# Energy Aware Routing Mechanism (EARM) for Effective Communication in Internet of Things

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**Article History**: Received: 11 January 2021; Revised: 27 February 2021; Accepted: 27 March 2021; Published online: 10 May 2021

**Abstract**

Advancements and wide range of applications of computing and networking create the innovative origination of the notion called Internet of Things (IoT) which enables varieties of devices and objects to connect and communicate via diverse communication medium. The sensors and the actuators are the fundamental building devices of IoT apart from the devices which are directly communicating with the humans. The devices exist with constrained capabilities like limited power like batteries and constrained processing power. As the devices are power-constrained and deployed in a large scale, establishing an energy efficient route among the devices is a challenging task. Frequent use of particular route for data transformation drains out the batteries very quickly. Many research works as stated in this paper, revealed that IoT needs mechanisms which effectively utilizes the energy of the node for effectual routing. This research work concentrates on the energy of the devices to be effectively utilized for a better routing among the devices. The proposed mechanism is simulated and compared with the existing research works which resulting in improved routing experience.

**Keywords:** 6LoWPAN, Communication, Energy, Internet of Things, RPL, Routing

## 1. Introduction

IoT attracts the researchers as well as the industrialists because of the enormous applications which are very much useful to automate the industrial jobs as well as home environments and the challenges which enable the researchers to perform research on improvement and betterment of the protocols and algorithms. The different applications of IoT are categorized under consumer, commercial, industrial, and infrastructure. Some of the examples of the applications are like smart home, internet of medical things, automation of manufacturing jobs, smart agriculture, environmental monitoring, and internet of battlefield things for military purposes, etc. The IoT shows a lot of opportunities for directly incorporating the physical world into computer-based systems which leads towards a fully automated era [1][2].

Many definitions are given by various people to the term IoT. As per the standard definitions, IoT is a combination or networking of interrelated computing devices or objects or animals or people which are having a unique identifier (UID) and the capability of transferring information through a network without the need of human interaction [3]. One of the fundamental and important parts of IoT is sensor. In general, a sensor is a type of apparatus or device that observes the physical environment and converts the measured stuff into electrical signals for further anatomization and processing. A sensor node that is also known as mote is a compacted autonomous device including computing elements to process and distribute the sensed data. Thus, a sensor or a mote senses and generates the data from the physical environment, and transmits the sensed data towards the server or the sink node. A sensor node usually consists of the following units: sensor, microcontroller, communication, power and memory. The requirements of applications are different and based on the requirements of the application, other units such as GPS, locomotory, energy harvesting, etc, are also included [4]. The sensors are designed in such a way that it can sense and measure the physical world matters like temperature, humidity, motion, speed and direction, etc. The sensors convert the measurements that may be in analog into electric signals or into a digital format that can be observed by a smart agent which is a human or a device). The actuators receive the control signals that activate a physical reaction such as motion, force, etc [6].

The term smart object is referred to various terms like intelligent device, smart device, smart sensor, IoT device, thing, smart thing, intelligent node, intelligent product, ubiquitous thing, and intelligent thing. The smart objects which are wirelessly connected, generally, include any one of the communication prototypes such as (i) Event-driven: diffusion of sensed information is prompted only when a smart object notices an event or predestined threshold, and (ii) Periodic: Transmitting sensed information only at periodical intervals.

Based on power supply, two different types of nodes are available such as powered nodes and battery-powered nodes. A powered device or node usually has an undeviating connection to a power supply, and communications are not restricted by energy consumption criteria. However, easiness of installation of powered nodes is restricted by the accessibility of a power source, which projects mobility as more intricate. The battery-powered nodes offer much more suppleness to the IoT devices and these nodes are categorized by the requisite lifetimes of the batteries. The motes are battery-powered devices, since it is a challenging task of running a mains supply to the deployment site. The power supply is usually provided by primary batteries to the nodes which are connected wirelessly [5]. The wireless access technologies play major role in communication among IoT and some of the familiar protocol stacks are based on IEEE 802.15.4 such as ZigBee, 6LoWPAN, ZigBee IP, ISA100.11a, WirelessHART and Thread. The protocols like 6LoWPAN, RPL and CoAP get attention of the researchers because of the range of applications as well as the challenges that create new concepts and products.

The expansion of 6LoWPAN is IPv6 over Low - Power Wireless Personal Area Networks which is standardized and documented by IETF [7]. The aim of the development of 6LoWPAN is that the Internet Protocol (IP) is to be utilized for the smallest devices and these nodes having low-powered and constrained capabilities should be able to participate in IoT. The implementation cost of 6LoWPAN is lesser than or nearly equivalent to other related protocols and also other overheads are much lower [8].

A simplified model called Open Systems Interconnect (OSI) is considered as a general model of communication and networking area which consists of layers of stack. The simplified OSI model and two different examples of stacks used for IoT devices are as shown in Figure 1.

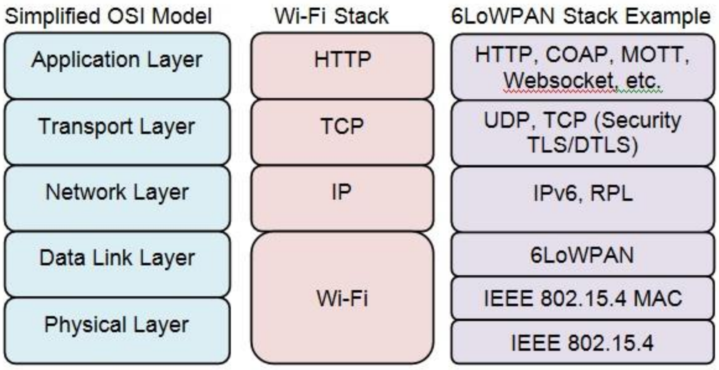


**Figure 1. OSI Model, Wi-Fi stack and 6LoWPAN stack [9]**

A 6LoWPAN enabled network establishes connection with other IP networks via one or more edge routers and these routers encompass the capability of forwarding the IP datagram among the different media. The connectivity can be launched by having any arbitrary link, such as Wi-Fi, Ethernet or 3G/4G. The devices like routers and hosts are also available in a typical 6LoWPAN network. Routers perform the operation of routing the data intended to another device of the network. The end devices do not have the capacity of routing the data to other devices. The host may be a sleepy device and the process of waking up sporadically to verify its parent or a router makes use of low power consumption.

6LoWPAN employs stacked headers as shown in Figure 2. The headers of 6LoWPAN have three sub-headers such as mesh addressing, fragmentation and header compression [10]. The mesh addressing headers are useful for the data link layer and the fragmentation headers are helpful for the transmission of IPv6 MTU (Maximum Transmission Unit). The header type field describes the header format which is at the start of each header. The fragmentation header is combined with the packets that fit into a frame of IEEE 802.15.4 and it will used if the payload is bigger to fit the frame. If the data is sent over a single hop, the mesh header will not be employed. The three fields of the fragment header are datagram size, datagram tag and datagram offset. The address header of mesh is utilized for forwarding the packets of multiple hops within a 6LoWPAN network. There are three fields available in mesh address header as follows: hop limit, source address and destination address.

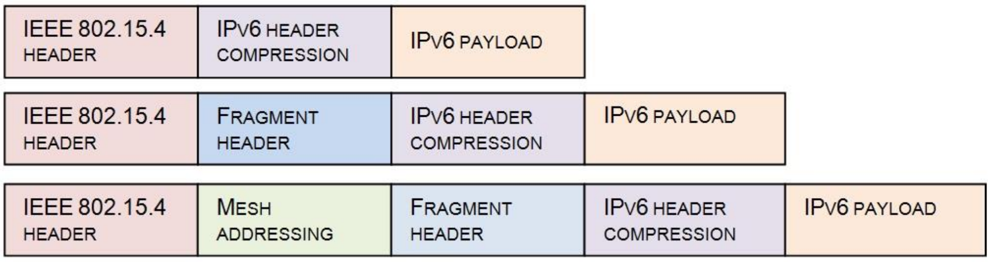


**Figure 2. 6LoWPAN stacked headers**

Depending on the layer on which the routing mechanism is executed, there are two kinds of routing available such as route-over and mesh-under. The first one, mesh-under makes use of the link layer addresses (IEEE 802.15.4 MAC or short address) to forward the packets and the next one called route-over makes use of network layer addresses (IP addresses). RPL has two different routing modes such as storing mode and non-storing mode. If the storing mode is considered for any network, the nodes of 6LoWPAN network are configured as routers and these configured nodes maintain the routing as well as neighbor table. If the non-storing mode is considered, source routing is employed because the only device which has a routing table is the edge router. For auto configuration and neighbor discovery, there are four types of messages described namely Router advertisement (RA), Router solicitation (RS), Neighbor solicitation (NS) and Neighbor advertisement (NA).

As the devices are running by batteries and the constrained other resources, establishing a stable route for effective communication is a challenging task. The protocol, 6LoWPAN gives a space for improvement to optimize the routes through various parameters. Through a literature survey, it is found that the energy of the nodes plays a key role in establishing the stable route which leads towards achieving a higher Packet Delivery Ratio (PDR). Hence, this research work concentrates on the procedure to effectively use the energy of the nodes for establishing communication among the devices of IoT which achieves improved PDR.

This paper is planned as follows: the first segment of the paper explores the fundamentals of IoT and other related terms. The second section elaborates various related research works carried over by different researchers over the globe. The third section elucidates the research contribution of the author and the fourth section projects the simulation and discussion of the research work. The final section concludes the research paper which is followed by references.

## 2. Related Works

There are many researchers who rendered their contributions towards establishing a stable route in IoT for effective communication especially considering the energy of the nodes. This section lists out various research contributions offered by various researchers.

Jau-Yang Chang [11] proposed a scheme to decrease the distances of data transmission nodes considering the cluster structure concepts. He stated that energy saving is an important concern in large-scale of IoT arrangements and also new energy efficient schemes must be invented to lessen the energy consumption and to lengthen the lifetime of the sensing nodes. K´assio Machado et al. [12] proposed a routing protocol with a load balancing scheme that is based on energy and link quality, specifically for IoT applications, such as automation of comfortable homes and offices, healthcare, smart parking and monitoring environmental properties. They also proposed an end-to-end route selection method by having cross-layer information and with a minimal overhead. Their proposed REL is still need improvement for a large-scale test-bed.

A cluster algorithm was proposed by S. Madhurikkha et al. [13] and the algorithm took account of an energy harvesting technique to enhance the energy and the throughput of the network. Their algorithm tried to decrease the number of repeated rounds required to elect the cluster head. HEED (Hybrid, Energy-Efficient, and Distributed) algorithm was modified with an energy harvesting technique which uses wireless charging technique and this algorithm attempts to select the suitable channel in the multi-channel system. Saima Abdullah et al. [14] proposed an algorithm for energy efficient recovery and backup node selection and also energy efficient message scheduling technique. The best possible way of managing the faulty or failed nodes was the aim of their scheduling algorithm. The identification of failures or mistakes is done to begin the recovery or replacement measures. In order to uncover the better replacement nodes installed for the sensor network, they took the energy as a sparse resource. Farzaneh Mortazavi et al. [15] proposed a routing protocol and it considered the remaining energy of the devices of the routing in IoT traffic.

The implementation of energy based schemes for IoT scenarios is an exigent task as the IoT establishments become larger. The existing techniques of wireless sensor networks (WSN) are not suitable to be executed directly on IoT, stated by Youngbok Cho et al. [16]. They proposed architecture for hierarchical network to solve the energy utilization and also proposed a routing mechanism to handle the low powered devices which are mainly battery operated. Kirshna Kumar et al. [17] proposed a routing algorithm named as EELSR to utilize the energy of the devices in an optimized manner and to provide the link stability for enhancing the life span of a network. In their research, an analytical model for link stability and residual energy were proposed and an optimal route selection algorithm which considers link stability, residual energy, and distance, was designed. Sarwesh P et al. [18] proposed an energy efficient network architecture to extend the network existence. They stated that sensors and relay nodes were positioned in hierarchical manner to evade patchy energy drainage issues. The sensors execute sensing process and the relay nodes manage the communication that is the data transmission from sensor to sink, which attempted to reduce the complexity. The placement of the relay node was fixed by data traffic of the network and to attain balanced energy consumption, energy based routing mechanism was also implemented.

Samia Allaoua Chelloug [19] proposed routing protocol named as EECBR to minimize the energy consumption of IoT devices. The protocol used a virtual topology built in a centralized method and forwards the events from the publishers to the intended subscribers in a distributed scheme. Sang-Hyun Park et al. [20] proposed a routing algorithm called EEPR to deal with the diffusion of the route request packets in order to enhance the lifetime of the network and to decrease the packet loss that is happening under the flooding algorithm. The EEPR algorithm implements the energy-efficient probabilistic control by parallel utilization of residual energy of each node and ETX metric. A routing protocol for WSN was presented by Wasan Twayej et al. [21]. Ineffective energy consumption of nodes which are active throughout the network is addressed by using an adaptive sleep mode method to keep up the better performance of the network. A Multilevel Clustering Multiple Sink (MLCMS) with 6LoWPAN was executed for choosing cluster heads (CH) for each level, so as to expand the network existence. An enhanced network performance was attained through an adaptive sleep mode scheme. In their research work, the sensor ground was partitioned into quarters with various levels of cluster heads and two optimal position sinks.

A protocol called MAEER for IoT was proposed by Sonali Sunil et al. [22] supporting mobility and nearly optimum routes with abridged energy consumption. The protocol attempts to reduce the number of partaking nodes in route discovery in order to reduce the energy consumption and also it supports mobility with improved packet delivery ratio. Antar Shaddad et al. [23] proposed a scheme which comprises of following techniques: first, a zone-based hybrid-placement scheme, second, a Multi-Stage Weighted Election heuristic (MSWE) scheme, and third, a Minimum Cost Cross-layer Transmission model (MCCT). The researchers considered the following scenarios: a scalable pre-deterministic assignment of energy-harvesting nodes, an even-random employment of heterogeneous devices, a rational energy-load balancing mechanism among all the zones, and a lowest amount of energy-cost for data transmission starting the bottom layer to the top layer. They named it as SEES (Scalable and Energy-Efficient Scheme) which supports up to n levels of heterogeneity and m number of election factors, and they claimed that it may be considered for any sort of IoT-based establishment.

IPv6 Routing Protocol for Low-Power and Lossy Networks, shortly named as RPL, is a standard routing protocol developed for low-power low-cost and resource constrained networks. In order to tackle the wide of range of connection qualities in these networks, the Minimum Rank with Hysteresis Objective Function (MRHOF, RFC 6719 [24]) is standardized as the de facto Objective Function (OF) for the protocol RPL. MRHOF is helpful for a mote in selecting a path to direct the traffic with the minimum cost amongst the existing paths. The Expected Transmission Count (ETX) defined in RFC 6551 [25] is the most widely used MRHOF routing metric. Since ETX does not take into consideration of the energy level of the motes, it does not balance the energy consumption amid motes. After providing this criticism, Mai Banh et al. [26] developed a Radio Duty Cycle (RDC) based method to compute the energy consumption of mote and also performed the execution on various combinations of ETX and energy consumption as routing metrics. Many researchers are trying to improve the RPL and at the same time researchers like Seelam Srinivasa Rao et al. [32] criticized that if the number of nodes in a network is increased, the primal RPL protocol consumes energy more quickly (leads to killing of nodes at the very early stage) where the internal layers carried too much of data-forwarding tasks.

From the literatures reviewed, it is found that IoT needs effective mechanisms to handle the energy in an efficient way to sustain and improve the performance of IoT data transfer as well as communications. Many researchers contributed various mechanisms and algorithms to tackle the power constrained nodes of IoT and still it need further improvement since the energy consumption of the motes are different from one another. A single node which may be a sink node or any other collecting agent cannot measure the energy that is available in various motes. The energy consumption during various modes like sleep mode, idle mode, transmitting and receiving modes, are to be considered at the time of energy calculation. Hence, it is the need of the hour to propose a mechanism which effectively handles the energy of the nodes to keep the communication live and to prolong the life of the communicating nodes.

## 3. Energy Aware Routing Mechanism

The nodes of IoT environment are powered by batteries and the entire life of the node depends on the batteries. The energy of the network node is exhausted very hastily if the node is continuously or frequently utilized for communication as well as data transfer. The data sensed by the sensors are to be transferred to the sink node or the collection agent through different set of nodes and the transfer of data is executed through hops among various nodes. During the transfer among the nodes, the energy of the nodes is to be utilized effectively so that the nodes in the particular route will not lose energy quickly and also the communication will be more effective.

Various influencing factors exist which have considerable impact on the power consumption characteristics of a radio and the factors include the kind of modulation scheme, transmit power, data rate and the operational duty cycle [27]. Generally, the radios function in four discrete modes of operation: Transmit, Receive, Idle, and Sleep. From the literatures it is found that functioning in idle mode results in considerably high power consumption, sometimes, the consumption is almost equivalent to the amount of power consumption while functioning in the Receive mode [28]. While constructing the routes, the energy of the nodes that spent on different modes should be considered. The existing works, during the route establishment, gave much importance to the energy which is consumed during transmission or receiving modes and other modes are not considered. Each node is capable of measuring its own energy and also capable of calculating the needed energy for the particular data transaction. This self measurement reduces burden of the sink node that is considered as the source node, because the source node does not need to calculate the energy of the all of the nodes which are available in the route to be established. The quantity of data transmission holds an inevitable role in transmission rate of the entire network. Even given global information, developing or deciding an optimized and energy balanced algorithm for a IoT based network is still a challenging task [29].

The microcontroller unit (MCU) takes care of the jobs like controlling the sensors, executing the signal processing algorithms and communication protocols on the congregated sensor data. While the selection of MCU is stated by the requisite performance levels, it can also considerably affect the power utilization characteristics of the nodes. For example, when executing the instructions, the ATmega103L AVR microcontroller of Atmel consumes power about 16.5 mW, but offers lesser performance and the StrongARM microprocessor of the Intel Corporation used in high-end sensor devices, takes power around 400 mW [27]. In various operational modes such as (i) transmit mode, (ii) receive mode, (iii) idle mode, and (iv) sleep mode (v) sense mode, the wireless radio consumes power [30][31]. If the node is in sleep mode, it consumes lesser power to keep the radio in a low power state and the nodes can be brought back into active mode.

The energy that is consumed for transmission ($TrEn_i$) of a node i is computed through the summation of the energy taken for the reception of a packet ($ReEn_i$) and the energy used for sending or forwarding a packet ($SeEn_i$).

$TrEn_i = ReEn_i + SeEn_i$

The remaining energy ($RmEn_i$) for the node i depends on the energy before processing ($BfEn_i$) and the energy after processing ($AfEn_i$) and it is calculated as

$RmEn_i = BfEn_i – AfEn_i$

This is valid for all the modes of operation. If a node is considered to be in idle mode, the mobile node is involving in neither sending the packets nor receiving the packets. If a particular node is in sensing mode, the node pays attention to the wireless signals and this sensing also consumes a considerable energy. The consumed energy of the node i while it is in idle and sense mode ($IdEn_i$) is calculated for a period of time ($t_1$ to $t_2$) as

$IdEn_i = Ent_1 – Ent_2$

The energy consumption of the node's applications and other processes ($ApEn_i$) are also considered because these are the parts of the factors which drain out the battery.

As per the standards of the protocol 6LoWPAN, the messages like Router advertisement (RA), Router solicitation (RS), Neighbor solicitation (NS) and Neighbor advertisement (NA) are utilized for establishing communication by transferring the mandatory information like energy. The source node or called the sink node which actually initiates the data transfer computes the needed energy for transmitting the packets. The computation and anticipation of the energy needed for completing entire transaction is performed by having the parameters such as time for completing the transaction and the size of the packets.

Before establishing the route, the different energy consumption of the intermediate nodes (the nodes which are available to participate in the current communication) and the remaining energy of the nodes are obtained by the source node to decide on the best path. Based on the received information regarding the energy consumption of the intermediate nodes, two dissimilar paths are established: the main path is executed immediately which has the nodes with maximum energy and the second path considered as an alternate. Despite the fact that the path for data transmission is decided by taking into account of the maximum energy, there are two chances for any node to drain out swiftly; one possibility is the greedy nature of the applications/processes and another possibility is that the node could engage in communication with the nodes of the network (source and destination nodes within the same network). Because of the aforementioned issues, an alternate path is constructed in order to shun unwanted delay. While deciding the paths to be established, the cumulative energy of a path and the remaining energy of the each node are computed, because the power capacity differs from one node to another.

An example diagram is shown in Figure 3 which shows twelve nodes and the nodes demanding the communication are shown different colors. The S node is the source or called sink which collects sensed data from the destination node D. The arrow marks with solid lines shows the path to be established and the dashed lines show the alternate path. The path for communication is established by taking account of the energy of each node. The nodes 4, 2 and 3 are chosen because these nodes have enough energy to perform the transaction between the source and the destination. The energy needed for the particular transaction is calculated by having the amount of data. Other nodes like 1, 5, 9 and 10 don't have enough energy or they may be involving in other transactions or application processes. Hence, while choosing the path the energy available in the nodes, the energy being spent on different modes and different processes, and the amount of data to be transacted are considered.

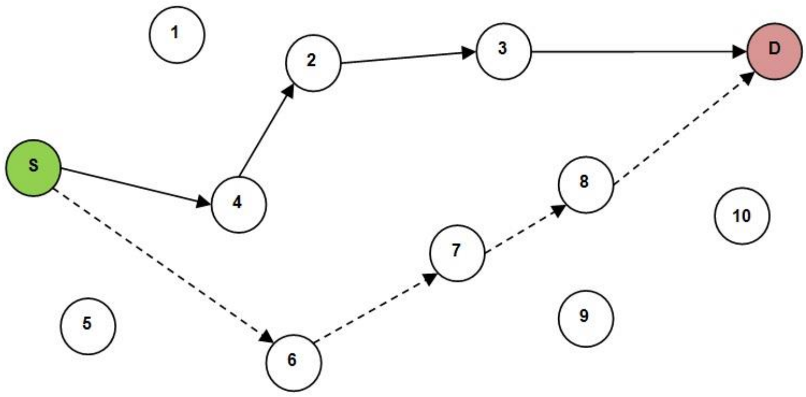


**Figure 3. Example Network Diagram**

The algorithm is as follows:

1. Read Energy ($TrEn_i$ , $ReEn_i$ , $SeEn_i$ , $RmEn_i$ , $BfEn_i$ , $AfEn_i$ , $IdEn_i$ , $Ent_1$ ,$Ent_2$) for all nodes of $path_i$
2. compute Packetsize and Packetduration of the packet to be sent
3. compute the energy needed to transmit the packets // set threshold
4. For node i=1 to n // all the nodes of the path
5. If node_energy > threshold then
6. Construct route
7. Else ignore node i
8. Find next-route // Loop
9. Sensor node begin transaction

The algorithm which proposed in this research work considers the energy of each node which is going to participate in the communication. The energy spent on each mode is important so that the source node gets the ability to decide the suitable nodes for establishing communication in the IoT networks.

## 4. Simulation and Discussion

The proposed mechanism is simulated by Cooja Simulator of Contiki OS 2.7 with 25 and 50 motes dispersed over a 200x200m area as shown in Figure 4. The simulation is started initially with 10 nodes and later it is increased to 25 and 50 nodes. The energy of the nodes is set with random joules starting from lowest energy to highest energy (measured in the unit of Joules), intentionally. In general, the Carbon-zinc type of AA battery has the energy of 2340J and the same type of AAA battery has 1268J. During the simulation, few nodes are made to involve in other communication so that the energy of the node is drained fast. With these kinds of different settings the proposed mechanism is compared with the benchmark protocols namely, 6LoWPAN and RPL.

During the simulation the sink or called source node is enabled to establish a communication with the destination node for consuming the sensed data. Through the standard messages of 6LoWPAN the initial establishment is taken place and at the same time the nodes which are placed between the source and destination calculates the residual energy and other energy being spent on various processes. This computation of energy is already known by the corresponding nodes and so, the nodes do not spend much time on the computation. Only calculation which is done by the nodes is that it checks whether it capable of transferring the entire data which has to be travelled between the source and the destination. In this aspect, this proposed mechanism never puts burden on the nodes which are very constrained in various parameters.

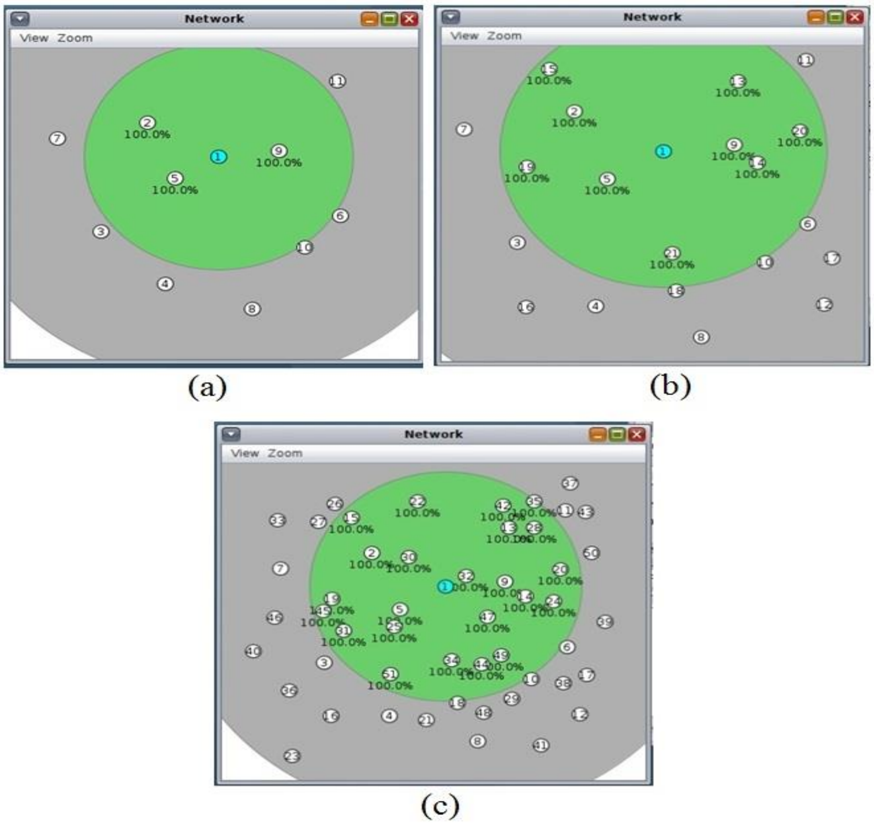


**Figure 4. (a) Simulation with 10 nodes (b) with 20 nodes (c) with 50 nodes**

In general, the hop count is considered whenever an algorithm is developed for routing. From the simulation and the literatures, it is found that hop count alone could not improve the performance of any network especially when the nodes are highly depending on the batteries and other constrained resources. The proposed mechanism is compared with the benchmark protocols of 6LoWPAN and RPL by considering the parameters like energy consumption, network life time, end-to-end delay and packet delivery ratio (PDR). The energy consumption is almost equal for both 6LoWPAN and the proposed mechanism because the proposed mechanism is based on the protocol 6LoWPAN. PDR is calculated by having the number of packets sent by the sender and the number of packets successfully received by the receiver. Generally, PDR is affected by a number of reasons such as packet fails to reach the destination due to network error or the receiving node fails to receive the packets due to congestion or the intermediate nodes fail to forward the packets due to draining out of energy. The energy of the intermediate nodes is important in establishing a stable route, because, if the energy of the node is drained out quickly then the particular node cannot forward the packets towards the destination and the link will be terminated abruptly. Hence the energy of the nodes cerates impact on PDR. This research work improves the PDR by considering the energy of the nodes while establishing the communication among the network. The result of the simulation which considers PDR is shown in Figure 5.

The network life time is affected if the energy of the nodes is not handled properly. The network life time depends on the energy of the nodes available in a network which is to be utilized effectively, so that, the communication of the network is not terminated and the packets are able to reach the destination through the alternate path. If an intermediate node is used continuously for packet forwarding among the network, it is drained out very quickly and it affects the network by terminating further forwarding processes of packets. This unwanted negative effect affects the network life time by halting the communication among the nodes. This research work contributes towards stabilizing the network life time and the result of the simulation is shown in Figure 6. The end-to-delay increases if a packet takes longer duration due to a number of network issues. One among the issues is that an intermediate node is unable to forward the packets on time because the node gets drained out quickly. The delay in the communication is an unwanted effect which affects the overall performance of the network and this research work shows a good result which is shown in Figure 7.

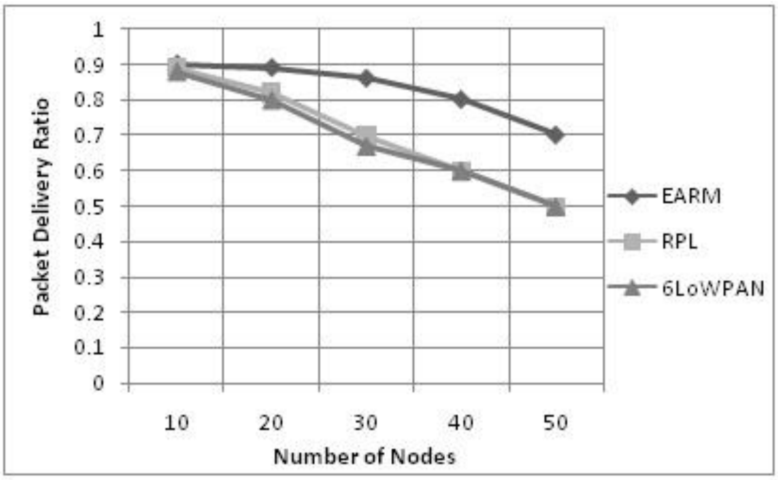


**Figure 5. Packet Delivery Ratio (PDR)**

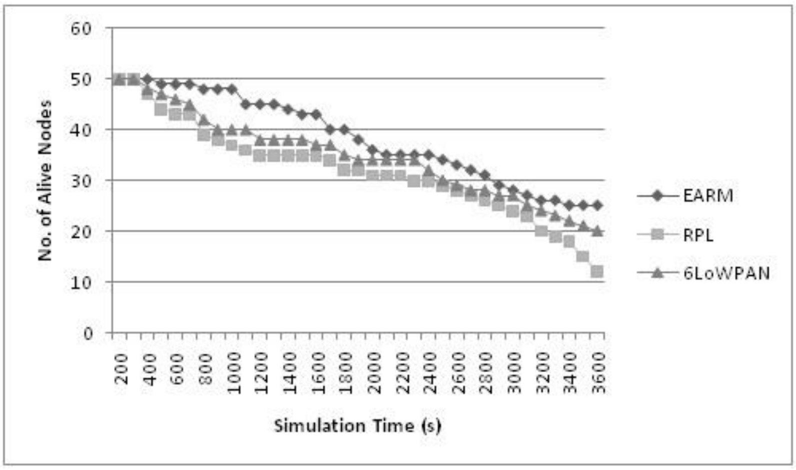


**Figure 6. Network Lifetime**

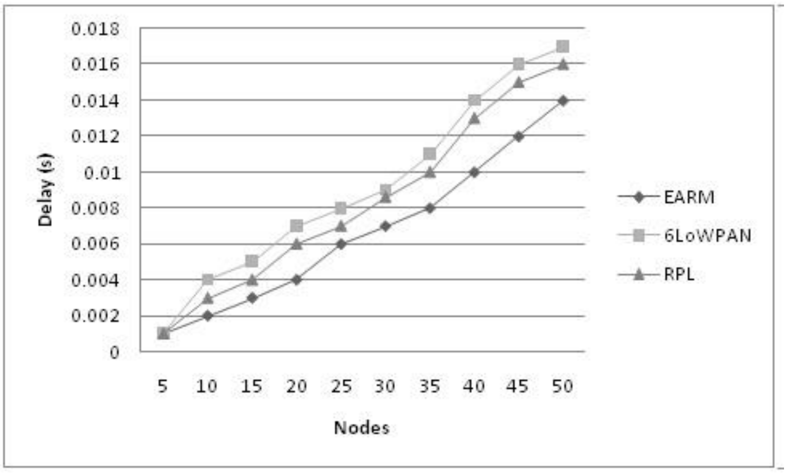


**Figure 7. End-to-end delay**

The proposed mechanism, EARM is compared with the standard protocols called 6LoWPAN and RPL which had been considered as a bench mark protocol by many existing research works as it has been discussed in the literature review. The delay of the network, life time of the network and the PDR are influenced by the energy of the nodes because if the energy gets drained out the node will not be functioning and the performance of the entire network gets affected. While establishing a stable route to forward the sensed information in an IoT environment the aforementioned parameters are to be considered. During the simulation, the proposed research shows that it performs well better than the existing protocols.

## 5. Conclusion

IoT is gaining attention of the researchers because of the variety of applications starting from the home automation to industry automation. There are lots of sensing devices utilized for establishing the IoT environment which are actually constrained in many factors like energy. In order to establish a stable route for communication among the network, the nodes of the network or the nodes which are involving in communication should have good energy or the energy should be utilized in an optimized way. The nodes are spending the energy for various purposes when they are in different modes. Even if a node is in idle state, it consumes some energy for listening to the radio bands. All those different utilization of energy are considered in this research work for establishing a good route from the source to destination that is from the sensing node to the sink node. The simulation is done through the Cooja simulator and the results are compared with the existing standard protocols like 6LoWPAN and RPL which was considered by many researchers around the world. The results show that the proposed research work, EARM performs better than the existing protocols. In future, the research work will be extended by incorporating other parameters of quality of service to improve the performance further.

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