Development of Edge, Fog and Cloud Computing for Health Monitoring using Raspberry Pi as Fog device and IOT Sensors as Edge Devices

Kiransing P. Paradeshi, PhD
Professor, Department of Electronics Engineering,
PVPIT, Budhgaon, Sangli, Maharashtra, India

Siddharth B. Kamble
Student, Department of Electronics Engineering
PVPIT, Budhgaon, Sangli, Maharashtra, India

Supriya G. Mhetre
Student, Department of Electronics Engineering
PVPIT, Budhgaon, Sangli, Maharashtra, India

Suhana M. Magdum
Student, Department of Electronics Engineering
PVPIT, Budhgaon, Sangli, Maharashtra, India

Uzma M. Khatib
Student, Department of Electronics Engineering
PVPIT, Budhgaon, Sangli, Maharashtra, India

ABSTRACT
In this paper a health monitoring system that supports edge, fog, and cloud computing architecture is implemented. Edge, fog computing is all about bringing the power of the cloud closer to where the data is being generated. It combines edges computing, fog computing and cloud computing to create a distributed network that can handle data processing, storage and analysis at the stage of edge and fog level of the network. This means that instead of sending all the data to a centralized cloud server, it can be processed and analyzed right where it's being generated, reducing latency and improving response times. The system utilizes IoT sensors as edge devices to collect real-time health data from individuals. This data is collected by the edge device, then processed and analyzed by fog devices and cloud computing is indeed used in health monitoring system for storage.
In this health monitoring system, the IoT sensors act as the "eyes and ears" of the system, collecting health data such as heartbeat and temperature. Therefore, combination of cloud computing and IoT can provide the best performance for users. Cloud Computing nowadays provides lifesaving healthcare. applications by collecting data from bedside devices viewing patient information and diagnosis in real time. There may be some concerns about security and other issues with the patient's data, but utilization of IoT and cloud technologies in the healthcare industry would open a new era in the field of healthcare.

General Terms
In this project, we work on the computing methods of edge computing. Fog Computing, Cloud Computing, Internet of Things (IoT), Health Monitoring, Data Processing, Real-Time Monitoring, Sensor Networks.

Keywords
Edge Computing, Fog Computing, and Cloud Computing, Arduino UNO, Raspberry Pi, IoT Sensors.

1. INTRODUCTION
Internet of Things is one of the fastest growing industries bringing social and economic benefits to emerging and developing economies. The Internet of Things (IoT) is a collection of interconnected computing devices, physical devices and sensors with unique identifiers and the ability to carry data over a network without human or computer intervention. IoT enables remote control of systems over the Internet. IoT is gaining traction in many sectors such as medicine, transportation and agriculture. These sensors act as vanguards for data collection and capturing real-time health measurements with high accuracy and reliability information. The collected data is then transmitted to nearby fog nodes, where Raspberry Pi devices are used to perform initial data preprocessing. The fog layer acts as an intermediate computing bridge. Offering proximity to edge devices and reducing communication overhead between edge and cloud components. Raspberry Pi collects data from sensors and then transfers it to the cloud. Cloud computing is a general expression for any technical service provided over the Internet. Using sensors in our project has many advantages. Which is real-time monitoring, cost effectiveness, scalability, accessibility. Basically, we focus on the idea of integration between IoT sensors, Arduino UNO, Raspberry Pi and cloud computing. Health sensors attached to the patient's body provide services such as receiving, storing and processing data after collecting the data and sending it to the cloud.

2. RELATED WORK
2.1 Mohammad S. Jasses et al. [1]. The cloud-based system focuses on body temperature monitoring using a Raspberry Pi board. In this paper, Raspberry monitors body temperature and then these parameters are transferred through a wireless sensor network. (WSN). This data is then added to a cloud-based website. Using this website, one can monitor body temperature.

2.2 Deepika Agarwal et al. [2]. An IoT-based healthcare monitoring system is proposed that integrates all medically relevant data on patients including heart rate, blood pressure and ECG and sends alerts to the patient's doctor regarding the patient's entire medical context, providing informed, fast and reliable healthcare services.

2.3 Ravi Kishore Kodali etc. [3]. Proposed healthcare monitoring, which is implemented to check the patient's temperature. Hospital records are stored in the cloud. IoT-enabled devices here at the same time regularly enrich the quality of care actively monitor and collect data and control the cost of care and analytics.

2.4 Jasmeet Chhabra and others. [4]. Propose a plan and emergency medical service-based implementation on an IoT

health monitoring system. In this project, the patient's health related problems and healthcare costs are reduced by collecting, recording, analyzing and sharing the data stream through the Internet, which reduces the speed of the patient going to the doctor every time to check the heart rate, temperature and health parameters. blood pressure.

2.5 Owaisi et al. [5] specifically proposed an efficient healthcare IoT based on fog computing to increase efficiency and security, they proposed an efficient healthcare IoT architecture based on fog computing. Then, to increase security, they use an identity-based user authentication method.

3. PROBLEM FORMULATION

The problem we're aiming to solve is to design a system. that can seamlessly collect real-time health data from IoT sensors at edge level in Arduino UNO, process it efficiently at the fog using the Raspberry Pi, and then the transmit the processed data to the cloud for further analysis. We want to ensure that the system is capable of handling a large number of sensors, processing the data in a timely manner, and providing actionable insights to healthcare professionals.

3.1 PROPOSED SYSTEM

This paper presents a robust health monitoring system that intelligently monitors patients automatically. Using IOT and layers of computing. Levels of Computing Edge computing is used for devices and networks that are physically close to the user. Instead of sending all data to a central server, it is processed closer to the source. This helps reduce delays and makes things easier. Quick examples: smart watches, sensors, smartphones, speakers, etc.

3.1.1 Fog computing essentially includes application components running in the cloud as well as sensors and edge devices in the cloud, i.e. smart gateways, routers or dedicated fog devices. Fog computing brings data storage and computation. Close to the network edge. This reduces the need to rely on the cloud for resource-intensive tasks. Examples: Raspberry Pi, routers, access points, etc.

3.1.2 Cloud computing refers to the delivery of various computing services over the Internet. These services may include servers, storage, databases, networking, software, analytics, and more. Instead of owning and maintaining physical hardware and infrastructure, users can access these resources on demand from a cloud service provider. Examples: Google Cloud Storage, One Drive, etc. Arduino Uno is a popular microcontroller board. Based on ATmega328P processor. It has 14 digital input/output pins, 6 analog inputs, a USB connection for programming and a power jack. The board is often used for prototyping and DIY electronics. project due to its ease of use and large community of developers. Arduino Uno is compatible with Arduino software, making it accessible for beginners and versatile for advanced users.

3.1.3 The Raspberry Pi 4 Model B is a powerful and versatile single-board computer. There are some. Raspberry Pi features such as improved performance, enhanced connectivity, multiple USB ports, video and display capability, 40-pin GPIO, operating system compatibility and is versatile and popular. The board is used for a wide range of home automation and robotics projects in media centres and IoT application.

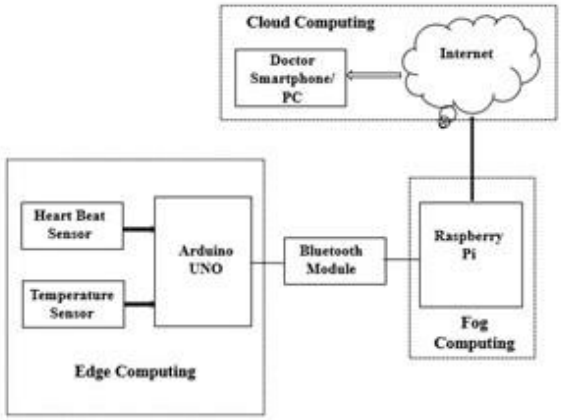

Fig 1: Block Diagram of Project.

4 . METHODOLOGY

The method of implementing a health monitoring system involves several steps:

1) Problem Definition: Clearly define the requirements. and objectives of health surveillance systems. Identify specific health parameters to monitor, such as heart rate, ECG or temperature.

2) Sensor Deployment: Deploy IoT sensors and devices. To collect health data from patients.

2.1) Heart Beat Sensor: Alternate name of this sensor is Heartbeat Sensor or Heart Rate Sensor. The work of this sensor can be done by connecting from a fingertip or human ear to an Arduino board. So that the heart rate can be measured easily.

2.2) Temperature sensor: The DS18B20 temperature sensor is a popular digital sensor used to measure temperature in various applications. It provides accurate temperature readings with a resolution of up to 12 bits.

3) Collection: Arduino UNO is used as an edge device to collect data from various sensors and send it to Raspberry Pi for further processing.

4) Communication: Using the Bluetooth module HC-05, we connected the edge devices to the fog devices, i.e., Arduino Uno to Raspberry Pi.

5) Data Processing: Raspberry Pi is used as a fog device to process data and send this data over the internet.

6) Cloud Computing: Set up a central cloud infrastructure for deep data analysis, storage and long-term monitoring. Thingspeak is actually an Internet of Things (IoT) platform that allows you to collect, analyze and visualize sensor data. It is not directly related to cloud computing, but it can be used in conjunction with cloud computing services to store and process data collected from IoT devices. With Thingspeak allows you to build IoT applications and monitor real-time data from various sensors.

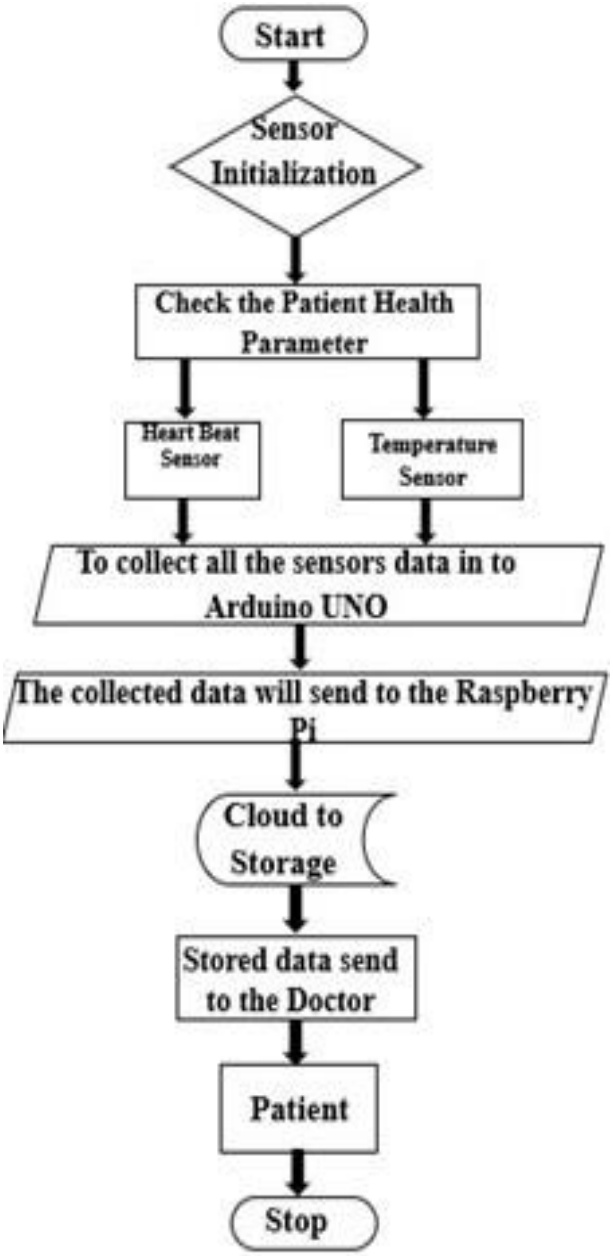

Fig 2: Flow chart

5. IMPLEMENTATION

Innovative development of edge, fog and Cloud Computing for Health Monitoring with Raspberry Pi as Fog Device and IoT Sensor as Edge Device, Marc An important step towards improving the health care system. This integrated approach enables real-time monitoring and analysis of health data at the Edge, ensuring timely and localized insights. Using Raspberry Pi as fog Optimizes device computing performance, reduces Improving latency and response.

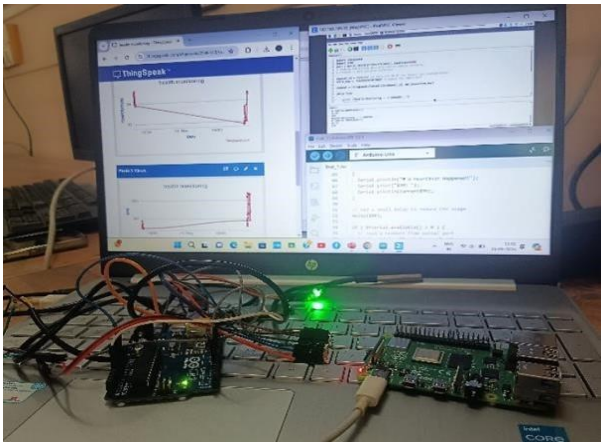

Fig 3: Implementation of project /Snap of Project.

6. RESULT AND DISCUSSION

Edge Level Result-

At edge level the IOT sensors are used to collect the temperature and heartbeat data of patient on Arduino uno as showed below.

```
14:51:38.196 -> 33.06°C
14:51:38.196 -> 91.51°F
14:51:38.229 -> ♥ A HeartBeat Happened!
14:51:38.229 -> BPM: 64
14:51:38.806 -> 33.06°C
14:51:38.839 -> 91.51°F
14:51:38.839 -> ♥ A HeartBeat Happened!
14:51:38.881 -> BPM: 72
14:51:39.450 -> 33.06°C
14:51:39.450 -> 91.51°F
14:51:39.482 -> ♥ A HeartBeat Happened!
14:51:39.482 -> BPM: 76
14:51:40.060 -> 33.06°C
14:51:40.092 -> 91.51°F
14:51:40.092 -> ♥ A HeartBeat Happened!
14:51:40.132 -> BPM: 84
14:51:40.715 -> 33.13°C
14:51:40.715 -> 91.62°F
14:51:41.346 -> 33.06°C
14:51:41.346 -> 91.51°F
14:51:41.965 -> 33.06°C
14:51:41.965 -> 91.51°F
14:51:42.554 -> 33.13°C
14:51:42.594 -> 91.62°F
14:51:43.180 -> 33.13°C
14:51:43.213 -> 91.62°F
14:51:43.213 -> ♥ A HeartBeat Happened!
14:51:43.254 -> BPM: 220
14:51:43.819 -> 33.13°C
14:51:43.819 -> 91.62°F
14:51:43.852 -> ♥ A HeartBeat Happened!
14:51:43.852 -> BPM: 196
```

Fig 4: Screenshot of Arduino serial Mentoring

Fog Level result-

At fog level, data received form edge level is process and classified and made ready for sending to the cloud level.

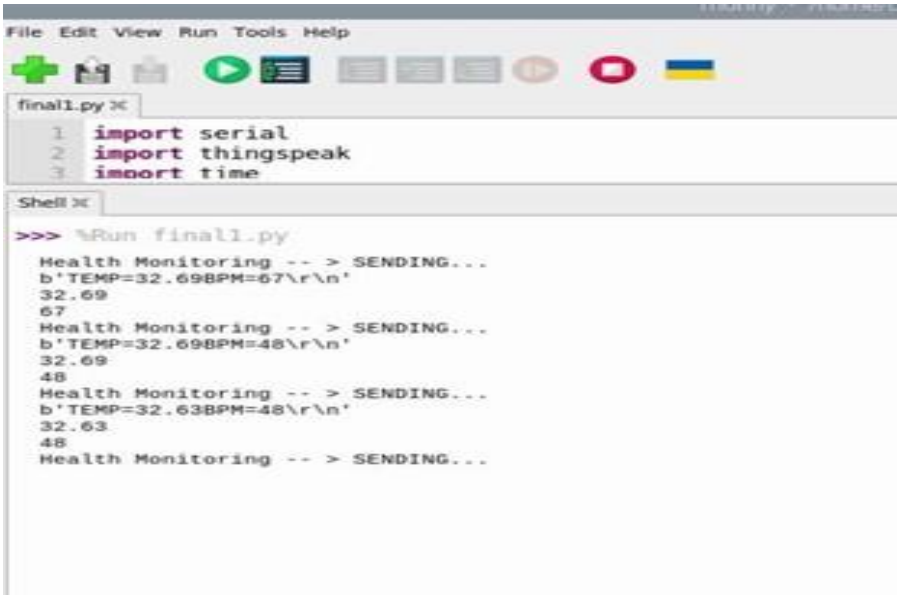

Fig.5. Screenshot of Raspberry Pi

Cloud Level Result –

At the cloud level, data received from the fog level is represented in graphical from in real time. This data will be available for the both doctor and patient for monitoring purpose.

Fig 6: Chart of Body Temperature/ Chart of BPM

6.1. DISCUSSION / CONCLUSION

The current project Real-Time Health Monitoring System using Edge, Fog, and Cloud Computing can be concluded to have provided the integration of edge, fog, and cloud computing for health monitoring through IoT sensors and Raspberry Pi. Of course, the proposed system minimizes latency and enhances the response time as it deals with data at the edge and fog levels before sending the results to clouds for further processing and storage. Thus, they use IoT sensors to continuously monitor health parameters and obtain credible data. Application of this system is possible in many aspects of health care; therefore, it will be easy to implement a scalable strategy of health monitoring. Further work will involve enhancing the protective measures of the collected data and conducting research using sophisticated machine learning techniques for better and more accurate predictions.

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