EVALUATION AND ANALYSIS OF NETWORK LIFETIME FOR ROUTING PROTOCOL OF WSN

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Abstract –

In the community of wireless sensors, routing protocols play a totally dominating role, which significantly enables sensors to extend their lifetimes and be used more often. In wireless sensor networks that are restricted by the available signal strength, poor signal strength utilisation and imbalanced energy distribution are having a significant impact on the community's ability to function. Therefore, the most significant challenge in wireless sensor networks is the development of strength-efficient routing protocols that are both environmentally friendly and economical routing algorithms (WSNs). It provides a classification and evaluation according to a newly proposed taxonomy that differentiates nine classes of protocols. These nine classes are as follows: latency-conscious and energy-efficient routing; next-hop choice; community structure; initiator of verbal exchange; community topology; protocol operation; delivery mode; direction status; and application type. The results of simulations using the NS-3 simulator for the LEACH, Mod-LEACH, iLEACH, and M-Gear protocols reveal that the routing project has to be largely focused on a variety of practical ways to improve the network lifetime and ensure greater coverage of the sensing site.

Keywords:Wireless sensor networks; routing; energy efficiency; reliability; lifetime.

1. *Introduction*

The wireless sensor network (WSN) is gaining popularity in a wide range of diverse sectors [1–4] because to its cheap cost, miniaturisation, and capacity to perform several tasks at the same time. Both improvements in the efficacy of wireless communication and developments in the compilation of electronic statistics have contributed to the realisation of this goal. However, in the vast majority of cases, the nodes that make up a WSN get their power from the use of batteries. In addition, they are often deployed in unmanned settings that are situated outdoors or in environments that are very hazardous, making it impossible to restock their energy sources. The vast majority of the time, the expense of redundant deployment as well as the cost of replacing nodes is seen as being expensive. As a consequence of this, a sustainable routing strategy is required in order to limit the amount of energy that is consumed by the network and to lengthen the amount of time the community will continue to exist.

Because the power of the sensor node is particularly used for the reception and transmission of data [5,] the conventional routing method primarily considers how to use the shortest route to transfer data from the supply node to the destination as quickly as possible. This is because the power of the sensor node is particularly used for these two functions. This is due to the fact that the power of the sensor node is being used specifically for these two purposes. However, in the community of power-constrained sensors, a vast number of statistics is sent from the source

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node to the sink by applying the "many-to-one" approach. This method allows for more nodes to participate in the transfer. This may very quickly generate severe examples of problems such as the "funnel effect" and the "energy hole." Because of this, the power consumption of nodes that are located across the shortest path or the sink node is a great deal quicker than that of other nodes, which results in an imbalance of power and a reduction in the lifetime of the community as a whole.

In addition, the "many-to-one" mode of record transmission has the potential to be a factor in the congestion that exists in the community. For instance, when a large event is triggered, all of the nodes in the network are required to transmit a substantial volume of data to the sink node in a very short period of time, and this is the moment when congestion is most likely to take place. Because of congestion, the transfer of records may become less reliable as a consequence of the loss of a considerable number of data packets, which may be caused by congestion.

It is possible to specify the lifetime in a number of different ways, and its length is highly dependant on the routing protocol that is currently being used. A community's lifespan could, for instance, be defined as the amount of time that has elapsed since the first node (or the closing node) within the community has depleted its supply of energy and, as a result, passed away [6]. This would be one example of how the lifespan of a community could be defined. It is essential that all nodes remain operational for as long as they possibly can under certain circumstances because the performance of the network suffers significantly when even a single node is lost. Because of this, it is essential that all nodes remain operational for as long as they possibly can. The finding of a fireplace or the beginning of an invasion are both potential events that may result from this situation. In circumstances like this, it is of the utmost importance to be aware of the time at which the very first node in the network dies. Utilizing the metric known as "First Node Dies" is one way to derive an estimate of the price that will be associated with this event (FND). The deletion of a single node or a small number of nodes does not always result in a reduction in the quality of service (QoS) that is supplied by the community in a few particular applications. In the context of this scenario, the term "half of the Nodes Alive" (HNA) refers to an anticipated cost for the length of time that a WSN is expected to be in existence for half of its lifetime. On the other hand, the term "remaining Node Dies" (LND) offers an anticipated cost for the length of time that a WSN is expected to be in existence for the entirety of its lifetime.

This inquiry has two primary objectives, which are as follows: First, we do a study of the lifetime of the WSN by using a variety of common routing protocols in a way that is in line with the standard TinyOS routing architecture [7]. This allows us to determine how long the WSN is expected to remain operational. Metrics are observed in a range of real-world situations, however some sensitive regions that have been highlighted in more recent studies [4] that offer a clear image into the routing protocols that are being evaluated are left out of the observation. Second, we provide a novel strategy that has been devised with the intention of elongating the lifetime of the network. HEED is modified to include the recommended process, and the resulting protocol, EHEED, is assessed in comparison to a wide variety of other procedures.

2. *Model of Network*

For the most part, the wireless sensor network explored in this study is employed for event detection and series recording. Sensor nodes generally convey information to the bottom station in stages or "hops," utilising many communication channels, because of the restricted communication distance between sensor nodes. Routing algorithms are tasked with finding the least-energy-consuming route between two nodes (a supplier node and a sink node).
WSN topology is shown in Figure 1 for your viewing convenience. Although it may seem to be conventional nodes, it is really the information gathering terminals that deliver assembled data to another node through the multi-hop routing protocol. There are a number of ubiquitous nodes and a single sink node in the sensor community with a location that is L L, and all nodes are not moved after deployment. When [8] is entered, the distance between nodes is calculated. A single-hop or multi-hop link may be established between any two sensor nodes, and the beginning state is the same for each. They're all the same shape. E 0 denotes the initial energy, and the node load is zero at this point.
The following is the node-to-node information exchange strategy: [9]. In other words, each node has a unique identifier (identity), which is responsible for maintaining a buffer that maintains statistics, including residual power, packet id, next-hop identification, sender IDs, and so on. Monitoring the modifications made by the neighbour in front of it ensures that this information is always up-to-date. Nodes are stated to have a limited number of visitors, and data packets are processed in FIFO manner (which stands for first-in, first-out).
The surrounding environment and a node's performance have a negative impact on the selection of the next hop during the WSN routing selection process (such as energy status and queue length). The top-ranking routes based on several characteristic indexes are unique and even contradictory. The DS proof concept, a classic approach for picking several qualities, is able to cope well with indeterminate and partial data. Allows for full assessment of sensor node overall performance by providing a theoretical foundation and fusion principles.

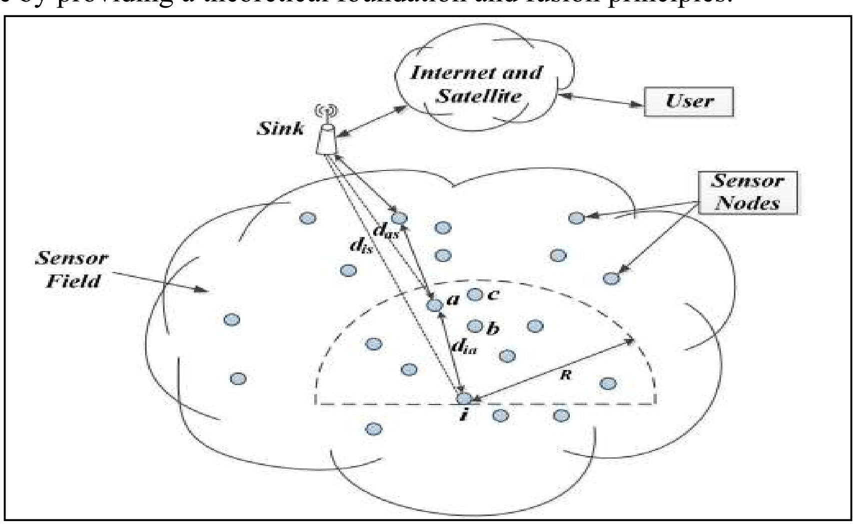

Fig.1: Wireless Sensor Network (WSN) topology

3. Crucial Consideration for WSN

3.1.1 Community lifetime:
Community lifetime is described because the round wide varieties while the first useless nodeseems due to the power exhaustion.
3.1.2 Forward neighbor node set:
In order tominimise data backhaul, it is critical that the sink node receives the information. As a result, neighbours in the forward semicircle of node I within the greatest verbal interaction radius R are included in the set of ahead neighbour node neighbours. According to Figure 1's nodes spatial dating and the forward transmission version in [10], the following is a description of the forward neighbour node set.

$$FN(i) = \{a \backslash d_{ia} \leq R, d_{as} < d_{is}\}$$

(1)

Where node 'a' is any forward neighbor node of node i, d_{ia} is the distance from node i, to node a, d_{as} and d_{is} are the distance from node i and a to the sink node and R is the maximum radius.
3.1.3 Forward energy consumption**:**
For any node a $FN(i)$, the energy consumption during the communication between node a and sink node is the forward energy consumption which denoted as e_{as}.
3.1.4 Candidate node fix:
For any node i, the candidate node fix $CN_{next}(i)$ is the node in $FN(i)$.
In WSN routing selection, a node's surroundings and performance are taken into account while determining the next hop (which include energy popularity and queue period). Using different characteristic indices, the best routings may be unique or even used in combat. The DS evidence notion can effectively cope with uncertain and partial records, which may provide a theoretical framework and fusion rules for a thorough evaluation of sensor node overall performance as a traditional multi-characteristic choice technique.

4. Routing Protocol Categorization

If the data packets may be transmitted after an occurrence or frequently, the routing protocol is said to be event-driven. If the data packets are sent periodically, the routing protocol is said to be time-driven. Routing protocols might represent prominent groups based on the use application.
4.1 Event-driven:
In event-driven protocols, a sensor node may only send information after the detection of a full-size event across its sensing region, as shown in Figure 2. This is because event-driven protocols are triggered when a full-size event occurs. This is because events are what set off event-driven procedures in the first place. These protocols are used in a wide range of various industries because they provide a number of distinct benefits that make them desirable to employ. In point of fact, they make it feasible to recognise certain induced occurrences as soon as they take place

thanks to the fact that they make it possible. Additionally, they make it possible to cut down on the amount of communication that is exchanged and to prevent the wasteful use of the energy and compute resources of individual nodes. This is made possible by the fact that they make it possible to reduce the amount of communication that is exchanged.

[11] Because (RT) 2 was designed to be a dependable and timely transport protocol that makes use of collaborative transportation of activities, congestion may be located and addressed with the support of actor nodes. This is made possible as a direct result of the development of the protocol. The authors of [12] show that the (RT) 2 protocol may easily adapt to the different characteristics of WSNs due to the configuration of the protocol itself. Additionally, it provides communication in real time and meets several dependability standards, both of which contribute to a reduction in the amount of power used. Loss A protocol known as the Tolerant reliable occasion (event) Sensing (LTRES) Protocol was created expressly for the purpose of dynamic event detection in wireless sensor networks (WSNs). It does this by basing the calculation for the occasion sensing consistency level on the manner in which the stop-nodes alter their supply rates [13].

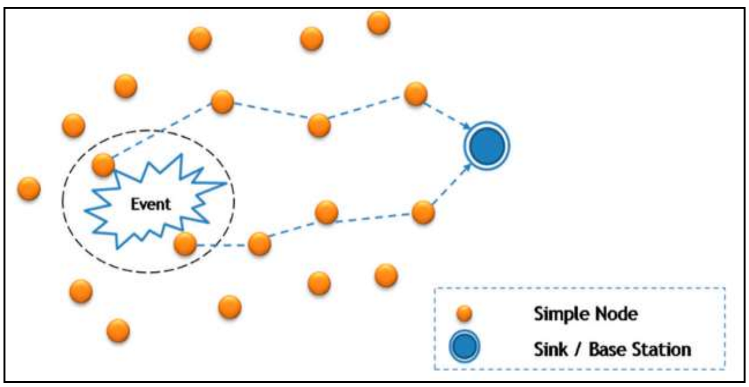

Fig. 2: Network Lifetime

4.2 Time driven:

The detection of the passage of time is an essential part of many WSN applications, particularly those that include some kind of content. In time-driven protocols, sensed records are sent on a periodic basis. The reporting length may be preset or set for the duration of operation, depending on the needs of the programme. Sensed data can also be supplied manually. The time-pushed dialogue format is simple to put into practise from a technical standpoint. In addition to this, putting nodes to sleep in between transmissions helps to save power and, as a result, increases the lifetime of the network. However, time-driven methods need a variety of synchronisation and coordination mechanisms in order to function properly.

The WB-youngster protocol, also known as the Properly (well)-Balanced-Threshold touchy power green sensor community protocol, is intended to function as a time-driven protocol that also includes a distributed clustering version [14]. To tell the truth, it is a more developed version of the youngster protocol [15]. The researchers that wrote [16] discovered that this approach improves power saving, but they also discovered that load balancing between nodes isn't always correctly managed.

The vast majority of applications that make use of WSNs operate in real time. These applications include monitoring for radiation and fires, as well as clinical surveillance and other similar tasks. And need a high degree of temporal precision; otherwise, the facts that are sensed are rendered meaningless, or the cost of using such programmes drops after the time limit has passed; such applications are known as real-time programmes. When it comes to WSNs, delays in verbal interaction tend to take precedence over processing delays. Because of this, the communication latency has to be capped so that such networks can support the shipping of information in real time [17–22].

5. Simulation Results

The overall performance of the recognised protocol in WSNs was tested using a sensing area of 100 metres by 100 metres including 50 sensors and a sink in the centre. This was done using the NS3 simulator, and the characteristics of the model were utilised to compare the protocols listed above.

Calculating the amount of energy needed to send n bits across a free space channel between a transmitter and a receiver that are separated by a distance d may be done with the help of Equation (2) [23-25]:

$$E_{Tx}(n,d) = n * \left(E_{ele} + \varepsilon_f * d^2\right), d <= T_d$$

(2)

Equation (2) Transmission power regardless of whether the channel is a free area channel or a multipath channel model with the application of Equation (3):

$$E_{Tx}(n,d) = n * (E_{ele} + \varepsilon_m * d^4), d > T_d$$

(3)

Equation (3) Transmission power through a multipath channel model while the receipt of n bits requires the power to be calculated by employing Equation (4):

$$E_{Rx}(n) = E_{ele} * n \quad (4)$$

Equation (4) Reception power of n bits with the understanding that threshold distance is calculated by Equation (5):

$$T_d = SQRT\ (\varepsilon_f \ / \ \varepsilon_m) \quad (5)$$

Equation (5) represents threshold fee for distance, and _f gives the amplifier electricity consumption used to maintain an appropriate sign in a free space channel version, while _m is utilised in multipath fading channel version based on a selected acceptable bit-error-fee (rate).

Equation (4) Reception power of n bits with the understanding that threshold distance is calculated by Equation (5):

Table I: Parameters for Model

Sl No	Network Parameters	Values
1	Sensing area	100 m × 100 m
2	Nbr of sensors	50
3	Location of the sink	25, 25
4	Packet size	2000 bits
5	Sensor energy	0.5 J
6	Energy consumption on the circuit, E_{ele}	40nJ/ bit
7	Dissipation energy, ε_f	5 pJ/ bit/ m2
8	Transmission energy, E_{Tx}	25 nJ
9	Reception energy, E_{Rx}	25 nJ
10	Data aggregation	3 nJ/ bit/ report

Within the following, the protocols are in comparison in terms of community lifetime, balance/instability intervals and energy consumption considering the above parameters

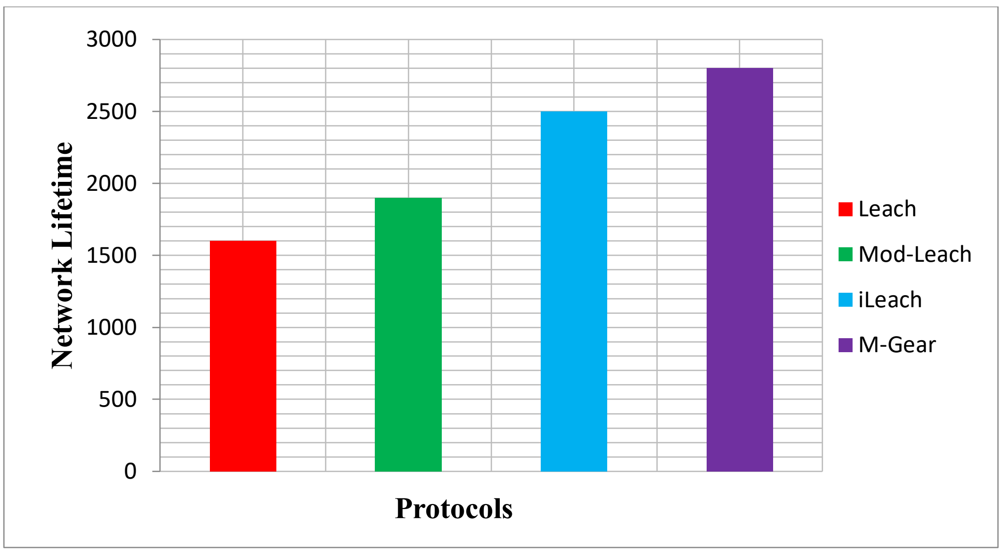

Fig. 3: Network Lifetime

The basic goal of routing protocols is to prolong the lifespan of the network to its maximum capacity while simultaneously retaining the quality of service. This may be accomplished via a combination of many different strategies. The evolution of the network lifespan with time is shown for each of the protocols that were examined in Figure 3, which can be seen below.
The limited community lifetime is designed to offer a way for the random selection of CHs, which is then followed by the LEACH and Mod-LEACH protocols respectively. This is the primary objective of the restricted community lifespan. In point of fact, many nodes may concurrently fulfil the role of a CH without any extra effort being needed from the network administrators. This has an impact on the amount of energy that is produced by the sensors, which ultimately leads to the formation of a great deal of disconnected areas. On the other hand,

in comparison to more conventional ways, the lifetime of a network may be increased with ILEACH and M-equipment (Gear). This is specified, respectively, as a consequence of the direct communication mechanism in the non-clustered regions and the use of a charged gateway in the instance of M-Gear. This is characterised in the instance of iLEACHas a consequence of the high-quality effect that the energy management function has. In addition to this, this is defined as a consequence of the use of a records aggregation tree that is completely predicated on a multi-hop model.

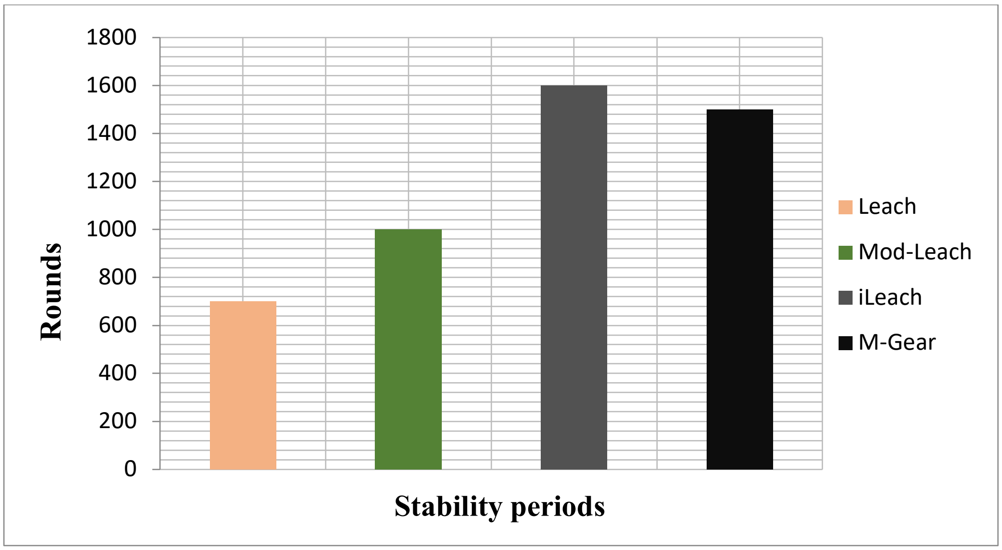

Fig.4: Stability Periods

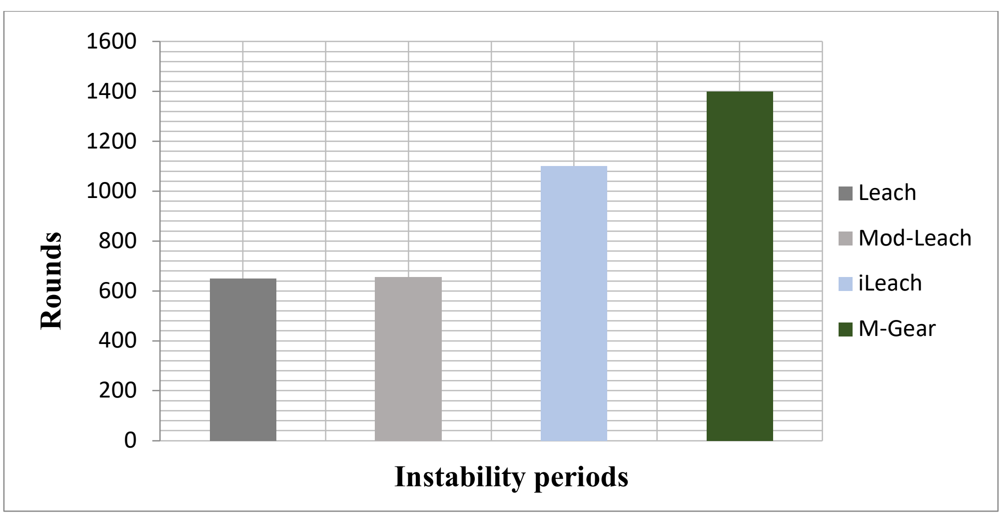

Fig.5: Instability Periods

The lifespan of the village may be broken down into two distinct parts, each of which is located next to the other. The first phase, known as the time of the steadiness, starts with the birth of the community and goes on until the passing of the main node. This section lasts till the end of the primary node's life. In contrast to this, the duration of the instability starts with the death of the main node and continues until the last node that is contained inside the network. This is in contrast to the length of the instability. The following timing considerations for the comparison methods are outlined below with reference to Figures 4 and 5: i-Leach has a remarkable stability period that lasts for more than 1200 rounds. This is described by the energy advantage that comes as a consequence of the sink's mobility, while the great length of instability is done by using the M-Gear protocol as a method to the excessive energy levels of certain sensors. The sink's mobility comes as a consequence of the fact that it is mobile.

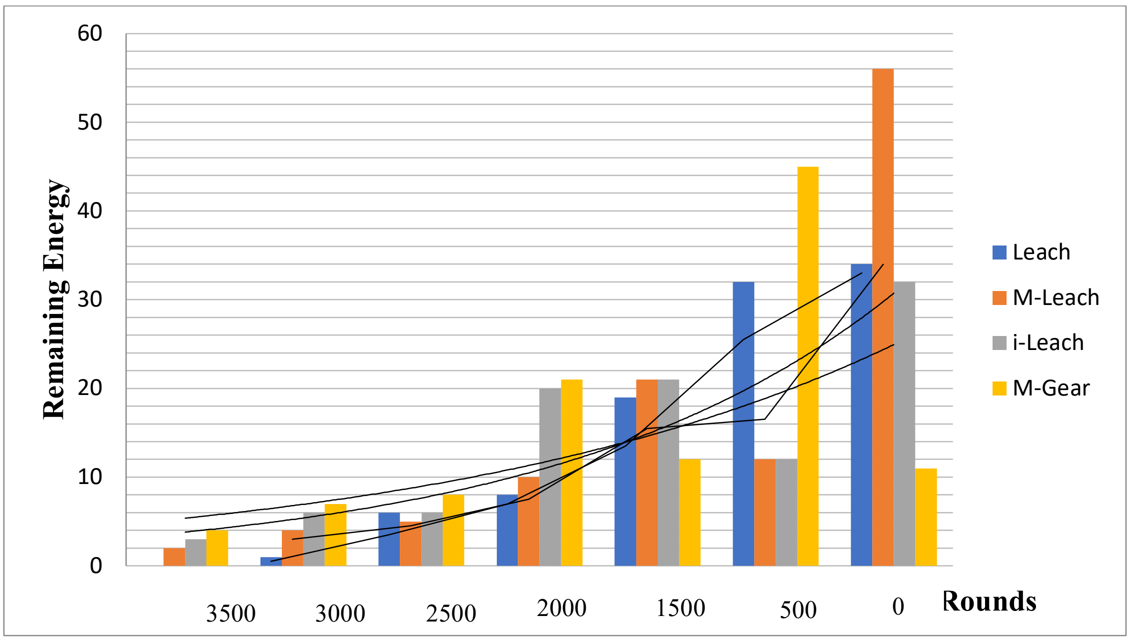

Fig. 6: Energy consumption (Energy versus Rounds)

The energy variance (EV), which is shown in Figure (6), shows the difference in the amount of residual energy that each node in the network has. This difference may be affected by a variety of characteristics, such as distribution, sensor location, and interest rate. The shape conveys information that is more specific and easily accessible on the load distribution taking place inside the network. In point of fact, the network's strength is more evenly distributed and better maintained when the cost is lower and the curve volatility is also lower. As a consequence of this, the M-Leach technique has the most favourable results, as measured by the constructive impact of sink mobility.

6. Conclusion

In recent years, the growth of WSNs in supporting a wide variety of programmes has motivated academics and garnered broad interest. As a result, routing responsibilities in WSNs have become one of the most active and challenging study topics. Through the utilisation of our taxonomy, we categorised the most recent mainstream proposed protocols into a variety of distinct classes of protocols. These classes include the following: software type, delivery mode, initiator of communication, community architecture, path established order (direction discovery), community topology (shape), protocol operation, and so on. The obtained results demonstrate that the i-Leach and M-Gear protocols extend the lifetime of the network in comparison to other protocols. This led us to the conclusion that the utilisation of intelligent strategies not only extends the lifetime of the network but also ensures better protection within the sensing location.

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