Performance Analysis of Energy-Efficient Distributed Relay Selection Method in WSN for Internet of Things

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Abstract: The growing Internet of Things (IoT) is increasing wireless sensor networks (WSN) for different applications. Energy efficiency and reliability are key factors for the source of multiple jump access to flow. A relay node sends data from other nodes to the receiver, so it consumes more power. When the relay runs out of battery, it may cause a network failure in IoT WSN. A retransmission selection in multi-hop transmission can play an important role in increasing network lifetime. A stable WSN is the fundamental requirement for IoT data collection in multi-hop networks from the origin to the receiver. In this paper, an energy-efficient distributed relay (EDRS) selection technique for multi-hop WSN is analyzed using well known simulation tool, NS-2. The performance analysis of EDRS method is done on behalf of parameters like total energy consumption, packet delivery ratio and throughput.

***Index Terms* - IoT, Energy strategy; Relay node; Network lifetime; Power allocation; Stability; Reliability.**

I. Introduction

Al The main concept of IoT is to interconnect digital devices, objects, people and physical entities, which have a unique identifier and have the ability to transmit data via a network without human interaction [1, 2] . IoT does not target a specific technology or application, it is a broader area that can be used for a variety of applications. Recently, IoT has received a lot of healthcare, education and intelligent detection, where smart objects interact with wireless sensors and collect data. IoT has evolved from wireless technologies, which can be used to automate different features. In today's modern world, human beings rely on digital devices because people have limited time, focus and precision [3]. Therefore, obtaining meaningful and reliable information is a difficult task. Automating basic functionality and collecting data without user intervention can reduce costs and improve system performance. This would help when parts need to be repaired, replaced or removed. With the emergence of new technologies, it is easy to design new devices that can be integrated into IoT using WSN. This provides a possibility of installing cost-effective and smart systems in towns and villages to solve common problems.

Because IoT is a relatively new concept, many companies and employees in the industry are not familiar with and are still investigating. This limited information could cause fear, or as in the earlier example, to completely ignore the possible security and privacy issues related to their IoT distribution [4]. This is why many companies want to learn more about the possible threats, advantages, disadvantages and security related solutions along with IoT. In addition, they need to know what information security skills are needed to achieve cost-effective security along with their IoT implementation. This knowledge and expertise should help facilitate the transition from a non-IoT company to an IoT company, as it will allow employees and management to understand and address their concerns and concerns in terms of investments and the resulting security risks. In this way, managers can perform a balanced risk-benefit analysis of the IoT adoption for an application or a family of specific applications.

The IoT concept includes all kinds of different technologies and all the possible forms of communication between objects (virtual or physical) through the Internet. The breadth of this concept makes it rather complex due to the heterogeneity of the components. Because each type of device can use its specific hardware and software, it is necessary to consider a wide variety of operating systems and applications. In some cases, the device may not even have an operating system, for example, there are devices that only have a network interface, a controller, and an application that generates (or sinks) data.

Devices from different providers often speak different protocols. In some cases, these protocols are proprietary, therefore, unknown to the public. Experience has taught us that safe protocols require peer review to provide a solid assessment and, therefore, attract broad acceptance and use [5].

In short, the problem lies in how to identify, authenticate, communicate and transfer data; at the same time protecting the privacy and integrity of the individual and the company by ensuring the "things" and their data used in the process.

A very critical challenge for the future IoT network is the expansion of an appropriate architecture, services and communication protocols. It can effectively reduce battery consumption and, as a result, increase the life and stability of the network for IoT devices. Energy efficient routing protocols [6, 7, 8 and 9] can save energy. If the transmission between the source and the destination could be divided into a smaller number of jumps, the total transmitted power would be reduced as the wireless power increases with distance. Controlled transmission power [10], used for communication, affects the lifespan of devices in many different ways. The reduction of the transmitted power may not significantly affect the operating life of the devices, where the transmitted power only counts for a lower percentage of the total power used. On the other hand, for small computing devices with built-in radio or connected with a reduced transmission power [11, 12], it is possible to significantly extend the useful life of a network or device, thus, to improve the overall user experience.

The overview of internet of things (IoT) is shown in Figure 1. With the analysis of the IoT architecture and its main components, various literature tools were selected publicly available in wireless sensors networks as in IoT. A total of twenty-one instruments have been selected. After the initial analysis, only seven of the tools have been identified as useful tools to simulate different aspects of the IoT application.

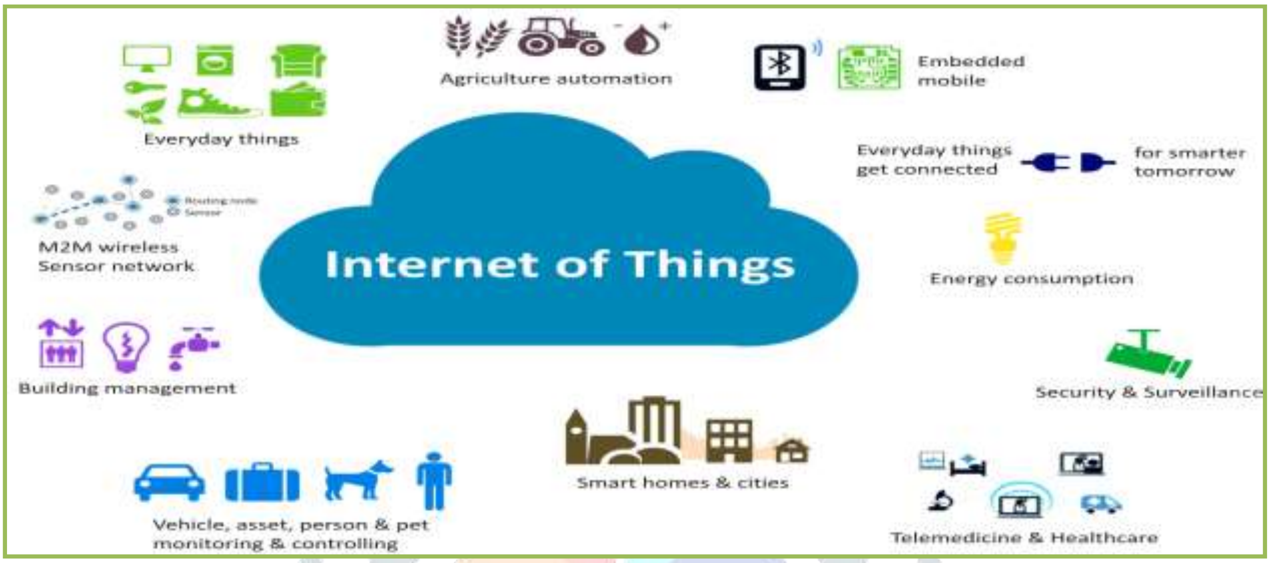

Figure 1: Internet of Things

The rest of the paper is planned as follows. Section 2 provides theoretical detail about related work. Section 3 gives complete detail about the EDRS Method. Analysis & Results are presented in Section 4. Finally, Section 5 concludes with future directions.

II. RELATED WORK

T Mohamed Riduan Abid; Rachid Lghoul; Driss Benhaddou - presented the architecture of a real test bank for smart micro-networks to be distributed on a university campus. They highlighted their main components with an emphasis on the ICT component. They presented that SG will use the Internet of Things (IoT) to get all kinds of data and, in this way, bring the whole system into the Big Data field. To manage the large amount of data that will be collected, they recommended the implementation of a private local cloud using an open source platform for High Performance Computing (HPC) along with Hadoop / MapReduce as an underlying model of data storage and processing. They considered that this project is an ideal model that can be easily adopted for similar test beds of the intelligent micro network in the real world in Africa and in the world. [13]

Andrea Zanella; Nicola Bui; Angelo Castellani; Lorenzo Vangelista; Michele Zorzi - specifically focused on urban IoT systems which, despite being a fairly large category, are characterized by their specific application domain. Urban IoT, in fact, is designed to support the vision of Smart City, which aims to exploit the most advanced communication technologies to support value-added services for city administration and citizens. Therefore, this document provides a complete overview of enabling technologies, protocols and architecture for an urban IoT. In addition, the document will present and discuss the technical solutions and best practices adopted in the Smart City project in Padua, a proof-of-concept demonstration of an IoT island in the city of Padua, realized in collaboration with the city council. . [14]

John A. Stankovic, many technical communities are actively looking for research topics that contribute to the Internet of Things (IoT). Nowadays, when the detection, action, communication and control become even more sophisticated and omnipresent, there is a significant overlap in these communities, sometimes from slightly different perspectives. Greater cooperation between communities is encouraged. To provide a basis for the discussion of open research problems in the IoT, a vision of how the IoT could change the world in the distant future is presented for the first time. Then, eight key search topics are listed and search problems are discussed within these topics. [15]

Wu He; Gongjun Yan; Li Da Xu, introduced an innovative multilayer data platform for vehicles through the use of cloud computing and IoT technologies. There are also two innovative services offered in the vehicle data cloud, an intelligent cloud parking service and a data mining cloud service for vehicle assurance analysis in the IoT environment. Two modified mining models are presented in detail for the vehicle data mining cloud service, a Naïve Bayes model and a logistic regression model. Challenges and instructions for future work are also provided. [16]

Muhammad Abrar; Rooha Masroor; Ifra Masroor; Asif Hussain: in research work, a device is installed between users of mobile phones and devices that will act as gateways between the two. To communicate, the devices must overcome different quality limits of service and system conditions. We have proposed a bidirectional approach. The first devices must become candidates for re-use by the mobile user, so the optimal resource allocation method will be used. In the optimal resource allocation method, the maximum bipartite coincidence graph theory is used. The results of the simulation showed the validity of the system. [17]

Prianka Agrawal; Gaurav Chitranshi - presented the Web server design using the ATmega328 based Internet and the W5100 Shield Shield Ethernet Ethernet chip with some I / O devices. To create an HTML Web page for which a server-side IP address is required. enter your browser as an Internet browser, Firefox and Google Chrome on the client side. The input / output devices are LM35 temperature sensors, rain sensor, BMP180 pressure. The conditions of temperature, pressure, altitude and precipitation are controlled and a system is developed and tested in which, in emergency situations, different devices are controlled in real time. [18]

Reeta Koshy; Nemil Shah; Madhuri Dhodi; Anand Desai - The communicative gap between teachers and students is one of the predominant factors for students' lower grades. There are cases in which students are unaware of the allocation periods and tests that lead to degrading scores. To fill this gap, the Internet of Things (IOT) can be used to provide academic information about students. This feature would help achieve the goal of a verbal zero communication between the student and the teacher. The teacher can load tasks and deadlines that will be retrieved from the mobile phone when the student enters the range of the device. To achieve this, they used Beacon technology, which allows mobile applications to listen to beacon signals in the physical world and react accordingly. The strategic and creative implementation of location-based technology has great potential to reduce the hassles a student faces. They aim to use IOT in the field of education to reduce communication barriers in the student-teacher relationship. [19]

Adi Candra Swastika; Pramudita yield; Rifqy Hakimi - proposed the design of an intelligent network system based on IoT for the smart home. The architecture of the proposed protocols to be used, the functioning of the system and the challenge in the design of the system are analyzed in such a way that the proposed design can improve the optimization of the Smart system itself. [20]

Sheikh Tahir Bakhsh is proposed, an energy-efficient distributed retransmission selection (EDRS) technique for multi-use WSN networks. Power consumption is reduced by selecting a stable relay and a power assignment for collaboration. In addition, the EDRS proposal selects a relay node with optimal power levels to extend the life of the network. The results of the simulation show that EDRS reduces energy consumption and increases the useful life of the network. [21]

Rahman et al. [22] have exhibited the vitality effective crisscross steering convention for WSN. In this investigation creator has gone through the issues of sensor hubs i.e. constrained power and built up a steering convention to improve the vitality utilization.

An exploration consideration was completed by ***Li et al***. [23] on security systems for WSN. The creator has comprehensively clarified the different steering conventions and basically centered around the SPIN steering convention. Creator has thought about the each steering convention by playing out the recreation over NS2 Simulator and through examination reasoned that the SPIN calculation is secure what's more, keeps up greater secrecy.

The consolidated investigation of ***Tarabovs and Zagursky*** [24] gave the effective correspondence reason medium access convention for grouped WSN. In WSN, the asset designation and vitality effectiveness is the testing issues as its SN have low power battery. Thus creator has displayed the bunch based MAC convention for WSN to bring productivity.

The low power versatile RP for WSN is displayed in ***Ji et al.*** [25]. To bring the vitality proficiency and resolve, the information conglomeration issue creator has exhibited the versatile steering calculation for grouping. In this grouping, head was chosen in view of hub thickness in the estimating region. The consequences of versatile steering calculation are contrasted and LEECH calculation and presumed that the calculation brings vitality enhancement and enhanced correspondence quality in conveyance circumstance.

Crafted by ***Hu and Li*** [26] introduced the geology locale based bunching calculation in WSN. In this, the each district picks its individual bunch head. To decrease the vitality use what's more, appropriate asset designation, multi-jump and single bounce blend is utilized. The recreation consequence of the geographic locale calculation fulfills the above necessity.

An instrument of load adjusts in WSN utilizing compressive detecting is depicted in ***Cao and Yu*** [27]. In this work the vitality utilization of SNs is considered. The heap is adjusted by utilizing compressive detecting, and the execution is assessed by Tiny OS and reproduction comes about speak to the critical outcomes.

The multipath steering for group tree WSN (ZigBee) was presented in ***Bidai et al***. [28]. The examination is additionally worried about effectiveness, throughput and information transmission at low and high information rates.

Thaskani et al. [29] have presented a cross-layer plan convention for WSN to bring the vitality effectiveness utilizing token passing component. To beat the issues of conventional vitality productive WSN technique, the outline, and improvement layer of WSN is exhibited. The component gives effective comes about than some other directing components.

Othman et al. [30] have actualized the self stabilizing calculation to limit the vitality use in WSN. In this, the guess calculation is introduced to construct the spine for a sensor that brings the productive directing. The creator has accomplished the productivity in their strategy by reenactment comes about.

Keeping in mind the end goal to adjust the heap in WSN, a multipath steering convention is displayed in ***Ming-hao et al.*** [31]. A heap adjust calculation is intended to adjust the system over the built up ways. The information parcels are conveyed over additional number of SNs and help in vitality improvement. The reenactment is performed and contrasted the outcomes and a different steering convention. The system brings the vitality enhancement in WSN.

For the uneven hub sending of WSN, a bunching steering calculation is exhibited in ***Gu et al***. [32]. In this, the detecting zone was isolated as different hubs and concentric annuli which are dispersed over uneven territory. The strategy results with better load adjusting system and vitality streamlining. The summary of the survey is given in table 1.

Table 1: Comparison of Energy Efficient techniques

Authors	**Mechanism**	**Method**	**Purpose**
Rahman et al. [13]	Energy efficient zigzag routing protocol	zigzag routing protocol	To get energy efficiency in WSN
Li et al. [14]	Security mmechanisms	SPIN routing protocol	Comparison of SPIN algorithm with other algorithm
Tarabovs and Zagursky [15]	medium access protocol for clustered WSN	MAC protocol	To bring efficiency
Ji et al. [16]	Low power adaptive RP for WSN	Low power adaptive RP	To brings energy optimization
Hu and Li [17]	Geography region based clustering algorithm for WSN	Clustering algorithm	to reduce the energy usage and proper resource allocation
Cao and Yu[18]	A mechanism of load balance for WSN	Compressive sensing	Energy consumption minimization
Bidai et al. [19]	Multipath routing for cluster tree WSN (ZigBee)	Multipath routing protocol	efficiency, throughput and data transmission at low and high data rates
Thaskani et al.[20]	token passing mechanism	A cross layer design protocol	Energy consumption Minimization
Othman et al.[21]	Self stabilizing algorithm to minimize the energy usage in WSN	self stabilizing algorithm	minimize the energy usage

III. ENERGY EFFICIENT DISTRIBUTED RELAY SELECTION - OVERVIEW

Before The section discuses the existing technique for selecting retransmission for IoT based on WSN. A retransmission is an import resource in WSN and consumes more power than other nodes. Because increased relay power consumption can cause the network to be disconnected, transmission fails in IoT based on WSN. Therefore, a node that has a higher residual energy should be selected as a relay to increase the useful life of the network. A distributed and intelligent relay selection technique is presented in the existing system to achieve reliable communication. The EDRS architecture for IoT is shown in Fig 2; however, this existing system focuses on the WSN tire.

The EDRS method selects an optimal number of relays with an optimal power level to avoid collusion in the network. Suppose, a set of relays (R) exists in the neighborhood of a source (Src), each relay can directly communicate with the destination (Dst).

Where the relay is unknown, the EDRS method selects a relay that influences the least number of connections. The source sends a packet to the DST, including energy per bit, on receiving the Src packet each relay adjusts its transmission power and forwards to the destination. Energy consumption is calculated from source-relay and relay-destination for a single bit successful transmission. The Src transmits with maximum transmission power (Pm), only nodes successfully receive the message participate as candidate relay.

The EDRS method is executed in three main steps. In the first step, it reserves a slot from source to relay and relay(s) to the destination. While in the second step a suitable relay is selected from candidate relays. Finally, it assigns power to the selected nodes. The EDRS modifies 802.11 MAC protocol to achieve the desired results. Upon receiving a collaboration request/response packet (CP), each node activates its Network Allocation Vector (NVA) to reduce collusion in the network.

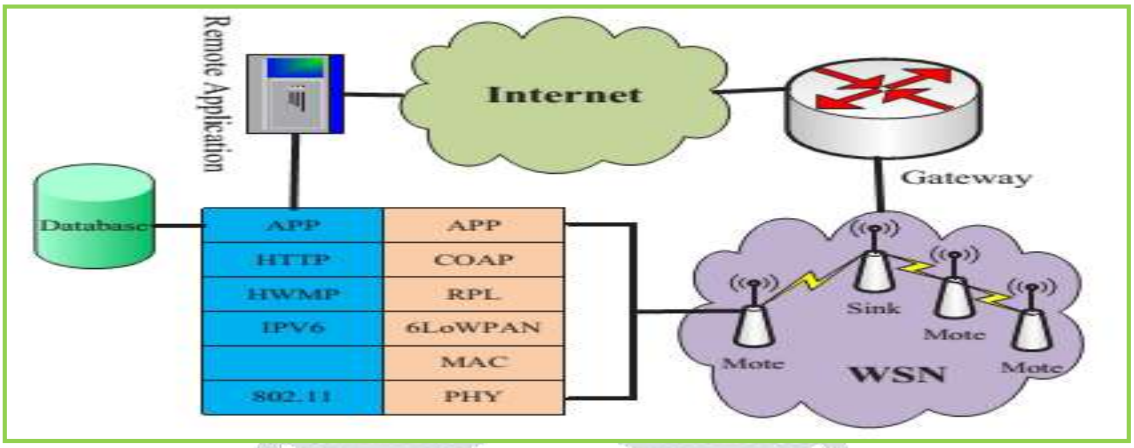

Figure 2: the IoT architecture for EDRS

To reserve a slot a source node transmits a Request To Send (RTS) packet, upon receiving an RTS, each relay and destination estimate average signal-to-noise ratio (SNR). If the SNR is below than a threshold; source and destination select the relay for collaboration. Once the relay nodes are finalized, the source and each relay start its timer to calculate slot duration for sending a control packet. The timer sets individual node's priority and avoids collusion in the network.

The CP contains nodes IDs for the current flow, SNR among (source, relay, and destination), and power allocation vector. On receiving the CP a relay node updates power assignment and updates its collaboration set. Each relay node finds its role in the collaboration if it is helpful to reduce energy consumption and collision avoidance it participates as candidate otherwise it goes to the sleep state.

As shown in Fig 3, there are three relay nodes in the range of the Src node. The Scr broadcasts a message to one-hop neighbors and intendeds to select a suitable relay. There are three relays receive the REQUEST message and update their 1-hop information and wait to rebroadcast the message.

Suppose R1 timer expires first, and it rebroadcasts the received request packet, R1 includes its relative power. Whereas R2 and Dst receive the packet, R2 also checks for the relative power and neighbor nodes, as R1 has tree active nodes in its range.

Once the R2 timer expires, it broadcasts the CP with the new power assignment. The relay R3 and R1 will receive the R2 message; R3 will not broadcast its information as R2 affects the minimum number of nodes and has the best power assignment.

While R1 differs its collaboration and goes to the ideal state. This process is repeated until Dst receives the request packet. Once the route is constructed based on optimal collaboration, the Dst send a unicast acknowledgement packet to the Src.

Hence, the Src and the Dst start communication following optimal power level.

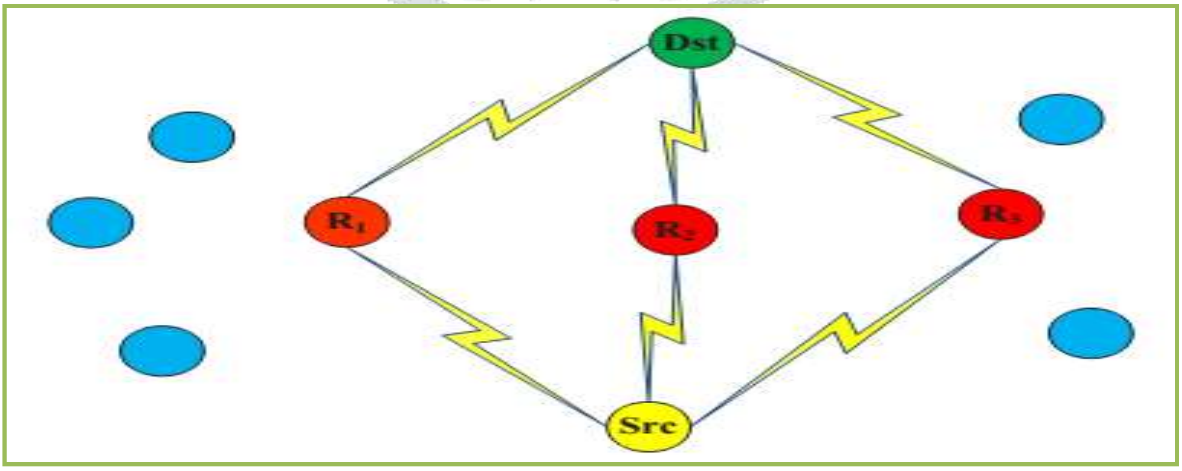

Figure 3: EDRS node structure

It is import to note that each relay takes its decision in a distribute manner, whether to participate in the collaboration set or not. The proposed EDRS sets a timer to avoid collusion in the network. Initially, each relay node transmits a CP to determine the channel characteristics, its cooperation, and collusion avoidance. Secondly, a relay randomly selects a slot; in this case, a collision may occur if multiple relays transmit at the same time. Therefore, optimal collaboration is not guaranteed.

IV. PERFORMANCE ANALYSIS OF EDRS METHOD

The goal of this research work to study the relative performance of selected energy efficient techniques named as EDRS methods with respect to varying scenarios and traffic loads. Pre-generated scenario files are used to subject each method to the same set of scenarios and traffic loads in an identical fashion to perform a fair comparison.

Table 2: Simulation parameters setup

Parameters	Value
Simulator Version	Network Simulator 2.35
Mobility Model	Random Way-point
Performance Parameters	Total Energy Consumption, PDR, Throughput
Methods Analysed	EDRS Method
Number of Nodes	40,60,80,100,120,140,160,180,200
Simulation Time	150 seconds
Traffic Type	CBR
Environment Area	1000 x 1000 meters square
Initial Energy	10.0 Joules
Transmission Energy	0.33 Joules
Idle Energy	0.10 Joules
Data packet Size	512 bytes
Transmission Range	250 meters

The graph showed in figure 4 is the total energy consumption of EDRS method. The graph shows that the total energy consumption is gradually increasing with each scenario since there is increasing number of nodes and more relay nodes, sender nodes sends their data towards destination node.

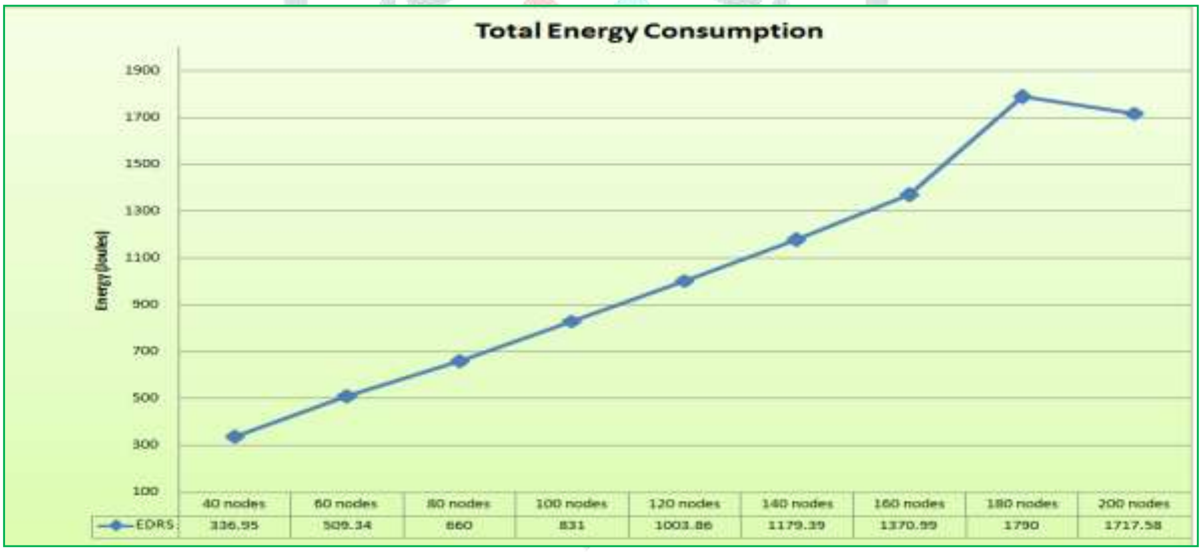

Figure 4: Total Energy Consumption

The graph showed in figure 5 is the throughput of EDRS method. The graph shows that the throughput is gradually increasing with each scenario since there is increasing number of nodes and more relay nodes, sender nodes sends their data towards destination node. But for 180 nodes, the throughput is decreased; the reason behind that scenario is that nodes are placed closely to each other in random manner in simulative experiment.

Figure 5: Throughput

The graph showed in figure 6 is the packet delivery ratio of EDRS method. The graph shows that the packet delivery ratio is gradually increasing and decreasing with each scenario since there is increasing number of nodes and more relay nodes, sender nodes sends their data towards destination node. But for 180 nodes, the packet delivery ratio is decreased; the reason behind that scenario is that nodes are placed closely to each other in random manner in simulative experiment.

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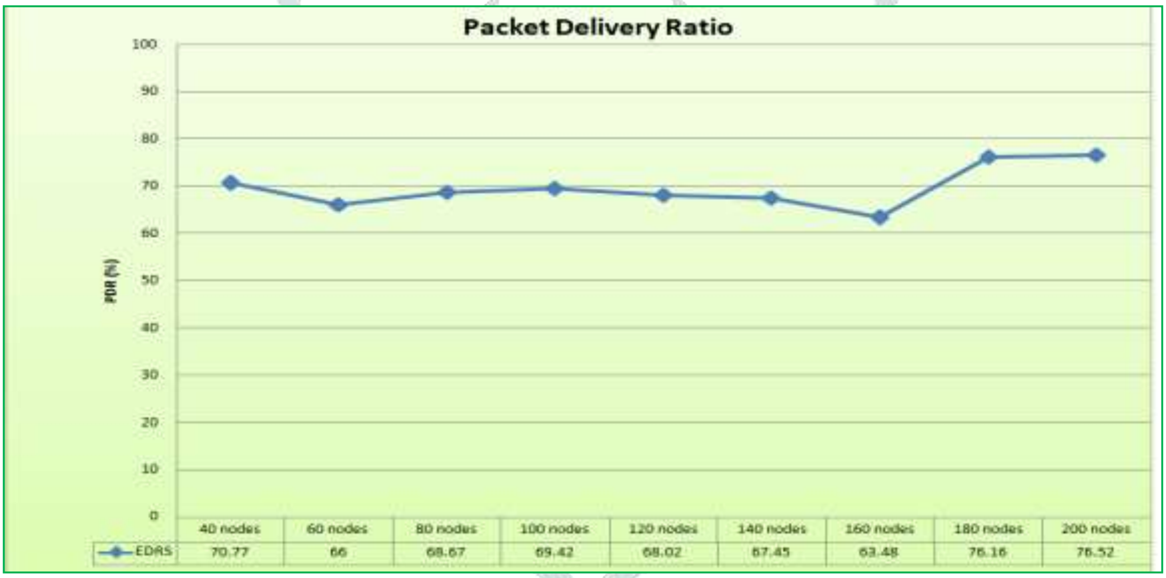

Figure 6: Packet Delivery Ratio

IV. CONCLUSION & FUTURE WORK

Place Energy saving techniques play an important role in developing a well organized IoT. Multi-hop WSN lifetime based on the power of the relay node, since power consumption is one of the most important problems of WSN. The EDRS offers the optimal retransmission selection strategy in the multi-hop IoT WSN to extend network life and reduce power consumption. Depending on the candidate nodes, an appropriate relay node is selected to avoid collusion. A relay candidate announces its collaboration via CP, other relays decide their function according to the SRN and the number of active neighboring nodes. The timers reduce control overhead and improve network performance. The results of the simulation show that the EDRS system works better and improving network performance. In the near future, the EDRS will be modified for IoT based on mobility WSN in real-world applications, such as home appliances, networks and healthcare.

So a new energy saving mechanism would be developed to overcome this above problem and make best use of energy efficiency & reliability which may best fits for IOT application.

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