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Congestion Avoidance in WSN Clusters using Token Bucket Algorithm

Prabhdeep kaur[1], Jaswinder singh[2]

Student (M.Tech), Dept. of Computer Science and Engineering, Guru Nanak Dev University, Amritsar, Punjab, India [1]

Assistant Professor, Dept. of Computer Science & Engineering, Guru Nanak Dev University, Amritsar, Punjab, India [2]

Abstract: Wireless sensor network is a widely emerging field due to its wide range of applications in different areas. There are many issues in this field like energy efficiency, routing, lifetime, battery power etc. To address these issues there are some approaches like congestion, clustering etc. This paper works on congestion avoidance in clusters of wireless sensor networks and presents an improved version of PASCCC (Priority Based Application Specific Congestion Control Clustering Protocol).

Keywords: WSNs, PASCCC, Congestion, Clustering, Token bucket algorithm.

I. INTRODUCTION

In a wireless Sensor network there are spatially scattered tiny device known as sensor nodes. In this type of network these tiny devices have resource constraint like storage capacity, capability of communication and battery power. In the network sensor nodes communicate with each other by radio interface. The applications of wireless sensor network include tracking of target, environmental monitoring, machine health monitoring etc [1][2]

There are different types [1] of wireless sensor networks. Mainly it can be classified into two categories:- Unstructured and structured. When sensor nodes are deployed in a region in an adhoc way, it is called unstructured WSN .When sensor nodes are scattered in a particular manner in the region then this type of network is called structured WSN.

On the basis of the environment [2] in which WSN is to be deployed, WSN can be classified into five categories:- Mobile , Multimedia, Underground, Underwater and Terrestrial WSNs.

A. Important Aspects of the Area.

1) Congestion control: In a network when data to be transmitted is more than the link capacity, congestion [3][12] occurs which causes overflow of buffer, dropping of packets and energy wastage of sensor nodes. As data transmitted in the network has utmost importance, there is a need to control the congestion which can be done either by enhancing the bandwidth or by reducing the traffic from the source.

2) Clustering: Clustering [4][11] is an energy efficient method of routing in which sensor nodes are organized into clusters. There is a base station which acts as a interface between a user and the network. There is a cluster head in every cluster to which member nodes send data. Cluster head receive data from sensor nodes and other cluster heads, perform data aggregation and send data to the base station. This method is helpful in extending lifetime of the network by saving energy.

LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is one of the protocols for constructing clusters.

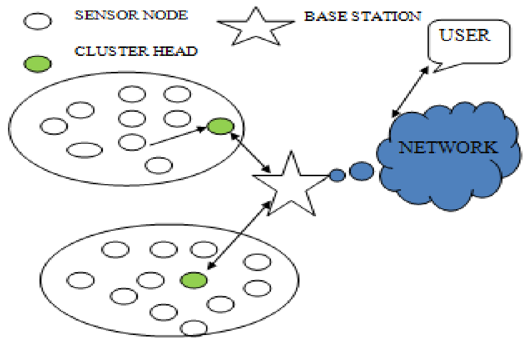

Fig. 1 A wireless sensor network

II. LITERATURE SURVEY

The nodes of the WSN have limited battery power so utilizing energy efficiently is an important aspect in the design of network routing. A new routing algorithm [5] was presented which had used greedy algorithm for inter-cluster routing and multi-hop algorithm for intra-cluster routing to reduce communication overhead, hop count and consumption of energy.

Communication protocols also have great importance in energy consumption of the network. A protocol called LEACH [6] protocol was proposed which stands for Low-Energy Adaptive Clustering Hierarchy. It was a protocol which is adaptive and was based on clustering and evenly distributes the load and energy between network's sensor nodes. Data aggregation was performed in it, which reduces data transmission amount. It was helpful in energy saving and increasing the lifetime of the network.

To avoid data flooding at sink due to aggregation of data by nodes and hence to reduce consumption of energy a new method of data aggregation [7] was proposed which was based on groups. In this method, grouping is done at two levels. First of all at intra-cluster level, data

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availability and correlation form a base for grouping of nodes. These nodes within the clusters are called cluster head nodes and transmit data to the cluster heads. . Then at cluster heads, for data aggregation functions like additive and divisible functions are used. This two level aggregation helps to decrease the consumption of energy.

Data transmitted in the network have very much significance and if data generation by the source node is high then this results in network congestion. Congestion[3] is not good for the network performance as it causes energy wastage, overflow of the buffers, dropping of packets, Congestion should be controlled for successful data transfer to the sink .This could be done either by reducing rate of data or by enhancing the bandwidth of the link. A new method was proposed to reduce the network congestion which uses 4 nodes near the sink .When control head starts increasing packet delivery ratio starts decreasing. So, optimal number of nodes near sink was 4 for better performance.

Congestion control protocols [8] can be classified into different types. On the basis of control policy it can be classified into two categories i.e. resource control and traffic control. Resource control policies are further categorized based upon the resource type to be utilized. Traffic control protocols can be divided into two types reactive and preventive .The reactive protocols are further classified according to the scale of reaction and preventive solution are categorized into two categories according to the limitation of the buffer and control of interference.

Congestion is also relieved by using LEACH due to evenly distribution of the load. An algorithm [9] was proposed which was based on the virtual heads, to control the congestion for the large networks which have hierarchical clustering and multi-hop structures. In the inner-cluster , this algorithm works by establishing a shortest path tree and in the extra-cluster this algorithm establish a multiplexing path .The main aim is to find the congested virtual head and this algorithm results in lower transmission delay and high throughput .Another algorithm STCP which stands for Sensor Transmission Control Protocol is proposed which relieve the congestion by adjustment of data sending rate and by path transfer, achieving energy efficiency and high throughput.

To detect congestion in the clusters of the network a new protocol PASCCC [10] was proposed which stands for priority-based application specific congestion control clustering protocol. It integrates nodes' heterogeneity and mobility to detect network congestion. Threshold is maintained according to the different applications. Priority is given to the time critical packets. This method is useful in many aspects like energy efficiency, network lifetime, Quality of service etc but this method uses queuing method for scheduling which results in packet drop.

So, In this paper we propose a new method which is an improvement of PASCCC, it uses token bucket algorithm instead of queuing method which helps in congestion avoidance as well as preventing packet drop.

III. OBJECTIVES AND GOALS

A. Objectives

1. To evaluate the performance of priority-based application specific congestion control clustering protocol.
2. To improve PASCCC i.e. priority based application specific congestion control clustering protocol further by using token bucket algorithm instead of queues.
3. To draw comparison between PASCCC and improved PASCCC based upon the following parameters:-
   a) Lifetime of the network.
   b) Energy consumption
   c) Throughput
   d) Packet drops

B. Algorithms

The algorithms under consideration are the PASCCC, LEACH, Queue, Token bucket. The PASCCC Is priority based application specific congestion control clustering protocol. It is used for congestion avoidance in the clusters of the wireless sensor networks. It employs LEACH protocol for constructing clusters in the network and queuing method for packet storage at the clusters. The proposed method employs token bucket algorithm instead of queuing method. Token bucket algorithm works on the concept of tokens. Only that node can send packet to the cluster head which has token.

C. Framework

The following figure shows the simulation of wireless sensor network .The area taken is 100*100 .Number of nodes are 100.The circles represent the sensor nodes, colourless circles represent the normal sensor nodes, area between the blue colour lines represents one cluster, green coloured circles represent the cluster heads, magenta coloured nodes with blue edge colour represent the dead nodes. Red dashed lines represent the data transfer between the cluster heads. Blue dashed lines represent the data transfer between the cluster head and the base station.

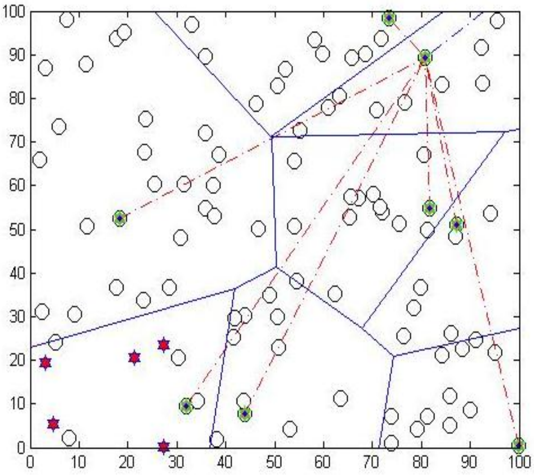

Fig.2. Wireless sensor network simulation

D. Methodology to be Followed

STEP 1:-Deploy the sensor nodes randomly.
STEP 2:-Initialize the network characteristics.
STEP 3:-Leach algorithm is used for constructing clusters.

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STEP 4:-Base station will distribute special type of tokens called CH-Tokens to the nodes randomly.
STEP 5:-Threshold function t(n)f(n) is applied and based on the threshold function and token bucket algorithm only those nodes will become cluster head which has token and also satisfy the threshold criteria.
STEP6:- Associate member nodes with their nearest CH
STEP 7: CH distribute special type of tokens called C-Tokens to the nodes randomly.
STEP 8:- Nodes which have Tokens send data to the cluster heads.
STEP 9:-Apply inter-cluster data aggregation.
STEP 10:-CH send data to the base station.
STEP11:- Evaluate and update energy dissipation
STEP 12:-Check is performed in every round for dead nodes and dead nodes are counted.
STEP 13:-If all nodes are dead then network lifetime is noted otherwise go to step 12.

E. Flow Chart

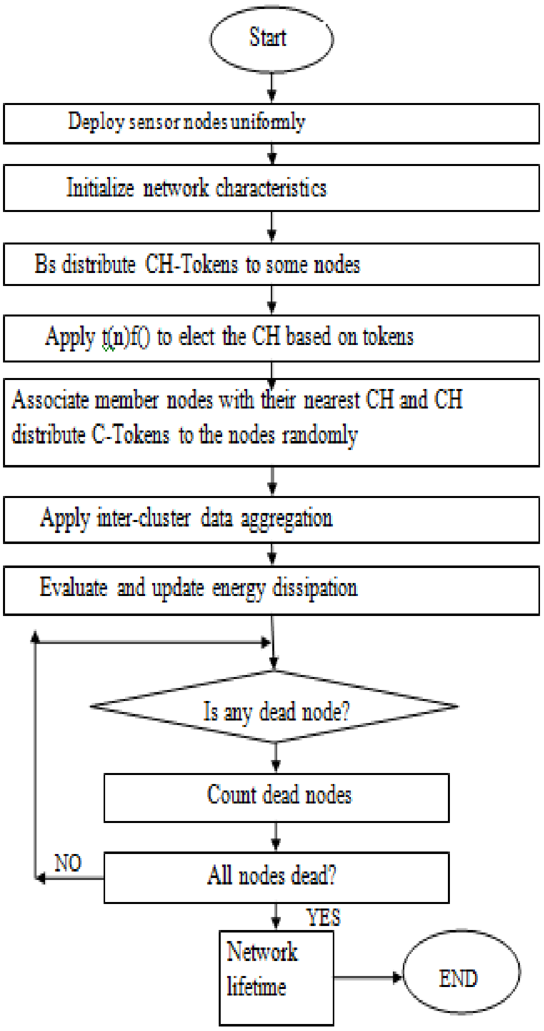

Fig.3.Flow chart of the algorithm

IV. IMPLEMENTATION and RESULTS

A. Implementation

The following values are taken for different parameters during the implementation

TABLE 1: PARAMETER TABLE

Area	100*100
Nodes	100
Initial energy	0.1 J
Transmitter energy	50*0.000000001 j
Receiver energy	50*0.000000001 j
Data aggregation energy	5*0.000000001 j
Max lifetime	400 rounds
Data packet size	4000 bits
Amplification energy when d is less than d0	10*0.0000000000001 j
Amplification energy when d is greater than d0	0.0013*0.000000000001 j

B. Results

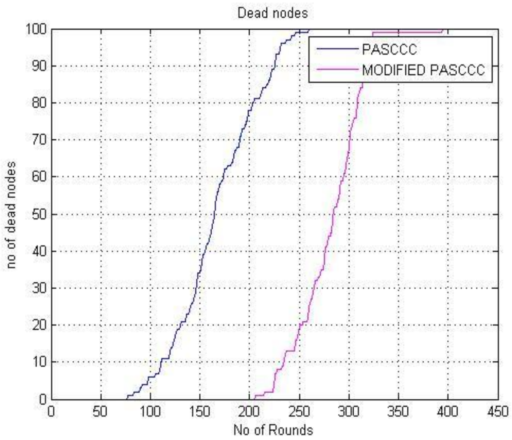

Fig.4. Comparison of lifetime of the network while using existing algorithm and proposed algorithm

This graph shows the comparison of lifetime of the network while using existing algorithm and proposed algorithm .X -axis shows the number of rounds for which the code executes and Y-axis shows the number of dead nodes .Blue line of the graph shows the number of dead nodes of the existing approach and magenta line shows the number of dead nodes of proposed approach. It is clearly visible that last node of proposed algorithm die later than the existing algorithm. Hence it proves that lifetime of the network increases with the proposed algorithm.

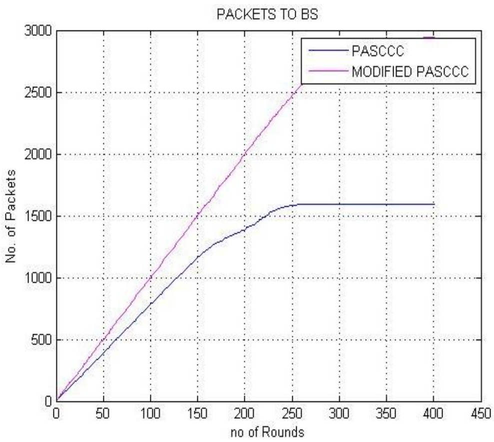

Fig.5. Comparison of number of packets sent to the base station while using existing algorithm and proposed algorithm

This graph shows the comparison of number of packets sent to the base station while using existing algorithm and proposed algorithm .X -axis shows the number of rounds for which the code executes and Y-axis shows the number of packets sent to the base station .Blue line of the graph shows the number of packets sent to the base station by the existing approach and magenta line shows the number of packets sent to the base station by the proposed approach. It is clearly visible that numbers of packets sent to base station by the proposed algorithm are more than the existing algorithm.

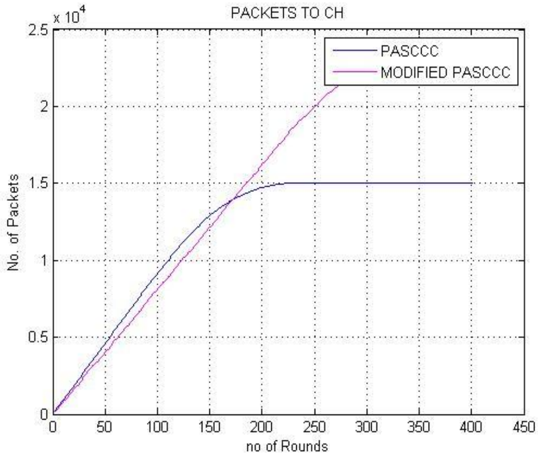

Fig.6. Comparison of number of packets sent to the cluster head while using existing algorithm and proposed algorithm

This graph shows the comparison of number of packets sent to the cluster head while using existing algorithm and proposed algorithm .X -axis shows the number of rounds for which the code executes and Y-axis shows the number of packets sent to the cluster heads .Blue line of the graph shows the number of packets sent to the CHs by the existing approach and magenta line shows the number of packets sent to the CHs by the proposed approach. It is clearly visible that numbers of packets sent to the CH by the proposed algorithm are more than the existing algorithm.

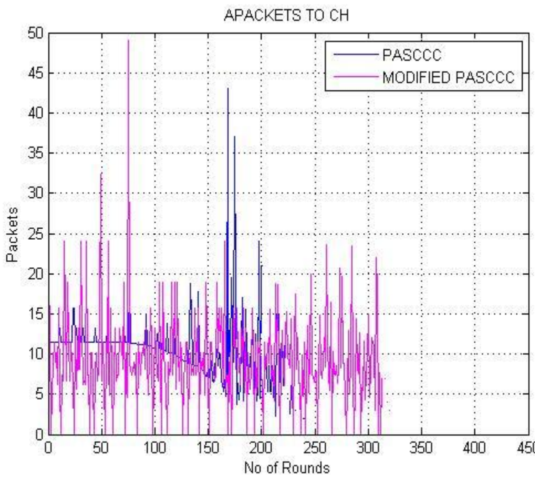

Fig.7. Comparison of average number of packets sent to the CH while using existing algorithm and proposed algorithm

This graph shows the comparison of average number of packets sent to the CH while using existing algorithm and proposed algorithm .X -axis shows the number of rounds for which the code executes and Y-axis shows the average number of packets sent to the base station .Blue line of the graph shows the number of packets sent to the CHs by the existing approach and magenta line shows the number of packets sent to the CHs by the proposed approach. It is clearly visible that average numbers of packets sent by the proposed algorithm are more than the existing algorithm.

From figure 5, 6 and 7 it is clear that packet loss decreases and throughput increases by using the proposed algorithm as compared to the existing algorithm

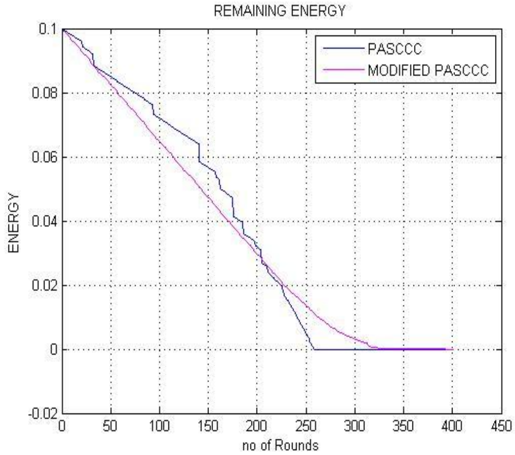

Fig.8. Comparison of remaining energy while using existing algorithm and proposed algorithm

This graph shows the comparison of remaining energy while using existing algorithm and proposed algorithm .X -axis shows the number of rounds for which the code executes and Y-axis shows remaining energy of the nodes .Blue line of the graph shows the remaining energy of nodes by the existing approach and magenta line shows the remaining energy of nodes by the proposed approach. It is clearly visible that the energy is decreasing smoothly by using proposed algorithm as compared to the existing algorithm. So, proposed approach is energy efficient.

V. CONCLUSION AND FUTURE WORK

The work done so for has tried to solve the problem of congestion in the clusters of the wireless sensor networks by using queuing method. This paper has used the token bucket approach instead of queue and comparison is done on the basis of network life, throughput, energy efficiency etc. Simulation results shows that the proposed approach shows better results as compared to the existing approach. In future, we will try to further enhance the approach for dense networks.

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BIOGRAPHIES

Prabhdeep Kaur, M.Tech, Department of Computer Science and Engineering, Guru Nanak Dev University, Amritsar, Punjab, India.

Jaswinder Singh, Assistant Professor, Department of Computer Science and Engineering, Guru Nanak Dev University, Amritsar, Punjab, India. Area of interest :- Wireless Sensor Networks

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