Review of Various Energy Efficient Protocols of Wireless Sensor Networks

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Abstract - The energy consumption is the major factor in sensor networks due to the simple, enduring, and resilient implementation of these networks to the topology or configuration changes. The cost of energy of a network is affected with these factors and its performance metrics represent these factors. The clustering are the energy efficient protocols which reduce energy consumption of WSN. In the clustering methods network will be divided into clusters and cluster head get selected in each cluster. In this paper, it is analyzed that with the increase in the level of protocol the energy consumption get reduced.

Keywords - WSN, Clustering, Cluster Head, LEACH, I-LEACH

I. INTRODUCTION

At present, WSNs (wireless sensor networks) are employed in the areas of wireless communications, computer networks and circuit systems. In these days, houses, buildings, parks and, cities generally make the utilization of various electronic devices working with different wireless technologies. The efficient integration of standards and protocols is determined through the kind of application. The energyrequirements are the major features of these wireless devices [1,2,3]. The devices comprised in WSN are classified as:small nodes, lower energy consumption, finite battery life, lower task processing and less storage capacity. Theseself-configuring networks can be easily executed and exploited. These networks employchannels with multiple interferences and computing capabilities for being operated at low energy in order to access the communications. Sensor networks provide an optimal performance with mitigated delays and provide reliable information at minimal energy utilization for offering valuable information for long periods. The powerconsumption is a main issue due to the low-battery power. The nodes must have longer duration foravoiding constant human intervention because of the harsh environment of some of their applications including the study of natural behaviour, risk areas, clinical industry, robotics, agriculture, battlefields and home networks [3,4].

The energy consumption is the major factor in sensor networks due to the simple, enduring, and resilient implementation of these networks to the topology or configuration changes.The cost of energy of a network is affected with these factors and its performance metrics represent these factors. In the WSN application, the acquisition node is capable of transmitting the data to the sinkin direct way or in multi-hop mode. The energy consumption of nodes is defined as the number and distance of data transmission [5,6]. Nodes that are located outside the sink or have to accomplish more forwarding tasks are utilized more energy as compared to other nodes due to which imbalance is occurred among energy andthe energy of some nodes is exhausted earlier. A major research in WSNs is focused on dealing with the issue of energy imbalance. For this, clustering routing protocol can be implemented. The clustering protocol concentrates on splitting all the acquisition nodes into several clusters. The CH (cluster head) is employed to gather the data in the cluster and forward to the sink [7,8]. The CH performs muchtask for transmitting the data, thus, more energy is consumed by them in comparison with other nodes. Clustering protocol assist in enhancing the energy imbalance in wireless sensor network (WSN). Generally, the cluster-based routing algorithms make the deployment of sensor nodes in efficient manner in the network in contrast tonon-clustering protocols [9,10].A cluster leader known as the CH is exploited to remove the correlated data for diminishing the final data volume. Thereafter, the aggregated data is forwarded to the sink by cluster head. Thecluster-based routing algorithms include the partition of sensor nodesinto various clusters for alleviating the energy consumption to accomplish long distance communication. The overall energy consumption is decreased and the workload due to which the large difference is occurred in the energy depletion amid the CHs and other nodes is balanced. Thus, clustering is an energy-efficient solution to prolong the durationof network and enhance the energy efficiency [11,12]. In addition,most clustering protocols select the CH optimally for avoiding the earlier death of the sensor nodes and extending the life span of the network.The operation of clustering protocol in a WSN is shown in Figure 2.

The nodes are partitioned into two clusters. The cluster heads are CH1 and CH2. For Node A, the clustering protocols such as EEUC (the Energy-Efficient Uneven Clustering), send its data along the path of A-CH1-CH2-BS, and reaches at the base station after two hops [13,14]. Apparently, The AC-BS path of data transmission consumes the least overall energy, in view of the overall energy consumption of the framework. Likewise, in the clustering

protocol, node B relates to the CH2 cluster, and its data communication path is B-CH2-BS.

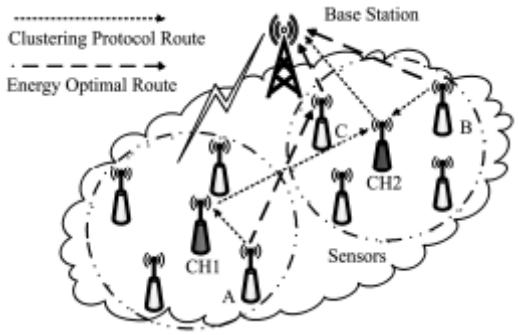

Figure 2. Route of clustering protocol in wireless sensor network

However, if node B sends data directly to BS, the overall energy could be saved. In some cases, the clustering protocol unavoidably increases the number of hops and the overall transmission distance from the acquisition node to the base station, resulting in the consumption of the total energy of the network [15,16]. LEACH(Low Energy Adaptive Clustering Hierarchy)algorithm is a typical clustering routing algorithm. The nodes in the cluster are responsible for gathering data and forwarding the data to CH using which the data is integrated and directly transmitted to the sink. A value is taken from 0-1 at randomthrough each node in WSN. If the randomly selected value by the node is lower than the threshold value$T(n)$, the selection of node is done as the CH.The expression to compute the threshold value $T(n)$ is expressed as:

$$T(n) = \begin{cases} \dfrac{p}{1 - p \times mod(r, 1/p)} & n \in G \\ 0 & \end{cases}$$

where$p$ defines the proportion of CH nodes in all the nodes of the WSN; $mod(r, 1/P)$ denotes the number of CH nodes whose selection is done in current round of circulation [17,18]. The set of the unselected CH nodes is represented by G in current 1/ p round; r is the round of the network. The design of $T(n)$has potential for balancing the energy consumptions of various nodes in the cluster. Theconcept of clustering and periodic data gathering is considered by the Low Energy Adaptive Clustering Hierarchy algorithm that leads to lessen the data transmission among the nodes and the sink. Thus, this protocol assists in mitigating the energy loss as well as prolonging the duration of network.Power-Efficient Gathering in Sensor Information Systems (PEGASIS)is a chain-based protocol and an improvised adaptation of LEACH protocol [19,20]. Each node in PEGASIS establishes communication only with a neighbouring node to transfer and obtain data. It transmits alternately to the base station, thus reducing the volume of energy consumed in every round.The nodes are arranged to form a chain. The sensor nodes either do this themselves through a greedy algorithm initiating at some node, or the base station can measure this chain and transmit it to all sensors. The Threshold Sensitive Energy Efficient Sensor Network Protocol (TEN) is a hierarchical protocol which is developed to measure the sudden changes in environmental conditions. Accountability is significant for time-based applications, in which the network operates in a reactive mode [21,22]. In TEEN, the design of a sensor network relies upon on a hierarchical group where neighbouring nodes create clusters and the process moves to another level until it reaches the sink. The cluster-head transmits hard threshold (HT) and soft threshold (ST) to its members in this approach. HT denotes a threshold value for the sensed property. This is the ultimate value of the propertyoutside which, a node sensing this value should activate its transmitter and report to its CH (Cluster Head) [23,24]. There is a small change in the value of the ST sensory characteristic that triggers the node to activate its transmitter and broadcast.The nodes sense their environmental conditions continually.The first time a parameter from the feature set reaches its hard threshold level, the node activates its transmitter and broadcasts the sensed data. Then, the sensed value is stored in an internal variable in a node. Adaptive Threshold sensitive Energy Efficient sensor Network (APTEEN) is an updated version of TEEN. The main objective of this protocol is to capture periodic data collections and react to time-crucial episodes [25,26]. The moment the base station creates the cluster, the CHs transmit the features, threshold values, and communication schedules to each node in the network. The CHs then carry out data aggregation, resulting in energy savings.In the VGA (Virtual Grid Architecture) routing (VGA) combines data aggregation with in-network processing for attaining energy efficiency and increasing the duration of network. There are two stages of entire technique:clustering and routing of aggregated data. The initial stage focuses on arranging the sensors in a fixed topology due to the necessity ofstationary sensors in most of the applications [27,28]. A CH called local aggregatoris implemented to carry out the aggregation in every cluster.The global or in-cluster aggregation is done by selecting asubset of this LA (Local Aggregator) and its members are calledMA (master aggregator). In the second stage, TTDD (Two-Tier Data Dissemination) protocol makes the hypothesis that the sensor nodes are static and location aware and the base stations can change their location in dynamic manner. When the sensors sense an event, one sensor acts as thesource that for producing data reports [29,30]. Thereafter, the virtual grid structure is developed and the source node initiates it. This structure considers itself as a start crossing point of a grid.A data announcement message is forwarded to its 4 different adjacent crossing points with the help of greedy geographical forwarding in this approach. The message stops after reaching at a node which is located nearer to the crossing point. This process is going on tilltransmission of the message to the boundary of the network.

II. LITERATURE REVIEW

Haneul Ko, et.al (2019) suggested an EU-OCA (energy utilization-aware operation control algorithm) for mitigating the energy outage probabilities of sensor nodes (SNs) when the energy utilization of the main grid was maintained [31]. Theactive as well as sleep modes and the transmission powers of renewable energy-based sinks were determined using a controller. For this, the statistical information related to the energy arrival of sinks and the energy consumed by the sensor nodes was considered. The evaluation results depicted that the suggested algorithm provided greater life span in comparison with other algorithms when the energy consumption was balanced.

Ali Abdul-Hussian Hassan, et.al (2020) introduced an IEECP (improved energy-efficient clustering protocol) for prolonging the duration of the WSN (Wireless Sensor Network) [32]. Initially, the overlapping balanced clusters were verified usingan optimal number of clusters. Subsequently, the balanced-static clusters were created depending upon the modified FCM (fuzzy C-means) algorithm for alleviating and balancing the energy consumed by the sensor nodes. Finally, the selection of CHs (cluster heads) was done inoptimal locations. The introduced protocol was capable of diminishing the energy utilized by nodes and maximizing the life span of network. The results revealed the superiority of introduced protocol over the traditional algorithm.

Chuan Xu, et.al (2019) developed a newER-SR (energy efficient region source) routing algorithm.ADER (distributed energy region) algorithm was put forward for selecting the nodes with high residual energy in the wireless sensor network [33]. Afterward, the optimal source routing path was computing for each common node using thesource routing nodes. Using this,the partial nodes were entered in the routing process and the energy consumption of sensor nodes was balanced. In addition, an effective distance-based ACO (ant colony optimization) algorithm was put forward for decreasing the energy consumed by nodes so that the global optimal transmission path was searched for each node. The simulation results indicated that the developed algorithm provided superior energy efficiency and enhance the duration of network, PDR (packet delivery ratio) and delivery delay in contrast to other routing protocols in WSNs.

Wei-Chang Yeh, et.al (2020) established a novel bSSO (bi-objective simplified swarm optimization) algorithm in which the concepts of simple routing, SSO and crowd distance were utilized [34]. Eight parameter settings were considered to conduct the experiments on 10WSN benchmarks so that the established algorithm was proved applicable. The experimental results revealed that the established algorithm was capable of mitigating the energy consumed by nodes and prolonging the duration of network as compared to other algorithms.

Sudhir Kumar, et.al (2018) presented the compartmental model-based cluster size optimization for which opportunistic signals were employed in WSN (wireless sensor network) [35].The variation of opportunistic signal power was defined with the propagation distance using this model. The energy utilization was decreased by evaluating theoptimal number of clustersfor different orders of the Taylor series expansion of the compartmental model. The second-order Taylor series expansion had performed well. A theoretical analysis was carried out on the basis of metrics in the experiments.

S. M. Mahdi H. Daneshvar, et.al (2019) designed a novel technique named GWO (grey wolf optimizer) for selecting the cluster heads (CHs) [36]. The CHs were selected using these solutions on the basis ofthe predicted energy consumption and current residual energy of each node. The similar clustering was utilized in multiple consecutive rounds for enhancing the energy efficacy. Consequently, the energy was saved for reforming the clustering using this protocol.A new dual-hop routing algorithm was executed for CHs and proved that the designed technique provided minimum and balanced energy consumption. The evaluation results exhibited that the designed technique assisted in enhancing the duration of network as compared to other protocols.

Cheng Zhan, et.al (2019) projected an efficient iterative algorithm for mitigating thepower utilization for which the block-coordinate descent and successive convex optimization methods were implemented [37]. A low-complexity and systematic initialization technique was put forward for the trajectory design and allocating the transmission bits on the basis of trade-off structure on the number of visited sensor nodes to accomplish the estimation. The extensive simulation results indicated that the projected algorithm was efficient with regard to energy consumption in contrast to other benchmark techniques.

Weiwei Shi, et.al (2019) investigated an ADCOCDS (Adding Duty Cycle Only in Connected Dominating Sets) in order to alleviate the energy consumed by nodes and network delay [38]. A part of nodes was selected as a connected dominating set and the mode of duty cycle was adopted using these nodes. The radio transmitter was turned off for savingthe energy in case of no data for transmission.The duty cycle of nodes was maximized in accordance with their energy consumption for decreasing the delay. The results of experiments validated that the investigated algorithm was applicable for lessening the power utilization from12.09%-43.17% and delay up to 21.85%-57.96%.

Xinlu Li, et.al (2019) intended a new EBAR (Energy-Efficient Load Balancing Ant-based Routing Algorithm) for WSNs (Wireless Sensor Network) [39].A pseudo-random route discovery algorithm and an improved pheromone trail update system were utilized for balancing the energy consumed throughthe sensor nodes. In the end, the energy consumption was mitigated using an energy-based opportunistic broadcast technique. The results depicted that the intended algorithm attained a significant enhancement as comparedto the existing techniques with regard to energy consumption, delay.

Endong Tong, et.al (2020) suggested an energy-aware QoS-guaranteed workflow management technique [40]. Initially, a novelQoS model was implemented for enhancing the QoS evaluation. Later on, an adaptation system was utilized to balance the energy utilization. At last, the local service was selected effectively. The experimental results demonstrate the suggested approach was applicable for diminishing the energy consumed by nodes and prolonging the life span of network.

Table 1: Comparison Analysis

Author	Year	Description	Outcome
Haneul Ko	2019	An EU-OCA (energy utilization-aware operation control algorithm) for mitigating the energy outage probabilities of sensor nodes	The evaluation results depicted that the suggested algorithm provided greater life span in comparison with other algorithms when the energy consumption was balanced.
Ali Abdul-Hussian Hassan	2020	An IEECP (improved energy-efficient clustering protocol) for prolonging the duration of the WSN (Wireless Sensor Network). Initially, the overlapping balanced clusters were verified usingan optimal number of clusters	The results revealed the superiority of introduced protocol over the traditional algorithm.
Chuan Xu	2019	A new ER-SR (energy efficient region source) routing algorithm. ADER (distributed energy region) algorithm was put forward for selecting the nodes with high residual energy in the wireless sensor network	The simulation results indicated that the developed algorithm provided superior energy efficiency and enhance the duration of network, PDR (packet delivery ratio) and delivery delay in contrast to other routing protocols in WSNs.
Wei-Chang Yeh	2020	A novel bSSO (bi-objective simplified swarm optimization) algorithm in which the concepts of simple routing, SSO and crowd distance were utilized [34]. Eight parameter settings were considered to	The experimental results revealed that the established algorithm was capable of mitigating the energy consumed by nodes and prolonging the duration of network as compared to other algorithms.
Sudhir Kumar	2018	The compartmental model-based cluster size optimization for which opportunistic signals were employed in WSN	The second-order Taylor series expansion had performed well. A theoretical analysis was carried out on the basis of metrics in the experiments.
S. M. Mahdi	2019	A novel technique named GWO (grey wolf optimizer) for selecting the cluster heads (CHs) [36]. The CHs were selected using these solutions on the basis ofthe predicted energy consumption and current residual energy of each node	The evaluation results exhibited that the designed technique assisted in enhancing the duration of network as compared to other protocols.
Cheng Zhan	2019	An efficient iterative algorithm for mitigating the power utilization for which the block-coordinate descent and successive convex optimization methods were implemented	The extensive simulation results indicated that the projected algorithm was efficient with regard to energy consumption in contrast to other benchmark techniques.

III. CONCLUSION

Wireless sensor networks are employed in the areas of wireless communications, computer networks and circuit systems. In these days, houses, buildings, parks and, cities generally make the utilization of various electronic devices working with different wireless technologies. The efficient integration of standards and protocols is determined through the kind of application. The various energy efficient protocols are proposed in the previous year which are based on the clustering methods. In this paper, it is concluded that with the increase in the hierarchy of the protocol energy consumption get reduced for the data aggregation.

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