

# **Best Fit Cloud Computing Solution for Bangladeshi Startups and Businesses Using Machine Learning Approach.**

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This Report Presented in Partial Fulfillment of the Requirements for the Bachelor of Science in Computing and Information System Degree.

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## APPROVAL

This Thesis titled “Best Fit Cloud Computing Solution for Bangladeshi Startups and Businesses using machine learning approach,” Submitted by MD FARIDUZZAMAN, ID No: 181-16-235 to the Department of Computing & Information Systems, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computing & Information Systems and approved as to its style and contents. The presentation was held on- 19-07-2023.


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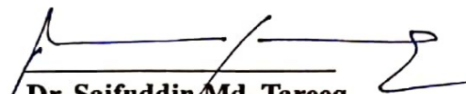
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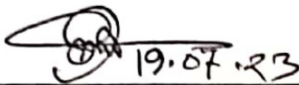
  
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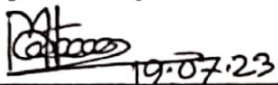
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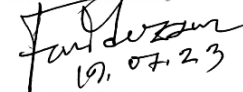
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## ABSTRACT

This research study aims to identify the most suitable cloud computing service for Bangladeshi startups and growing online businesses. Bangladesh's digital economy fast expansion has given rise to many startups and online businesses over all the digital economy, generating demand for dependable and cost-effective cloud computing services. This research aims to find the best suitable cloud computing solution for Bangladeshi startups and online enterprises through a comprehensive survey and the use of machine learning techniques for competitive and predictive analysis. The study questionnaire focuses on aspects critical to the success of these firms, such as price, scalability, performance, security, customer support services, and also a limitation of the old system.

The following study will provide significant insights into the present level of cloud computing usage in Bangladesh and advice for startups and existing online businesses looking for the best cloud services to match their individual needs. We are collecting data from 1000+ local Startups and online companies and interviewing 50+ individual tech entrepreneurs.

Based on the study, we are doing a machine learning competitive and predictive analysis. We used our collected data and based different parameters in the visual data and competitive analysis. Then we find the best-fit cloud computing service model type from IaSS, PaaS, SaaS, FaaS, and Hybrid. In this analysis, find the best cloud computing model is the Hybrid approach (A combination of PaaS & FaaS). This hybrid approach to cloud computing best fits Bangladeshi startups and online businesses based on survey data. After that, We are doing predictive & competitive analysis on machine learning based on our collected data. In this analysis, we are trying to find the market's best hybrid approach cloud computing service provider. Based on the different parameters. Cloud computing services is cost-effective, secure, migration, payment method, developer community, and service eco-system and are easy to migrate, has the best performance, and are accessible to payment methods for startups and online businesses. We list the top 5 market players like AWS, GCP, Azure, IBL Cloud, and Alibaba Cloud. This study recommends the best-fit cloud computing service AWS for Bangladeshi startups and online businesses.

In this research, a limitation we are trying to recommend based on present-time data and technology. FaaS and PaaS models have some limitations, but if the business has proper guidelines and architecture, then it will work fine. If technology comes and the ecosystem changes, this recommendation will change. This study helps Bangladeshi tech startups & online businesses reach their business next level and overall help the digital economy of Bangladesh.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Bangladesh is way to be a smart Bangladesh transformed by technology and IT. Bangladesh's digital economy is developing day by day. In recent years, digital platform-based economic activities have grown in popularity. Bangladesh's B2C e-commerce industry is estimated to reach \$10.5 billion by 2026 (Research and Markets, 2022). The country's software business is likewise expanding, with expected annual IT export sales of \$1.3 billion (BASIS, 2021). .Cloud computing technology is revolutionized the way organizations manage their IT infrastructure and services, offering scalability, agility, flexibility, and also cost-efficiency. The Internet to store and manage data on remote servers. We already know that Cloud computing is on-demand over the internet pay-as-you-go basis—our data and application run or store third-party cloud provider hardware. The consumer does not need any physical infrastructure for cloud computing. They use third-party rent infrastructure. People love cloud computing because Broad network access, resource pooling, and rapid elasticity are among the best features.

Bangladesh is a developing country, and we are developing our technology daily. We are on the way to making smart Bangladesh. Right now, the government is trying to make everything online-based. E-governing and governor all services online. Bangladesh trying to build Startup Eco-System is important to us for us. Bangladesh has some startup unicorns and 2000+ startups, and also thousands of growing online businesses in Bangladesh. When anyone builds a startup then, they try to get more traffic once a time. Startup Goal will go viral and get huge traffic at a time. But when startups get more traffic at a time, they can't be able to handle traffic at a time. That's why they have to use cloud computing services. for handling huge traffic loads. On the other hand, Cloud computing services are also costly and need cloud computing experts.

In this research paper, we will find the best-fit computing services for the Bangladeshi startups and online businesses. Bangladeshi most of the application is not fully adopted with cloud computing. Most of the applications and software are developed with no cloud computing advanced model-supported language. In that case, migration is one of the biggest challenges to for using cloud computing. That's why we recommend a hybrid model of cloud computing (FaaS) serverless cloud computing for migrating specific workloads to the cloud. Which is most cost-effective for any startup and growing online business. and PaaS for managing traditional web applications and software. There a lot of FaaS and PaaS cloud computing in this market. But we recommend the best cost-effective, scalable, better eco-system & community, secure, easy to payment method, Easy to migrate cloud computing service in Bangladesh.

## 1.2 Aim Of Research

The aim of research we are to offer the best suitable and innovative cloud computing services for the growing startups and Online business using a machine learning model. This paper proposes the best Cloud computing services for government & Startups and businesses. Which service is cost-effective and easy maintenance and also a more secure cloud service? The research will use a questionnaire to gather data on their specific requirements, preferences, and challenges. Subsequently, the collected data will be analyzed using machine learning-based predictive analysis and competitive analysis techniques. Here we are using startups and businesses real survey data from local startups and business entities, and individual CTO , CEO entrepreneurs, and cloud developers. In addition, we are discussing Cloud cost and Cloud Optimization Migration and, most importantly, adaptation-related issues. Which type of issue will be faced in the future if they want to migrate traditional hosting to Cloud computing. The research aims to recommend the best suitable cloud computing solution and cloud model for growing Startups and online businesses in Bangladesh.

## 1.3 Objective

Objective of the research is to find the best-fit cloud computing technology for the Bangladeshi startups and businesses. To achieve the goal of the research, we have completed some steps. In this paper, we are focused on some critical points and features of serverless cloud computing. Identify suitable cloud computing models and recommend the best cloud computing service environment.

- **Find out the cloud adoption challenges in Bangladesh:** We are gathering data from businesses and startups. Our aim is to conduct a research survey to gather information on the needs, preferences, and challenges of adapting to cloud computing for Bangladeshi startups and online businesses.
- **Proposed a hybrid (FaaS-PaaS) Approach for cloud computing:** We are proposing a feasible and advanced technology cloud computing model based on the context of Bangladeshi startups and the digital ecosystem. After collecting data from startups and businesses, we analyze the information using various machine learning models. Our analysis includes predictive and competitive analysis of survey data. Based on the collected data, we suggest a hybrid FaaS-PaaS approach for online businesses and startups in Bangladesh.

- **Best fit Cloud Computing Service Provider Recommendation:** After analysing the data, we find that we recommend the best-fit cloud computing solution for the proposed model which is best for Bangladeshi startups & online businesses. Best platform and best fit, which has a good eco-system, easy to migrate, cost-effective, Secure, and scalable for any business.

## 1.4 Research Scope

The goal of this study's research is to identify the best cloud computing solution for Bangladeshi startups and online businesses also the government organizations. A research questionnaire will be used in the investigation to gather pertinent information on the unique needs, difficulties, and expectations of both startups and online business organisations in Bangladesh with regard to cloud computing services.

The gathered data will be thoroughly examined using machine learning strategies for competitive and predictive analysis. Using this analysis, the research hopes to learn more about the various cloud computing service providers operating in the market, their products, and how well they meet the particular requirements and preferences of Bangladeshi entrepreneurs and government organisations.

Analyzing important aspects, including scalability, security, pricing, availability, performance, and support services provided by various cloud computing companies, will be part of the research. The study will also look into any particular compliance and regulatory issues pertinent to Bangladesh's government and startup sectors.

The research's scope also encompasses a comparison study of the results, allowing for determining the best cloud computing solution for Bangladeshi startups and Online business . The decision-makers will use this analysis to decide which cloud computing service best suits their needs.

It is crucial to remember that the conclusions of this study may not apply to other areas or business sectors because it is specifically targeted at Online businesses and startups in Bangladesh. The study will abide by ethical standards, guaranteeing participant anonymity, data protection, and confidentiality. which will help the industry with a new hybrid cloud methodology. To support informed decision-making that maximizes operational efficiency, cost-effectiveness, and overall performance in the cloud computing space, this research seeks to provide a thorough evaluation of cloud computing services for Bangladeshi startups and government organizations. On this specific topic, research and study are limited, especially in the Bangladesh context research papers and study limited. But cloud technology is the biggest the of future and nowadays.

## **1.6 Expected Output:**

After the research, We recommend an efficient evidence-based best-fit cloud computing approach and cloud computing service provider for Bangladeshi startups and Business services. Based On survey data, we can find the most scalable, secure, cost-effective, Performance key factor. Below we discuss briefly the expected output from this study.

### **Challenges of adaptation:**

We can find the most effective cloud service based on data and adaptability. The examination of the questionnaire data and the use of machine learning techniques will influence this recommendation. Which actually help startups and business make the right choices. here we will find new adoption challenges for startups business.

### **Suitable Cloud computing model:**

Based on the survey data, we will then analyze data to propose a new hybrid approach ( FaaS-PaaS) for our target audience. We using serverless cloud computing technology and platform as a service on our model to make it more effective. But most of the applications are not adoptable FaaS services. That's why we are proposing a hybrid approach for the startups and online businesses of Bangladesh.

### **Best fit cloud computing service provider:**

Based on our proposed hybrid approach, We compare and try to find out which cloud service providers fulfil our requirements. based on the research proposed approach. This rating is based on how effectively each service meets the needs and preferences of Bangladeshi startups and internet companies. Based On their community, Support, Cost, and Security.

### **Predict cloud computing future trends:**

Leveraging predictive analysis, the study will also aim to identify potential trends and shifts in the preferences of Bangladeshi startups and online businesses regarding cloud computing services. This will offer valuable insights into the future landscape of the cloud computing market in Bangladesh.

In the Study, we will assist startups, online business applications, and developers to elevate their businesses to the next level. We will provide a more efficient, scalable, and secure business solution. Our expected output will directly benefit the digital economy by improving data security and ensuring better service for application end-users.

## **CHAPTER 2**

### **BACKGROUND STUDY**

#### **2.1 Problem Background**

This is the time of the 4th Industrial Revolution when we used advanced technology. We use AI, IoT and Machine learning-based systems and applications for our business and regular life. According to the Bangladesh Telecommunication Regulatory Commission (BTRC), there were approximately 110 million internet users in Bangladesh as of March 2022. This represents a roughly 65% penetration rate. But private services, especially startups and businesses and also government systems, need to be capable of handling massive traffic at a time on the system. Bangladesh has approximately 1,000+ e-commerce platforms and over 300,000 online & f-commerce business websites. An additional million websites live in Bangladesh.

Most of the startups and online businesses are facing problems when more traffic comes to their website most of the time will be down. And also government services website goes down occasionally. In that case, cloud computing will be the best solution for them. Most startups aim to increase traffic and go viral but struggle to handle the influx of users. Similarly, government services often fail to manage high traffic, causing long wait times for users.

In recent years, Bangladesh has emerged as a centre for technological innovation and innovative companies. Additionally, the government employs technology to facilitate digital transformation and enhance governance. Cloud computing plays a crucial role in this development by providing scalable computational resources that are crucial for enterprises' growth and sustainability and government operations' efficiency. However, cloud computing adoption has challenges. There are many cloud service providers, and selecting the optimal cloud computing service is crucial for business operations' efficacy, cost-effectiveness, and security.

This research will contribute to identifying the most suitable cloud computing service for Bangladeshi startup entrepreneurs and online business owners and also government agencies. In addition, it is anticipated that the findings of this study will assist these organizations' decision-makers in selecting a cloud computing service, thereby enhancing their operational efficiency and global market competitiveness.

Inefficient architecture can make cloud computing expensive. However, in this paper, we propose a hybrid approach that is both cost-effective, scalable, and secure using advanced technology. The aim is to offer evidence-based suggestions to assist companies in selecting a cloud computing model and service provider. This will promote their digital transformation and facilitate business growth in the digital era.

## 2.2 Related Work:

There is a lack of comprehensive research on the adoption of cloud computing among growing startups and digital online businesses in Bangladesh. Although some studies have been conducted, they are limited in scope and insufficient. Furthermore, most of these studies were conducted using frameworks without any survey data. Before I work on this research I use to work for a cloud computing consultancy company in Bangladesh. I deal with real local clients and businesses directly. But here we discuss about some papers that give over of cloud computing in Bangladesh

(Sobhan, R. et al 2019) the author tries to find the concept of cloud accounting and its adoption in Bangladesh theoretical aspect of cloud computing adoption of Bangladesh. this paper is to explain the need of cloud accounting in a developing country like Bangladesh and to suggest a framework. But this study can't ensure which cloud computing service is best for Bangladeshi startups & online based on their requirements and eco-system.

The author of (Mazmuder et al. 2018) on this study discusses about the barriers to the adoption of Cloud Computing, especially in smaller businesses. In addition, frameworks address the drivers (incentives) and barriers to adopting Cloud Computing. This study provides an overview of adoption barriers to cloud computing for SMEs business and the conceptual frame of adaptation.

In this study, researchers (Khayer et al. 2020) are discuss about the SMEs and cloud providers in recognizing various important adoption factors which lead to the successful implementation of cloud computing. The results of importance-performance map analysis (IPMA) and neural network analysis, and neural network analysis indicate that the most significant predictor of cloud adoption for SME business of Bangladesh. Which overall overview only SME industry cloud adoption.

Another study conducted by (Lukman, H. 2020) evaluates the use of cloud computing using the Technological, organizational, and environmental (TOE) framework approach. In this paper, the author try to conduct a conceptual framework of cloud computing implementation on a start-up company's approach.

Another case study conducted by (Ferri, L. et al 2019) implementation that is increased opportunities, reduced costs, scalability, access to global markets, and access to international venture capital and try to provide he paper also finds that the success of cloud adoption depends on the favorable contextual conditions, such as regulation, technology readiness, and financial availability, and the communicative rationality of the founders.

Another case study conducted by (Anivesh Gani et al. 2020) The paper suggests that cloud computing is a crucial resource for various sectors and smart living, but it also raises some challenges and concerns regarding security, privacy, and integration. The paper aims to provide a basic overview of cloud computing and its development trends for readers who are interested in this topic.

Then we go to a hybrid cloud computing network which blending of two or more cloud services ( Son, M. et al 2022 ) In this research uses multiple cloud computing services FaaS and PaaS. This also provides a cost-efficient blending scheme for serverless applications with multiple chained functions their talk about Amazon Web Services (AWS) using an Abstract Syntax Tree (AST).

On this another research paper (Aalto-Yliopisto. et al 2019) in this research discusses about FaaS platforms can provide cost-effective and scalable web backends for low-traffic applications but have technical challenges and drawbacks compared to PaaS platforms.

(Nade, G. et al 2021) This paper shows how cloud computing helps startups with technology issues and compares AWS and Microsoft Azure for website hosting. The paper suggests that cloud computing is a good option for startups that want to save money and time and improve their performance and security

## **2.2 Rational Study.**

Many of the research was done on this topic, especially cloud service adaptation challenges on Bangladesh but most of the research didn't get, but most research did not get the expected results. Most of the research about cloud computing is on other issues but exactly on this topic. I read many research papers, literature reviews, and case studies about cloud computing. But there are no papers or evidence-based recommendations for startups and Online businesses and also govt entities companies on which cloud computing service is best.

This research survey will be used to collect data from startups, SMEs, online businesses, and also from government agencies, focusing on factors such as cost, scalability, security, performance, and compliance with local regulations. Then collected data were analyzed by machine learning using machine learning, different models, and competitive and predictive analysis then we proposed a hybrid cloud computing approach for this study endeavors to provide a data-driven, rigorous, and comprehensive evaluation of the cloud computing services ecosystem.

## 2.3 Research challenges

We faced a lot of abstraction and challenges in this research. Mostly we are facing when I collect data from startups and businesses and individuals tech entrepreneurs. After the data collection, the data labels and building models of the Data. Keeping up with these changes and assuring that the research findings are current is a persistent challenge. As we know, cloud computing changing frequently their features so that's why it is hard to the generalizability of the findings may be limited.

When we are labeling our data from the raw data it's one of the challenging parts and also, after having done a predictive analysis then, we have chosen a particular type of cloud computing it's tough. then we have proposed a cloud computing hybrid approach . However, we chose based on survey data no single data type of cloud computing matched with business requirements. After that, we have proposed a hybrid cloud computing system for the startup and business of Bangladesh. One of the challenges of research based on the proposed system is choosing the right service provider from the industry. Most challenge part is to recommend anything which is not our control.

### **Research challenges:**

- (a) Raw data collecting from local online businesses & startups
- (b) Data pre-processing for analysis
- (c) Data labeling before conducting analysis
- (d) Choosing the right cloud computing hybrid approach
- (e) Recommend the right service provider & better e-co system

These were the challenges we faced regarding research time, but we overcame them with appreciation and motivation from our CTO. Amazon Cloud Computing Architects and young entrepreneurs from Bangladesh helped us with this research. Most tech entrepreneurs are helpful and cooperative.



## 2.4 Research Questionnaires

Conducting research and gathering data from startups, businesses, and individual entrepreneurs and developers can be quite a challenge. To simplify the process, I break down the research questionnaires into three parts. The first part focuses on their business, the second part on their current systems or any issues they faced prior to adopting cloud computing, and the final part on their reasons for wanting to use cloud computing and their knowledge of its benefits. Our survey comprises 13 questions related to cloud computing, their experiences prior to using it, and their expectations. We have reached out to the entrepreneurial and business community in Bangladesh, including startups and the tech industry. We are delighted to share that some of Bangladesh's most prominent startups have participated and shared their valuable data.

### Research Questions On bellow:

1. Your Business Industry?
2. Your Application Type?
3. Your business application or system category?
4. Your business application or system category?
5. What is the biggest challenge of using cloud computing in Bangladesh?
6. What type of limitations do you facing? (when you do not use cloud computing)
7. Is your application compatible with cloud computing?
8. How much are you willing to spend for cloud monthly?
9. How much traffic did you get monthly?
10. What specific workloads or applications are you looking to move to the cloud?
11. Are you open to using multiple cloud service providers or do you prefer a single-provider solution?
12. Do you think cloud computing is cost-effective?
13. Do you think cloud computing is cost-effective?
14. Do you think cloud computing is secure?

These are the research questions for this survey. We have made the questions easy and simple for survey participants. Over 60% of respondents have answered the survey

## **CHAPTER 3**

### **SYSTEM WORKFLOW**

#### **3.1 Introduction**

We created a full roadmap system of techniques to find the best-fit cloud computing system for Bangladeshi startups and businesses. We collect data from businessmen and entrepreneurs running their businesses online. then we used a machine learning model for competitive and predictive analyses. The system methodology for this research on identifying the best cloud computing service for Bangladeshi startups and online businesses will involve the

#### **3.2 Workflow diagram**

To conduct our research, we begin by collecting survey data from the target audience. We then preprocess this data for Data Analysis and Machine Learning model. Our analysis includes both Competitive and Predictive analyses. Using the results from our Competitive analysis, we select the best cloud computing model that fits our needs. Following the Predictive analysis, we determine the best cloud computing service solution for our proposed approach.

We compare our proposed system and recommended cloud service provider with other service providers and discuss our reasons for choosing this model and service. This workflow diagram visualise the sequence of the our work process for this research.

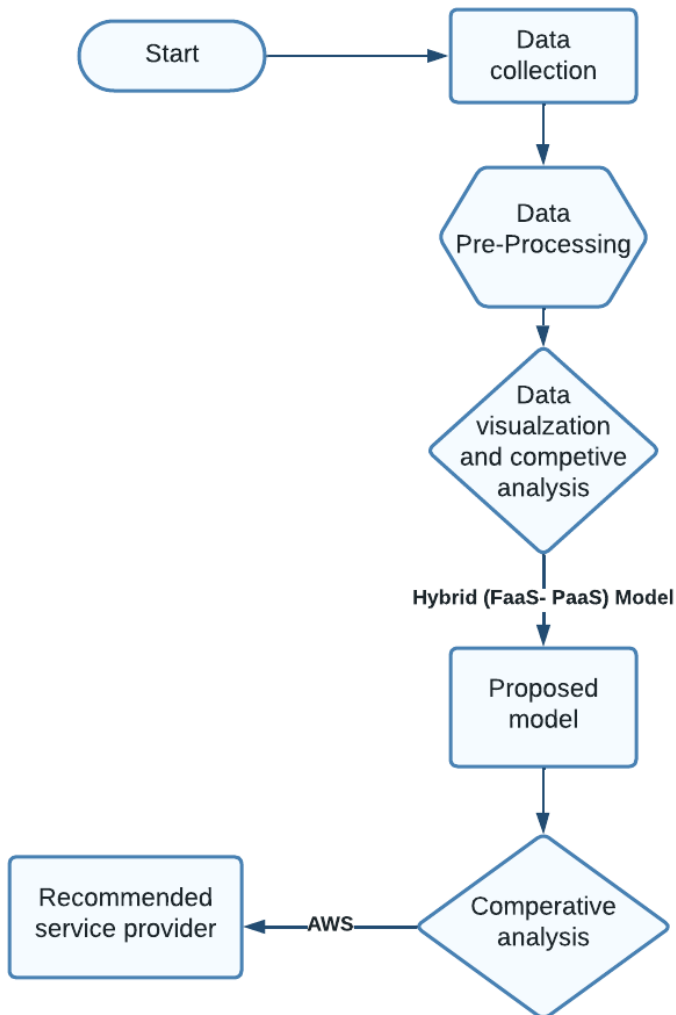


Fig 1: Flowchart of Research workflow diagram

In this workflow diagram, we present the workflow of this research and how to conduct research, here's the workflow for your academic research "Best fit Cloud Computing Solution for Bangladeshi Startups and Online Businesses using machine learning approach."

## CHAPTER 4

### SYSTEM METHODOLOGY

#### 4.1 System Overview:

In this methodology, we will discuss how to conduct system research effectively. Once we have obtained the raw survey data, our focus will be on obtaining more accurate and refined data. The next step involves processing the data collected from local businesses and startups. Once the data is ready, we will analyze it and select a cloud computing approach that best suits Bangladeshi startups and online businesses. We conducted a predictive analysis of the available market services to achieve this. Finally, we will recommend a suitable service provider for our proposed system. The following are the steps involved:

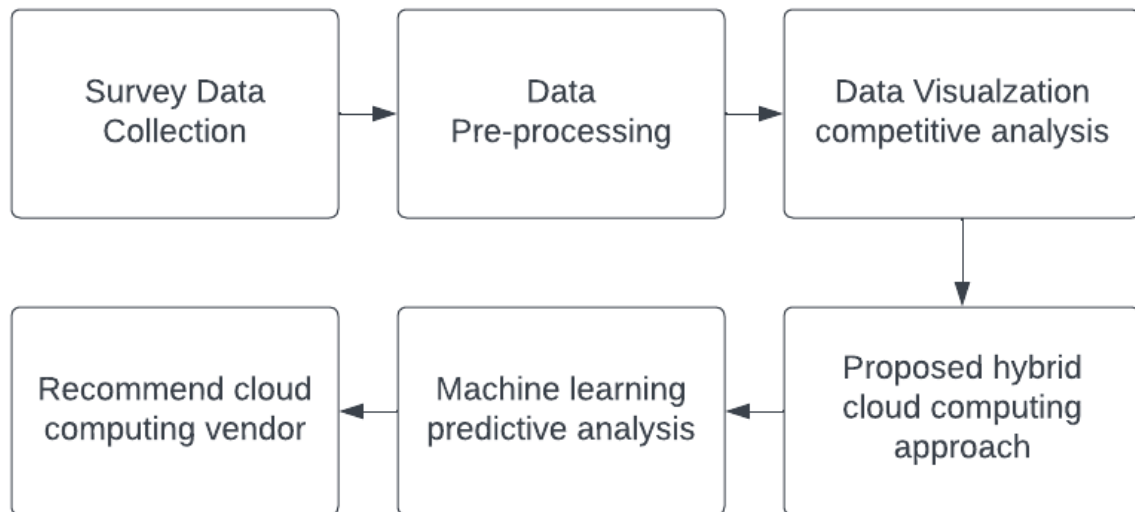


Fig 2: Research methodology process block diagram.

Here we will present a process diagram for the research methodology used in this study. The diagram provides an overview of the major parts of the process but does not include all micro elements of the major work process.

## 3.2 Data Collection.

As a part of our research, collecting data from startups and individual entrepreneurs through interviews can be challenging. To ensure a diverse group of participants, we plan to distribute a research questionnaire to a representative sample of Bangladeshi startups and online businesses across various industries, company sizes, and stages of development. The survey will consist of quantitative and qualitative questions to gain insight into the respondents' expectations, technical requirements, and budget constraints regarding cloud computing services.

The survey will target individuals such as founders, CEOs, CTOs, or IT managers in these companies. In addition, we conducted a survey at the AWS Bangladesh Day event, where we spoke with over 20 tech entrepreneurs face-to-face about their challenges in adopting cloud solutions.

## 3.3 Data Processing

We collect data directly and manually from local online businesses & startups. After collecting the survey responses, the data will be preprocessed to prepare it for machine learning competitive analysis and predictive analysis. Data processing is important for the get more accurate results. For the analysis, we have labeled the raw data. We divided the data tow portation into one for competitive analysis and one portion for predictive analysis. Once the survey data has been collected, it undergoes a thorough cleaning and preprocessing phase to ensure its suitability for analysis. This crucial process involves managing missing values, encoding categorical variables, and normalising numerical variables. By properly preprocessing the data, we can accurately and efficiently apply machine learning techniques to it, making it an essential step in the research process. Data preprocessing steps include

We cleaning data from row data and remove some null values

- (a) **Data Cleaning:** Removing incomplete or inconsistent responses and handling missing values to ensure the integrity of the dataset. The first stage is to clean the data, which involves finding and correcting any errors, inconsistencies, or missing information. For missing values, you can either remove the entries or impute the missing values with an acceptable estimation, such as the variable's mean or median. In addition, examine for duplicate records and decide whether to delete or maintain them based on the study context

```
[ ]
Index(['application type', ' compatible with cloud computing', 'Cost',
      'workloads or full?', 'Provider ', 'Cloud computing Model ',
      'Unnamed: 6', 'Unnamed: 7', 'Unnamed: 8', 'Unnamed: 9', 'Unnamed: 10'],
      dtype='object')
```

```
[ ] df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 217 entries, 0 to 216
Data columns (total 11 columns):
#   Column                                     Non-Null Count  Dtype
---  ---
0   application type                           216 non-null    object
1   compatible with cloud computing            216 non-null    object
2   Cost                                       216 non-null    object
3   workloads or full?                        217 non-null    object
4   Provider                                  214 non-null    object
5   Cloud computing Model                     217 non-null    object
6   Unnamed: 6                                217 non-null    object
7   Unnamed: 7                                0 non-null      float64
8   Unnamed: 8                                0 non-null      float64
9   Unnamed: 9                                0 non-null      float64
10  Unnamed: 10                               1 non-null      object
dtypes: float64(3), object(8)
memory usage: 18.8+ KB
```

```
[ ] df.rename(columns = {'Unnamed: 6':'cloudcomputingname'}, inplace = True)
df.rename(columns = {'application type':'applicationtype'}, inplace = True)
df.rename(columns = {' compatible with cloud computing':'CWCC'}, inplace = True)
df.rename(columns = {'workloads or full?':'workloadOrFull'}, inplace = True)
df.rename(columns = {'Cloud computing Model':'CloudComputingModel'}, inplace = True)
```

We remove null and unwanted values from the data

- (b) **Data Transformation:** Converting categorical variables into numerical values, such as encoding binary variables or performing one-hot encoding. Following data cleaning, you may need to alter or normalize the data for further analysis. This could include normalization or scaling for numerical variables. Scaling modifies the values such that they have a standard distribution with a mean of 0 and a standard deviation of 1. Normalisation rescales the values to fit within a specific range, such as [0, 1]

whereas scaling rescales the values to fit within a certain range, such as [0, 1]. You may need to encode categorical variables into numerical values using one-hot or label encoding techniques.

- (c) **Data Partitioning:**

The preprocessed data must be divided into separate training and testing sets to assess the prediction model's performance. The training set is used to construct the model, while the testing set assesses its performance. A usual data split ratio is 70% for training and 30% for testing, which may vary based on the study environment.

- (d) **Feature Scaling:** Standardizing or normalizing the input features to ensure equal importance is given to each variable during model training.

### 3.4 Data Labeling.

Data labelling is one of the tough jobs for us. In this study, we collect our data manually then we are . Data labelling is an essential step in preparing your dataset for competitive analysis using machine learning algorithms. In the context of your research, the survey data collected from Bangladeshi startups and online businesses need to be labelled before it can be used for clustering or decision tree algorithms. Here are some general steps for labelling the data:

```
[ ] X_train = scaled.fit_transform(X_train)
    X_test = scaled.transform(X_test)

[ ] X_train
    [ 0.56581838, -0.87559381, -2.41701103, -0.40677712, 0.5      ,
      0.46820441],
    [ 0.56581838, 0.42574745, -2.41701103, -0.40677712, -1.75   ,
      -0.55678363],
    [ 0.56581838, -0.87559381, 0.63011572, -0.40677712, 0.5     ,
      -0.55678363],
    [ 0.56581838, 0.42574745, 0.63011572, 2.45834869, 0.5     ,
      -0.55678363],
    [ 0.56581838, 0.42574745, 0.63011572, 2.45834869, 0.5     ,
      -0.55678363],
    [-2.89314684, -0.87559381, -0.89344766, -0.40677712, 0.5     ,
      -0.55678363],
    [ 0.56581838, 0.42574745, 0.63011572, -0.40677712, 0.5     ,
      -0.55678363],
    [ 0.56581838, 0.42574745, -0.89344766, -0.40677712, 0.5     ,
      1.49319245],
    [ 0.56581838, -0.87559381, -0.89344766, -0.40677712, 0.5     ,
      -0.55678363],
    [ 0.56581838, 1.7270887 , 0.63011572, -0.40677712, 0.5     ,
      -0.55678363],
    [ 0.56581838, 0.42574745, -0.89344766, -0.40677712, -1.75   ,
      1.49319245]
```

we are using Label Encoder and StandardScaler for the labelling data

- (1) identify the variables:
- (2) Categorize the variables
- (3) Encode categorical variables
- (4) Normalize numerical variables
- (5) Handle missing values

## **2.5 Cloud computing adaptation challenges:**

Cloud computing is a highly promising solution for businesses worldwide, offering scalable and cost-effective options for data storage, software applications, and infrastructure. However, startups and online businesses in Bangladesh encounter several challenges when it comes to adopting cloud computing. Limited infrastructure and internet connectivity pose significant obstacles, which can hinder the effective use of cloud-based services. Slow and unreliable connections can impact performance, leading to a suboptimal user experience.

Furthermore, data security and privacy concerns are significant obstacles to cloud adoption in Bangladesh. Companies may hesitate to store sensitive data on third-party servers due to potential risks such as data breaches and unauthorized access. Additionally, navigating regulatory compliance can be challenging, as cloud computing services often involve storing and processing data across borders. Startups and online businesses need to comply with local and international data protection regulations, such as GDPR.

Another challenge is the lack of technical expertise, as having a skilled workforce that understands cloud architecture, security, and management is essential for successful implementation and operation. Moreover, vendor lock-in and interoperability issues can complicate cloud adoption. It may be difficult or costly for businesses to switch providers or migrate data, and interoperability between different cloud services and platforms can be challenging.

Lastly, effective cost management is crucial for Bangladeshi startups and online businesses using cloud computing. To avoid unexpected expenses, it is essential to understand the pricing models of different cloud services and monitor resource usage. To overcome these challenges, businesses should invest in technical training, collaborate with experienced cloud service providers, and develop a comprehensive cloud adoption strategy that addresses security, compliance, and cost management concerns.

### **(a) Lack of human cloud technology resources:**

Lot of challenges in Bangladesh to use cloud computing. Lack of cloud computing expertise and human resources. We interviewed entrepreneurs are faced many barriers. The most significant part of 40% of entrepreneurs thinks they need to start using cloud technology for the need for expert human resources.



**(b) Application not compatible with cloud computing technology:**

Another most significant part of (36%) of entrepreneurs thinks they need not to use the cloud technology Application not compatible with cloud computing. Most of the cases, coding structure and system architecture do not cloud computing support.

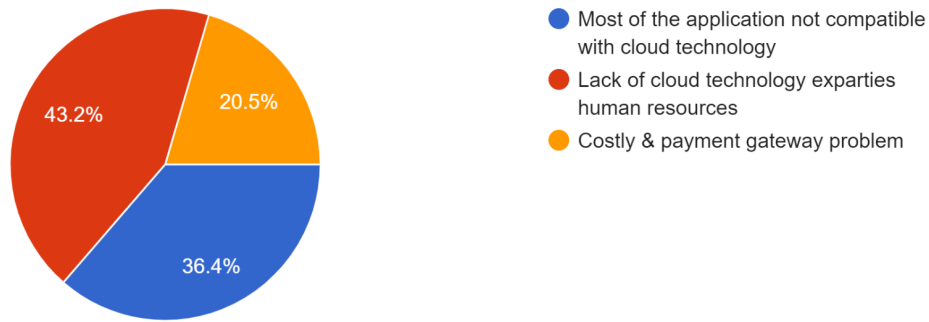


Fig 3: Biggest Challenges to Adoption in Bangladesh.

But most of the applications are adaptable to cloud computing if they use hybrid technology. they are most of the time, think about data security, but if they use the on-premise system and with public cloud computing, that will be better for the organization,

**(C) Cost & Payment Method:**

For businesses and startups in Bangladesh, choosing a payment method when adopting cloud computing is critical. Many of these businesses need access to dual currency cards, which means that owners cannot use cloud computing services for their online operations.

Outside of those several challenges, Data privacy and security are top concerns for startups and online businesses considering cloud adoption, Financial Constraints, There's also the risk of vendor lock-in, where businesses find it difficult and costly to switch providers or migrate data back on-premises due to restrictive contracts or proprietary technology. These challenges underscore the need for empirical research to guide startups and online businesses in Bangladesh in their cloud adoption journey.

### 4.3 Data visualization Analysis & competitive analysis.

After collecting the survey responses, the data will be preprocessed to prepare it for analysis. Data preprocessing steps include. Based on the application type, application are fully compatible or partially compatible. To conduct predictive analysis using machine learning for this research paper, begin by collecting data through a research survey questionnaire administered to a representative sample of Bangladeshi startups and online businesses. Preprocess the collected data to ensure quality and suitability, then perform feature selection to identify the most relevant variables contributing to the prediction of the best-fit cloud computing approach.

In this phase, different predictive models are tested to find the one that best suits the study's requirements. This includes regression models, decision trees, neural networks, and others. The selection of the model depends on the nature of the problem and the data, with the aim of achieving the highest accuracy and generalisation ability. The selected model is then trained using a portion of the preprocessed data, and its performance is validated using a separate subset of the data, which was not used in the training process. This helps ensure that the model can generalise well to new, unseen data, and it is balanced to the training data. Hyperparameters may be adjusted to improve the predictive accuracy depending on the model's initial performance. This process often involves techniques like grid search or random search to systematically explore the model's parameter space.

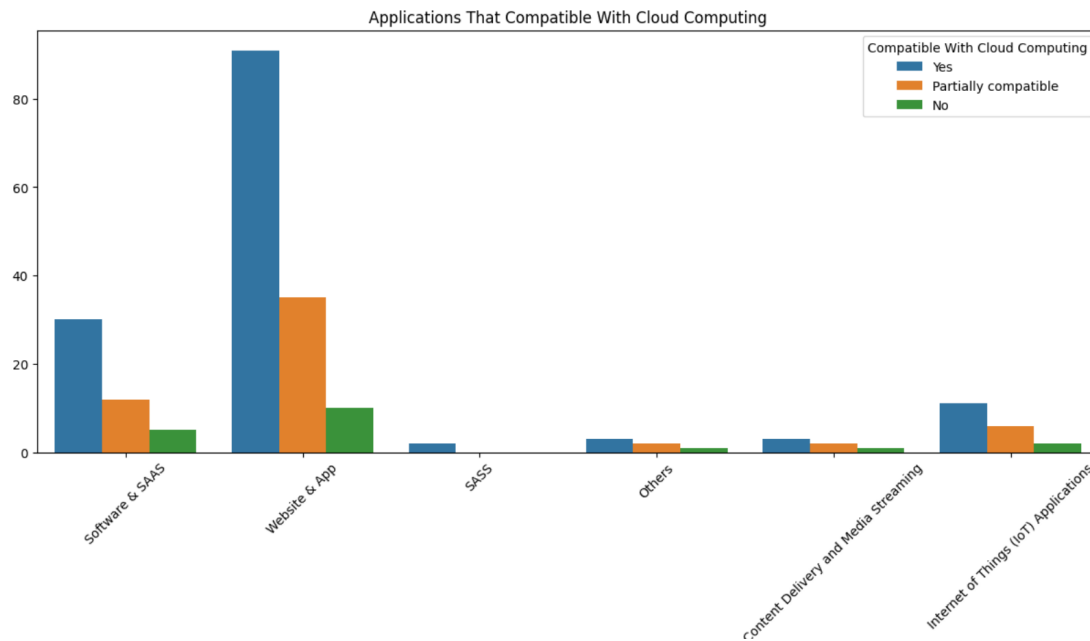
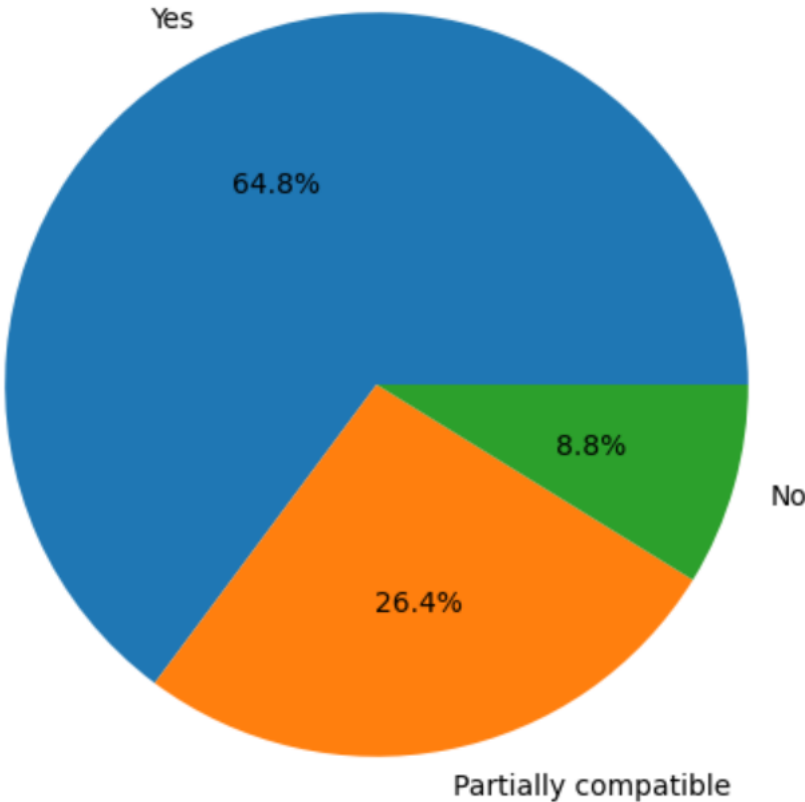


Fig 4: Applications compatibility with cloud technology/.

We use Seaborn to visualise data. This study analysed Bangladeshi applications by type and compatibility with cloud computing technology.

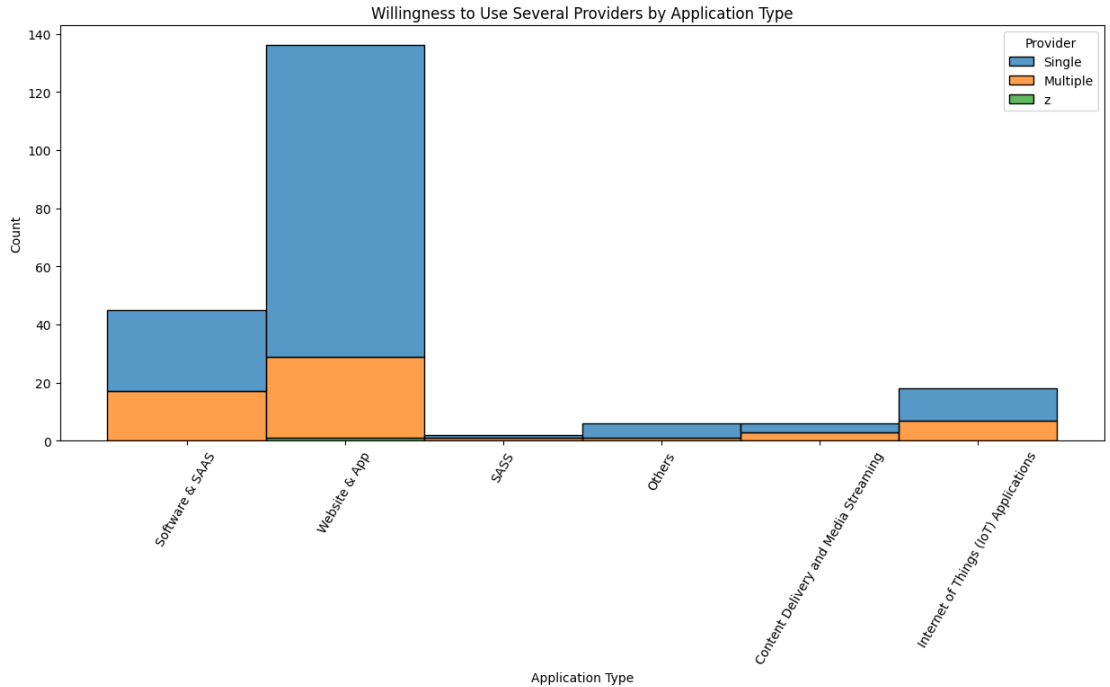
We found that websites and apps are the largest groups of applications, with most being partially compatible with the cloud. SAAS and software applications are mostly compatible with cloud computing technology, but a small proportion are only partially supported.

Most IoT projects support cloud technology, but only a few IoT applications partly support cloud computing. Overall, most applications are only partially compatible with cloud computing technology.



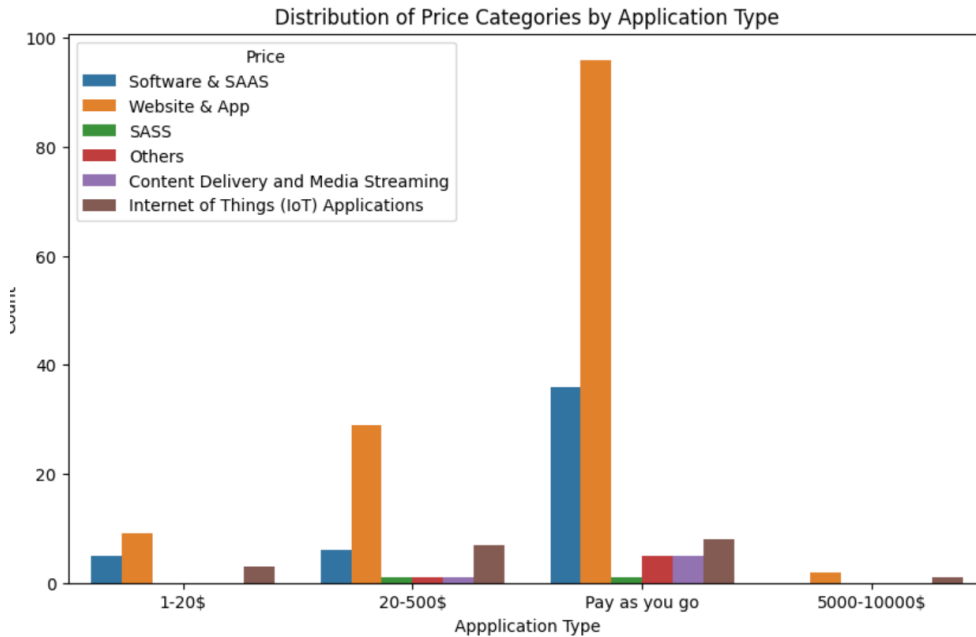
**Fig 5:** Percentage of supported applications compatibility

A majority of 64% of applications are compatible and supported by cloud computing technology, while 26.4% offer partial cloud computing support. Only 8.8% of applications do not support cloud computing technology. Based on this information, it is reasonable to assume that a cloud computing model proposed for Bangladeshi startups and online businesses should support partially compatible applications and incorporate the latest technology.



**Fig 6:** Different types of applications want to use single or multiple cloud providers

Now, we see this visualization most of the applications are not want to use a single cloud provider service, and also business owners are interested to use multiple cloud computing systems. So, we have thought of the hybrid methodology for the cloud computing model.



**Fig7:** Types of applications that will pay money for cloud computing

Many applications prefer a "Pay-as-you-go" pricing model, which is well-suited for cloud computing. Some businesses are willing to pay a monthly fee ranging from \$20 to \$500 for cloud computing services, while very few are interested in paying upwards of \$500 to \$1000 per month. So, if we want to propose a new model, it should be budgeted-friendly for the startup and business.

Here code for the competitive analysis.

```
[ ] 0 cloud_provider_name      217 non-null      object
    [ ] 7 Unnamed: 7          0 non-null      float64
      8 Unnamed: 8          0 non-null      float64
      9 Unnamed: 9          0 non-null      float64
     10 Unnamed: 10         1 non-null      object
dtypes: float64(3), object(8)
memory usage: 18.8+ KB

[ ] data.drop(['Unnamed: 7', 'Unnamed: 8', 'Unnamed: 9', 'Unnamed: 10'], inplace=True, axis=1)

[ ] data.rename(columns={'application type': 'Application Type'}, inplace=True)
data.rename(columns={'compatible with cloud computing': 'Compatible With Cloud Computing'}, inplace=True)
data.rename(columns={'Cost': 'Price'}, inplace=True)
data.rename(columns={'workloads or full?': 'Workloads or Full Application'}, inplace=True)
data.rename(columns={'Provider ': 'Provider'}, inplace=True)
data.rename(columns={'Cloud computing Model ': 'Cloud Computing Model'}, inplace=True)
data.rename(columns={'cloud provider name': 'Cloud Provider Name'}, inplace=True)

[ ] dt = data.copy()
dt.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 217 entries, 0 to 216
Data columns (total 7 columns):
#   Column                                Non-Null Count  Dtype
---  ---                                -
0   Application Type                       216 non-null    object
1   Compatible With Cloud Computing         216 non-null    object
2   Price                                   216 non-null    object
3   Workloads or Full Application          217 non-null    object
4   Provider                                214 non-null    object
5   Cloud Computing Model                  217 non-null    object
6   Cloud Provider Name                    217 non-null    object
dtypes: object(7)
```



To conduct predictive analysis using machine learning for this research paper, begin by collecting data through a research survey questionnaire administered to a representative sample of Bangladeshi startups and online businesses. Preprocess the collected data to ensure quality and suitability, then perform feature selection to identify the most relevant variables contributing to the prediction of the best-fit cloud computing approach.

Next, Utilize these predictions to recommend the FaaS-PaaS cloud computing approach to Bangladesh's relevant startups and online businesses.

```

+ Code + Text Copy to Drive
# Calculate the counts of each cloud computing model within each price category
low_model_counts = low_price_df['Cloud Computing Model'].value_counts()
mid_model_counts = mid_price_df['Cloud Computing Model'].value_counts()
high_model_counts = high_price_df['Cloud Computing Model'].value_counts()
extra_high_model_counts = extra_high_price_df['Cloud Computing Model'].value_counts()

# Create a stacked bar plot
plt.figure(figsize=(10, 6)) # Adjust the figure size as desired
models = np.unique(dt['Cloud Computing Model'])

low_counts = [low_model_counts.get(model, 0) for model in models]
mid_counts = [mid_model_counts.get(model, 0) for model in models]
high_counts = [high_model_counts.get(model, 0) for model in models]
extra_high_counts = [extra_high_model_counts.get(model, 0) for model in models]

plt.bar(models, low_counts, label='1-20$',
        plt.bar(models, mid_counts, bottom=low_counts, label='20-500$',
        plt.bar(models, high_counts, bottom=np.add(low_counts, mid_counts), label='Pay as you go',
        plt.bar(models, extra_high_counts, bottom=np.add(mid_counts, high_counts), label='5000-10000$')

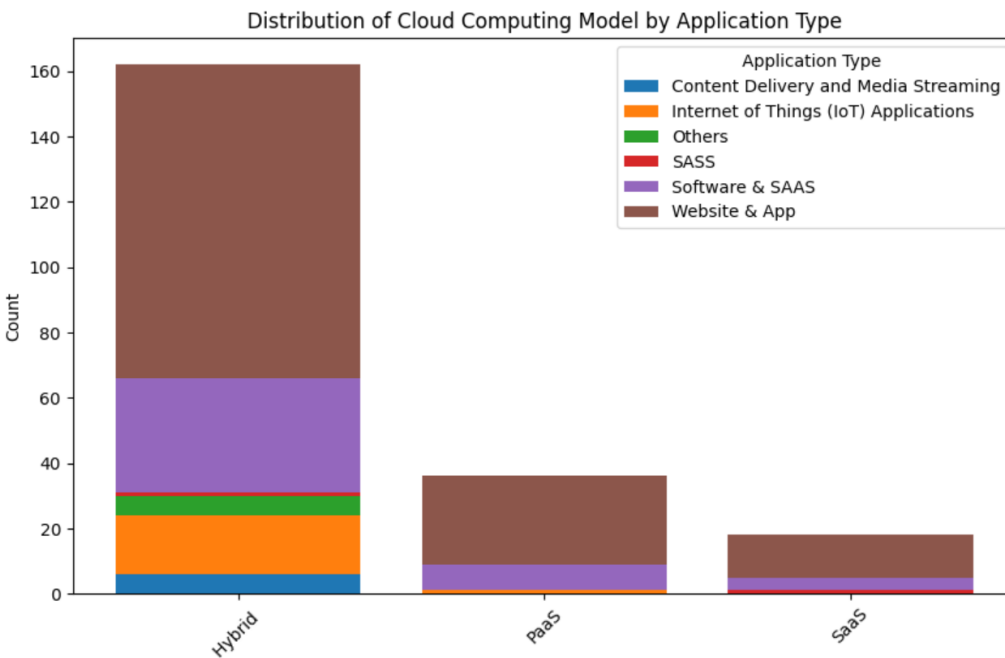
# Set the title and labels
plt.title('Cloud Computing Models by Price Category')
plt.xlabel('Cloud Computing Model')
plt.ylabel('Count')

# Rotate the x-axis tick labels if needed
plt.xticks(rotation=45)

# Add a legend
plt.legend(title='Price Category')

# Display the plot
plt.show()

```



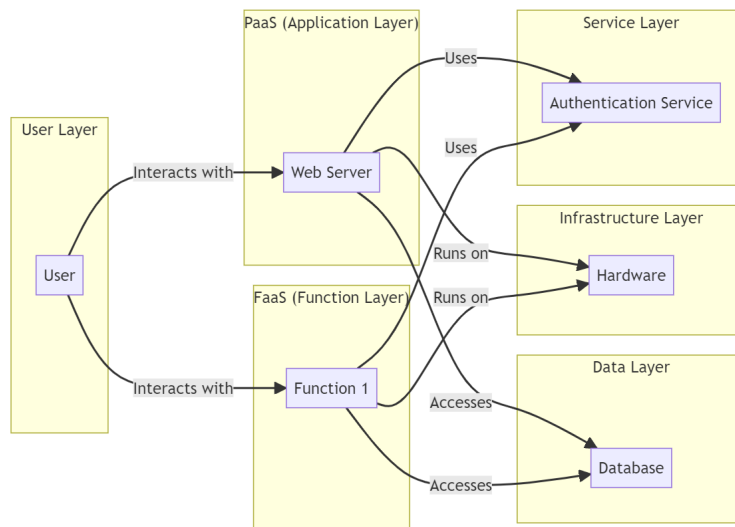
**Fig 8:** Based on application category recommend cloud computing model

Based On the above data, most the business and startup owners are want to use pay as you go model. And they also want to use some time single or multiple cloud service providers. On the other hand , Most of the applications are not adoptable advance cloud computing technology like (FaaS) Function as a Service. So, we decided to a hybrid cloud computing approach will be the best and most feasible cloud computing model for the target group of our research.

The FaaS-PaaS hybrid approach offers benefits but has potential drawbacks like latency, resource limitations, increased complexity, vendor lock-in, and provider lock-in. Traditional monitoring and debugging tools may not function effectively in serverless environments, and the pay-as-you-go model can make expenses unpredictable. Users share responsibility for application security, and misconfigurations can lead to vulnerabilities. It's crucial to weigh these drawbacks against the benefits when choosing a cloud strategy.

### 3.6 Proposed FaaS- PaaS Hybrid Model:

Based on the survey data, predictive analysis reveals that most Bangladeshi startups and online businesses prefer to utilize cloud computing to handle high traffic and business operations smoothly. Business owners often migrate to cloud technology, partially or fully. However, they prioritize cost-effective and secure solutions for their business needs.



**Fig 10:** How to work proposed model (FaaS- PaaS)

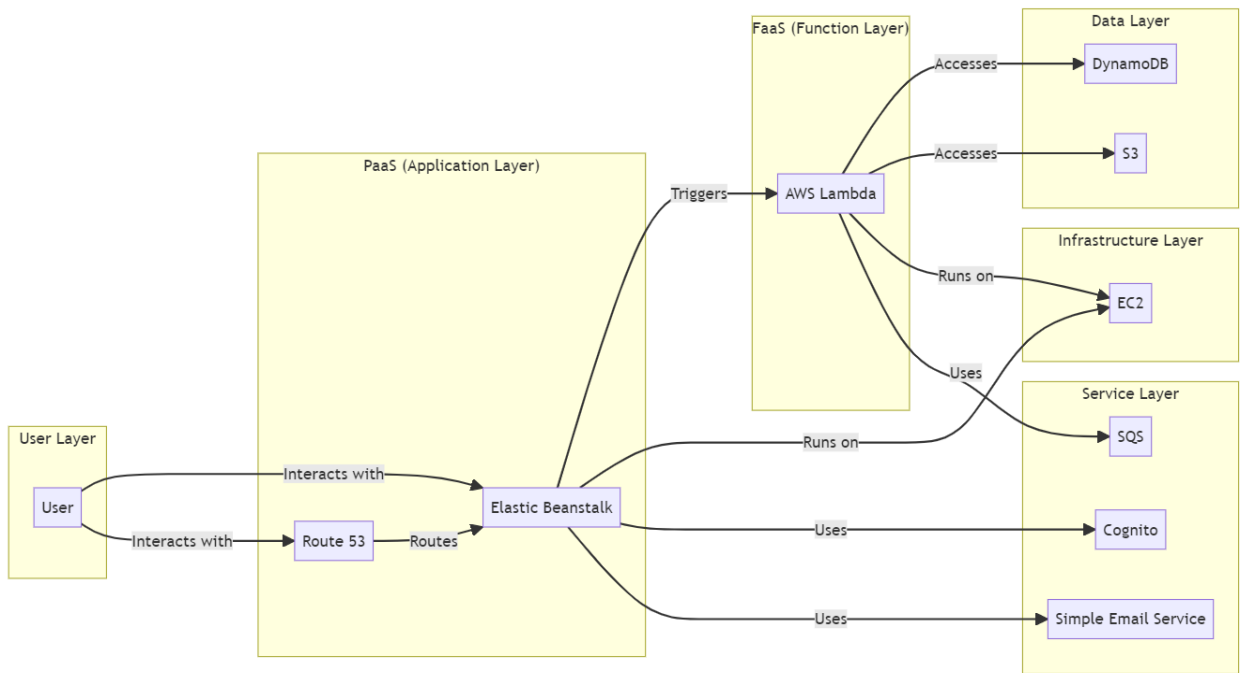
Our proposed hybrid FaaS-PaaS hybrid approach is feasible for Bangladeshi startups and growing online businesses. Most startups and Online businesses are websites & applications so we have to . The FaaS component is responsible for managing tasks triggered by events, while the PaaS component manages services that run for longer periods. After the function or service completes its execution, the response is sent back to the API Gateway and eventually delivered to the client. When we choose any architecture for the hybrid cloud computing model, it should focus on three points, connected, modernized, and secure. Bangladeshi most of the businesses are e-commerce systems & applications and some SaaS applications.

Suppose a business is considering migrating to cloud computing. In that case, they may need several barriers, including a lack of cloud computing experts and human resources in their country, as well as the challenge of fully or partially adopting cloud computing technology. However, a hybrid approach that combines Function as a Service (FaaS) and Platform as a Service (PaaS) can provide a flexible and cost-effective solution for startups and online businesses.

This approach enables developers to build, deploy, and manage applications and services using a mix of serverless functions and platform-based resources. FaaS is ideal for event-driven, stateless, and highly scalable applications, while PaaS is more suitable for traditional web applications, APIs, or services that require a persistent runtime environment and greater control over infrastructure configurations.

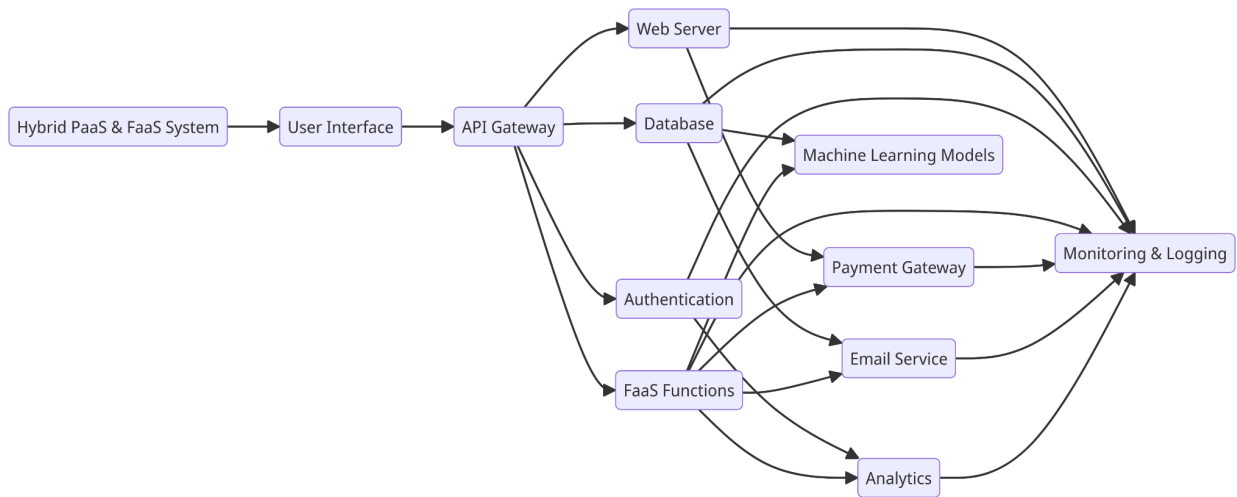
The FaaS component is responsible for managing tasks triggered by events, while the PaaS component manages services that run for longer periods. After the function or service completes its execution, the response is sent back to the API Gateway and eventually delivered to the client.





**Fig 11:** Represent using a hybrid approach (FaaS- PaaS ) hybrid using AWS services

Here, we represent the proposed cloud computing hybrid approach for e-commerce and Online business.



**Fig 11:** Relational Model Hybrid approach (FaaS-PaaS) model for e-commerce

In summary, the FaaS-PaaS hybrid approach offers a tailored solution that combines the advantages of both FaaS and PaaS, providing startups and online businesses with a flexible, scalable, and cost-effective cloud computing model. While other models may be more suitable for specific use cases, the hybrid approach caters to the unique needs and challenges of these organisations, enabling them to grow and compete in the digital landscape

The FaaS-PaaS hybrid approach offers benefits but has potential drawbacks like latency, resource limitations, increased complexity, vendor lock-in, and provider lock-in. Traditional monitoring and debugging tools may not function effectively in serverless environments, and the pay-as-you-go model can make expenses unpredictable. Users share responsibility for application security, and misconfigurations can lead to vulnerabilities. It's crucial to weigh these drawbacks against the benefits when choosing a cloud strategy.

While specific examples of companies using a FaaS-PaaS hybrid approach in Bangladesh may not be readily available, there are several companies worldwide that have successfully leveraged a combination of FaaS and PaaS for their cloud computing needs. These examples can demonstrate the potential benefits and use cases of this approach

### **4.3 Machine Learning predictive analysis:**

Next, split the preprocessed dataset into training and testing subsets and select an appropriate classification algorithm, such as logistic regression, kneighbors classifier, gradientboostingclassifier, and also randomforestclassifier. Train the selected algorithm using the training dataset, and evaluate its performance on the testing dataset using metrics like accuracy, precision, recall, and F1-score. Fine-tune the algorithm's hyperparameters, if necessary, to improve its performance. Once the predictive model is optimized and demonstrates satisfactory performance, deploy the model to make predictions on new, unseen data. Utilize these predictions to recommend the FaaS-PaaS cloud computing approach to Bangladesh's relevant startups and online businesses. In the final analysis phase, the selected classification algorithm will be employed to predict the most suitable cloud computing service for unobserved startups and online businesses. The model will be trained on the preprocessed data and validated using a holdout sample or cross-validation techniques to ensure its generalizability

**Data Cleaning:** Removing incomplete or inconsistent responses and handling missing values to ensure the integrity of the dataset.  
**Data Transformation:** Converting categorical variables into numerical values, such as encoding binary variables or performing one-hot encoding.

**Feature Scaling:** Standardizing or normalizing the input features to ensure equal importance is given to each variable during model training.

**Train:** the trained and tuned model is evaluated on a final test set of data. This step provides a final measure of the model's predictive performance and validates its ability to generalize to new data. The last step involves interpreting the predictions made by the model and extracting actionable insights. In this study, these insights are used to propose the FaaS-PaaS hybrid approach as the most suitable cloud computing solution for Bangladeshi startups and online businesses

```
from google.colab import drive
drive.mount('/content/drive')
```

Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force\_remount=True).

```
import re
import string
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder
from sklearn.utils import resample
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
lb = LabelEncoder()
```

Fig: Here we call some algorithm models and libraries for this analysis

The first step involves collecting data about different cloud service providers. This could include factors such as cost, scalability, security features, support for FaaS and PaaS, global reach, reliability, and customer service. Data can be gathered from various sources, including provider documentation, customer reviews, and independent benchmark studies.

```

cloudComputing.ipynb ☆
File Edit View Insert Runtime Tools Help Changes will not be saved
+ Code + Text Copy to Drive

[ ] df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 217 entries, 0 to 216
Data columns (total 11 columns):
#   Column                                Non-Null Count  Dtype
---  -
0   application type                       216 non-null   object
1   compatible with cloud computing        216 non-null   object
2   Cost                                   216 non-null   object
3   workloads or full?                    217 non-null   object
4   Provider                               214 non-null   object
5   Cloud computing Model                  217 non-null   object
6   Unnamed: 6                             217 non-null   object
7   Unnamed: 7                             0 non-null     float64
8   Unnamed: 8                             0 non-null     float64
9   Unnamed: 9                             0 non-null     float64
10  Unnamed: 10                            1 non-null     object
dtypes: float64(3), object(8)
memory usage: 18.8+ KB

[ ] df.rename(columns = {'Unnamed: 6': 'cloudcomputingname'}, inplace = True)
df.rename(columns = {'application type': 'applicationtype'}, inplace = True)
df.rename(columns = {'compatible with cloud computing': 'CWCC'}, inplace = True)
df.rename(columns = {'workloads or full?': 'workloadOrFull'}, inplace = True)
df.rename(columns = {'Cloud computing Model': 'cloudComputingModel'}, inplace = True)

[ ] df.head()

   applicationtype  CWCC   Cost   workloadOrFull  Provider  cloudComputingModel  cloudcomputingname  Unnamed: 7  Unnamed: 8  Unnamed: 9  Unnamed: 10
0  Software & SAAS  Yes    1-20$  Partial specific workloads  Single          Hybrid          AWS             NaN         NaN         NaN         NaN

```

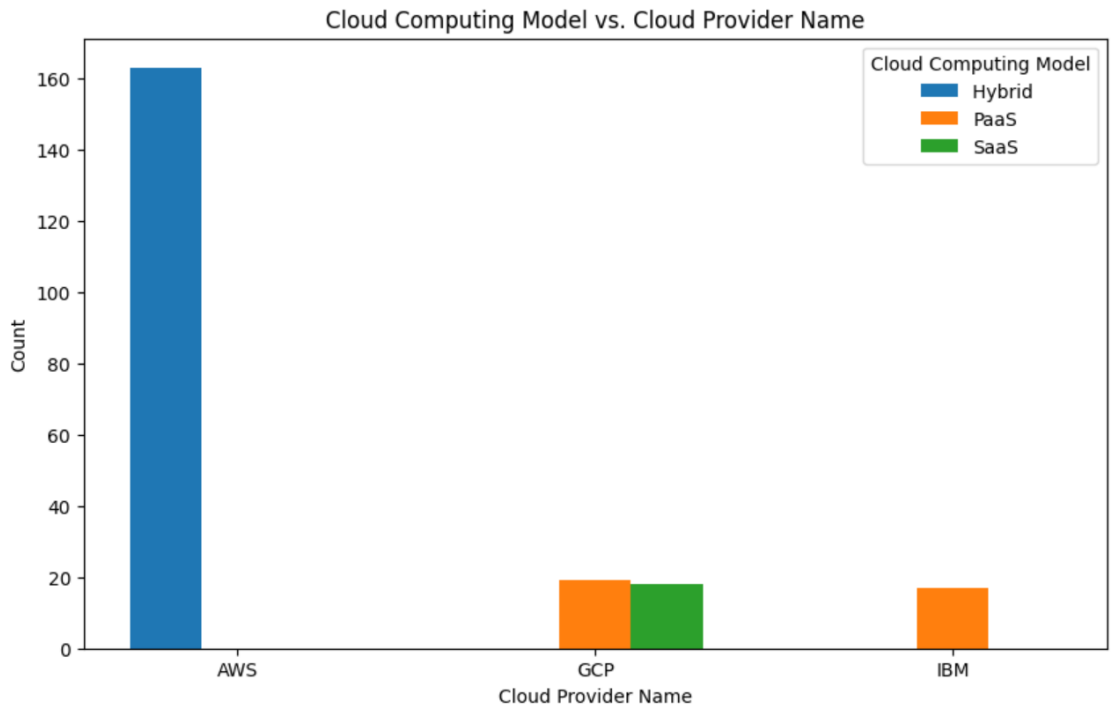


Fig 12: Recommend service for Hybrid approach

```
[ ] applicationtype      object
      CWCC              object
      Cost              object
      workloadOrFull    object
      Provider          object
      cloudComputingModel object
      cloudcomputingname object
      dtype: object
```

```
[ ] for col in df.columns:
      if df[col].dtype=='object':
          df[col] = lb.fit_transform(df[col])
```

```
df.head()
```

	applicationtype	CWCC	Cost	workloadOrFull	Provider	cloudComputingModel	cloudcomputingname
0	4	2	0	1	2	0	0
1	5	2	1	0	2	0	0
2	5	2	4	1	2	0	0
3	5	2	1	1	2	2	1
4	3	2	4	1	1	0	0

```
[ ] X = df.drop('cloudcomputingname',axis=1)
      y = df.cloudcomputingname
```

```
[ ] X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state=101)
```

Fig: Ready data for the train using and convert the string value to numeric value.

```
[ ] X = df.drop('cloudcomputingname',axis=1)
      y = df.cloudcomputingname
```

```
[ ] X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state=101)
```

```
[ ] scaled = StandardScaler()
```

```
[ ] X_train = scaled.fit_transform(X_train)
      X_test = scaled.transform(X_test)
```

```
[ ] X_train
```

```
[ 0.56581838, -0.87559381, -2.41701103, -0.40677712,  0.5      ,
 0.46820441],
 [ 0.56581838,  0.42574745, -2.41701103, -0.40677712, -1.75   ,
-0.55678363],
 [ 0.56581838, -0.87559381,  0.63011572, -0.40677712,  0.5      ,
-0.55678363],
 [ 0.56581838,  0.42574745,  0.63011572,  2.45834869,  0.5      ,
-0.55678363],
 [ 0.56581838,  0.42574745,  0.63011572,  2.45834869,  0.5      ,
-0.55678363],
 [-2.89314684, -0.87559381, -0.89344766, -0.40677712,  0.5      ,
-0.55678363],
 [ 0.56581838,  0.42574745,  0.63011572, -0.40677712,  0.5      ,
-0.55678363],
```

✓ 0s completed at 11:09 PM

Fig: Transfer the data using standardScaler

We using a different model for accuracy

```
knn = KNeighborsClassifier(n_neighbors=2)
knn.fit(X_train, y_train)
y_pred = knn.predict(X_test)

print(classification_report(y_test, y_pred))
print(accuracy_score(y_test, y_pred))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	46
1	1.00	0.86	0.92	7
2	0.67	1.00	0.80	2
accuracy			0.98	55
macro avg	0.89	0.95	0.91	55
weighted avg	0.99	0.98	0.98	55

0.9818181818181818

**Fig:** Using KNeighborsClassifier algorithm and accuracy rate 9.80.

```
[ ] gbc = GradientBoostingClassifier(random_state=0)
gbc.fit(X_train,y_train)
```

▼ GradientBoostingClassifier  
GradientBoostingClassifier(random\_state=0)

```
[ ] y_pred = gbc.predict(X_test)
```

```
[ ] print(classification_report(y_pred,y_test))
print(accuracy_score(y_pred,y_test))
print(confusion_matrix(y_pred,y_test))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	46
1	1.00	1.00	1.00	7
2	1.00	1.00	1.00	2
accuracy			1.00	55
macro avg	1.00	1.00	1.00	55
weighted avg	1.00	1.00	1.00	55

**Fig:** Using GradientBoostingClassifier algorithm and model accuracy rate 1.00.

```
[ ] pred = rfc.predict(X_test)
```

```
[ ] pred
```

```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 1,
       0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1,
       0, 2, 0, 0, 2, 0, 0, 0, 1, 0, 0])
```

```
[ ] print(classification_report(y_test,pred))
print(accuracy_score(y_test,pred))
print(confusion_matrix(y_pred,y_test))
```

	precision	recall	f1-score	support
0	1.00	1.00	1.00	46
1	1.00	1.00	1.00	7
2	1.00	1.00	1.00	2
accuracy			1.00	55
macro avg	1.00	1.00	1.00	55
weighted avg	1.00	1.00	1.00	55

Fig: Using RandomForestClassifier algorithm and model accuracy rate 1.00

Based on the model accuracy, we run the test to predict the cloud computing Service provider for the proposed model. We input condition application compatibility, price, and number of service providers that want to use.

```
[ ] new_data = np.array([4,2,0,1,2,0])
new_data_reshaped = new_data.reshape(1, -1)
prediction = lg_from_joblib.predict(new_data_reshaped)
print(prediction)
```

```
[0]
```

```
[ ] new_data = np.array([4,2,0,0,1,0])
new_data_reshaped = new_data.reshape(1, -1)
prediction = knn_from_joblib.predict(new_data_reshaped)
print(prediction)
```

```
[0]
```

Fig: Model predicts the result 0, mean AWS.

Based on the machine learning data analysis based on the selected parameter system recommended to use AWS for the proposed (FaaS-PaaS) hybrid approach.

For the proposed hybrid methodology ( FaaS -PaaS ) there are some service provider available on marketing. To ensure efficient access from Bangladesh, it is recommended to consider utilizing international cloud providers with data centers located within the region or those that offer global coverage. Below are the top five cloud providers that can be utilized for a FaaS-PaaS hybrid approach. Choosing the best service for hybrid FaaS and PaaS use cases depends on your specific requirements, technology stack, and preferences. Here are some popular cloud providers that offer both FaaS and PaaS services:

	Amazon web services (AWS),	Microsoft Azure,	IBM Cloud	Google Cloud Platform (GCP),	Alibaba Cloud
PaaS	AWS Elastic Beanstalk, AWS App Runner	Azure App Service, Azure Kubernetes Service (AKS)	IBM Cloud Foundry	Google App Engine	Alibaba Cloud Function Compute
FaaS	AWS Lambda	Azure Functions	IBM Cloud Functions	Google Cloud Functions	Alibaba Cloud Web App Service

**Table 1:** Available Services for proposed system (PaaS -FaaS ) hybrid approach.

### **Amazon Web Services (AWS)**

AWS has a vast global infrastructure, and although it does not have a data center in Bangladesh, it has numerous data centers in the Asia-Pacific region, which can provide relatively low-latency access from Bangladesh. AWS offers both FaaS (AWS Lambda) and PaaS (AWS Elastic Beanstalk) services that can be leveraged for a hybrid approach.

### **Microsoft Azure**

Microsoft Azure has a broad global coverage. While it doesn't have a data centre directly in Bangladesh, it has data centers in nearby regions such as India and Southeast Asia. Azure provides FaaS (Azure Functions) and PaaS (Azure App Service) services that can be used for a FaaS-PaaS hybrid approach.



## **Google Cloud Platform (GCP)**

Google Cloud Platform has an extensive global network, and even though it doesn't have a data center in Bangladesh, it has data centers in the Asia-Pacific region that can offer relatively low-latency access. GCP offers both FaaS (Google Cloud Functions) and PaaS (Google App Engine) services for a hybrid approach.

## **IBM Cloud**

IBM Cloud has a global presence with data centers in various regions, including the Asia-Pacific. While it doesn't have a specific data center in Bangladesh, the nearby data centers can be used for relatively low-latency access. IBM Cloud offers FaaS (IBM Cloud Functions) and PaaS (IBM Cloud Foundry) services for a hybrid approach.

## **Alibaba Cloud**

Alibaba Cloud, the cloud computing arm of Alibaba Group, has a growing global presence with data centers in the Asia-Pacific region. Although it doesn't have a data center in Bangladesh, the nearby data centers can be used for relatively low-latency access. Alibaba Cloud provides FaaS (Alibaba Cloud Function Compute) and PaaS (Alibaba Cloud Web App Service) services for a FaaS-PaaS hybrid approach.

Here we are comparing this service provider for their service Why we choose AWS from the market AWS is most suitable for our business and startup.

- (1) Mature and feature-rich services:
- (2) Broad range of complementary services
- (3) Strong developer ecosystem:
- (4) Global infrastructure
- (5) Flexible pricing

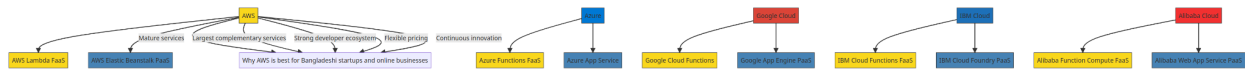


Fig 13: Comparison AWS with another service

Additionally, a feature importance analysis will be conducted to identify the most influential factors in determining the best-fitting cloud computing service. This analysis will provide valuable insights for startups and online businesses to prioritize their requirements when selecting a cloud computing service and for cloud service providers to improve their offerings to better cater to the needs of the Bangladeshi market.

FaaS-PaaS hybrid cloud architecture using AWS services. The architecture includes:

- Amazon API Gateway for handling API requests
- AWS Lambda for serverless functions (FaaS)
- Amazon S3 for storing static files
- Amazon RDS as a relational database
- AWS DynamoDB as a NoSQL database
- Amazon SQS for message queuing

AWS Elastic Beanstalk for deploying and managing web applications (PaaS)

The diagram also includes a web application and a worker application hosted on AWS Elastic Beanstalk. The services are color-coded based on their service category, with FaaS services in yellow and PaaS services in blue.

here we visualized our proposed system with AWS Services

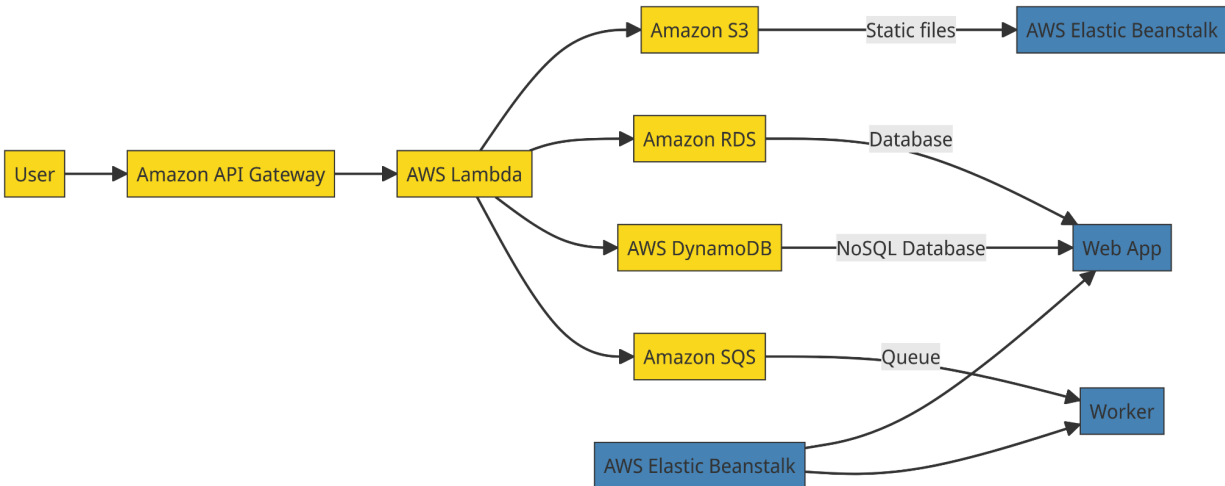


Fig 15: Using AWS Proposed system architecture

Amazon Web Services (AWS) is an ideal cloud computing service provider for Bangladeshi startups and online businesses due to its extensive service offerings, scalability, cost efficiency, global reach, robust security, continuous innovation, and strong support system. AWS offers a vast catalog of services that support both Function as a Service (FaaS) and Platform as a Service (PaaS) models, essential for the proposed hybrid approach. Services such as AWS Lambda for FaaS and Elastic Beanstalk for PaaS provide an environment where applications can be developed, deployed, and scaled without the need to manage underlying infrastructure. AWS's pay-as-you-go pricing model aligns with the financial constraints of startups, allowing them to pay only for the services they use. The provider's vast network of data centers worldwide ensures reduced latency and improved application performance, critical factors for online businesses serving customers globally. AWS also prioritizes security, offering end-to-end encryption and a wide range of compliance certifications, assuring businesses handling sensitive data. Lastly, the strong support system and large developer community surrounding AWS provide a reliable source of assistance and shared knowledge, an invaluable resource for startups and online businesses navigating their growth journey.

AWS is a leading cloud service provider with complex service offerings, a steep learning curve, and a complex cost structure. Its global presence may impact specific markets, and vendor lock-in can be a significant concern. Additionally, AWS's shared responsibility model requires proactive measures to ensure application security, but its benefits often outweigh the drawbacks.

## CHAPTER 5

### DATASET & DISEASE DESCRIPTION

#### 5.1 Dataset Description

Based On Data we gather after machine learning competitive and predictive analysis. Most of the Bangladeshi startup's full applications did not adopt with cloud computing. Most of the startups are interested in partial workloads and applications to run the cloud. In that case, a Serverless cloud computing service is best for startups. Serverless cloud computing is part of the Platform As Service ( PaaS) part. In a serverless architecture, you only pay for the actual usage and execution time of your functions, instead of pre-allocating and paying for dedicated servers.

We collected data from 1000+ plus startups and are using those data to train our system. We made a dataset on ourselves with a cloud expert. We interviewed most of the biggest startups in Bangladesh and also famous startups in Bangladesh. We conducted 3,000 entrepreneurs. we get responses of almost 250+. All our work has been done on Google Collab.

#### 5.2 Evaluation of Proposed Hybrid Approach

Based on the on predictive analysis we are proposing (4.5) Hybrid FaaS- PaaS cloud computing approach for the startups and growing online businesses of Bangladesh.

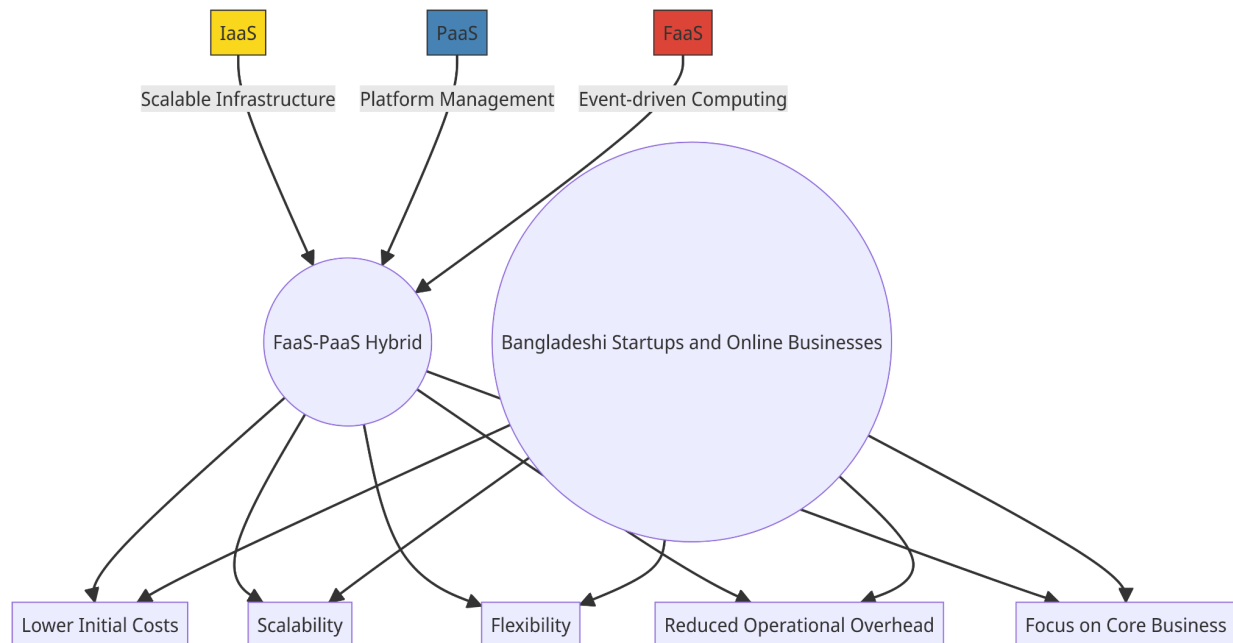


Fig 16: Comparison Hybrid (FaaS-PaaS) with the other cloud service model.

If you're a startup or online business in Bangladesh, you might be wondering why a FaaS-PaaS hybrid approach to cloud computing is the best choice. This approach offers the benefits of both Function as a Service (FaaS) and Platform as a Service (PaaS) for a customized solution. To better understand how this model stacks up against other cloud computing options, let's compare the features of Infrastructure as a Service (IaaS), Software as a Service (SaaS), and FaaS-PaaS.

**Infrastructure as a Service (IaaS):** IaaS provides virtualized computing resources over the Internet, allowing users to deploy and manage their own operating systems, applications, and middleware. Users have more control over their infrastructure than PaaS and SaaS but also have increased management responsibilities.

**IaaS compare to the FaaS-PaaS hybrid approach,** IaaS offers more flexibility in terms of configuration and customization. However, it also requires more management effort and expertise from the user. The hybrid approach, however, abstracts away infrastructure management while still providing flexibility in application development and deployment, making it particularly suitable for startups and online businesses with limited resources and expertise.

**Platform as a Service (PaaS):** PaaS offers a platform for developing, deploying, and managing applications without worrying about the underlying infrastructure. While PaaS provides a higher level of abstraction than IaaS, it still requires users to work with application-level components.

**PaaS Compared to the FaaS-PaaS hybrid approach:** The FaaS-PaaS hybrid approach complements PaaS by integrating FaaS's event-driven architecture, which allows for more granular resource utilization and cost savings. This combination results in a solution that enables efficient application development while optimizing resource usage and costs.

**Software as a Service (SaaS):** SaaS provides fully functional software applications over the Internet, with users not needing to worry about infrastructure, platform, or application management. While SaaS offers the highest level of abstraction among cloud computing models, it also provides the least amount of flexibility and customization.

**SaaS Compared to the FaaS-PaaS hybrid approach:** SaaS is more suitable for organizations that require ready-to-use applications with minimal customization. However, startups and online businesses that need to develop custom applications or features can benefit more from the flexibility and resource optimization provided by the FaaS-PaaS hybrid approach.

### 5.3 Proposed hybrid approach Cloud service provider Evaluation:

Our proposed hybrid approach of cloud computing service we here are many of services available on the market for FaaS and PaaS at this moment we are going to select AWS for our hybrid FaaS- PaaS approach model.

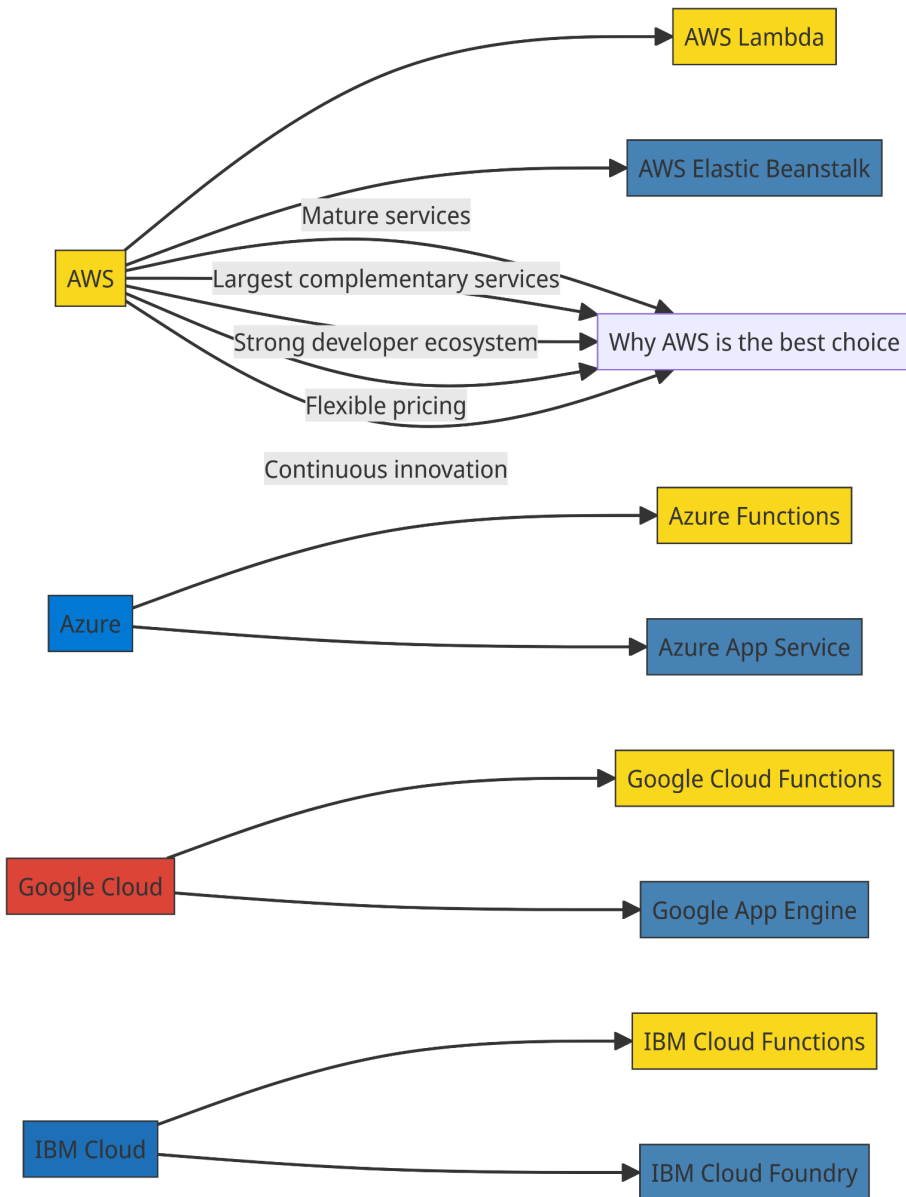


Fig:

AWS is considered the best FaaS-PaaS hybrid cloud computing approach for Bangladeshi startups and online businesses for several reasons:

**Mature services:** AWS has been in the market since 2006 and has developed a mature and reliable set of services. Their FaaS (AWS Lambda) and PaaS (AWS Elastic Beanstalk) offerings are well-established, with a proven track record of performance, making them a reliable choice for startups and online businesses.

**Largest complementary services:** AWS offers the most comprehensive set of complementary services, including storage (Amazon S3), databases (Amazon RDS, Amazon DynamoDB), messaging (Amazon SQS, SNS), and many others. This extensive ecosystem allows for seamless integration and scaling of applications as the business grows.

**Strong developer ecosystem:** AWS has a vast community of developers, providing abundant resources, tutorials, and tools to help startups build, deploy, and maintain their applications. This support accelerates development and reduces the learning curve for new users.

**Flexible pricing:** AWS offers a pay-as-you-go pricing model, which allows startups and online businesses to pay only for the resources they consume. This model is particularly beneficial for businesses with fluctuating workloads, as they can scale resources up or down as needed without incurring unnecessary costs.

By offering a robust, scalable, and flexible FaaS-PaaS hybrid cloud computing approach, AWS caters to the unique needs of Bangladeshi startups and online businesses, helping them focus on their core competencies while reducing infrastructure and operational overhead.

AWS's robust support system and large developer community provide a reliable source of assistance and shared knowledge, proving invaluable for startups and online businesses navigating their growth. Considering these factors, AWS emerged as the optimal choice for implementing the proposed FaaS-PaaS hybrid approach for Bangladeshi startups and online businesses

## CHAPTER 6 CONCLUSION & FUTURE WORK

### 6.1 Conclusion & future work

Our study aimed to identify the ideal cloud solution for startups and online businesses in Bangladesh. To gather data, we conducted a research survey questionnaire, which was later analyzed through machine learning. Our predictive analysis led us to recommend the FaaS-PaaS cloud computing approach as the best fit for our target audience. In the second phase, we conducted a competitive analysis and found AWS to be the top choice for the proposed FaaS-PaaS approach.

The results of our research have significant implications for the cloud computing landscape in Bangladesh. Startups and online businesses can benefit from our findings by adopting the FaaS-PaaS hybrid approach using AWS services. This approach offers a flexible, scalable, and cost-effective solution, allowing businesses to focus on their core competencies while minimizing operational and infrastructure overhead.

### 6.2 Future Work:

#### Future Research Scope

While the research outcomes are promising, several opportunities exist for further exploration and expansion of the findings:

**Broadening the scope:** The current study focused on Bangladeshi startups and online businesses. Future research could assess the applicability of the FaaS-PaaS hybrid approach across other sectors and geographical regions to evaluate its wider relevance and potential benefits.

**Long-term impact analysis:** Researchers can conduct a longitudinal study to assess the long-term effects of implementing the FaaS-PaaS hybrid approach and AWS services on the growth and success of Bangladeshi startups and online businesses.



**Incorporating emerging technologies:** Investigating the integration of cutting-edge technologies, such as edge computing, artificial intelligence, and IoT, within the FaaS-PaaS hybrid cloud architecture could enhance the functionality and capabilities of the cloud solution for the startups and online businesses in Bangladesh.

Exploring multi-cloud strategies: Future studies may delve into the advantages and challenges of adopting multi-cloud strategies, in which businesses utilize multiple cloud service providers to optimize their operations and mitigate risks associated with vendor lock-in.

By pursuing these avenues of future research, scholars can continue to contribute to the understanding of cloud computing and its potential impact on various industries and regions, further refining the insights provided in this study.

As an employee of a cloud computing company, I am highly interested in topics related to my work. Specifically, I am eager to delve into the realm of serverless cloud computing. I anticipate further opportunities to conduct research in the field of cloud computing, as I plan to pursue a Master's degree in cloud technology. This is my actual future plan for my research study.

End

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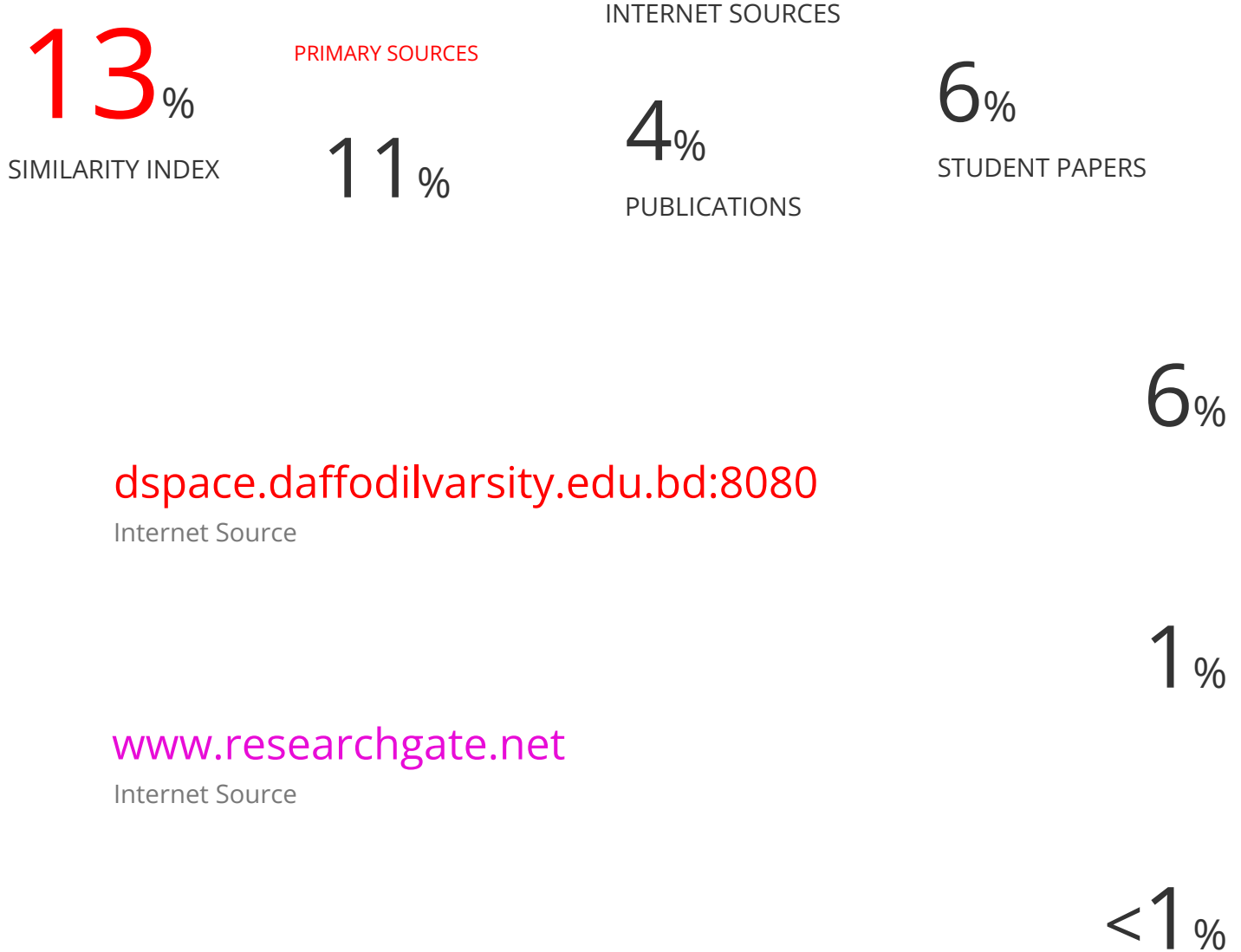
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