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Research Paper

WCA FOR ENERGY SAVING CLUSTER HEAD ELECTION IN QOS ENHANCED BASE STATION CONTROLLED DYNAMIC CLUSTERING PROTOCOL

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A standard Wireless Sensor Network comprises of a huge number of sensor nodes with data processing and communication capabilities. The sensor nodes pass the gathered data using radio transmitter, to a sink either straightforwardly or through other nodes in a multi-hop approach. Wireless sensor network is a power consuming system, since nodes performs on restricted power batteries which decreases its lifetime. Well-organized energy routing protocol is extremely vital technique in wireless sensor networks since sensor nodes are exceedingly energy based. Therefore, numerous routing protocols for sensor networks have been developed, particularly routing protocols based on clusters protocols. The usage of cluster based routing has numerous advantages like reduced control messages, re-usability of bandwidth and most importantly better power control. The cluster heads, which form a leading set in the network, choose the topology and are in charge for its stability. In this paper, a Weighted Clustering Algorithm (WCA) was used in QoS Enhanced Base Station Controlled Dynamic Clustering Protocol (QBCDCP) which considers the ideal degree, transmission power, battery power and mobility of a mobile node. The simulation result shows that the proposed approach has more number of alive nodes than the existing technique.

Keywords: Wireless sensor network, QBCDCP, Cluster Head Election, Weighted Clustering Algorithm (WCA), Energy efficiency

INTRODUCTION

Recently there has been a tremendous improvement in the growth and development of Wireless Sensor Networks (WSN). WSN has been used in several application areas consist of environmental, medical, armed forces, transportation, entertainment, and smart spaces (Puneet Garg *et al.*, 2011).

Additionally, the major advantage of the WSN is that considerably reducing the

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installation costs, wireless sensor networks have the capability of dynamically adjust to changing atmosphere. Adaptation method can react to transformations in network topologies or can make the network to alter between significantly different modes of operation. For illustration, the same network which performs leak monitoring in a chemical industrial unit possibly will be reconfigured into a network intended to localize the starting place of a leak and follow the diffusion of poisonous gases. The network (Feng *et al*., 2005) could then guide the workers to the safest way for emergency evacuation.

It is to be noted that distributed systems are wired, have limitless power, are not instantaneous, have user interfaces, for instance, screens and mice, have a permanent set of resources, treat every node in the system as extremely significant and are location independent. On the contrary, wireless sensor networks are the systems which are wireless, have limited power, are real-time, make use of sensors and actuators as interfaces, have dynamically shifting sets of resources, aggregate behavior is significant and location is vital. A lot of wireless sensor networks also make use of minimal capacity devices which places an additional difficulty on the ability to use past solutions.

At present the wireless networks only dependent on the wired backbone through which each and every base station are linked, means that networks are permanent and constrained to a physical area within a pre-defined boundary. The implementation of such wireless network consumes time and cannot be set up in times of extreme emergency. Such circumstances require a network in which all the nodes comprising the base stations are potentially mobile and communication must be supported untethered among several two nodes.

Multi-cluster, multi-hop packet radio network structural designs for wireless systems must be capable of dynamically adjust itself with the varying network configurations (Li *et al*., 2005). Certain nodes, recognized as cluster heads, are in charge of the construction of clusters (equivalent to cells in a cellular network) and preservation of the topology of the network. A group of cluster heads is called as a dominant set. A cluster head carry out the resource distribution to all the nodes belonging to its cluster. Because of the dynamic character of the nodes, their association and dissociation to and from clusters disturb the stability of the network and consequently reconfiguration of cluster heads is inevitable.

QBCDCP is an improved version of BCDCP with the recently added functionality of QoS dependent route selection. QoS (Cano-Tinoco and Fapojuwo, 2007) is maintained in QBCDCP by including delay and bandwidth detail in route selection. Performance of QBCDCP is provided on the basis of energy consumption and end-to-end image delay by means of analytical and simulation approaches (Yanyan Zhuang Jianping Pan and Guoxing Wu, 2009), permitting the selection of network parameters that optimize energy consumption for all nodes in the network.

In this approach, a weighted clustering algorithm (WCA) is used in QBCDCP. The performance of the proposed approach is evaluated by considering a multi-hop wireless sensor network that includes significant network operational feature, the energy spent while performing the sensing tasks.

RELATED WORKS

The QBCDCP protocol presented by Abraham Fapojuwo (2009) is similar to the approaches in Akkaya and Younis (2004) and Mahapatra, *et al*. (2006) by being both energy-aware and delay-constrained, but is this approach has some uniqueness from all the above mentioned techniques:

i. QBCDCP protocol uses cluster-based network architecture and a rotating head clustering technique to guarantee less energy consumption by the sensor nodes to extend their life span.

ii. QBCDCP integrates the bandwidth metric in choosing the QoS route. Multimedia applications need both bandwidth guarantees and delay guarantees. Thus, bandwidth guarantees are very vital for the future for multimedia applications through WSNs (Misra *et al*., 2008).

The clustered network architecture in BCDCP (Li *et al*., 2005) forms the basis of QBCDCP. But, the routing protocol implemented in QBCDCP is an improvement of that of BCDCP by adding the QoS metrics of bandwidth and delay, in addition to energy metric used in BCDCP. The problem of scalability is resolved with cluster-based routing protocols via a suitable choice of the time interval between successive re-clustering operations.

The principles energy optimization with multi-level clustering algorithm for wireless sensor networks is presented by Ghazvini *et al*., (2007); and Rasid *et al*., (2007). In order to minimize the amount of data transmission from the energy efficiency perspective, clustering approach is featured by routing algorithm used in the wireless. But, the clustering approach results in high energy consumption at the cluster head node. Dynamic clustering is an approach used to resolve such a problem by distributing energy consumption through the re-selection of the cluster head node. Still, dynamic clustering alters the cluster structure every time the cluster head node is re-selected, which causes energy consumption. In other words, the dynamic clustering techniques observed in previous studies involve the repetitive processes of cluster head node selection. This takes a high amount of energy during the set-up process of cluster generation. To resolve the energy consumption problem associated with the repetitive set-up, this paper proposes the round-robin cluster header (RRCH) method that fixes the cluster and selects the head node in a round-robin method. The RRCH approach is an energy-efficient method that realizes consistent and balanced energy consumption in each node of a generated cluster to prevent repetitious set-up processes as in the LEACH method. The propriety of the proposed approach is substantiated with a simulation experiment.

WSNs are poised by battery supplied nodes. Node lifetime is the time when there is good functioning of the node, before battery depletion. The needed radio output power level to guarantee consistent connectivity among them is decided by the distances between nodes, which influences node battery current consumption. If certain node runs out, it could build defective network function. Thus, it is very vital to execute a deployment which guarantees longer node lifetime; but, this issue is a very forced and non-lineal. In this paper, Barboni and Valle (2008) presented a heuristic approach for searching network deployments. The algorithm identifies number of nodes, nodes distances and nodes output power level to present a deployment that achieves highest battery duration and satisfies user specifications.

In WSNs, frequent extraction of data from the networks for later analysis is very important. But, correct data extraction all sensor readings is not easy and is very expensive and moreover it is not necessary that the readings themselves only denote samples of the true state of the world. Clustering and prediction approaches which make use of spatial and temporal correlation among the sensor data minimize the energy consumption of continuous sensor data collection. Incorporating clustering and prediction approaches makes it important to devise a new data collection approach, in order to attain network energy efficiency and stability. Hongbo Jiang *et al.* (2011) presented an energy effective structure for clustering based data collection in WSNs by incorporating adaptively enabling/disabling prediction approach. A cluster head denotes all sensor nodes in the cluster and gathers data values from them.

METHODOLOGY

Wireless Sensor Network Model

The network model assumed in this study was characterized as follows:

(a) The wireless sensor network is considered that contains *M* sensor nodes in scattered manner in a sensor field. The operation situation is illustrated in Figure 1, here the sensor field is a square area of side *L* at a distance d_{bs} from a lone fixed base-station.

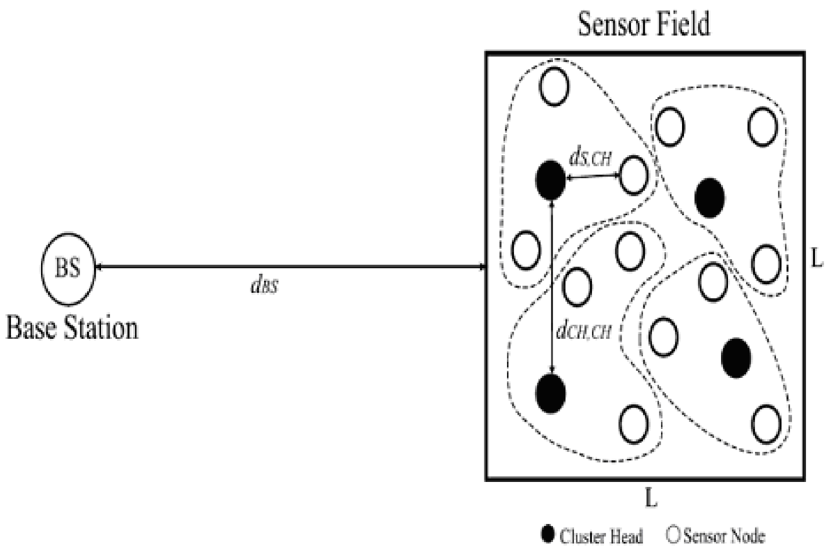
(b) The *M* sensor nodes are provided with restrictions in battery power, processing power and memory space.

(c) The *M* sensor nodes are fixed and are grouped physically into clusters. The nodes in a cluster may possibly carry out any of the two functions: cluster head or sensing. Every cluster head carry out functions like scheduling of intra cluster and inter cluster communications, data aggregation and data forwarding to the base station with the help of multi-hop routing. Conversely, a cluster head node cannot carry out the sensing process. The purpose of cluster head is rotated between the non-sensing nodes in a cluster. Alternatively, a sensing node will be dynamically sensing the situation or in the inactive mode if it is not sensing. The nodes to be used for sensing tasks are decided by the base station.

(d) The data sensed by the sensing nodes in a cluster are broadcasted straightly to their cluster head that afterwards aggregates and/or pass the data to another cluster head which will direct it to the base station. Different from the sensor nodes, the base station is not with the restricted resources. Thus the communication from the base station to the sensor nodes can be performed straight forwardly.

(e) The base station has information of the position of every node in the network that is situated within the sensor field.

Figure 1: Example Wireless Sensor Network Model



QoS Enhanced Base Station Controlled Dynamic Clustering Protocol (QBCDCP) assume homogeneity in sensor node capability and constraints due to its simplicity of its deployment and investigation, and for reliability with most of the offered work in routing for wireless sensor network.

But there are several applications that would advantage from QoS routing for networks with homogeneous nodes, and methods presented here to realize satisfactory QoS and lesser consumption of energy may also be appropriate to the construction of protocol handling with heterogeneous networks. The supposition of immobile nodes is based on the detail that, for several applications, sensor nodes will be fixed at certain position after deployment, because the energy necessary to offer mobility to such nodes is unaffordable.

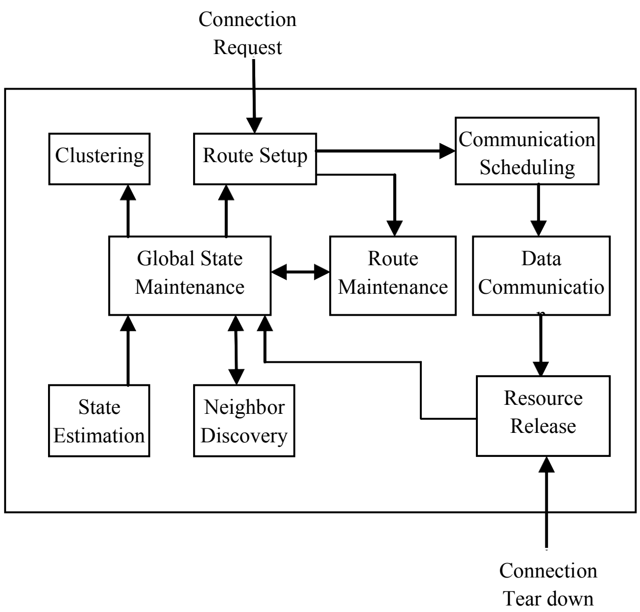
QoS Enhanced Base Station Controlled Dynamic Clustering Protocol

QBCDCP is an improved technique of BCDCP with the recently added functionality of QoS based route selection. QoS is maintained in QBCDCP by including delay and bandwidth detail in route selection. Also the energy necessary for transmission is considered here. The functional components of QBCDCP and the associations among them are depicted in Figure 2. Every data round, specified by a fixed time interval t_{DR}, the base station groups the sensor nodes into balanced clusters with the help of weighted clustering algorithm (WCA) (Yanyan Zhuang Jianping Pan and Guoxing Wu, 2009).

Clustering Process

A cluster head possibly will not be capable of handling a huge number of nodes because of resource restrictions even if these nodes are its neighbors and ranges well inside its transmission range. As a result, the load handling ability of the cluster head puts a higher bound on the node-degree. In other words, just wrapping the area with the least number of

Figure 2: QoS Enhanced Base Station Controlled Dynamic Clustering Protocol



cluster heads will put more loads on the cluster heads. Simultaneously, additional cluster heads will lead to a computationally costly system. This might provide high-quality throughput, but the data packets have to go through multiple hops resulting in elevated latency. In general, selecting a best possible number of cluster heads which will provide high throughput, however incur as little latency as possible, is still a significant difficulty. At the same time as the exploration for enhanced heuristics for this trouble continues, hence the utilization of a combined weight metric that considers a number of system parameters like the ideal node-degree, transmission power, mobility and the battery power of the nodes.

In a Wireless Sensor Networks where the entire nodes divide the equivalent responsibility and act as cluster heads. On the other hand, more cluster heads produces additional number of hops for a packet when it acquires routed from the source to the destination, because the packet has to go through larger number of cluster heads. Therefore this result leads to superior latency, additional power consumption and more information processing for each node. Also, to make the most of the resource consumption, the least number of cluster heads are used to cover the entire area over which the nodes are distributed. The entire area can be divided into zones; the size of each zone can be decided by the transmission range of the nodes. This can put a lesser bound on the number of cluster heads necessary. To achieve this lesser bound, a consistent distribution of the nodes is essential over the complete area. In addition, the sum of nodes for each unit area must be limited in order that the cluster head in a zone can handle all the nodes therein. On the other hand, the zone based clustering is not a feasible solution because of the following reasons.

The cluster heads would characteristically be centrally situated in the zone, and when they travel, new cluster heads have to be chosen. It may so occur that not any of the other nodes in that zone are centrally situated. As a result, to discover a new node which can operate as a cluster head with the additional nodes inside its transmission range might be complicated. An additional difficulty occurs because of non-uniform distribution of the nodes over the entire area. If a certain zone develops into a thickly populated then the cluster head possibly will not be competent to manage all the traffic produced by the nodes because there is a natural limitation on the number of nodes a cluster head can handle. Hence, this paper is proposed to choose the least number of cluster heads which can maintain all the nodes in the system satisfying the above restrictions.

Basis of the Proposed Algorithm

To make a decision how well suitable a node is to be a cluster head, its degree, transmission power, mobility and battery power are considered. The following characteristics are taken into consideration in this weighted clustering algorithm (WCA) (Mainak Chatterjee *et al.*, 2000).

- The cluster head election process is not periodic and invoked as not often as achievable. This diminishes system updates and consequently computation and communication costs.
- Every cluster head can perfectly support M (a pre-defined system threshold) nodes to guarantee well-organized MAC functioning. An elevated throughput of the system can be attained by limiting or optimizing the number of nodes in all clusters.
- The battery power can be resourcefully used inside the certain transmission range. Utilization of the battery power is added when anode acts as a cluster head rather than a normal node.
- Mobility is a significant feature in choosing the cluster heads. Reaffiliation takes place when one of the normal nodes moves out of a cluster and links another existing cluster. In this scenario, the quantity of information exchange among the node and the equivalent cluster head is local and comparatively small. The information update in the event of a change in the dominant set is greatly more than a reaffiliation.
- A cluster head is capable of communicating enhanced to its neighbors if they are nearer to the cluster head inside the transmission range. This is because of signal attenuation with rising distance.

Proposed Algorithm (WCA)

Based on the previous characteristics, QBCDCP uses an algorithm which efficiently integrates all the system parameters with certain weighing factors, the values of which can be selected based on the system requirements. For instance, power control is incredibly vital in Wireless Sensor networks, as a result the weight of that feature can be made bigger. The flexibility of varying the weight factors assists in applying this algorithm to different networks. The process for cluster head selection is provides below. The result is a group of nodes (dominant set) which generates the cluster heads for the network. In accordance with the information, the number of nodes that a cluster head can manage perfectly is M. The cluster head election procedure is called upon at the point of system establishment and also when the current dominant set is not capable of covering all the nodes.

Cluster Head Election Procedure

Step 1: Obtain the neighbors of all nodes v (i.e., nodes inside its transmission range). This provides the degree, d_v, of this node.

Step 2: Compute the degree-difference, $D_v = |d_v - M|$, for every node .

Step 3: For every node, compute the sum of the distances, P_v, with all its neighbors.

Step 4: Compute the running average of the speed for every node. This gives a measure of mobility and is denoted by M_v.

Step 5: Compute the time T_v, of a node v, during which it acts as a cluster head.Indicates how much battery power has been consumed since we assumed that consumption of battery power is more for a cluster head than for an ordinary node.

Step 6: Calculate a combined weight $I_v = c_1D_v + c_2P_v + c_3M_v + c_4T_v$, for each node v. The coefficients c_1, c_2, c_3 and c_4 are the weighting factors for the corresponding system parameters.

Step 7: Select the node with a least to be the cluster head. The entire neighbors of the selected cluster head can no longer take part in the election algorithm.

Step 8: Reiterate Steps 2 to 7 for the remaining nodes not y*et al*located to any cluster.

System Activation and Update Policy

When a system is bringing up, each node broadcasts its id which is scheduled by all other nodes lying within's transmission range, . It is implicit that a node getting a broadcast from an additional node can approximate their common distance from the power of the signal received. Consequently, all nodes are prepared responsive of its adjacent nodes and their subsequent distances. Note that these adjacent nodes are simply the geographical neighbors and do not essentially indicate neighbors in the similar cluster. Once the adjacent nodes list is completed, WCA algorithm decides the cluster head for the first time. All nodes keep a record of its condition. If it is a non-cluster head node, then it is supposed to recognize the cluster it corresponding to and the related cluster head.

As a result of the dynamic character of the system considered, the node in addition with the cluster heads is likely to move in dissimilar directions, thus disorganizing the stability of the configured system. As a result, the system has to be reorganized from time to time. The update possibly will result in development of new clusters. It might also effect in nodes varying their point of attachment from one cluster head to an additional inside the existing dominant set, which is called reaffiliation. The regularity of update and consequently reaffiliation is a significant concern. If the system is reorganized periodically at a high frequency, then the newest topology of the system can be utilized to discover the cluster heads which will provide a good dominant set. On the other hand, this will lead to elevated computational cost resulting in the loss of battery power or energy. If the regularity of update is low, there are probabilities that current topological information will be lost resulting in sessions completed in the middle.

Every node in any WSN periodically exchange control information with the base station [4]. Equivalent idea is applied here, in which all the nodes constantly observe their signal strength as obtained from the cluster head. When the mutual separation among the node and its cluster head rises, the signal power diminishes. In that case, the Wireless sensor network has to report its current cluster head that it is no longer capable of attach itself to that cluster head. The cluster head attempts to handover the node to an adjacent cluster, this method being called a reaffiliation. The cluster head of the reaffiliated node renews its member list. If the node goes into a region not covered by any cluster head, then the cluster head election algorithm is called and the fresh dominant set is achieved.

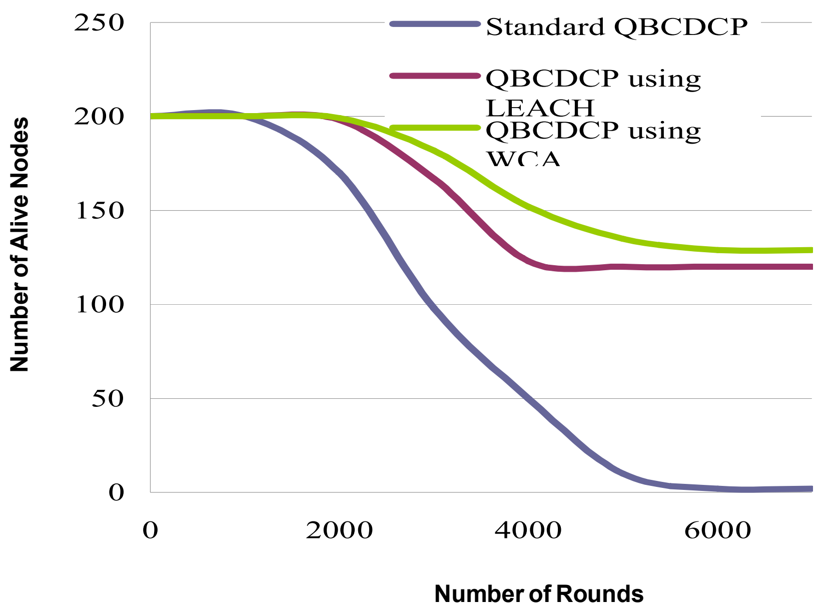
The purpose of the cluster head election algorithm is to reduce the number of alterations in dominant set update. Once the adjacent nodes lists for all nodes are generated, the degree-difference is calculated for each node . Also, is computed for each node by summing up the distances of its neighbors. The mobility is calculated by averaging the speed of the node. The total amount of time, it remained as a cluster head is also calculated. All these constraints are normalized, which implies that their values are made to lie in a pre-defined area. The corresponding weights or are kept fixed for a given system. The weighing factors also provide the flexibility of altering the efficient contribution of all the parameters in determining the combined weight. For example, in a system where battery power is more important, the weight associated with can be made higher. It is to be taken that the amount of these weighing factors is 1. The node with the least total weight,.is chosen as a cluster head. The chosen cluster head and its adjacent nodes are no longer adequate to take part in the remaining part of the election procedure. The election procedure is reiterated with the anticipation of every node is established to be either a cluster head or a neighbor of some cluster head.

EXPERIMENTAL RESULTS

The multi-hop wireless sensor network considered for the simulation consists of 200 nodes distributed randomly across an area of 100x100 meters. Every node is prepared with an energy source whose total amount of energy accounts for 1 J at the starting of the simulation. Each node transmits a 200-bit message per round to its actual cluster head.

Figure 3 shows the simulation result comparison for the standard QBCDCP method, QBCDCP using LEACH and the proposed method using WCA. From the graph, it can be observed that initially there are 200 nodes in the network before starting execution. After 1000 rounds of execution, the number of alive nodes for the standard QBCDCP using LEACH and the proposed method using WCA are same, i.e., 200. When 2000 executions are completed, the number of alive nodes for the standard QBCDCP method is 170, 198 nodes remains by using the QBCDCP using LEACH whereas 199 nodes remains by using the proposed method using WCA. After 3000 executions are completed, 182 nodes remaining by using the proposed technique and only 167 nodes are remaining by using the QBCDCP using LEACH and 98 nodes are remaining by using the Standard QBCDCP. When 4000

Figure 3: Number of Alive Nodes Per Round



executions are completed, the number of alive nodes for the Standard QBCDCP is 50 and 123 for the QBCDCP using LEACH, whereas, 152 nodes remains by using the proposed technique. When 6000, executions are completed, all the nodes in the network were dead, whereas, still 120 nodes remains by using the QBCDCP using LEACH for routing and 135 nodes remaining by using the proposed technique. This clearly indicates the less energy consumption by using the proposed QBCDCP using WCA protocol for routing when compared to the existing methods.

CONCLUSION

Wireless sensor networking is a rapidly growing subfield in the field of wireless networking. It is very vital technology for the upcoming future. In this paper, WCA was used for carrying out the clustering process in QBCDCP in which weighted clustering algorithm (WCA) is dynamically adjust itself with the constantly changing topology of Wireless sensor networks. The WCA has the flexibility of handing over different weights and considers a combined outcome of the ideal degree, transmission power, and mobility and battery power of the nodes. The algorithm was carried out only when there is a requirement, i.e., when a node is no longer capable of attaching itself to any of the existing cluster heads. The proposed system performs considerably better than both of the standard QBCDCP method, QBCDCP using LEACH. The simulation results showed that the proposed QBCDCP using WCA technique results in more number of live nodes when compared to the existing techniques. This obviously represents the lesser energy consumption with the use of the proposed WCA clustering based routing protocol when compared to the other existing protocols for wireless sensor network.

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