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The Application Deployment Process Using AWS

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Abstract

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This thesis aims to study the opportunities and challenges of cloud computing and shows the application deployment process to the cloud using AWS, the most popular cloud service provider. The process of creating an account in AWS and using the AWS free tier service to deploy a React-based application is shown in detail at the end of this thesis.

Cloud computing is becoming a popular buzzword and is being a dominant computing platform enabling cross-platform and cross-location experiences. Therefore, I have used a cloud computing platform to show how easy and fast it is to deploy any web or mobile application to the cloud. AWS cloud service provider is used to experiment with the deployment process because it is the most popular and widely used service provider as of now.

The result showed that there are many advantages of cloud computing such as high speed, quick deployment, cost-saving, flexibility, mobility, quality control, and so on. Although there are several advantages, it cannot be denied that there are certain challenges of cloud computing such as the risk of data leakage, requiring an Internet connection, the risk of attack, possible technical problems, and so on. Along with discussing the opportunities and challenges of cloud computing, the possible solutions to it are also discussed in this thesis. High speed/quick deployment, which is the most common advantage of cloud computing, is tested by deploying an application using AWS amplify.

As a result, some workloads could be taken over by cloud computing both in front end and back end which enables the cloud users to focus on the content and UI of the application.

Keywords: Cloud computing, SaaS, PaaS, IaaS, AWS

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List of Abbreviations

EC2:	Elastic Compute Cloud
CD:	Compact disc
DVD:	Digital Versatile Disc
USB:	Universal Serial Bus
ASP:	Application Service Provider
CRM:	Customer Relationship Management
ITIL:	Information Technology Infrastructure Library
IT:	Information Technology
ITSM:	IT Service Management
API:	Application Programming Interfaces
OS:	Operating System
CPU:	Central Processing Unit
AWS:	Amazon Web Services
IaaS:	Infrastructure as a Service
PaaS:	Platform as a Service
SaaS:	Software as a Service
No:	Number
SMS:	Short Message Service
CDN:	Content Delivery Network
GIT:	Global Information Tracker

1 Introduction

Cloud computing is already well known to most of us. Since cloud computing has been around for a while, it is now one of the biggest advancements in technology ever. In general, cloud computing has revolutionized computing. In recent years, cloud computing has attracted widespread attention within the IT community. A major objective of this project is to research Cloud computing, its challenges, and opportunities. The study shows the history and evolution of Cloud computing to this date where Cloud computing is growing rapidly and is the most important technology to business computing today. The study also describes the Cloud computing Service Models 'Software as a service', 'Platform as a service', and 'Infrastructure as a service'.

The Study comprehensively highlights the deployment models for cloud computing services. Some examples of the deployment model types are public, private, community and hybrid cloud. Moreover, it explains not only the public, private, community and hybrid cloud deployment models but also the computing opportunities and challenges in depth. In this research, a self-teaching method is employed, in which many publicly available resources are used as well as the prior knowledge and understanding of the field gained from courses relevant to the field. In this research small project work is conducted to show how easily a static web app built in react can be deployed over the internet using one of the AWS cloud services features called 'Amplify'. The advantages and disadvantages of cloud services are also discussed in this thesis.

The result shows that cloud computing can be used to build and deploy sophisticated web and mobile applications taking some workload off and focusing on delivering a quality product in a very short matter of time compared to other traditional deliveries. However, the project conducted in my research, deployment of an app using AWS Amplify shows only a single example of the benefits of cloud services. In the future, it would be useful to explore other features of cloud-computing.

2 Cloud Computing

2.1 Definition of Cloud computing

Every year, cloud computing has gained more popularity than ever before. Technology journals or blogs use it as one of the most common buzzwords today. Cloud computing can be described as the on-demand availability of computing resources such as computing power and data storage to the users whenever needed over the internet. It helps businesses and organizations to add and subtract computing resources as per the demand, quickly and effectively in almost real-time. Cloud services include on-demand distribution of software, infrastructure, and storage via the Internet according to the user demand[11]. Cloud computing enables on-demand access to shared networks, storage, servers, services, and applications that help in minimizing management effort where large and scalable IT services are delivered to the external customer using the Internet technology.

Using cloud computing, users can access data storage, computing power, and computing resources on-demand without having to manage their systems. The cloud computing system can provide users online access to resources like computing power, computing infrastructure, and applications to take advantage of whenever and wherever they need them[14]. The system allows organizations to add and subtract resources almost immediately by using a set of approaches. Cloud computing, according to Wikipedia, is “a distributed and parallel computing service consisting of widely distributed and interconnected computers that are dynamically provisioned having service-level agreements signed between service providers and users”[12].

In short, the cloud provides computing services such as servers, software, or storage over the Internet using self-service mechanisms. In place of installing, maintaining, and managing these resources, they can be accessed and used through a web browser or user interface designed specifically for them. Data

centers have limitations, which can be overcome with cloud computing. Data centers are locations where servers and storage are installed, managed, and operated by enterprises.

To function properly, a data center requires many resources such as power, cooling, and maintenance. A data center is primarily responsible for controlling many activities including lighting, communication, energy, Internet access, transport, traffic, banks, entertainment, public health, and security systems. Data centers are essential to the operations and availability of many services. It is not possible to add or remove resources from a traditional data center in an automated manner, users can always subscribe for additional resources and unsubscribe them when not required.

One of the main reasons why businesses and consumers choose the cloud is that it can expand and contract easily. Increasing enterprise size also requires IT departments to buy new hardware for the data center and to upgrade existing software. These factors lead to the data center becoming bigger and more complex. The introduction of technological advancements such as virtualization eases the stress to manage a large and expanding data center. Despite these technological advancements allowing companies to be more efficient and cost-effective, companies still do not know how to meet customers' requirements. The public cloud allows companies to leverage resources to become more responsive to user requests without investing in licensing new software, new infrastructure, or training employees. As a result, cloud computing takes the burden from maintaining servers, giving companies more time to focus on other essential tasks.

To use cloud computing, you simply access and store programs and files onto the internet. You can get data in the form of music, files, images, documents, and so on. An internet connection is all the user needs to access the data. Cloud computing requires registration and the user to provide both an ID and a password for security reasons. In addition to internet speed and server capacity, the speed of the transfer is affected by several factors. The Cloud computing

service is run by the hosting company itself since they constantly come up with new modifications to the service, so the data is accessed quickly. The host has huge storage capacity, as well as fast processing servers, to enable the quick access of data. In cloud computing, users can concentrate only on their jobs, while all maintenance work is taken care by the service provider. Below, figure 1 shows the types of Cloud computing its services, and the pros and cons of Cloud computing.

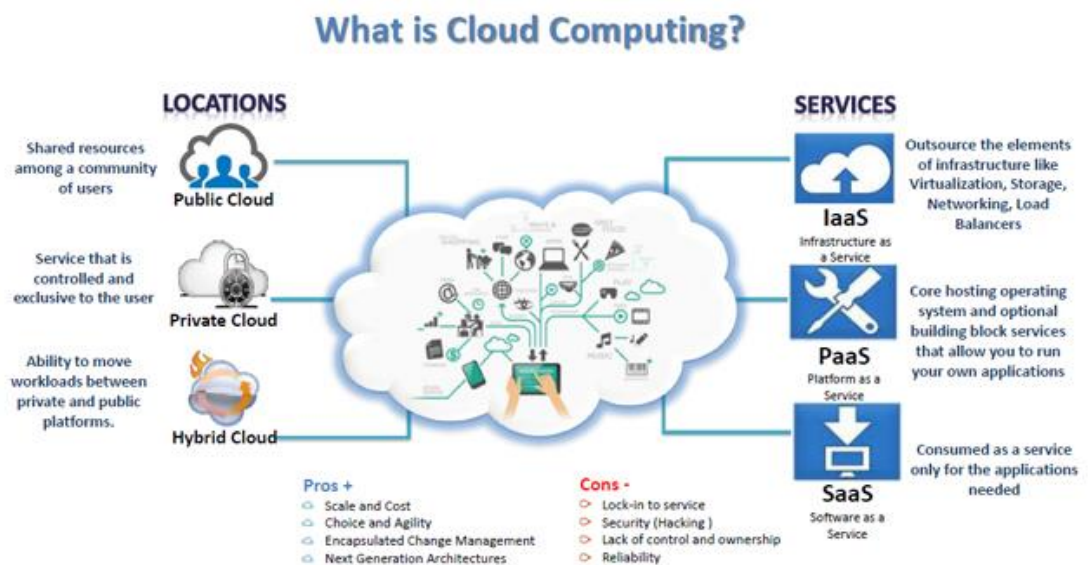


Figure 1. A brief illustration of Cloud computing. [1]

With the cloud, we already have a technology-enabled self-service model for allocating technology resources. Cloud services have abstracted technology away from the users, which is one of the main characteristics. A cloud service provider, for example, takes on the responsibility of maintaining IT assets. In using cloud services, customers can focus on the benefits their business receives, not how the service works. Based on a dynamic architecture that's scalable, request-driven, and able to handle a wide range of different types of workloads at once, cloud services can support large numbers of different workloads simultaneously.

As the world becomes more and more complex, cloud services need to provide assurances of security, reliability, and ease of management. Moreover, they must have the capability to scale massively to avoid constraining growth.

2.2 History of Cloud computing

We live in an era where cloud computing is very popular and well known, but for cloud computing to be as it is now, there has been a series of evolution in the computing sector. Now cloud computing provides agility, cost savings, and global access to resources. But the question is how did we get here?

As we want to progress with the study that what new digital era is bringing next, we are still learning how to apply cloud-based data. The advantages of cloud-based data are growing exponentially, meanwhile significantly complex applications are not confined any longer physically at a premise. Although Millennials consider the cloud as their contribution, researchers have found that the concept of non-local computing dates to the early 1950s. From floppy disks to zip drives, from CDs to DVDs to USB drives, the technology has progressed over the past 50 years[2]. Below, Figure 2 shows how cloud computing has evolved from the 1960s to 2019.

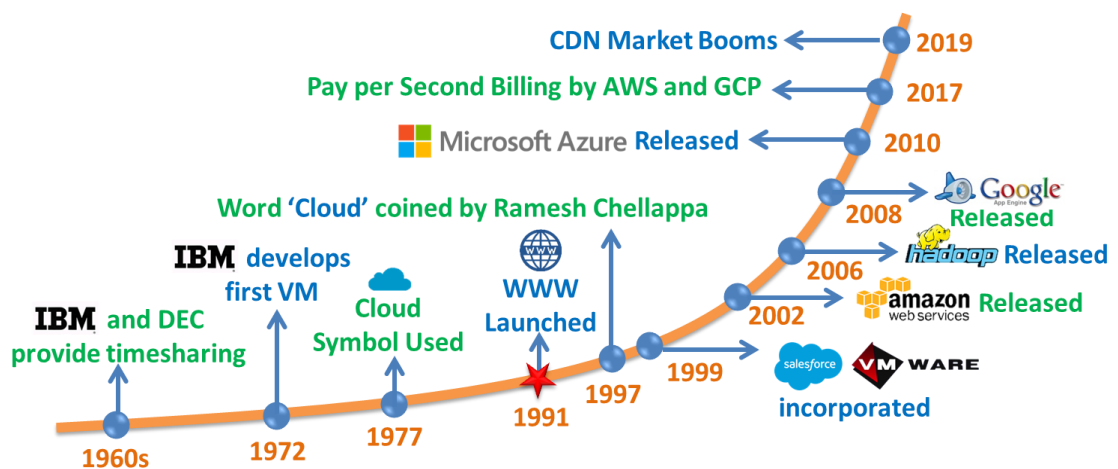


Figure 2. Cloud computing History. [3]

In 1950, non-local storage technology was developed to connect computers via an internal matrix for military use. When it reached the scientific community, it advanced rapidly. Back then, two or more people would need access to technology because computers cost several million dollars and computing was costly. Compaq's internal document from 1996 coined the term "cloud computing". Early in the 1990s, Apple-bred firm General Magic branded the term "cloud," and it had been mentioned even earlier by academic researchers[4].

During the 1990s, as the digital world was growing, cloud computing became a common term. Within a short time, Microsoft and Google were competing for market share. A new industry, cybersecurity, was born as PaaS, SaaS, and IaaS boomed.

A gold rush was underway to join this new sector which was affecting entertainment, healthcare, finance, and government at a rapid pace. Culture has never changed in such a dramatic way as it was caused by the cloud. The world was being changed by small startups. It was becoming the nation's domain to create wealth in remote locations and to innovate.

On August 25, 2006, Amazon Web Services launched Elastic Compute Cloud (EC2), allowing users to rent virtual computers, and run their applications online. Meanwhile, Google Docs Services was introduced. Netflix was one of the first video streaming websites in the world when they launched their services one year later. IBM and Apple also jumped on board with Smart Cloud and iCloud, respectively. The Oracle Cloud was also released around the same time. Despite the important role played by virtualization in the emergence of cloud computing, which is not the only technology that laid the groundwork for the phenomenal development of cloud computing services. Additionally, Application Service Provider (ASP), Service-Oriented Architecture (SOA), IT Service Management (ITSM), Information Technology Infrastructure Library (ITIL), and others have significantly contributed to modern cloud computing services. The presence of the high-speed Internet connections has contributed remarkably. APIs, or Application Programming Interfaces (APIs), which allow users to access Internet

resources, also contributed to the accomplishment of cloud computing services[5].

Public and private clouds were traditionally considered two types of clouds until recently. Public clouds are providers of computing services that make them available to you via the public internet so that anybody can use or purchase them. Private clouds are usually used for more precise needs, such as storing and sharing sensitive information. In essence, private clouds are controlled security systems where data is stored. Cloud technology will likely continue to evolve in the long run, though it can't be predicted precisely what it will become. We can only hope that this wide access to data and information will continue to benefit us all, while also avoiding its pitfalls.

2.3 Cloud Deployment Models

In cloud deployment models, you can see how users can utilize cloud services. Cloud computing consists of four deployment models:

- Private Cloud
- Hybrid Cloud
- Public Cloud
- Community Cloud

Private clouds are managed by a single organization, as their name suggests. An organization may manage such infrastructure by itself, or a service provider may manage it offsite or on-site. The cost of maintaining and acquiring a private cloud is higher than that of a public cloud. Today, organizations are more concerned about security and privacy which is better addressed by private clouds[6].

A hybrid cloud combines public and private cloud resources within an organization. The public cloud complements capacity within a private cloud, which is a model widely used when organizations need to expand their IT infrastructure rapidly. For example, During the holiday season, an online retailer

may utilize public clouds to acquire the computing resources it needs for its Web applications[7].

The public cloud provides free computer resources (OS, storage, memory, CPU) and application servers (databases) for all users on a subscription basis, as the name suggests. Public cloud services are offered by outsourced cloud providers and allow businesses to pay as they go for use of the service. Applications are usually developed and tested in public clouds, they're used for non-mission-critical activities like file sharing, and e-mail is typically delivered via public clouds.

A community cloud enables organizations to collaborate on shared computing resources within a community, for instance, colleges collaborating on work in certain research areas, or areas of law enforcement sharing computing resources within a county. Members of a community are usually the only ones with access to a community cloud environment.

Cloud-based services typically require fewer resources to operate and don't require capital investment from the end-user. Since private clouds are designed to consolidate and pool resources, they can still be cheaper to utilize than owning and maintaining infrastructure. Private clouds are more secure than public clouds. For these reasons, companies may choose private clouds for the development and testing of secure applications, but public clouds can also be used for basic tasks like e-mail delivery and application development.

2.4 Features of Cloud computing

Having studied the architecture of cloud computing, Figure 3, below shows some of the features of cloud computing.

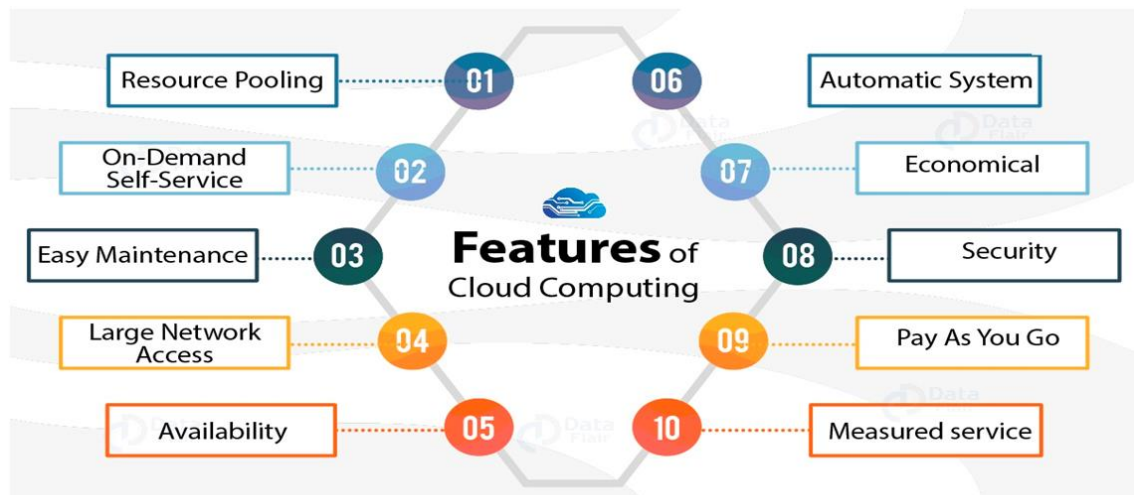


Figure 3. Features of Cloud computing. [9]

Cloud computing has several characteristics that demonstrate its market importance[8]. Some of the most important features of cloud computing are described below.

Resources Pooling

In a Cloud computing environment, resource pooling is an essential feature. Resource pooling refers to a cloud service provider can share resources among many clients, providing each with a different set of services according to their requirements. In terms of data storage, processing, and bandwidth, the strategy can be applied to multiple clients. The real-time allocation of resources doesn't conflict with the clients' experience[10].

On-Demand Self-Service

One of the important and valuable aspects of cloud computing is monitoring the availability, capabilities, and allocated network storage of the cloud server. This feature also allows users to monitor their computing capabilities. Customers can access computing resources such as server time and network storage without asking for permission. Most of these tasks can be automated, without the need for human involvement or IT support.

Easy Maintenance

We have very little downtime on our servers, and maintenance is easy to perform. It constantly improves by introducing a new update. With the updated software, bugs have been fixed and the devices are more compatible with them.

Large Network Access

The user can access the cloud data or upload data to the cloud with the help of a device and an internet connection. Internet access allows users to access these capabilities all over the network.

Availability and flexibility

A great deal of flexibility is offered by the Cloud since it can be customized to suit specific needs. By analyzing the storage usage, it enables the user to purchase extra Cloud storage if needed.

Automatic System

Some cloud computing services include metering capabilities that automatically analyze the data required. Monitoring, controlling, and reporting the usage is possible. Both the host and the customer will benefit from it.

Economical

The host must make a one-time investment in buying the storage as per the requirement of the company which makes cloud computing economical.

Security

Cloud computing's greatest feature is its security. Data is stored in a snapshot so that even if a server is damaged, the data will not be lost. Storage devices securely store data, which can't be hacked by anyone else. It is reliable and fast to use the storage service.

Pay as you go

Cloud computing customers pay for the services or space they use. It is not necessary to pay any hidden fees. Most services are affordable, and some storage is free.

Measured Service

Monitoring and recording are carried out using cloud computing resources. Charge-per-use capabilities are used to analyze this resource utilization. This means that cloud service providers are monitoring, measuring, and reporting the resource usages of the virtual servers running in the cloud. According to the pay-as-you-go model, payments are variable according to the number of units consumed by the manufacturing organization.

2.5 Cloud computing Service Models

As part of cloud computing, there are three main service models - Infrastructure as Services (IaaS), Platform as Services (PaaS), and Software as Services (SaaS). Each of them offers businesses different storage options and resource pooling capabilities, but they can also be used together to create a comprehensive cloud computing model. Figure 4 below shows the types of Cloud computing Service models i.e., SaaS, Paas, and IaaS.

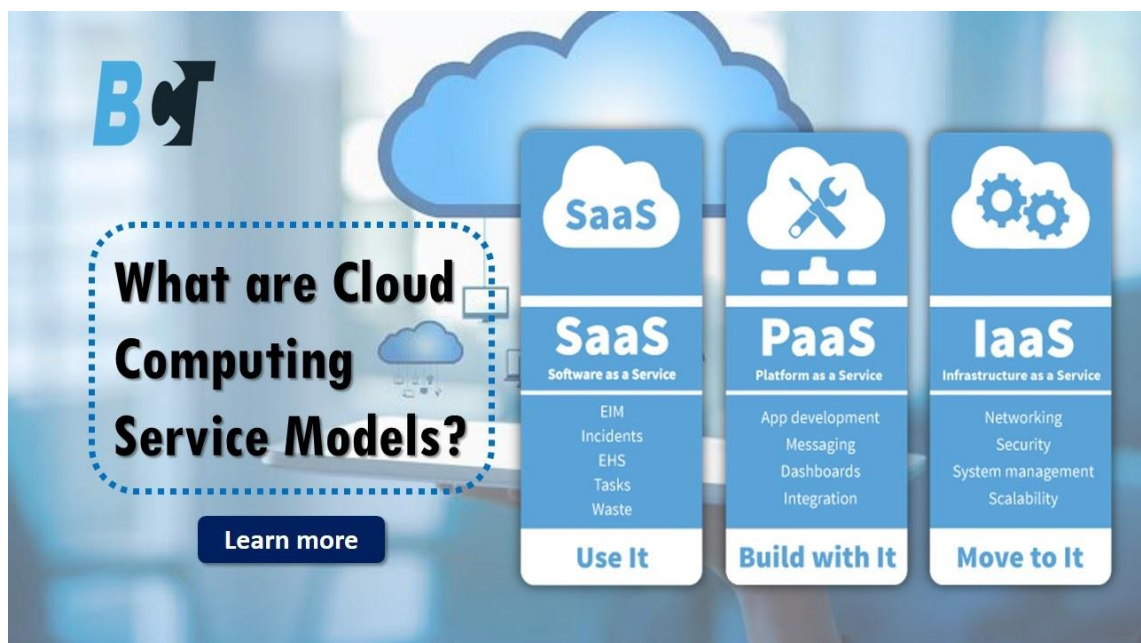


Figure 4. Cloud computing Service Models. [13]

SaaS

The term SaaS refers to software as a service. Various businesses pay subscription fees or pay per use for cloud computing software in this model. Mobile sales management software, for example, relies heavily on it and it is a good tool for CRMs. Businesses don't need to worry about maintaining SaaS themselves since it is managed from a central location. In addition to its numerous benefits, SaaS is also economical since the user pays only some of the basic costs. These costs include licensing, installation, and support. Gmail, Yahoo! Mail, and Hotmail are some examples of SaaS.

PaaS

The term PaaS refers to Platform as a Service. It facilitates users with the capability of publishing, automating, and customizing software in a hosted environment. Businesses can develop and run their applications on cloud computing companies' infrastructure and software frameworks. By using PaaS, it is possible to create web applications quickly and easily, and each application is flexible and robust as well. Multi-developers can work on a single project using PaaS solutions, which are highly scalable. You can do it using the internet. Also, it is more affordable, as only the essentials need to be paid for, and has lower costs. PaaS hosts have their hardware and software. As a result, the user does not have to install hardware or software to run a new application.

IaaS

Providing virtual servers, operating systems, networks, and storage drives are the most common service models of cloud computing. With the cloud, businesses can benefit from flexibility, reliability, and scalability, and they won't have to worry about maintaining hardware. A cost-effective IT solution that supports business growth can be implemented by small and medium-sized businesses. A pay-for-use infrastructure as a service can be either public, private, or hybrid.

3 Opportunities and Challenges of Cloud Services

While cloud computing has many advantages, it also has many disadvantages. Businesses of all sizes can benefit from the use of cloud computing if it is used properly. On-demand self-service, ubiquitous access to networks, location-independent resource pooling, and risk transfer are among the major advantages of cloud computing. In addition, the service offers convenience, quality, and reliability. Cloud computing has two major challenges: privacy and security[15]. The privacy of users can be compromised as data can be accessed from any location. There are also security concerns. IT security consists of keeping data secure. Many individuals would rather not hand over their private information. Cloud computing security issues are being addressed by vendors, researchers, and security professionals. Cloud computing can be problematic for some applications due to latency. This refers to the time it takes for data to be delivered from the point of request. A lack of standards is also a problem. Cloud computing adoption has been slowed by these concerns and challenges.

3.1 The Opportunities of Cloud Services

Sixty-nine percent of businesses use cloud computing in some capacity, according to the International Data Group. Meanwhile, 18% intend to implement cloud computing solutions soon. A study by Dell indicates that companies that invested in big data, cloud, mobility, and security experienced revenue growth up to 53 percent more rapidly than their competitors[16]. All of this indicates that this might be the best time to get into cloud computing. During the last few years, the term cloud computing has gained increasing popularity. For example, employees can have access to customer information via cloud-based CRM software in the way salesforce do from their smartphone or tablet at home or while commuting. Moreover, they can quickly share that information with other authorized parties anywhere in the world.

High Speed – Quick Deployment

As a result, software development has become more agile and fast thanks to the ability to create new cloud computing instances in seconds. Applications can be designed and tested without being constrained by on-site hardware limitations or lengthy procurement processes.

Cost Savings

Cloud computing offers many benefits, including cost savings. As no physical hardware is needed, you save considerable capital costs and time for the company. The pay-as-you-go system enables users to reduce the usage cost of cloud services. In addition, you would choose how much storage you need based on the actual needs and not be charged for any space that you don't need. The result is a higher return at a lower cost. Furthermore, the hardware does not need to be maintained by trained personnel. It is the cloud service provider who purchases and manages equipment.

Data Security

Cloud computing has security concerns for many organizations. It can be much safer to keep sensitive information offsite than to keep in the premise. Looking at the data as stated by Rapid Scale, 94% of businesses have seen security improve since moving to the cloud, and 91% reported easier compliance with government guidelines. Encryption of network traffic and data stored in databases is key to this improved security. Data encrypting makes it more difficult for hackers or others to steal your information. Different security settings can be set for users of most cloud-based services as an added measure of security. The networked backup ensures data security even in the event of hardware failures.

Flexibility

A business can only divide its attention between a finite number of responsibilities. You will be unable to concentrate on business goals and customer satisfaction if your current IT solutions are forcing you to fix computer and data storage issues. In comparison to a local server, the cloud provides businesses with greater flexibility. Additionally, cloud-based services are often

able to accommodate extra bandwidth instantly rather than having to undergo a costly and complex upgrade to IT infrastructure. By improving the organization's flexibility and freedom, it can produce significant results. Cloud services can be customized, and users can access them from any location with an internet connection.

Mobility

In an era when over 6 billion smartphones are used globally[17], cloud computing makes it possible for mobile workers to access corporate data on smartphones and devices, thus ensuring that no one is left behind. The feature is useful for employees who have a busy schedule, or who live far from the office. They can stay connected at any time with clients or colleagues. Remote employees, independent contractors, and traveling sales staff can have convenient access to information using a cloud-based solution, improving their quality of life. Therefore, organizations prioritizing employee satisfaction are more likely to expand cloud usage.

Insight

Cloud analytics provides a bird's-eye view of your data. Cloud storage reduces administrative burdens, enables easy tracking mechanisms, and enables you to build custom reports for analyzing information throughout the organization. You can use those insights to improve efficiencies and develop action plans to help your organization meet its goals.

Increased Collaboration

A business with two or more employees should prioritize collaboration. Achieving success requires teamwork. Collaboration is made easier by cloud computing. Cloud-based platforms allow team members to easily and securely share information.

Quality Control

For any company, keeping data under control is crucial. Having a document in the wrong hands, even a staff member who isn't trained can cause all kinds of

chaos. Having poor and inconsistent quality control is detrimental to a company's success. You have full control and visibility over your data when you use the cloud. The level of access to data is easily set by the administrator. In addition to giving you control, you can streamline work by letting staff know which documents they are to handle. The consistency of data will be maintained, the human error won't occur, and any revisions or updates will have a clear record. Additionally, it will make collaboration easier and more efficient.

Disaster Recovery

A small amount of downtime can have a detrimental effect to the business. Downtime in services damages productivity, revenue, and reputation. In an emergency, from a natural disaster to a power outage, cloud-based backup and recovery services provide quick data recovery. Disaster recovery is faster when previous versions of the software are stored in the cloud and production instances are running on multiple cloud availability zones or regions. Using multiple locations for deployment allows for automatic recovery when one goes down, the end-users won't be affected.

Loss Prevention

All organizations are concerned about data loss and data security. Your data will be accessible even if your laptops or computers are damaged because the cloud keeps your data safe. Data can be quickly and easily recovered using cloud-based services, from natural disasters or power outages. Loss prevention is another benefit of cloud infrastructure. Even if you lose your work computer, your data stored in the cloud is still accessible from any computer with an internet connection.

Automatic Software Updates and Integration

There is nothing more annoying than waiting for the installation of system updates when you have a lot to accomplish. The cloud-based applications will be automatically updated and refreshed instead of requiring a manual update by the IT department. Continuous Integration and Continuous Delivery rely on the fact that new software versions can be easily tested and deployed in the cloud

environment, which allows for the higher velocity release of new features to the end-users, weekly, and in some cases even daily basis. DevOps tools and logging systems are also integrated into cloud environments, making it easier to monitor and detect problems in production.

Competitive Edge

The adoption of cloud computing is increasing every year, but not every company has fully benefited from it. Those who take advantage of this world-class enterprise technology and make it a part of their business will reap the rewards and become a standout organization. The business that chooses to store its data locally places itself at a significant competitive disadvantage when compared to the business that chooses to use the cloud. You'll be further ahead of your competitors if you switch to a cloud-based solution before they do. According to a recent study by Verizon, 77% of businesses believe cloud technology gives them a competitive advantage, and 16% believe that the advantage is significant[18].

Sustainability

In the current climate situation, Organizations should not limit themselves to placing recycling bins in break rooms and claiming that they're helping the planet. For a corporation to achieve real sustainability, it needs to address wastefulness on all levels. With cloud hosting, the carbon footprint is lessened. Low energy use, reduce in greenhouse gases production, Dematerialization are the environmental benefits of cloud computing. In the study, titled 'A Study on the Microsoft Cloud,' the two organizations found that cloud computing is beneficial for the environment. Cloud computing from Microsoft is 93% more energy-efficient and emits 98% fewer carbon emissions than on-site data centers[19].

3.2 The Challenges of Cloud Services

Cloud computing has its benefits, but there are also some disadvantages of this system. Some risks include[20]:

Risk of data leakage

It is always possible for other people to access user data. It is important to have good cloud and data protection so that data confidentiality is not compromised.

Internet connection required

Cloud computing can only be accessed via the internet. If your place does not have an Internet connection or the connection to the cloud provider is down, automatically you will lose access to cloud computing. There is a major obstacle to public cloud usage in developing countries and remote areas with poor internet connections. The public cloud has the disadvantage that everyone has access to the same server, which increases the possibility of attack and slows it down.

Security level

The privacy and security of cloud computing are among the most questionable aspects. The use of cloud computing means that we give our data to companies who provide cloud computing servers with the highest level of security and confidentiality. The server cannot be sued for corruption of data when you have a problem. The server cannot be sued for data errors if you encounter a problem.

At the risk of attack

Cloud computing faces many criticisms, one of which is computing. The online work system of cloud computing makes each component vulnerable to a wide range of threats, which leaves servers wide open for attack. Data security and privacy are issues that arise when being attacked by hackers.

Technical problem

When using Cloud computing, you cannot manage it yourself whenever there is a problem. Instead, you must contact customer support, which may not always be available. In addition to that, some support may require additional fees.

Poor connection

When the connection is slow, this doesn't work well. One of the most crucial factors before deciding which cloud computing provider to use is the quality of the servers. We will be harmed by poor server quality if the server goes down or if the performance is low.

It is undeniable that Cloud computing is a revolutionary system, even though it has many disadvantages. It also evolves constantly in terms of technology which will affect the future of cloud management. Although there are a few disadvantages, there are also several advantages of cloud services. However, it is crucial to find the right cloud service provider before moving to the cloud.

4 Application Deployment Process

The cloud offers businesses on-demand resources, storage, and data storage. Renting access to cloud computing applications is an alternative to owning their own data centers. Businesses can operate more efficiently by lowering up-front costs and reducing the time and resources spent maintaining a complex IT infrastructure. Cloud services are used by many companies to externalize their IT systems. Choosing the right cloud solution provider is important to gain the many benefits of the cloud. A company's success and operations will be greatly affected by this choice. Cloud solutions are offered by many companies. The most recognized names in the industry are Amazon, Microsoft, and Google. However, Other smaller providers can also offer customized cloud services.

Cloud computing is dominated by three large providers. The breakdown is as follows[21]:

- Amazon Web Services (AWS) (63%)
- Microsoft Azure (29%)
- Google Cloud Platform (GCP) (8%)

4.1 Choosing The Right Cloud Provider

To choose the right cloud services for your business, you need to understand what your organization needs and match that with a provider. Choosing a cloud service provider involves following these three steps[22]:

Meets Business Needs- It is not a good idea to immediately go with the biggest provider. Research must be conducted to find the available options that meet the organization's needs.

Reliability- To avoid the risk of data loss and cyberattacks, organizations must choose a provider that offers reliable security and storage services. A good cloud service provider is one you can rely on no matter what circumstance. Basic protection packages, however, don't provide sufficient protection, so you need an environment tailored to your business.

Flexibility- The cloud provider should be flexible so that its services can scale along with the company's success and growth. Growth should be supported, not hindered by the cloud provider.

4.2 Overview of AWS

AWS, a powerful, constantly evolving cloud computing platform, combines infrastructure as a service, platform as a service, and software as a service offering. AWS services are used to manage computing resources, store databases, and deliver content.

As part of Amazon's online retailing operations, Amazon built its infrastructure for Amazon Web Services in 2006[23]. AWS was one of the first companies to offer pay-as-you-go cloud computing services, which allowed users to purchase compute resources, storage space, or bandwidth as needed. Cloud computing services are available in more than 190 countries through Amazon Web Services[24]. Companies, educational institutions, non-profit organizations, and government agencies can use Amazon Web Services.

In the deployment project, I will be using one of the AWS features known as AWS Amplify. It allows the creation and deployment of any application very simply and quickly.

4.2.1 AWS Amplify

AWS Amplify is a JavaScript library that allows developers to quickly manage, configure and create applications with AWS Cloud. With AWS Amplify, developers can rapidly and easily build applications, leveraging the wide range of AWS services. JavaScript, Angular, React, Vue, and Next.js are supported by Amplify for developing web apps. Also available are iOS, Android, Ionic, React Native, and Flutter to develop and maintain mobile apps[25]. AWS Amplify has many modules we can use to speed up the development such as Auth, Analytics, Storage, API, Caching, UI components, etc.

4.2.2 GitHub

A high-level description of GitHub is that it is a website and cloud-based service that is designed to make it easier for developers to manage, track, and control the changes to their code[27]. The two connected principles that make up GitHub are version control and Git. Developers can track and manage versions of code with version control. Git, the most used version control system is a free open-source software designed to handle projects of all sizes with speed and efficiency. When using Git, you can keep track of all changes you have made to files, and if you need, you can revert to specific versions. Furthermore, Git allows multiple people to work together, with their changes being merged into one source.

In this experiment, I will be using a shopping list app built in React.js that is pushed into GitHub. The react app was built with `npx-create-react-app`. My goal is to show how easy and simple it is to deploy an app with AWS Amplify. For this experiment, I have used an AWS free tier. In the AWS Free Tier included are some free services, services that are free for a year, and some short-term free trials.

4.3 The Steps to Deploy the Application

The deployment process involves two major steps:

4.3.1 Creating an AWS Account

The project started with creating an AWS account. AWS cloud services were chosen because it is the most used cloud service worldwide. Creating an AWS account is simple and easy. Down below, I have instructed the steps of creating an account and included the screenshot of all the steps carried out through the process.

Below figure 5 is presented as the screenshot of the home page of AWS. It is achieved by going to the AWS official website "<https://aws.amazon.com/>". To create an account, click the Create an AWS Account button.

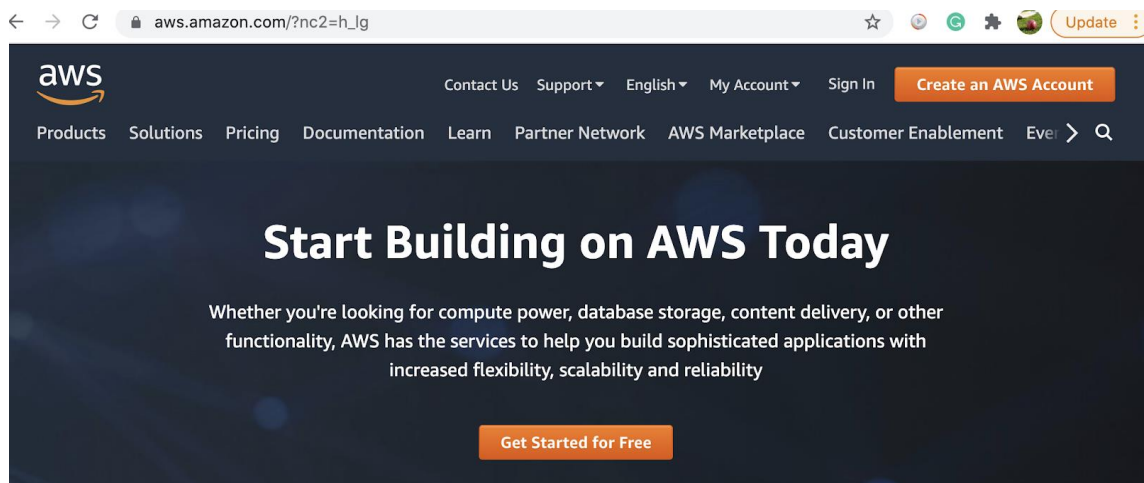


Figure 5. Amazon Web Service Homepage.

After the button to create an account is clicked, the screen for sign up appears as shown in Figure 6 below.

portal.aws.amazon.com/billing/signup?nc2=h_ct&src=header_signup&redirect_url=h... Update

English

aws

Sign up for AWS

Email address
You will use this email address to sign in to your new AWS account.

Password

Confirm password

AWS account name
Choose a name for your account. You can change this name in your account settings after you sign up.

Continue (step 1 of 5)

[Sign in to an existing AWS account](#)

Figure 6. The Sign-up Screen.

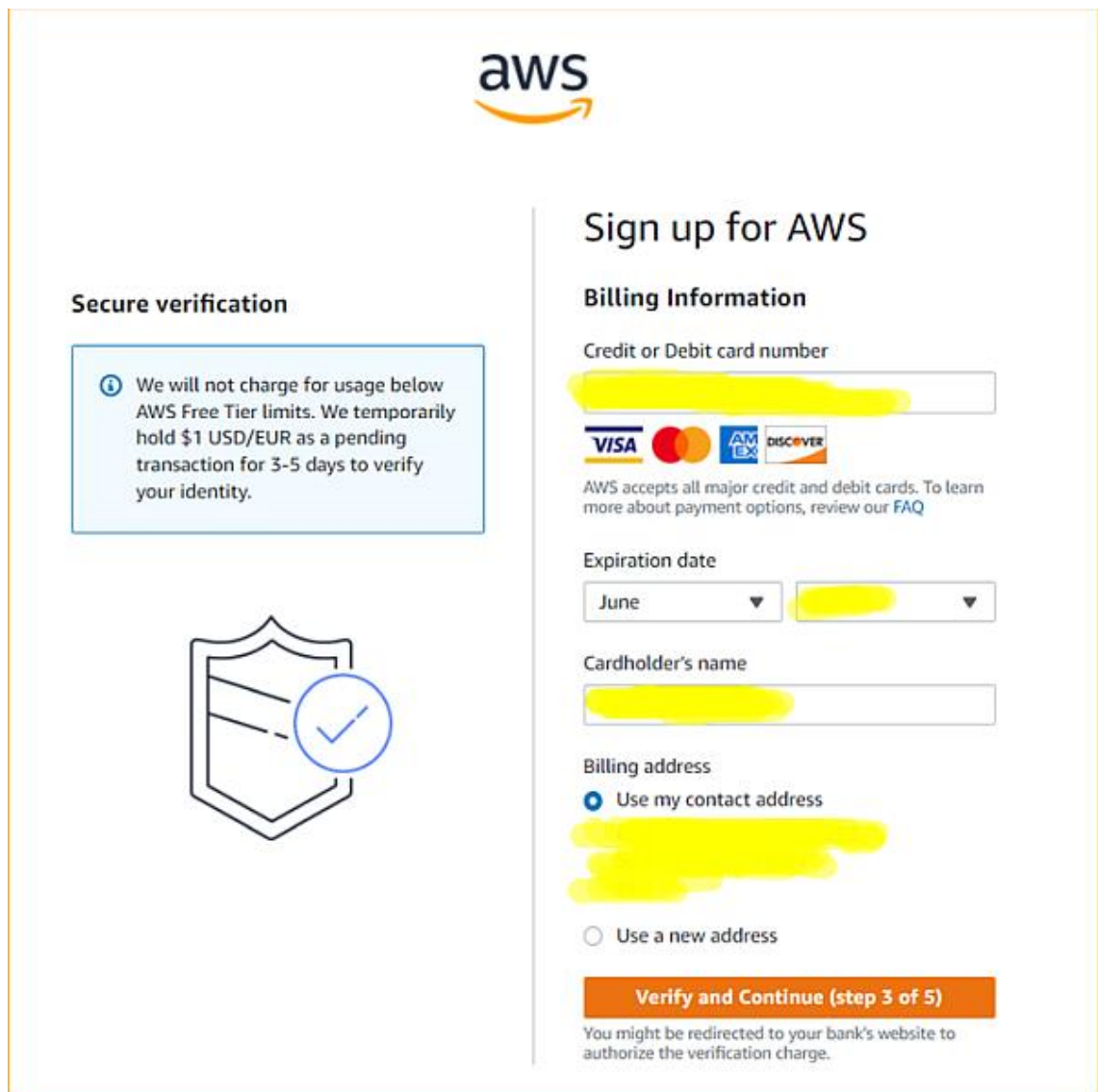
If you have an AWS account already, you can directly sign in to the AWS by clicking on the small sign-in link that is to the left side of the big Create an AWS Account button as you can see in figure 5. Otherwise, to create a new account enter your account information, and then choose to continue. The account information must be entered correctly including the email address. If the email address is incorrect, it is impossible to get access to the account you have created. Read and accept the AWS Customer Agreement and Choose Create Account and Continue.

You receive a confirmation email once the account is created. You can sign into your new account using the email address and password you registered with. However, before finishing the activation process the AWS services can't be used.

The next step is to add a payment method. You won't be charged any amount until you use any AWS services. Here in this project, I will be using AWS free tier.

With the AWS Free Tier, you can choose from always free services, free services for a year, and short-term free trials.

Below Figure 7 shows the screen for billing information. After correctly filling in the information asked, click Verify and Continue button that is at the bottom of the form.



The screenshot shows the AWS sign-up process for billing information. At the top center is the AWS logo. On the left, under the heading "Secure verification", there is a light blue box with an information icon and the text: "We will not charge for usage below AWS Free Tier limits. We temporarily hold \$1 USD/EUR as a pending transaction for 3-5 days to verify your identity." Below this box is a shield icon with a checkmark. On the right, under the heading "Sign up for AWS", there is a "Billing Information" section. It includes a "Credit or Debit card number" field (blurred), logos for VISA, Mastercard, AMEX, and DISCOVER, and a note: "AWS accepts all major credit and debit cards. To learn more about payment options, review our FAQ". Below this is an "Expiration date" section with two dropdown menus (one showing "June", the other blurred). The "Cardholder's name" field is also blurred. The "Billing address" section has two radio buttons: "Use my contact address" (selected) and "Use a new address". At the bottom right is an orange button labeled "Verify and Continue (step 3 of 5)". Below the button is a small note: "You might be redirected to your bank's website to authorize the verification charge."

Figure 7. Page to provide billing information.

It is also possible to use different billing information if you require it. It is not possible to continue the sign-up process unless you provide a valid payment method.

After providing the billing information you are directed to the identity confirmation page which is done by the mobile number verification. From the list, select your country code and enter the phone number which you can access in the next few minutes. Enter the code displayed in the CAPTCHA, and then click Send SMS Button. You will receive an automated message shortly. Select Continue after entering the PIN.

Below is Figure 8 which shows the screenshot of the page to confirm the identity via mobile phone number verification.



Sign up for AWS

Confirm your identity

Before you can use your AWS account, you must verify your phone number. When you continue, the AWS automated system will contact you with a verification code.

How should we send you the verification code?

Text message (SMS)


Voice call

Country or region code

Finland (+358) ▼

Mobile phone number

Security check



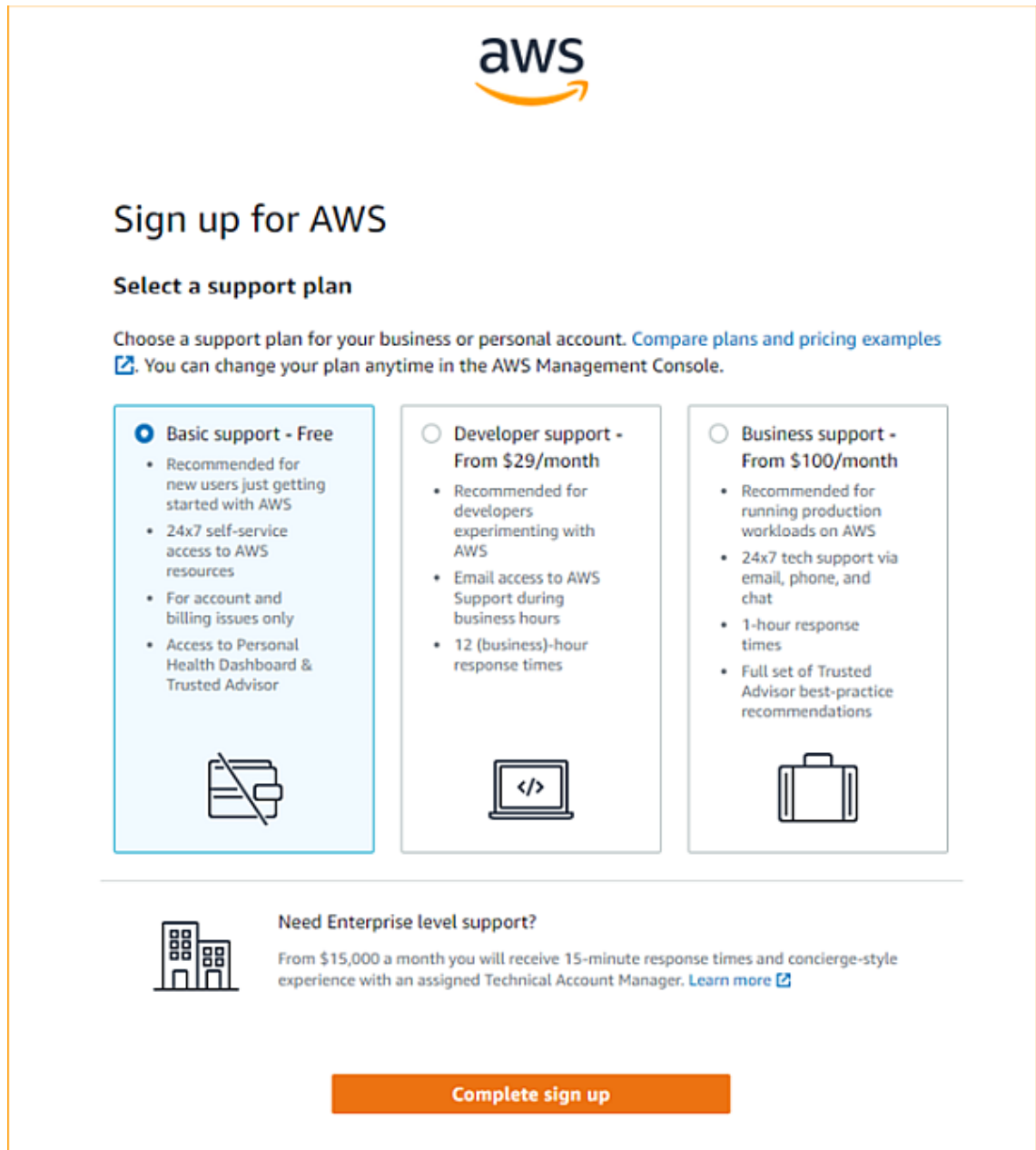
Type the characters as shown above

Send SMS (step 4 of 5)

Figure 8. Page to verify identity.

The next step is to choose an AWS support plan. Choose one of the available support plans on the support plan selection page. Wait for account activation to find the description of the available plans and their benefits. A confirmation page appears after the support plan is selected. The process of activating an account usually takes a few minutes, but it can also take up to 24 hours.

Below is Figure 9, a section to select the support plan with short details about each plan. The support plan is to be chosen as per your requirement.



The screenshot shows the AWS 'Sign up for AWS' page. At the top is the AWS logo. Below it is the heading 'Sign up for AWS' and a sub-heading 'Select a support plan'. A note states: 'Choose a support plan for your business or personal account. Compare plans and pricing examples [link]. You can change your plan anytime in the AWS Management Console.' There are three support plan options presented in cards:

- Basic support - Free** (Selected): Recommended for new users just getting started with AWS. Features include 24x7 self-service access to AWS resources, support for account and billing issues only, and access to Personal Health Dashboard & Trusted Advisor. Icon: a wallet with a slash through it.
- Developer support - From \$29/month**: Recommended for developers experimenting with AWS. Features include email access to AWS Support during business hours and 12 (business)-hour response times. Icon: a laptop with code symbols.
- Business support - From \$100/month**: Recommended for running production workloads on AWS. Features include 24x7 tech support via email, phone, and chat; 1-hour response times; and a full set of Trusted Advisor best-practice recommendations. Icon: a briefcase.

Below these options is a section for 'Need Enterprise level support?' with a building icon. It states: 'From \$15,000 a month you will receive 15-minute response times and concierge-style experience with an assigned Technical Account Manager. [Learn more](#)'

At the bottom of the page is an orange button labeled 'Complete sign up'.

Figure 9. Page to select a support plan.

To work on this project, I have chosen the Basic support plan which is completely free and is also recommended for the new AWS users.

Below is Figure 10, a congratulations page that is achieved after successfully creating an AWS Account.

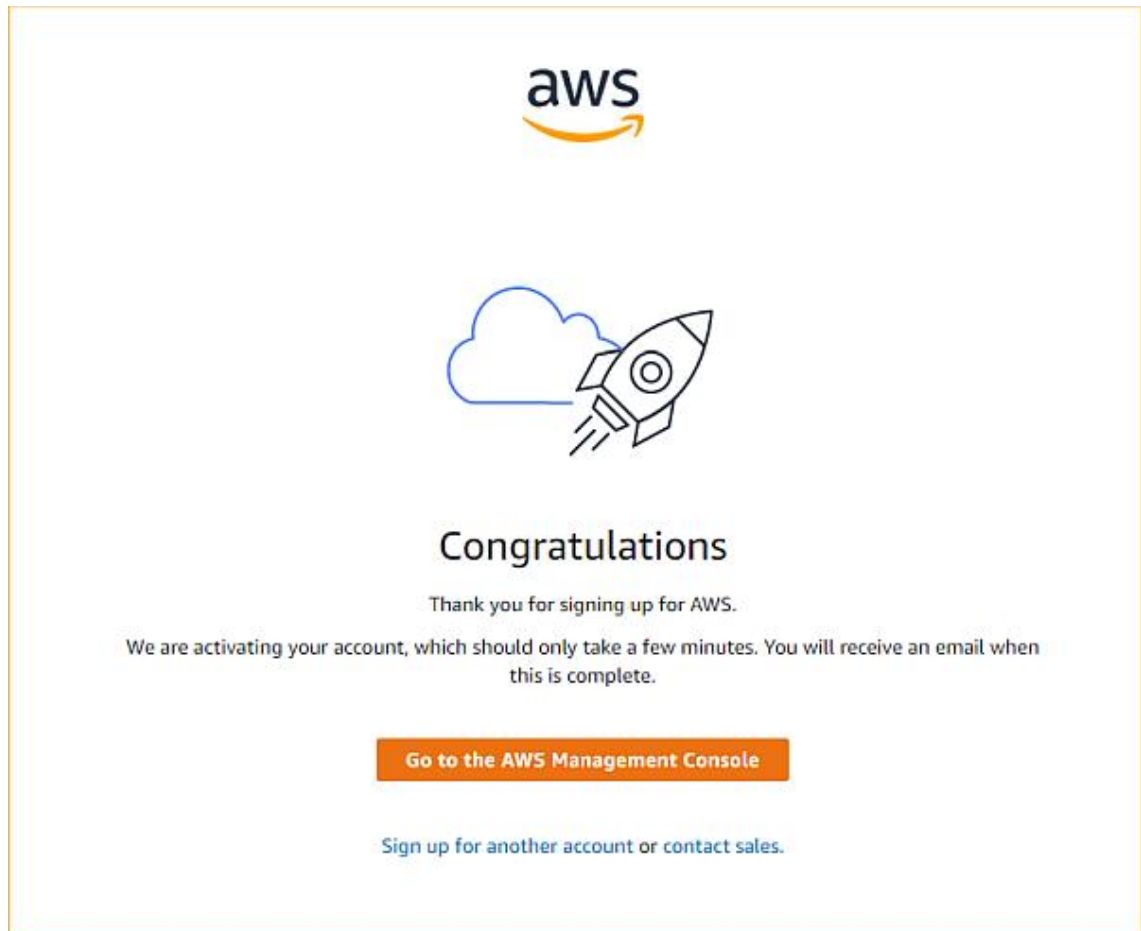


Figure 10. A congratulations page.

You might see the Complete Sign-Up button on the AWS landing page during this period, even if you have completed all the steps in the sign-up process. A confirmation email is received once the account is activated. After receiving the confirmation email, you gain full access to all the services provided by AWS. Now you can sign in and go to the AWS management console and use the services provided by the AWS Cloud.

4.3.2 Connecting GitHub Repository to AWS Amplify

To host the app on AWS Amplify, a repository containing the source code must be connected. To do this, first, you must sign into the AWS Management Console and search for AWS Amplify in the search bar[26]. Below, figure 11

demonstrates how the search is carried out and the search results.

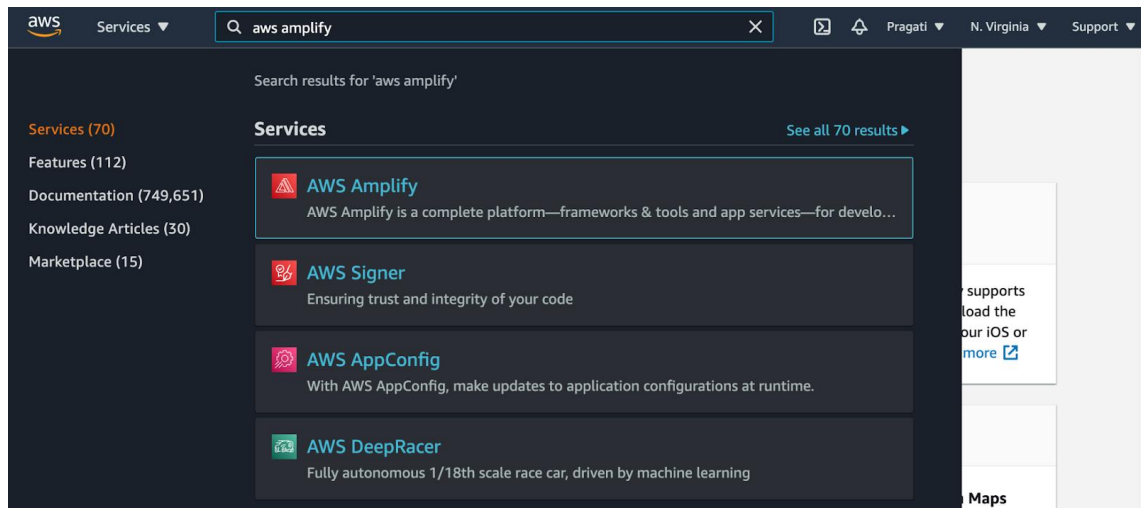


Figure 11. The search in AWS management console.

Click the AWS Amplify from the search result and navigate to Deliver and press the, get started button as shown in figure 12.

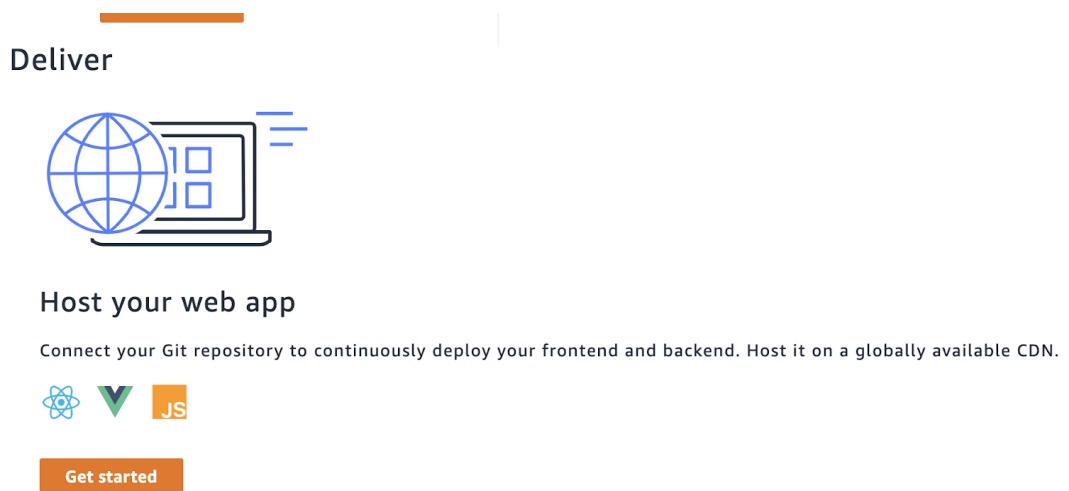


Figure 12. The screenshot of the part of the AWS Amplify page.

After clicking the Get started button, a new page will appear, where your repository with source code can be connected. Below Figure 13 represents the page that asks to connect AWS Amplify with the source. Select the repository service provider which you have used to store and update your source code.

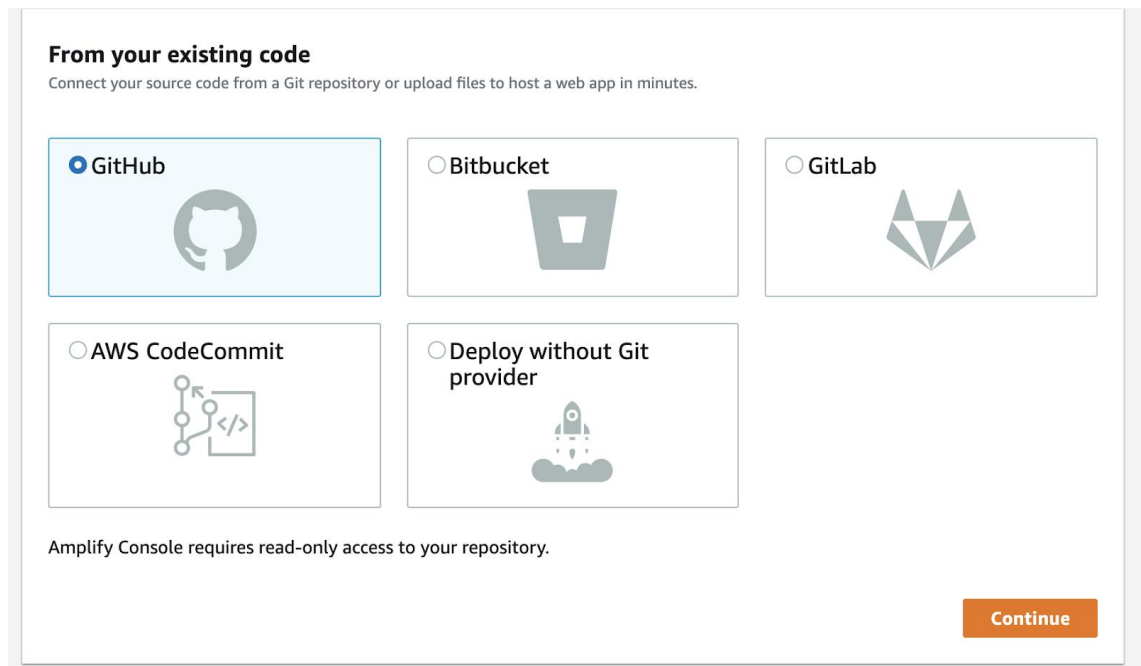


Figure 13. A page to connect source code with AWS Amplify.

For this experiment, I am choosing GitHub, but AWS Amplify also supports Bitbucket, GitLab, AWS CodeCommit, and also deploying without a Git provider is also possible. Press the continue button after the selection.

After connecting the repository service provider, a repository must be chosen, and choose a corresponding branch to build and deploy.

Below in figure 14, I am selecting a repository named ShoppingListApp and in the master in the branch section.

Step 1
Add repository branch

Step 2
Configure build settings

Step 3
Review

Add repository branch

GitHub

✔ GitHub authorization was successful.

Repository service provider
GitHub

Recently updated repositories
If you don't see your repository below, please push a commit and then click the refresh button.
pragatibhandari/ShoppingListApp

Branch
Select a branch from your repository.
master

Connecting a monorepo? Pick a folder.

Cancel Previous Next

Figure 14. Page to add a repository branch.

Using your repository, amplify determines the sequence of build commands that should be executed for the selected branch. Figure 15 represents the auto-detected apps build settings.

Build and test settings

We've auto-detected your app's build settings. Please ensure your build command and output folder (baseDirectory) are correctly detected.

```

1 version: 1
2 frontend:
3   phases:
4     preBuild:
5       commands:
6         - npm ci
7     build:
8       commands:
9         - npmrun build
10  artifacts:
11    baseDirectory: build
12    files:
13      - '**/*'
14  cache:
15    paths:
16      - node_modules/**/*
17
```

Build and test settings

Download

Edit

Figure 15. Auto-detected apps build settings.

Verify that the build commands and build output directory are accurate. Choose Edit to open the YML editor if the modification is needed. YML files can be downloaded and added to the root of the repository, or you can save your build settings on the servers.

A review page is displayed after you have checked and completed the build and test settings. Below figure 16 is a review page that shows repository details and app settings.

Review

Repository details

Repository service	Branch environment
GitHub	
Repository	Application root
pragatibhandari/ShoppingListApp	
Branch	
master	

App settings Edit

App name	Framework
ShoppingListApp	React
Build image	Build settings
Using default image	Auto-detected settings will be used
Environment variables	
None	

Cancel Previous Save and deploy

Figure 16. A review page.

Make sure your settings are correct by reviewing them all. To deploy your web app to a global content delivery network (CDN), Choose Save and deploy. App size affects how long it takes to build the front end. The build typically takes one to two minutes.

Below is figure 17 that shows the deployment steps i.e., Provision, Build, Deploy and Verify.

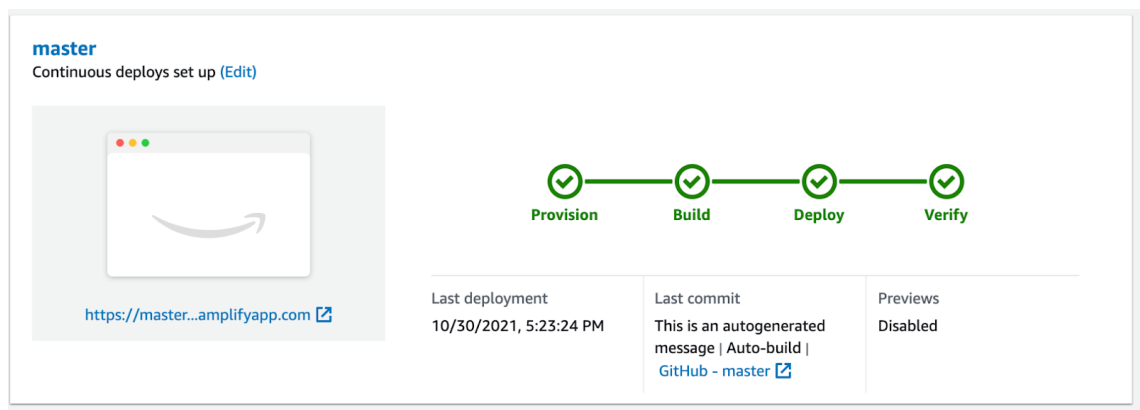


Figure 17. Four steps of the deployment process.

Choosing a progress indicator from the branch tile will lead you to the build logs screen. The stages of a build are as follows:

Build - There are three stages in the build phase: setup to clone the repository, deploy to deploy backend resources by running Amplify CLI, and build a front end to build your front-end.

Deploy - Upon completion of the builds, all artifacts are deployed to an Amplify-managed hosting environment. The entire deployment is atomic to ensure that there are no maintenance windows. Atomic deployments ensure that the web app is only updated once the entire deployment is complete.

Verify - Uses Headless Chrome to render screenshots of your app's index.html in multiple resolutions so you can verify that it is working correctly.

When AWS has completed deploying, you will be able to see your newly deployed application on the Amplify home page. Below figure 18 is the screenshot of the AWS Amplify management console page after the deployment of the app. You can access the deployed page by clicking anywhere in the box. You can also click the link generated on the left side of the deployment steps page as shown in figure 17.

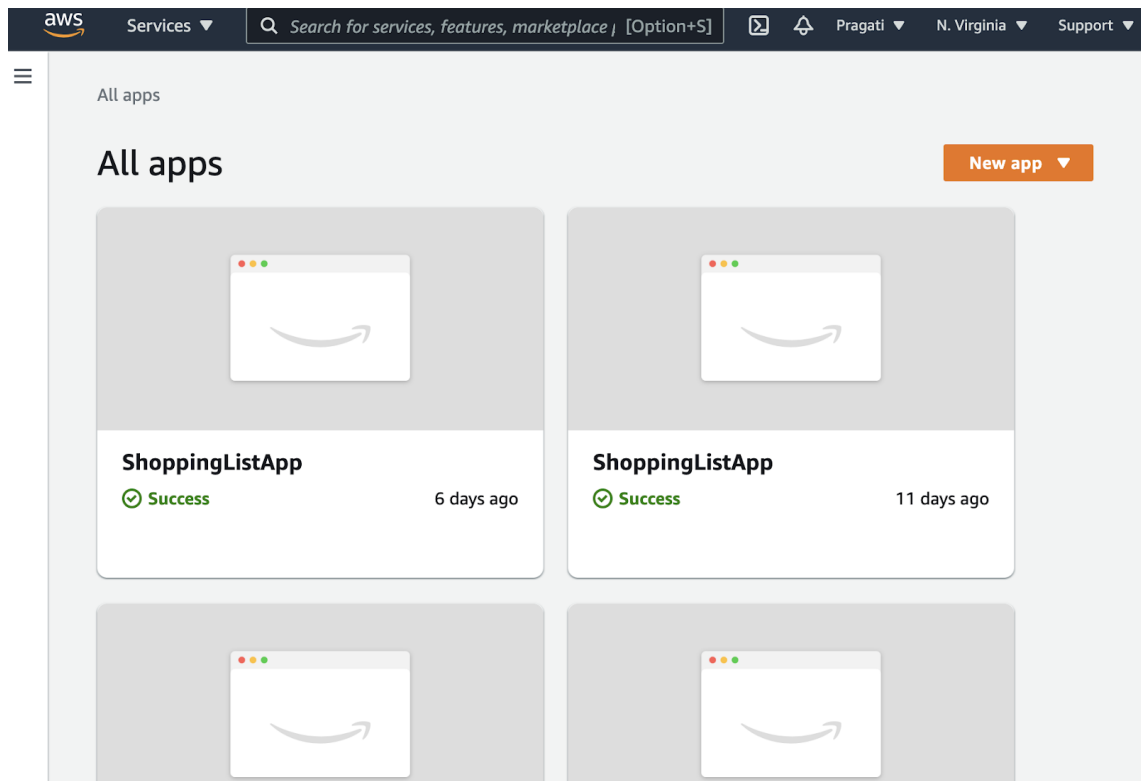


Figure 18. AWS Amplify management page after the deployment.

Below figure 19 shows the final web page which contains an auto-generated URL of the deployed web application.

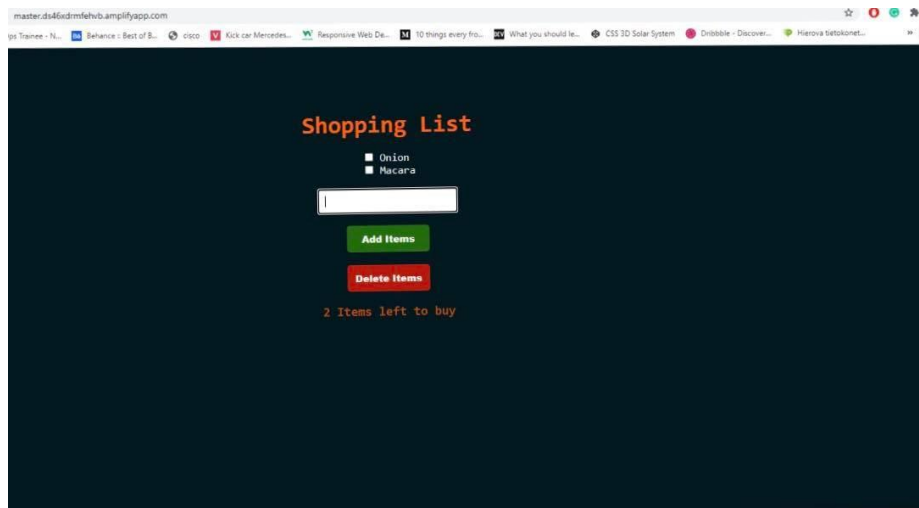


Figure 19. The deployed web page.

Furthermore, you can also add your custom domain name for your business. I am not using any custom domain name because this was done solely for the experiment purpose. Along with the frontend deployment, there is also a backend environment available where you can build your app backend with Amplify admin UI. The backend environment is a visual interface for developing an app backend and managing app content. You can also add authentication to your app and a database if needed.

5 Conclusions

Three major goals were set for this thesis. The first goal was to study the characteristics of Cloud computing and to discuss the pros and cons of Cloud computing. The second goal was to show the working example of cloud computing which was achieved by deploying a react app using an AWS service called Amplify. The third goal was to document all the research and the process the project was conducted. You can find all the necessary guides and instructions in the documentation regarding the pros and cons of Cloud computing and the application deployment process using Cloud Services. I consider the project success since I have achieved all the goals that were set for this thesis.

Although I have studied and documented Cloud computing and its Pros and Cons, further deep studies regarding this topic can be conducted in the future. The project, deployment of an app using AWS Amplify has been successfully conducted during this thesis however building the full-stack application with backend setup in AWS Amplify can be done in future projects. During this thesis, I have only used AWS as a cloud service provider however other cloud services like Google Cloud and Microsoft Azure can also be used to conduct the deployment of the application and the process of deployment can also be compared to each other.

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