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RESEARCH ARTICLE

COST-EFFICIENT RESOURCE MANAGEMENT IN SMART HOME AUTOMATION

J. Bharathi [1, *] and C. Anuradha [2]

[1] Department of Electronics and Communication Engineering, Deccan College of Engineering and Technology, Hyderabad, Telangana 500001 India.

[2] Department of Electrical and Electronics Engineering, SRM Institute of Science and Technology, Kattankulathur, Tamil Nadu 603203 India.

[*]*Corresponding e-mail: bharathi@deccancollege.ac.in*

Abstract – In this modern generation, there is a lot of technological improvement in Smart Home Automation. Real-time data collection and transmission through sensing devices is possible in the rapidly expanding "Internet of Everything" network of interconnected objects. The most realistic solution seems to be the affiliation of semantic information with all these diverse data sets via resource management, empowering their reusing and the implementation of rationale processes meeting up as well as skills for several momentary home automation control apps for a development's building providers of sub-standard systems lacking in intelligence. To overcome these issues in this paper, CREM has been proposed. In this research, a novel Cost-efficient Resource Management has been proposed in Smart Home Automation. The presented CERM has been simulated using MATLAB. A comparison is made between the suggested framework and current methods like VRP, SVM, PSO, and TBSA. Considerations include energy use, network longevity, bandwidth, latency, and response time. According to experimental findings, the proposed CERM technique by 39.75%, 25.725%, and 19.25% compared with VRP, SVM, PSO, and TBSA methods.

Keywords *– Internet of Things, Constrained Application Protocol, Hidden Markov Model, Cost-effective Resource Management, Smart Home Automation.*

1. INTRODUCTION

Internet of Things is a network of embedded devices that can connect to the internet and exchange data with one another. Different sensors and actuators are employed by IoT networks to create intelligent systems [1]. As new emerging technologies rise, the contribution of IoT to care has become increasingly important. As a result, automation will be required across every field in the near future. Transportation gridlock, disposal of waste, means the greater, logistics, security, control systems, emergency services, and healthcare are all improved by IoT technologies [2].

As technology has developed in recent years, human-machine interaction (HMI) has become increasingly practical in daily life. The Internet, which was previously utilized for interaction but was also used for objects, i.e., the Internet of Things, has been used to further HMI research in recent years. Connecting anything to the Internet so that it may be accessed from anywhere is the aim of this application [3].

A smart home automation system gives customers control over a number of frequently used items., as well as one that makes doing so much simpler and more energy-efficient. These days, automation systems for buildings and homes are employed often [4]. More people today are conscious that they must make their houses environmentally friendly. Smart houses assist users save money and energy by managing irrigation, lighting, window coverings, and usage [5].

Resource management, rather than the way of coordinating and allocating resources to application fields, was the main principle of shared databases [6]. A high-quality service while reducing energy consumption to reduce household electricity costs is achieved by managing variables with sophisticated multi-objective decision-making. On networks with more than 250 systems, slower transmit cycles (CoAP) are essential for resource discovery. By using MQTT, you can subscribe to topics in a flexible manner. Security issues with encryption on a large scale [7].

In this paper, a novel proposed CERM-SHA uses a COAP protocol for security into account when dealing with IoT protocols The most effective solution seems to be the affiliation of semantic information with all these diverse data sets via resource management, empowering their reusing and the implementation of rationale processes meeting up as well as skills for several momentary home automation control apps for a development's building providers of sub-standard systems lacking in intelligence [17-19]. To overcome these issues in this paper, CREM has been proposed.

The remaining portion of the paper is arranged as follows: The Literature Survey is described in Section 2. Section 3 describes the proposed system. Section 4 presents the results and discussion. Conclusion and future work are described in Section 5.

2. LITERATURE REVIEW

The Internet of Things (IoT), which refers to actual objects with sensors, processing power, software, and other techniques that exchange data and interact with other systems and devices over the Internet or another communications network, encompasses the topic of resource management in this study.

In 2018, Al-Kuwari, et al. [8] have been proposed a solar-house monitoring system. The proposed system is managed by the same IoT platform that communicates to EmonCMS immediately via NodeMCU. There is a problem with the NodeMCU board having just one analog input, which restricts its use to that of a single system for monitoring data.

In 2021, Yar, et al. [9] have suggested a low-cost, complete smart home system built on the principles of edge computing and the IoT. The proposed solution consists of edge computing stores sensitive data on a customer's local cloud to preserve their privacy One disadvantage The disadvantage of wireless home automation systems is also that they can only be utilized in a single room indoors or within the scope of the Bluetooth signal. In comparison to cutting-edge methods, the proposed system detects movement 5% faster and switches the relay around within 5 and 4 minutes, respectively. Additionally, it is 6% more energy-efficient than the alternatives now in use.

In 2019, Gill, et al. [10] suggested a resource management method that uses PSO to optimize many resources at once for fog-enabled cloud computing systems. According to the survey, implementing us technique will reduce the bandwidth of the network by 10%, reaction time by 12%, latency by 12.35%, and energy consumption by 14%.

In 2016, Pirbhulal, et al. [11] has been suggested a Triangle Based Security Algorithm (TBSA), which is based on an efficient key generation mechanism. TBSA was integrated into WSNs and the Internet to create a ground-breaking. IoT-based smart house capable of secure data transmission more than long-distance across all various relevant sensor nodes within the network. Based on the results of hardware design, the proposed algorithm TBSA is far more effective in every other aspect of cryptography.

In 2018, Jabbar, et al. [12] has been suggested a low-cost, Wi-Fi-based Smart Home (SH) automation system with an Android app that enables remote device management and monitoring. This study proposes, but does not plan, a simplified Wi-Fi-based Automation System for Smart Home prototype using an Arduino and an Android smartphone.

In 2020, Majeed, et al. [13] proposed a novel concept of home automation that employs a machine-learning method for smart decision making, as well as blockchain, which are used to ensure IoT device verification and identity. Sensor data such as temperature, smoke, and lamp are included in the input dataset. The status classes of the challenging task, such as "ON" and "OFF." creates status classifications, such as "ON" or "OFF." A value of y = 0 means the device is "OFF," while a value of y = 1 means the device is "ON." When y = 0, the gadget is said to be "OFF," and when y = 1, it is said to be "ON."

In 2019, Jabbar, et al. [14] Proposed an IoT@HoMe offering a low-cost perfect blend (local and remote) Sensor home automation system with a consumer interaction for laptops and smartphones. An IoT-based home-automation system may conveniently and inexpensively operate devices. So, via the Internet, to improve home security through automatic control. The suggested IoT@HoMe system also contrasts sharply with the current arrangement to highlight the key features.

In 2017, Yadav, et al. [15] suggested a versatile, affordable, and multipurpose smart home monitoring and management solution. The plan is working. Thanks to the node-MCU ESP32, this gadget may be controlled remotely and has access to the Internet. It transmits sensor data to the Firebase database and is capable of receiving commands from the server, which enables automated control. The proposed system will provide greater flexibility for dealing with things automatically. This will reassure the user of improved security. The current system has many limitations, such as the issue of energy consumption, water waste, child safety, and so on.

In 2019, Sarmah, et al. [16] proposed a safe and efficient smart home system capable of protecting homes from theft or unusual activity while saving power. The system is evaluated using upon which at KU college, analysing 30 apartment buildings for 60 days and exploring people to be amazingly beneficial in terms of thieves' safety and electricity savings when compared to existing systems.

In 2018, Rout, et al. [17] proposed SHAS prototype along with its Android App has been successfully implemented. proposed technology demonstrator smart home scheme, including an Android app and an ATmega16 central controller, has been effectively applied, and the results are presented. it can control the status of the fan or AC, according to the humidity and temperature of the room.

3. PROPOSED SYSTEM

In general, IoT devices gather and send information to Resource Management (RM), which can process it. As Connected systems and servers proceed to interact, large amounts of data are transmitted through IoT networks, causing significant operational costs and potential concerns in the network. The proposed work investigates the hidden Markov (HMM) prototype sequential data generated by IoT devices. HMM, functions are processed at Resource Management. The findings are generated by HMM's hidden states. HMM is an excellent tool for trying to capture and model string sequences. The great powers in HMM are enclosed and non - observable.

Device Layer

The devices layer, also known as the input nodes, ought to be the initial area of the proposed models. In this, different kinds of variable and graphical sensing devices are used for automation, safety, and safety. They also help save energy inside the smart home by enclosing the environment for door verification and particle sensors like fingerprint images. This implementation incorporates low-level sensors into the smart home system to gather environmental information. This same lamp is controlled by a similar Vibration motor that detects movement within the house. The thermostat sensor uses the temperature of the bed to control the cooling and heating systems. If the average temp exceeds a present threshold and there is motion, the air conditioning system will automatically turn on; otherwise, the air conditioning unit will turn off.

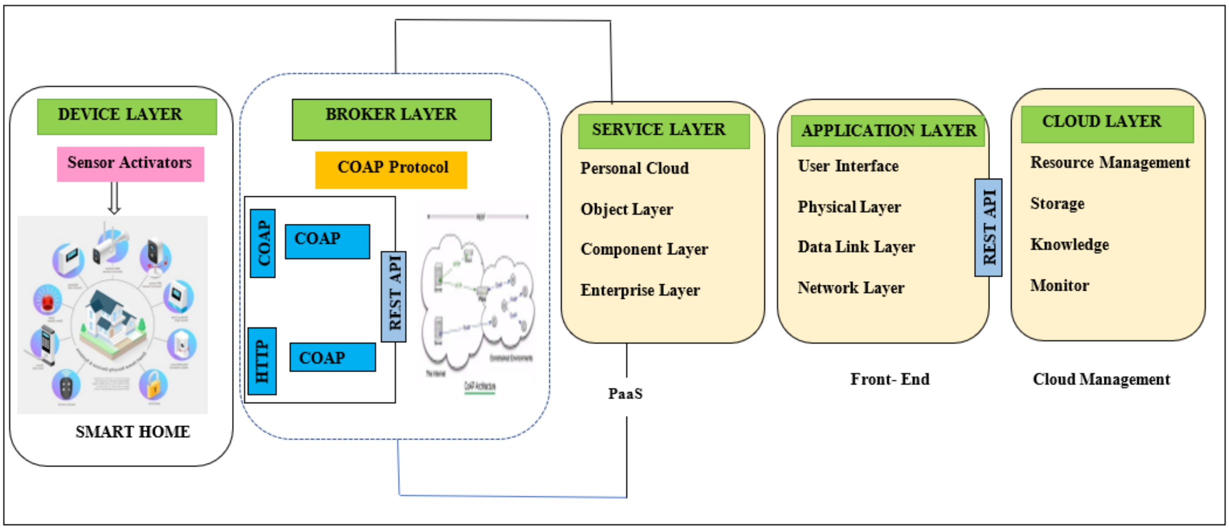

Figure 1. Proposed Hidden Markov Model for efficient CoAP Protocol

The intensity of sunlight is measured using photoresistor sensors. The house's outdoor lighting program basically turns on if the number of lights goes below a predefined level, and vice versa. Devices which measure water are used to estimate the volume of water in a tank. When the water level drops below a certain point, the liquid engine immediately starts., while when the liquid tank is full, the liquid engine turns off automatically.

The possibility to take up smoking also was identified, in addition to Liquefied petroleum gas flow in the restaurant and residences. As an alternative, flame sensors are utilized to locate flames in the region. The siren activates and an SMS alert is issued to the designated officer when gas, smoke, or fire are discovered. Security has improved, and the data set is safeguarded from unauthorized access using a proper authentication strategy to preserve system confidentially. The graphical sensor is used to stream video to homeowners' laptops and cell phones.

Broker Layer

The Constrained Application Protocol (CoAP) protocol is used by the broker layer to transmit commands and data from many sensors to the server side. The operating principle of CoAP protocols is depicted in Figure 1. The REST and CoAP protocols comprise the broker layer. Representational State Transfer (REST) is commissioned by the European on which Rest API services are based. REST is a software system that makes filled use of all HTTP characteristics such as browser connectivity, expandability, verification, and encoding.

Service Layer

The layer is in charge of monitoring the brokerage layer's data receipt when RPI is only utilized as a portal service. The Node-JS dashboard is configured at the service layer. Other layers are served by this cross-layer utility. Subscribers throughout Node-JS receive messages for topics that they have signed either through Node-JS, this completely carries out these publication strategies. The nodes that can send messages are found in Node-JS. JSON and HTML files were stored within a Node-JS-Flow node. The node connects to other nodes for sharing of information and provides a frictional pressure visual web-based editor. The flow designer can be accessed via an internet browser at http://ipaddress:1880. (Retrieved July 10, 2021) Node-JS offers inputs, outputs, functionality, and community nodes. Within such processes, we can switch on and off our equipment, monitor the state of several sensors, and keep an eye on the surroundings. In the Node-JS process, enabling a device is as basic as simply dragging and dropping ends, such as by allocating a GPIO (General Purpose Input and Output) pin. Node-JS also allows for rapid scaling. The service layer also controls software, data, private clouds, and data aggregation. We were storing data via two different methods of stockpiling: a device called My-Personal cloud device and cloud storage. A simple-to-use personal storage device called My-Personal cloud plugs straight into a Wi-Fi router at home to store all visual data in one area while the cloud provides cloud storage. Cloud computing refers to the exchange of cloud computing such as apps, servers, networking, and so on. Cloud computing, for example, makes use of the Internet to provide storage, information access, and computer resources. Cloud deployment models that are most commonly used are IaaS, SaaS, and PaaS. Data aggregation, software administration, personal cloud, and data management are the four main characteristics of the service layers.

Application Layer

Using a user-friendly design, Specific IoT management front-end applications are developed using the developer portal. The user interface for viewing and managing multiple Node-JS gadgets is implemented in this layer. The end-user application is designed to dynamically display sensor data and instantaneously control electronic equipment when the change takes place. The front-end implementation is examined to confirm appropriate operation of the remote and automated electronic component control systems. The Node-JS base station analyses alterations in the environment and analyses how electrical equipment reacts to those alterations. The controller must function in a way that satisfies the necessary requirements and react swiftly to environmental changes. In addition, the remote control must react immediately to the right device. Applications thus need to be responsively designed. Today, the large bulk of commonly produced web-based apps adhere to this criterion. Users of this system frequently want to use the internet software to manage their household control system from a smartphone. Type equation here. To connect a phone to the control centre over the internet, users must verify themselves in the application level.

Cloud Layer

A large amount of unstructured data is produced in a home setting by the multiplication of sensors and actuators at the device layer, this could be used to extract connections and important information. Frequently, there isn't enough storage to accommodate all of the input data. To extract significant and helpful information for coordinating local and household services, centralized storage is necessary. Using cloud services and a Simple Conscious Experience cloud device, we save personal information in a suitable database management system. In order to store the sensor data for future research, we average it at the conclusion of the era and transfer it to a cloud server.

Hidden Markov Model in Resource Management

HMM is a statistics theory that describes how inner, superficially visible processes result in compared to goals. We named the information a "symbol" and the unobserved heterogeneity component producing the measurement a "state"; together, these two unpredictable events, one unseen with hidden units while the other apparent with visible symbols, combine to form an HMM. The underpinning state causes the posterior distribution of the visible sign, when the Markov chain is made up of state variables. In light of this, alternative term for an HMM is a doubly-embedded stochastic process**.**

$$M\{b_{l+1} = i|b_l = j, b_{l-1} = j_{l-1}..., b_1 = j_1\} = M\{b_{l+1} = i|b_l = j\} = s(j, i) \quad (1)$$

For every state j, each is, and every l 1. The likelihood of transitioning from node j to state I represented by the symbol s, is known as the transition probability (j,i). We write the possibility of that nation for the original state b1 as (j)= M b1 = j for all j S. The underlying state bl alone determines the likelihood that the nth observation will be al = an, so

$$M\{a_l = a|b_l = j, b_{l-1}, a_{l-1}, ...\} = M\{a_l = a|b_n = j\} = d(a|j) \quad (2)$$

For every chance to try something new, every j opportunity, and every l 1. This is referred to as the emissions probability of x at the state I is represented by the representation d (a | j). An HMM has completely specified by the three probability measurements s(j), I(j), and d(a|j). For simplicity, we'll call this collection of parameters Q.

$$M\{a, b|Q\} = M\{a|b, Q\}M\{b|Q\} \quad (3)$$

Where

$$M\{a|b, Q\} = d(a_1|b_1)\, d(a_2|b_2)\, d(a_3|b_3) ...\, d(a_n|b_n) \quad (4)$$

$$M\{b|Q\} = \pi(b_1)\, s(b_1, b_2)\, s(b_2, b_3) ...\, s(b_{n-1}, b_n) \quad (5)$$

As we can see, trying to calculate the monitoring possibility is simple when we know the quality of the soil sequence.

Basic Problems and Algorithms for HMMS

Three principal concerns must be resolved before HMMs can be used in real world applications. Consider a new symbol sequence a=a 1a 2a 3....a n. How can we measure the monitoring chances based on a given HMM? Mleftx |Are you sure? This problem is also known as the goals scored problem because calculate the possibility Mlefta|0right is a natural way of'scoring' a testable theory sequence based on the model in question. It's important to remember that the underlying state sequence for a given an isn't readily observable, and multiple state sequences may exist resulting. As a result, one method for calculating the monitoring Probability is calculated by adding all possible case sequences b for the given a.

$$M\{a|10\} = \sum_b M\{a, y|10\} \quad (6)$$

But this requires a lot of processing power because there are numerous future governments. As a result, we urgently need a more effective way to calculate Mleftx |Qright. The forward algorithm in dynamic programming is capable of quickly calculating Mleftx |Qright. The following forward variable is defined by this algorithm rather than all possible state combinations.

$$\alpha(l, j) = M\{a_1 .... a_l, b_l = j|Q\} \quad (7)$$

The computation of this parameter could be performed out repeatedly by employing the same theoretical calculation.

$$\alpha(a, j) = \sum_z [\alpha(l-1, c) t(c, j) d(a_l|j)] \quad (8)$$

For $l = 2...n$. We can calculate Ma|Q = c (N, c) at the end of the recursions. With only Q(NP2) computations, this technique computes the observation probability of a as a result, instead of increasing exponentially increasing sequences unit Length, the computation of probability grows just quadratic.

Identifying the optimal path, or ideal state sequence, for the HMM that increases the detection probability of the provided symbol sequence x is another real-world problem. People are interested in discovering the governmental order that adequately describes the measurable symbol series among all potential state action sequences y. It is commonly referred to as the optimal alignment issue since this can be seen as determining the best alignment here between phase is the process as well as the HMM. Formally, we are looking for the optimum path y* that satisfies the conditions listed below.

$$b^* = xuf \max_{b} M\{a|a,Q\} \tag{9}$$

As we have Ma, b | @, this is the same as finding the maximizes state sequence Ma, b |. $M\{b|a,Q\} = \frac{M\{a,b|Q\}}{M\{a|Q\}}$ (10)

It's indeed practically difficult to compare every Pn alternative action patterns to get the "ideal" series b*. However, we may effectively figure out the best path b* to use a different dynamic computing algorithm called the Viterbi algorithm [14, 15]. The parameter is determined via the Viterbi algorithm.

$$\gamma(l,j) = \max_{b_1,\dots,b_{n-1}} M\{a_1\dots a_l, b_1\dots b_{l-1} b_l = j|Q\} \tag{11}$$

Finally, we can calculate the maximum observation as follows

$$M^* = \max_{b} M\{a,b|Q\} = \max_{c} \gamma(n,c) \tag{12}$$

By going back through the nested loops that resulted in the greatest likelihood M = Ma, b|Q, identifying the best path y* is simple. The Viterbi algorithm, like the backward approach, discovers the best state sequence in Q(NP2) time.

The Viterbi algorithm, as demonstrated repeatedly, determines the best course to take in order to maximise the probability that its full symbol sequence would be observed. Finding the best states for each symbol position may be more beneficial in particular circumstances. In this situation, we may determine the best state, bl, that is the most like to be the condition that underlies al as follows.

$$\widehat{b_l} = \text{x } \gamma\text{f}\max_{j} M\{b_n = j|a,Q\}, \tag{13}$$

according to the supplied a and Q The post-hoc likelihood Mbl = j | a, Q can be calculated from

$$M\{b_l = j|a,Q\} = \frac{M\{a_1\dots a_l, b_l = j|Q\} M\{a_{n+1}\dots a_n|b_l = j,Q\}}{M\{a|Q\}} \tag{14}$$

$$= \frac{\alpha(l,j)\beta(l,j)}{\sum_c \alpha(l,c)\beta(l,c)} \tag{15}$$

The backwards algorithm, as shown below, allows for a cyclical determination of this backward variable (l,j).

$$\beta(l,j) = \sum_c [t(j,c) d(a_l|c) \beta(l+1,c)] \tag{16}$$

where n = L-1, L-2,..., 1. Making distinct forecasts for ideal states maximises the expected number of correctly predicted states, which is a benefit. Px, y |Px, y| will result from the overall state sequence, y=y1y2...yL, which is less than optimal. When this occurs, Px, y|=0 since there is a chance that the projected path y isn't even a valid path in the given HMM. Due to this, the posterior-decoding method is typically chosen when our main concern is forecasting the best outcome at a fixed position rather than determining the best state sequence for the entire monitoring interval. You may estimate a government's dependability using the posterior probability in. For instance, after using the Viterbi method to find the best course of action y=y1...yL, we may compute the prior distribution Pyn=yn|x to determine the dependability of each state prediction yn. Using the provided HMM, both scoring and alignment issues analyse a new observation sequence. But only if the HMM can faithfully represent the sequence in concern would the answers to such issues be meaningful. Consider if people obtain a set of related inspection sequence alignments A = a1, a2, as, which we want to describe using an HMM. They could be distinct speech samples containing the same word or protein structures from the same stable family. The real question now is how to select the HMM variables in a rational way based on these observational data. This is usually referred to as the learning problem. Even though no appropriate way exists for assessing variables from a limited amount of tracking action scenes there are methods to locate the HMM variables that maximise the regional observation probability. The Baum-Welch learning algorithm and the HMM are two examples. Algorithm Baum-Welch is a forward-backward assumption (EM) method that assumptions and updates values iteratively. People can also employ basic gradient-based methods to find the best HMM. variable in this kind of situations even though assessing the HMM variables is largely an optimization., The Monte Carlo EM (MCEM) technique, that also uses the Monte Carlo strategy for estimating the Prediction algorithm's so-called E-step (expectation step) can be used to train the HMM. There are also probability optimization-based training techniques, such as evolutionary algorithm, that attempt to improve results by avoiding local maxima. For any further discussion of the estimation of parameters for concealed Markov models, this same viewer is guided to this published research.

4. RESULT AND DISCUSSION

In the result section evaluates the proposed technique with the existing techniques VRP, SVM, PSO, and TBSA, methods. The simulation of every existing approach and the proposed model is carried out using MATLAB R2020b.

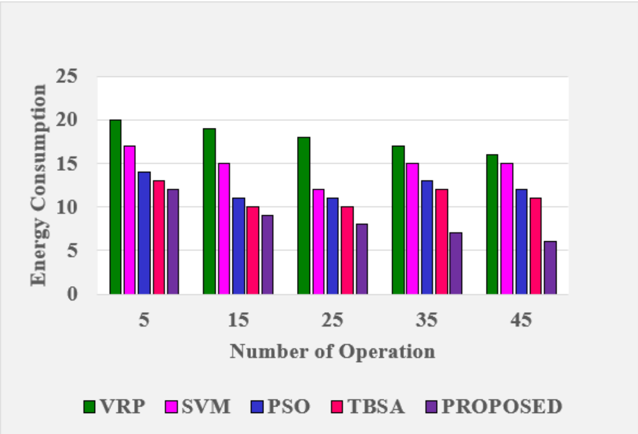

Figure 2. Number of Operation Via Energy Consumption

Figure 2 displays the energy usage for various node counts and data transmission rates. These variables are examined and compared to the existing VRP, SVM, PSO, and TBSA. Through active-sleep state switching, the proposed technique maintains a significant number of energy-efficient nodes for use in future transmission. This prevents any node from ever being used and depleted. This lowers overall energy consumption because not all nodes need to use energy for a predefined transmission.

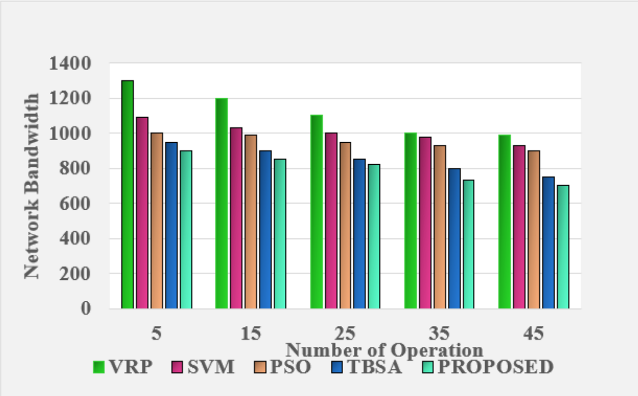

Figure 3. Number of Operation via Network Bandwidth

Figure 3 compares the network bandwidth consumption across different methods VRP, SVM, PSO, TBSA, and a Proposed method over varying numbers of operations. VRP consistently shows the highest bandwidth usage, particularly at lower operation counts, while the Proposed method demonstrates the lowest bandwidth consumption across all operations, indicating its efficiency. SVM, PSO, and TBSA exhibit moderate bandwidth usage, with a gradual decrease as the number of operations increases. This analysis highlights the Proposed method is superior performance in minimizing network bandwidth, making it a more scalable and efficient solution as operations grow.

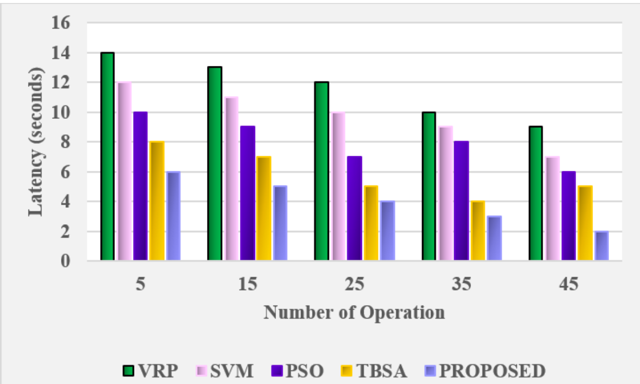

Figure 4. Number of Operation Via Latency

Figure 4 compares the Latency analysis to alternative approaches. The proposed, HQCA, VRP, SVM, PSO, and TBSA, respectively. Despite this, the proposed technique has been able to reduce the Latency, proving its feasibility with fluctuating node counts.

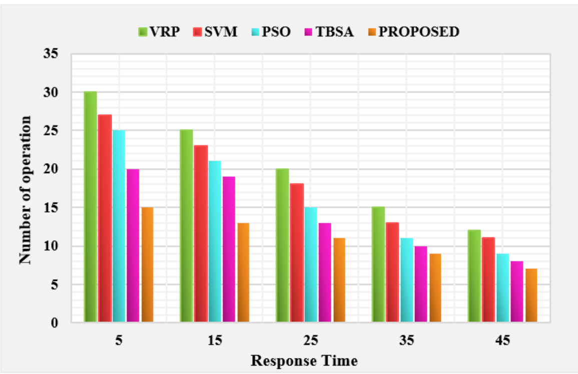

Figure 5. Response Time Via Number of Operations

Figure 5 depicts the performance of five approaches VRP, SVM, PSO, TBSA, and a proposed method based on the number of operations completed for varying response times (5 to 45 units). The proposed method consistently shows a higher number of operations across all response times, indicating superior efficiency and adaptability compared to the others, especially at lower response times, where its advantage is more pronounced.

5. CONCLUSION

In this paper CERM has been proposed a lot of technological advancement in Smart Home Automation inside this modern generation. The term "IoT" describes a rapidly growing network of linked devices that have embedded sensors that allow them to gather and send data in real time. The best solution appears to be the association of semantics with these heterogeneous data through resource management, allowing them to be reprocessed and reasoning mechanisms to be executed. We proposed a novel Proposed Cost-Effective Resource Management in Smart Home Automation throughout this paper (CERM). MATLAB was used to simulate the presented CERM. The conceptual methodology is compared to existing techniques including such VRP, SVM, PSO, and TBSA in regards in terms of network lifetime, network bandwidth, latency, and response time. According to experimental data, the proposed CERM method outperformed the VRP, SVM, PSO, and TBSA methods by 39.75%, 25.725%, and 19.25%, respectively. The progress will see a gain in the latest equipment and technology along with appliances, reducing manual every aspect of smart home automation.

CONFLICTS OF INTEREST

Not applicable.

FUNDING STATEMENT

Not applicable.

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AUTHORS

J. Bharathi an academician with 26 + years of teaching experience. I obtained my MTech in Digital Systems and Computer Electronics from JNTU Hyderabad in the year 1997 and Ph.D. from JNTUA in 2016. My research interests lie in the domain of Signal and Image Processing, Pattern Recognition and Data Clustering.

C. Anuradha received her B.E. degree in Electrical and Electronics Engineering in Madras University and M.Tech degree in Power Electronics and Drives from SRM University, in 2004 and 2010 respectively. She has done her Ph.D. on Design and analysis of multi-port converter for micro grid applications in 2021 at SRMIST. She has published more than 21 journal papers on reputed and indexed journals in the field of Renewable energy system and power electronics converters design. She also filed and published 2 patents. She got 1 patent granted. Her research area of interests are Renewable energy sources, electric vehicles, energy management, design of power electronic converters etc. She has been working as an Assistant Professor in the Department of Electrical and Electronics Engineering, SRM Institute of Science and Technology, Kattankulathur since Feb 2007.She is a member of various professional societies like IEEE, ISCA, MISTE.

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