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Dynamic Routing Protocol in The Internet of Things (IoT)

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ABSTRACT

In March 2012, Internet Engineering Task Force adopted IPv6 for lossy and low power networks (RPL) as the standard IoT routing protocol. After then, it found use in a wide variety of IoT settings. Although RPL provides a great deal of what an IoT network requires, it was not initially designed for such uses. Therefore, there are still some significant difficulties. However, massive amounts of data were gathered from these networks, including movies and photographs, which might cause congestion inside the core network region. Our research recommends using a CCR-based RPL, in which the content is the determinant of the routing paths, to address this issue. Suppose the relevant data is sent to the intermediate relaying nodes for processing, which may lead to a higher data aggregation ratio, effectively producing traffic inside the network. As a result, a substantial delay may be avoided. Wireless communication also significantly reduces energy consumption, which is very helpful for conserving the limited battery. CCR and the IETF RPL protocol were integrated and used inside the MATLAB environment. In the end, data from both implementation and simulation show that CCR-based RPL performs better than alternatives regarding the number of dead nodes it can handle, the latency between packets it can tolerate, and the energy efficiency of its transfers.

KEYWORDS: IoT, content centric, Energy, routing protocol, wireless communication.

1 INTRODUCTION

Recently, there has been a rise in the use of distributed computing over wireless networks, especially for IoT-related data transmissions, which are considered an emerging trend where IoT equipment is equipped with processing, storage, and communication capability [1]. Instead of using a pricey (multi-hop) wireless network to send all raw data, typically associated with energy consumption and a high time delay, the primary impression is that a more cost-effective method reduces the amount of data sent by just sending the results of in-network processing. As a result, constrained IoT networks may better use their resources by reducing their energy consumption and data transfer times while increasing their longevity [2]. As a result of the IoT, many different kinds of applications will be impacted, such as home automation [3], intelligent grids [4, 5], drone-based systems [6], healthcare systems [7], and industrial monitoring [8, 9]. To support such innovative IoT applications and allow large-scale connectivity amongst IoT policies, novel wireless technologies are essential. However, combining the IoT ecosystem with present wireless networks leads to numerous challenges, such as self-organizing operations, coexistence with human-type devices, and limited communication resources [7, 10]. Furthermore, IoT tools are usually machine-type tools, differing considerably from usual human-kind devices, such as smartphones, in terms of computation, memory, energy constraints, and traffic patterns [11]. Furthermore, the IoT tools will need low latency, short packets, and ultrareliable transmissions. Hence, the present wireless networks must be replanned to satisfy these IoT problems. We presented a distributed learning method with the RPL protocol (CCR-based RPL protocol) [12] to address this issue for effective data collection in multi-hop IoT networks. Utilizing distributed techniques, limited resources are appropriately allocated in terms of the QoS requirements of the IoT tools.

The IoT tools must have the ability to obtain their communication resources separately since it is not practical to suppose them regularly communicate with the Root node while considering the limitations of their stringent resource. In addition, the root cannot efficiently manage the tools' communication needs in a massive IoT due to a lack of sufficient resources. Hence, it is essential to distribute resources to all assignment locations in the IoT and consider the restricted abilities of the IoT tools based on memory and computation. To distribute resources in a way that accommodates specified requirements, deploying the IoT over the present networks with restricted communication resources will be restricted. In this study, we concentrate on two vital aspects of IoT networks, including transfer rates and energy efficiency within a network with a high and heavy dynamic load. In the present work, a novel OF is suggested for recursively examining the last states of the nodes' chains in the pathway toward the root; however, it avoids passing additional message requests within the network. Moreover, a novel routing metric is provided for responding to the dynamicity requirement in the network. Moreover, we provide a novel method for selecting the parent.

2 IPV6 ROUTING PROTOCOL FOR LOSSY AND LOW-POWER NETWORKS (RPL)

With its foundation in IPv6, RPL is a distance-vector proactive routing system that may be used for unicasting and multicast traffic. In RPL, a tree-like topology results in a directed acyclic graph (DAG) (destination-oriented directed acyclic graph). In this case, a DODAG is implanted at a sink node, also called a root, which acts as a gateway between DAGs and IPv6 networks. The DAG shown in Figure 3 is connected to two DODAGs through a backbone connection at their nodes. The orientation of the arrows in

Figure 1 indicates the preferred parent of each child node. The four prominent instance values in RPL are the case ID, DODAG ID, rank, and DODAG version number. A DODAG topology is kept in place using these four unique values. The 4 case values, in particular, allow for the unique identification of each node in RPL. The DODAGs that provide a functionally equivalent service is isolated using the RPL instance. Connected nodes that share a root all have the standard DODAG ID. When the DODAG structure is modified, the version number is incremented. Nodes in RPL are critical, and their rank is used to show their distance from the root. In particular, the closer a node is to the root, the lower its rank. According to RPL, downhill routes extend outward from the root node to other nodes, whereas upward routes originate at other nodes and go back to the root.

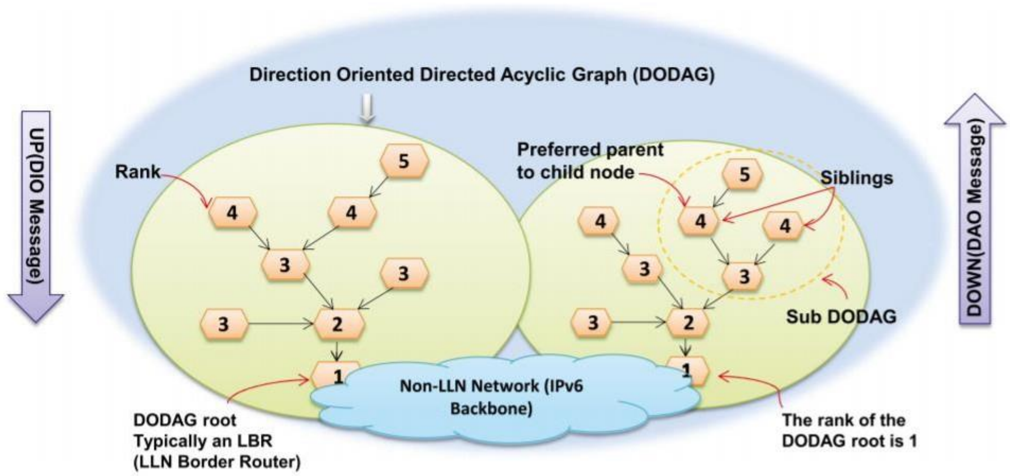

Figure 1: The RPL routing domain architecture

3 RELATED WORKS

Time delay, energy consumption, and load balancing are just a few objective functions (OF) that have been studied concerning adaptive routing on the Internet of Things. However, there is a lack of broad-based research on distributed learning in routing. We present a few studies on context-aware routing below.

Mohamed, Reem E. et al. [13] evaluated the techniques of proactive routing with re-arrangement, which have the lowest energy consumption for a unified network. Fault tolerance, flexibility, overhead during network setup, and data transmission route selection all contribute to WSN's energy efficiency. To have a long existence, the network must be adaptable while keeping overhead to an absolute minimum and using multi-hop routing. Therefore, care must be taken when selecting energy-efficient routing protocols to ensure they meet both the system and application requirements. In this study, we aim to use reactive routing protocols to analyze the lifespan of a network in both homogeneous and heterogeneous environments. Aman, Kumar Yelamarthi, Md Sayedul, and Ahmed Abdelgawad [14] compared the results of their examination into RPL in the Cooja simulator to those found in the existing network and found that the acceptability of the former was higher. In contrast to the Cooja simulation, both sink and client nodes use more power in a practical network. The results showed that in real-world circumstances, PDR was lower and was significantly attenuated by the size and breadth of the underlying network.

On the other hand, there is no participation from asymmetric connections, external wireless, or signal reflection. To this day, this framework is used in a wide variety of publications. Mardani, Mohammad Reza, Salman Mohebi, and Mohammad Ghanbari [15] present a new technique for allocating uplink bandwidth in highly congested 4G networks that support H2H and M2M applications simultaneously. Using interval type-2 fuzzy logic, the algorithm resolved system ambiguities. Each M2M/H2H service flow has a unique optimal bandwidth ratio calculated by an intelligent type-2 fuzzy algorithm. The solution considers M2M/H2H requirements, such as the greatest potential for RT services, the HTC output, and the power level of MTC tools for NRT services, for each kind of flow to arrive at an appropriate bandwidth ratio. The proposed system's latency, throughput, and bandwidth utilization were measured to evaluate its performance.

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Kim, Svetlana, and Yong-Ik Yoon[16] proposed a context-aware framework known as Awareness Cognition (AC), which focuses on the middleware layer of the AMI system. This framework solved the prediction problem by merging multiple contexts to detect personalized knowledge. Moreover, A fusion contextual learning model for discovering behavioral knowledge was developed using knowledge-based cognition methods to discover future changes. In addition, modeling was presented in the AmI system within a single meaningful context to collect data from various sensors.

Huang, Jun, et al.[17] presented two algorithms with restrictions to challenge the IoT's multimedia communication multicast routing issues. Using the entropy method to integrate multiple restrictions into a complete metric, the complication of the multi-constrained multicast routing problem is dramatically reduced by the suggested algorithms, making it possible to apply some famous algorithms for solving the problem. Furthermore, large-scale simulations were run to measure how well the suggested algorithms perform, and theoretical analysis was presented on the approximation and complexity of the algorithms. One of the suggested methods is quicker and more precise than a benchmark multi-constrained multicast routing algorithm, as shown by both simulations and real-world data. The findings provide valuable insight into developing an algorithm for multicast routing in IoT multimedia communication. Rani, Shalli, et al. proposed an enhanced solution. [18] to the problem of organizing objects in implementing a scalable and energy efficient IoT. At first, the framework was given for deploying the IoT with scalability properties, making it more extensible. Then, regarding the framework, deploying an energy efficient IoT is supported by an optimization outline restricted by the loads on energy expenditure and wireless links. Numerical tests proved that the suggested outline is superior to traditional WSN outlines based on time, scalability, and network lifetime. The work includes the challenges of using the advantages of heterogeneity; however, enhancements of end-to-end delay, throughput parameters, data compression methods, and packet delivery ratios are proposed for achieving a more effective green.

Qiu, Tie, et al. [19] introduced the Enhanced Transparent Self-Organizing Protocol (ETSP) for IoT sensor networks. By limiting a tree-based network fast, more energy is saved and the network's lifespan is increased. They also factored in the node's hop, remaining energy, its potential as a sink node was determined by considering its distance from other nodes and the number of its children. That's why ETSP is so useful; it increases the tree's depth. The network's topology is constantly modified during the data transmission method. There will be a reselection of sink nodes on the fly due to the fact that it consumes energy at a higher rate than the rest of the nodes. According to the simulation results, ETSP can provide trustworthy tree-based networks, cut down on energy usage, and increase the lifespan of the sensor networks.

Shen, Jian, et al. [20] proposed a unique EECRP (energy-efficient centroid- based routing protocol) by resolving the forming clusters issue in terms of the distance to the energy centroid. in order to regulate the power consumption of WSN-assisted IoT. In our study propose an improvement approach depending on the ratio of cluster heads to total nodes. The simulation findings show that a large volume of data could be sent via the EECRP with extremely minimal energy dissipation if the BS were placed strategically throughout the network. The EECRP also has a longer network lifespan than LEACH, GEEC, and LEACH-C. Improving the protocol will include finding the multi-hop route from the CH nodes to the BS as part of our future effort. The CH nodes rely on a multi-hop method to transmit data packets. We expect our future protocol to be useful for BS deployments outside of the network.

4 PROBLEM STATEMENT

RPL, mainly planned for lossy and low-power networks, possesses numerous exceptional properties such as loop-freeness, self-healing mechanism, quick topology construction, and low-battery usage. However, because it was designed for low-traffic networks and cannot handle the challenges of high-traffic networks. In cases, high network traffic exists, RPL is not able to control it well making multiple problems for the network including load imbalance, low reserves and a high dropout rate for packets. The issue becomes more disturbing if a node that has been depleted is the sole intermediate node for a significant chunk of the network close to the hub. Specifically, we divide RPL issues that arise during extreme and prolonged periods of dynamic loading as:

1) By computing the rank via OF (Objective Function) as MRHOF and OF0 in normal RPL, numerous investigations are performed to change function objectives for RPL based on previous research. However, as we know, the standard RPL OFs and other provided OFs do not consider the former parents of a node in the sequence. A node may appear to be appropriate for being a parent, however, it is possible that the node's parent, or another parent in the parent sequence, has insufficient buffer space or running power. This leads to the inappropriate parent choosing in a high traffic network.

2) The route creation is performed in terms of the Rank. When a node tries to connect the network or alter its parent, it selects the network possessing smaller rank value. However, In the early stages of entering a network, the parent's rank is determined, numerous inconveniences may exist in the pathway toward the route followed by computing the rank. Hence, the rank value may not be a reliable indicator of the true and most recent mode of the potential parents in a network with a lot of fluctuating traffic.

5 METHODOLOGY

Any newly-joined node in a DODAG graph that receives a DIO message may do one of three things with it.

1) Due to RPL requirements, the DIO package is being removed.
2) Message processing for the purpose of network location maintenance
3) Getting a lower DODAG ranking will help its visibility.

When a node drops in status, it must unlink itself from any of its parents that are ranked lower than it is now. It does this to stop a network loop from forming. At this point, once a connection is established, data packages may be sent from any node to the root.

The current simulation result will show that the CCR-based RPL routing approach is very effective in recognizing and aggregating data in an IOT network. So far, by employing the content-Based RPL approach is compared to traditional RPL method in terms of data aggregation speed, number of active nodes, data accuracy, power consumption, and network equilibrium. Tabulated in Table 1 below are details about the simulation used in this study:

Table.1 Characteristics of the simulated network

Parameter	**Value**
Area of the network	$800m \times 800m$
Node numbers	50
Node velocity	0
Transfer range	100 m

Load size	512 Bytes
Rate of packet transfer	25 KB
Rate of data aggregation	0.0011 μJ
Consumption of data reception energy	8.22 μJ
Consumption of data transfer energy	9.72 μJ
Simulation numbers	20

Like the characteristics presented in table 1, the simulation is completed and the routing of the nodes in the network is observed.

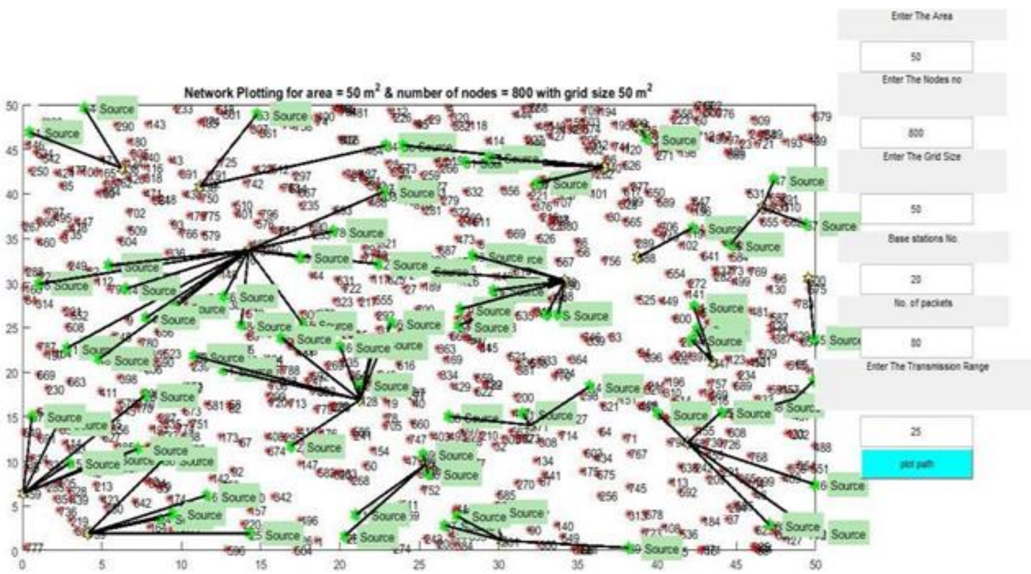

Figure 2: routing the topology of the network

In this research, we describe a content-based method for improving IOT network routing efficiency. To determine how many packages have reached the root, each node in this system employs root-inquiry packets to identify its parents. Then, it takes this knowledge and uses it to determine how confident it is in the parent-provided path. A high degree of certainty and malignancy in the parent

when the considered node's trust in its parent's computation is low, it picks a parent from its pool of possibilities who has the highest degree of confidence. Each node may then more easily avoid the cancerous ones using this strategy. In order to increase the data collection ratio, it is possible to route the data associated with intermediate relay node in order to process. As a result, it is able to significantly lessen the load on the network. This means that it may be possible to significantly speed up the data transport. Battery life may be prolonged by eliminating unnecessary data transfers after data gathering. This results in less power being used for wireless communications overall.

This method has three main units:

1) Data collection unit: By regularly delivering root-inquiry packages, this node learns how many data packets have successfully reached the root.

2) Confidence level calculation unit: The confidence in the parent-provided route is determined with the use of data gathered by the unit below, using the formula:

$$\begin{array}{ll} T(p) = 1 - \dfrac{pk\ sent_{ij} - pk\ delivered_{ij}}{pk\ sent_{ij}} & if\ pkrecieved = pk_{delivered} \\ T(c) = T(c) - 0.01 & else \end{array} \quad (1)$$

3) Parent selection unit: this unit selects a parent having a higher confidence level among the candidate parents as the selected parent.

6 ASSESSMENT

In our research, we simulated CCR-based RPL using the widely-used MATLAB Simulator to determine the efficacy of our protocol in the Internet of Things. In this section, we evaluate CCR-RPL in contrast to standard RPL. We modify the protocol factors using the CCR-based RPL ones, with MRHOF serving as the OF of Ordinary RPL (Table 1). In our setting, there are 800 nodes with 20 Base Station, deployed in a 50m × 50m area. The transmission range is 25m, and the Base Station acts as the root.. Within this setting, we disabled duty cycling to reach a high load within the network and utilized the FIFO line with a volume of 80 packets. Parameters for the simulation seen in Figure 2 are listed in Table 1. Moreover, numerous traffic rates and nodes are taken into account to assess our protocol under various circumstances. In the beginning, we will evaluate each system based on their queue loss ratio. In Fig. 3, we see two procedures in action under varying traffic loads (increasing). According to the findings, the CCR-based RPL successfully increases the network's total number of active nodes. Figure 3 also shows the worst-case queue loss percentage inside the nodes under different traffic loads, which is an important feature. This is seen as evidence of CCR-based RPL's capacity to construct a more uniformly loaded DODAG throughout the network.

After applying the simulation, the below results are presented:

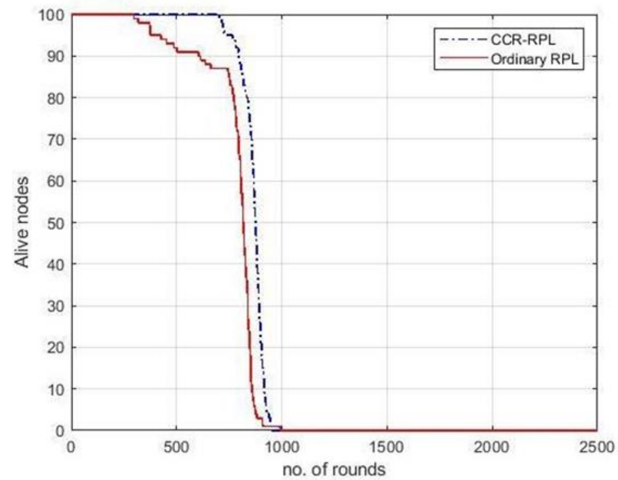

Figure 3: Comparison between the number of the live nodes after sending and receiving the data

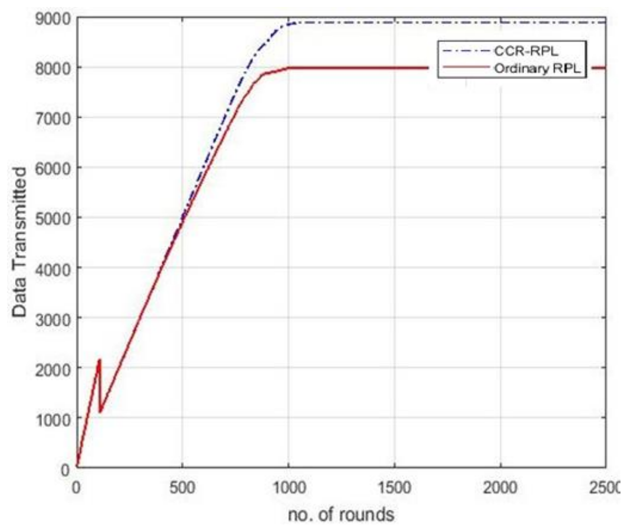

Figure 4: Comparison between the rates of transferred packages

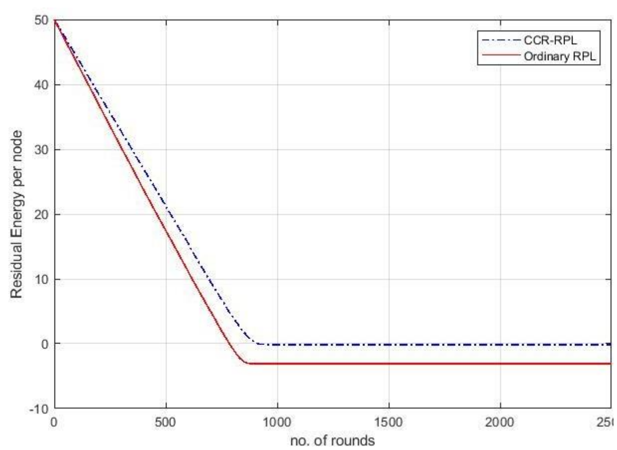

Figure 5: Comparison between the rates of the remaining energy

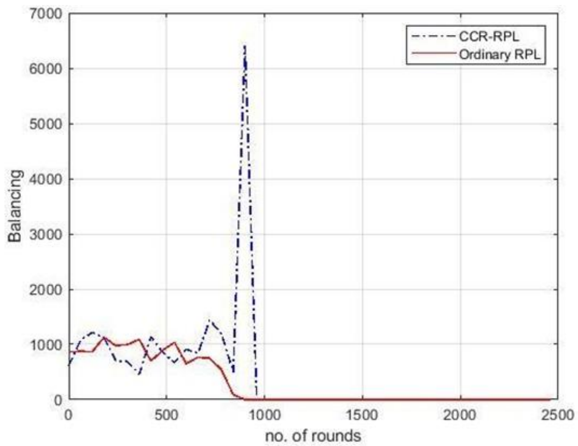

Figure 6: Comparison between the balances dominating on the system

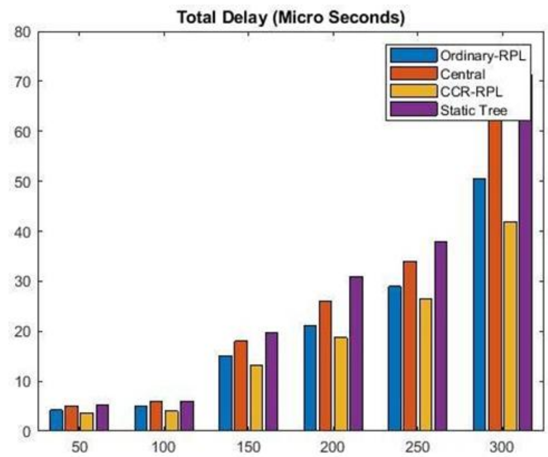

Figure 7: The delay rates in transferring the packages by the simulation result with respect to node changes.

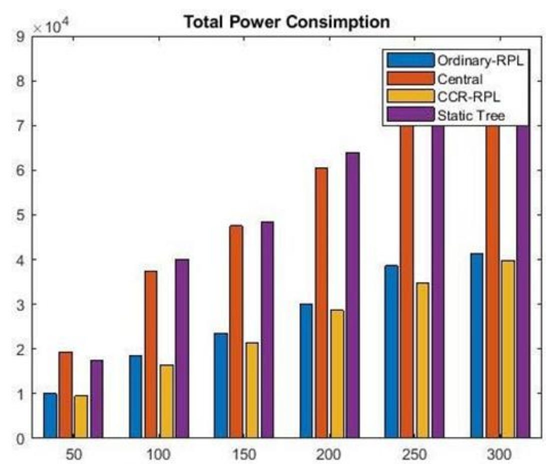

Figure 8: Power consumption during package transmission compared at different rates by the simulation result with respect to node changes.

As it was observed in figures 3-8, the CCR-RPL method has a higher proficiency than the ordinary RPL method in reduction of energy consumption and increase of system efficiency. Therefore, as a result of a decrease in the percentage of inactive nodes, the system's overall power and efficiency improve while its carbon footprint shrinks.

7 CONCLUSION

This research focuses on the difficulties of the RPL routing protocol while operating under fluctuating and large loads, with an emphasis on conserving energy and maximizing the network's lifespan. We discovered that conventional RPL fails to manage the varying and demanding workloads adequately. We presented a mechanism that considers a node's context and loads before choosing the parent at the end of the parent-rank chain. As a result, we tried to ensure that the network was manageable. We considered the residual queue and prospective parents' energy levels for this study. Furthermore, we slowed the issue of hastily racing to a suitable parent, which was causing a high rate of control messages and network instability. We tested our protocol in MATLAB under various conditions, and the results show that CCR-RPL provides much superior performance over RPL without imposing an excessive strain on the network.

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