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Internet of Things Applications: Routing Protocols for Low Power and Lossy Networks

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Abstract: Many scholars are interested in the development of the Internet of Things (IoT) and its applications. The 6LoWPAN stack was suggested by the Internet Engineering Task Force (IETF) in an attempt to enable IPv6 and promote interoperability for IoT devices. However, the unique characteristics and hardware constraints of networks connected to IoT devices provide a number of difficulties, particularly for routing protocols. The RPL (IPv6 Routing Protocol for Low-Power and Lossy Networks) is standardised by the IETF as the routing protocol for Low-power and Lossy Networks (LLNs). The proactive routing protocol RPL builds acyclic networks between the nodes to enable data transfer. Various recent research have shown its limits and shortcomings, despite the fact that it is frequently recognised and used by contemporary applications. Weak support for mobility and P2P traffic, limitations on multicast transmissions, and poor dynamic throughput adaptation are only a few of them. Numerous novel solutions have evolved in recent years as a result of the challenges that have been raised. The strategies vary from taking into account various routing parameters to developing a brand-new technique that was motivated by previous routing protocols. This paper attempts to give a thorough survey research of routing options for IoT/LLN, not only RPL improvements, in this context. The routing needs of LLNs, the original protocols, and the most current techniques are all discussed throughout the study. The IoT routing improvements are broken down into sections based on their primary goals, and each section is then examined separately to highlight its most significant advantages and disadvantages. Additionally, as the primary contribution, this research offers a thorough analysis of the methodologies taken into consideration, highlighting any unresolved problems and outlining potential future paths that may be addressed by fresh ideas.

Keywords: Internet of Things; low-power and lossy network; LOADng; routing protocol; RPL

1. INTRODUCTION

Wireless communication systems have attracted a lot of interest recently from a variety of businesses in order to facilitate quick decision-making. Wireless communication systems have proven crucial for surveillance, monitoring, and control, healthcare, wildlife monitoring, and defence systems, among other things. In actuality, these applications need Quality of Service (QoS) supply regardless of network circumstances and topological limitations. This has inspired academics and industry to create more effective and reliable communication paradigms in order to fulfil these rapidly increasing needs. Wireless Sensor Networks (WSNs), one of the main communication technologies, have drawn interest because of its decentralised, affordable, and infrastructure-free operating style.

However, WSNs are the most frequently used wireless communications method to fulfill the previously specified purpose or application. However, increasing network complexity as well as resource-constrained QoS requirements, and problems with networks, etc. have sparked the interest of researchers to develop specific routing protocols that are more efficient. Furthermore, as a network that is energy-constrained, WSN requires efficient energy-efficient routing. However the rise of Internet of Things (IoTs) and the corresponding Low Power Lossy Network (LLN) demands have stimulated academia and industries to create routing protocols that have minimal latency, minimal energy consumption, and greater throughput , while ensuring fault-proof communication. The demand for QoS has been mapped across the horizon of application. In such situations, using traditional WSN protocols using IEEE 802.15.4 standard may not be best solution and thus requires upgrading in terms of resource-efficient routing and also QoS-centric routing decisions.

In the case of major Mission Critical Communications (MCC) as is the norm in modern LLN's applications in order to ensure QoS delivery, data needs to be transmitted with minimal delay, with the least chance of transmission retransmission, secure link formation, and no packet loss. However, the their dynamic nature and their network conditions usually result in link-outages that ultimately force Retransmission. This reduces the life of the network, resulting in increased energy loss and delay and reduces efficiency. The possibility of such a violation isn't likely in today's MCC communications requirements.

To find the best solution attempts have been made for a long time, but the increasing complexity of networks usually requires researchers to come up with a more efficient solutions. When considering IoT machine-to-machine (M2M) communication, which requires an event-driven, scalable, and real-time communications The main focus is placed on creating an efficient routing system that minimizes the data loss, latency as well as other issues. To accomplish this, many efforts have been put into. But the idea of fault-tolerant communication in dynamic network conditions has been investigated in a couple of. Particularly, when the network is constrained, dynamic topology M2M communication , especially in the case of mobility, suffers from failures by immature link-outage, energy loss, node death or other reasons.

2. REVIEW OF LITERATURE

Numerous research projects have been carried out on adaptive routing of IoT and objective functions such as energy consumption, load balancing as well as time-delay. There is very few studies that focus regarding distributed-learning in the routing. A few studies on the use of context information in routing are discussed here.

Mohamed et al. [5] investigated the proactive routing protocols that have the highest efficiency in energy consumption for an unidirectional system. It is believed that the Wireless Sensor Network (WSN) energy efficiency is a result of three essential elements that include network overhead in arrangements and re-arrangements, selecting the best path for data transmission and resilience or fault tolerance of the network. To ensure a greater duration of the network, it's essential to have a flexible network. In addition, the overhead needs to be kept to a minimal amount and multi-hop routing should be employed. So, selecting the energy-efficient routing protocols should be made with care, based on the needs of the application and the requirements of the system. This paper attempts to tackle the analysis of the lifetime of networks for reactive routing protocols of heterogeneous as well as homogeneous systems.

Aman et al. [15] compared the results of real networks to determine the RPL acceptance in Cooja's simulator. The Cooja simulation calculations showed a higher energy consumption for both the client and sink nodes in real networks. In actual scenarios, the packet delivery rate (PDR), was lower and is significantly affected by network size and distance. External wireless interference, signal reflection and asymmetric links do not cause interference. This model has been extensively used in many other works.

Mardani and colleagues presented a new algorithm for assigning uplink bandwidth. Mardani et al. [9] developed a new uplink bandwidth assignment algorithm for dense 4G networks that provide high-speed human-to-human (H2H), and machine-tomachine(M2M) services in co-existing environments. For system ambiguities, the algorithm used interval type-2 fuzzy logic. The intelligent type-2 fuzzy algorithm determines the optimal bandwidth ratio for each M2M/H2H service flow. The M2M/H2H requirements were used to determine the optimal bandwidth ratio for each type of flow. This included the output of the Human Type Communication (HTC), the power level for Machine Type Communications (MTC), and the maximum potential for real time services. The system's performance was evaluated based on throughput and bandwidth utilization.

III PROPOSED SYSTEM

This section explains the multicast routing protocol. It was specifically designed for RPL routing purposes. These are some of the key design principles and their implementation:

A node is connected to a Destination Oriented Directed Acyclic Graph. If a DODAG Information Object message (DIO) is received by it the node can process the message in the following ways.

1) Removing DIO packages to meet RPL criteria.

2) Processing the message to keep it in the network

3) Improving the location of the organization by gaining a lower rank within DODAG.

When a node's rank drops, it must remove from its parents list those parents whose ranks are lower than its new rank. As a result, the network's loop development is stopped. the the the the, the, the, the, the, the, the, the, the, the, the, the, the, the, the, the, the The simulation findings show that the CCR-based RPL routing technique performs well at data aggregation and recognition in IOT networks. In this part, we compare the number of active nodes, energy use, network balance, and accurate data transfers with those in the traditional RPL method utilising the content-based RPL technique in the direction of data aggregation rate.

In this study, we introduced a content-based solution for improving the routing effectiveness in IOT networks. In the system as it is now implemented, each node makes use of the root-inquiry packages to identify the parent nodes and keep track of the amount of packages that are arriving at the root. The degree of confidence for the route that the parent gives is computed using this knowledge. The relevant node selects a parent with a greater confidence level among the prospective parents in circumstances when the parent has cancer and when the degree of confidence for parent node computation is lower. Each node effectively prevents cancerous nodes using this technique. By routing the data from the intermediate relay node in the processing sequence, it is possible to increase the data collection ratio. As a result, it helps lower the rate of network traffic. As a result, the amount of time the data transmission takes might be greatly decreased. Additionally, we may stop data transfers after data collection, which will reduce the energy used for wireless connections and save battery power.

TABLE 1. Properties of the simulation employed in our work.

Parameter	Value
Network-area	750m-×-750m
number-of-nodes	60
Velocity-of-Node	0
Transfer-range-	100
Load-size	512
Packet-transfer-rate	30
Data-aggregation-rate	0.004
Data-reception-energy-consumption	8.99
Data-transfer-energy-consumption	10.25
Simulation numbers	25

IV. EVALUATION

The CCRbased RPL was simulated using the MATLAB simulator, which is often used for IoT, to evaluate the protocol suggested in our study. The CCR-RPL was then contrasted with traditional RPL. The protocol factors were altered based on the CCR-based RPL factors, and MRHOF was changed to be OF of standard RPL (Table 1). In our environment, there are 800 nodes with 20 BS that were created in a 50m by 50m space. The transmission range is 25m, with the BS acting as the root. Duty cycling was turned off in this configuration due to the high network traffic, and an 80 packet per second first-in-first-out (FIFO) line was used. Figure 2 and Table 1 show the simulation environment and the simulation settings. Additionally, varied traffic rates and nodes are taken into account while evaluating the protocol suggested in our study under various circumstances. The following outcomes were attained as a consequence of the simulation:

Figures 1-4 show that the CCR-RPL strategy performs better than the standard RPL approach in improving system efficiency and cutting energy use. As a result, it boosts the system's power and efficiency while decreasing the number of dead nodes and energy consumption.

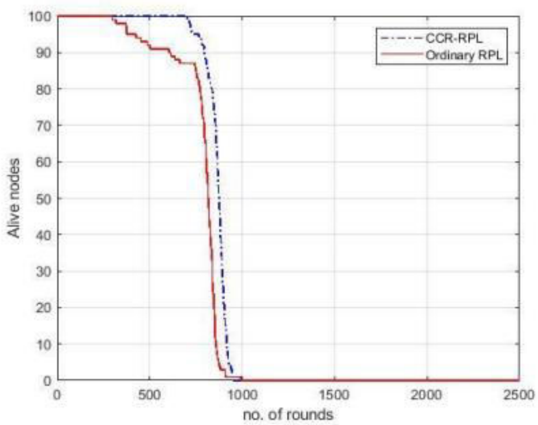

Figure 1. evaluating the quantity of active nodes

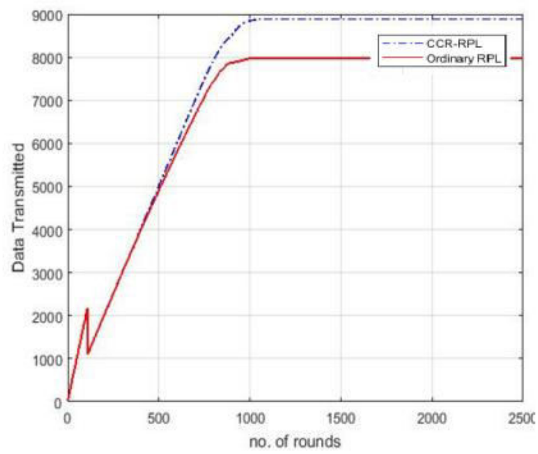

Figure 2. evaluating the transfer rates for packages

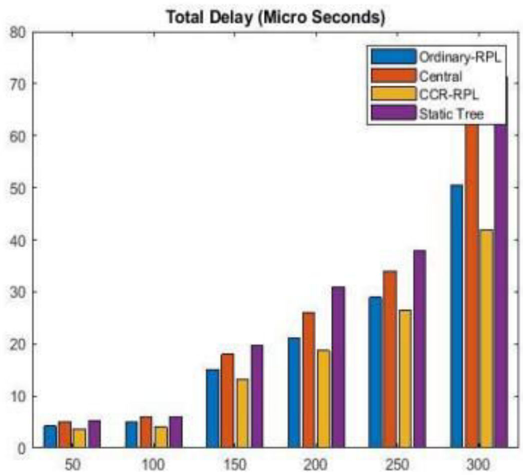

Figure 3. The frequency of package transmission delays

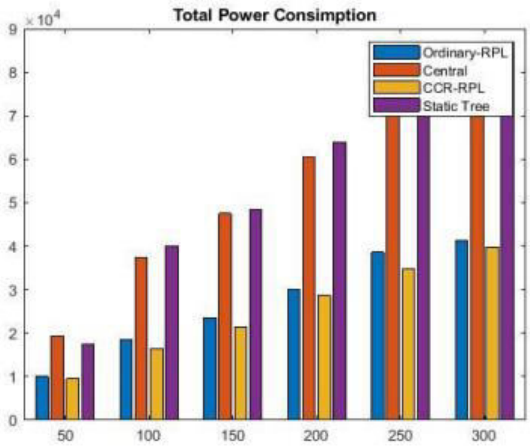

Figure 4. comparing the amounts of energy used

V CONCLUSION

The current effort focused on the network lifespan and energy and solved difficulties with the RPL routing protocol under severe and dynamic load. An conventional RPL was shown to be unable of effectively controlling large and dynamic loads. The suggested load-balancing and context-aware protocol takes into account the parent-chain rank before selecting the chain's ultimate parent as the node's preferred parent in order to address this problem. As a result, the network sought to balance the load. The potential parents' remaining queue and level of energy were taken into consideration in the current investigation. Furthermore, a proper parent's rush was stopped, causing network instability issues and a high control message rate. In MATLAB/PYTHON, our suggested methodology was evaluated under various circumstances. It has been shown that CCR-RPL performs noticeably better than RPL while without imposing a major network overload.

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