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# Power and Energy Optimized Approach towards Sustainable Mobile Ad-hoc Networks and IoT

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# Power and Energy Optimized Approach towards Sustainable Mobile Ad-hoc Networks and IoT

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## Introduction

When compared to Wireless Sensor Networks (WSN), the approach of modelling the energy usage for IoT devices is different for a variety of reasons and metrics. IoT layers differ from the Open System Interconnection (OSI) layers in a number of ways, including the use of communication protocols such IPv6 Low Current Wireless Personal Area Networks (6LoWPAN) [1, 2], Routing for Low-Power and Low-Load Networks (RPL), and Constrained Application Protocol (CoAP). As a result, it becomes necessary to create effective Medium Access Control (MAC) [3, 4] protocols in order to strike a compromise between system performance and minimal energy usage. It is necessary to solve the issue of MAC protocol compatibility for IoT implementation [5].

IoT serves as the link between pervasive computing and future communication systems. Through cross-layer protocols, the IoT aims to allow more linked devices. The wireless and mobile technologies including WSN, Nanotechnology, and Radio Frequency Identification are combined in Internet of Things (IoT) based systems (RFID). Energy is therefore the primary aspect that is accountable for handling such linked systems when numerous technologies are integrated together on a single platform [6, 7]. It is crucial to pay attention to matters of energy and power usage. Due to a variety of elements and measurements, the modelling of the energy consumption for IoT systems differs from WSN [8].

Routing is an important aspect of power optimization in the Internet of Things (IoT). By choosing an appropriate routing strategy, power consumption can be reduced, and the lifetime of the devices can be extended. Here are some examples of how routing can be used for power optimization in IoT:

Energy-efficient routing: Routing algorithms can be designed to minimize the power consumption of the devices by choosing routes that minimize the number of hops or the distance between the devices. This can be done by using metrics such as the remaining energy of the devices or the signal strength of the wireless link.

Sleep-mode routing: Routing algorithms can be designed to put devices into sleep mode when they are not needed, reducing their power consumption. This can be done by using metrics such as the traffic load on the network or the number of active devices.

Clustering-based routing: Routing algorithms can be designed to group devices together into clusters, reducing the power consumption of the devices by minimizing the number of messages that need to be sent. This can be done by using metrics such as the similarity of the devices or their location.

Multi-path routing: Routing algorithms can be designed to use multiple paths between devices, reducing the power consumption of the devices by balancing the load on the network. This can be done by using metrics such as the remaining energy of the devices or the signal strength of the wireless link.

Hybrid routing: Routing algorithms can be designed to combine multiple routing strategies, such as energy-efficient routing and sleep-mode routing, to optimize the power consumption of the devices.

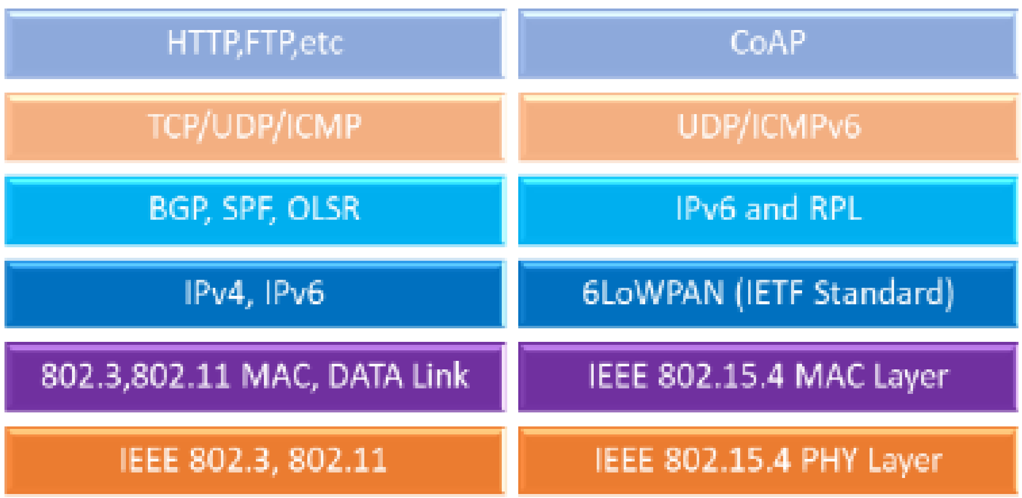


**Figure 1 : OSI and IoT Layered Approach**

A communication protocol known as 6LoWPAN that is part of the adaption layer includes RFC6282-compliant packet encapsulation and header compression methods [9, 10]. It may be used to low power RF technologies as well. RPL is implemented for networks with minimal power consumption by using information broadcasting over the Directed Acyclic Graph (DAG). To convey the updates to its neighbour nodes and lower the total cost of establishing and developing a new item, the projected transmission hops and counts are built into a tree-based structure [11, 12].

**Integration and Association of MANET and IoT**

Mobile Ad-hoc Network (MANET) and the Internet of Things (IoT) are related fields that share some similarities but also have some key differences.

MANET is a type of wireless network that is composed of mobile nodes that can communicate with each other without the need for a fixed infrastructure. In contrast, IoT is a network of interconnected devices that can communicate with each other and with the internet.

Both MANET and IoT have the potential to be used in a wide range of applications, such as industrial automation, smart cities, and healthcare.

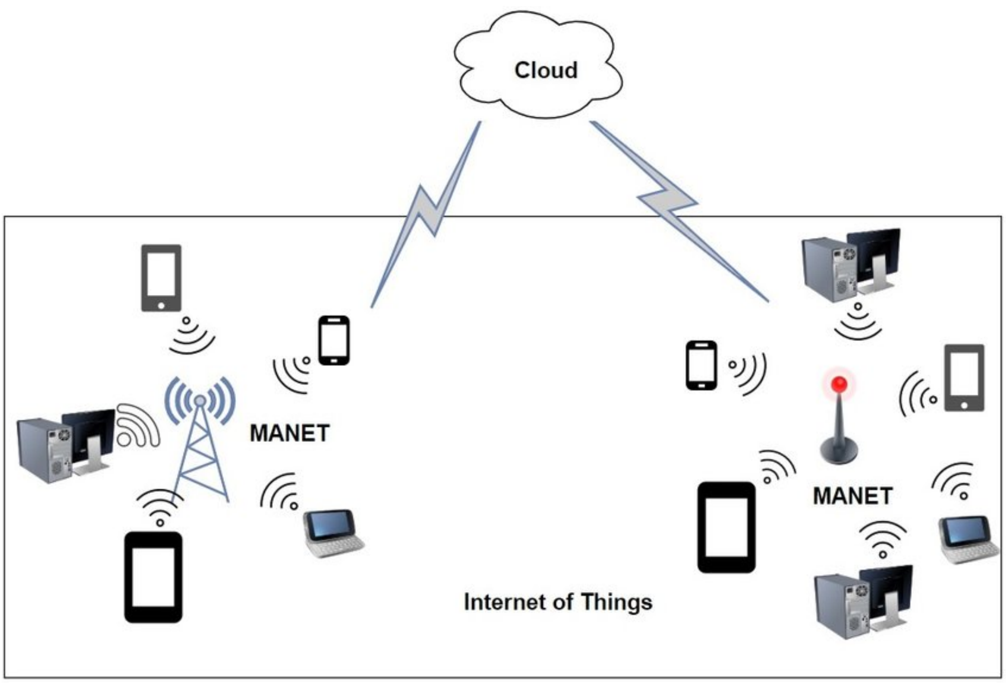


**Figure 2 : Association of IoT and MANET**

One of the key similarities between MANET and IoT is that they both rely on wireless communication. This means that they both face similar challenges, such as limited power resources, security, and scalability.

One of the key differences between MANET and IoT is that MANET is typically composed of mobile nodes that are free to move, whereas IoT devices are often fixed in place. This means that MANET networks must be able to adapt to changes in the network topology, whereas IoT networks do not have this constraint.

Another difference is that IoT devices are often resource-constrained, and therefore must be designed to minimize power consumption. In contrast, MANET nodes are often equipped with more powerful processors and larger batteries, which allows them to handle more complex tasks and communicate over longer distances.

MANETs can be used as the backbone of an IoT system, allowing IoT devices to communicate with each other and with the internet. Additionally, IoT devices can be integrated into MANETs, allowing them to communicate with each other and with the internet while they are mobile.

In summary, both MANET and IoT have their own strengths and weaknesses, and can be used together to build robust and flexible networks that can support a wide range of applications.

**Key Areas of Research in IoT**

There are many areas of research in the Internet of Things (IoT), and new areas are constantly emerging as technology advances. Some of the main areas of research in IoT include:

Connectivity: Research in this area focuses on developing new wireless technologies and protocols that can be used to connect IoT devices, such as 5G, Zigbee, Bluetooth Low Energy (BLE), and LoRaWAN.

Security: Research in this area focuses on developing new security technologies and protocols that can be used to protect IoT devices and networks from cyber-attacks, such as encryption, authentication, and intrusion detection.

Edge computing: Research in this area focuses on developing new architectures and technologies that can be used to process data closer to the source, reducing the amount of data that needs to be sent to the cloud, and reducing the latency of the system.

Power optimization: Research in this area focuses on developing new technologies and techniques that can be used to minimize the power consumption of IoT devices and extend their battery life, such as power-saving modes, alternative power sources, and energy-efficient hardware.

Artificial Intelligence and Machine Learning: Research in this area focuses on developing AI and machine learning algorithms that can be used to optimize the performance of IoT devices and networks, such as predictive maintenance, anomaly detection, and resource allocation.

Human-computer interaction: Research in this area focuses on developing new technologies that can be used to interact with IoT devices in a natural and intuitive way, such as voice recognition, gesture control, and augmented reality.

Blockchain: Research in this area focuses on developing new technologies that can be used to secure and manage data in a decentralized way, such as blockchain.

Internet of Medical Things (IoMT): Research in this area focuses on developing new technologies that can be used to monitor and track health data, such as wearables, telemedicine and remote patient monitoring.

These are just a few examples of the many areas of research in IoT. As the field continues to evolve, new areas of research will emerge, and existing areas will continue to be explored in greater depth.

IoT may be roughly divided into two categories: industrial IoT and commercial IoT platforms. In a world connected by IP networks, industrial IoT connects to IoT devices. IoT devices can only connect with local devices in this scenario since local communication is either wires or wireless (Bluetooth or Ethernet) [13, 14]. Since new networking techniques are being created for the creation of low-cost, low-power wide area networks of tiny intelligent devices, one of the important research endeavours for IoT comprises IoT devices entirely depending upon EH as their primary sources of energy [15]. Applications that concentrate on energy harvesting must complete their duty as quickly as feasible.

There are several wireless networks that are commonly used in the Internet of Things (IoT) and each of them has its own power consumption characteristics. A comparison of power usage between some of the most commonly used wireless networks is given below:

**Table 1 : Evaluation Aspects of Power in Wireless Networks**

| Wireless Network | Power Consumption |
|---|---|
| Zigbee | Low |
| Bluetooth Low Energy (BLE) | Low |
| LoRaWAN | Low |
| WiFi | Medium |
| Cellular (4G/LTE) | High |

Zigbee, BLE and LoRaWAN are low-power networks that are specifically designed for IoT applications. They consume less power than other networks, making them suitable for devices with limited power resources.

WiFi is a medium-power network that is commonly used in IoT applications. It consumes more power than Zigbee or BLE, but it is still suitable for devices with moderate power resources.

Cellular networks such as 4G and LTE are high-power networks that are commonly used in IoT applications. They consume more power than other networks, making them less suitable for devices with limited power resources. They are more suitable for devices that have access to a power source or are able to recharge frequently.

It's important to note that the power consumption of a wireless network also depends on factors such as the data rate, the distance between the devices, and the power management strategies used.

## Need of Power Optimization

Power optimization in wireless networks is important for several reasons:

Battery life: Many IoT devices are battery-powered and rely on wireless networks to communicate. Power optimization can help to extend the battery life of these devices by reducing the power consumption of the wireless network.

Cost-efficiency: Power consumption is a significant cost factor for IoT devices, and the power usage of wireless networks is a major contributor to this cost. 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 of wireless networks 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 wireless networks, promoting energy conservation and reducing the environmental impact of IoT.

Network lifetime: Wireless networks in some cases have limited lifetime because of the power consumption, power optimization can help to increase the lifetime of the network.

Reliability: Wireless networks are affected by the environment and its conditions, power optimization can help to increase the reliability of the network by reducing the power consumption and increasing the lifetime of the devices.

Quality of Service: Power optimization can help to improve the Quality of Service of the network by reducing the power consumption of the devices, this can help to increase the battery life of the devices, and increase the lifetime of the network.

## Approach and Key Methodology

Metaheuristics are a class of optimization algorithms that can be used to find approximate solutions to complex problems, such as power optimization in the Internet of Things (IoT). Here are some examples of metaheuristic approaches that can be used for power optimization in IoT:

Genetic algorithms: Genetic algorithms (GA) are a type of metaheuristic that can be used to optimize the power consumption of IoT devices by simulating the process of natural selection. GA can be used to evolve a population of solutions, with each solution representing a set of power management parameters. The solutions are then evaluated based on their power consumption, and the best solutions are selected for the next generation.

Particle swarm optimization (PSO): PSO is a metaheuristic algorithm that can be used to optimize the power consumption of IoT devices by simulating the behavior of a swarm of particles. Each particle represents a solution, and the particles move through the solution space in search of the optimal solution. The best solutions are then used to update the position of the particles.

Ant colony optimization (ACO): ACO is a metaheuristic algorithm that can be used to optimize the power consumption of IoT devices by simulating the behavior of ants. Ants move through the solution space in search of the optimal solution, and the best solutions are used to update the position of the ants.

Simulated Annealing (SA): SA is a metaheuristic algorithm that can be used to optimize the power consumption of IoT devices by simulating the process of annealing in metallurgy. The algorithm starts with a randomly generated solution and gradually improves it by making small changes to the solution and accepting or rejecting the changes based on a probability function.

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.

## Algorithmic Approach

*1. Activation and Initialization of Nodes IoT[n] =>Sequence of IoT Sensor Nodes {n<requirednodes}*

*2. Initialize Layers[m] =>Layers {m<=Threshold)*

*3. Deployment of IoTMotes with Randomization Aspects {PS[j] =>IoT[n]}=>Layers[m]*

*4. Power Vector[k] Activationand Initialization*

*5. Activate Power Vector[k], L[m] and WSN[n] for recursive operations and measurements.*

*6. Initialize l=random rounds () [Random Rounds Activated]*

*7. for (v=0;v<=l;v++)*
*Calculate MV[WSN[i][j]) Movement and Power Vector*
*End*
*8. Measure Power Vector of Each Node*
*9. Update PV [Power Vector]*
*10. If PV<=Th (Threshold)*
*Activate BS[i] => Base Stations*
*Communication Vector (CV) =>STl[i] => Satellite*
*Recharing*
*Replenish[i]=>TidalWaves[Vector]*
*11. If PV<Required Vector Then go to step7 in Recursive manner*
*12. Generate Vectors of Power Consumed, Power Throughput and related parameters*

**Outcomes**

The nodes also serve as relays to send data to nearby nodes. Since node localisation can be determined simply to produce a higher rate of data collecting and forwarding toward this mobile sink node, this method works well for networks with lower densities [15].

**Table 2 : Performance Outcomes**

| Nodes | Packets Loss : Classical | Packets Loss : Proposed | Power Optimization (Classical) | Power Optimization (Proposed) |
|---|---|---|---|---|
| 15 | 22 | 4 | 30 | 70 |
| 25 | 34 | 6 | 42 | 87 |
| 35 | 23 | 3 | 42 | 74 |
| 45 | 13 | 6 | 12 | 76 |

In wireless sensor networks, communication always occurs from the source nodes to the sink station. Some nodes that are randomly deployed can connect with the base station directly. Some nodes use multi-hop communication, in which the data packet from the source node must pass via relay nodes before being sent to the base station. As a result, the network delay may fluctuate between being very low and excessive [19].

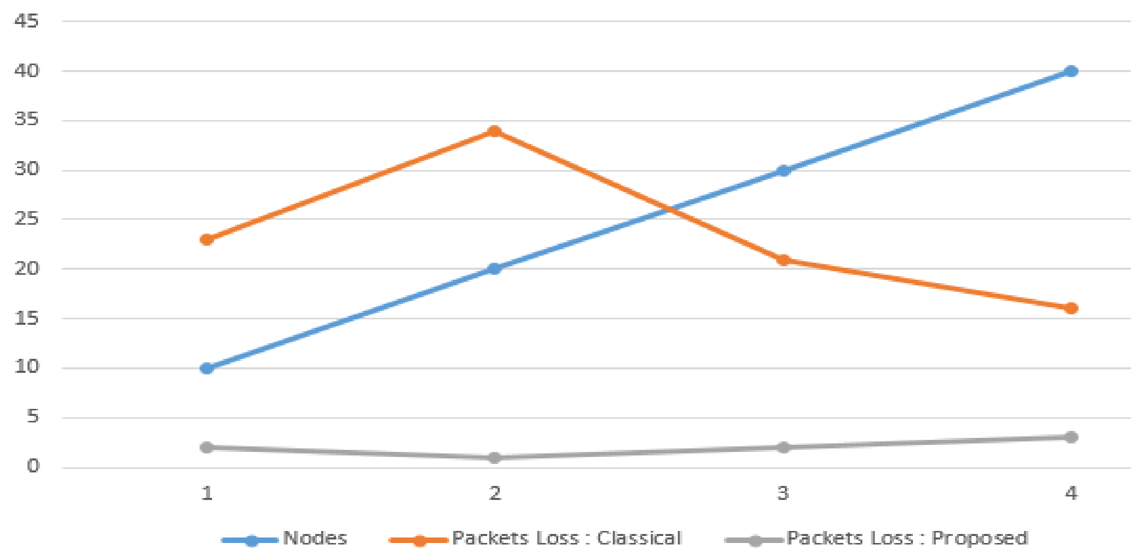


**Figure 2 :Performance Outcomes and Plot**

There are two ways for the sensor nodes to provide data to the sink node when they are situated in a region: To deliver data directly to the main base station, it generally employs the direct connection protocol. This strategy makes the nodes consume more energy, which ultimately leads the nodes to exhaust more quickly if the transmit power between the sensor cell tower and the node is larger.

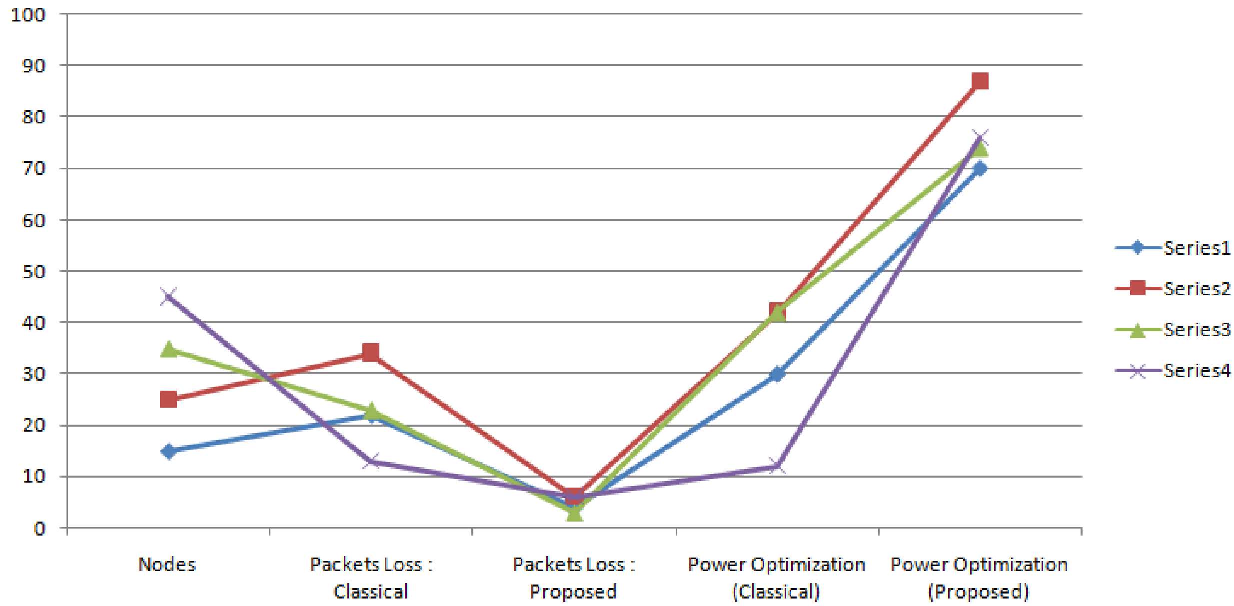


**Figure 3 : Performance Outcomes and Plot**

A connected device's power consumption may rise as a result of widespread data transfer. There are simple methods for removing unnecessary data transfers, nevertheless, without affecting usefulness.

First, keep in mind that embedded radios in IoT devices use considerably more power than their components connected to compute and memory. Therefore, minimising the amount of time the radio is active can reduce a device's power usage.

The use of a wake-up radio might guarantee timely transmission without exhausting a battery, according to research. In that idea, a radio transceiver with a primary radio and a minimal radio that only turns on in response to receiving data is used.

With this method, the gadget may sleep for a longer period of time without suffering performance penalties. It makes it possible for IoT batteries to last years as opposed to months.

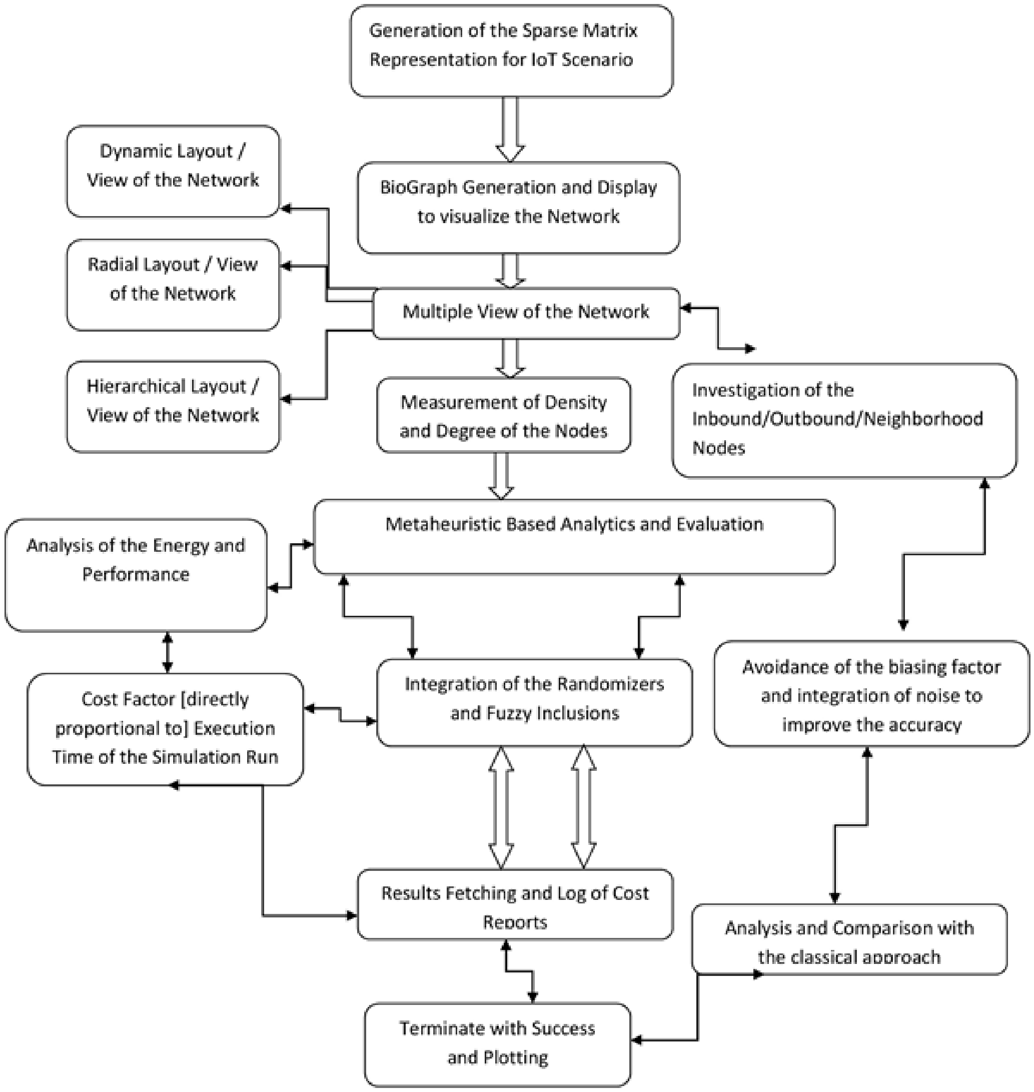


**Figure 4 : Flow of the Projected Approach**

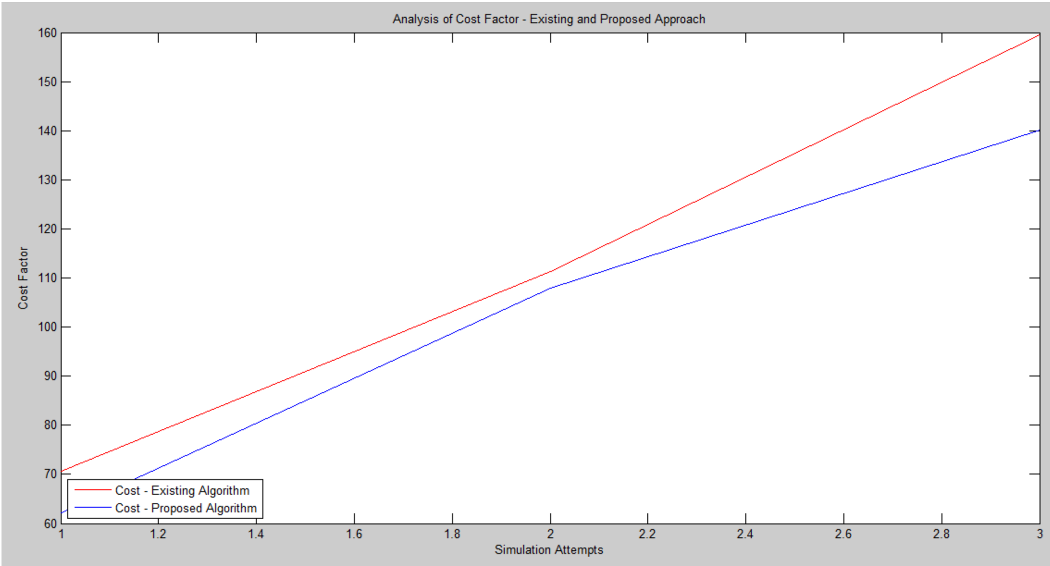


**Figure 5 : Analytics of Cost Factor**

A significant body of research that has provided solid findings has suggested that internet protocols in sensor networks utilise clustering approaches to reduce the energy used during data gathering and aggregation procedures. Longer transmission distances between the node and the sink result in increased energy consumption, which is reduced by the clustering approach [16-18]. Additionally, it shortens the range of connections inside a network's clusters, simplifying duty-cycling processes and giving Cluster Heads responsibility for packet forwarding (CH). Controlling the radio of a sensor node's changing statuses is also necessary to prPVent energy loss and maintain timing between packet delivery and job scheduling.

## Conclusion

The Internet of Things (IoT) can be seen as a necessary component of daily life, with the goal being to shift the focus from the Internet of People to the IoT. IoT is intended to engage a larger population of older, non-interconnected devices to encourage information sharing and cross-layer communication. Future IoT services have been envisioned for industries including healthcare, agriculture, smart cities, transportation, energy conservation, and many more, with the aim of offering major advantages to customers and promoting the long-term sustainability of society.This research project, which intends to concentrate on how to cut energy usage when millions of such devices are connected and communicating in a cost-effective and efficient manner, might therefore be extremely important to society.

According to the methodology of this study, research gaps such as connectivity of current MAC protocols in IoT deployments and optimal performance in the presence of multiple harvesting technologies must be addressed. Such significant findings can significantly lay the long - term strategy for IoT communication systems. The suggested solutions might be anticipated as a hopeful guidance towards possibly useful consequence to the academics and IoT researchers in today's world where living without a mobile phone and the internet can no longer be envisioned.

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