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Enhancing Smart Cities with IoT and Cloud Computing: A Study on Integrating Wireless Ad Hoc Networks for Efficient Communication

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Abstract

Smart cities have recently undergone a fundamental evolution that has greatly increased their potentials. In reality, recent advances in the Internet of Things (IoT) have created new opportunities by solving a number of critical issues that are allowing innovations for smart cities as well as the creation and computerization of cutting-edge services and applications for the many city partners. In order to further the development of smart cities toward compelling sharing and connection, this study will explore the information innovation in smart cities in light of the Internet of Things (IoT) and cloud computing (CC). IoT data is first collected in the context of smart cities. The data that is gathered is uniform. The Internet of Things, which enables gadgets to connect with one another mostly without human involvement, is made possible by AI. In line with this, The Ad Hoc Routing Function (ARF) AI computation is used for multi-rule simplification, the use of Adaptive Cloud Computing Virtual Machine Asset Allotment Technique (ACC-VMRA) is advised. To confirm its viability, the applied developments of IoT and CC in smart cities is examined and duplicated. The experiment results show that the recommended enhancement calculation is more productive than other currently used methods.

Keywords: Ad Hoc Networks, Cloud Computing, Smart Cities, Technique, Wireless.

Introduction

Finding a common definition for the concept of the "Smart City" is now quite difficult. In fact, there entire concentrations solely devoted to describing this concept[1]. The European Commission defines a smart city as "cities that best utilize contemporary, coordinated innovation administrations and framework in energy, transport, and ICT to answer the social and financial requirements of society" as one of the many definitions of the term available. Different definitions also cover the metropolitan development of the city, enhancing quality of life (QoL), working on executives' everyday resources, enhancing proficiency and viability, the notion of a smart city as a framework, and peoples' interests. Additionally, as lawmakers go forward with their efforts to develop the presentation of cities in various aspects, new Smart City initiatives are being developed. These criteria are being used in smart cities all around the world to improve the quality of life for their citizens.

Utilizing a single invention throughout the city could not be effective since the initiatives made to make a city a smart city could change and have different requirements. Although wired arrangements offer a reliable route for information transmission, establishing a wiring organization that connects all devices is expensive, and the result would be incredibly wasteful. Wireless innovations have emerged as a response to the rapid growth of organizationally related technology as well as the growing need for services that allow for city-wide monitoring. IoT is becoming more commonplace

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quickly, and applications include smart metering, weather monitoring, health monitoring, and animal observation [2]. Around the world, Wireless Sensor Networks (WSN) are used as a low-cost, low-energy method of providing a communication system. However, wireless advancements vary, and depending on the application, their utilization should be considered. When deciding how to convey the gathered information, factors like traffic type, distance, energy consumption, and hub count should be considered. Additionally, misuse of wireless innovations may contribute to certain problems.

Cloud computing, which permits the utilization of data innovation capabilities for help, is the next stage of internet-based computing. As smart devices leave the cloud computing environment, the Internet of Things (IoT) has the potential to boost productivity, execution, and throughput. Private locales referred to as "smart cities" make conscious efforts to keep track of modern correspondence and record-keeping advancements, attain natural supportability, metropolitan framework authority, better wellbeing, information improvement, and network-driven innovation. Cloud computing, which considers how ICT (information and communication technology) resources are distributed inside an organization, is the next stage of internet-based computing. Increased effectiveness, execution, and payload with cloud basis may be advantageous for the IoT. The advancement of cloud computing has aided in the bundling, distribution, and evolution of today's electronic commerce. Due to their compatibility with IoT frameworks, IoT and cloud are currently highly near-future web advances.

The Internet of Things is mostly interested in problems that arise in a dynamic, social setting. The Internet of Things (IoT) is a broad category that comprises a variety of adaptable and unexpected devices with limited storage, power, and performance capabilities [3]. These imperatives, which also handle challenging issues like similarity, efficacy, full utility, and accessibility, limit and impede the development of IoT frameworks. Undoubtedly, the most hopeful strategy that may be used with IoT to get beyond these limitations is cloud computing. Organization, capacity, PCs, and programming are some of the shared resources that the cloud offers. These resources are renowned for their ubiquity, affordability, and aesthetic appeal. The current communication, handling, and capacity applications for smart cities on a cloud-based IoT platform are discussed in this article. This stage may leverage cloud resources and services for data collection, transportation, analysis, reprocessing, and storage. To collect, transmit, search, analyse, and store data produced by complex scenarios, it may also leverage cloud resources and services. Fig.1 shows the cloud-based IoT stage to enable apps.

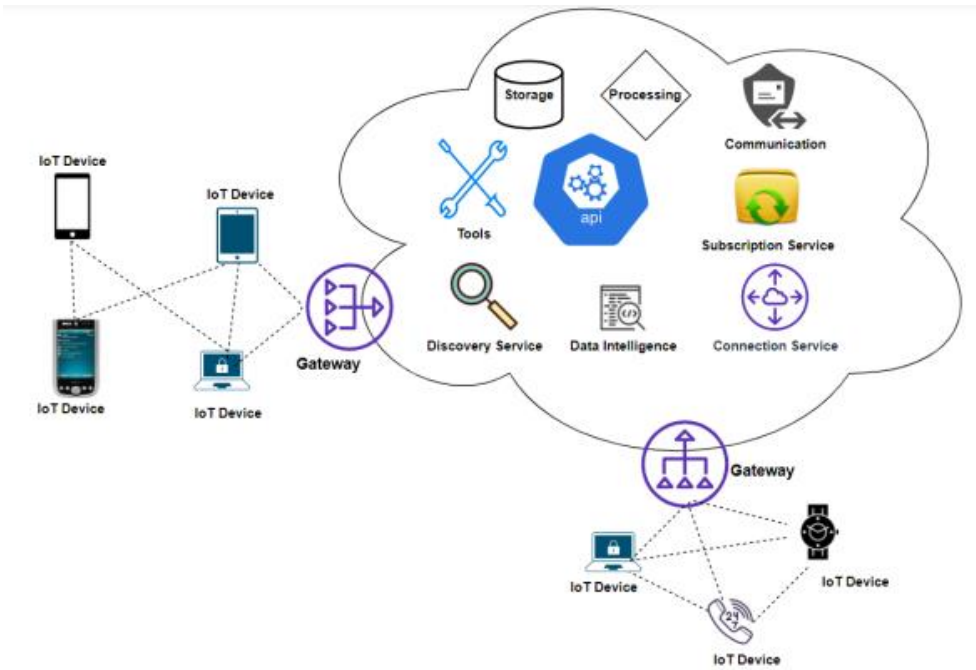

Figure 1. IoT system based in the cloud.

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Objective of The Study

- Creating a method for integrating wireless ad hoc networks with cloud computing for effective communication in smart cities.
- Improving the scalability and dependability of wireless ad hoc networks in smart city settings with cloud computing.
- By utilizing cloud computing strategies for smart cities, data transmission through wireless ad hoc networks may be made more secure and private.

Literature Review

An energy-conscious and quality-of-service (QoS)-conscious method to assignment offloading is put forth by Li, Li, and Cao for flexible edge computing in smart cities [4]. The developers overcome the challenge of modifying energy consumption and QoS requirements by using adaptable edge computing resources to offload tasks from resource-required devices. In consideration of energy and QoS, the study offers a computation that gradually assigns tasks to cloud or edge servers.

An overview of cloud computing for wireless sensor networks (WSNs) in smart cities is provided by Sharma, Mishra, and Sharma. The role of cloud computing in resolving WSN challenges in the context of smart cities is highlighted in the study [5]. It discusses several cloud computing strategies and models that enable effective information processing, storing, and research for WSNs, advancing the development of smart cities.

A thorough review of portable cloud computing (MCC) is provided by Hassan et al., focusing on best practices and emerging trends [6]. The study provides a summary of MCC designs, challenges, and possible entry points for smart cities. It discusses the integration of MCC with emerging technologies like edge computing and the Internet of Things (IoT), highlighting these technologies' genuine ability to enable effective and flexible city-level services.

An evaluation of cloud computing's energy efficiency for the Internet of Things (IoT) in smart cities is presented by Chen et al. The authors discuss the challenges associated with IoT devices' energy usage and look at how cloud computing could increase energy efficiency [7]. The study analyzes several energy-efficient cloud computing strategies, such as task offloading, asset the board, and energy advancement calculations, and provides information about how they might be used in smart city scenarios.

For smart cities, Gupta et al. introduce a novel method of cloud computing using wireless ad hoc networks. In relation to smart cities, the developers emphasize the need for skillful asset usage and intelligent dynamic systems [8]. Their suggested method makes advantage of the capabilities of cloud computing to transfer calculation-intensive tasks from resource-required devices in ad hoc networks. By utilizing cloud assets, the developers demonstrate more variety and faster handling in applications for smart cities. The analysis provides important insights into the use of cloud computing and wireless ad hoc networks to enhance the presentation of frameworks for smart cities.

Zhang et al. suggest an architecture for wireless ad hoc networks in smart cities that is based on cloud computing. The focus of the designers is on the organization and planning of a flexible and productive engineering that supports information handling and supports the executives in massive smart city environments [9]. In order to improve asset designation and facilitate reliable communication among devices in ad hoc networks, their methodology makes use of cloud-based administrations and virtualization approaches. In addition to outlining the need of flexibility and adaptability in smart city organizations, the analysis provides a thorough framework for cloud-based ad hoc networks in relation to smart cities.

Wireless ad hoc networks are used in Alazab et al.'s proposal for a cloud computing topology for smart cities. The authors discuss issues with managing information in a smart city environment, energy efficiency, and asset management [10].Their technology makes use of the concept of "haze computing," which extends cloud computing capabilities closer to the organization's edge, enabling efficient information processing and resource use. The suggested method enhances communication and information transfer among devices in smart city applications by employing

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wireless ad hoc networks. The review provides key insights into how cloud computing methods are implemented in relation to wireless ad hoc networks for smart cities.

Methods

This section looks at how smart cities are implemented in light of IoT combined with streamlined innovation [11]. This study will look at how the IoT and CC are utilized to create smart cities, enhance data sharing, and manage systems.

1. Data Sample

The 81 Internet of Things devices scattered around the United States and the Unified Realm provide data feeds for its construction. Cameras, smart hubs, home automation, TVs, music players, and machines are unquestionably covered. The dataset included a total of 40588451 samples of 68 IoT devices that were tagged.

The 81 Internet of Things (IoT) devices adopted in the study are a diverse set of devices, including:

- Cameras: These devices are used to collect images and videos, which can be used for security, surveillance, and traffic monitoring.
- Smart hubs: These devices act as central points for controlling other IoT devices in a home or office.
- Home automation devices: These devices can be used to control lights, thermostats, and other appliances in a home or office.
- TVs: These devices can be used to display information from IoT devices, such as weather updates or traffic reports.
- Music players: These devices can be used to play music from IoT devices, such as streaming services or personal libraries.
- Machines: These devices can be used to monitor and control industrial equipment.

The specific types of IoT devices used in the study will depend on the specific application. For example, a study on traffic monitoring might use cameras and sensors to collect data on traffic flow, while a study on energy efficiency might use smart thermostats and sensors to collect data on energy usage.

2. Data Pre-processing

1. Handling is made more challenging by the information's ZZ range of attributes and the fact that each feature has a distinct arrangement of numeric whole integers.
2. A standardization strategy is utilized to balance the information ZZ in the range of 0 to 1 and lessen the processing burden. There are several techniques for standardizing data [12]. The suggested remedy makes use of a workable min-max standardization method. In order to show a quantitative score from the supplied dataset into Znor with a range [0, 1], this technique employs condition 1.
3. $Z_{inor} = \frac{Z^{z}-Z_{min}}{Z_{max}-Z_{min}} \times [new\_max - new\_min] + new\_min$ 1
4. Here, $new_{max} = 1 and\ new_{min} = 0$ is utilized. Each attribute is given a value between 0 and 1, or anywhere within that range, using this procedure.

3. Machine Learning

AI makes the Internet of Things possible, and the IoT permits human-free machine-to-machine communication. In this work, Ad Hoc Routing Function (ARF) was used.

ARF typically outperforms a single tree classifier in terms of accuracy. It offers a system for categorizing various kinds of supplied information. Essential RF, on the other hand, chooses highlights at random, making it simple to choose elements that are superfluous or annoying. This makes choosing the incorrect qualities quite straightforward. As a result, the characterisation's overall findings might not be particularly promising. The information lattice used for type classification is insufficient for a large number of factors. To use the required RF in the search structure configuration, adjustments must be made [13]. There are many unaccounted-for values in the preparatory informative collection as a result of the limited element space. Due of the vast amount of missing data, the qualities are crucial. The randomized element choosing method used for bootstrap testing may yield a significant amount of irrelevant data, which would result in an incorrect tree structure being created. To create a top-notch class, it seems acceptable to develop a structure for highlight weighting. There was a choice to use the

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fundamental RF more broadly. The weighting measures are shown as a scenario (2) and are currently meant to be 2.

$$\mathcal{Y}^2 = \sum_{j=1}^{n} \sum_{k-1}^{2} \frac{(P_{jk} - f_{jk})^2}{f_{jk}} \qquad 2$$

In this case, n = highlights, and condition 3 is the meaning of Pjk as an intentional worth, which denotes the quantity of a combined occurrence.

$$P_{jk} = count(B = b_j \cap D = d_k \qquad 3$$

Similarly,

$$expected\ value = f_{jk} = \frac{count\ (B = b_j) \times count(D = d_j)}{N} \qquad 4$$

Despite Condition 2, the weight of each component of the element is not entirely fixed. Only properties with high loads are considered while building the decision tree. The process began by building many decision trees, and after combining the results from each class, a method for likelihood evaluation was applied. Accept that the testing case is the information case x and that each classifier's decision tree, hj [j = 1... k], chooses dj as a feasible objective class [14]. To evaluate the performance of each classifier, use the formula Q (J(y) = dj ik). The final outcomes of the arrangement are then determined by adding the quality of the probabilities, as shown in condition 5:

$$Q(J(\mathcal{Y}) = d_j) = \frac{1}{l} \sum_{k=1}^{l} Q(J(\mathcal{Y}) = d_j | i_k) \qquad 5$$

The Y input vector is regarded as a component of dj if and only if dj has the highest probability. If there were n includes, where n is the number of includes and f is the recurrence of component choice, the preparation set would consist of highlights. Only a few courses have perfected using the preparatory information offered. How information is prepared is chosen using the bootstrapping method. Test with substitution is employed in the given scenario, where t = [log 2n+1], to choose t highlights from n' highlights. At the end of each round, the prepared selected tree that is put to the woodlands M* is used to identify the unlabelled samples in accordance with condition 5.

Optimization Algorithm

Due to discrepancies and equipment disparities in the metropolitan server farm, genuine assets are being tested on the board during the growth of smart cities. The virtualization technology used by the cloud server farm ensures that the assets related to figure, stockpiling, and systems management are combined into a single, reliable virtual unit. With the help of the virtual asset executive's innovation, clients may purchase the assets as needed, and programmed distribution and work plans, custom creation, and fast arrangement of CC assets are entirely made possible [15]. This is considered as a reasonable and logical approach for the coordinated management of assets. The development of smart cities led to the creation of ACC-VMRA, a multi-measures enhancement calculation. In the multi-target virtual machine section, the accessible assets of each actual hub are addressed by an n-layered vector, where each aspect n denotes a separate asset. Every VM asset is also a vector of d attributes. The goal is to reduce the total number of hubs and the load distribution among them by consolidating a substantial number of virtual machines (VM) onto a small number of physical hubs. A depiction of the ACC-VMRA calculation for multi-measures augmentation may be seen below:

$$e_{OM} = \min \sum_{e} D_e \qquad 6$$

$$e_{KA} = min \frac{\sum_n C\mathcal{E}_j}{c} \qquad 7$$

The terms eOM and eKA, respectively, stand for the quantity of dynamic real hubs and the reasonable load differential of the server group. A ranking of de esteem is shown below:

$$D_e = \{ \begin{matrix} 1, Ph\mathcal{Y}sical\ nodeiin\ use \\ 0\ Else \end{matrix} \qquad 8$$

In Eq. 2, Cj stands for the j-layered change, and c for full dimensionality. The components of the articulation Cj are as follows:

$$C\mathcal{E}_j = \frac{\sum_n (O_{ji} - \bar{o}_j)^2}{n} \qquad 9$$

In the formula above, j stands for the mean value along the j th aspect for all hubs, and m stands for the total number of genuine hubs [16]. As was already said, the presentation qualities are consistent traits that only account for a small portion of the actual jth aspect components that are scattered across the actual hub.Oji is defined as "s I. Execution credits in aspect j for I the basic actual hub".

$$\sum_j S_j^{epu} * w_{j\to i} \le O_i^{mem} \qquad 10$$

$$\sum_j S_j^{mem} * w_i \le O_i^{mem} \qquad 11$$

$$\sum_j S_j^{J/P} * w_i \le O_i^{J/P} \qquad 12$$

I wji is 1 when VM j is allocated to the actual hub, but it is 0 in all subsequent situations. Eqs. 10– 12 could contain these results. In this case, Ocpu j, Omem I, and OJ/O I j refer to the central processor, memory, and organization transfer speed available to physical hub I, while j Sepu j, j Smem j, and j SJ/P j stand for the computer chip, memory, and organization data transfer capacity available to VM j.

On cm virtual machines, the application framework O may be added, and the VM execution pointers must meet the SLA of each application framework O. The state underneath might be identified.

$$\sum_{DN} S_{jp} \ge SLAo \qquad 13$$

Condition 13 is used in the "powerful asset booking" of a few application areas in smart cities. Programming for asset verification focuses on execution. When the load is too great, new virtual PCs are dispatched to spread it out. If condition 13, as in the declining of network data transmission capacity [17], the amount of VM may also do so [18]. Based on the presentation of the fundamental program administrators, a virtual machine dynamic booking strategy is created to address the problem of virtual machine overflow or unfavourable utilization rate. One such model is the ersatz code for a powerful planning technique that sets low expectations for the resources of a virtual machine.

Algorithm 1. Algorithm for dynamically scheduling virtual machines

```
For each VM in cloud VM
PI=get VMUR(VM)
asIndex=get AS(VM)
        If PI(VM) dissatisfy SLA
        Type=get New VM type (VM)
         Nvm=Add New VM()
         Deploy (nvm,asIndex)
          End if
          IF PI(VM)>75%
          DelASInstance(VM)
          Recover(VM)
          End if
Next
```

Get VMUR () and get AS () are the functions that, respectively, yield the application administration fag and the virtual machine usage rate in the pseudo code calculation. The VM's open exhibition points lead to the OI; acquire the return result of New VM type () displays the new virtual machine type that will be built. The most popular method for building new virtual machines is Add New VM (). The three functions, Deploy (), DelAS Instance (), and Recuperate (), separately send the comparing application administration, wipe the application administration instance, and recover the resources of the previously dispersed virtual machine.

Experimental Results

In this section, the experiment was evaluated by how well old and new approaches are presented. Dormancy, energy use, throughput, and organization lifespan are the boundaries. GA, ACO, and ARO are the currently used techniques.

The interval that exists between a client's request and the server's response is known as inactivity. The correlation of idleness in the conventional and suggested techniques is shown in Fig.2 and Table 1. Compared to the ACC-VMRA, investment requirements for current schemes like GA, ACO, and ARO are greater. It illustrates that the adoption of smart cities in conjunction with our

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recommended improvement is more effective than the other current advancement strategies.

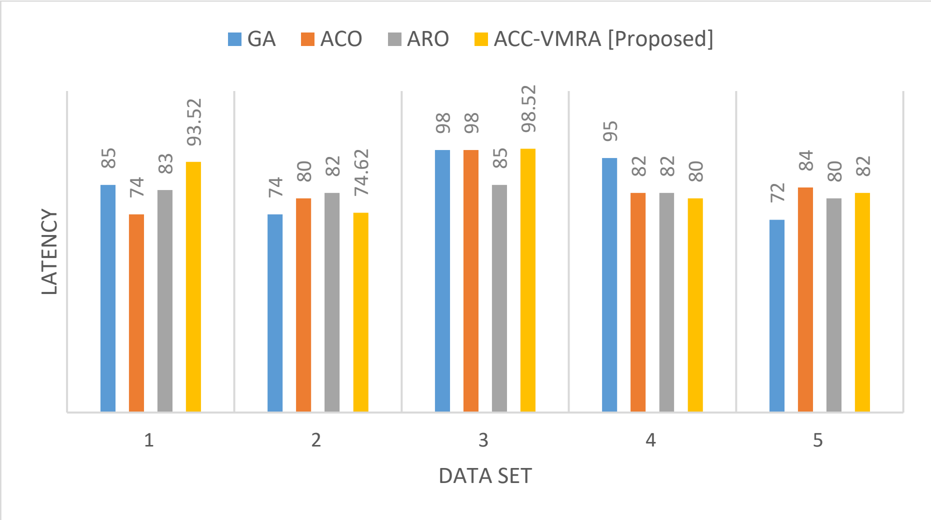

Figure 2. Comparison of the recommended method's and the old method's lag.

Table 1. Analyzing latency.

Data set	Latency (%)			
	GA	ACO	ARO	ACC-VMRA [Proposed]
1.	85	74	83	93.52
2.	74	80	82	74.62
3.	98	98	85	98.52
4.	95	82	82	80
5.	72	84	80	82

Energy utilization is a crucial factor to consider while planning tasks. The quantity of energy utilized by each hub when sending shipments is what is measured as the organization's overall energy consumption. Joules (J) are used to express the estimate. Energy use and assignment booking have both significantly increased. Fig.3 and Table 2 show the analysis of energy usage in the traditional and suggested ways. When compared to currently widespread techniques like GA, ACO, and ARO, the ACC-VMRA utilizes less energy. The proposed ACC-VMRA outperforms preceding systems like GA, ACO, and ARO because of its high errand planning.

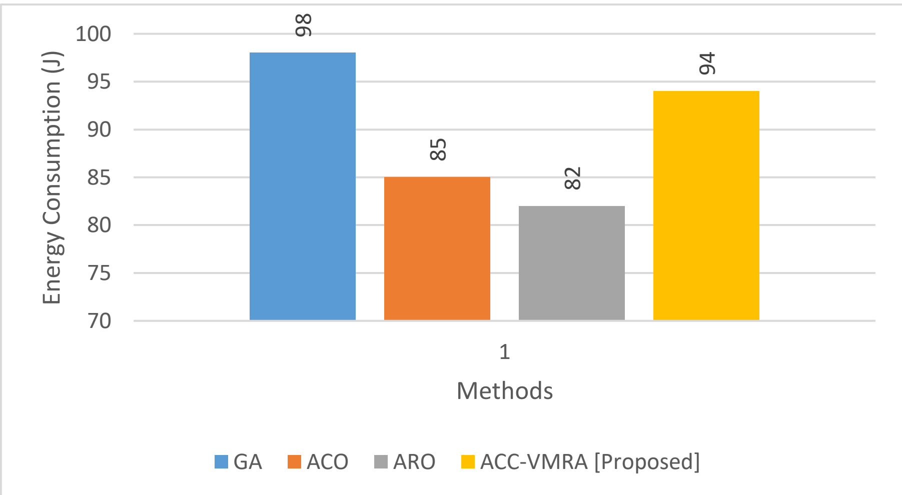

Figure 3. Energy use comparison between the conventional and suggested techniques.

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Table 2. A comparison of energy use.

Methods	Energy Consumption (J)
GA	98
ACO	85
ARO	82
ACC-VMRA [Proposed]	94

How much data a framework can process or communicate in a given period of time is referred to as its throughput. In Fig. 4 and Table 3, the throughput correlation for the conventional and suggested procedures is displayed. The proposed approach, ACC-VMRA, performs data transmission or processing significantly better than the current methods, GA, ACO, and ARO.

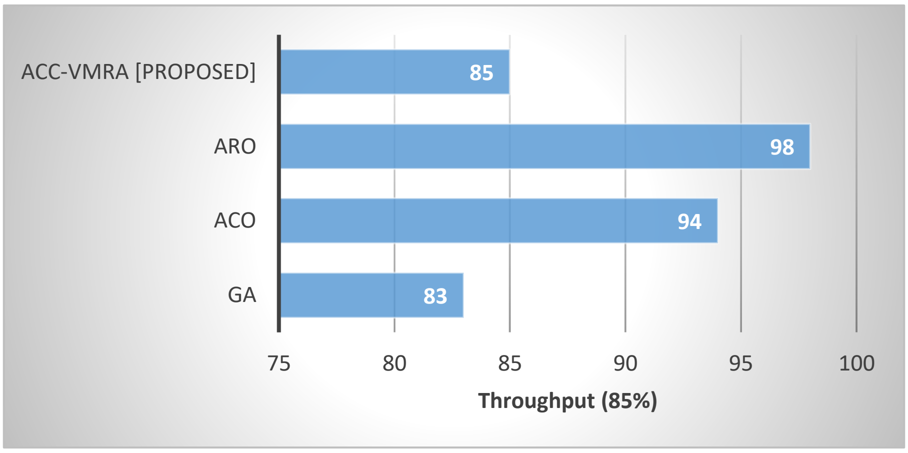

Figure 4: Throughput comparison of conventional and alternative approaches.

Table 3. Analyzing throughput.

Methods	Throughput (%)
GA	83
ACO	94
ARO	98
ACC-VMRA [Proposed]	85

The period of time before the organization's main hub runs out of power is referred to as the network lifespan [19, 20]. The correlation between throughput using the conventional and suggested techniques is shown in Fig. 5 and Table 4. Using the suggested method, ACC-VMRA, it is evident that the recommended strategy has a longer network lifespan when compared to existing techniques like GA, ACO, and ARO.

Figure 5. Network lifespan in standard and recommended methods are compared.

Table 4. Lifetime of the network comparison.

Data set	Network life time (s)			
	GA	ACO	ARO	ACC-VMRA [Proposed]
1.	83	92	80	83
2.	82	80	92	85
3.	84	95	93	82
4.	85	94	95	84.98
5.	83	95	82	85

Conclusion

In conclusion, our evaluation of both old and new approaches in the context of dormancy, energy use, throughput, and organization lifespan has provided valuable insights into the effectiveness of these techniques. ACC-VMRA is employed, along with existing methodologies such as GA, ACO, and ARO, as benchmarks for comparison. Regarding dormancy, which represents the interval between a client's request and the server's response, our analysis, as depicted in Fig. 2 and Table 1, revealed that the ACC-VMRA outperformed the existing methods in terms of reducing latency with percent 98.52%. It is worth noting that the ACC-VMRA demonstrated the lowest latency across all datasets, making it a promising choice for real-time applications.

Energy consumption is a critical consideration in today's resource-conscious world. Our assessment of energy utilization, as shown in Fig. 3 and Table 2, demonstrates that the ACC-VMRA consumed significantly less energy compared to GA, ACO, and ARO with percent reach to 94%. This finding indicates that the ACC-VMRA not only excels in task planning but also contributes to energy efficiency, which is crucial for sustainable and eco-friendly systems. Throughput, the measure of a system's data processing or communication capability, was another aspect that was examined. Figure 4 and Table 3 clearly indicate that the ACC-VMRA surpasses GA, ACO, and ARO in terms of throughput with a percent reach of 85%. This suggests that the ACC-VMRA is better equipped to handle data transmission and processing, making it a robust choice for applications requiring high data throughput.

The network lifespan is assessed, which represents the time before the organization's main hub runs out of power. Our findings, as depicted in Fig.5 and Table 4, revealed that the ACC-VMRA exhibits a longer network lifespan when compared to GA, ACO, and ARO with percent of 85%. This extended network lifespan is a significant advantage, ensuring the longevity and reliability of the network infrastructure.

Our evaluation underscores the superiority of the ACC-VMRA in various aspects, including latency reduction, energy efficiency, improved throughput, and an extended network lifespan. These results highlight the potential of the recommended ACC-VMRA approach for enhancing the performance and sustainability of networked systems, especially in scenarios where real-time responsiveness and energy conservation are paramount. Future research may focus on further refining and implementing the ACC-VMRA technique in practical applications to harness its full potential.

Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and Images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' Contribution Statement

H. M. A. contributed to the proposed idea based on the problem statement. He collected all the information and proposed a method to solve the problem statement. Y. A. S.A contributed to proposing the method as well as collecting the data. She contributed to organizing and writing the paper.

M. A. Y. contributed to the organization of the whole paper and writing it. M. J. J contributed in writing–review and editing the paper, and S. H. H. M. contributed to writing as well as to the organization.

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تقنية الحوسبة السحابية على الشبكات اللاسلكية المخصصة المستخدمة في المدن الذكية

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الخلاصة

شهدت المدن الذكية تطورا جوهريا زاد من امكانياتها بشكل كبير .في الواقع ، لقد أتاحت التطورات الحديثة في انترنت الاشياء (IOT) فرصا جديدة من خلال حل عدد من المشاكل الحرجة والتي ادت الى ابتكار المدن الذكية بالاضافة الى انشاء و حوسبة الخدمات و التطبيقات المتطورة للعديد من المجاميع المطورة في المدينة . من اجل تعزيز تنمية المدن الذكية بأتجاه التواصل و المشاركة ،تركز هذه الدراسة على التطور في مجال المعلوماتية في ضوء انترنت الاشياء (IOT) و الحوسبة السحابية (CC) .جمعت بيانات انترنت الاشياء والتي تخص المدن الذكية بشكل متجانس . اصبح انترنت الاشياء الذي يسمح بتواصل الاشخاص مع بعضهم ممكنا باستخدام الذكاء الاصطناعي .بناءا على ذلك ،استخدمنا (ARF) في حسابات الذكاء الاصطناعي .للتبسيط ،ننصح باستخدام تخصيص اصول الالة الافتراضية للحوسبة السحابية التكيفية (ACC-VMRA) .لتاكيد جدواها ،سنفحص و نضاعف كيفية تطبيق تطورات انترنت الاشياء (IOT) و الحوسبة السحابية (CC) في المدن الذكية.تظهر نتائج التجربة ان حساب التحسين الموصى به اكثر انتاجية من الطرق الاخرى المستخدمة حاليا.

الكلمات المفتاحية: الشبكات المخصصة ، الحوسبة السحابية ، المدن الذكية ، التقنية، الشبكات اللاسلكية .