloud system connects multiple servers, in the event of any specific failure, the other server automatically takes over the workload - ensuring the company runs smoothly and without interruption. paragraph. Therefore, even if there is any risk arising during the company's use of the Public Model, the service provider side will ensure that all activities between the company and its affiliates are continuous and uninterrupted discontinuity.

9.3. Service Model

We recommend using the PaaS service of cloud computing, as in recent years, businesses and especially small businesses like ATN have used it effectively to tackle mathematic computing power. Here are some of the reasons we use PaaS:

The main benefit of PaaS is simplicity and convenience for users - the PaaS provider provides most of the infrastructure and other IT services, which can be accessed by managers, or employees. anywhere via web browser. The solvency on a per-use basis allows businesses to eliminate the cost of capital they normally have on on-premises hardware and software.

Secondly, PaaS is distributed and supported through a variety of clouds such as public, private, or hybrid clouds. If the ATN company uses a public cloud PaaS, the manager only needs to control the software deployment. On the other hand, the cloud provider will provide all the major IT components needed to host applications, including servers, storage systems, networks, operating systems, and databases.

Thirdly, the use of PaaS reduces investment costs such as server space, software for programming environments, security, and continuous maintenance. PaaS automates many old manual tasks and provides an environment that supports the entire development lifecycle. This means companies can enjoy marketing speeds faster than they can have and also reduce labor costs for the company. So, PaaS is very reasonable when using applications to share information between the store branch in the system with the company side, and also utilizes the infrastructure that has been pre-built and maintained intermittently. Other, the PaaS architecture gives companies the option to start with small implementations, then scale as needed. This will be more efficient, as well as cheaper, when it comes to developer tools already in the cloud. For a medium sized company like ATN, the cost savings will help the company plan to invest in a longer-term service.

Other reason, PaaS has built-in best practices for managing applications. Activities can be completely codified and applied the latest developments and best practices. This helps companies using PaaS keep up with new technology that best suits the company's needs.

PaaS gives companies a great deal of responsiveness to their applications. Any update or fix can be implemented automatically, which means the change happens much faster than the other way, because

company sales data at companies every year will increase, the use of PaaS will avoid the data center becoming overloaded and allow the company to quickly expand back-end responsiveness when needed.

Last but not least, like other cloud-based solutions, PaaS inherently supports collaboration from around the world. This makes them a great solution for companies with development teams located in different locations like company ATN. As an integrated solution, PaaS allows companies to improve workflows and create globally efficient processes. This means that branch stores in different locations within the ATN corporate network can collaborate in real time and the company is not busy managing servers or other infrastructure.

9.4. Technical Specs

9.4.1. NodeJS & JavaScript

According to (Nodejs, n.d.), here's a formal definition as given on the official Node.js website:

- Node.js® is a JavaScript runtime built on Chrome's V8 JavaScript engine.
- Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient.
- Node.js' package ecosystem, npm, is the largest ecosystem of open-source libraries in the world.

Node.js has a unique advantage because millions of frontend developers that write JavaScript for the browser are now able to write the server-side code in addition to the client-side code without the need to learn a completely different language.

In Node.js the new ECMAScript standards can be used without problems, as you don't have to wait for all your users to update their browsers - you are in charge of deciding which ECMAScript version to use by changing the Node.js version, and you can also enable specific experimental features by running Node.js with flags.

The programing language which I use is Node.js, because of some advantage of Node.js, that is the reason why we choose Node.js:

- Node.js is an open-source framework under the MIT license. (MIT license is a free software
- license originating at the Massachusetts Institute of Technology (MIT).)
- Uses JavaScript to build the entire server-side application.
- The lightweight framework includes bare minimum modules. Other modules can be included as per the need of an application.
- Node.js' package ecosystem, npm, is the largest ecosystem of open-source libraries in the world.
- Node.js uses an event-driven, non-blocking I/O that is saving time.
- Asynchronous by default. So, it performs faster than other frameworks.
- The cross-platform framework that runs on Windows, MAC or Linux.

9.4.2. Database

9.4.2.1 MongoDB

MongoDB is a document database with the scalability and the flexibility that you want with the querying and indexing that you need.

There are some several reasons why we apply MongoDB in the project:

- MongoDB's document model is simple for developers to learn and use, while still providing all the capabilities needed to meet the most complex requirements at any scale. They provide drivers for 10+ languages, and the community has built dozens more.
- MongoDB stores data in flexible, JSON-like documents, meaning fields can vary from document to document and data structure can be changed over time
- The document model maps to the objects in your application code, making data easy to work with
- Ad hoc queries, indexing, and real-time aggregation provide powerful ways to access and analyze your data
- MongoDB is a distributed database at its core, so high availability, horizontal scaling, and
- geographic distribution is built-in and easy to use
- MongoDB is free to use (Heroku, n.d.) (Mongodb, n.d.)

9.4.2.2 SQL Ser

According to (Sqlservertutorial, n.d.), SQL Server is a relational database management system, or RDBMS, developed and marketed by Microsoft. It is built on SQL, a standard programming language for interacting with relational databases. SQL Server is linked with Transact-SQL or T-SQL, Microsoft's SQL implementation that adds a set of proprietary programming constructs.

SQL Server operates exclusively on a Windows environment for more than 20 years. In 2016, Microsoft made it available on Linux. SQL Server 2017 is generally available in October 2016 running on both Windows and Linux.

SQL has many advantages that make it popular and highly requested. It is a reliable and efficient language used to communicate with databases. Some of the advantages of SQL are as follows:

- Faster query processing: Large amounts of data are retrieved quickly and efficiently and in almost no time.
- No coding skills: No large numbers of lines of code are required for data retrieval. Query commands and syntax rules are also straightforward, making it a user-friendly language.
- Standardized languages : Due to its long established and documented history, it provides a unified worldwide platform for all users.
- Portable: It can be used in programs on PCs, servers, laptops independent of any platform (Operating System, etc.).
- Interactive language: Easy to learn and understand, answers to complex queries can be received in seconds.
- Multiple data views (Geeksforgeeks, n.d.).

9.4.3. Cloud Platform

9.4.3.1 Heroku

According to (Heroku, n.d.), Heroku is a cloud platform that lets companies build, deliver, monitor, and scale apps — they the fastest way to go from idea to URL, bypassing all those infrastructure headaches.

There is several benefits of Heroku for project:

- Heroku is a container-based cloud Platform as a Service (PaaS). Developers use Heroku to deploy, manage, and scale modern apps. Our platform is elegant, flexible, and easy to use, offering developers the simplest path to getting their apps to market.
- Heroku is fully managed, giving developers the freedom to focus on their core product without the distraction of maintaining servers, hardware, or infrastructure. The Heroku experience provides services, tools, workflows, and polyglot support—all designed to enhance developer productivity.
- Heroku can seamlessly integrate GitHub which means that every pull request creates a disposable App for testing and every repo can be set up to automatically deploy with each push of GitHub to a branch. be selected

- The most popular in-memory, key-value datastore — delivered as a service.

9.4.3.2 Microsoft Azure

Acorrding to (Bigelow, n.d.), Microsoft Azure, formerly known as Windows Azure, is Microsoft's public cloud computing platform. It provides a range of cloud services, including compute, analytics, storage and networking. Users can pick and choose from these services to develop and scale new applications, or run existing applications in the public cloud.

Azure provides a number of benefits for businesses:

- Perfect for small businesses and established enterprises: Azure is designed for every business regardless of size. It's easily scalable to meet your IT demands and operates on a pay-as-you-go pricing model to meet any budget.
- Complements and expands your current IT infrastructure: The platform makes it fast and easy to deploy your current apps with little to no downtime.
- Security, compliance, and disaster recovery.
- Industry-specific applications: Individualized security needs, simplified compliance, and modernized customer apps.

9.4.4. GitHub: Version Control System & Collaboration

In my opinion, GitHub, WebStorm are the needed tools to deploy this project.

According to (GITHUB, 2017), GitHub is a code hosting platform for version control and collaboration. It lets us and others work together on projects from anywhere.

We choose GitHub because of the advantage of it such as:

- It makes it easy to contribute to our open-source projects
- GitHub is one of the largest coding communities around right now, so it's wide exposure for our project.
- Track changes in our code across versions.

- GitHub can integrate with common platforms such as Amazon and Google Cloud, services such as Code Climate to track our feedback, and can highlight syntax in over 200 different programming languages.

In another tool, we choose WebStorm. Because it supports a lot extension for Node.js, helps developer increase code quality, reduces your mistakes, allows you to write code faster, easy to use code and debug.

9.4.5 Technical Solution for project

Based on the technologies of programming languages, databases, and cloud services, the author offer two solutions for the project:

- Solution 1: Nodejs + MonogoDB + Heroku
- Solution 2: Nodejs + SQL Server + Microsoft Azure

In the context of ATN company, the author decides to choose the first technology solution. Select the system design language is Nodejs, database is MongoDB and cloud platform is Heroku.

Firstly, the author chooses database is MongoDB instead of SQL Server, because:

- MongoDB allows them to build applications faster, process a variety of data types, and manage applications at scale. The development is simplified as native MongoDB map documents for modern object-oriented programming languages. Using MongoDB removes the complex object mapping class (ORM) that translates the objects in the code into relational tables. MongoDB's flexible data model also means that your database schema can evolve as business requirements.
- In addition, MongoDB can also be scaled within and between multiple distributed data centers, providing new levels of availability and scalability previously not possible with relational databases. Like SQL Server. As your deployment grows in terms of data volume and throughput, MongoDB easily balances with no downtime, and no changes to your application. In contrast, achieving scale with SQL Sercer often requires significant custom engineering work.

- MongoDB is used to save unstructured data in JSON format. When working, the data is as a flexible JSON document rather than rigid rows and columns. This helps developers to move faster, and save time storing and querying data.

Secondly, the author chooses Heroku system instead of Microsoft Azure, because:

- Heroku can be classified as a tool in the "Platform as a Service" category, while Microsoft Azure is grouped under "Cloud Hosting".
- Besides, the author chose the website development project for ATN company, Nodejs. That Heroku allows for quick deployment for Ruby, Node.js, Clojure, Java, Python, Go, and Scala. But Microsoft Asezu supports .Net or open source tools. Therefore, the author chose Heroku by using Heroku as an advantage for developing platforms based on the Nodejs language. Heroku supports running and expanding any kind of application. Total visibility across your entire application. This leads to cost and manpower savings.
- A few other factors let us choose Heroku over Microsoft Azure. Heroku is easy to deploy, free of charge for side projects, and big time saver.

10. Cloud Architecture

According to (Thomas Erl, 2013), the dynamic scalability architecture is an architectural model based on a system of predefined scaling conditions that trigger the dynamic allocation of IT resources from resource pools. Dynamic allocation enables variable utilization as dictated by usage demand fluctuations since unnecessary IT resources are efficiently reclaimed without requiring manual interaction.

The auto scaling listener is configured with workload thresholds that dictate when new IT resources need to be added to the workload handle. This mechanism can be provided with logic that determines the amount of additional IT resources that can be dynamically provisioned, based on the terms of a given cloud consumer supply contract.

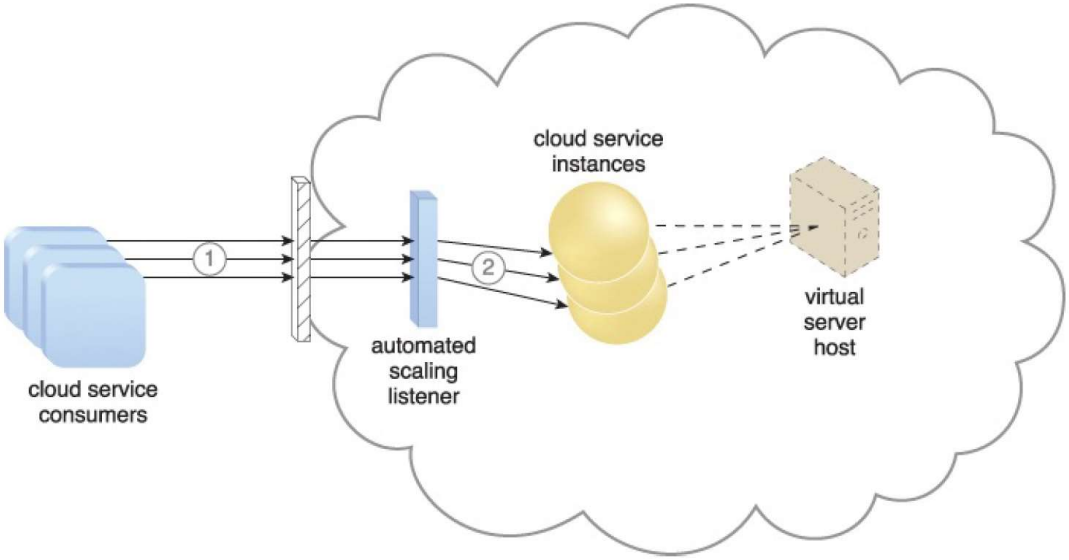


Figure 11.5 Cloud service consumers are sending requests to a cloud service (1). The automated scaling listener monitors the cloud service to determine if predefined capacity thresholds are being exceeded (2).

Based on the above image, we can describe an example of Cloud architecture.

(1) Firstly, cloud service consumers are sending requests to a cloud service.

(2) In the next step, the automated scaling listener monitors the cloud service to determine if the predefined capacity threshold is exceeded. Here there will be two possible scenarios.

Case 1: In this process, if the workload does not exceed the power threshold. That is, the workload is less than or equal to the capacity threshold, the request will be sent to the cloud service as usual. For example, the workload is 3, the production threshold is 4, the request will be sent to the cloud service to continue execution.

Case 2: However, the number of service requests coming from cloud service consumers is increasing. Workload exceeds performance threshold. The scaling listener automatically determines the next course of action based on a predefined scaling policy.

- The scaling listener would immediately initiate the scaling process if the implementation of the cloud service is considered eligible for additional scaling.
- Then, the scaling listener then sends the signal to the resource duplication system automatically, generating several copies of the cloud service to accommodate the number of customer demands.
- Now that the increased workload has been provided, the automatic listener continues to monitor and devalue and add IT resources, as required. However, if the implementation of the cloud translation does not qualify for additional scaling, the user's request will be returned or canceled.

For example, when the workload is increased to 6, however, the current threshold is only 4. The rate handler automatically determines the next process of action based on the predefined rate policy. If enough resources can scale the deployment like enough RAM, then the auto-scaling process will initiate the sharing process. The scale listener then automatically sends a signal to the resource replication mechanism, generating multiple instances of the cloud service in response to the number of requests from users. Now when the workload amount and the current threshold is met, the resource or some request will be sent to the provided cloud service. However, if the storage capacity does not meet the scale of deployment, requests from the user to the cloud service will be canceled.

Conclusion

Cloud computing trends are emerging around the world. There are many different cloud computing models but their overall goal is to engage and advance every business plan with the evolving capabilities of technology. The above report I have presented about an overview of cloud computing including its definition, but the characteristics, outstanding services and benefits that cloud computing brings to companies and society. With the specific scenario, we have come up with the method and the arguments and the reasons for us to choose the cloud computing over traditional data management ways.

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