CLOUD COMPUTING
REPORT ASSIGNMENT 1

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ASSIGNMENT 1 FRONT SHEET

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INTRODUCTION

Cloud computing is the delivery of different services through the Internet. These resources include tools and applications like data storage, servers, databases, networking, and software.

Rather than keeping files on a proprietary hard drive or local storage device, cloud-based storage makes it possible to save them to a remote database. As long as an electronic device has access to the web, it has access to the data and the software programs to run it.

Cloud computing is a popular option for people and businesses for some reasons including cost savings, increased productivity, speed and efficiency, performance, and security.

Through this report, the knowledge of cloud computing will be presented in detail and will show how a company, when implementing, deploying from the old sales system to cloud computing will be like.

The fundamentals of Cloud Computing and its architectures

1. The evolution and fundamental concepts of Cloud Computing

1.1. The fundamental of Cloud Computing

What is cloud computing?

Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user. The term is generally used to describe data centers available to many users over the Internet. Large clouds, predominant today, often have functions distributed over multiple locations from central servers. If the connection to the user is relatively close, it may be designated an edge server. (wikipedia, n.d.)

Types of cloud computing:

Not all clouds are the same and not one type of cloud computing is right for everyone. Several different models, types, and services have evolved to help offer the right solution for user needs.

First, the user needs to determine the type of cloud deployment, or cloud computing architecture, that cloud services will be implemented on. There are three different ways to deploy cloud services: on a public cloud, private cloud, or hybrid cloud.

- **Public cloud:**

Public clouds are owned and operated by a third-party cloud service provider, which deliver their computing resources, like servers and storage, over the Internet. Microsoft Azure is an example of a public cloud. With a public cloud, all hardware, software, and other supporting infrastructure is owned and managed by the cloud provider. Users access these services and manage accounts using a web browser. (azure, n.d.)

- **Private cloud:**

A private cloud refers to cloud computing resources used exclusively by a single business or organization. A private cloud can be physically located on the company's on-site datacenter. Some companies also pay third-party service providers to host their private cloud. A private cloud is one in which the services and infrastructure are maintained on a private network.

- **Hybrid cloud:**

Hybrid clouds combine public and private clouds, bound together by technology that allows data and applications to be shared between them. By allowing data and applications to move between private and public clouds, a hybrid cloud gives business greater flexibility, more deployment options, and helps optimize existing infrastructure, security, and compliance.

Types of cloud services:

Most cloud computing services fall into four broad categories: infrastructure as a service (IaaS), platform as a service (PaaS), serverless, and software as a service (SaaS). These are sometimes called the cloud computing "stack" because they build on top of one another. Knowing what they are and how they're different makes it easier to accomplish business goals.

- **Infrastructure as a Service (IaaS):**

Picture 1. Infrastructure as a Service (IaaS)

IaaS contains the basic building blocks for cloud IT. It typically provides access to networking features, computers (virtual or on dedicated hardware), and data storage space. IaaS gives users the highest level of flexibility and management control over IT resources. It is most similar to the existing IT resources with which many IT departments and developers are familiar. (amazon, amazon, n.d.)

- **Platform as a service (PaaS):**

Picture 2. Platform as a Service (PaaS)

PaaS removes the need for users to manage underlying infrastructure (usually hardware and operating systems) and allows users to focus on the deployment and management of applications. This helps users be more efficient as users don't need to worry about resource procurement, capacity planning, software maintenance, patching, or any of the other undifferentiated heavy lifting involved in running applications.

- **Software as a Service (SaaS):**

Picture 3. Software as a Service (SaaS)

SaaS provides users with a complete product that is run and managed by the service provider. In most cases, people referring to SaaS are referring to end-user applications (such as web-based email). With a SaaS offering, users don't have to think about how the service is maintained or how the underlying infrastructure is managed. The user only needs to think about how the user will use that particular software.

1.2. The evolution of Cloud Computing

The evolution of cloud computing can be bifurcated into three basic phases: (seasiainfotech, n.d.)

- **The Idea Phase:** This phase incepted in the early 1960s with the emergence of utility and grid computing and lasted till the pre-internet bubble era. Joseph Carl Robnett Licklider was the founder of cloud computing.
- **The Pre-cloud Phase:** The pre-cloud phase originated in 1999 and extended to 2006. In this phase the internet as the mechanism to provide Application as Service.
- **The Cloud Phase:** The much talked about real cloud phase started in the year 2007 when the classification of IaaS, PaaS, and SaaS got formalized. The history of cloud computing has witnessed some very interesting breakthroughs launched by some of the leading computer/web organizations of the world.

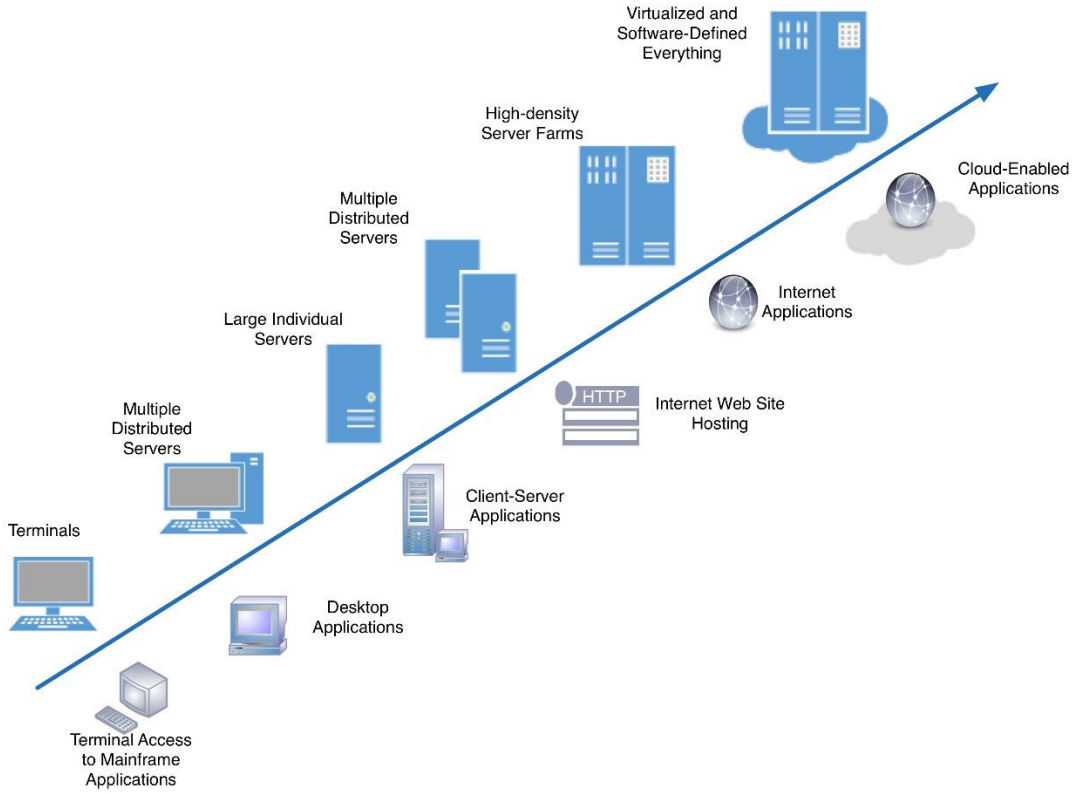
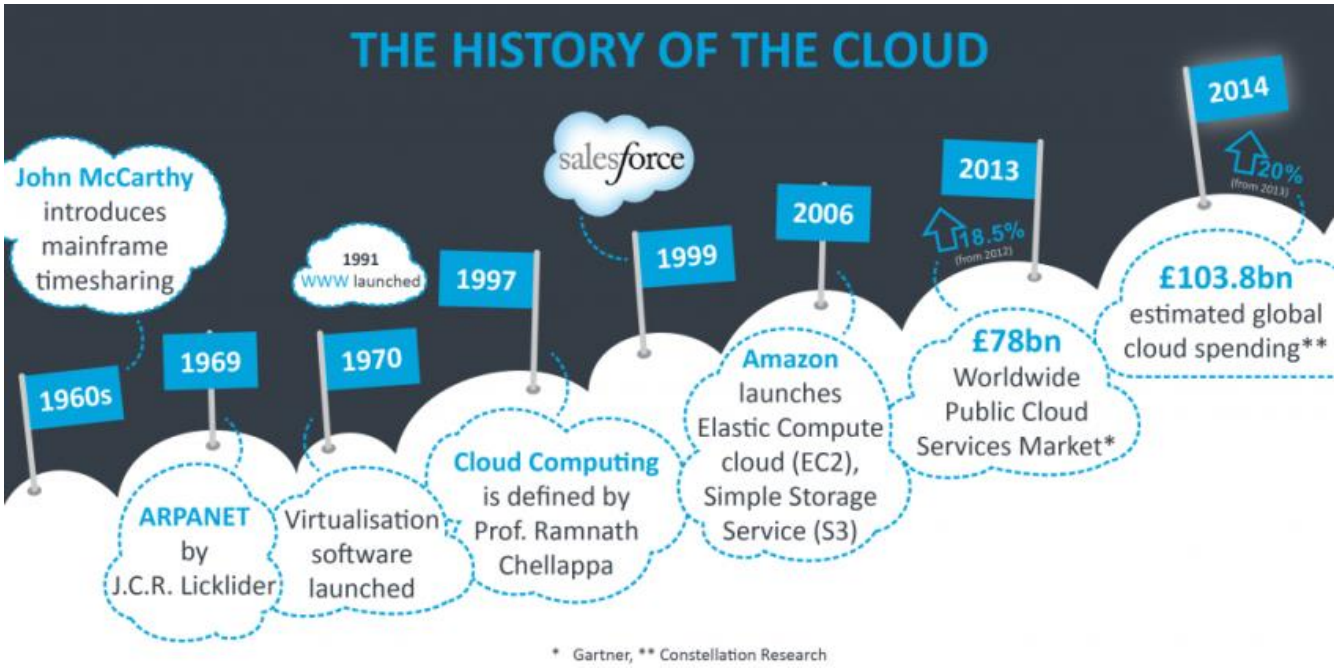


Figure 1. The evolution of Cloud Computing. (packtpub, n.d.)

What's next for Cloud Computing in 2020?



Picture 4. The history of Cloud Computing. (report.cloud, n.d.)

IT executives and entrepreneurs are turning more of their attention on how they use technology to achieve their business goals for 2020. Below is the list of a few trends in cloud computing that business should prepare for in the coming year:

- **Cloud Storage Capacity:**

As cloud services progressively turn into an essential part of doing business, we anticipate data storage to develop exponentially in the coming time. To achieve this, organizations will arrange more data centers online with bigger capacity storage equipment. As indicated by the Cisco analysis, the aggregate amount of data stored in the data centers would be 370 EB, while worldwide storage capacity would reach 600. These numbers are set to develop in 2020 to an expected aggregate storage limit of 1.1 ZB, which is around double the space accessible in 2019.

While the owners of data centers are going to increase the available storage, forward-thinking organizations will have the capacity to use that space to fulfill their requirements. For instance, organizations that work with big data will utilize this expanded space to store large data indexes or sets and perform analytics on them, and reap valuable insights into areas, for example, client behavior, human frameworks, and strategic financial investment. For small private companies, expanded storage capacity implies that 2020 will give custom or bespoke storage alternatives at far lower costs than were accessible in 2017.

- **Better Internet Quality and the Rise of 5G**

Similarly, to the measure of data produced and stored around the globe is expected to grow enormously in 2020, purchasers will also expect better and quicker connections from network providers.

Improved network speed will increase the buyer's desires for exceedingly responsive, quick loading services and applications. Keen entrepreneurs will move rapidly to re-examine and overhaul their SaaS, PaaS, and websites to be more responsive. The IOE and IOT will additionally take advantage of the faster network by allowing companies in this space to receive and deliver data efficiently in real-time.

Worth reading: Role of Cloud Computing in the Internet of Things

- **The IoE will become the dominant focal point**

In 2018, IoT and AI played a stellar part in the tech world. While industry experts expect that IoT will see its development, nonstop innovations in the real-time data analytics and the developing technology cloud computing are set to push the IOE to fore in 2020. IoE depends on the machine to machine interaction, process, and data and how people speak with everything in their condition. Cloud computing will play a major role as the IoE forms into complex frameworks aimed at simplifying all interactions.

For people, this implies we will have the capacity to interact cleverly with each gadget in a network—simply like IoT. People will have the capacity to interact effectively in human-to-human communications. For instance, Google's Pixel Buds are a headset equipped with the capacity to translate and recognize 40 dialects for its client.

IoE will also furnish organizations with more insight into how shoppers relate to their services or products, customer care units, and each other. This information would then be used in numerous ways, including simplifying client experience through automation and the utilization of savvy robots. Japanese hospitality robots, which can welcome guests, chat in real-time, and give certain services, give a sneak look into what IoE could achieve in the future.

- **Security challenges and the cloud**

Because cyber-attacks are turning out to be more complex, security examiners in government, private and public areas will also need to become more refined and auspicious in their techniques for recognizing and preventing attacks. Organizations will recognize the need for investing in tools like security data, event management, and malware detection frameworks as crucial defense mechanisms for digital security. Cloud services can play a role here also, with managed security service providers offering strong services to organizations that couldn't generally execute full security measures.

2. The architectural Cloud Computing design

2.1. Cloud computing architecture

Cloud computing architecture refers to the components and subcomponents required for cloud computing. These components typically consist of a front-end platform (fat client, thin client, mobile device), back end platforms (servers, storage), a cloud-based delivery, and a network (Internet, Intranet, Intercloud). Combined, these components make up cloud computing architecture.

Cloud computing comprises of two components front end and back end:

- The front end consists of the client part of the cloud computing system. It comprises of interfaces and applications that are required to access the cloud computing platform.
    - User Interface: The user interface refers to all the things that end-user access to send requests or perform any task on the Cloud. Some of the popular cloud-based user interfaces are Google Doc, Gmail, etc.
    - Software: The software architecture in the front end is the software that runs on the user's end. Frontend software architecture primarily comprises client-side applications or browsers.
    - Client Device or Network: Being a crucial part of the frontend architecture, Client Device or Network refers to the hardware at the end user's side. It can be any input device or PC. In cloud computing, the client-side device doesn't require extraordinary ability to process the heavy load. The cloud can take the entire heavy load and processes the same.
- Back end refers to the cloud itself, it comprises of the resources that are required for cloud computing services. It consists of virtual machines, servers, data storage, security mechanism, etc. It is under the provider's control. (guru99, n.d.)
    - **Application**: The Application is a substantial part of the backend architecture. It refers to the user interface that the backend offers to the end-user to send queries. This layer of the backend takes care of the client's requests and requirements.
    - **Service**: This is a magical area of the backend cloud architecture. It adds utility to the entire backend architecture. The service handles every task that runs on the cloud computing system. Some of the cloud services are application development environment, storage, and web services. Besides, service can execute a wide array of tasks on the cloud runtime.
    - **Cloud Runtime**: The term 'Cloud Runtime' is the concept where the services run. It's like a cloud operating system where technology like virtualization is used. Virtualization as a key technology on the cloud which allows multiple runtimes on the same server. For instance, virtualization is a way via which we can create a base of software. In simple words, it's the virtual representation of apps, servers, storage as well as networks. When we create runtimes with the support of virtualization software, they are called as Hypervisors. Some of the leading hypervisors are Oracle Virtual Box, Oracle VM for x86, VMWare Fusion, etc.
    - **Storage**: Storage in the cloud is where the data resides of a cloud application. The data storage varies as per different cloud service provides. However, all of them have a common dedicated segment for cloud storage. Some of the examples of storage are solid-state drives, hard drives, Intel Optane DC Persistent storage, etc. The hard drives in the server bays form storage in the cloud backend architecture. And especially in a cloud computing system, the software partitions the drives as per the needs of the OS in the cloud to run myriad services.

- **Infrastructure**: The engine that steers all the cloud software services is called infrastructure. It includes CPU, Motherboard, Graphics Processing Unit (GPU), network cards, accelerator cards, etc. The infrastructure models always depend on the workloads of the clients.
- **Management**: The management software allocates specific resources to specific tasks and responsibilities for the flawless functioning of any cloud environment. In technical terms, management is the 'middleware' and it coordinates between the frontend and backend architecture in a cloud computing system.
- **Security**: Security is an integral and critical part of any cloud computing infrastructure. We create security infrastructure by keeping the debugging process in mind. In case of any issue, debugging should be easy. Regular storage backup is the first step to ensure security in a cloud computing system. And virtual firewalls are other crucial elements of the cloud security infrastructure.

The cloud also has an architecture that describes its working mechanism. It includes the dependencies on which it works and the components that work over it. The cloud is a recent technology that is completely dependent on the Internet for its functioning.

The cloud architecture can be divided into four layers based on the access of the cloud by the user. They are as follows.

- **Layer 1 (User/Client Layer):**

This layer is the lowest layer in the cloud architecture. All the users or clients belong to this layer. This is the place where the client/user initiates the connection to the cloud. The client can be any device such as a thin client, thick client, or mobile or any handheld device that would support basic functionalities to access a web application. The thin client here refers to a device that is completely dependent on some other system for its complete functionality. In simple terms, they have very low processing capability. Similarly, thick clients are general computers that have adequate processing capability. They have sufficient capability for independent work. Usually, a cloud application can be accessed in the same way as a web application. But internally, the properties of cloud applications are significantly different. Thus, this layer consists of client devices.

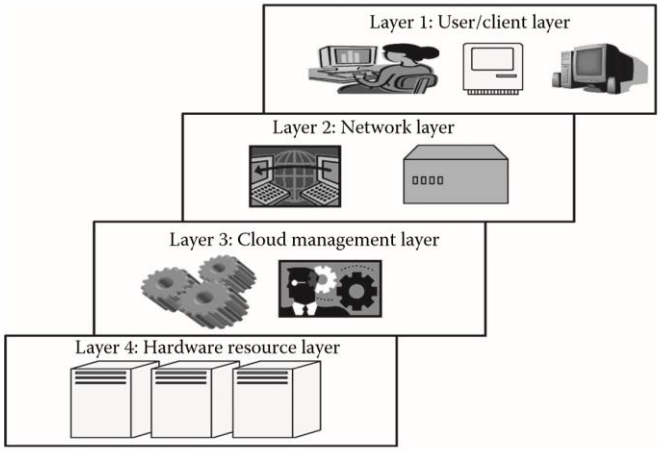


Figure 2. Cloud architecture

- **Layer 2 (Network Layer):**

This layer allows users to connect to the cloud. The whole cloud infrastructure is dependent on this connection where the services are offered to the customers. This is primarily the Internet in the case of a public cloud. The public cloud usually exists in a specific location and the user would not know the location as it is abstract. And, the public cloud can be accessed all over the world. In the case of a private cloud, the connectivity may be provided by a local area network (LAN). Even in this case, the cloud completely depends on the network that is used. Usually, when accessing the public or private cloud, the users require minimum bandwidth, which is sometimes defined by the cloud providers. This layer does not come under the purview of service-level agreements (SLAs), that is, SLAs do not take into account the Internet connection between the user and cloud for quality of service (QoS).

- **Layer 3 (Cloud management Layer):**

This layer consists of software that is used in managing the cloud. The software can be a cloud operating system (OS), a software that acts as an interface between the data center (actual resources) and the user, or management software that allows managing resources. This software usually allows resource management (scheduling, provisioning, etc.), optimization (server consolidation, storage workload consolidation), and internal cloud governance. This layer comes under the purview of SLAs, that is, the operations taking place in this layer would affect the SLAs that are being decided upon between the users and the service providers. Any delay in processing or any discrepancy in service provisioning may lead to an SLA violation. As per rules, an SLA violation would result in a penalty to be given by the service provider. These SLAs are for both private and public clouds Popular service providers are Amazon Web Services (AWS) and Microsoft Azure for public cloud. Similarly, OpenStack and Eucalyptus allow private cloud creation, deployment, and management.

- **Layer 4 (Hardware Resource Layer):**

Layer 4 consists of provisions for actual hardware resources. Usually, in the case of a public cloud, a data center is used in the back end. Similarly, in a private cloud, it can be a data center, which is a huge collection of hardware resources interconnected to each other that is present in a specific location or a high configuration system. This layer comes under the purview of SLAs. This is the most important layer that governs the SLAs. This layer affects the SLAs most in the case of data centers. Whenever a user accesses the cloud, it should be available to the users as quickly as possible and should be within the time that is defined by the SLAs. As mentioned, if there is any discrepancy in provisioning the resources or application, the service provider has to pay the penalty. Hence, the data center consists of a high-speed network connection and a highly efficient algorithm to transfer the data from the data center to the manager. There can be a number of data centers for a cloud, and similarly, a number of clouds can share a data center.

Thus, this is the architecture of a cloud. The layering is strict, and for any cloud application, this is followed. There can be a little loose isolation between layer 3 and layer 4 depending on the way the cloud is deployed.

2.2. ATN's company architectural framework design

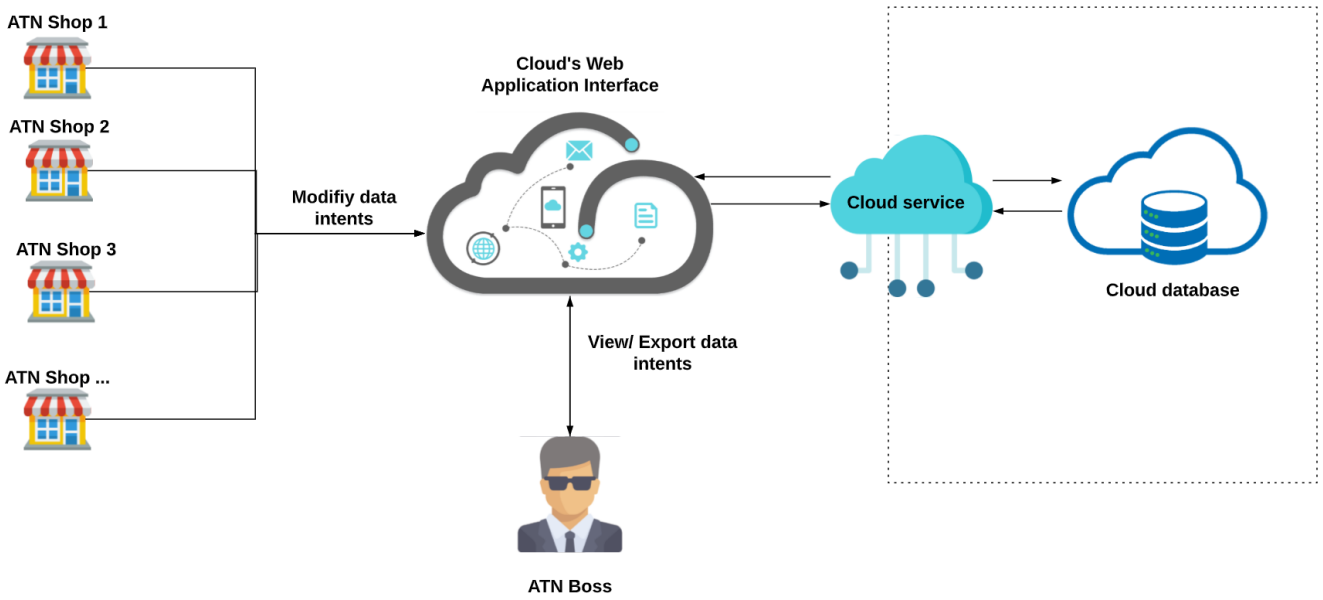


Figure 3. ATN's company architectural design.

As in the information visualized in figure 3., the ATN's cloud architecture should be implemented the same with the framework design. In this cloud framework design, 4 distributed ATN shop's manager have rights to insert the transactions data into entire company's database, however, only the ATN's board director has rights to modify or export those data, which means having the highest authority to interact with the company's database.

Every end-user (including distributed shop's managers and the boss) interacts with the database through the Website application interface. The database is rented and maintained by making a contract with one Cloud service provider for cloud database hosting solution.

By implementing this cloud architectural framework, the company's data exchanging processes will be faster, more efficient and simpler compared to the traditional method.

3. The reason that organizations should migrate to a Cloud Computing solution.

3.1. Cloud Server vs. Local Server

Cloud server:

The users are already using several cloud-based tools including email providers (Gmail, Outlook, etc…), storage/backup Softwares (iCloud, Dropbox, Box, etc…) and all social media platforms that users might have an account in.

Pros

- Maintenance & upgrades
- Easy adjustment of storage space
- Data stored remotely
- Accessible wherever there is internet access
- Ease of use.
- Cost-effectiveness

The first proof of using a cloud is that the cloud provider handles all of the maintenance and upgrades. This means the user has one less thing to worry about. It is also easy to up or downscale the amount of space in the cloud. So, the users are just paying for the number of users' needs.

The data is also stored remotely and never stored on the computer, meaning it is not occupying space unnecessarily. If there are technical issues on-site, data will be safe in the cloud. A final pro is that the users can access the data stored in the cloud from wherever there is an internet connection.

Cons

- Cannot access data without the internet
- Transferring data out of the cloud
- Bandwidth restrictions
- Premium subscriptions for additional disk space
- Expensive subscriptions for additional SQL storage
- No guarantee for 100% uptime
- No personal control on the website's performance

On the other side of accessing via the internet, a con can be that if the internet connection is not very strong users could have trouble accessing the data. However, with some software, users are still able to access the data offline. But users will either be unable to edit the data offline or users can edit it and then it will sync later. The users will also need to check how easy it would be to transfer the data elsewhere should users stop using the cloud.

Local Server:

In the research group, department or institute users might already have a local service available. Instead of storing microscope data in the microscope computer, the users are transferring it to another storage device, so that user can access it from other computers and also assure that the microscope computer does not get filled with data in 1 day.

Pros:

- Up/download speed
- System set-up control
- Security

The first proof using a local server is the speed. The speed refers to that with which users can up/download data to the server. Users also have total control of the system setup, to make sure it fits exact needs.

The control also extends to backups, and everything else to do with the data since it owns the server completely. It may also feel more secure to have a local server, onsite, since only users and the team can physically, and of course digitally, access it.

Cons:

- Installation of expensive hardware
- Will need maintenance
- High price
- Installation, setup and maintenance issues that require IT knowledge to solve
- No data backup and retrieval other than local mechanisms
- No supervision and technical support

The main con of installing a local server is needing to install it and then maintain it. Sometimes the hardware can be costly and if problems arise, the users will need to do the troubleshooting. However, this would, of course, be where the IT team would come to save the day!

3.2. Benefits of Migrating to the Cloud

- **Reduced costs:**

Establishing and running a data center is expensive. Users need to purchase the right equipment and hire technicians to install and manage the center. When users shift to cloud computing, the customer will only pay for the services procured.

Providers charge cloud computing services based on the features, storage, number of users, time, and memory space among other factors. Hence, the customer can choose a package that suits the budget and save costs.

- **Flexibility:**

One of the major benefits of cloud computing is mobility. The service gives customers and employees the flexibility to work from any location. Employees can complete their tasks at home or from the field.

Customers can reduce the number of workstations in the office and allow some employees to work from home to save costs further. Cloud computing enables the user to monitor the operations in business effectively. Users just need a fast internet connection to get real-time updates of all operations.

- **Scalability:**

Another reason why it's a good idea to implement a cloud strategy migration is its scalability. Users can scale up or scale down storage based on business needs. If a business belongs in a fluctuating market, the cloud enables users to add or reduce the space in the cloud environment.

The traditional way of planning for unexpected growth is to purchase and keep additional servers, storage, and licenses. It may take years before users use the reserve resources. Scaling cloud computing services is easy. Users can get additional storage space or features whenever users need them. the provider will simply upgrade the package within minutes as long as users meet the additional cost.

- **Full Document Control:**

The cloud stores document via a centralized data center. Users don't have to go through a series of tedious processes just to share the document with the rest of the team. Anyone who has access to a document can edit or view the file depending on the type of access users have permitted. Circulating the same file allows better collaboration across workers, partners, customers, and companies.

- **Data Security:**

It is not a good practice to store sensitive data on the laptop, doing so makes it very easy for someone to corrupt or destroy files. Data stored on the cloud can be accessed from anywhere without unnecessarily exposing information to cybercriminals.

- **Data Protection:**

When users move data into the cloud, the user avoids the risk of losing data at the hands of power outages or viruses. Moving data into the cloud will spare users the headache of recovering everything from scratch because the cloud can store backup copies of data in a secure location so users can access it from the cloud.

The deployment models, service models and technological drivers of Cloud Computing and validate the user

1. The appropriate deployment models

Deployment models can be defined as the different ways in which the cloud can be deployed. These models are fully user-centric, that is, these depend on users' requirements and convenience. A user selects a model based on his or her requirements and needs. There are four types of deployment models in the cloud:

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

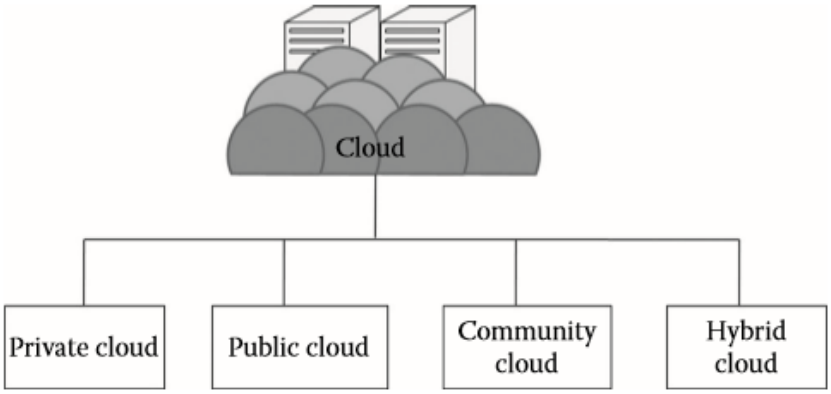
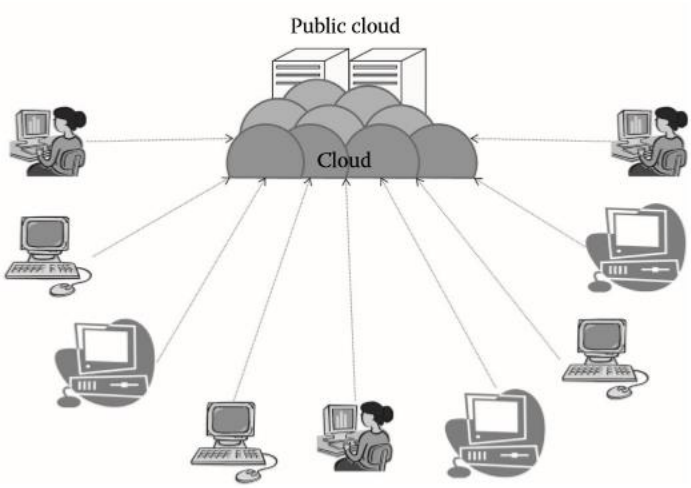


Figure 4. Cloud deployment models

1.1. Public Cloud

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.



Picture 5. Public cloud

The typical public cloud consists of users from all over the world. A user can simply purchase resources on an hourly basis and work with the resources. There is no need for any prebuilt infrastructure for using the public cloud. These resources are available on the cloud provider's premises. Usually, cloud providers accept all the requests, and hence, the resources in the service providers' end are considered infinite in one aspect.

Some of the well-known examples of the public cloud are Amazon AWS, Microsoft Azure, etc.

Picture 6. Amazon Web Services & Microsoft Azure

Characteristics:

- **Highly scalable:** The public cloud is highly scalable. The resources in the public cloud are large in number and the service providers make sure that all the requests are granted. Hence, the public cloud is considered to be scalable.
- **Affordable:** The public cloud is offered to the public on a pay-as-you-go basis; hence, the user has to pay only for what he or she is using (usually on a per-hour basis). And, this does not involve any cost related to the deployment.
- **Less secure:** The public cloud is less secure out of all the four deployment models. This is because the public cloud is offered by a third party and they have full control over the cloud. Though the SLAs ensure privacy, still there is a high risk of data being leaked.
- **Highly available:** The public cloud is highly available because anybody from any part of the world can access the public cloud with proper permission, and this is not possible in other models as geographical or other access restrictions might be there
- **Stringent SLAs:** SLA is very stringent in the case of the public cloud. As the service provider's business reputation and customer strength are dependent on the cloud services, they follow the SLA strictly and violations are avoided. These SLAs are very competitive.

Suitability:

There are several occasions and environments where the public cloud is suitable. Thus, the suitability of the public cloud is described. The public cloud can be used whenever the following applies:

- The requirement for resources is large, that is, there is a large user base.
- The requirement for resources is varying.
- There is no physical infrastructure available.
- An organization has financial constraints.

The public cloud is not suitable, where the following applies:

- Security is very important.
- The organization expects autonomy.
- Third-party reliability is not preferred.

Advantages:

- There is no need of establishing infrastructure for setting up a cloud.
- There is no need for maintaining the cloud.
- They are comparatively less costly than other cloud models.
- Strict SLAs are followed.
- There is no limit to the number of users.
- The public cloud is highly scalable.

Disadvantages:

- Security is an issue.
- Privacy and organizational autonomy are not possible.

1.2. Private Cloud

The private cloud deployment model is discussed. 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 (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.

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. The private cloud can be deployed using Opensource tools such as Openstack, Eucalyptus.

Picture 7. Openstack

The private cloud is small in size as compared to other cloud models. Here, the cloud is deployed and maintained by the organizations itself.

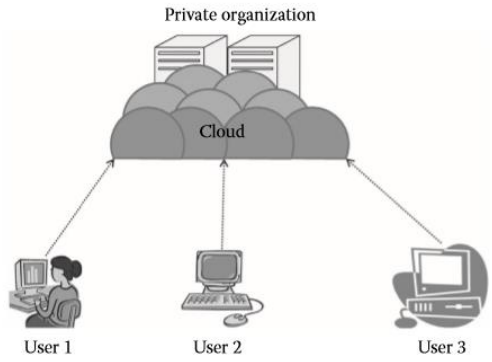


Figure 5. On-premise private cloud

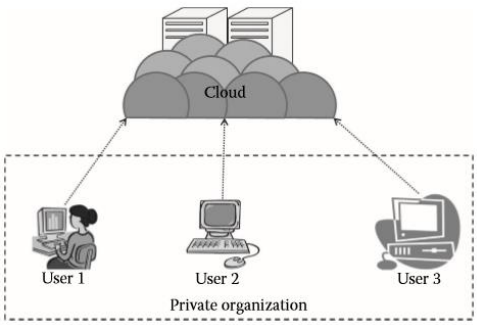


Figure 6. Outsourced private cloud

Characteristic:

- **Secure**: The private cloud is secure. This is because usually the private cloud is deployed and managed by the organization itself, and hence there is the least chance of data being leaked out of the cloud. In the case of outsourced cloud, the service provider may view the cloud (though governed by SLAs), but there is no other risk from anybody else as all the users belong to the same organization.
- **Central control**: The organization mostly has full control over the cloud as usually the private cloud is managed by the organization itself. Thus, when managed by the organization itself, there is no need for the organization to rely on anybody.
- **Weak SLAs**: Formal SLAs may or may not exist in a private cloud. But if they exist they are weak as it is between the organization and the users of the same organization. Thus, high availability and good service may or may not be available. This depends on the organization that is controlling the cloud.

Suitability:

Suitability refers to the instances where this cloud model can be used. It also signifies the most suitable conditions and environment where this cloud model can be used, such as the following:

- The organizations or enterprises that require a separate cloud for their personal or official use.
- The organizations or enterprises that have a sufficient amount of funds as managing and maintaining a cloud is a costly affair.
- The organizations or enterprises that consider data security to be important.
- The organizations that want autonomy and complete control over the cloud.
- The organizations that have a less number of users.
- The organizations that have a prebuilt infrastructure for deploying the cloud and are ready for timely maintenance of the cloud for efficient functioning.
- Special care needs to be taken and resources should be available for troubleshooting.

The private cloud platform is not suitable for the following:

- The organizations that have a high user base
- The organizations that have financial constraints
- The organizations that do not have a prebuilt infrastructure
- The organizations that do not have sufficient manpower to maintain and manage the cloud

Advantages:

- The cloud is small in size and is easy to maintain.
- It provides a high level of security and privacy to the user.
- It is controlled by the organization.

Disadvantages:

- For the private cloud, the budget is a constraint.
- The private clouds have loose SLAs.

1.3. Community Cloud

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 (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. It is a further extension of the private cloud. Here, a private cloud is shared between several organizations. Either the organizations or a single organization may collectively maintain the cloud.

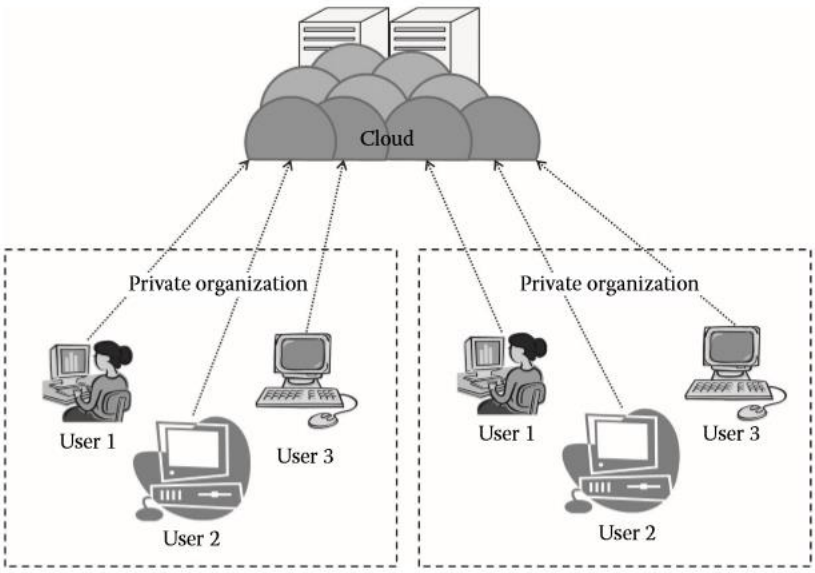


Figure 7. Community Cloud

The main advantage of the public cloud is that the organizations can share the resources among themselves based on specific concerns. Thus, here the organizations can extract the power of the cloud, which is much bigger than the private cloud, and at the same time, they can use it at a usually less costly. The community is formed based on any common cause, but eventually, all the members of the community are benefitted.

This model is very suitable for organizations that cannot afford a private cloud and cannot rely on the public cloud either.

Characteristics:

- **Collaborative and distributive maintenance**: The community cloud is wholly collaborative, and usually no single party has full control over the whole cloud (in some cases, it may be controlled by one party). This is usually distributive, and hence, better cooperation gives better results. Even though it may be outsourced, collaboration based on purpose always proves to be beneficial.
- **Partially secure**: Partially secure refers to the property of the community cloud where few organizations share the cloud, so there is a possibility that the data can be leaked from one organization to another, though it is safe from the outside world.
- **Cost-effective**: The community cloud is cost-effective as the whole cloud is being shared by several organizations or a community. Usually, not only the cost but every other sharable responsibility is also shared or divided among the groups.

Suitability:

This kind of cloud is suitable for organizations that:

- Want to establish a private cloud but have financial constraint
- Do not want to complete the maintenance responsibility of the cloud
- Want to establish the cloud to collaborate with other clouds
- Want to have a collaborative cloud with more security features than the public cloud

This cloud is not suitable for organizations that

- Prefer autonomy and control over the cloud
- Does not want to collaborate with other organizations

There are two types of community cloud deployments:

- On-premise community cloud
- Outsourced community cloud

Advantages:

- It allows establishing a low-cost private cloud.
- It allows collaborative work on the cloud.
- It allows the sharing of responsibilities among the organization.
- It has better security than the public cloud

Disadvantages:

- The autonomy of an organization is lost.
- Security features are not as good as the private cloud.
- It is not suitable if there is no collaboration.

1.4. Hybrid Cloud

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 hybrid cloud usually is a combination of both public and private clouds. This is aimed at combining the advantages of private and public clouds. 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. There are several advantages of the hybrid cloud. The hybrid cloud can be regarded as a private cloud extended to the public cloud. This aims at utilizing the power of the public cloud by retaining the properties of the private cloud. One of the popular examples for the hybrid cloud is Eucalyptus. Eucalyptus was initially designed for the private cloud and is a private cloud, but now it also supports hybrid cloud. Figure 4.6 shows the hybrid cloud. The hybrid cloud can be further extended into a vast area of federated clouds that is discussed in subsequent chapters.

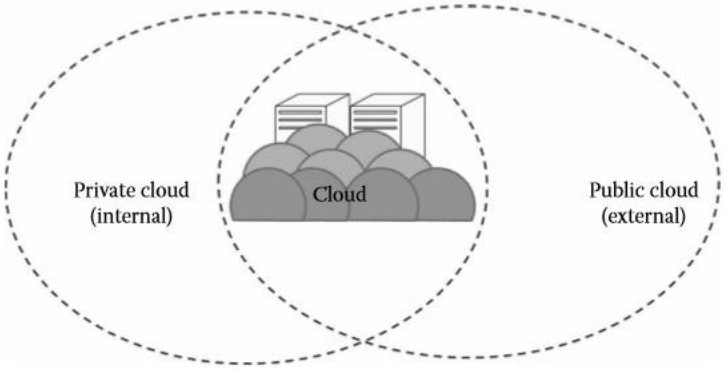


Figure 8. The hybrid Cloud

Characteristics:

- **Scalable**: The hybrid cloud is a combination of one or more deployment models. Usually, the private with the public cloud gives a hybrid cloud. The main reason for having a hybrid cloud is to use the property of a public cloud with a private cloud environment. The public cloud is used whenever needed; hence, as the public cloud is scalable, the hybrid cloud with the help of its public counterpart is also scalable.
- **Partially secure**: The hybrid cloud usually is a combination of public and private. The private cloud is considered to be secured, but as the hybrid cloud also uses the public cloud, there is a high risk of the security breach. Thus, it cannot be fully termed as secure but as partially secure.
- **Stringent SLAs**: As the hybrid cloud involved a public cloud intervention, the SLAs are stringent and might as per the public cloud service provider. But overall, the SLAs are more stringent than the private cloud.
- **Complex cloud management**: Cloud management is complex and is a difficult task in the hybrid cloud as it involves more than one type of deployment models and also the numbers of users are high.

Suitability:

The hybrid cloud environment is suitable for

- Organizations that want the private cloud environment with the scalability of the public cloud
- Organizations that require more security than the public cloud

The hybrid cloud is not suitable for

- Organizations that consider security as a prime objective
- Organizations that will not be able to handle hybrid cloud management

Advantages:

- It gives the power of both the private and public clouds.
- It is highly scalable.
- It provides better security than the public cloud.

Disadvantages:

- The security features are not as good as the public cloud.
- Managing a hybrid cloud is complex.
- It has stringent SLAs.

1.5. Deployment Model Justification

Based on the characteristics of the Private Cloud deployment model the **Outsourced Private Cloud** is a good model for this business case. It can be easily considered this model is the best deployment model for ATN to deploy the cloud infrastructure:

- **Efficiency**:

By deploying **Outsourced Private Cloud**, **ATN** can have a better data storage solution, where the database of each shop now got moved into the cloud, instead of storing physically at each shop. Therefore, every end-user, including each shop manager and the board director, can access the data on-time by accessing through the Internet.

The outsourced private cloud is maintained by a third-party organization where the cloud is deployed. Because of that, the **ATN company** will no longer waste time and resources in terms of maintaining and optimizing the physical infrastructure of the database.

- **Data security**:

Cyber-attacks are becoming more sophisticated and harder to defend against. It can be a virtual nightmare for any IT department, even with **ATN company**, to keep up with new malware or what new devices need to be protected in this world of the Internet of Things. An outsourced private cloud data center has the professional technical staff and computer resources from the service provider to keep the data safe from any latest security threats.

- **Financial effectiveness:**

It is a mistake to think that a DIY cloud is naturally going to be less expensive. A business typically cannot afford the cost of redundant high-bandwidth Internet carriers at their headquarters location, and effective management of those Internet feeds is highly specialized.

A reputable data center service provider will be able to deliver redundant, resilient, highly scalable, flexible Internet bandwidth for one-tenth of the cost of a DIY arrangement. For cloud applications that are inherently dependent on reliable Internet performance, this is the ultimate, logical reason to outsource cloud applications to a local, private cloud provider.

ATN company's current revenue earns 500,000$ profit per year. With this large amount of budget, it is worth it for the company to invest and deploy the entire system into an outsourced private cloud.

In conclusion, **Outsourced Private Cloud** is the most suitable deployment model for **ATN** to improve the current working system into a far advance and efficient system.

2. The compare service models for choosing an adequate model

Cloud computing is a model that enables the end-users to access the shared pool of resources such as compute, network, storage, database, and application as an on-demand service without the need to buy or own it. The services are provided and managed by the service provider, reducing the management effort from the end-user side. The essential characteristics of the cloud include on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. The National Institute of Standards and Technology (NIST) defines three basic service models, namely, IaaS, PaaS, and SaaS.

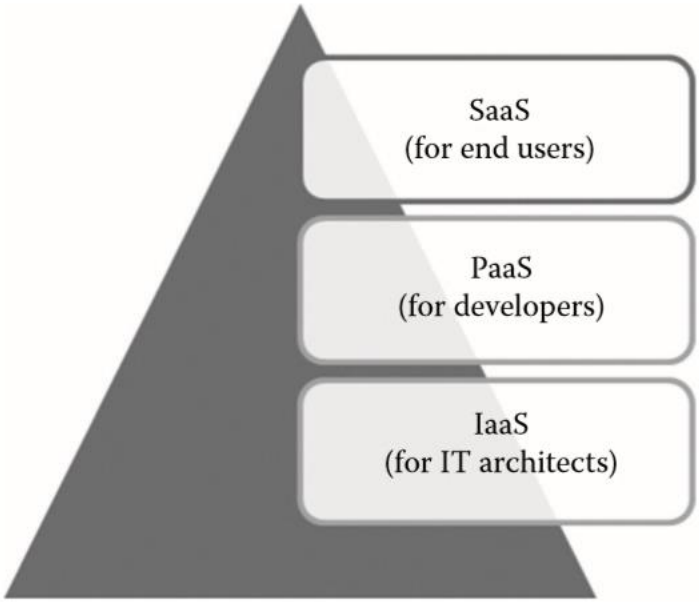


Figure 9. The basic cloud service models

- **IaaS**: The ability given to the infrastructure architects to deploy or run any software on the computing resources provided by the service provider. Here, the underlying infrastructures such as compute, network, and storage are managed by the service provider. Thus, the infrastructure architects are exempted from maintaining the data center or underlying infrastructure. The end-users are responsible for managing applications that are running on top of the service provider cloud infrastructure. Generally, the IaaS services are provided from the service provider cloud data center. The end users can access the services from their devices through the web command-line interface (CLI) or application programming interfaces (APIs) provided by the service providers.

Some of the popular IaaS providers include Amazon Web Services (AWS), Google Compute Engine, OpenStack, and Eucalyptus

- **PaaS:** The ability given to developers to develop and deploy an application on the development platform provided by the service provider. Thus, the developers are exempted from managing the development platform and underlying infrastructure. Here, the developers are responsible for managing the deployed application and configuring the development environment. Generally, PaaS services are provided by the service provider on an on-premise or dedicated or hosted cloud infrastructure. The developers can access the development platform over the Internet through web CLI, web user interface (UI), and integrated development environments (IDEs).

Some of the popular PaaS providers include Google App Engine, Force.com, Red Hat OpenShift, Heroku, and Engine Yard

- **SaaS**: The ability given to the end-users to access an application over the Internet that is hosted and managed by the service provider. Thus, the end-users are exempted from managing or controlling an application, the development platform, and the underlying infrastructure. Generally, SaaS services are hosted in a service provider– managed or service provider-hosted cloud infrastructure. The end users can access the services from any thin clients or web browsers.

Some of the popular SaaS providers include Saleforce.com, Google Apps, and Microsoft office 365.

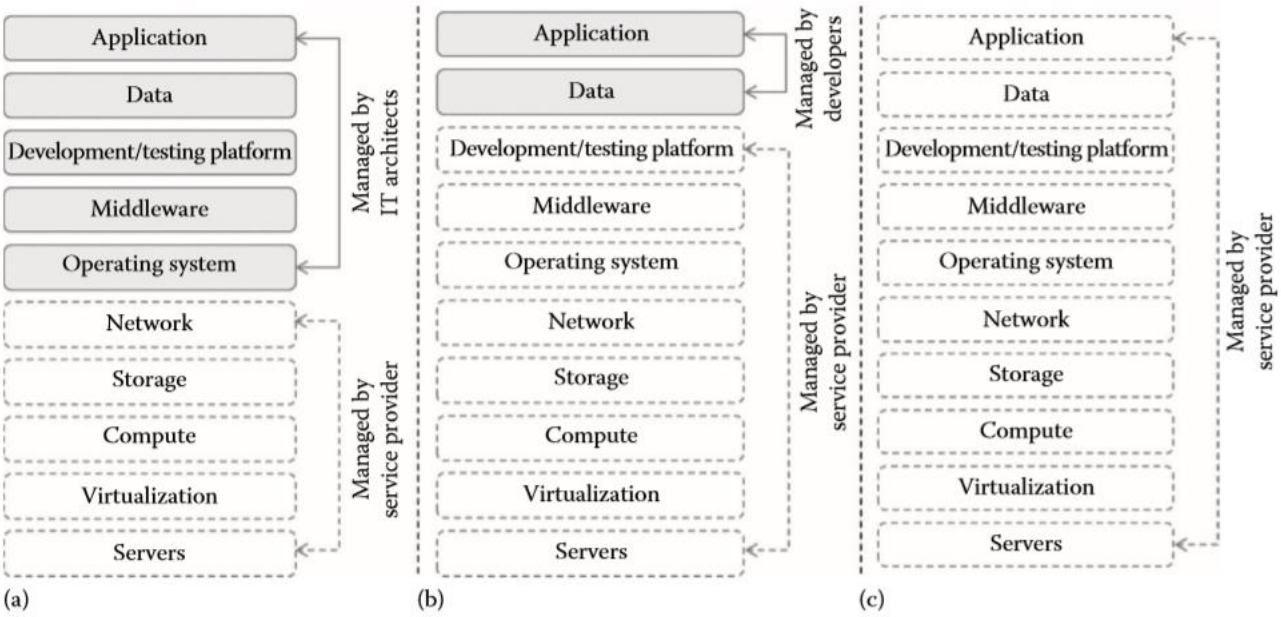


Figure 10. User and service provider responsibilities of cloud service models: (a) IaaS, (b) PaaS, and (c) SaaS

Attributes	Infrastructure as a Service (IaaS)	Platform as a Service (PaaS)	Software as a Service (SaaS)
Service providers	IBM, Amazon Web Services (AWS), Google Cloud Platforms, Microsoft Azure	Microsoft Azure, Red Hat OpenShift	Google Docs, Microsoft Office 365, Salesforce
Application management	By IT architects	By developers	By the service provider
Data management	By IT architects	By developers	By the service provider
Development & testing platform management	By IT architects	By the service provider	By the service provider
Middleware & operating system management	By IT architects	By the service provider	By the service provider
Intended user	Large business company/ enterprise system manager	Developers and deployers	Business user
Visibility	Network architects	Application developers	End users
Advantages	- Spin up virtual machines - Install operating systems - Deploy middleware - Create storage buckets and backups for workloads - Eliminate the upfront cost of managing and setting up an on-site data center - Maintaining direct access to the server	- Lower software maintenance costs - Reduce coding time - Multiplatform development - Analytics and business intelligence - Microservices and APIs	- Zero installation and maintenance costs - Pay-per-use pricing - Web accessibility - Enterprise-grade software - Remote access
Disadvantages and risks	Business efficiency and productivity largely depend on the vendor's capabilities. Potentially greater long-term costs	Data security needs to be considered and scrutinized, as information is stored off-site. Not every part of the company's existing infrastructure may be built for the cloud	Loss of control in terms of software applications Limited range of applications Connectivity requirement Performance sometimes may get a slower speed

Table 1. Compare 03 service models (IaaS, PaaS, SaaS)

After comparing all Cloud service models, Platform as a Service PaaS becomes the most appropriate model for ANT company to deploy

PasS can be used in ANT company because:

- Programming languages: PaaS providers provide a wide variety of programming languages for developers to develop applications. Some of the popular programming languages provided by PaaS vendors are Java, Perl, PHP, Python, Ruby, Scala, Clojure, and Go.
- Application frameworks: PaaS vendors provide application frameworks that simplify application development. Some of the popular application development frameworks provided by a PaaS provider include Node.js, Rails, Drupal, Joomla, WordPress, Django, EE6, Spring, Play, Sinatra, Rack, and Zend.
- Database: Since every application needs to communicate with the databases, it becomes a must-have tool for every application. PaaS providers are providing databases also with their PaaS platforms. The popular databases provided by the popular PaaS vendors are ClearDB, PostgreSQL, Cloudant, Membase, MongoDB, and Redis.
- Other tools: PaaS providers provide all the tools that are required to develop, test, and deploy an application.
- Collaborative development: To increase the time to market and development efficiency, there is a need for a common place where the development team and other stakeholders of the application can collaborate. Since PaaS services provide a collaborative development environment, it is a suitable option for applications that need collaboration among developers and other third parties to carry out the development process.
- Automated testing and deployment: Automated testing and building of an application are very useful while developing applications in a very short time frame. Automated testing tools reduce the time spent on manual testing tools. Most of the PaaS services offer automated testing and deployment capabilities. The development team needs to concentrate more on development rather than testing and deployment. Thus, PaaS services are the best option where there is a need for automated testing and deployment of the applications.
- Time to market: The PaaS services follow the iterative and incremental development methodologies that ensure that the application is in the market as per the time frame given. For example, PaaS services are the best option for application development that uses agile development methodologies. If the software vendor wants their application to be in the market as soon as possible, then the PaaS services are the best option for the development.

With the company's yearly revenue of **$500,000**, this amount of profit is not reason enough for the company to deploy the **IaaS model**, which that requires much time and budget to configure unnecessarily (compared to the company’s context) modules.

By deploying **PaaS**, ANT company can get to focus on the developments that will drive business results, which are the User interface (UI) and User Experience (UX) of the company’s management website, instead of also putting resources into deployment and maintaining the servers as in IaaS.

Therefore, **ATN** company can reduce not only the budget investing into the development of cloud infrastructure, but also reduce the time and human resources, since server maintenance and security methods are all got taken care of by the service provider.

3. Deployment models in a real-world example

3.1.Google

Google is one of the leading cloud providers that offer secure storage of user's data. It provides a cloud platform, app engine, cloud print, cloud connect, and many more features that are scalable, reliable, as well as secure. Google offers many of these services for free or at a minimum cost making it user friendly.

- **Cloud Platform**:

Google Cloud Platform enables developers to build, test, and deploy applications on Google's highly scalable and reliable infrastructure. Google has one of the largest and most advanced networks across the globe. Software infrastructures such as MapReduce, Bigtable, and Dremel are the innovations for industrial development.

Google Cloud Platform includes virtual machines, block storage, NoSQL datastore, and big data analytics. It provides a range of storage services that allow easy maintenance and quick access to user's data. The cloud platform offers a fully managed platform as well as flexible virtual machines allowing the user to choose as per the requirements. Google also provides easy integration of user's applications within the cloud platform.

- **Cloud Storage**

Google Cloud Storage is a RESTful online file storage web service for storing and accessing one's data on Google's infrastructure. Representational state transfer (REST) is an architectural style consisting of a coordinated set of architectural constraints applied to components, connectors, and data elements within a distributed system. The service combines the performance and scalability of Google's cloud with advanced security and sharing capabilities. Google Cloud Storage is safe and secure. Data are protected through redundant storage at multiple physical locations.

- **Google Cloud Connect**:

Google Cloud Connect is a feature provided by Google Cloud by integrating cloud and the application programming interface (API) for Microsoft Office. After installing a plug-in for the Microsoft Office suite of programs, one can save files to the cloud. The cloud copy of the file becomes the master document that everyone uses. Google Cloud Connect assigns each file a unique URL that can be shared to let others view the document.

When the user uploads a document to Google Cloud Connect, the service inserts some metadata into the file. Metadata is information about other information. In this case, the metadata identifies the file so that changes will track across all copies. The back end is similar to the Google File System and relies on the Google Docs infrastructure. As the documents sync to the master file, Google Cloud Connect sends the updated data out to all downloaded copies of the document using the metadata to guide updates to the right files.

- **Google App Engine:**

Google App Engine lets the user run web applications on Google's infrastructure. App Engine applications are easy to build, easy to maintain, and easy to scale as traffic and data storage needs grow. With App Engine, there are no servers to maintain: Just upload the application, and it is ready to serve users.

With App Engine also, the user has to only pay for what he or she uses. There are no setup costs and no recurring fees. The resources used by the application such as storage and bandwidth are measured in gigabytes and billed at competitive rates. One has to control the maximum amount of resources one's app can consume, so it always stays within one's budget.

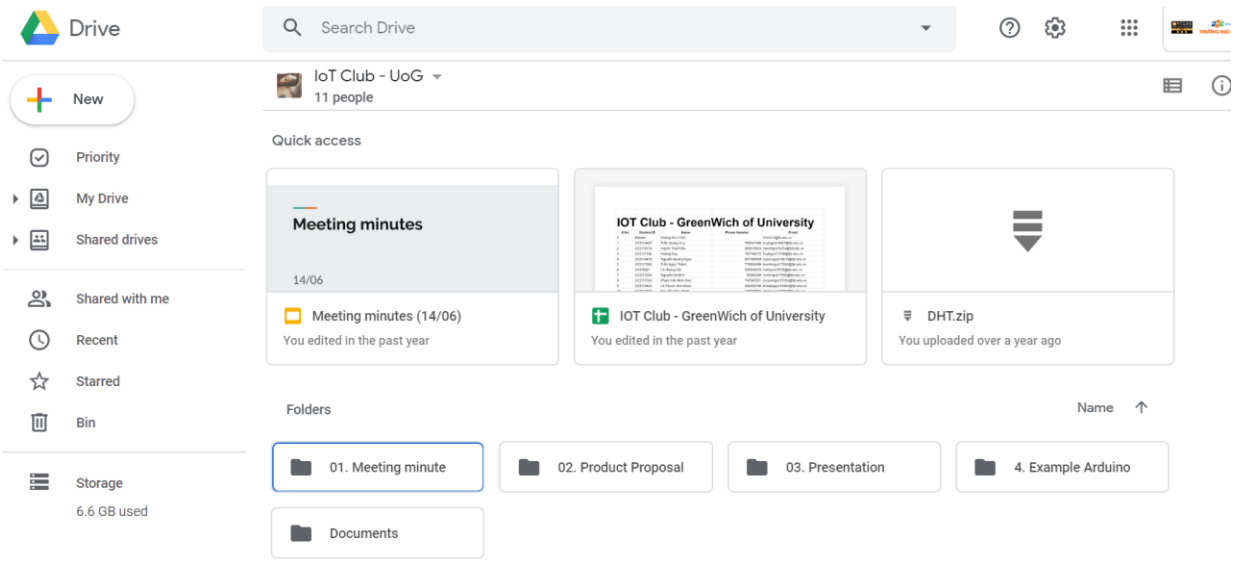
App Engine costs nothing to get started. All applications can use up to 1 GB of storage and enough CPU and bandwidth to support an efficient app serving around five million-page views a month, absolutely free. When billing is enabled for the application, free limits are raised, and one has to only pay for resources one uses above the free levels.

Google Drive in a real-life example:

Picture 8. Google Drive

- **Sharing**: Google Drive incorporates a system of file sharing where the user controls the public visibility file or folder. Recall that file ownership is transferable. The file can be shared with other Google users using Google account (email address). File and folders can be found and accessed by the public provided it is made available on the web.
- **File viewing**: Google drive allows different file formats to be viewed on the web. Such as image files (JPEG, PNG, GIF, and TIPP), Audio formats (MP4, MP4, and WAV), video files (WEBM, .MPEG4, .WMV), text files (TXT).
- **Third-party apps**: Chrome web store made some external applications available for Google drive. For a user to be able to use this feature he or she has to sign up into a chrome web store which is supported by a web browser.
- **Storage**: Google drive comes with free 15GB free space. This is shared with another Google cloud storage service such as email and google photos but Google sheets, docs, and slides are exempted from the storage limit.

- IoT Club (University of Greenwich) Using Google Drive to share and store the document.



Picture 9. Using google drive to store club data

- **eBay** is also now exporting 1B+ items in their live catalog to Google Cloud Platform. See a full list of case studies and companies utilizing different services on Google Cloud Platform. (kinsta, n.d.)
- **PayPal** is enabling new markets with a purpose: Helping people everywhere join the global economy with financial services that are simple, convenient and secure. By leveraging the power of Google Cloud, they are serving more than 300 million customers and developing online, mobile, and in-store services across 200 markets, in 100 currencies intending to serve a billion users daily.

  Mobile Payments. Credit. Remittances. Working capital. Card processing. PayPal is creating economic opportunities that are personal, flexible, and support compliance with regulations. Google Cloud is helping to make that a reality.

  Faster developer environment setup. Container-based workloads deployed in seconds. Transactions near the source that align with local regulations. Unsurpassed network security, layers of encryption and next-generation fraud detection. Data analysis that adds value and steers product creation. All on Google Cloud.

  Over the past three years, PayPal has moved mission-critical workloads to Google Cloud. The new PayPal will be hybrid and multi-cloud, unifying disparate providers, locations, and capabilities for shared future success.

3.2.Amazon Web Services

Amazon Web Services (AWS) is a collection of remote computing services (also called web services) that together make up a cloud computing platform, offered over the Internet by Amazon.com. The most central and well known of these services are Amazon Elastic Compute Cloud (Amazon EC2), Amazon Simple Queue Service (Amazon SQS).

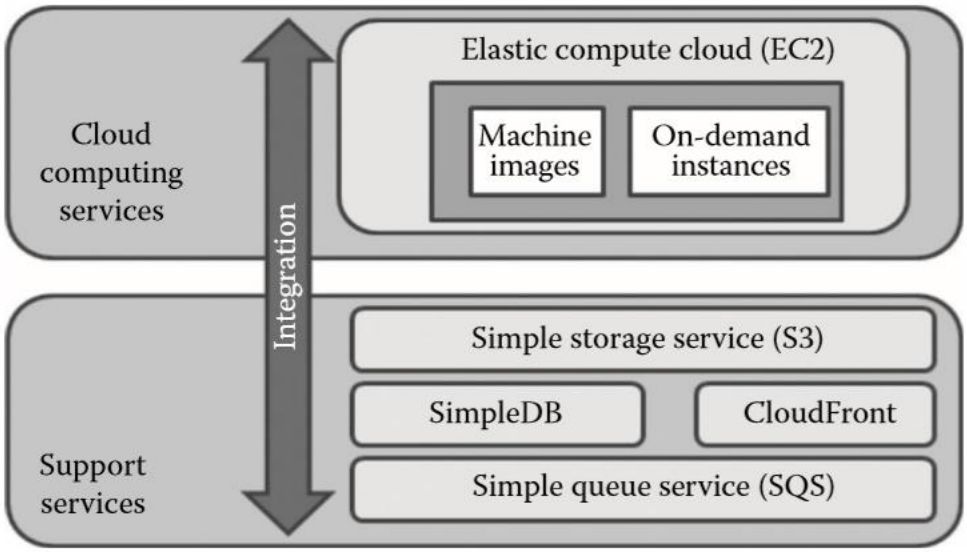


Figure 11. AWS

Amazon EC2 is a computing service, whereas Amazon SQS and Amazon S3 are support services. The service is advertised as providing a large computing capacity (potentially many servers) much faster and cheaper than building a physical server farm. Amazon's data center is located at Ashburn, Virginia, Dallas/Fort Worth, Los Angeles, Miami, Newark, New Jersey, Palo, Alto, California, Seattle, St. Louis, Amsterdam, Dublin, Frankfurt, London, Hong Kong, Singapore, Tokyo, etc.

- **Amazon Elastic Compute Cloud:**

Amazon EC2 is an IaaS offered by AWS and is the leading provider of IaaS in the current market. Powered by a huge infrastructure that the company has built to run its retail business, Amazon EC2 provides a true virtual computing environment. By providing a variety of virtual machine or instance types, operating systems, and software packages to choose from, Amazon EC2 enables the user to instantiate virtual machines of his choice through a web service interface. The user can change the capacity and characteristics of the virtual machine by using the web service interfaces, hence named elastic. Computing capacity is provided in the form of virtual machines or server instances by booting Amazon Machine Images (AMI), which can be instantiated by the user. An AMI contains all the necessary information needed to create an instance. The primary Graphical User Interface (GUI) interface is the AWS Management Console (point and click) and a web service API that supports both the Simple Object Access Protocol and Query Requests. The API provides programming libraries and resources for Java, PHP, Python, Ruby, Windows, and .Net. The infrastructure is virtualized by using Xen hypervisor, and different instance types are provided as follows:

- Standard instances: Suitable for most applications
- Micro instances: Suitable for low-throughput applications
- High-memory instances: Suitable for high-throughput applications
- High-CPU instances: Suitable for compute-intensive applications
- Cluster compute instances: Suitable for high-performance computing (HPC) applications

The instances can be obtained on demand on an hourly basis, thus eliminating the need for forecasting computing needs earlier. Instances can be reserved earlier, and a discounted rate is charged for such instances. Users can also bid on unused Amazon EC2 computing capacity and obtain instances. Such instances are called as Spot Instances. Those bids that exceed the current Spot Price is provided with the instance, which allows the user to reduce costs. The Spot Price is varying and is decided by the company.

An instance is stored as long as it is operational and is removed on termination. Persistent storage can be enabled by using either Elastic Block Storage (EBS) or Amazon Simple Storage Service (S3). EBS provides a highly reliable and secure storage, and the storage volumes can be used to boot an Amazon EC2 instance or be attached to an instance as a standard block device. Amazon S3 provides a highly durable storage infrastructure designed for mission-critical and primary data storage. Storage is based on units called objects whose size can vary from one byte to five gigabytes of data. These objects are stored in a bucket and retrieved via a unique, developer-assigned key.

It is accessible through a web service interface and provides authentication procedures to protect against unauthorized access.

- **Amazon Simple Storage Service:**

Amazon Simple Storage Service known as Amazon S3 is the storage for the Internet. It is designed to make web-scale computing easier for developers. Amazon S3 provides a simple web service interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web. It gives any developer access to the same highly scalable, reliable, secure, fast, inexpensive infrastructure that Amazon uses to run its global network of websites. The service aims to maximize benefits of scale and to pass those benefits on to developers.

Along with its simplicity, it also takes care of other features like security, scalability, reliability, performance, and cost. Thus, Amazon S3 is a highly scalable, reliable, inexpensive, fast, and also easy to use service that meets design requirements and expectations.

Amazon S3 offers a scalable, secure, and highly durable solution for backup and archiving critical data. For data of significant size, the AWS Import/ Export feature can be used to move large amounts of data into and out of AWS with physical storage devices. This is ideal for moving large quantities of data for periodic backups, or quickly retrieving data for disaster recovery scenarios. Another feature offered by Amazon S3 is its Static Website Hosting, which is ideal for websites with static content, including HTML files, images, videos, and client-side scripts such as JavaScript.

- **Amazon Simple Queue Service:**

Another service of AWS is Amazon SQS. It is a fast, reliable, scalable, fully managed message queuing service. SQS makes it simple and cost-effective to decouple the components of a cloud application. SQS can be used to transmit any volume of data, at any level of throughput, without losing messages or requiring other services to be always available.

Amazon SQS is a distributed queue system that enables web service applications to quickly and reliably queue messages that one component in the application generates to be consumed by another component. A queue is a temporary repository for messages that are waiting to be processed.

Amazon SQS offers various features like allowing multiple readers and writers at the same time, providing access control facilities, guaranteeing high availability of sending, and retrieving messages due to redundant infrastructure. It also gives provision for having variable-length messages as well as configurable settings for each queue.

AWS in a real-life example:

- **Netflix**

Among enterprises, Netflix was the most prominent early user of AWS, adopting it in 2009. (contino, n.d.)

According to an article in Business Insider from January 2016, **Netflix** placed enormous demands on the resources available to AWS at the time, often pushing the service to its limits and beyond. The ongoing pressure from Netflix, combined with Amazon's willingness to improve its service and meet its customers' requirements, pushed AWS to develop into the full, enterprise-scale integrated set of services that it is today.

By mid-2015, Netflix had gone 'all-in', closing the last of its major data center and moving all of its IT operations to AWS. Other enterprises have also gone all-in with AWS, including Intuit, Hertz, and Time, Inc. These companies have demonstrated their willingness to trust AWS with their entire IT operations, including transactions, customer databases, and the rest of the information infrastructure on which they depend. This level of commitment and trust on the part of long-established (and often very conservative) enterprises speaks volumes about the ability of AWS to meet the needs of enterprise-level clients.

According to Amazon, Netflix uses more than 100,000 server instances on AWS for "nearly all its computing and storage needs.'' This includes databases, analytics, recommendation engines, and video transcoding.

- **GoPro Reduces Compute Footprint by 70% Using Amazon ECS:**

Picture 10. GoPro Logo

GoPro makes versatile cameras that help people capture and share their meaningful experiences. Whether handheld or mounted to drones, helmets, or other gear, GoPro hardware makes it easy to take photos and videos indoors and out, in motion or at rest, and even underwater. Customers who subscribe to GoPro Plus—the company's cloud-based video service—can also upload, edit, and store their videos easily. (amazon, amazon, n.d.)

GoPro runs its entire cloud-based IT infrastructure on Amazon Web Services (AWS), serving hundreds of millions of API requests daily and storing multiple petabytes of data. Its architecture uses a loosely coupled microservices approach. For GoPro Plus, functions such as identity management, user-profile updates, and media processing are handled by independent microservices that communicate with but do not rely on one other.

Initially, the company was running each GoPro Plus microservice using virtual machines on a single Amazon Elastic Compute Cloud (Amazon EC2) Auto Scaling group. It used Iron.io to manage worker queueing, batch jobs, and short-running instances. Although this approach worked reasonably well, it did not utilize server capacity as efficiently as possible. Managing individual Auto Scaling groups was complex for GoPro's DevOps team, and working with a third-party vendor slowed down the team's ability to make changes and innovate. The company wanted a solution that would simplify management and deployment, increase development agility, and use resources more efficiently.

GoPro decided to adopt a container-based approach to achieve these goals. The company considered several container-orchestration technologies—including the Kubernetes open-source platform—before choosing Amazon Elastic Container Service (Amazon ECS). Seamlessly integrating with other AWS services that GoPro already uses, Amazon ECS provides the detailed security permissions, monitoring, and metrics GoPro requires. The familiar development environment also made for a minimal learning curve.

All GoPro Plus worker processes now run in Docker containers managed by Amazon ECS, and the company uses Amazon Simple Queue Service (Amazon SQS) to handle the process queue. Microservices publish events using Amazon Simple Notification Service (Amazon SNS), which can then be consumed by other microservices as needed. This loose coupling provides additional orchestration flexibility because it removes the failure points that exist when microservices need to communicate with one another directly.

Using Amazon ECS has enabled GoPro to greatly increase resource utilization. "We just set parameters such as CPU and memory requirements for each service, and then leave it up to Amazon ECS to place individual containers on the cluster," says Zaven Boni, DevOps engineering lead at GoPro. "We have been able to reduce our Amazon EC2 footprint of 60 c4.2xlarge instances by 70 percent, and we are no longer paying third-party licensing fees."

Using Docker containers managed by Amazon ECS allows the GoPro DevOps team to take an infrastructure-as-code approach, making management and deployment transparent, seamless, and fast. "Our previous solution was a bit of a black box," says Boni. "The old model had a lot of homegrown code involved, as well as code from Iron.io. By taking advantage of Amazon ECS, all aspects of deployment, networking, and orchestration are standardized and visible to us as code, so we have the power to understand, manipulate, and manage our environment easily."

3.3.Microsoft

Cloud computing provides a new way of looking at IT at Microsoft called Microsoft IT (MSIT). Cloud computing is now the preferred and default environment for new and migrated applications at Microsoft. MSIT has developed a methodology and a set of best practices for analyzing its current application portfolio for possible candidates to migrate to cloud computing. This analysis enables MSIT to select the ideal cloud computing-based environment for each application. MSIT has captured these best practices and documented them for other Microsoft customers who wish to migrate their organizations to cloud computing.

- **Windows Azure:**

Windows Azure Cloud Services (web and worker roles/PaaS) allow developers to easily deploy and manage application services. It delegates the management of underlying role instances and operating system to the Windows Azure platform.

The Migration Assessment Tool (MAT) for Windows Azure encapsulates all the information to be aware of before attempting the application migration to Windows Azure. Based on the response to a series of simple binary questions, the tool generates a report that outlines the amount of development effort involved to migrate the application or the architecture considerations for a new application.

The Windows Azure Pricing Calculator analyses an application's potential public cloud requirements against the cost of the application's existing infrastructure. This tool can help to compare current operational costs for an application, against what the operating costs would be on Windows Azure and SQL Azure.

Windows Azure Pack for Windows Server is a collection of Windows Azure technologies available to Microsoft customers at no additional cost for installation into their data center. It runs on top of Windows Server 2012 R2 and System Center 2012 R2 and, through the use of the Windows Azure technologies, it allows the customer to offer a rich, self-service, multi-tenant cloud, consistent with the public Windows Azure experience.

Microsoft Assessment and Planning Toolkit:

The Microsoft Assessment and Planning Toolkit (MAP) is an agentless, automated, multiproduct planning and assessment tool for cloud migration. MAP provides detailed readiness assessment reports, executive proposals, and hardware and software information. It also provides recommendations to help organizations accelerate the application migration process for both private and public cloud planning assessments. MAP analyzes server utilization data for server virtualization and also server consolidation with Hyper-V.

- **SharePoint:**

Microsoft offers its online collaboration tool called SharePoint. Microsoft SharePoint is a web application platform that comprises a multipurpose set of web technologies backed by a common technical infrastructure. By default, SharePoint has a Microsoft Office-like interface, and it is closely integrated with the Office suite. The web tools are designed to be usable by nontechnical users. SharePoint can be used to provide intranet portals, document and file management, collaboration, social networks, extranets, websites, enterprise search, and business intelligence. It also has system integration, process integration, and workflow automation capabilities. Unlike Google Cloud Connect, Microsoft SharePoint is not a free tool. But it has additional features that cannot be matched by Google or any other company.

Microsoft in a real-life example:

- **Machine translation speaks Volkswagen – in 40 languages**

Picture 11. Volkswagen logo

The Volkswagen Group serves customers all over the world and delivers a huge range of documents in more than 40 languages. Up to a billion words must be translated within the Group every year, and the volume is rising sharply. New communication streams as a result of digitalization and new demands regarding translation turnaround times ideally in real-time meaning that existing translation systems need to be enhanced and expanded. Volkswagen has turned to the Azure cloud, which offers a faster, more precise, and more cost-effective solution, and one that also has better learning capabilities. (customers.microsoft.com/, n.d.)

There are several advantages to the cloud solution. First, VW wants to replace the language combinations offered through the internal portal and have them translated by the cloud solution. And, unlike the previous portal, the cloud solution is accessible by smartphone a practical advantage for VW employees. Second, the cloud is connected to the systems used by human translators. Finally, the cloud streamlines processes by making the updates to translation memories available through uploads through the web interface. Previously, a service provider was needed to handle this task.

The basis for this, in addition to Azure translation functions, will include other Azure services such as Data Lake, Machine Learning, Databricks, Stream Analytics, SQL Database, and Microsoft Power BI.

3.4.IBM

IBM is one of the players in the field of cloud computing offering various cloud services to consumers. IBM cloud computing consists of cloud computing solutions for enterprises as offered by the global IT company IBM. All offerings are designed for business use, marketed under the name IBM Smart Cloud. IBM cloud includes IaaS, SaaS, and PaaS offered through public, private, and hybrid cloud delivery models, in addition to the components that make up those clouds. IBM offers an entry point to cloud computing whether a client is designing their virtual private cloud, deploying cloud service, or consuming cloud workload applications. The IBM cloud framework begins with the physical hardware of the cloud. IBM offers three hardware platforms for cloud computing, which offer built-in support for virtualization. The next layer of the IBM framework is virtualization. IBM offers IBM WebSphere application infrastructure solutions that support programming models and open standards for virtualization.

The management layer of the IBM cloud framework includes IBM Tivoli middleware. Management tools provide capabilities to regulate images with automated provisioning and de-provisioning, monitor operations, and meter usage while tracking costs and allocating billing. The last layer of the framework provides integrated workload tools. Workloads for cloud computing are services or instances of code that can be executed to meet specific business needs. IBM offers tools for cloud-based collaboration, development and test, application development, analytics, business-to-business integration, and security.

- **Cloud Models:**

IBM offers a spectrum of cloud delivery options ranging from solely private cloud to solely public cloud and numerous variations in between. IBM gives the option to build a customized cloud solution out of a combination of public cloud and private cloud elements. Companies that prefer to keep all data and processes behind their firewall can choose a private cloud solution managed by their own IT staff. A company may also choose pay-as-you-go pricing that allows them to run lower-profile applications on a secure public cloud model. Hybrid cloud options allow for some processes to be hosted and managed by IBM, while others are kept on a private cloud or a VPN or Virtual Local Area Network. IBM also offers planning and consultation throughout the deployment process. Cloud computing is the best choice for mobile software. IBM offers five different cloud provision models:

- Private cloud, owned and operated by the customer
- Private cloud, owned by the customer but operated by IBM (or another provider)
- Private cloud, owned and operated by IBM (or another provider)
- Virtual private cloud services, based on multitenant support for individual enterprises
- Public cloud services, based on the provision of functions to individuals

For building strictly private clouds, IBM offers IBM Workload Deployer and Cloudburst as ready-to-deploy, cloud in a box–style solutions. Cloudburst provides blade servers, middleware, and virtualization for an enterprise to build its cloud-ready virtual machines. Workload Deployer connects an enterprise's existing servers to virtualization components and middleware to help deploy standardized virtual machines designed by IBM. For customers who prefer to perform their integration of private clouds, IBM offers a choice of hardware and software building blocks, along with recommendations and reference architecture, leading the way to deployment. Clients may choose from IBM virtualization–enabled servers, middleware, and SaaS applications.

- **IBM SmartCloud:**

IBM SmartCloud is a branded ecosystem of cloud computing products and solutions from IBM. It includes IaaS, SaaS, and PaaS offered through public, private, and hybrid cloud delivery models. IBM places these offerings under three umbrellas: SmartCloud Foundation, SmartCloud Services, and SmartCloud Solutions.

SmartCloud Foundation consists of the infrastructure, hardware, provisioning, management, integration, and security that serve as the underpinnings of a private or hybrid cloud. Built using those foundational components, PaaS, IaaS, and backup services makeup SmartCloud Services. Running on this cloud platform and infrastructure, SmartCloud Solutions consists of some collaboration, analytics, and marketing SaaS applications.

Along with **IaaS**, **PaaS**, and **SaaS**, IBM also offers Business Process as a Service (BPaaS). Infrastructure cloud services provide the consumer with the provision of processing, storage, networks, and other fundamental computing resources where the consumer can deploy and run arbitrary software, which can include operating systems and applications. In platform cloud services, a consumer can deploy consumer-created or consumer-acquired applications onto the cloud infrastructure created using programming languages and tools supported by the provider. Application cloud services allow consumers to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based e-mail). Business process cloud services are any business process (horizontal or vertical) delivered through the cloud service model (multitenant, self-service provisioning, elastic scaling, and usage metering or pricing) via the Internet with access via web-centric interfaces and exploiting web-oriented cloud architecture. The BPaaS provider is responsible for the related business functions.

IBM in a real-life example:

- **American Airlines:**

Picture 12. American Airlines with IBM

To become more responsive to customer needs, American Airlines needed a new technology platform and a new approach to development that would help it deliver digital self-service tools and customer value more rapidly across its enterprise. IBM is helping the airline migrate some of its critical applications to the IBM Cloud while using new methodologies to create innovative applications quickly while improving the customer experience. (ibm, n.d.)

Working with IBM to migrate some of their key legacy customer-facing applications to VMware HCX on IBM Cloud, while simultaneously transforming them to a cloud-native based microservices architecture is enabling the world's largest airline to innovate faster in response to changing customer needs.

In the highly competitive airline industry, customer experience is a major point of differentiation – and digital channels are increasingly important.

American Airlines wanted to provide convenient digital services for customers and understood there was an opportunity to remove the constraints of the existing legacy architecture, platform, organization, development, and operations approach. Customer-facing applications were based on monolithic code, duplicated and managed in silos. Every change required the same work in up to three places, each managed by different teams.

To respond better and faster to customer needs, American Airlines needed to transform the way they worked to take advantage of new technology features. There was a need to update its technology stack, further increase agility, and introduce DevOps concepts while leveraging an open and flexible cloud platform.

Migrate: IBM's comprehensive proposal addressed American's immediate and long-term operational concerns through a seamless migration of on-premise servers to IBM Cloud's Infrastructure as a Service with VMware Cloud Foundation solution.

Transform: IBM also proposed to accelerate the transformation of American's application development, organization, and skills, based on its IBM Garage Method. As IBM and American jointly developed the new cloud-native apps in Cloud Foundry on IBM Public Cloud Platform as a Service, the old components would be retired.

Operate: The solution brings operations into the development squads and leverages IBM's Cloud Solutions Operations Center to provide 24-hour application support and management services, with the IBM team located both onsite at American's location and an IBM off-shore location.

Solution components for American Airline:

- Cloud Services - IBM CLD for VMWare (Cloud BU)
- IBM Cloud Virtual Servers
- IBM Garage
- Public Cloud IaaS
- Watson & Cloud Platform

The Tools to realize a Cloud Computing solution

1. Deployment frameworks and services

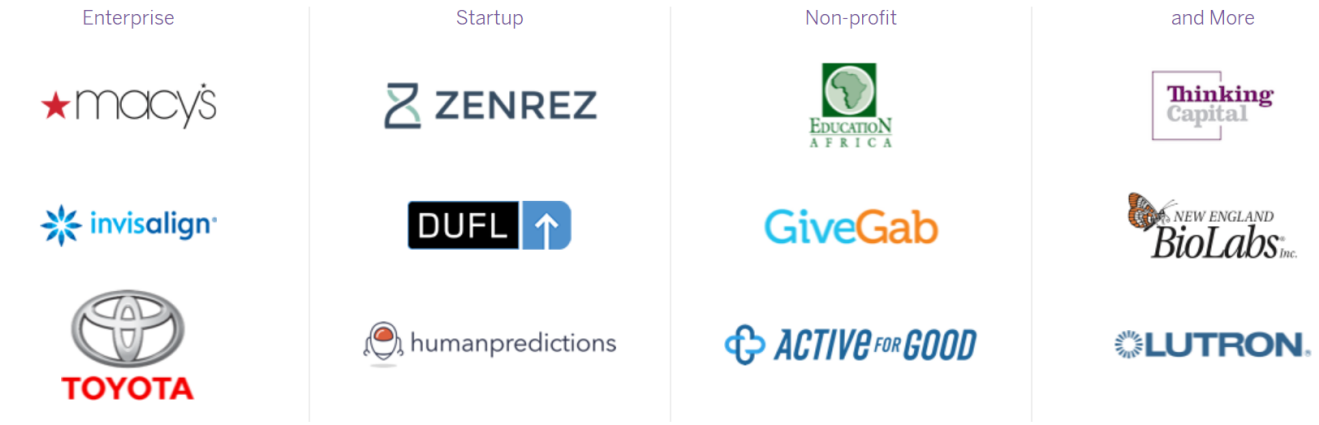
The Heroku platform

Picture 13. Heroku logo

Heroku is a platform as a service based on a managed container system, with integrated data services and a powerful ecosystem, for deploying and running modern apps. The Heroku developer experience is an app-centric approach for software delivery, integrated with today's most popular developer tools and workflows.

- **Heroku Runtime**: Heroku runs apps inside dynos smart containers on a reliable, fully managed runtime environment. Developers deploy their code written in Node, Ruby, Java, PHP, Python, Go, Scala, or Clojure to a build system that produces an app that's ready for execution. The system and language stacks are monitored, patched, and upgraded, so it's always ready and up-to-date. The runtime keeps apps running without any manual intervention.
- **Heroku Developer Experience (DX):** The Heroku Developer Experience is an app-centric approach to software delivery so developers can focus on creating and continuously delivering applications, without being distracted by servers or infrastructure. Developers deploy directly from popular tools like Git, GitHub or Continuous Integration (CI) systems. The intuitive web-based Heroku Dashboard makes it easy to manage app and gain greater visibility into performance.
- **Heroku Operational Experience (OpEx):** The Heroku Operational Experience is a key component of the platform. It helps developers through troubleshooting and remediation of common issues and customizing their ops experience to quickly identify and address negative trends in their application health. Heroku provides a set of tools to alert users if something goes wrong, or to automatically scale web dynos if the response time for web requests exceeds a threshold user specifies. Application metrics, Threshold Alerting, and Autoscaling are some of the feature's users get access to with no extra cost.
- **Data Services and Ecosystem**: Heroku Elements let developers extend their apps with Add-ons, customize their application stack with Buildpacks and jumpstart their projects with Buttons. Add-ons are 3rd party cloud services that developers can use to immediately extend their apps with a range of functionality such as data stores, logging, monitoring and more. Heroku provides three fully-managed data service Add-ons: Heroku Postgres, Heroku Redis, and Apache Kafka on Heroku.
- **Security and Compliance**: Developers from around the world entrust sensitive data to Heroku, and nothing is more important to us than honoring our custodial commitments to protect this data. Heroku regularly performs audits and maintains PCI, HIPAA, ISO, and SOC compliance to further strengthen our trust with customers. Learn more by visiting our compliance center.

Who builds apps on Heroku?



Picture 14. Who builds apps on Heroku?

In order to develop ATN's cloud-based web application to improve the current context of the company, Heroku is the easiest cloud service provider that provides all of the best features that any Platform as a Service should have.

With Heroku, ATN's company will understand the importance of cloud computing, after that, if they want to upgrade the cloud system, AWS is the most suitable for this scenario.

Amazon Web Service (AWS)

Figure 12. AWS logo

Amazon Web Services (AWS) is a secure cloud services platform, offering to compute power, database storage, content delivery, and other functionality to help businesses scale and grow. In simple words AWS allows you to do the following things:

- Running web and application servers in the cloud to host dynamic websites.
- Securely store all your files on the cloud so you can access them from anywhere.
- Using managed databases like MySQL, PostgreSQL, Oracle or SQL Server to store information.
- Deliver static and dynamic files quickly around the world using a Content Delivery Network (CDN).
- Send bulk emails to your customers.

Basic Terminologies:

- Region: A region is a geographical area. Each region consists of 2 (or more) availability zones.
- Availability Zone: It is simply a data center.
- Edge Location: They are CDN (Content Delivery Network) endpoints for CloudFront.

Compute:

- C2 (Elastic Compute Cloud): These are just the virtual machines in the cloud on which you have the OS level control. You can run whatever you want in them.
- LightSail: If you don't have any prior experience with AWS this is for you. It automatically deploys and manages to compute, storage and networking capabilities required to run your applications.
- ECS (Elastic Container Service): It is a highly scalable container service to allows you to run Docker containers in the cloud.
- EKS (Elastic Container Service for Kubernetes) — Allows you to use Kubernetes on AWS without installing and managing the Kubernetes control plane. It is a relatively new service.
- Lambda: AWS's serverless technology that allows you to run functions in the cloud. It's a huge cost saver as you pay only when functions execute.
- Batch: It enables you to easily and efficiently run batch computing workloads of any scale on AWS using Amazon EC2 and EC2 spot fleet.
- Elastic Beanstalk: Allows automated deployment and provisioning of resources like a highly scalable production website.

Storage:

- S3 (Simple Storage Service): Storage service of AWS in which we can store objects like files, folders, images, documents, songs, etc. It cannot be used to install software, games or Operating systems.
- EFS (Elastic File System): Provides file storage for use with EC2 instances. It uses the NFSv4 protocol and can be used concurrently by thousands of instances.
- Glacier: It is an extremely low-cost archival service to store files for a long time like a few years or even decades.
- Storage Gateway: It is a virtual machine that you install on on-premise servers. On-premise data can be backed up to AWS providing more durability.

Databases:

- RDS (Relational Database Service): Allows you to run relational databases like MySQL, MariaDB, PostgreSQL, Oracle or SQL Server. These databases are fully managed by AWS like installing antivirus and patches.
- DynamoDB: It is a highly scalable, high-performance NoSQL database. It provides single-digit millisecond latency at any scale.
- Elasticache: It is a way of caching data inside the cloud. It can be used to take a load off of the database by caching the most frequent queries.
- Neptune: It has been launched recently. It is a fast, reliable and scalable graph database service.
- RedShift: It is AWS's data warehousing solution that can be used to run complex OLAP queries.

Migration:

- DMS (Database Migration Service): It can be used to migrate on-site databases to AWS. It also allows you to migrate from one type of database to another. Eg -from Oracle to MySQL.
- SMS (Server Migration Service): It allows you to migrate on-site servers to AWS easily and quickly.
- Snowball: It is a briefcase-sized appliance that can be used to send terabytes of data inside and outside of AWS.

Networking:

- VPC (Virtual Private Cloud): It is simply a data center in the cloud in which you deploy all resources. It allows you to better isolate resources and secure them.
- CloudFront -It is AWS's Content Delivery Network (CDN) that consists of Edge locations that cache resources.
- Route53: It is AWS's highly available DNS (Domain Name System) service. You can register domain names through it.
- Direct Connect: Using it you can connect the data center to an Availability zone using a high speed dedicated line.
- API Gateway: Allows you to create, store and manage APIs at scale.

Developer Tools:

- CodeStar: It is a cloud-based service for creating, managing, and working with software development projects on AWS. You can quickly develop, build, and deploy applications on AWS with an AWS CodeStar project.
- CodeCommit: It is AWS's version control service that allows you to store code and other assets privately in the cloud.
- CodeBuild: It automates the process of building (compiling) code.
- CodeDeploy: It is a way of deploying code in EC2 instances automatically.
- CodePipeline: Allows you to keep track of different steps in a deployment like building, testing, authentication, and deployment on development and production environments.
- Cloud9: It is an IDE (Integrated Development Environment) for writing, running, and debugging code in the cloud.
- X-Ray: It makes it easy for developers to analyze the behavior of their distributed applications by providing request tracing, exception collection, and profiling capabilities.

Management Tools:

- CloudWatch: It can be used to monitor AWS environments like CPU utilization of EC2 and RDS instances and trigger alarms based on different metrics.
- CloudFormation: It is a way of turning infrastructure into the cloud. You can use templates to provision a whole production environment in minutes.
- CloudTrail: A way of auditing AWS resources. It logs all changes and API calls made to AWS.
- OpsWorks: It helps in automating Chef deployments on AWS.
- Config: It monitors the environment and notifies you when you break certain configurations.
- Service Catalog: For larger enterprises, it helps to authorize which services will be used and which won't be.
- Trusted Advisor: Gives you recommendations on how to do cost optimizations, and secure environment.
- AWS Auto Scaling: Allows you to automatically scale resources up and down based on CloudWatch metrics.
- Systems Manager: Allows you to group resources, so you can quickly gain insights, identify issues and act on them.
- Managed Services: It provides ongoing management of AWS infrastructure so you can focus on applications.

ATN's shop can take months to get a building plan drawn up, submitted, and approved. The process involves multiple parties and multiple steps, often with drawn-out communication back and forth between resident and local council. With ATN's company, customers can plan and get instant approval in minutes. ATN's company will adopt the AWS Cloud using services like **Amazon Simple Storage Service** (Amazon S3) to scale the platform quickly and deliver an improved user experience. Using the cloud, ATN's company can scale and deliver services in real-time to serve all parties across the country.

Git

Picture 15. Git logo

Git is a free and open-source distributed version control system designed to handle everything from small to very large projects with speed and efficiency.

Git is easy to learn and has a tiny footprint with lightning-fast performance. It outclasses SCM tools like Subversion, CVS, Perforce, and ClearCase with features like cheap local branching, convenient staging areas, and multiple workflows.

- **Performance:** The raw performance characteristics of Git are very strong when compared to many alternatives. Committing new changes, branching, merging and comparing past versions are all optimized for performance. The algorithms implemented inside Git take advantage of deep knowledge about common attributes of real source code file trees, how they are usually modified over time and what the access patterns are.
- **Security:** Git has been designed with the integrity of managed source code as a top priority. The content of the files as well as the true relationships between files and directories, versions, tags and commits, all of these objects in the Git repository are secured with a cryptographically secure hashing algorithm called SHA1. This protects the code and the change in history against both accidental and malicious change and ensures that the history is fully traceable.

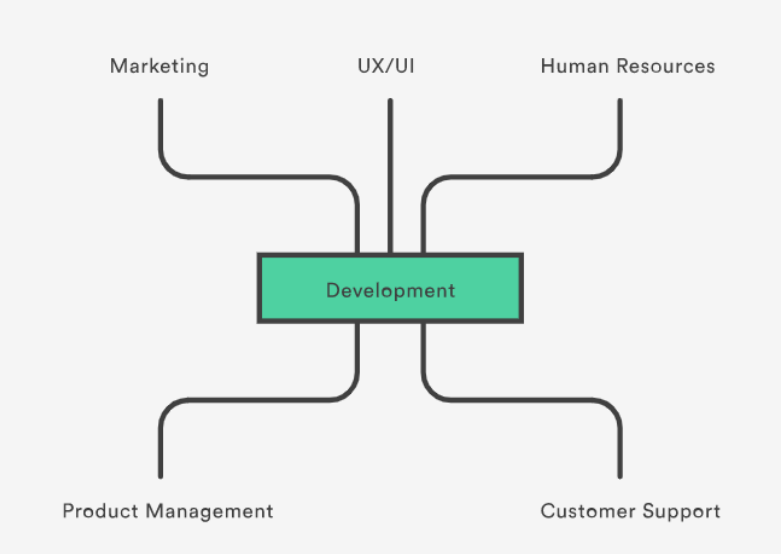
  With Git, customers can be sure that customers have an authentic content history of source code.

  Some other version control systems have no protections against secret alterations at a later date. This can be a serious information security vulnerability for any organization that relies on software development.

- **Flexibility:** One of Git's key design objectives is flexibility. Git is flexible in several respects: in support of various kinds of nonlinear development workflows, in its efficiency in both small and large projects and its compatibility with many existing systems and protocols.

  Git has been designed to support branching and tagging as first-class citizens (unlike SVN) and operations that affect branches and tags (such as merging or reverting) are also stored as part of the change history. Not all version control systems feature this level of tracking.

- **Git for the organization:** Switching from a centralized version control system to Git changes the way the development team creates software. And, if you're a company that relies on its software for mission-critical applications, altering development workflow impacts the entire business.



Picture 16. Git for organization

Companies & Projects Using Git:

Picture 17. Companies & Projects using Git

In the development of ATN's cloud-based web application, after choosing Heroku as the PaaS provider, Git should be used in order to deploy to Heroku.

2. Database infrastructure development

mongoDB

Picture 18. mongoDB logo

MongoDB is a general-purpose, document-based, distributed database built for modern application developers and the cloud era. No database makes users more productive, which means it stores data in JSON-like documents. We believe this is the most natural way to think about data and is much more expressive and powerful than the traditional row/column model.

Rich JSON Documents:

- The most natural and productive way to work with data.
- Supports arrays and nested objects as values.
- It allows for flexible and dynamic schemas.

Picture 19. JSON Documents

Powerful query language:

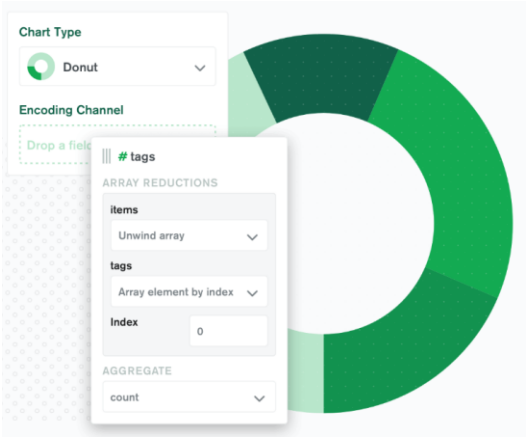
- Rich and expressive query language that allows users to filter and sort by any field, no matter how nested it may be within a document.
- Support for aggregations and other modern use-cases such as geo-based search, graph search, and text search.
- Queries are themselves JSON, and thus easily composable. No more concatenating strings to dynamically generate SQL queries.

Picture 20. Powerful query language

More than just a database:

MongoDB is a true data platform with a comprehensive suite of tools to make working with data remarkably easy for everyone, from developers to analysts to data scientists.

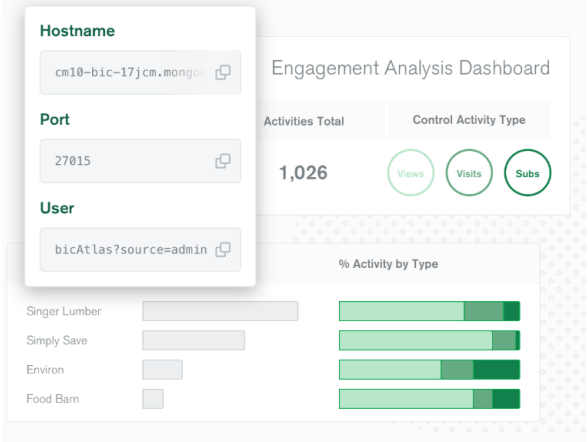
- **Charts**:



Picture 21. Charts in mongoDB

  - The fastest way to create visualizations of MongoDB data.
  - Built for the document model.
  - Visualize live data from any of MongoDB instances. Available on MongoDB Atlas.

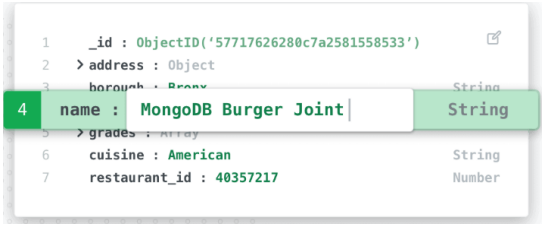
- **BI Connector**:



Picture 22. BI in mongoDB

  - Allow any BI tool that can speak the MySQL protocol to work with MongoDB data.
  - Leverage the BI tools organization already uses.
  - Perform federated analytics, combining data from MongoDB and other databases.

- **Compass**:



Picture 23. Compass in mongoDB

  - Search, visualize and work with data through an intuitive GUI.
  - Manipulate data with a powerful visual editing tool.
  - Understand performance issues with visual explain plans and manage indices.

Used by millions of developers to power the world's most innovative products and services:

Picture 24. Used by millions of developers to power the world's most innovative products and services

By using **Heroku** as a web application deployment service, the combination of **Heroku** and **mongoDB** will make the **ATN's web application** system more powerful and manageable. **Heroku mongoDB** helps developers maximize their data instead of spending time on database setup and maintenance by providing Fork, Follow, Dataclips and credentials authorizing into the database, allowing developers to set and manage varying access permissions.

3. Web application interface design and development

WebStorm

Picture 25. WebStorm logo

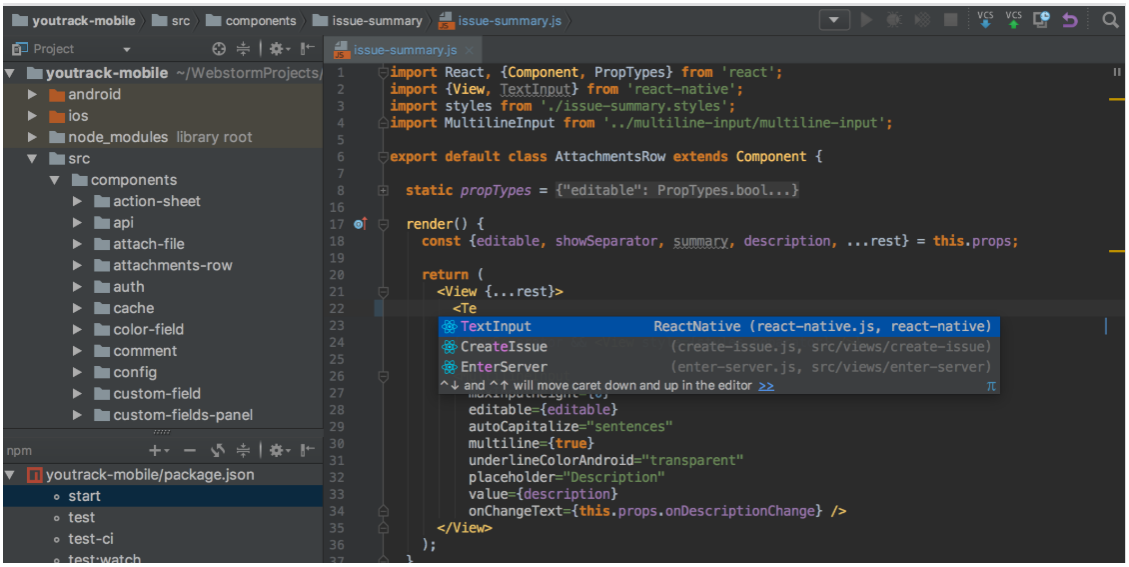
WebStorm is a powerful IDE for modern JavaScript development. WebStorm provides full support for JavaScript, TypeScript, HTML, CSS as well as for frameworks such as React, Angular, and Vue.js right out of the box, no additional plugins are required.

Besides client-side applications, WebStorm helps users develop server-side applications with Node.js, mobile apps with React Native or Cordova, and desktop apps with Electron. Note that having Node.js is highly recommended although the core WebStorm features are still at disposal without it.

In order to develop the ATN's website front-end and back-end, WebStorm becomes the most suitable IDE thanks to its JavaScript, React and Nodejs web development features

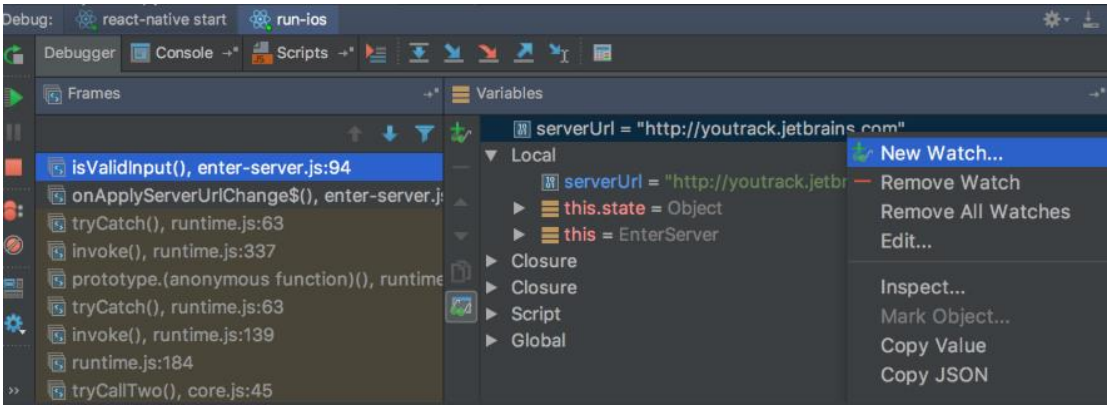
The smartest editor:

Use the full power of the modern JavaScript ecosystem – WebStorm's got users covered! Enjoy the intelligent code completion, on-the-fly error detection, powerful navigation and refactoring for JavaScript, TypeScript, stylesheet languages, and all the most popular frameworks.



Picture 26. The smartest editor WebStorm

Debugger:



Picture 27. Debugger in WebStorm

Debug client-side and Node.js apps with ease in the IDE – put breakpoints right in the source code, explore the call stack and variables, set watches, and use the interactive console.

Seamless tool integration:

Take advantage of the linters, build tools, test runners, REST client, and other tools, all deeply integrated with the IDE. But any time users need Terminal, it's also available as an IDE tool window.

Unit testing:

Run and debug tests with Karma, Mocha, Protractor, and Jest in WebStorm. Immediately see test statuses right in the editor, or in a handy treeview from which users can quickly jump to the test.

Integration with VCS:

Use a simple unified UI to work with Git, GitHub, Mercurial, and other VCS. Commit files, review changes, and resolve conflicts with a visual diff/merge tool right in the IDE.

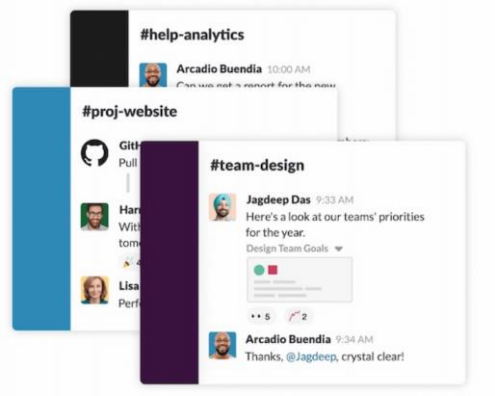
4. Communication tool

Slack:

Picture 28. Slack logo

Slack is a collaboration hub that can replace email to help you and your team work together seamlessly. It's designed to support the way people naturally work together, so you can collaborate with people online as efficiently as you do face-to-face.

A Slack workspace is made up of channels, where team members can communicate and work together. Keep reading to learn about four key features of Slack.



Picture 29. Channel in slack

Trello:

Trello is a collaboration tool that organizes your projects into boards. In one glance, Trello tells you what's being worked on, who's working on what, and where something is in a process.

Imagine a whiteboard, filled with lists of sticky notes, with each note as a task for you and your team. Now imagine that each of those sticky notes has photos, attachments from other data sources like BitBucket or Salesforce, documents, and a place to comment and collaborate with your teammates. Now imagine that you can take that whiteboard anywhere you go on your smartphone and can access it from any computer through the web. That's Trello!

CONCLUSION

Cloud computing is named as such because the information being accessed is found remotely in the cloud or a virtual space. Companies that provide cloud services enable users to store files and applications on remote servers and then access all the data via the Internet. This means the user is not required to be in a specific place to gain access to it, allowing the user to work remotely.

Cloud computing takes all the heavy lifting involved in crunching and processing data away from the device you carry around or sit and work at. It also moves all of that work to huge computer clusters far away in cyberspace. The Internet becomes the cloud, your data, work, and applications are available from any device with which you can connect to the Internet, anywhere in the world.

Cloud computing can be both public and private. Public cloud services provide their services over the Internet for a fee. Private cloud services, on the other hand, only provide services to a certain number of people. These services are a system of networks that supply hosted services. There is also a hybrid option, which combines elements of both the public and private services.

Businesses can employ cloud computing in different ways. Some users maintain all apps and data on the cloud, while others use a hybrid model, keeping certain apps and data on private servers and others on the cloud.

When it comes to providing services, the big players in the corporate computing sphere include:

- Google Cloud
- Amazon Web Services (AWS)
- Microsoft Azure
- IBM Cloud
- Aliyun

Amazon Web Services is 100% public and includes a pay-as-you-go, outsourced model. Once you're on the platform you can sign up for apps and additional services. Microsoft Azure allows clients to keep some data at their sites. Meanwhile, Aliyun is a subsidiary of the Alibaba Group.

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