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# Novel Approach for Improving Secure Scheduling in Fog Environment and in Context of Smart Homes

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***Abstract:*** The increasing demand for Internet of Things-based smart home automation systems in the modern period is having an effect on the scheduling in fog environments. During the implementation of a smart home automation system, there is a pressing need for an innovative strategy that is able to significantly enhance the scheduling problems and fog environment. There are many different scheduling techniques available, each of which has its own set of limitations. The incoming real-time home automation is handled by a fog node that functions like a little cloud and has restricted resources. This node evaluates the input locally and sends a response back to the edge device. This method has the benefit of minimizing latency, which is widely recognized as one of the most significant limitations of cloud computing in the present day. Because fog computing is still in its early stages of development, it faces numerous obstacles and challenges, such as the limited resources of fog nodes and the processing of real-time job(s) while making the most use of available resources, which is also referred to as task scheduling in fog computing. Task scheduling is one of the main components of fog computing. It has the potential to improve the latency of a service and decrease the amount of network traffic. In this study, we analyze a variety of problems and difficulties associated with fog task scheduling using previous research. In addition, the articles provide a unique task scheduling model that is tailored specifically for use in fog computing environments in context of smart home, which offers a solution to a number of the challenges associated with task scheduling. Present research is providing task scheduling and allocation of optimized and authentic nodes to pending task by integrating machine learning mechanism with task scheduling.

***Keywords:*** *Fog computing, Internet of Things, Smart Home, Scheduling, Performance, machine learning*

## 1. Introduction

Numerous studies have been conducted that contributed to the development of fog computing. Future directions and taxonomy of fog computing are considered [1]. A survey of fog computing principles, uses, and challenges [2] has been done. In addition, the Framework is made to look at the architecture of fog computing and the best ways to optimize it [3]. It has been noted that the fog environment may benefit from a more effective scheduling system. Therefore, in fog computing designs [4] where the system may be heterogeneous, energy-efficient scheduling has been suggested. Many studies have shown that fog computing may help schedule production in a smart factory while also balancing the load on the system in terms of energy consumption [5]. The Cuckoo optimization method is considered by some authors for job scheduling in fog computing [6], while the immune scheduling network mechanism is considered by others for implementing tasks in the case of decentralized fog computing [7]. Scheduling in fog computing systems also makes advantage of the divisible load structure [8]. Load scheduling for Internet of Things (IoT) applications in a fog computing environment employs a combination of quantum zed and other approaches [9]. Fair scheduling with respect to deadlines is conducted on offloaded jobs in [10] whereas load distribution is used for fog balancing in [11] the context of small cell cloud computing. In a fog computing setting, several classification mining mechanisms are used to schedule tasks [12,13]. For stochastic operations in the cloud and fog, a trust model based scheduling approach has been presented recently [14]. Deadline-based dynamic resource allocation and provisioning methods in a fog-cloud setting [15] were introduced and two-tier bipartite graph job allocation system [16] were used afterward. Hyper heuristic algorithms were also used in the real world application of fog computing to provide security-aware scheduling [17, 18]. In the case of homogeneous fog networks, further work has been done on delay energy balanced job scheduling [19]. Afterward, a ranking of fog nodes was created for scheduling jobs via a fuzzy logic technique [20]. The development of rank scheduling mechanisms for use in fog [21] also contributed to this phenomenon

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### 1.1. Fog computing

Computing resources, such as data, computation, storage, and applications, are dispersed between the data source and the cloud in a fog computing architecture. The concept of fog computing is similar to that of edge computing in that it brings cloud computing advantages and capabilities closer to the physical locations where data is actually created and used. In fog computing, data from IoT devices is gathered in near real-time and processed by a distributed network of nodes. Incoming data is processed by each of these nodes in real time, with a response time in the millisecond range. At regular intervals, the nodes will upload a summary of their data analytics to the cloud. Since fog computing relies only on low-end computers, mobile phones, and personal devices, it is able to deliver lower latency than cloud computing. Numerous studies have suggested a new framework for IoT-based monitoring to manage real-time notification using fog computing.

### 1.2. Internet of things

The goal of an IoT based home automation system is, as the name implies, to manage your smart home's many electronic components remotely, through the internet or a cloud-based server. To automate one's house with the help of internet-connected devices is to provide such devices remote electronic control. Alarms and lighting controls for home security may be programmed in advance and operated through a mobile app, as can the central heating and lighting system.

### 1.3. Smart Home

A home that has been automated via the use of domotics is referred to as a smart home or smart house. A home automation system may monitor and control the lights, the temperature, the entertainment devices, and the appliances. Alarm systems, gates, and other forms of home security are sometimes bundled together. Connected appliances in the home have a major impact on IoT. A smart home hub is the brains of a home automation system The system may be controlled by a variety of user interfaces, including wall-mounted terminals, tablets, desktop computers, a mobile phone app, and a Web interface that could be accessible remotely via the Internet. Open source software is getting more attention as a solution to the market's fragmentation and the proliferation of competing companies. However, there are problems with the present state of home automation, such as the deprecation of older devices without backwards compatibility and the absence of established security measures. In the future, home automation might lead to energy-saving measures that would have a good influence on the environment and would allow for the safe exchange of information between family members or other trusted persons for the sake of personal protection.

### 1.4. Novel techniques and algorithms for Scheduling

Fundamental to every operating system is the idea of scheduling tasks. Using it is a big assistance when deciding which procedures to run. FCFS, SJF, Priority, Round Robin, etc. are only a few of the various scheduling algorithms that may be used in a multi-programmed OS. The Round Robin technique for allocating time slots was the primary focus of our attention. As part of a paper titled "A Novel Approach for Scheduling," many authors presented a novel algorithm. Both the Round Robin algorithm for scheduling and the Dynamic Time Quantum method are components of this system. This system incorporates both the Round Robin scheduling technique and the Dynamic Time Quantum approach. Results for Waiting Time, Turnaround Time, and the number of Context Switch are better than those obtained using the Round Robin scheduling technique with static time quantum, the Average Mid Max Round Robin scheduling algorithm, and the Min-Max Round Robin scheduling strategy.

## 2. Literature Review

Recent years have seen a great deal of study devoted to the intersection of fog computing, scheduling, and the Internet of Things. This section discusses the relevant studies. Computed in the fog: a categorization system, overview, and road map was the topic of R. Mahmud et al. 2018 .'s paper. [1]. S Yi, et al.(2015) focused on problems that might be found in fog computing. This review explains what fog computing was, how it differs from related ideas, provides examples of useful applications, and points out potential problems with future fog computing implementations [2]. Y. Liu, et al.(2017) reviewed the design, difficulties, and potential for optimization inside the fog computing framework [3]. Nazir et al. [4] suggested a modified GA as a heuristic approach for scheduling IoT queries in a manner that minimises latency overall. For example, J. Wan et al. (2018) proposed using fog computing in a smart factory to coordinate workloads and plan output while taking energy usage into account [5]. Scheduling tasks in the cloud and with fog computing in a smart grid using the Cuckoo optimization algorithm [6] was the focus of Alsmadi et al. Task scheduling in distributed fog computing using immune scheduling networks was reviewed by Y. Wang et al. (2018) [7]. Schedules in fog computing systems were investigated by Zhang et al. (2020) who relied on a close form design predicated on the idea of divisible loads [8]. Using quantum mechanics, M. Bhatia et al. (2020) detailed a method for organising tasks in fog computing-based applications. [9]. M. Mukherjee, et al.(2019) reviewed fair scheduling of offloaded jobs with deadline awareness and inter-fog dependencies in fog computing [10]. Naeem, et al. (2015) provided Small cell cloud computing load balancing in the fog [11]. L. Liu,et al. (2018) presented fog computing system, a classification mining-based task scheduled method is implemented [12]. Lavanya Rajagopalan argues that the Fog was the optimal infrastructure for a number of crucial Internet of Things services and applications, including those involving linked automobiles, smart grids, smart cities, and WSANs (2019) [13]. JAJ.Sujana, et al.(2018) scheduled large data management tasks in a fog environment [14]. Gad-Elrab AA, et al. (2020) focused on the fuzzy clustering in a two-tiered bipartite network to divide up work in a cloud-and-fog setting [15]. RK Naha, et al.(2020) provided algorithms for dynamically allocating and provisioning resources in a cloud-based, fog-based setting with firm deadlines [16]. By comparing the given approaches, Shadroo et al. (2021) demonstrate that FE using DL may enhance clustering in a manner that minimises the missing rate of jobs in the cloud and fog while also keeping costs to a minimum. [17]. N Auluck, et al.(2019) Used security-aware scheduling in real-time for jobs in fog networks. When combined with a micro data centre (mdc), fog computing may bring cloud resources closer to an end user, resulting in faster response times for time-sensitive programmes [18]. Y Yang , et al.(2018) presented homogenous fog networks, balancing latency and energy consumption while scheduling tasks was a significant challenge. In this research, they provide a multilayer analytical framework to investigate the tradeoff between service latency and energy use [19]. Teoh, et al.(2019) did work on fog-cloud settings, fog node rankings for task scheduling using fuzzy logic [20]. This paper by Moh et al. (2018) provides a comprehensive overview of the IoT, its development, FC, and ML strategies for protecting IoT gadgets and fog computing infrastructure. It provides a broad overview of machine learning methods for spotting anomalies and assaults, offers concrete strategies for dealing with the exponential increase in data produced by the Internet of Things, and delves deeply into the safety concerns raised by the widespread use of fog computing. It also addresses potential avenues for further study on this critical subject. [21]. Vignesh V, et al.(2013) provided scheduled and managed available resources in the cloud. Cloud environments have a high process to resource ratio, hence Resource Management was essential for processes to run smoothly [22].

**Table 1:** Literature survey

| ***Sno.*** | ***Author/Year*** | ***Title*** | ***Methodology*** | ***Limitation*** |
|---|---|---|---|---|
| [1] | Mahmud R/2018 | The fog computing ecosystem, its current state, and where it may go in the future. The connectivity of all things. | Fog computing | Scope of work is limited |
| [2] | Yi S /2015 | An overview of fog computing's key ideas, use cases, and challenges | Fog computing, | Did not considered Real life solution |
| [3] | Liu Y/2017 | This paper presents the architecture, difficulties, and potential optimizations of fog computing. | Fog computing, Optimization. | There is not performed in future |
| [4] | Aburukba /2019 | In order to reduce delays in hybrid Fog-Cloud computing, requests from the IoT must be scheduled in advance. | IoT, Fog Computing, Cloud Computing | Lack of efficiency |
| [5] | Wan J/2018 | With the help of fog computing, a smart factory can schedule and balance loads while keeping energy consumption in mind. | Fog computing, Scheduling | Need to improve the performance and accuracy |
| [6] | Alsmadi /2018 | Smart city algorithm for scheduling in the fog of computing. | Fog computing, Smart city | There is lack of performance |
| [7] | Wang Y/2018 | Task scheduling in decentralised fog computing using immune scheduling networks | Task scheduling, Fog computing | Research is limited to traffic flow |
| [8] | Zhang /2020 | Building a fog computing and IoT service platform for urban environments. | Fog Computing , IoT | There is less technical work |
| [9] | Bhatia M/2020 | An IoT fog computing environment with a quantified approach to load scheduling | IoT , Fog computing | Lack of security and accuracy |
| [10] | Mukherjee M/2019 | Due date-aware, inter-fog-dependent scheduling for offloaded jobs in fog computing | Fog computing | There is lack of performance |
| [11] | Naeem /2019 | The role of fog computing in the IoT and its potential future developments. Technology and Applications for Peer-to-Peer Networking. | Fog computing , IoT | Lack of technical work |
| [12] | Liu L/2018 | In a fog computing system, a classification mining-based task scheduling algorithm is implemented. | Fog computing , Scheduling | Performance of this research is very low |
| [13] | Lavanya /2019 | What is fog computing and how does it fit into the IoT? | Fog Computing , IoT | Did not considered Real life solution |
| [14] | Sujana JAJ/2019 | Scheduling stochastic cloud & fog computing operations using a trust model | Fog computing | Need to consider optimization technique |
| [15] | Gad-Elrab AA/2020 | In a cloud-fog setting, we propose using a bipartite graph with fuzzy clustering to divide up tasks. | Fog environment, clustering | Need to enhance the scope of work |
| [16] | Naha RK/2020 | Algorithms for dynamically allocating and supplying resources in a cloudy, foggy setting with hard deadlines | Fog environment | Need to do more work on accuracy |
| [17] | Shadroo /2021 | Scheduling in the Internet of Things uses a two-stage process informed by deep learning. | Deep Learning, IoT | Lack of flexibility |
| [18] | Auluck N/2019 | Security-aware task scheduling in real-time fog networks | Scheduling, Security | There is lack of technical work |
| [19] | Yang Y/2018 | Overdue: homogeneous fog network job scheduling with delayed energy balance | Scheduling, Fog computing | There is lack of security, salability |
| [20] | Teoh / 2021 | Model for predictive maintenance in IoT and fog computing for efficient asset management in the 4.0 manufacturing sector | IoT and fog computing , Machine learning | This work is not long-lasting work |
| [21] | Moh /2018 | Protecting Internet of Things and Fog Computing Infrastructure Using ML Techniques. | Machine learning, Fog computing, IoT | Performance of this work is less |
| [22] | Vignesh V/2013 | Controlling and allocating cloud-based resources | Scheduling, cloud environment | There is lack of technical work |

## 3. Problem statement

There have been several researches in area of fog computing and scheduling. But it is observed that present research have limited scalability and reliability. Moreover, conventional research did limited work on secure scheduling. There is need of research that should be capable to provide efficient task scheduling by allocating scheduled task to optimized and authentic fog nodes. In order to make work more scalable, there is also need to make use of such mechanism for IoT based smart home. Moreover, machine learning mechanism might improve the performance of task scheduling.

## 4. Proposed Research methodology

Present research is considering scheduling of tasks in fog environment where fog nodes are allotted task on the bases of scheduling mechanism. Novel scheduling approach has been developed to allocate pending task or operations to optimized nodes.

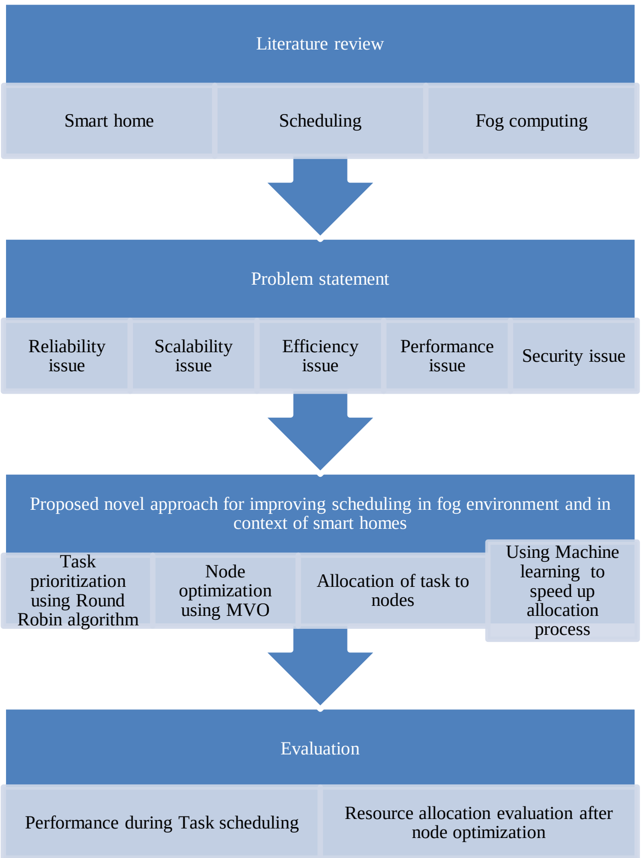



**Fig. 1.** Process flow of work

Existing research in area of IoT based smart home, resource scheduling, task scheduling is considered along with fog environment. Issues in present research such as performance and scheduling issue are considered. Moreover, it is also observed that conventional mechanisms are providing limited scalability and reliability. There is need to proposed novel scheduling approach that should be capable to schedule tasks and allot them to optimized and authentic fog node. There is need to evaluate the task and resource scheduling in fog environment for smart homes. Machine learning model would keep track of task scheduling in different cases and improve the speed of task allocation to fog nodes on the bases of previous experiences.

## 5. Improved MVO

The derivation of improved of MVO has been shown below.

### 5.1. Deriving Equation for base MVO

**Phase 1: In phase one equation of PSO is considered.**

A mechanism based on the behaviour of social birds or fish has been developed. This PSO is made up of the Pbest and the Gbest. As well as updating positions, these arthimic equations can be used to adjust velocities in response to a change in course.

$$v_{ij}^{t+1} = wv_{ij}^{t} + C_1R_1(Pbest^t - X^t) + C_2R_2(Gbest^t - X^t) \ldots(1)$$

$$X^{t+1} = x^t + v^{2t+1}(i = 1,2..NP) And\ (J = 1,2..NG) \ldots\ldots(2)$$

Where

$$W = w^{\max} - \frac{(w^{\max} - w^{\min}) * iteration}{maxiteration} \ldots\ldots\ldots\ldots(3)$$

$w^{max}$ = 0.4

$w^{min}$ = 0.9

$v_{ij}^{t}$ , $v_{ij}^{t+1}$ already assumed velocity of "j" member of "i" particle in iteration number ( t ) and ( t + 1 ) . (Normally C1 is equal to C2 is equal to 2), r1 and r2 Random number (0, 1).

**Phase 2: Multi-verse optimizer equation**

The MVO algorithm finds inspiration in the three holes (black, white, and wormhole) that make up the alphabet. All of these alphabets have been meticulously produced in an artificial format. The sections it delves into are "operation," "research studies," and "domestic finding," in that order. The white hole is thought to have a significant part in the creation of our universe. The astounding gravitational impact of black holes is the main reason why they are so popular. Wormholes are conduits in the fabric of space and time that allow for transit between different points in time. In this way, it is feasible to rapidly transport items around the globe. MVO uses the following procedures in its productions:

- The likelihood of a white hole is increased if the inflation rate is high.
- The likelihood of black holes is reduced if inflation is low.
- Some populations are able to keep inflation rates high by dispersing chemicals through white holes.
- Those who don't keep inflation rates sky high are more likely to use black holes to bring in new substances.

Everything in the cosmos is working to advance the fittest populations. Wormholes have made it possible. Therefore, we are not factoring in the current rate of inflation. From a universe with a rapid dispersal rate, all particles go towards the direction of population where the rate of spread is slower. In the company of transformation, it assumes responsibility for a rise in the mean propagation velocity of whole cosmoses. As soon as a shift takes place, the populace is stratified in accordance with the rate at which word travels. Thereafter, it picks one at random. A white-hole-shaped roulette wheel is used for this purpose.

### 5.2. Derived hybrid PSO-MVO equation

A Hybrid PSO-MVO Set is made by combining the two sets' strongest points. To discover an optimum solution that satisfies a set of requirements, the hybrid PSO-MVO combines the strengths of the two approaches. Value Pbest from PSO is being replaced with the Universe value from MVO.

$$v_{ij}^{t+1} = wv_{ij}^{t} + C_1R_1(Universes^t - X^t) + C_2R_2(Gbest^t - X^t)$$

**Proposed Objective function**

In following objective function x is the parameter , Array is the array of task t1, t2…n.
Where n is number of task. SUM1 is containing evaluation of equation for each task and o is containing the best solution retured by objective function.

**function o = F14(x)**

```
Array=[ a1 a2 a3……………..an];
for j=1:n
   SUM1(j)=sum((x'-aS(:,j)).^6);
end
o=(1/500+sum(1./([1:n]+bS))).^(-1);
end
```

## 6. Architecture of Novel scheduling mechanism

It has been observed that every research work has its own limitation. Research work that provided energy balanced job scheduling, are ignoring ranking and classification of jobs. On other hand there is need of security aware scheduling along with delay energy balanced job scheduling. Building novel approach for secure job scheduling is challenging task. Thus there is need of meta heuristic optimizer MVO for selection and ranking of jobs.

**Algorithm:** Novel approach for task scheduling in fog computing

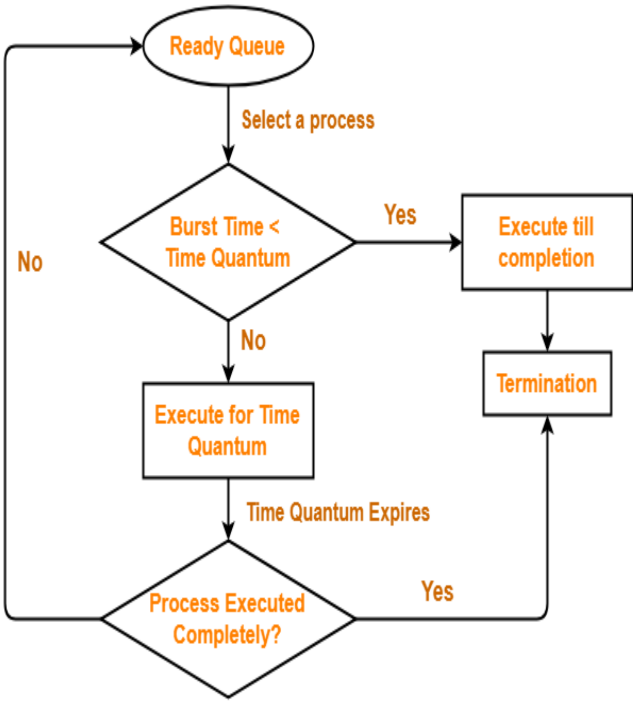
Nodes is presented by N, m is indicating total number of nodes.

Tasks are presented by T, x is indicating total number of tasks.

1. Initialize fog nodes N1,N2, N3....Nm
2. Initialize MVO parameters
   Number of iterations
   objective function
   upper bond
   lower bond
3. Passing fog nodes to MVO objective function
4. Finding optimized value solution during MVO algrithm
5. Filter the nodes below optimized value

6. Calculate the node weight considering node parameters
   Node_type
   Node_configuration
   Node_successor
   Node_predicessor
7. Prioritize the nodes to peform ranking operations
8. Initialize the task T1,T2,T3,T4......Tx
9. Prioritize the task using round robin algorithm
10. if scheduling of task has been made before and saved in machine learning model
   If node is available
   Make allotment according to previous status
   otherwise
   move to step 10
   end if

   otherwise
   Schedule the task
   Save status in machine learning model
   end if
11. Allocate tasks to fog nodes considering node availability and task status
   for i=1 to x
   for j=1 to m




   if Ti is not alloted
   if Nj is free
   if Nj is authentic
   allot Ti to Nj
   save status in machine learning model
   end if
   end if
   end if
   end for
   end

**Following flowchart is presenting round robin scheduling for task (process)**

**Fig. 2.** Working of round robin scheduling

**Proposed Flowchart**

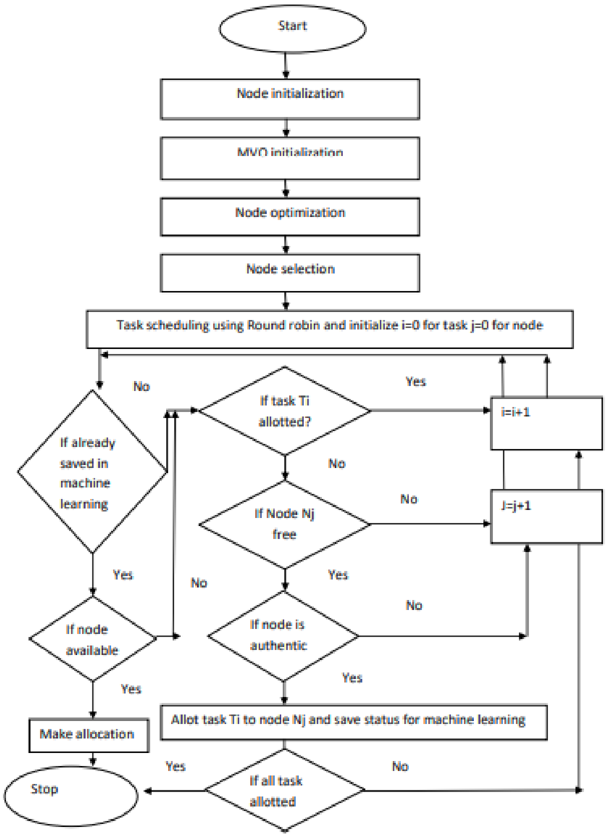



**Fig. 3.** Flow chart of proposed work

## 7. Result and discussion

Proposed work has considered three cases during simulation. In case 1 tasks are allotted to fog nodes without considering security, case 2 is considering the allocation of tasks to fog nodes considering node authenticity, case 3 is considering allocation of fog nodes considering previous experience that is saved in machine learning model. Following table is presenting the time comparison of task allocation in above mentioned three cases.

**Table 2.** Comparison of performance for different cases

| *Number of tasks* | *Fog scheduling without optimization (sec)* | *Optimized fog scheduling (Case 1)* | *Secure and optimized fog scheduling (Case 2)* | *Machine learning based secure and optimized fog scheduling (case 3)* |
|---|---|---|---|---|
| 2 | 10.42710708 | 1.501255 | 1.826292 | 0.025266 |
| 4 | 33.36012505 | 2.091546 | 28.99778 | 1.752884 |
| 6 | 33.45053055 | 5.739184 | 25.44338 | 4.853624 |
| 8 | 26.66877337 | 10.56031 | 19.55254 | 9.437248 |
| 10 | 32.30345967 | 13.96927 | 30.88769 | 12.44566 |
| 12 | 45.37426065 | 17.52013 | 39.95815 | 17.42789 |
| 14 | 36.53316936 | 29.22829 | 30.04627 | 28.15799 |
| 16 | 34.47773542 | 28.90852 | 31.63612 | 28.22745 |
| 18 | 54.30614613 | 49.25368 | 53.94066 | 48.2472 |
| 20 | 74.1170771 | 56.89226 | 64.44614 | 55.14698 |

Table 2 is presenting the comparison of performance in non optimized fog scheduling to case 1,case 2 and case 3. Its graphical presentation is shown below.

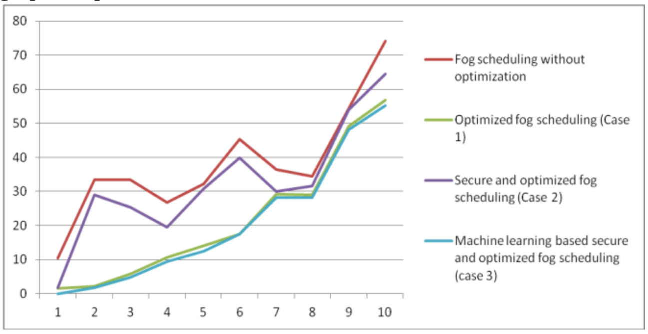



**Fig. 4.** Comparative analysis of performance in case of different scheduling mechanisms

**Table 3.** Comparison to conventional research

| *Ref.* | *Hybrid approach* | *Scheduling* | *Dynamic scheduling* | *Deadline-aware fair scheduling* | *Energy aware load balancing* | *Fog based* | *Optimization* | *Machine learning* |
|---|---|---|---|---|---|---|---|---|
| [4] | Yes | Yes | No | No | No | Yes | No | No |
| [5] | No | Yes | No | No | Yes | Yes | No | No |
| [6] | No | Yes | No | No | No | Yes | No | No |
| [7] | No | Yes | No | No | No | Yes | No | No |
| [8] | No | No | No | No | No | Yes | No | No |
| [9] | No | Yes | No | No | Yes | Yes | No | No |
| [10] | No | Yes | No | Yes | Yes | Yes | No | No |
| [16] | Yes | Yes | Yes | Yes | No | Yes | No | No |
| [17] | No | No | No | No | No | No | No | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| [21] | No | No | No | No | No | No | No | Yes |
| **Proposed work** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

## 8. Conclusion

It is concluded that proposed research is providing solution of task scheduling by round robin fashion while nodes are optimized using MVO approach. Optimized nodes are allotted task considering node availability and task status. In this way task are scheduled and nodes that are acting as resource are managed. This is novel approach that is increasing the reliability of scheduling operation in fog environment. However research has make use of conventional approach for task scheduling but node selection has been made using Multi-verse optimizer. Then novel algorithm has been developed for allocating scheduled tasks to optimized nodes to provide improved scheduling solution. Simulation result concludes that secure optimized scheduling is time consuming but the integration of machine learning based approach has improved the performance.

## 9. Scope of research

Growing demand of smart home has raised the requirement of task and resource scheduling in fog environment. Fog node are allotted task considering fog node availability, authenticity and task status. Such scheduling mechanism would be capable to provide solution of smart home in IoT system. Moreover such system could be applied in industrial automation.

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