Highly Energy Sensitive Routing Protocol For An Actuator Based Wireless Sensor Networks

Baranidharan V, Vijay Krishna M, Poovarasan S, Rahool M M, and Sivasundar T P

Abstract: The wireless sensor networks (WSN) are having both the sensor and actuator nodes. These nodes are connected with each other using wireless links. The actuator nodes act as link nodes to collect the data from all other sensor nodes. In this paper, we proposed a new routing protocol that provides quality of service in terms of less energy consumption and less delay. The network consists of cluster heads (CHs) which is used to act as an actuator for gathering the information from all other sensor nodes. Those cluster heads (CHs) are elected based on their connectivity and energy capability to reach the destination, the data are looted by using this delay and energy sensitive routing protocols based on- demand routing technique. This protocol has a very less delay and energy consumption. This evaluation was done by the simulations. The result show that it will out performs than the existing systems.

Index Terms: Routing, Wireless Sensor Networks, Clustering, Data Link, Data transmission, Connectivity, Energy consumption, and Delay.

1. INTRODUCTION

The wireless sensor networks (WSN) are having both the sensor and actuator nodes. These nodes are connected with each other using wireless links. The actuator nodes act as link nodes to collect the data from all other sensor nodes. In this paper, we proposed a new routing protocol that provides quality of service in terms of less energy consumption and less delay. The network consists of cluster heads (CHs) which is used to act as an actuator for gathering the information from all other sensor nodes. Those cluster heads (CHs) are elected based on their connectivity and energy capability to reach the destination, the data are looted by using this delay and energy sensitive routing protocols based on- demand routing technique. This protocol has a very less delay and energy consumption. This evaluation was done by the simulations. The result show that it will out performs than the existing systems. Wireless sensor networks consist of N number of applications in various domains such as military application, Home automation, Navigation, Disaster management and prediction, Sea swarm control, Network robot etc.., This wireless sensor networks are having a large number of sensor nodes with the sensing unit, processing unit and communication unit [1]. These nodes can communicate the sensed information to the remote monitoring stations via the actuator unit. The sensed data may be temperature, humidity, motion detection, etx; The sensed information is transmitted to the actuator unit. The transmitted data was aggregated or segmented processed in the actuator unit and aggregated is transmitted to the monitoring system for further processing [2-3]. These actuators are responsible to take any decisions and to react based on event area according to the data received. To receive the best advantage, the actuator notes are designed in way to efficient co-operative communication is required. At finally, the sensor-actuator and actuator-actuator co-operative co-ordination is also required to perform the appropriate negotiation of other actuator unit. The cooperation is always based on semi-automated architecture. This architecture is based on the base stations, which is very responsible for monitoring and managing the networks.

In this architecture, the sensor nodes send the corrected information/ data to base station controller through actuator units and the actuator unit/nodes are used to perform the necessary actions. All these co ordinations in this architecture are automated without the existence of the central controller. Several protocols have been proposed to reduce the energy consumptions and to minimize the network life time. In order to proceeding Quality of Service (QOS) requirements are in terms of end to end delay in such networks, the actions are performed on the surveillance field immediately after the event occurs [4]. To optimizing end to end delay and energy consumptions achieved in order to ensure the QOS requirements, based on their routing decisions. In this paper, we propose an energy efficient routing protocol WSN that provides a very low delay and less energy consumption. The actuator nodes are act as a cluster heads which consists of group of sensor nodes. Thus we have introduced a novel metric for CHs selection. The metric is based on the distance in terms of multiple between the given candidate nodes. The node/network reliability was maintained by reducing the end to end communication delay. We proposed an on- demand routing protocol based approach, which will allow to transmit the data from source to the destination based on their minimum delay and reduced energy consumption. Thus, the obtained result is out performing than the other concurrent approaches. The paper is organized as follows, in section 2 represents the related works, In section 3 gives the details about network model and proposed algorithm, In section 4, present the results of performance evaluation and finally conclusions are made is section 5.

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2 RELATED WORK

In this literature, there are many proposed protocols for WSN. This WSN is introduced to having a many open research challenging. In this section, some routing protocols are received and its solutions are discussed. In [5] Melodia etal, have proposed a frame work for distributed WSN. This frame work is based on the event based clustering algorithm. This

algorithm provides a good reliability with low latency and energy consumption. The major disadvantage in this algorithm is that this algorithm is based only event driven. These algorithms will co-ordinate only the sensor node not with actuator node. In [6] Xiang etal, has proposed routing protocol to improve the QOS of automated WSN. This routing protocol is highly interested on clustered and actuator nodes. This protocol is based on the sensor actuator event reporting algorithm. This algorithm is to make ordering the task assignments for multiple events in different priorities. In [7] Sanap etal, have proposed an algorithm for WSN in real time algorithms. From the physical observation, the nodes will collect the data and forward it to the actuator node. The actuator node transmits aggregated information to the monitoring system. The major problem in this routing protocol is that the energy consumption is high by the sensor node to connect the data to its monitoring system. In [8] Kim etal, have proposed a new clustering algorithm for WSNs. This algorithm supports a multi-level hierarchical structure and special type heuristic path search algorithm was also used to determine and to connecting or selecting the intermediate nodes. This Routing Protocol reduces the interference between the neighboring the sub-clusters. In [9] Kakarla etal, has proposed a novel actor based Routing Protocol which is directional any east routing protocol, this routing protocol will support many traffic. This Routing Protocol uses a directional antenna and actuators to transmit the data from the source to the destination across the given network. This Routing Protocol exploits to routing the anchors to reduce the traffic road from all other sensor nodes [10 -11]. The main drawback of all given existing solution is the absence of the parameters of considering the accessibility degree of sensor nodes with actuator nodes. By addressing this important issues are,

1. In clustering, the CH election is done by based on the multi-hop distance of the candidate sensor nodes. The best positions of the actuator nodes are decided based on this metrics.
2. After CH elections, on demand routing protocols is used to transmit the data from source to the destination.

3 NETWORK MODEL AND PROPOSED ALGORITHM

This section presents the network model to propose the clustering find the routing. This network considers the set of the sensor and the actuator nodes. These nodes are interconnected by the wireless links. The actuator units are deployed uniformly throughout the entire area. These actuators are able to communicate with the both sensor nodes and the actuator to reach the monitoring systems. In this sensor network model, the sensor nodes are very small, static and limited battery power. In this model, we assumed that these actuator nodes are static nodes. The actuators nodes are having a high battery power with long range of transmission compared with other the given sensor nodes. The clustering mechanism is widely used to organize sensor nodes. The cluster heads are elected by the other sensor nodes based on their distance. This cluster can be easily adjusted based on their geographically adjusted nodes. When the event occurs automatically, the sensor nodes will detect the event and sends the data to the corresponding actuator nodes through the cluster heads. The communication model explained is expressed in this given description. This network model is designed for a static node for potential application field. This routing protocol is only for the fully distributed cluster formation protocol to maintain the balanced relationship between the nodes. The scaling of this network is also applicable.

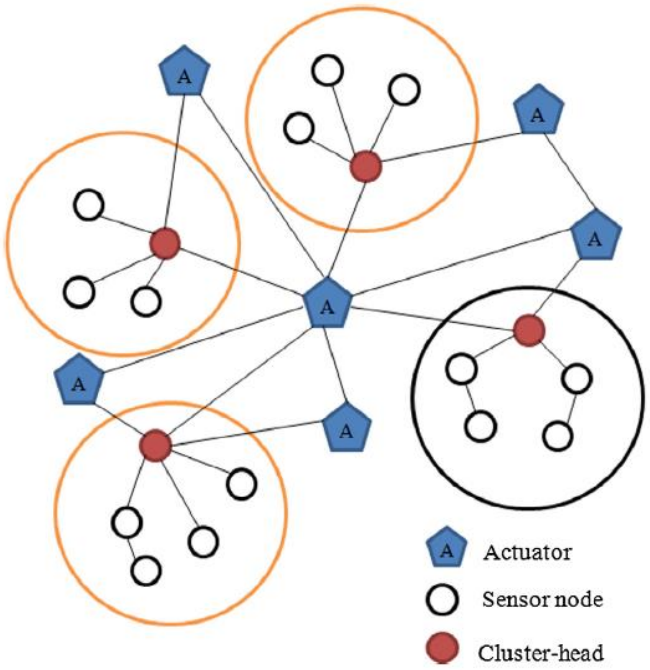

***Fig.1**. Network Model*

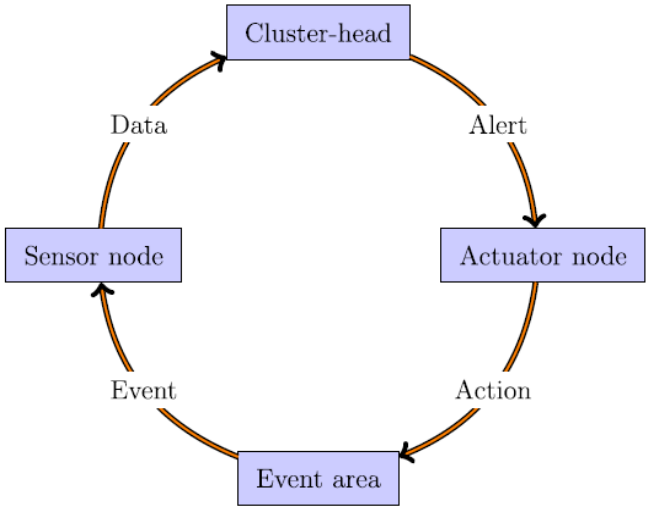

***Fig.2**. Communication Model for proposed Algorithm*

The cluster formation is performed after the node and actuator deployment over the given networks. The total number of nodes is not fixed in this WSN. Each node in the clusters are not depends upon the other clusters members (i.e. ordinary sensor nodes). The ordinary sensor nodes are also allowed to election of CHs. The selection of CHs is based on their energy consumption and distance between the sensor nodes. Let N be the total number of sensor nodes and WSN based the residual energy. The beacon messages are used to receivers the basic information about the other sensor nodes. The beacon messages are transmitted to all other nodes with in a time t. After that the weight of each nodes will be calculated based on the below equation,

$$W_i = ((NEi \times Rnd \times Ei) / Di) + (1 - Rnd)R/K \quad \text{-- (1)}$$

Where, Rnd in the Random Number or Coefficients of each sensors node, NE_i is the i^{th} neighbor node, I is the total number of neighbor node, D_i is the average distance between the sensor nodes, K is the total number of actuator nodes in the networks, W_i is the Weight of the sensor nodes. After receiving the beacon messages each sensor nodes saves the information in its local storage of the sensor nodes. Each sensor nodes are arranged based on their weights. The weights are Wn is calculated based on their appropriate candidate sensor nodes. The nodes will check the weight Wn. The below algorithm illustrate the code for CH the election and selection,

each node I maintains the list of cluster members CM:
function Init_CH_Elelection_Selection ()
for all Node I € Sensor_set_do
compute W_i
if $W_i > W_{th}$ then
send_Weight (W_i) to j;
end if
end for
max_Weight ← W_i;
end function
Upon receiving the weight W_i for j do
function Reception_weight()
n ← card (j);
for j (0,…N)
max_Weight ←n;
CH ← Max_Weight_node;
end if
end for
end function

Fig.3*. Pseudo code for energy aware routing algorithm*

After CH elections the sensor nodes will send the data from the nodes to all other sensor/actuator nodes. The weight value is now changed as best weight value. Again the ith node will changed as a best node value. After the CH election algorithm, the data routing algorithm will be used to route the data packets in the networks. In the above algorithm the actuator node responds to receive the routing protocols for on-demand routing protocols. At this situation, the actuator nodes will not able to reply positively for request packets from the other nodes. At such case the negative ACK is generated and then transmitted. This may happen, if the given actuator nodes do not able to transmit the data from the source nodes to destination. In this cases the solution is based on the on-demand routing protocol of WSN.

4 PERFORMANCE EVALUATION

This section presents the various simulation parameters and the obtained results in terms of clustering based routing protocols. The performance analysis of the proposed approach is implemented by using the MATLAB environment. The simulation study is more appropriate regarding the performance metrics to evaluate the proposed algorithm. The whole environment is setting up by realizing the experiments by evaluating such metrics.

Table.1*. Simulation Parameters*

Parameter	Value
Surface interest size (m^2)	500 x 500
Number of sensor nodes	400
Number of actuator nodes	20
Node deployment type	Random
Actuator node deployment type	Uniform
Sensor node communication range (m)	20
Actuator node communication range (m)	40
Packet size (Bytes)	50
Initial energy of sensor nodes (J)	1
Initial energy of actuator nodes (J)	5
Timeout (Sec)	5
Number of total Events	80

The performances are evaluated for our approach with comparing with two routing protocols. The proposed framework gives solution the two complement solutions. The first part of solution is clustering and second solution is about routing. This clustering approach is used to give the reliable communication between the sensor nodes with the actuators. The second solution is based on the routing aspect is addressed independently with to the clustering. In this routing, the Cluster Heads are assumed as source nodes and the destination node is targeted destination node. We compare this part with proposed framework with the existing routing protocols. In terms of clustering, we notice that the HESRP protocol is the most representative solution for the comparison. We simulate the WSN with stationery static nodes, which are deployed randomly over the entire surface. In this WSN, the large numbers of sensor nodes are deployed randomly. In order to evaluate the scalability criteria is the most important. We have considered the 400 sensor nodes with 10 actuators nodes. In this simulation, we have considered the message loss rate at the value α. This WSN is a special type of Low Power Lossy Networks (LLN), where the sensor node deployments are most important for hostile scenarios. The environment is has a direct impact on the radio transmission quality over the obstacles, noise, temperature and interference with the observed systems.
In addition to calculate the collision probability (β) and computed as,

$$\beta=1-1/(s+1) \quad -- (2)$$

where S is the average number of neighbour nodes with respect to single nodes. The parameter β is collision probability of the neighbouring density.

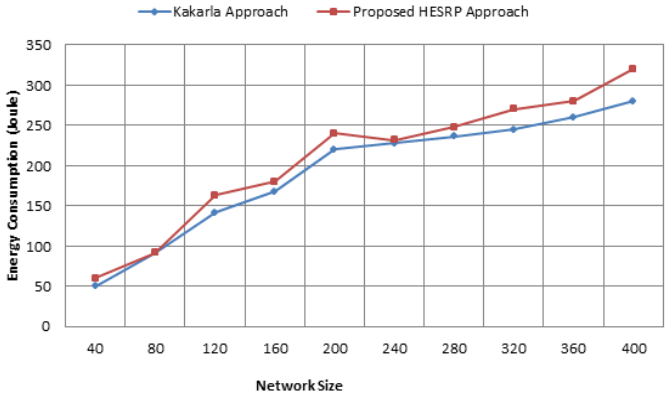

Fig.4*. Comparison of Energy Consumed with network size*

The average residual energy is defined as the total remaining stored energy in the sensor nodes after the simulation. The average residual energy is comparatively high in this proposed algorithm as shown in the figure 4. In this proposed routing protocol, the cluster heads are very closest to the actual node,

which gives minimum energy consumption. The actuator nodes are cannot able to respond the CH forwarded request. Thus, the routing protocol gives high residual energy by the way to minimized energy consumption of the sensor nodes. In these algorithms, the cluster heads sends the request directly or with the second actuator nodes. So the energy consumption of this proposed approach is less than the residual energy and node density.

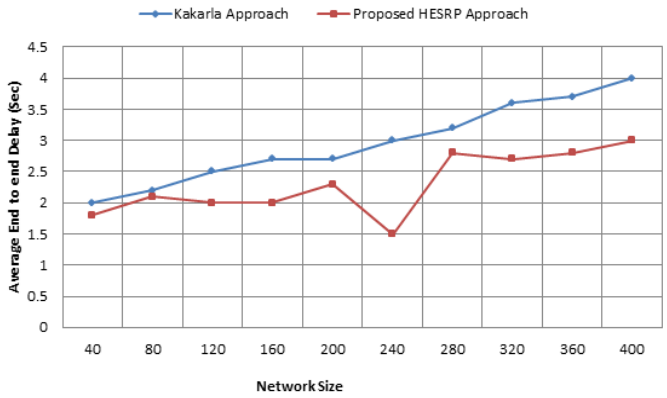

***Fig.5**. Comparison of End to end delay with Network size*

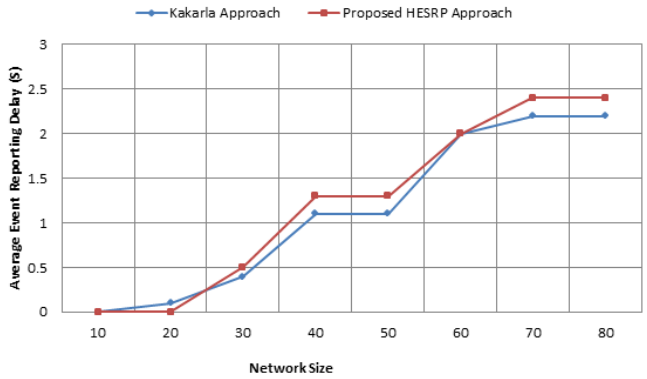

***Fig.6**. Average event reporting time with Total events*

The above figure shows that our approach provides a very low end to end packet delay. This is because of this approach is having a cluster heads to transmit the data. The sensor nodes are used to transmit the data to its CH's. The cluster heads are responsible to forward the aggregated data to the monitoring systems. This approach is having an lower event reporting delay as shown in the figure 5. The figure 6 represents the intersection of the residual energy consumed by the sensor nodes and the maximal value of the energy consumed by all other sensor nodes for the different scenarios based on the event of frequency occurs. As we expected, the communication delay is also low in the network is the function of the number of the sensors nodes. The end to end delay of this proposed approach is increased when the network size increases. However, the end to end delay is also comparatively less than the existing approach because its choose the optimal path for data forwarding.

5 CONCLUSION AND FUTURE WORK

In this paper, we have proposed the highly energy sensitive QOS aware routing protocol for Wireless Sensor Networks. This algorithm is having an new clustering mechanism to take consideration of the degree of the actuator nodes for CH election. This approach combines with two important parameters, one is energy sate and another one is degree of connectivity of candidate of its sensors. This approach reduces the energy consumption as well as the communication delay and balanced energy consumption among the sensor and the actuator nodes. This approach is also addressed the sensor-actuator communication and the sensor-sensor communication problems. The simulated results are shows the performance results of our framework. The energy of both the sensor and actuator nodes are effectively utilized through this lightweight communication protocols achieved by the less delay and longer network lifetime. In the futuristic approach, we are planning to adopt the fully distributed solution based on the actuator tracking mechanism is executed. Several security attacks solution will be designed and addressed.

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