A

Project Seminar Report

on

Intelligent Load-Balancing Framework for Fog-Enabled Communication in Healthcare

Submitted for partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

in

COMPUTER SCIENCE AND ENGINEERING

By

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Year: 2022-23

CERTIFICATE

This is to certify that this Project Seminar Report entitled "Intelligent Load Balancing Framework for Fog-Enabled Communication in Healthcare" is a Bonafide work carried out by KONDRU AMULYA (2451-19-733-154), PANUGANTI SUHAS KUMAR (2451-19-733-155), LAKAVATH SHRAVYA (2451-19-733-156) in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering in Computer Science and Engineering from Maturi Venkata Subba Rao (MVSR) Engineering College, affiliated to OSMANIA UNIVERSITY, Hyderabad, during the Academic Year 2022-23 under our guidance and supervision.

The results embodied in this report have not been submitted to any other university or institute for the award of any degree or diploma.

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DECLARATION

This is to certify that the work reported in the present project entitled "*Intelligent Load Balancing Framework for Fog-Enabled Communication in Healthcare*" is a record of bonafide work done by us in the Department of Computer Science and Engineering, Maturi Venkata Subba Rao (MVSR) Engineering College, Osmania University during the Academic Year 2022-23. The reports are based on the project work done entirely by us and not copied from any other source.

The results embodied in this project report have not been submitted to any other University or Institute for the award of any degree or diploma.

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Finally, we would like to take this opportunity to thank my family for their support through the work. We sincerely acknowledge and thank all those who gave directly or indirectly their support in the completion of this work.

PANUGANTI SUHAS KUMAR (2451-19-733-155)

VISION

- To impart technical education of the highest standards, producing competent and confident engineers with an ability to use computer science knowledge to solve societal problems.

MISSION

- To make the learning process exciting, stimulating, t, I ng and interesting.
- To impart adequate fundamental knowledge and soft skills to students.
- To expose students to advanced computer technologies to excel in engineering practices by bringing out creativity in students.
- To develop economically feasible and socially acceptable software.

PEOs:

PEO-1: Achieve recognition through demonstration of technical competence for successful execution of software projects to meet customer business objectives.

PEO-2: Practice life-long learning by pursuing professional certifications, higher education, or research in the emerging areas of information processing and intelligent systems at a global level.

PEO-3: Contribute to society by understanding the impact of computing using a multidisciplinary and ethical approach.

PROGRAM OUTCOMES (POs)

At the end of the program the students (Engineering Graduates) will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
2. **Problem analysis:** Identity, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, ad the need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions**.**

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

13. (PSO-1) Demonstrate competence to build effective solutions for computational real-world problems using software and hardware across multi-disciplinary domains.

14. (PSO-2) Adapt to current computing trends for meeting industrial and societal needs through holistic professional development leading to pioneering careers or entrepreneurship.

COURSE OBJECTIVES AND OUTCOMES

Course Objectives:

➢To enhance practical and professional skills.

➢ To familiarize tools and techniques of systematic literature survey and documentation

➢ To expose the students to industry practices and teamwork.

➢ To encourage students to work with innovative and entrepreneurial ideas

Course Outcomes:

CO1: Summarize the survey of the recent advancements to infer the problem statements with applications to society

CO2: Design a software-based solution within the scope of the project.

CO3: Implement test and deploy using contemporary technologies and tools

CO4: Demonstrate qualities necessary for working in a team.

CO5: Generate a suitable technical document for the project.

ABSTRACT

The present technological era significantly makes use of Internet-of-Things (IoT) devices for offering and implementing healthcare services. Post-COVID-19, the future of the healthcare system is highly reliant upon the inculcation of Artificial-Intelligence (AI) mechanisms in its day-to-day procedures, and this is realized in its implementation using sensor-enabled smart and intelligent IoT devices for providing extensive care to patients relative to the symmetric concept. The offerings of such AI-enabled services include handling the huge amount of data processed and sensed by smart medical sensors without compromising the performance parameters, such as response time, latency, availability, cost, and processing time. This has resulted in a need to balance the load of the smart operational devices to avoid any failure of responsiveness. Thus, in this paper, a fog-based framework is proposed that can balance the load among fog nodes for handling the challenging communication and processing requirements of intelligent real-time applications.

PANUGANTI. SUHAS KUMAR (2451-19-733-155)

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Chapter-1 INTRODUCTION

Visualization of the future connected world is incomplete without including the Internet of Things (IoT). IoT devices are artificially intelligent and are available to be utilized by various applications that can provide efficient performance for end-users. The data of various applications are collected by these devices. Various smart devices produce a large amount of data, which is utilized by various applications for better decision-making and better services for end-users

The interconnections between various devices and application help in learning the existing system and improving it for efficient functionality. IoT is utilized in various fields for day-to-day activities, such as smart offices, buildings, healthcare, grid system, traffic management, healthcare, agriculture, and many more fields. Medical services are an important concern in everyone's life. The contribution to health services can reduce the cost and provide better services to people

Various routine activities can be monitored with IoT devices, such as incorrect posture, unhealthy eating habits, and a prolonged sedentary schedule. These activities can cause multiple diseases when repeated frequently. If these activities are monitored well by IoT devices, many drastic diseases can be prevented. Some other routine activities that can be monitored include nutritional habits, sleep duration, workout duration, etc. Patient health routine information, health emergencies, temperature,e, and blood information can also be handled by IoT devices effectively. Additionally, the use of IoT has increased the quality of various healthcare environments, such as continuous real-time tracking, management of patient information, health emergency management, the management of blood informationt, ion, and health management

Various medical sensors and healthcare devices produce data at high speed as patients are monitored in real-time; the information thus produced is stored, processed, and analyzed. Generally, devices equipped with sensors have less power, limited battery, less storage, e, and limited networking capabilities. Thus, the data collected depend on another framework that can perform computation storage ra, ge, and analysis. The main concern in implementing smart healthcare is the storage and security of huge data produced by smart healthcare devices. One possible solution for this is the cloud.

Cloud computing has massive storage and processing capability. The major requirement of healthcare resources is sharing of data and information Cloud computing can share and maximize resources by utilizing virtualization. Location-independent services are provided by cloud computing. Cloud services can be utilized by end-users from anywhere and through any device.

1.1 PROBLEM STATEMENT

The main objective is to improve health monitoring systems based on IoT devices such that data collected from Wireless Sensor Networks (WSNs) are processed quickly and context-sensitive data that is relevant to the patient is taken into account. We do this by implementing a fog layer that reduces the latency in health monitoring systems and allows for real-time monitoring. In doing so, we hope to secure patient information security, ensuring that patient privacy is protected and that data tampering by third parties is prevented.

1.2 OBJECTIVES

- To develop an intelligent load-balancing framework that optimizes the allocation of resources and enhances the overall efficiency of healthcare applications running on fog computing infrastructure.
- To use machine learning algorithms to predict future demand and optimize resource allocation, taking into account factors such as network conditions, resource availability, and security and privacy concerns.
- To design and implement a resource manager, load balancer, and monitoring and analytics module that work together to provide a scalable and reliable solution for developing healthcare applications on the fog computing infrastructure.
- To improve patient outcomes and reduce healthcare costs by providing real-time data processing and analysis capabilities to healthcare applications running on the fog computing infrastructure.
- To ensure compliance with regulations and industry standards for healthcare applications, such as HIPAA and HITECH, and to address security and privacy concerns associated with the storage and processing of sensitive healthcare data.

1.3MOTIVATION

The motivation of the project was to develop an intelligent load-balancing framework that leverages machine learning algorithms to optimize resource allocation and enhance the overall efficiency of healthcare applications running on the fog computing infrastructure. The framework is designed to address the specific challenges of healthcare applications, such as compliance with regulations and industry standards, and security and privacy concerns.

The need for real-time data processing and analysis. The project aims to improve patient outcomes and reduce healthcare costs by providing a scalable and reliable solution for developing healthcare applications on the fog computing infrastructure

1.3 SCOPE

Developing an intelligent load-balancing framework that optimizes the allocation of resources for healthcare applications running on fog computing infrastructure. Designing and implementing a resource manager, load balancer, and monitoring and analytics module that work together to provide a scalable and reliable solution for developing healthcare applications on the fog computing infrastructure. Using machine learning algorithms to predict future demand and optimize resource allocation, taking into account factors such as network conditions, resource availability, and security and privacy concerns. Improving patient outcomes and reducing healthcare costs by providing real-time data processing and analysis capabilities to healthcare applications running on the fog computing infrastructure.

SOFTWARE & HARDWARE REQUIREMENTS

Software Requirements

- PYTHON
- TENSOR FLOW
- SCIKIT-LEARN
- KERAS

Hardware Requirements

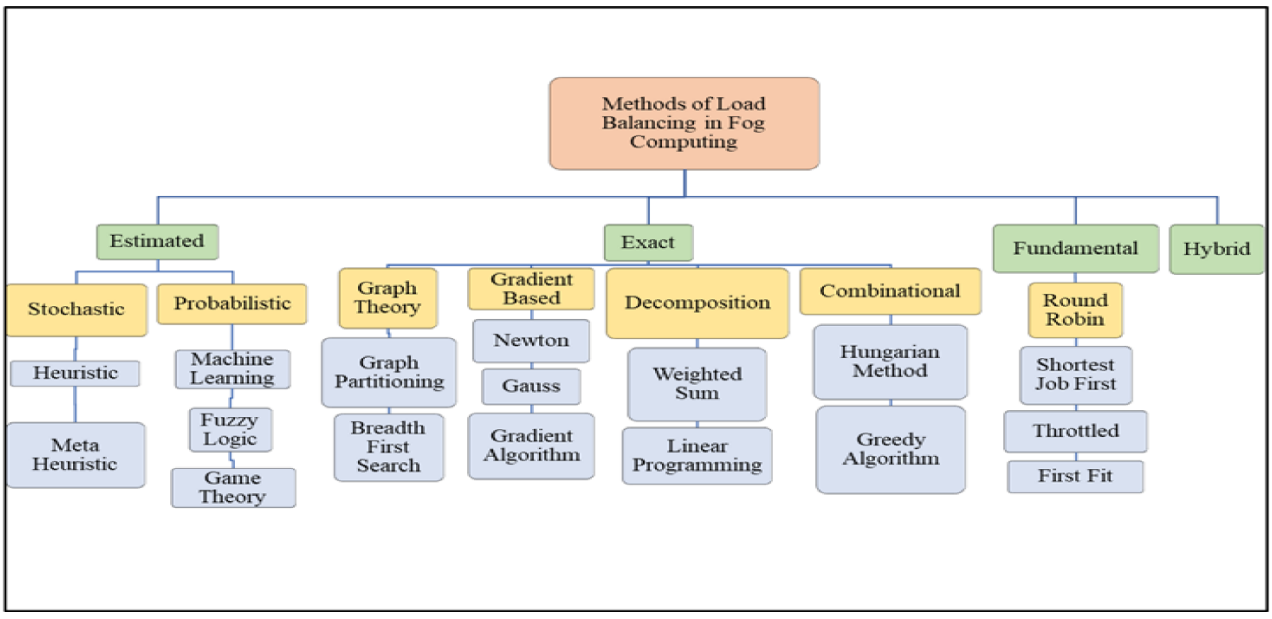
- PROCESSOR: ANY PROCESSOR
- RAM: MIN 4GB
- HARD DISK: MIN 100GB

Chapter-2
LITERATURE SURVEY

2.1 SURVEY OF MAJOR AREA

The literature survey related to fog load balancing. Although there are multiple ways of classifying the load-balancing algorithms, broadly these can be classified as approximate, exact, fundamental, and hybrid methods (Figure 1). However, some other classifications are also possible, such as centralized, distributed, semi-distributed, and by who initiated the process or system state. The literature survey highlights the differences between these techniques, the evaluation tools used, parametric evaluation, the evaluation methods, and the pros and cons.

Figure 1. Methods of load balancing in fog computing.



Acquisition

The acquisition process for the "Intelligent Load Balancing Framework for Fog-Enabled Communication in Healthcare" project involves identifying stakeholders and defining requirements, researching and selecting technology solutions, developing a proposal, selecting a vendor if outsourcing, negotiating a contract, and managing the project. The goal is to ensure that the intelligent load-balancing framework meets the project's requirements and goals, stays within budget and timeline, and provides the best possible outcome for the stakeholders involved.

Preprocessing

Preprocessing is an essential step in developing the "Intelligent Load Balancing Framework for Fog-Enabled Communication in Healthcare" project. It involves preparing the raw data for analysis and modeling to ensure the accuracy and reliability of the results. The following are five key points of the preprocessing.

- Data Collection: The first step in preprocessing is to collect data from various sources such as sensors, IoT devices, and healthcare systems.
- Data Cleaning: The collected data may contain errors, inconsistencies, or missing values, which need to be identified and corrected to ensure data quality.
- Data Integration: The collected data from various sources need to be integrated and merged to form a single data set that can be used for analysis and modeling.
- Data Transformation: The collected data may require transformation to fit the modeling and analysis techniques used. This may include scaling, normalization, and encoding.
- Data Reduction: The collected data may contain redundant or irrelevant features, which can be removed through feature selection or dimensionality reduction techniques to improve the efficiency and accuracy of the model.

Feature Extraction

Feature extraction is the process of identifying and selecting relevant features from raw data that can be used to train a machine-learning model. The selected features are transformed into new, more informative features that can improve the performance of the model. The goal is to reduce the

dimensionality of the data, while still retaining the most important information. Feature extraction is a crucial step in developing an accurate and efficient machine learning model for load balancing in healthcare systems, which can improve resource utilization, reduce latency, and enhance the quality of care.

Matching

Matching is a critical step in developing an intelligent load-balancing framework for healthcare. systems. The process involves identifying similarities between the task requirements and available resources t allocate the most suitable resource for a given task. Feature matching is used to find similarities between two or more sets of features extracted from the data, while task matching involves identifying the most appropriate resource for a given task based on its requirements. Resource matching is used to identify the best resource available based on its availability, capacity, and workload. Load balancing is the process of distributing tasks among multiple resources to optimize resource utilization, reduce latency, and improve the overall performance of the system. By incorporating matching into the intelligent load-balancing framework, it becomes possible to enhance the quality of care and optimize resource allocation in healthcare systems.

2.2 TECHNIQUES AND ALGORITHMS

Estimated Methods

In this method, techniques, such as stochastic, probabilistic, and statistics are studied. Stochastic methods are also known as random methods. These are the mathematical model for such processes, which vary randomly.

Stochastic Methods and Probabilistic Methods

- Probabilistic methods tend to combine logic and reasoning to handle uncertainty with deductive logic. Statistical methods are concerned with the collection, organization, interpretation, and analysis of parameters and factors associated with a phenomenon. This deals with various aspects of data, such as planning for collecting data, creating a survey design,n, and experiments.
- Heuristic Methods

  Heuristic methods are based on experience for applications that seek to attain optimization for finding the best possible solution to a problem. This “trial and error” method is used for finding the best possible solution in the most favorable amount of time. In this approach, the solution can be better than the optimal solution. Sometimes they can outperform the guess. Hill climbing, Min-conflicts and

- Meta-Heuristic Methods

  As a higher-level heuristic method, a meta-heuristic technique is problem-independent and can be

Used to solve a wide range of issues. All recent higher-level approaches are referred to as "meta-heuristics", today. Diversification and intensification are the two major components of current meta-heuristics.To develop an influential and effective meta-heuristic method, it is necessary to strike a balance between diversification and intensification. A metaheuristic method investigates the entire solution space; a new set of solutions should be generated, and the search should be intensified around the optimal or near-optimal solutions. Some meta-heuristic methods have been studied in the literature, including Particle Swarm Optimization, the Fireworks Algorithm and the Bat Algorithm.

- fuzzy logic and game theory are examples of probabilistic/statistic load-balancing mechanism mentioned in this section. Singh et al.also presented a load balancer based on fuzzy logic in fog networks, with several levels of tuning and design of fuzzy controls. The proposed fuzzy logic model was utilized to analyze links as interconnects for traffic management. Abedin et al.proposed a fog-load-balancing problem to reduce the cost of fog-load-balancing in a Narrow-Band Internet of Things environment (NB-IoT). To begin, the NB-temporal IoT's resource scheduling challenge was modeled as a bankruptcy game. The transportation problem was then solved using Vogel's approximation methodology, which finds a feasible load-balancing solution.

2.3 APPLICATIONS

1. **Telemedicine**: The framework can be used to improve telemedicine services by optimizing resource allocation and reducing latency. This can improve the quality of care and increase patient satisfaction.
2. **Medical Imaging:** Medical imaging generates large amounts of data that need to be processed quickly and efficiently. The framework can optimize resource allocation to ensure that the data is processed promptly and reduce the time it takes to diagnose patients.
3. **Electronic Health Records (EHRs):** EHRs contain large amounts of patient data that need to be accessed quickly and securely. The framework can optimize resource allocation to ensure that patient data is accessed promptly and that the system is secure.
4. **Healthcare Analytics**: Healthcare analytics involves analyzing large amounts of data to identify trends and patterns. The framework can optimize resource allocation to ensure that data is analyzed in a timely and efficient manner.

Chapter-3 SYSTEM DESIGN

3.1 SYSTEM ARCHITECTURE

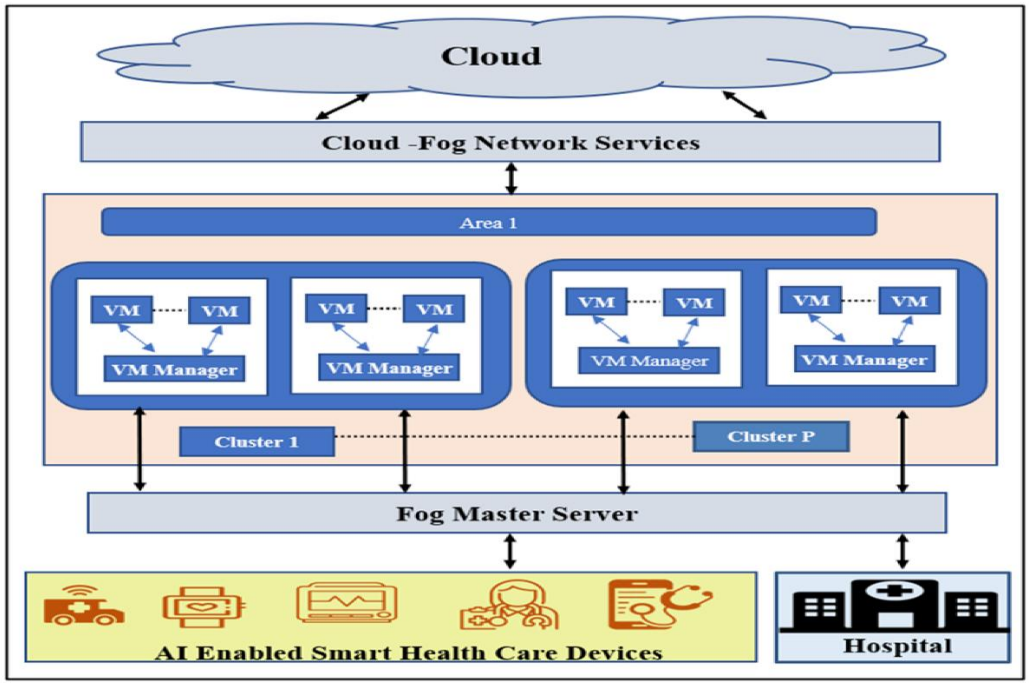


Fig-3.1.1 Framework

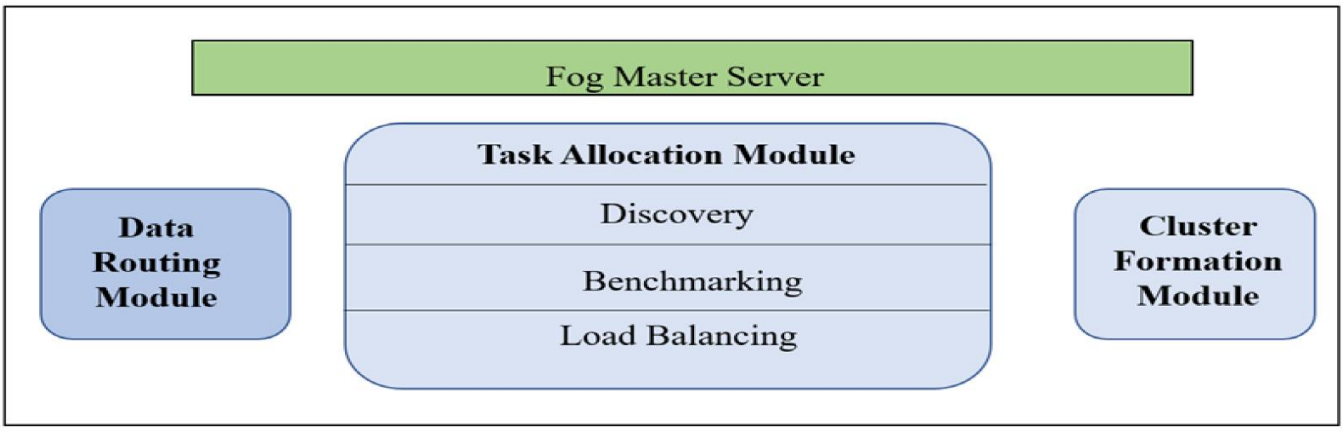
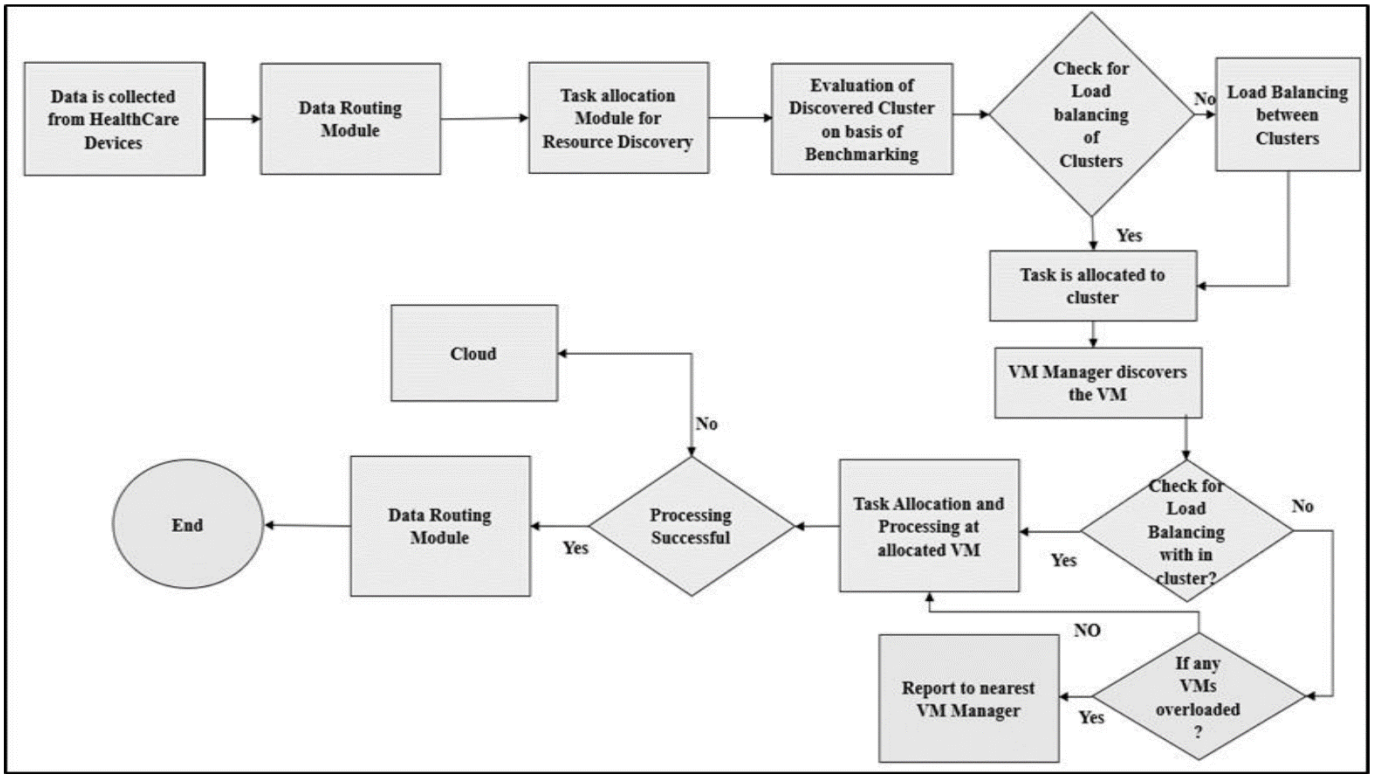


Fig-3.1.2 Key point Description steps



Step 1.

Fog computing layers consist of multiple virtual machines. These VMs are grouped based on similar parameters to form a cluster. Each cluster in the fog layer has a virtual machine manager.

Step 2.

The fog layer has a Fog Master Server (FMS), which is further connected with the Virtual Machine manager of each cluster.

Step 3.

Whenever any healthcare device or end-user device needs to utilize the services of the fog layer, it sends a request to the nearest Fog Master Server present in the geographical region.

Step 4.

The Fog Master Server will perform the allocation of resources within the region, this allocation is done with the help of modules present at the FMS. Modules present in FMS are explained previously. One unique idea in this work is the two-layer load balancing.

Step 5.

Consider the case when the demand for Virtual Machines increases while executing the task in real-time, then the Fog Master Server will have communication the with next nearest Fog Master present in different geographical regions and completes the execution of the real-time task.

Step 6.

Another possibility while executing Step 5 is that if the data needed to perform a task are not available within the area covered by that FMS, then, in this case, the FMS will send the data request to the cloud layer with the help of cloud–fog network services.

Step 7.

Finally, the updated data and task execution details are sent to the cloud layer, so that, in the case of non-availability of data and details at the fog layer, the cloud layer can be utilized.

The importance of the fog layer in this scenario is that patients can be provided with appropriate guidelines with minimum delay and also that they can rely on the fog layer for complex computations to be done at the fog layer. The fog nodes have greater computation capability than intelligent and smart end devices but are lower than the cloud layer.

If the fog layer is incapable of handling the requests from patients or users, they can be sent to the cloud layer. The cloud has enormous storage and computation capability. Although the delay will be more when the requests are handled at the cloud layer, they can be handled well as the computation capability does not have any bounds at the cloud layer.

3.2 MODULE DESCRIPTION

3.2.1 Data Preprocessing Module

This module is responsible for collecting data from various sources, such as medical devices, sensors, and electronic health records.

3.2.2 Training Module

The output of the previous module, which is the cleaned dataset, is taken as input in this module. The model is trained on this data. Input: Cleaned Dataset

- Output: Trained Model

3.3 PROJECT PLAN

We have divided our project into major parts namely,

- Data Acquisition: This module is responsible for collecting data from various sources, such as medical devices, sensors, and electronic health records.
- Preprocessing: The preprocessing module is responsible for cleaning and transforming the raw data into a format that can be used for feature extraction and analysis.
- Feature Extraction: Feature extraction is used to identify and extract the most relevant features from the data. This module uses techniques such as principal component analysis (PCA), discrete wavelet transform (DWT), and time-frequency analysis to extract features from the data.
- Matching: The matching module is responsible for identifying the most suitable resource for a given task based on its requirements. This involves feature matching, task matching, and resource matching.
- Load Balancing: The load balancing module is responsible for distributing tasks among multiple resources to optimize resource utilization and reduce latency.
- Evaluation: The evaluation module is used to assess the performance of the load balancing framework and make improvements as necessary.

Chapter-4 IMPLEMENTATION

4.1 ENVIRONMENTAL SETUP

Spyder is an open-source tool, utilized for huge data processing and intensive scientific computing in Anaconda. Anaconda is a programming language for Python. Conda, the package management system, keeps track of package versions.

Anaconda Installation

Go to anaconda.com and download the most recent version of Anaconda. For the right architecture, make sure to download the "Python Version."

Step 1: Check if conda is installed in your path.

- Open up the anaconda command prompt.

Type *conda -V* and press enter.

If the conda is successfully installed in your system you should see a similar output.

Step 2: Update the conda environment

- Enter the following in the anaconda prompt.
  conda update conda

Step 3: Set up the virtual environment

- Type conda search "^python$" to see the list of available Python versions.
- Now replace the endgame with the name you want to give to your virtual environment and replace x.x with the Python version you want to use. *conda create -n endgame python=x.x anaconda*

Step 4: Activating the virtual environment

- To see the list of all the available environments, use command conda info -e To activate the virtual environment, enter the given command and replace your given environment name with endgame *conda activate endgame*

When the conda environment is activated, it modifies the PATH and shell variabpointingints specifically to the isolated Psetupset up you created.

Step 5: Installation of required packages to the virtual environment

- Type the following command to install the additional packages to the environment and replace endgame with the name of your *environment. conda install -n yourenvname package*

Step 6: After all the necessary modules and packages are installed, we are good to continue with the project as the entire environment is done setting up.

4.2 IMPLEMENTATION

1. Python Programming Language: Python is a popular programming language used for machine learning and data science. It has a wide range of libraries and frameworks that can be used to implement the project, including sci-kit-learn, TensorFlow, and Keras.
2. Cloud Computing Platforms: Cloud computing platforms such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) can be used to deploy the project. These platforms provide scalable and reliable cloud infrastructure to host and run the project.
3. Big Data Processing Tools: Big data processing tools such as Apache Hadoop, Apache Spark, and Apache Flink can be used to handle large volumes of data generated by the project. These tools provide distributed computing and data processing capabilities.
4. Data Visualization Tools: Data visualization tools such as Tableau, Power BI, and matplotlib can be used to visualize and analyze the data generated by the project.

Intelligent end-user devices coordinate and monitor the user's or patient's health remotely. End-user health care devices have limited computing capabilities. They can rely on the fog layer for advanced computation capability. Most of the responses can be automatically generated for the patient but some situations still require intervention from the hospital in the case of an emergency for which no automated response works well.

To minimize the latency, response time, and bandwidth requirements, the fog layer can effectively handle such situations and respond to patients in minimal time. However, if all the requests from various applications are handled by the cloud directly, it could be possible that latency-sensitive applications may suffer as the cloud is having enormous computation and large storage. It deals with multiple applications and their data at a time. If the fog layer is introduced between the cloud and the end-user, latency-sensitive applications will be served better. As request processing is done at the fog layer, it can work with a limited amount of resources, such as bandwidth, cost, and time. The processing is done

closer to the end clients.

1. All the end-user devices are AI-enabled smart devices that are capable of sensing the parameters related to the human body.
2. The fog master server is assumed to be self-adaptive.

The fog layer consists of fog nodes with various virtual machines. To provide better services to patients, an efficient load-balancing mechanism is required at the fog layer. These VMs are grouped according to their storage, functionality, computation capability, and specifications. This group of VMs along with the virtual machine manager is known as a cluster. This grouping is expected to help in the speedy allocation of tasks and reduce latency time. Each Virtual Machine Manager (VM Manager) is further connected with the Fog Master Server (FMS) of that area.

FMS is near the end-user and hospital. The fog master server is responsible for allocating the tasks cluster-wise and balancing the load among clusters considering the availability of resources. Within a cluster, the fog master server consists of three modules: Data Routing, Task

Allocation and Cluster Formation. The task allocation module further consists of three modules, namely Discovery, Benchmarking, and Load Balancing. Each VM manager is further connected with the FMS of that area. The elaboration of the modules of the FMS is presented as follows.

Data Routing Module: This module is responsible for routing the data between fog nodes, end devices and hospitals.

Task Allocation Module: Task Allocation is done in three parts, including the discovery of the best suitable VM according to the request generated by end devices and a benchmarking process that involves computing the success count after the completion of a job/task assigned to it. The load-balancing procedure

ensures that neither of the VM is underloaded or overloaded. Algorithmic steps are required for the functioning of the task allocation module. A cluster-based algorithm for a load-balancing algorithm is presented in Algorithm 1.

Discovery: Discovery module is responsible for finding the suitable cluster and VM for allocating the task.

Benchmarking: This module collects the feedback after the allocation of the task, such as the delay, response time, and QoS parameters related to task allocation. This information is further utilized at the time of the next task allocation.

Load Balancing: Generally, the load balancing module ensures that none of the virtual machines present

within the network are overloaded and the load is almost equally distributed.

Here, the uniqueness of the load balancing module is because of the concept of two-level load balancing used. In this proposed scenario, load balancing will be done at two levels. Once it will be done by the virtual machine manager within the clusters, another load balancing will be done at the fog master server for equal load distribution among clusters. Thus, neither virtual machines should be overloaded nor clusters should be overloaded.

Cluster Formation Module: This module is responsible for the grouping of VMs, which have similar specifications, storage, and computation capabilities.

The virtual machine manager communicates with the fog master server for auditing and reporting the information about the cluster. The virtual machine manager at each cluster is responsible for task allocation and balancing the load within the cluster. By using the efficient clustering mechanism, load balancing can be achieved in the proposed scenario. The hospital can monitor and communicate with the patient in case of additional help and monitoring for diagnosis and prevention of disease. Hospitals can provide appropriate guidelines to patients either through an automated system or manually depending upon the circumstances and parameters collected by end devices and the fog layer. These guidelines can be given by video conferencing or calling.

Algorithm 1: Cluster-Based Algorithm for Load Balancing in Fog Computing

1. Set up the N number of fog devices $FN1, FN2 \ldots FNN$
2. Estimate the R number of incoming requests $RQ1, RQ2 \ldots RQR$
3. Estimate the total number of clusters C as $C1, C2 \ldots CC$
4. Assign fog devices to each cluster (Ci), and the cluster size (CS) is computed as follows:
   $$Cluster\ size = Total\ number\ of\ fog\ devices / Total\ No.\ of\ clusters$$
   $$CS = N/C$$
5. Assign each cluster with CS number of Virtual Machines as $VM1, VM2 \ldots, VMS$.
6. **For every incoming request** $RQi = RQ1, RQ2 \ldots RQs$ **do:**
7. **For each cluster** $Cj = C1, C2 \ldots CZ$, **do**
8. Find out the locally optimal virtual machine having better efficiency (MIPS), least loaded in Cj and high value for success count. Success count is computed by each VM as follows:
   $$Success\ Count = Total\ number\ of\ requests\ successfully\ fulfilled\ by\ the\ VM / Total\ number\ of\ requests\ assigned\ to\ a\ VM.$$
9. Store the index of the best virtual machine of Cj in the array, $Local - Best[j]$
10. **End of For loop of step 7.**
11. **For each cluster indexed** $j = 1 \ldots Z$, **do**
12. Find out the Global Best VM, GVM for Ri having better efficiency (MIPS), least loaded among the local best machines and having higher value of success count for selected VM in each cluster, from the array: $Local - Best[j]$.
13. **End of For loop of step 11.**
14. Assign the task Ri to the Global Best VM, GVM.
15. Repeat step 5 until all requests/tasks have been completed.
16. **End of For loop of step 6**

Chapter-5
RESULTS

5.1 DATASET

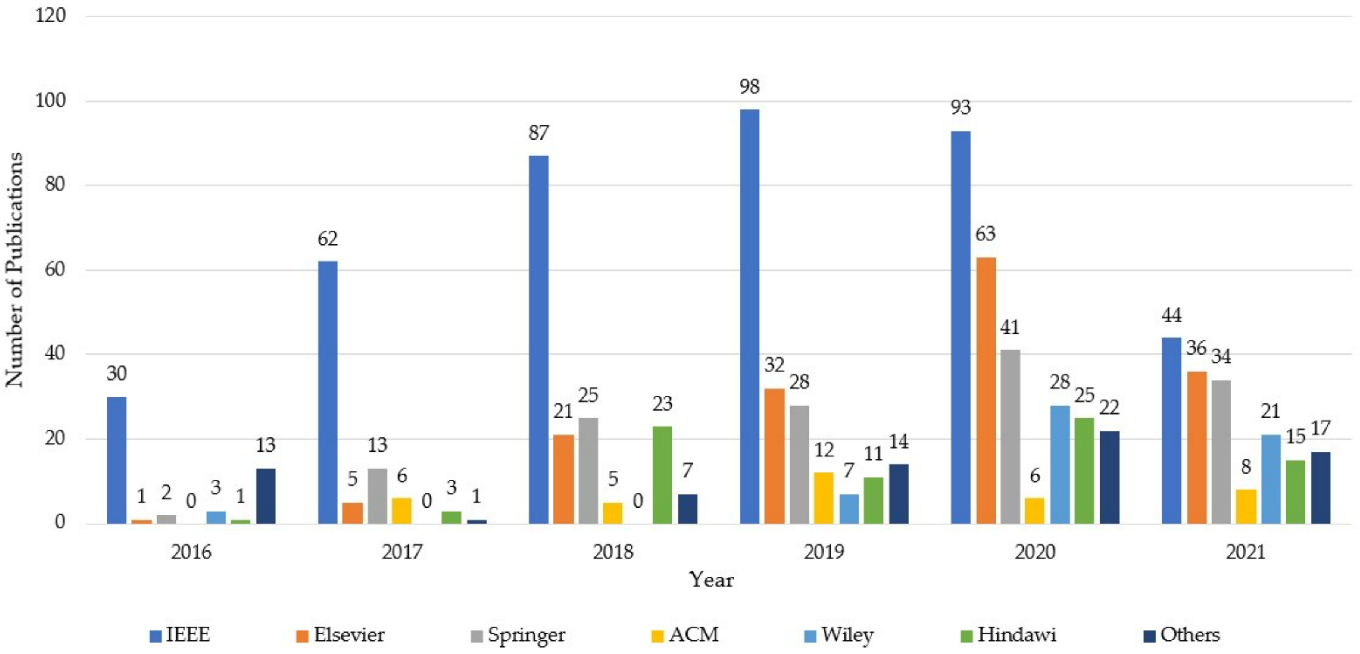
Various publicly available healthcare datasets can be used for the project, including:

1. MIMIC-III: The Medical Information Mart for Intensive Care (MIMIC-III) is a publicly available dataset that contains de-identified health data for over 40,000 patients admitted to the intensive care unit (ICU) at a tertiary care hospital in the United States. The dataset contains various types of data, including clinical notes, laboratory values, and vital signs.
2. PhysioNet: PhysioNet is a repository of physiological data and clinical data for researchers and healthcare professionals. The repository contains various datasets, including the MIT-BIH Arrhythmia Database, which contains electrocardiogram (ECG) signals for arrhythmia detection, and the Sleep Heart Health Study, which contains sleep-related data.
3. eICU Collaborative Research Database: The eICU Collaborative Research Database is a publicly available dataset that contains clinical data for over 200,000 patients admitted to ICUs across the United States. The dataset contains various types of data, including vital signs, laboratory values, and medications.

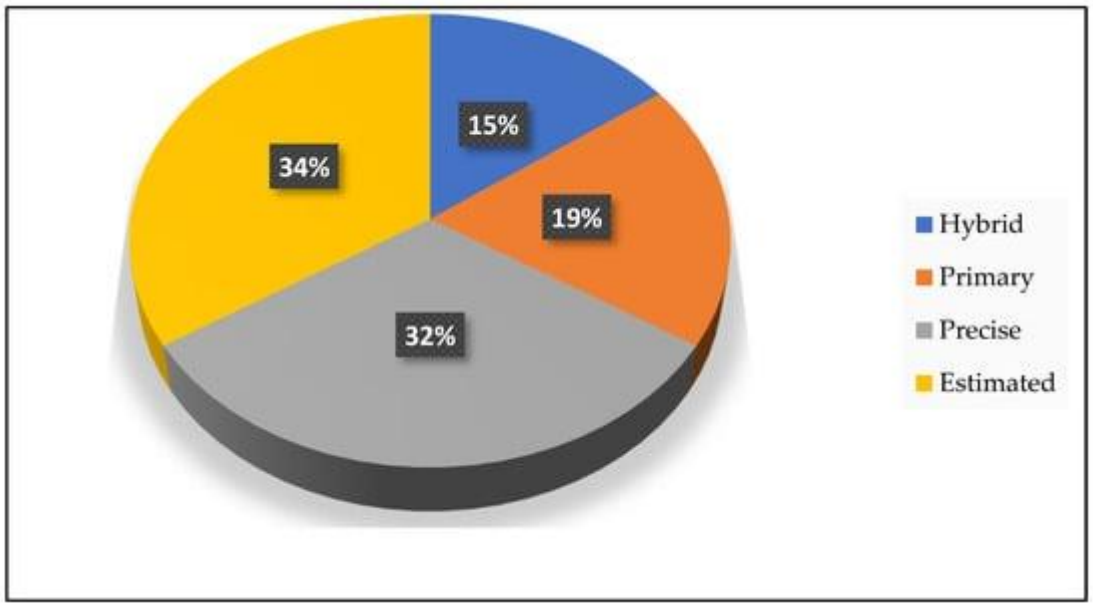
Fig- 5.1.1 Dataset Structure

5.2 OUTPUTS

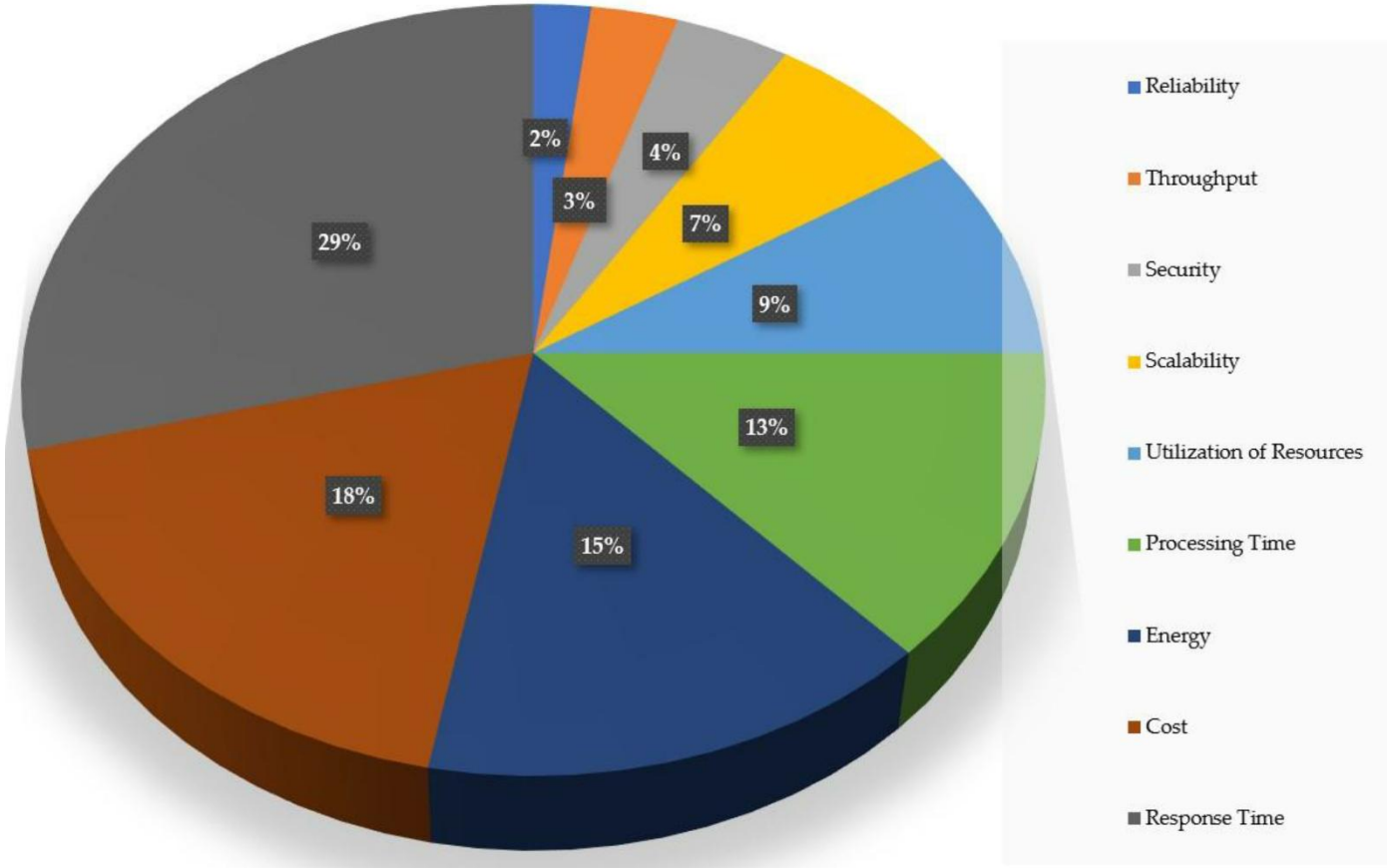
Various renowned publishers, such as IEEE, Elsevier, Springer, ACM, Wile,y, and Hindawi, have published a good number of papers. depicts the count of research documents publisher-wise according to year. Since 2016, IEEE has published the highest number of papers. Elsevier and Springer have an almost similar number of papers and are at second and third position respectively.



Load-balancing techniques are divided into the following categories, namely estimated, precise, primary , and hybrid. presents a percentage-wise distribution of load-balancing techniques in fog computing. Estimating techniques have a maximum share in the techniques utilized for balancing the load in a fog environment. Precise techniques are nearly equal to estimated techniques in terms of percentage. The hybrid techniques have the least share in the percentage-wise distribution of techniques.



Evaluation parameters for measuring the performance of load-balancing algorithms implemented in a fog environment are depicted percentage-wise in **Figure 4**. The maximum share of articles has focused on the response time of fog nodes. After that, 18% focused on cost minimization. The energy parameter also has a significant share among all i.e., 15%. Processing time was focused on in 13% of the research documents considered in the literature review.



The resource utilization and scalability were 13% and 9%, respectively. Security, throughput, and reliability were given less preference by researchers as a few documents are associated with improving these parameters in comparison to other parameters considered in this study. From time to time, various tools have been introduced to simulate and implement the techniques for load-balancing mechanisms. As fog computing

has been derived from cloud computing, some of the tools utilized for implementing cloud-based techniques have been utilized in fog computing also.

Figure 5 shows a percentage-wise tool used by researchers for implementing and simulating the load-balancing fog environment for improving the evaluation parameters. The highest percentage of researchers did not mention the tools for implementation. Cloud Analyst and MATLAB had similar utilization percentages, i.e., 19% and 16%. Cloud Sim, java, ifogsim, Ns-2/NS-3, and work Robots had 9%, 7%, 6%, 5,% and 4% shares in a tool pie chart. Scheer, custom simulator, Jmete,r, and Mininet had 3%, 3%, 2%and 2% shares in the tool chart.

AI in Health Care

Artificial intelligence (AI) in healthcare employs a large number of complicated algorithms that automate the completion of specific tasks. AI is a term that refers to technology that can mimic and recreate human-like activities. These processes are related to learning, adapting, and understanding. The simplest way to describe this technology is that it can “act like a person.” Artificial intelligence can take numerous forms and is based on tools or ideas, such as biology, logic,c, and mathematics. When data is injected into computers by researchers, doctors, and scientists, the newly developed algorithms can review, understand, and even suggest remedies to difficult medical problems [54,55]. Here are some of the most recent technological applications of AI in healthcare

Chapter-6

CONCLUSION & FUTURE ENHANCEMENTS

The proposed framework is expected to perform efficiently in terms of latency. Latency is expected to be less than in the cloud-only scenario when the end devices will be directly connected to the cloud. The cloud will handle the requests in a centralized scenario, whereas fog computing provides a decentralized scenario for handling the requests from users. The cloud has a large number of requests whereas, in the fog scenario, requests are distributed among fog nodes.

Other advantages of the proposed framework include that, in critical conditions, when the nurse or doctor is not available in person with the patient, an automated reply or steps for guiding the patient according to the problems faced can be dictated to the patient or the family member present nearby.

FUTURE ENHANCEMENTS

The proposed framework is capable of enhancing the service quality of intelligent healthcare scenarios in terms of establishing communication between the devices as a load balancing among fog nodes can effectively reduce the latency time for providing services to patients. The clustering of fog nodes can help in reducing the offloading overhead of a task. It is subtle as, in the case that one virtual machine fails, another virtual machine within the cluster can be assigned that task as virtual machines within a cluster have similar capabilities. The novelty of the present work is the implementation of two-level load balancing for improved access to the service machines. This work, when combined with various artificial intelligence-based technological applications, can enhance the various parameters associated with healthcare services.

In the future, this work will be simulated, implemented, and evaluated. Additionally, consultation sessions can be included in this framework. The patient can request teleconsultation or video consultation with a specialist health expert. As the records and clinical parameters are available either at the fog layer or cloud layer, the specialist can access the previously sensed and processed data and plan a consultation session accordingly. This framework can be utilized for providing immediate attention to critical patients that are in a state of emergency.

This framework is anticipated to help in determining the severity of the condition and can provide timely responses to patients as the fog layer is capable of handling the requests with a minimum delay. One aspect of

the proposed work that still requires improvement is the security and trustworthiness of the healthcare data. The overhead incurred in the framework is that no additional layer has been added to filter the data that is envisaged for routing the critical data.

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Note that from the first issue of 2016, this journal uses article numbers instead of page numbers. See further details here.

Data set

name	age	mobile no
suhas	12	6300759610
shravya	13	6300759610
chintu	14	6300759610
andrew	12	6300759610
blaze	12	6300759610
carles	12	6300759610
damon	12	6300759610
emily	12	6300759610
faraz	12	6300759610
golem	12	6300759610
hector	12	6300759610
ivan	12	6300759610
julious	12	6300759610
kernel	12	6300759610
luke	12	6300759610
marshall	12	6300759610
neon	12	6300759610
omen	14	6300759610
pekka	32	6300759610
quionton	12	6300759610
rajesh	12	6300759610
sherif	12	6300759610
tanmay	12	6300759610
uday	12	6300759610
vandal	12	6300759610
winzo	13	6300759610
xenon	31	6300759610
yamate	35	6300759610
zeref	26	6300759610
anya	8	6300759610
madara	55	6300759610
luffy	19	6300759610
gojo	23	6300759610
mikey	16	6300759610
saitama	24	6300759610
suzume	13	6300759610
nezuko	7	6300759610
tanjiro	17	6300759610
vegeta	28	6300759610
hashirama	67	6300759610
mitsuki	14	6300759610
gamur	18	6300759610
sasuke	32	6300759610
chad	21	6300759610
wisp	28	6300759610
jimmy	27	6300759610
abhuday	24	6300759610

APPENDIX

A: Pseudo code:

```
Import required libraries

Define constant NORMAL_HEART_RATE_RANGE
Define constant TWILIO configuration

Define function read_patient_data_from_excel(file_path)
    Load patient data from Excel file
    Return the loaded patient data

Define function simulate_heart_rate(heart_rate)
    If a random number between 1 and 100 is equal to 1
        Randomly adjust the heart rate within a range
    Return the adjusted heart rate

Define function check_heart_rate_cluster(cluster_name, patients)
    Initialize an empty list for rows
    For each patient in patients
        Extract patient information
        Simulate the heart rate for the patient
        Set the default status to 'Normal'
        If the heart rate is below the normal range
            Generate a low heart rate warning message
            Send an SMS notification
            Set the status to 'Low'
        Else if the heart rate is above the normal range
            Generate a high heart rate warning message
            Send an SMS notification
            Set the status to 'High'
        Append the patient information, heart rate, and status to rows
    Return the rows

Define function send_sms(to_number, message)
    Try sending an SMS notification using Twilio
    If successful, print a success message
    If an exception occurs, print an error message
```

```
Define main function
    Read patient data from Excel file
    Shuffle the patient data
    Divide patients into clusters with at least 6 patients in each cluster
    Determine if there are remaining patients
    Assign patients to clusters
    Randomly allocate clusters to values
    Infinite loop
        Initialize an empty list for all_results
        For each value in values
            Extract the cluster name and patients
            Check heart rate for the patients in the cluster
            Append the results to all_results
        Prepare data for table display
        Print patient data in a table format
        Pause for 1 second before displaying the next set of patients

Invoke the main function if the script is executed directly
```

Code

```
import random
import openpyxl
import time
from twilio.rest import Client
from tabulate import tabulate


# Define normal heart rate range
NORMAL_HEART_RATE_RANGE = (60, 100)




# Twilio configuration
ACCOUNT_SID = 'ACe36a34e81bf04b14a0cfa3736f38b861'
AUTH_TOKEN = 'b6d8b164e795232b1495c245017de8d4'
TWILIO_PHONE_NUMBER = '+12707139648'
TWILIO_CLIENT = Client(ACCOUNT_SID, AUTH_TOKEN)




# Read patient data from Excel file
```

```
def read_patient_data_from_excel(file_path):
    wb = openpyxl.load_workbook(filename=file_path)
    sheet = wb.active
    data = []
    for row in sheet.iter_rows(min_row=2, values_only=True):
        name, age, mobile = row[:3]
        data.append({'Name': name, 'Age': age, 'Mobile Number': '+91' + str(mobile)})
    return data




# Define function to simulate heart rate
def simulate_heart_rate(heart_rate):
    # Fluctuate heart rate randomly once in 100 times
    if random.randint(1, 100) == 1:
        heart_rate += random.randint(-20, 20)
    return heart_rate


# Define function to check heart rate and generate warnings
def check_heart_rate_cluster(cluster_name, patients):
    rows = []
    for patient in patients:
        name = patient['Name']
        age = int(patient['Age'])
        mobile = patient['Mobile Number']
        heart_rate = simulate_heart_rate(random.randint(NORMAL_HEART_RATE_RANGE[0],
NORMAL_HEART_RATE_RANGE[1]))
        status = 'Normal'  # default status
        if heart_rate < NORMAL_HEART_RATE_RANGE[0]:
```

```
            message = f"Warning: {name}, your heart rate is low ({heart_rate})"
            send_sms(mobile, message)
            status = 'Low'
        elif heart_rate > NORMAL_HEART_RATE_RANGE[1]:
            message = f"Warning: {name}, your heart rate is high ({heart_rate})"
            send_sms(mobile, message)
            status = 'High'
        rows.append([cluster_name, name, age, mobile, heart_rate, status])
    return rows

# Define function to send SMS
def send_sms(to_number, message):
    try:
        message = TWILIO_CLIENT.messages.create(to=to_number, from_=TWILIO_PHONE_NUMBER, body=message)
        print(f"Sent SMS to {to_number} with Message SID: {message.sid}")
    except Exception as e:
        print(f"Failed to send SMS to {to_number}: {str(e)}")

# Main function
def main():
    # Read patient data from Excel file
    patient_data = read_patient_data_from_excel("heartdata.xlsx")

    # Shuffle the patient data
    random.shuffle(patient_data)

    # Divide patients into clusters with at least 6 patients in each cluster
    num_clusters = len(patient_data) // 6
    remaining_patients = len(patient_data) % 6
```

```
    clusters = [patient_data[i * 6 : (i+1) * 6] for i in range(num_clusters)]

    if remaining_patients > 0:
        last_cluster = patient_data[num_clusters * 6:]
        random.shuffle(last_cluster)
        clusters.append(last_cluster[:remaining_patients])

    # Randomly allocate clusters to values
    values = [{'Cluster': i+1, 'Patients': cluster} for i, cluster in enumerate(clusters)]
    random.shuffle(values)

    # Display patient name, age, mobile number, and heart rate every second for patients in each value
    while True:
        all_results = []
        for value in values:
            cluster_name = f"Cluster {value['Cluster']}"
            cluster_results = check_heart_rate_cluster(cluster_name, value['Patients'])
            all_results.extend(cluster_results)

        # Prepare data for table display
        headers = ["Cluster", "Name", "Age", "Mobile Number", "Heart Rate", "Status"]
        data = [[row[0], row[1], row[2], row[3], row[4], row[5]] for row in all_results]

        # Print patient data in a table
        print(tabulate(data, headers=headers, tablefmt="grid"))

        # Wait for 1 second before displaying data for the next set of patients
        time.sleep(1)

if __name__ == '__main__':
    main()
```

Results :

Cluster	Name	Age	Mobile Number	Heart Rate	Status
Cluster 3	yamate	35	+916300759610	85	Normal
Cluster 3	uday	12	+916300759610	64	Normal
Cluster 3	mikey	16	+916300759610	86	Normal
Cluster 3	gamur	18	+916300759610	69	Normal
Cluster 3	chad	21	+916300759610	66	Normal
Cluster 3	siddu	28	+916300759610	65	Normal
Cluster 4	winzo	13	+916300759610	66	Normal
Cluster 4	robert	41	+916300759610	60	Normal
Cluster 4	tanmay	12	+916300759610	99	Normal
Cluster 4	quionton	12	+916300759610	68	Normal
Cluster 4	marshall	12	+916300759610	71	Normal
Cluster 4	nezuko	7	+916300759610	70	Normal
Cluster 1	omen	14	+916300759610	93	Normal

Cluster 1	hector	12	+916300759610	77	Normal
Cluster 1	julious	12	+916300759610	75	Normal
Cluster 1	tanjiro	17	+916300759610	75	Normal
Cluster 1	ivan	12	+916300759610	100	Normal
Cluster 1	luke	12	+916300759610	71	Normal
Cluster 2	xenon	31	+916300759610	65	Normal
Cluster 2	rajesh	12	+916300759610	93	Normal
Cluster 2	vandal	12	+916300759610	98	Normal
Cluster 2	pekka	32	+916300759610	97	Normal
Cluster 2	emily	12	+916300759610	89	Normal
Cluster 2	madara	55	+916300759610	74	Normal
Cluster 9	golem	12	+916300759610	70	Normal
Cluster 5	suhas	12	+916300759610	71	Normal
Cluster 5	neon	12	+916300759610	70	Normal
Cluster 5	anya	8	+916300759610	91	Normal

| Cluster 5 | mitsuki | 14 | +916300759610 | 94 | Normal |

| Cluster 5 | damon | 12 | +916300759610 | 73 | Normal |

| Cluster 5 | faraz | 12 | +916300759610 | 69 | Normal |

| Cluster 6 | gojo | 23 | +916300759610 | 63 | Normal |

| Cluster 6 | carles | 12 | +916300759610 | 86 | Normal |

| Cluster 6 | suzume | 13 | +916300759610 | 71 | Normal |

| Cluster 6 | chintu | 14 | +916300759610 | 76 | Normal |

| Cluster 6 | saitama | 24 | +916300759610 | 72 | Normal |

| Cluster 6 | andrew | 12 | +916300759610 | 71 | Normal |

| Cluster 7 | vegeta | 28 | +916300759610 | 100 | Normal |

| Cluster 7 | shravya | 13 | +916300759610 | 85 | Normal |

| Cluster 7 | sherif | 12 | +916300759610 | 85 | Normal |

| Cluster 7 | sasuke | 32 | +916300759610 | 97 | Normal |

| Cluster 7 | luffy | 19 | +916300759610 | 88 | Normal |

| Cluster 7 | wisp | 28 | +916300759610 | 94 | Normal |

| Cluster 8 | blaze | 12 | +916300759610 | 75 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 8 | jimmy | 27 | +916300759610 | 80 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 8 | abhuday | 24 | +916300759610 | 82 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 8 | hashirama | 67 | +916300759610 | 80 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 8 | zeref | 26 | +916300759610 | 70 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 8 | kernel | 12 | +916300759610 | 82 | Normal |

+----------+----------+-------+----------------+-------------+----------+

+----------+----------+-------+----------------+-------------+----------+

| Cluster | Name | Age | Mobile Number | Heart Rate | Status |

+==========+==========+=======+================+=============+==========+

| Cluster 3 | yamate | 35 | +916300759610 | 82 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 3 | uday | 12 | +916300759610 | 61 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 3 | mikey | 16 | +916300759610 | 70 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 3 | gamur | 18 | +916300759610 | 91 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 3 | chad | 21 | +916300759610 | 77 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 3 | siddu | 28 | +916300759610 | 75 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 4 | winzo | 13 | +916300759610 | 79 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 4 | robert | 41 | +916300759610 | 88 | Normal |

+----------+----------+-------+----------------+-------------+----------+

| Cluster 4 | tanmay | 12 | +916300759610 | 80 | Normal |

| Cluster 4 | quionton | 12 | +916300759610 | 83 | Normal |

| Cluster 4 | marshall | 12 | +916300759610 | 64 | Normal |

| Cluster 4 | nezuko | 7 | +916300759610 | 69 | Normal |

| Cluster 1 | omen | 14 | +916300759610 | 75 | Normal |

| Cluster 1 | hector | 12 | +916300759610 | 75 | Normal |

| Cluster 1 | julious | 12 | +916300759610 | 82 | Normal |

| Cluster 1 | tanjiro | 17 | +916300759610 | 73 | Normal |

| Cluster 1 | ivan | 12 | +916300759610 | 65 | Normal |

| Cluster 1 | luke | 12 | +916300759610 | 73 | Normal |

| Cluster 2 | xenon | 31 | +916300759610 | 98 | Normal |

| Cluster 2 | rajesh | 12 | +916300759610 | 99 | Normal |

| Cluster 2 | vandal | 12 | +916300759610 | 69 | Normal |

| Cluster 2 | pekka | 32 | +916300759610 | 101 | High |

| Cluster 2 | emily | 12 | +916300759610 | 69 | Normal |

| Cluster 2 | madara | 55 | +916300759610 | 95 | Normal |

Cluster 9	golem	12	+916300759610	95	Normal
Cluster 5	suhas	12	+916300759610	67	Normal
Cluster 5	neon	12	+916300759610	79	Normal
Cluster 5	anya	8	+916300759610	78	Normal
Cluster 5	mitsuki	14	+916300759610	70	Normal
Cluster 5	damon	12	+916300759610	93	Normal
Cluster 5	faraz	12	+916300759610	63	Normal
Cluster 6	gojo	23	+916300759610	64	Normal
Cluster 6	carles	12	+916300759610	82	Normal
Cluster 6	suzume	13	+916300759610	83	Normal
Cluster 6	chintu	14	+916300759610	55	Low
Cluster 6	saitama	24	+916300759610	70	Normal
Cluster 6	andrew	12	+916300759610	78	Normal
Cluster 7	vegeta	28	+916300759610	83	Normal
Cluster 7	shravya	13	+916300759610	67	Normal

| Cluster 7 | sherif | 12 | +916300759610 | 65 | Normal |

| Cluster 7 | sasuke | 32 | +916300759610 | 64 | Normal |

| Cluster 7 | luffy | 19 | +916300759610 | 95 | Normal |

| Cluster 7 | wisp | 28 | +916300759610 | 86 | Normal |

| Cluster 8 | blaze | 12 | +916300759610 | 86 | Normal |

| Cluster 8 | jimmy | 27 | +916300759610 | 99 | Normal |

| Cluster 8 | abhuday | 24 | +916300759610 | 75 | Normal |

| Cluster 8 | hashirama | 67 | +916300759610 | 61 | Normal |

| Cluster 8 | zeref | 26 | +916300759610 | 65 | Normal |

| Cluster 8 | kernel | 12 | +916300759610 | 95 | Normal |

| Cluster | Name | Age | Mobile Number | Heart Rate | Status |

| Cluster 3 | yamate | 35 | +916300759610 | 74 | Normal |

| Cluster 3 | uday | 12 | +916300759610 | 95 | Normal |

| Cluster 3 | mikey | 16 | +916300759610 | 80 | Normal |

| Cluster 3 | gamur | 18 | +916300759610 | 78 | Normal |

Cluster 3	chad	21	+916300759610	92	Normal
Cluster 3	siddu	28	+916300759610	86	Normal
Cluster 4	winzo	13	+916300759610	99	Normal
Cluster 4	robert	41	+916300759610	99	Normal
Cluster 4	tanmay	12	+916300759610	88	Normal
Cluster 4	quionton	12	+916300759610	75	Normal
Cluster 4	marshall	12	+916300759610	73	Normal
Cluster 4	nezuko	7	+916300759610	86	Normal
Cluster 1	omen	14	+916300759610	82	Normal
Cluster 1	hector	12	+916300759610	74	Normal
Cluster 1	julious	12	+916300759610	61	Normal
Cluster 1	tanjiro	17	+916300759610	82	Normal
Cluster 1	ivan	12	+916300759610	73	Normal
Cluster 1	luke	12	+916300759610	87	Normal
Cluster 2	xenon	31	+916300759610	92	Normal

| Cluster 2 | rajesh | 12 | +916300759610 | 78 | Normal |

| Cluster 2 | vandal | 12 | +916300759610 | 93 | Normal |

| Cluster 2 | pekka | 32 | +916300759610 | 72 | Normal |

| Cluster 2 | emily | 12 | +916300759610 | 67 | Normal |

| Cluster 2 | madara | 55 | +916300759610 | 89 | Normal |

| Cluster 9 | golem | 12 | +916300759610 | 92 | Normal |

| Cluster 5 | suhas | 12 | +916300759610 | 84 | Normal |

| Cluster 5 | neon | 12 | +916300759610 | 76 | Normal |

| Cluster 5 | anya | 8 | +916300759610 | 60 | Normal |

| Cluster 5 | mitsuki | 14 | +916300759610 | 86 | Normal |

| Cluster 5 | damon | 12 | +916300759610 | 69 | Normal |

| Cluster 5 | faraz | 12 | +916300759610 | 79 | Normal |

| Cluster 6 | gojo | 23 | +916300759610 | 93 | Normal |

| Cluster 6 | carles | 12 | +916300759610 | 72 | Normal |

| Cluster 6 | suzume | 13 | +916300759610 | 78 | Normal |

| Cluster 6 | chintu | 14 | +916300759610 | 70 | Normal |

| Cluster 6 | saitama | 24 | +916300759610 | 63 | Normal |

| Cluster 6 | andrew | 12 | +916300759610 | 69 | Normal |

| Cluster 7 | vegeta | 28 | +916300759610 | 70 | Normal |

| Cluster 7 | shravya | 13 | +916300759610 | 88 | Normal |

| Cluster 7 | sherif | 12 | +916300759610 | 67 | Normal |

| Cluster 7 | sasuke | 32 | +916300759610 | 100 | Normal |

| Cluster 7 | luffy | 19 | +916300759610 | 72 | Normal |

| Cluster 7 | wisp | 28 | +916300759610 | 69 | Normal |

| Cluster 8 | blaze | 12 | +916300759610 | 77 | Normal |

| Cluster 8 | jimmy | 27 | +916300759610 | 67 | Normal |

| Cluster 8 | abhuday | 24 | +916300759610 | 99 | Normal |

| Cluster 8 | hashirama | 67 | +916300759610 | 81 | Normal |

| Cluster 8 | zeref | 26 | +916300759610 | 72 | Normal |

| Cluster 8 | kernel | 12 | +916300759610 | 99 | Normal |

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PROJECT RUBRICS

RUBRICS FOR PROJECT

Focus Areas	C No	Criterion [c]	Exemplary 4	Satisfactory 3	Developing 2	Unsatisfactory 1
Problem Formulation (PO1,PO2, PO6, PO7,PSO1)	I	**Identify/Define Problem** Ability to identify a suitable problem and define the project objectives.	Demonstrates a skillful ability to identify/ articulate a problem and the objectives are well defined and prioritized.	Demonstrates ability to Identify/ articulate a problem and All major objectives are identified.	Demonstrates some ability to identify/articulate a problem that is partially connected to the issues and most major objectives are identified but one or two minor ones are missing or priorities are not established.	Demonstrates minimal or no ability to identify / articulate a problem and many major objectives are not identified.
	II	**Collection of Background Information:** Ability to gather background Information (existing knowledge, research, and/or indications of the problem)	Collects sufficient relevant background information from appropriate sources, and can identify pertinent/critical information;	Collects sufficient relevant background information from appropriate sources;	Collects some relevant background information from appropriate Sources.	Minimal or no ability to collect relevant background information

	III	**Define scope of the problem** Ability to identify problem scope suitable to the degree considering the impact on society and environment.	Demonstrates a skillful ability to define the scope of the problem accurately mentioning the relevant fields of engineering precisely. Considers, explains and evaluates the impact of engineering interventions on society and the environment.	Demonstrates ability to define problem scope mentioning the relevant fields of engineering broadly. Considers and explains the impact of engineering interventions on society and the environment.	Demonstrates some ability to define problem scope mentioning some of the relevant fields. Some consideration of the impact of engineering interventions on society and the environment.	Demonstrates minimal or no ability to define problem scope and fails to mention relevant fields of engineering. Minimal or no consideration of the impact of engineering interventions on society and the environment.

Project Design (PO3,PSO1)	IV	**Understanding the Design Process and Problem-Solving:** Ability to explain the design process including the importance of needs, specifications, and concept generation, and to develop an approach to solve a problem.	Demonstrates a comprehensive ability to understand and explain a design process. Considers multiple approaches to solving a problem, and can articulate the reason for choosing a solution	Demonstrates an ability to understand and explain a design process. Considers multiple approaches to solving a problem, which is justified and considers consequences.	Demonstrates some ability to understand and explain a design process. Considers a few approaches to solving a problem; doesn't always consider consequences.	Demonstrates minimal or no ability to understand and explain a design process. Considers a single approach to solving a problem. Does not consider consequences.
Build (PO4,PO5, PSO1)	V	**Implementing Design Strategy and Evaluating Final Design:** Ability to execute a solution taking into consideration design requirements using appropriate tool (software /hardware);	Demonstrates a skillful ability to execute a solution taking into consideration all design requirements using the most relevant tool.	Demonstrates an ability to execute a solution taking into consideration design requirements using the relevant tool.	Demonstrates some ability to execute a solution but not using the most relevant tool.	Demonstrates minimal or no ability to execute a solution. The solution does not directly attend to the problem.
Test & Deploy (PO4, PO5, PSO1)	VI	To evaluate/confirm the functioning of the final design. To deploy the project on the target environment	Demonstrates a skillful ability to evaluate/confirm the functioning of the final design skillfully, with deliberation for further Improvement after deployment.	Demonstrates an ability to evaluate/confirm the functioning of the final design. The evaluation is complete and has sufficient depth.	Ability to evaluate/confirm the functioning of the final design, but the evaluation lacks depth and/or is incomplete.	Demonstrates minimal or no ability to evaluate/confirm the functioning of the final design.
Ethical responsibility (PO8)	VII	Proper Use of Others' Work: Ability to recognize, understand and apply proper ethical use of intellectual property, copyrighted materials, and	Always recognizes and applies proper ethical use of intellectual property, copyrighted materials, and others' research.	Recognizes and applies proper ethical use of intellectual property, copyrighted materials, and others' research.	Some recognition and application of proper ethical use of intellectual property, copyrighted materials, and others' research.	Minimal or no recognition and/or application of proper ethical use of intellectual property, Copyrighted materials, or others' research.

		research				
Team Skills (PO9)	VIII	**Individual Work Contributions and Time Management:** Ability to carry out individual Responsibilities and manage time (estimate, prioritize, establish deadlines/ milestones, follow the timeline, plan for contingencies, adapt to change).	Designated jobs are accomplished by the deadline; completed work is carefully and meticulously prepared and meets all requirements.	Designated jobs are accomplished by the deadline; completed work meets requirements.	Designated jobs are accomplished by the deadline; completed work meets most requirements.	Some Designated jobs are accomplished by the deadline; completed work meets some requirements.
	IX	**Leadership Skills**: Ability to lead a team. (i) Mentors and accepts mentoring from others. (ii) Demonstrates capacity for the initiative while respecting others' roles. Facilitates others' involvement. (iv) Evaluates team Effectiveness and plans for improvements	Exemplifies leadership skills.	Demonstrates leadership skills.	Demonstrates some leadership skills at times.	Demonstrates minimal or no leadership skills.

	X	**Working with Others:** Ability to listen to, collaborate with, and champion the efforts of others.	Skillfully listens to, collaborates with, and champions the efforts of others.	Listens to, collaborates with, and champions the efforts of others.	Sometimes listens to, collaborates with, and champions others' efforts.	Rarely listens to, collaborates with, or champions others' efforts.
Project Presentation (P10)	XI	**Technical Writing Skills** Ability to communicate the main idea with clarity. Ability to use illustrations properly to support ideas (citations, position on the page, etc)	The main idea is clearly and precisely stated. Materials are seamlessly arranged in a logical sequence Illustrations are skillfully used to support ideas	The main idea is understandable. Material moves logically forward, Illustrations are properly used to support ideas	The main idea is somewhat understandable e. Material has some logical order and is somewhat coherent or easy to follow. Illustrations are for the most part properly used to support ideas	The main idea is difficult to understand. Material has little logical order and is often unclear, and incoherent. Illustrations are used, but minimally support ideas. (not properly cited etc)
	XII	**Communication Skills for Oral Reports** Ability to present strong key ideas and supporting details with clarity and concision. Maintain contact with the audience, and the ability to complete in the allotted time	The presentation is logically and skillfully structured. Key ideas are compelling and articulated with exceptional clarity and concision. The introduction, supporting details, and summary are evident and memorable and ascertain the credibility of the speaker The presentation fits perfectly within the time constraint.	The presentation has a clear structure. Key ideas are clearly and concisely Articulated… There is sufficient detail about the speaker's authority including an introduction and summary. The presentation fits within a time constraint, though the presenter has to subtly rush or slow down.	The presentation has some structure. Key ideas are generally identifiable, although not remarkable. Introduction, supporting details the summary may be broad. The credibility of the speaker may be questionable at times. The presentation does not quite fit within time constraints;	Presentation rambles. Not organized; key ideas are difficult to identify, and are unremarkable. No clear introduction, supporting details, or summary. The speaker has no credibility. Presentation is unsuitably short or unreasonably long.

Project Management (PO11,PSO2)	XIII	Use of software project management principles and tools (versioning, time schedules etc)	Employ all the appropriate tools or engineering techniques. Demonstrates mastery of several areas of the curriculum.	Employ the appropriate tools or engineering techniques	Employ some management tools	Does not make use of any tool
Lifelong Learning (PO12,PSO2)	XIV	**Extend Scope of Work:** Ability to extend the project through implementation in other study areas	Demonstrates a skillful ability to explore a subject/topic thoroughly and discusses the road map to extend the project in other areas.	Demonstrates an ability to explore a subject/topic, and shows possible areas in which the project can be extended	Demonstrates some ability to explore a subject/topic, providing some knowledge of areas in which the project can be extended	Demonstrates minimal or no ability to explore a subject/topic, and does not discuss future work mentioning other areas

Table-7.1 Rubrics for Project

	PO/PSO	PO1,PO2, PO6, PO7, PSO1			PO3, PSO1	PO4, PO5, PSO1	PO4, PO5, PSO1	PO8	PO9			PO10		PO11, PSO2	PO12 ,PSO2
Batch	**Rubrics**	R1			R2	R3	R4	R5	R6			R7		R8	R9
	Roll No	CI	CII	CIII	CIV	CV	CVI	CVII	CVIII	CIX	CX	CXI	CXII	CXIII	CXIV

Table-7.2 Rubrics Evaluation