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Key Perspectives in Power Aware Ad-hoc Internet of Things with Advanced Networks and Real Time Scenarios

Sanjay K. Bansal
Bikaner Technical University, skbansal30@gmail.com

Jyoti Prabha
Maharaja Ganga Singh University, jyotiprabhasingh@gmail.com

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Cover Page Footnote

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Key Perspectives in Power Aware Ad-hoc Internet of Things with Advanced Networks and Real Time Scenarios

Sanjay K. Bansal[1] and JyotiPrabha [2]
[1]Bikaner Technical University, Bikaner, Rajasthan, India
[2]Maharaja Ganga Singh University, Bikaner, Rajasthan, India
skbansal30@gmail.com and jyotiprabhasingh@gmail.com

Abstract: Smart gadgets with integrated power optimization segments are the key perspectives that use Internet of Things (IoT) enabled technology to promote lifestyle advancements. It has an influence on a few sectors in academia and/or business thanks to its strong integration with the current Cloud architecture. Recently, the Internet of Things has been acknowledged as a disruptive technology for the aerial ad hoc network. IoT may be thought of as a network inside a network. IoT-based networks rely heavily on the so-called self-organizing capability working in a dispersed manner in ad hoc networks, with users travelling at speeds ranging from walking pace to automobile, rail, or airline speed. IoT applications that assist logistics, and the administration of ad hoc networks may be found in a broad variety. Utility companies are under pressure now to produce ever more enormous amounts of electricity. In megacities, there is an exponential rise in the number of people and energy users. Thus, the need for energy conservation is growing significantly on a global scale. The best way to optimize the rising energy demands and consumptions is because of the development of energy-monitoring systems. These solutions can cut current utilization levels, stop energy waste, and make better use of our resources.

Keywords: Power Aware IoT, Power Optimization Based Ad-hoc Networks, Power Integrated IoT

Introduction

Power and Cost optimization can be achieved by utilizing IoT technology. Additionally, this technology may be used in conjunction with real-time localization systems to get information directly from the factory floor, allowing firms to continually monitor machine activity, maintenance requirements, and product movement throughout production. The deployment of these intelligent machines can save costs over digital ad hoc networks while giving data that enables producers to change production as needed. Schedule updates and quality-related information will be sent instantly and in real-time to production and assembly lines. Additionally, preventative, preventive, and

The work refers to a research area that focuses on developing energy-efficient and reliable communication protocols for IoT devices operating in ad-hoc networks. Ad-hoc networks are networks formed by devices that do not have a fixed infrastructure, such as mobile phones, laptops, and IoT devices. In such networks, the devices must work together to ensure reliable communication, which requires efficient power management.

The power-aware aspect of this research area aims to optimize the energy consumption of IoT devices while maintaining their performance. This involves developing techniques to reduce the energy consumption of devices during idle periods, as well as during active communication. For instance, devices can adjust their transmission power based on the distance between them and the other devices in the network. This helps reduce the energy consumed during data transmission while maintaining the reliability of communication.

The advanced networks aspect of this research area involves developing communication protocols that are robust and reliable in ad-hoc networks. This includes techniques for routing data between devices, ensuring data delivery, and predictive repairs and maintenance may be planned using IoT data [1].
managing the network topology. For example, devices can use a variety of routing protocols, such as reactive, proactive, and hybrid routing protocols, depending on the network environment and the application requirements.

The real-time scenarios aspect of this research area refers to the need for IoT devices to operate in real-time environments, where timely and reliable communication is critical. Examples of real-time scenarios include industrial automation, healthcare monitoring, and transportation systems. In such scenarios, devices must operate with minimal latency and high reliability to ensure safety and efficiency.

Overall, the research area of power-aware ad-hoc IoT with advanced networks and real-time scenarios is essential for the development of energy-efficient and reliable communication protocols for IoT devices operating in ad-hoc networks. Such protocols can enable a wide range of applications and services that require real-time, reliable communication, while minimizing the energy consumption of IoT devices.

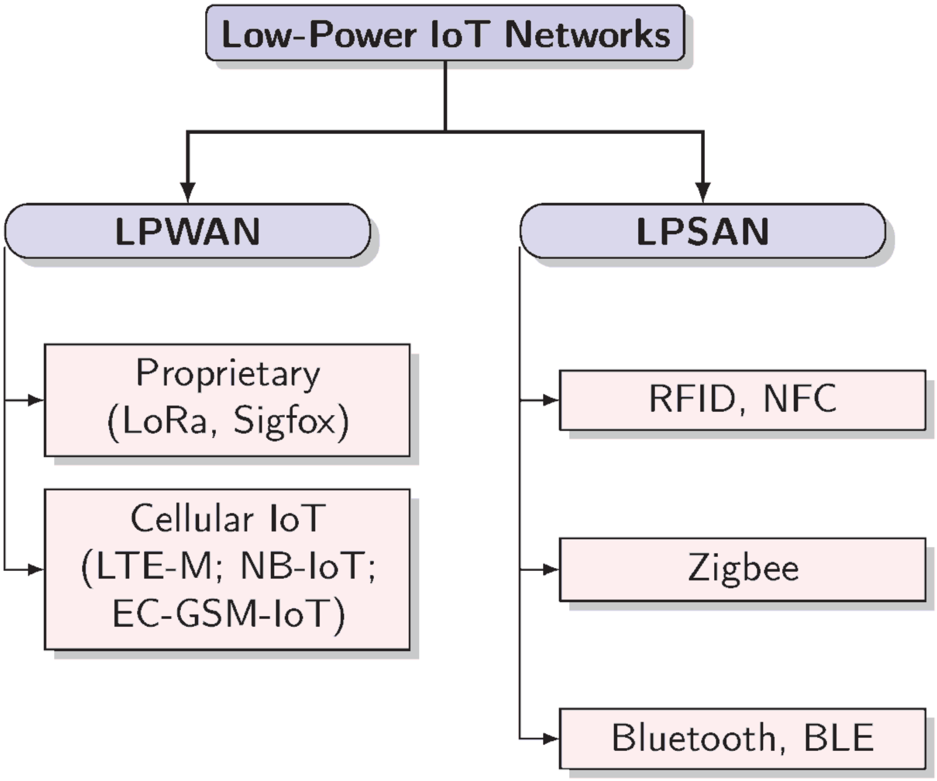

Figure 1 : Low Power IoT Networks

Ad hoc networks of things are one example of how IoT is being used in particularly designed systems, which is growing swiftly. To manage the whole rail network, Deutsche Bahn, the German railroads and freight carrier, established a system-wide inspection framework. More than 1 billion supply chain "hubs" are a part of this network, which is constantly monitoring the condition of each length of track, train car, station, motor, and switch. The information is fed into a control tower, which totals them on a regular basis to provide close-to-real-time information on the whole fleet. Deutsche Bahn has made use of this information to improve risk management procedures, such as continual rerouting and optimization, taking into account all system traffic now traversing these hubs.

Assorted Patterns

Whirlpool used radio frequency identification (RFID) labels and readers across an assembly plant to provide chiefs and administrators with continual access to data for incoming coordination to the paint line instead of ordinary bar codes or a comparable setup.

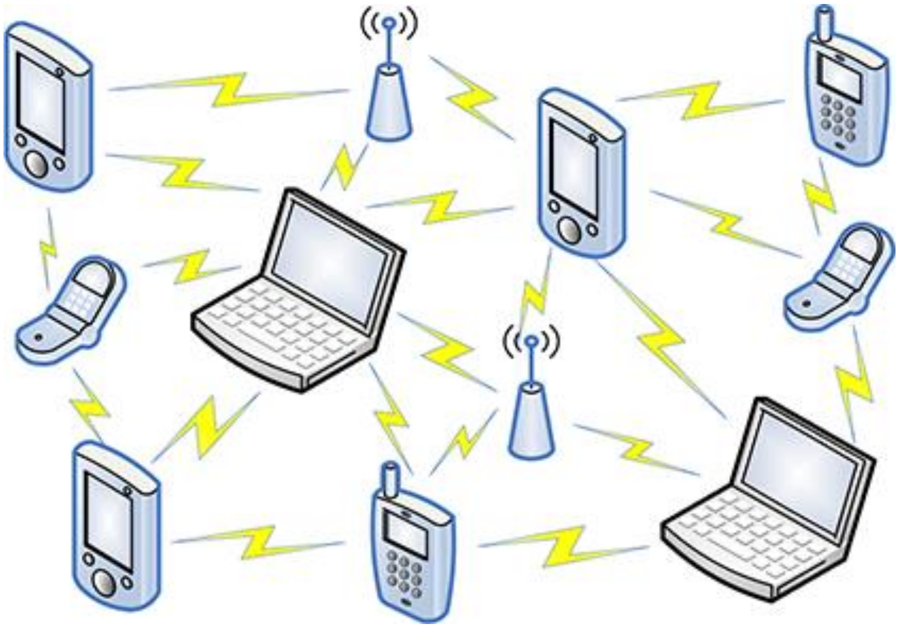

Figure 2: Ad hoc Network with IoT

The different supply chain partners may utilise the IoT to monitor the execution of the chain in real time and increase the efficacy and efficiency of energy consumption and cost savings. High visibility in production networks is now achievable thanks to recent IoT breakthroughs. The IoT, for instance, promotes food and agricultural products by enhancing their visibility and traceability and by guaranteeing consumer food safety [2, 3].Utilizing RFID, ambient intelligence, and multi-agent systems, industrial IoT deployment enables the creation of an ideal platform for collaborative warehouse order fulfilment and decentralised administration of warehouses.

The widespread adoption of the IoT paradigm today has made energy consumption a major concern for the linked communications networks' future. Therefore, it is important to discuss the primary causes of increased energy usage in IoT. Appliances in smart homes and buildings, sensor ad hoc networks in traffic and health systems, RFID tags and readers in smart identified spaces, etc. may all be major energy users in the IoT age [4].

Despite the enormous excitement of IoT and production network managers and other applications, there is still a gap in the monitoring and optimization of energy use. Administrators and automated controllers can respond to changes anywhere thanks to observation and monitoring frameworks in this field that can collect and send crucial information about the monitored resource's condition, hardware execution, testing, vitality utilisation, and environmental conditions. These skills are essential for clever production network operations where product deceivability and traceability are required.

IoT frameworks associated with inventory network activities use RFID as a component. Radio frequency waves, a tag, and a reader are all used in RFID systems. The tag has a larger data storage capacity than typical scanning tags. RFID readers, meanwhile, can automatically and gradually identify, monitor, and screen the goods associated with labels all around. However, remote developments have played a significant role in mechanical observation and control systems. Sensors, GPS, RFID labels, and sensor systems are used by watching and controlling applications in an average production network to reduce dispersion, theft, misfortune, and decay in distribution centres, transportation, and retail racks. Sensors are used to maintain products at the proper temperature and protect them from trash and material spills [5].

Literature Review

Q. Li, J. Xie, and J. Shi [6] propose an energy-efficient and reliable routing protocol for wireless sensor networks (WSNs) in the IoT. The protocol uses a combination of data aggregation, cooperative communication, and duty cycling to reduce the energy consumption of nodes while maintaining high reliability.

M. Raza, E. V. Belmega, and S. Malek [7] presents an energy-efficient and scalable routing protocol for the IoT based on cognitive networking. The protocol uses a cognitive radio approach to dynamically select the best path for data transmission based on the available spectrum and energy resources of the nodes.

A. Al-Fuqaha, M. Guizani, and H. Mohammadi [8] proposed an adaptive and efficient routing protocol for the IoT in smart cities. The protocol uses a combination of geographic and opportunistic routing to reduce energy consumption and improve network reliability in dynamic and heterogeneous environments.

M. Bagaa and A. Taleb [9] review and compare various power-efficient communication protocols for WSNs in the IoT. The protocols include hierarchical routing, location-based routing, and clustering, among others. The authors conclude that clustering-based protocols are the most energy-efficient for large-scale IoT networks.

S. Waharte and S. Cherkaoui [10] analyzed the real-time communication protocols for WSNs in the IoT. The protocols include TDMA-based protocols, duty cycling, and scheduling-based protocols, among others. The authors conclude that scheduling-based protocols are the most suitable for real-time IoT applications that require high reliability and low latency.

These analytics in the papers provide a good overview of the research area of Power Aware Ad-hoc Internet of Things with Advanced Networks and Real Time Scenarios, including energy-efficient and reliable routing protocols, cognitive networking, adaptive routing, and real-time communication protocols for IoT devices in ad-hoc networks.

Problem Formulation

Power optimization in the Internet of Things (IoT) is important for several reasons:

Battery life: IoT devices are often battery-powered and need to be replaced or recharged frequently. Power optimization can extend the battery life of these devices, reducing the need for maintenance and the cost of replacement batteries.

Remote locations: Many IoT devices are deployed in remote or hard-to-reach locations, making it difficult or expensive to replace batteries or perform maintenance. Power optimization can help to ensure that these devices continue to function even in the absence of regular maintenance.

Cost-efficiency: Power consumption is a significant cost factor for IoT devices. Power optimization can help to reduce power consumption, thereby reducing operational costs.

Scalability: With the increasing number of IoT devices, the power consumption and cost can become a bottleneck. Power optimization can help to scale the IoT infrastructure in a cost-efficient way.

Energy Conservation: Power optimization can help to reduce the overall energy consumption of IoT devices, promoting energy conservation and reducing the environmental impact of IoT.

The problem of power usage in the Internet of Things (IoT) refers to the need to ensure that IoT devices have a reliable and long-lasting power source. This is particularly important for IoT devices that are deployed in remote or hard-to-reach locations, as well as for devices that are designed to be portable or wearable. Some common strategies for addressing the power usage problem in IoT include using energy-efficient hardware and software, implementing power-saving modes, and using alternative power sources such as solar or kinetic energy. Additionally, it's important to consider the overall power management system and the communication protocols used to minimize the power consumption.

A problem statement for power usage in IoT could be: "To ensure that IoT devices have a reliable and long-lasting power source while minimizing power consumption in order to extend battery life and reduce the need for maintenance in remote or hard-to-reach locations."

Research Gaps

- Lack of energy-efficient and reliable routing protocols for IoT devices in ad-hoc networks with real-time applications.
- Insufficient research on power management techniques for IoT devices in ad-hoc networks with advanced communication technologies.
- Limited understanding of the impact of network topology and node mobility on the energy consumption and reliability of IoT devices in ad-hoc networks.

Motivations

- Increasing demand for IoT applications in various domains such as healthcare, transportation, and smart cities, which require energy-efficient and reliable communication protocols.
- Need for innovative power management techniques to extend the battery life of IoT devices in ad-hoc networks.
- Growing interest in advanced communication technologies such as cognitive networking and software-defined networking for IoT devices in ad-hoc networks.

Possible Effective Solutions for Power Usage Patterns and Optimization in IoT

There are several effective solutions for reducing power usage in IoT devices, including:

Energy-efficient hardware: Using energy-efficient components such as low-power microcontrollers and sensors can help to reduce power consumption.

Power-saving modes: Implementing power-saving modes, such as turning off or reducing the power consumption of certain components when they are not in use, can help to extend battery life.

Alternative power sources: Using alternative power sources, such as solar or kinetic energy, can help to reduce the need for battery replacement or recharging.

Communication protocols: Choosing communication protocols that have lower power consumption requirements can help to reduce power usage. Some examples are Zigbee, Bluetooth Low Energy (BLE) and LoRaWAN

Power management system: A comprehensive power management system that can monitor, control and optimize the power consumption of the devices can help to reduce power usage and extend battery life.

Cloud computing: Using cloud computing and edge computing to offload some of the computational tasks from the device to cloud servers. This can help to reduce the power consumption of the device.

Software optimization: Optimizing software algorithms and using power-aware programming techniques can help to reduce power consumption.

It's important to note that the solution will vary depending on the specific use case and requirements of the IoT device. A combination of these solutions can be used to achieve optimal power usage.

Approach and Outcomes

Metaheuristics are a class of optimization algorithms that can be used to find approximate solutions to complex problems. They are particularly well-suited for problems that are difficult to solve exactly, such as power optimization in the Internet of Things (IoT). Some ways that metaheuristics can be used for power optimization in IoT include:

Power scheduling: Metaheuristics can be used to schedule the power usage of IoT devices in a way that minimizes power consumption while meeting the performance requirements of the devices. This can be done by modeling the problem as an optimization problem and using metaheuristics to find an approximate solution.

Resource allocation: Metaheuristics can be used to allocate resources, such as battery power and network bandwidth, among IoT devices in a way that maximizes the overall performance of the system while minimizing power consumption.

Power management: Metaheuristics can be used to manage the power consumption of IoT devices by adjusting the parameters of the devices, such as the frequency of communication and the power consumption of individual components, in a way that minimizes power consumption while meeting the performance requirements of the devices.

Adaptive power management: Metaheuristics can be used to adapt the power management system based on the current state of the device, such as battery level and usage patterns, in order to optimize the power usage.

Multi-objective optimization: Metaheuristics can be used to optimize multiple objectives, such as power consumption and performance, simultaneously in order to find a trade-off solution that balances the objectives.

It's important to note that the specific metaheuristic used will depend on the specific use case and requirements of the IoT device, and the performance of the optimization algorithm can be improved by combining metaheuristics with other optimization techniques such as machine learning.

Soft computing techniques, such as artificial intelligence (AI), machine learning (ML), and fuzzy logic, can be used to optimize power usage in IoT devices. These techniques can be used to model, predict, and control power consumption, allowing for more efficient power management. Some examples of how soft computing can be used for power optimization in IoT include:

Predictive power management: ML algorithms can be used to predict power consumption based on historical data, allowing for more efficient power management.

Adaptive power management: Fuzzy logic can be used to adapt the power management system based on the current state of the device, such as battery level and usage patterns.

Anomaly detection: AI algorithms can be used to detect abnormal power consumption patterns, helping to identify and fix issues that may be causing excessive power usage.

Device clustering: Clustering algorithms can be used to group devices based on their power consumption patterns, allowing for more targeted power management.

Deep learning: Deep learning algorithms can be used to optimize the power consumption of IoT devices by learning the patterns of usage and adjusting the parameters of the device accordingly.

Reinforcement learning: Reinforcement learning can be used to optimize the power management strategy by learning the best actions to take in a given state to maximize the battery life of the device.

It's important to note that the specific soft computing techniques used will depend on the specific use case and requirements of the IoT device.

PROPOSED FLOW OF WORK

1. Investigation and Activation of the IoT Modes in the working panel and simulation scenario

2. Generation of the Dynamic Nodes with Effectual Graph of the Motes

3. Analytics Patterns of the Energy and Power of each node based on the ratio of the number of links between and to neighbors of u over the degree of u: $\rho\ (u)$ = (V, w) $\in E$ | V $\in$ $\{u$,N$(u)\}$, $w\in$ N(u) / $\delta\ (u)$

4. Add Random Number to the measured density of each node to avoid any biasing

```
Energy-Factor=[N-a N-b N-c N-d N-e N-f N-g N-h N-i N-j N-k N-l N-m N-n]
meanEnergy-Factor=mean(Energy-Factor)
rnd=rand(1, 100);
minrnd=min(rnd);
roundmeanEnergy-Factor=round(meanEnergy-Factor);
Energy-Factor=Energy-Factor+roundmeanEnergy-Factor-rand()+minrnd;
Energy-Factor
```

Following the determination of density, the likelihood of numerous cluster heads is integrated. This method moves the second cluster head in the scenario when one cluster head fails, minimising the energy loss. Due to the single CH idea, the classical technique has a greater energy loss. The installation of the Battery Consumption and Relative Neighborhood Graph is shown, along with the removal of Low Battery Nodes.

The dynamic random key, which is created fresh each time, is completely reliant on the calculation.

The cost is estimated using the following mathematical formula, which is not possible using the traditional method.

```
Energy Factor =((14*max(/Degree)/roundmeandeg) +time-factor+c
Performance =[costfactor cost];
```

5. The Threshold Value will be used to determine the Cluster Head's allocation.

6. The Threshold Value must be compared to all surrounding densities, and the factor is the minimal difference in densities.

7. Assume that the densities are 1.2, 3.2, 3.0, 4.9, and 2.

5. A dynamic threshold will now be determined based on the sum of all these.

8. The closest value to the threshold will therefore be regarded as the Cluster Head.

9. The graphs or comparison parameters must be

Power Optimization / Conservation between Existing and Proposed Approach
Cost Factor between Existing and Proposed Approach

To improve steering, sensor systems monitor traffic conditions, direct devices, and monitor the location of moving cars. The Wireless Sensor Network (WSN) is made up of geographically dispersed, self-sufficient sensor-equipped devices that can monitor environmental or physical conditions. It can also interact with RFID systems to more effectively track the status of things like their location, temperature, and developments. WSN has mostly been used in cold chain coordinations, which include moving temperature-sensitive goods around an inventory network using warm and cold wrapping techniques. WSN is also used for maintaining and monitoring frameworks. Sensors are sent by General Electric (GE) products in their motors [11], turbines, and wind farms. By continually analysing data, GE saves time and money with practical preventative support.

Online and passive energy consumers can be distinguished in terms of how much energy is used by the aforementioned IoT enabled devices and appliances. When an enabling technology is in the online (active) mode, it draws power from a constant electric source, like a wall outlet or a gas line. In the offline (passive) model, energy is utilised in accordance with its availability, as in the case of photonic sensors that rely on solar panels to collect their energy from the environment. In both situations, it is important to note that keeping an eye on energy use may help the service provider cut costs and improve performance. As a result, an important part of an energy-monitoring system is monitoring the total number of Watts utilised each hour in the aforementioned modes [12].

Therefore, placing Watt Hour Meters (WHM) everywhere is of tremendous importance to energy companies nowadays. Energy conservation benefits greatly from communication between utilities and consumers in manufacturing networks (supply chain). User behaviour varies in response to changes in utility price, but it also depends on whether the consumer is aware of the appliance's usage. This sort of immediate feedback aids in resource management for both the client and the provider as well as energy conservation [13, 14].

Power and Energy Analytics Patterns

The sensing device is a crucial part of any energy monitoring system. Voltage and current are two essential factors that must be understood in order to monitor energy usage with these sensing devices. Diverse techniques have been applied to various appliance kinds in order to measure these factors. These techniques may be divided into direct and indirect sensing methods.

The foundational idea behind Smart Energy Monitoring (SEM) is that the energy provided by the service business enters the house through a WHM and then travels to a load survey metre (LSM), which determines the overall load of the whole structure. End User Meters (EUM), which are placed independently for each device and calculate each appliance's unique energy use, are coming down in the system [15].

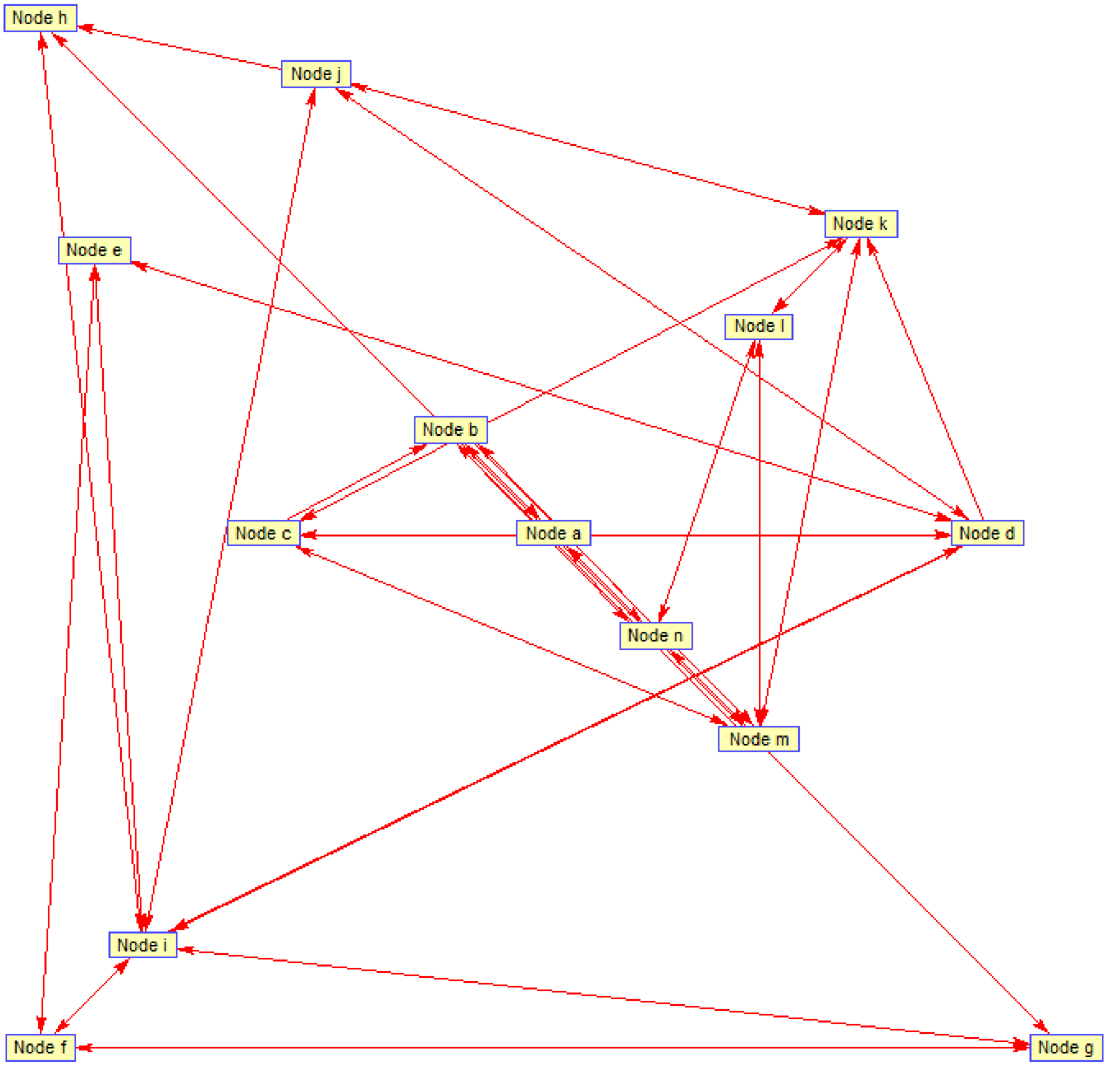

Figure 3 : Dynamic Patterns of IoT Motes

Table 1 : Evaluation of the outcomes

Power Usage (Classical Approach)	Power Usage (Proposed Approach)	Performance (Classical Approach)	Performance (Proposed Approach)
80	20	45	98
78	42	58	78
67	44	65	89
89	53	45	96
76	34	56	90

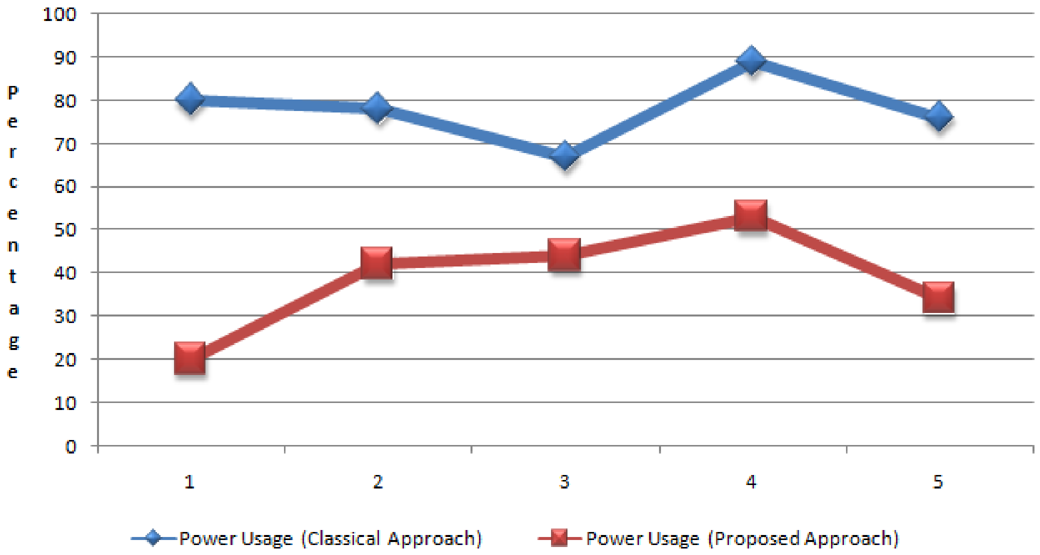

Figure 4 : Evaluation of the Power Usage

The outcome presents that the power optimization in the proposed approach is quite effective and giving better results as compared to the classical approach.

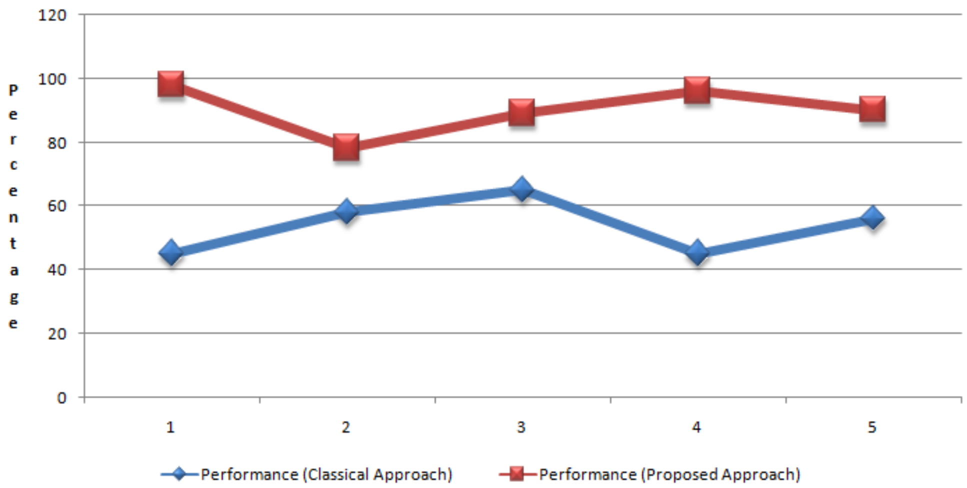

Figure 5 : Evaluation of the Cumulative Performance

Energy conservation is a difficult task for both the client and the provider, but both sides benefit from it. Customers that practise energy saving directly lower their electricity bills and leave a smaller carbon imprint. On the other hand, at the supplier level, energy conservation entails a constant eye on consumption growth, which may result in financial gains by avoiding the costs of further capacity additions and peak shifting. In turn, this promotes supply continuity. Additionally, it might benefit the nation's use of renewable resources and reduction of GHG emissions.

Conclusion

By their very nature, renewable energy sources are sporadic. It is more difficult for utilities to provide dependable and high-quality electricity as a result of the rising penetration of those non-dispatchable energy sources into the current power system. IoT/Cloud-inspired apps can fortunately provide excellent answers to the aforementioned difficulties by offering two-way communication techniques that can aid in altering traditional electricity. To properly accomplish their objectives, new businesses and a variety of sectors depend on energy monitoring. Energy savings and efficiencies can result from integrating Cloud/IoT technologies. The findings of several research studies and application cases demonstrate that the energy monitoring systems lead to greater energy consumption reduction. Real-time input to customers specifically causes a large shift in behaviour for energy consumption. The scope of future work in Power Aware Ad-hoc Internet of Things with Advanced Networks and Real Time Scenarios can be broad and can cover various aspects of the research area. Based on the existing literature and the problem statement of the work, some potential directions for future research could include the following aspects:

- Development of novel energy-efficient and reliable routing protocols for IoT devices in ad-hoc networks with real-time applications. These protocols can incorporate techniques such as data aggregation, topology control, and load balancing to minimize energy consumption and improve network performance.
- Investigation of power management techniques for IoT devices in ad-hoc networks with advanced communication technologies such as cognitive networking and software-defined networking. This can involve the design of energy-aware algorithms for resource allocation, traffic routing, and network optimization.
- Evaluation of the impact of network topology and node mobility on the energy consumption and reliability of IoT devices in ad-hoc networks. This can include the development of simulation models and experimental testbeds to assess the performance of IoT devices under different network scenarios.
- Exploration of real-time communication protocols for wireless sensor networks in the Internet of Things. This can involve the study of existing real-time protocols such as MQTT-SN, CoAP, and DDS, as well as the development of new protocols tailored to the specific requirements of ad-hoc networks with real-time applications.
- Integration of machine learning and artificial intelligence techniques for power management and network optimization in Power Aware Ad-hoc Internet of Things with Advanced Networks and Real Time Scenarios. This can involve the design of intelligent algorithms for resource allocation, data compression, and data fusion, as well as the development of machine learning-based models for predicting network performance and energy consumption.

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