# Priority-Based Task Allocation in Four-Tier Fog IOT Architecture For WBAN's

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SRM University – AP, Andhra Pradesh
for the partial fulfillment of the requirements to award the degree of

**Bachelor of Technology**

In
**Computer Science and Engineering**
**School of Engineering and Sciences**

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# Certificate

Date: 28-Nov-23

This is to certify that the work present in this Project entitled " **Priority-Based Task Allocation in Four-Tier Fog IOT Architecture For WBAN's**" has been carried out by **[ Jashvitha, Sravya, Moesha, TarunSai ]** under my supervision. The work is genuine, original, and suitable for submission to the SRM University – AP for the award of Bachelor of Technology/Master of Technology in **School of Engineering and Sciences**.

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Next, I want to sincerely thank our college, SRM University AP, for giving us the opportunity to do research as part of our course work. We had to learn to think critically and to extend our horizons by this experience.

We have recently developed an interest in research, so when we learned about this opportunity, we were thrilled to seize it. We also considered how it would benefit us should we decide to pursue a master's degree abroad by helping us secure a research publication in our names.

We are also appreciative of this project because everyone was able to contribute in some way, which made it easier to complete and finish quickly.

Our main worry was that we might graduate from college with a degree that only included our academic standing. However, when we learned that our college was giving us the chance to conduct research under supervision or guidance, it made us feel better about ourselves outside of our coursework. We will be conducting research as part of our curriculum, and with the right guidance, we also hope that the research paper we will submit for the final will be published and be of great assistance to us.

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# Abstract

In the era of the WBANs and the IOT have garnered significant attention due to their ability to enable real-time health surveillance.However, because of the growing complexity and volume of data in WBANs, efficient task allocation is necessary.According to the current situation, there is a growing need for WBANs to process sensitive and important data quickly and to make the best use of their resources.The resource management unit (RMU) integrates with the MEC servers and WBANs to optimize work distribution within the WBAN and servers. This paper addresses the current challenges by proposing a four-tier architecture that functions well for monitoring and allocating data of WBANs.To reduce latency and enhance real-time health monitoring, the MEC.

# Statement of Contributions

In this work, we introduced the architecture of the new system and gave a quick overview of its design by using an architecture diagram provided by Sravya and Moesha.

A four-tier task allocation system was examined by Tarun Sai. A contribution I made to this report is Fog IoT Architecture for WBANs, which produced insightful findings that are emphasized in the conclusion. A future scenario is included here as well. New avenues for investigation have opened up.

I give a brief overview of cloud, fog, and MEC Server. We have developed a new design system architecture through group discussions using information provided by group members.

# Abbreviations

| | |
|---|---|
| WBAN | Wireless body area network |
| MCC | Mobile Cloud Computing |
| MEC | Mobile Edge Computing |
| IOMT | Internet of Medical Things |
| RMU | Resource Management Unit |

# 1. Introduction

An emerging technology for healthcare management applications combines wireless, non-medical, and medical devices into a body area network that is WBAN. That is the (IoT) makes it possible. WBANs minimize the need for recurrent hospital visits by enabling healthcare providers to remotely monitor patients' health status. Patients who live in remote areas or those with chronic conditions will especially benefit from this.

It is suggested that Mobile Cloud Computing (MCC) move UEs' computational capacity can be increased and battery life extended by outsourcing computationally demanding tasks to public cloud services like Amazon EC2.It enables real-time data processing, analysis, and maintaining for health-related applications.This makes it possible to gather and analyze health data from various devices, which makes data-driven decision-making, personalized healthcare, and remote monitoring possible .

Since cloud platforms are typically located far from user equipment (UEs),Because the MCC cannot meet the strict demands of latency-sensitive applications, task offloading efficiency is decreased. In response to these constraints, a novel technology known as Mobile Edge Computing (MEC) has surfaced [6]. It permits data processing at the network edge, providing users with close access to computational and communication capabilities.

The physical separation that exists between cloud platforms and User Equipments (UEs) poses intrinsic difficulties for MCC, especially when trying to meet the demanding needs of latency-sensitive applications. Due to the potential for suboptimal data transmission delays between UEs and distant Cloud platforms, this limitation directly affects how well task offloading works.

In response to these difficulties, MEC is a major advancement in edge computing technologies[1]. By allowing data processing at the network edge and carefully placing computational resources close to end users, MEC provides an attractive solution. This close proximity not only lowers data transmission latency but also unleashes the combined power of instantaneous computational and communication capabilities near users.

By integrating MEC, the inefficiencies of MCC are remedied, offering a solution to the latency issues encountered by applications that require quick and accurate responses. Utilizing MEC's capabilities makes data processing more localized, which improves latency-sensitive applications' overall responsiveness and efficiency [5].

In addition to optimizing task offloading, this revolutionary move towards edge computing creates new opportunities for applications that demand low latency, high throughput, and close proximity to users. MEC is a crucial enabler for achieving edge computing's full potential in order to satisfy the changing needs of contemporary, dynamic digital ecosystems as technology develops.

Healthcare applications requiring large data storage, sophisticated computation, low latency, and high reliability can be supported by MEC servers [10]. They are located near the user. This makes sense because as the number of WBAN users expands, the MEC server has to work harder to keep up.Because fog computing offers secure, scalable, and low latency responses, it has been applied to the field of health monitoring.We propose a distributed optimization model for fog node assignment that aims to manage both periodic and irregular tasks allocation by optimizing the utility of each node participating in the task execution process while satisfying task delay constraints [2].

# 2. Literature Survey

Recently, there has been a lot of interest in the integration of cloud computing, fog computing, and mobile edge computing (MEC), particularly in the areas of resource allocation, computational offloading, resource optimization, and system performance improvements.

Numerous scholars have investigated the amalgamation of IOT technologies such as MEC, FOG, and CLOUD computing to tackle the obstacles presented by instantaneous situations and to enable intelligent healthcare services. For example, In order to effectively reduce the overall cost in terms of delay and energy consumption using the computational task offloading scheme, a three-tier architecture that consists of one RCS, multiple MESs, and multiple WBANs is proposed.

One of the main areas of research for MEC devices is computational offloading techniques. Previous research frequently makes the assumption that end devices have adequate processing power, which results in resource allocation algorithms for assigning from 5G edge computing systems to healthcare services [13].In order to balance latency and power constraints, these studies defines frameworks as Nash bargaining games and propose Lyapunov-based proportional-fairness allocation algorithms.Many of these computational offloading approaches, however, are inapplicable in scenarios where the user equipment's (UE) computational capacity is limited.

One potential way to address these issues with the Internet of Medical Things (IoMT) is through fog computing integration.Distributed fog nodes enable fog computing, which is thought of as an extension of the centralized cloud at the edge of wireless networks[11]. Fog computing-enabled devices are flexible enough to perform medical tasks efficiently, even though they lack the processing power of cloud servers in CloudC-IoMT. This flexibility results in lower latency and energy consumption when compared to sending medical tasks over long distances to distant cloud servers.

Although a few papers have examined task allocation strategies in MEC systems, there are still obvious gaps in the current methodologies. Many studies focus on models that are either server- or user-focused and do not have an interactive framework connecting the MEC server and users.Our objective is to make sense of these gaps. Both irregular and regular task requests are handled by the suggested task allocation strategy, with the last one being prioritized. It guarantees optimal resource utilization while reducing the percentage of unsuccessful jobs.

An optimized network architecture should be investigated in order to solve the issues and improve user experience and overall operational efficiency. Optimization techniques, real-time monitoring, and adaptive algorithms can minimize power consumption and dynamically adjust resource allocation based on healthcare application demands for healthcare monitoring in fog computing-based IoMT during the COVID-19 pandemic.To ensure the scalability and performance of these solutions, the proposed approaches should be verified in real-world scenarios and further refined based on evolving network conditions.Reducing the power consumption of fog computing nodes for healthcare monitoring can be accomplished through fog computing-based Internet of Medical Things (IoMT) optimization techniques.This entails using strategic task offloading techniques that take into account the processing power consumption as well as the computational load on the Mobile Edge Computing (MEC) server.

# Table for Literature Survey

| Authors | | Limitations |
| --- | --- | --- |

| | | |
|---|---|---|
| Liaoeal.[1] | In this study, researchers address the difficulty of attaining low latency in services for real-time health monitoring by proposing an upgraded computer architecture that integrates WBANs with MEC.<br><br>. | Due to their limited computing power and battery life, UEs are unable to fulfill the demands of tasks which are delay sensitive and high computation required. |
| Joshi and Srivastava [2] | In this paper, the difficulty of real-time analysis and action on massive amounts of vital data produced.They put out a distributed optimisation model for fog computing architectures that allocate tasks to fog nodes. | Service delay and Network delay |
| Sarkar et al.[3] | In this paper, researchers tackle the challenge of fair resource distribution in multi-tenant scenarios, particularly in resource-constrained medical emergency situations. | The limitations of the paper include simplifying assumptions about uniform intelligence and behavior of Local Data Processing Units (LDPUs). |

| | | |
|---|---|---|
| Qiu et al [4] | This work aims to investigate the role that the Internet of Medical Things (IoMT) played in the COVID-19 pandemic, with a focus on fog computing-based IoMT (FogC-IoMT) and healthcare monitoring. They solve a nonlinear and nonconvex minimization optimization problem while accounting for power constraints, wireless fronthaul limitations, and quality-of-service requirements. | The limitation of the paper stems from the fact that the minimization optimization problem for healthcare monitoring in fog computing-based IoMT (FogC-IoMT) is an irregular and nonconvex problem that includes Quality-of-Service demands, power constraints, and wireless fronthaul constraints. |
| Pradyuma Kumar and Bishoyi [5] | In this paper, researchers address the challenge of sustainability and energy consumption in MEC servers. The increasing number of users in wireless body area networks (WBANs) adds computational load to MEC servers, raising concerns about energy efficiency. | If every WBAN user shifts their computing duties to the MEC server, then the server's demand increases. Remember that since the MEC server requires electricity to process the work, its overall power consumption increases as its load does. |
| Rongrong Zhang and Chen Zhou [6] | The researchers discuss issues with Wireless Body Area Networks (WBANs) in this paper, which arise from sink nodes' constrained energy and computational capacities. The paper presents a computation task offloading scheme based on MCC and MEC for WBANs in order to get around these restrictions. | Due to the limitations of the sink node (mobile phones), which have limited computational power and energy resources, offloading computation jobs is problematic and makes it hard to complete all computation operations quickly and efficiently. |

| | | |
|---|---|---|
| Jiafu Wan et al.[7] | The authors of this paper investigate how to better deploy pervasive healthcare applications by integrating Mobile Cloud Computing (MCC) with Wireless Body Area Networks (WBANs). They admit that this integration has a number of technical difficulties in addition to its possible advantages. The applications of a cloud-enabled WBAN architecture in widely used healthcare systems are the main topic of discussion. | The absence of WBAN communication standards is one of the paper's shortcomings. Limited memory, energy, computation, and communication capabilities limit WBANs.computing scalability. |
| Kovacevic et al.[8] | The authors of this paper discuss the growing prevalence of wireless telehealth solutions in a range of healthcare use cases, from critical real-time scenarios like emergency patient monitoring in ambulances or intensive care units, to preventive home monitoring. | This paper's limitation is that telehealth cloud-based communication presents a challenge when it comes to providing quality of health (QOS). Which tasks should be executed at the data center and which on the edge is known as edge computing. |
| Dong et al.[9] | The authors of this paper discuss issues with ubiquitous healthcare networks brought about by the Internet of Medical Things' (IoMT) quick development. The growth of Medical Units (MUs) raises problems with inadequate wireless channel and computational capacity. | Static Nature of Game Models ,Scalability Issues ,Assumed Availability of Edge Servers.And Limited Discussion on Security and Privacy.Dependency on Information Accuracy Energy Efficiency Considerations. |

| | | |
|---|---|---|
| Zuo et al.[10] | This paper examines the growing use of wireless telehealth solutions in various healthcare contexts, ranging from home monitoring to emergency situations in real time. It draws attention to the difficulties in delivering sufficient Quality of Service (QoS) in cloud-based telehealth use cases because of problems with reliability and latency related to lengthy communication routes. | Sensitivity to Model Hyperparameters ,Scalability Issues ,Limited Comparison Metrics ,Environmental Variability and Overhead of RL Training. |
| Singh et al.[11] | The problem of real-time smart healthcare applications in remote health systems with latency limitations is discussed in this paper. It suggests using fog computing to allocate resources effectively. The researchers consider a linear combination of Medical Centers' profit and patients' costs as they formulate an optimization problem to maximize system utility. | The limitation of this paper is Generalization and Resource Constraints,Security Concerns ,Scalability and Evaluation Metrics |
| LIU et al.[12] | In this paper, researchers explored a Digital Twin Healthcare model (DTH), and constructed a reference framework for Cloud-DTH. The goal is to enable monitoring, diagnosing, and predicting health aspects using wearable medical devices in the cloud environment, ultimately demonstrating the feasibility through real-time supervision in various application scenarios. | Insufficient Validation and Testing ,Complexity of Healthcare and Dependency on Emerging Technologies Scalability Challenges. |

| | | |
|---|---|---|
| Sunita Rao and Neeraj Kumari [13] | This paper examines the Internet of Medical Things' (IoMT) explosive growth and how it is revolutionizing healthcare technology. It draws attention to the COVID-19 pandemic's increased need for online medical services and the advantages that edge-enabled online learning platforms offer. | The limitations of this paper are Privacy and Security Concerns ,Interoperability Issues.And Scalability Challenges,Reliability and Availability .Data Quality and Accuracy Cost and Resource Constraints. |
| Rahman [14] | In this research paper, the authors address es posed by the increasing complexity in healthcare applications, n wireless body area networks (WBAN) edge computing (MEC) systems. The s sustainability of MEC servers in terms of on and carbon emissions. | The limitations are Latency and Resource Consumption Heterogeneous Data Processing ,Security Concerns,Complexity of SDN Implementation Algorithmic Complexity Data Privacy and Compliance. |

# 2. Methodology:

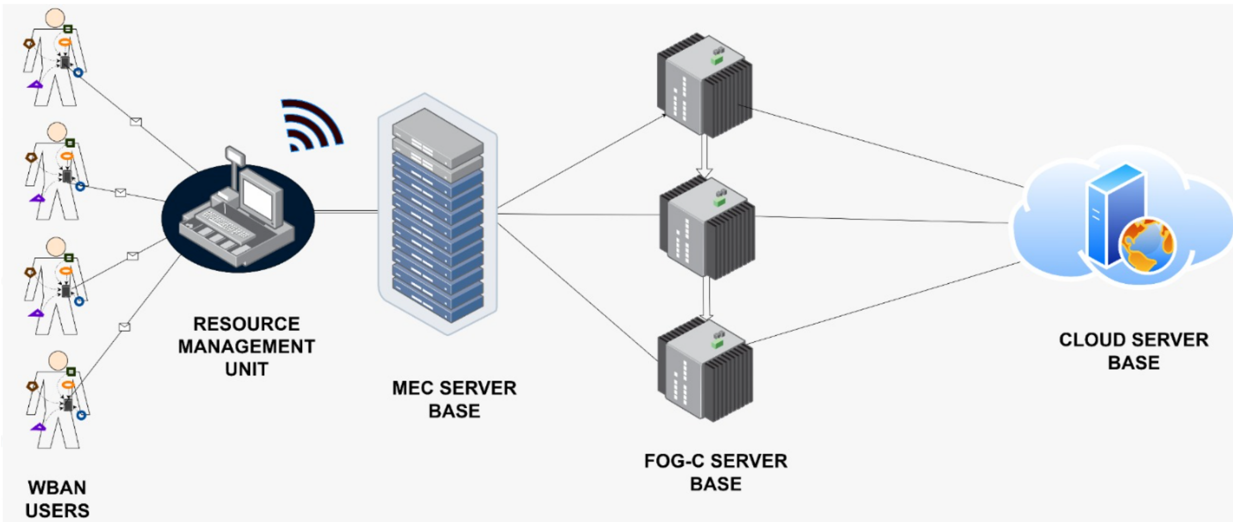


Fig-1 SYSTEM ARCHITECTURE

As seen in the above figure, we have proposed a four-tier architecture in this work that consists of a controller, MEC, several fog servers, and a cloud server. With this architecture, Wireless Body Area Networks are guaranteed a scalable and adaptable system with efficient task distribution and cloud, edge, and fog computing resource utilization. WBAN sensors are simulated in order to assign tasks.Important parameters including data criticality, data rate, and delay sensitivity are taken into account during this simulation process.

In order to distinguish between data that is less time-sensitive, like temperature readings, and data that is vital sign information that is updated in real time, such as heart rate, delay sensitivity measures the urgency attached to the data.When determining the relative importance of various health parameters, data criticality is used to determine, for example, that changes in heart rate are more significant than changes in physical activity.Another crucial factor for a WBAN to take into account in order to get accurate answers when it comes to time-sensitive and data-critical tasks is data rate.

Every user within the Wireless Body Area Network (WBAN) possesses data-gathering sensors. These users start the journey, and a priority-based method is used to send the controller the data that has been gathered. Let's now examine the parameters' significance.

The amount of data transmitted per second is measured by the data rate. Modulus brackets surround the entire expression as it relates to determining data criticality. In the meantime, the formula is as follows:

(present value-lower value)^2 - (upper value-present value)^2 / (|upper value| + |lower value|)^2. The resulting value is then multiplied by the weight assigned to data criticality.

WBAN devices have sensors built in to gather user data related to health. Vital signs and other pertinent health parameters are monitored by these sensors.The Resource Management Unit (RMU), which serves as a hub for receiving data from WBANs, is connected to these WBANs.

RMU employs a multi-criteria decision-making approach called TOPSIS for factors like data criticality, delay sensitivity, and data rate in order to efficiently determine the sensor priority. Based on how well each alternative performs across a number of criteria, TOPSIS is used to choose the best option from a group of options. The simulations' average resultant data is normalized. Priority based task allocation is used at RMU to determine which task should be assigned to the MEC server first after each WBAN's priority value has been calculated.

We are using TOPSIS-based calculations to determine the parameters of each WBAN in this proposed architecture, such as data rate, data criticality, and delay sensitivity. Prior to allocating the data to RMU, the WBAN will compute the values of the various parameters, including s, r, and c. Based on the WBANs whose criteria parameters are taken into consideration in the model in order to allocate the data to RMU, the WBAN creates a N*W decision matrix, where N is the number of WBANs and W is the number of criteria, which is three.

The following diagram shows the stages involved in formulating the TOPSIS mathematically to determine the value of sensors.

In this case, the cost attribute is denoted by criterion R, and the benefit attributes are S and C. The criterion that will be given high preference due to its higher value is the benefit attribute.The cost attribute is the criterion that will be prioritized even though its value is lower. The minimum value is regarded as ideal worst for criteria S and C, and the maximum value as ideal best. Similarly, we identify the ideal worst value for criteria R as the maximum value and the ideal best value as the minimum value.

1. Decision matrix =

$$
\begin{array}{cccc}
 & S & R & C \\
WBAN_1 & S_{1,t} & R_{1,t} & C_{1,t} \\
WBAN_2 & S_{2,t} & R_{1,t} & C_{1,t} \\
. & . & . & . \\
. & . & . & . \\
. & . & . & . \\
. & . & . & . \\
WBAN_n & S_{n,t} & R_{n,t} & C_{n,t}
\end{array}
$$

2. For criterion S, R, and C, determine the ideal best ($\vartheta$+) and ideal worst ($\vartheta$-) values.
We find the optimal value for many factors as

$\vartheta_S^+ = max(S_{j,t})$, $\vartheta_R^+ = min(R_{j,t})$ and $\vartheta_C^+ = max(C_{j,t})$ for all $j$ = 1...$N$.
Similarly we also choose the ideal worst values as
$\vartheta_S^- = min(S_{j,t})$, $\vartheta_R^- = max(R_{j,t})$ and $\vartheta_C^- = min(C_{j,t}t)$ for all $j$ = 1...$N$.
In this case, the cost attribute is denoted by criterion R, while the benefit attributes are S and C. The criterion that will be given high precedence due to its higher value is the benefit attribute. The criterion that will be given significant precedence despite its lower value is the cost characteristic. For criterion S and C, the greatest value is considered ideal best, and the minimum value is considered ideal worst. In a similar manner, we designate the maximum value as the ideal worst and the minimum value as the ideal best for criteria R.

3. Calculate Euclidean distance from the ideal best and ideal worst. The distance from ideal best alternatives is:

$$\varphi^{+}_{j,t} = \sqrt{(S_{j,t} - \vartheta^{+}_{S})^2 + (R_{j,t} - \vartheta^{+}_{R})^2 + (C_{j,t} - \vartheta^{-}_{C})^2}$$

The separation between the best and worst options is:

$$\varphi^{-}_{j,t} = \sqrt{(S_{j,t} - \vartheta^{-}_{S})^2 + (R_{j,t} - \vartheta^{-}_{R})^2 + (C_{j,t} - \vartheta^{-}_{C})^2}$$

4 .determine the value($j,t$), for all $j$ from 1...n.

$$F_{j,t} = \frac{\left[\varphi^{-}_{j,t}\right]}{\left[\varphi^{+}_{j,t} + \varphi^{-}_{j,t}\right]}$$

After calculating the performance the data is allocated to RMU

This makes it easier to transfer work to MEC servers effectively. Mobile edge computing (MEC) transfers workloads from mobile devices with limited resources to edge servers situated nearer the network edge, enabling expedited processing. Nevertheless, because edge servers are resource-constrained, it's important to assign tasks to them efficiently. In order to prevent tasks from being assigned to servers that are overloaded, the controller takes into account each edge server's capacity.

The fog servers are distributedly deployed between the cloud and the edge. Because FOG servers usually have more resources than edge servers, they can handle tasks that need longer processing times or are more complex.An edge server might not be able to handle every task that is offloaded to it if it reaches its capacity limit.Therefore, the last tasks are delegated to FOG servers that are situated farther away from the network edge.On Fog servers, tasks are processed up until their maximum capacity is achieved.Tasks are further transferred to cloud servers when their processing demands surpass those of the MEC and Fog servers combined.Cloud servers are located in the central data center and offer nearly infinite computational power, enabling them to manage complicated, large-scale, and data-intensive tasks.

Every WBAN user goes through this entire process once more, producing calculated values that are recorded. The user with the highest data criticality is assigned the task,which is crucial. This methodical approach guarantees a task distribution that is efficient, prioritized, and customized to meet the specific needs of every WBAN user.

# 4. Concluding Remarks

To ensure optimal healthcare management, a combination of critical parameter-based decision-making, scalability, flexibility, and personalized task distribution is proposed for WBANs. The architecture aims to enhance the efficacy of health monitoring in the network by adapting computing tasks to the individual needs of each user.The system is scalable and flexible, enabling it to accommodate an increasing number of devices and a wide range of user requirements while adapting smoothly to changing conditions.Through our focus on critical parameter-based decision-making, we raise awareness of the significance of task prioritization based on urgency and importance. Furthermore, in the context of WBANs, this method makes use of enhanced computing power at the network edge to enable real-time processing, lower latency, and improve the effectiveness and responsiveness of the healthcare system. This method meets the needs of each individual user while ensuring efficient task distribution in WBANs. Through improved computing capabilities at the network edge, the architecture's scalability and flexibility—combined with crucial parameter-based decision-making—contribute to optimized healthcare management.

# 5. Future Work

The creation of a simulation framework to imitate the suggested four-tier architecture for effective task distribution among MEC, FOG, and cloud servers is the next step in the research paper's work. Simulation tools like NS-3 and MATLAB/simulink are carefully chosen and integrated to improve the functionality of architecture.This methodology will enable a comprehensive assessment of the system's performance across a range of scenarios.

In this upcoming work, the parameters controlling sensor information and task prioritization will be improved to meet the demands of healthcare applications and improve accuracy. Performance evaluation metrics will be generated to assess the system's efficacy, responsiveness, and the rates at which resources from Fog, Cloud, and Mobile Edge Computing (MEC) are being used.We will investigate algorithmic

To identify the areas that need improvement, the suggested solution is compared to the current or alternative solution. Our work intends to provide a dependable and practically applicable solution for managing WBANs and an effective task allocation system by incorporating these advanced tools into future work. We will continue to improve this system and make it more ready for eventual use in the real world.

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