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Performance Analysis of Improved Congestion Control Clustering Protocol Using TBA/WDM

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Abstract- Wireless Sensor Networks (WSNs) are inclined to network traffic congestion, where unexpected event generates traffic in the network and this traffic is then transmitted to the base station. This paper deals with congestion control and multiplexing in wireless sensor networks (WSN), which is necessary for improving the congestion and saving the abundance of energy in networks where nodes have traffic patterns. A scheme called TBMCCCP (Token Bucket and Multiplexing based Congestion Control clustering protocol) is proposed. It maximises the lifetime as well as control the congestion of the network. The simulation result shows that the protocol reduces the loss of packet and has a better fairness of packet delivery ratio in networks. The proposed protocol is very effective in utilizing the available sources and reducing the drop of packets.

***Keywords:* Wireless sensor network (WSN), Congestion control, Multiplexing, Clustering, Network lifetime, Energy efficiency.**

I. INTRODUCTION

A wireless sensor network is a self organizing distributed network consists of sensor nodes that are deployed in large geographical area to sense the events and different physical environment collect information and route it to base station (also called as sink). WSN is equipped with processor, memory, transceiver and sensor nodes where these nodes are small batteries. On the basis of versatility, [12] these networks are suitable for many applications such as military surveillance, smart homes, automation, traffic management of vehicles and detection of disaster. [1,13] Cluster-based hierarchical routing protocols are best suited for energy constraints networks because these protocols organize the nodes into small clusters, where each cluster has exactly one cluster head (CH) node that collects data from its member nodes and transmits it to a base station(BS). In WSN, most of the energy is consumed via transmission of data rather than communication and computation because the increasing lifetime of the nodes is too important. Various Data Aggregation techniques are based on routing and clustering are the major techniques that are proposed to increase the lifetime of the network. The process of data aggregation (DA) is to collect the useful information by eliminating repeated readings of sensor nodes. It reduces the communication cost by improving energy consumption and network lifetime of WSN. It also helps to minimize the traffic load thereby conserving the energy in the sensor nodes. There are number of congestion control protocols like IACC, GMCAR, HTAP etc that can extenuate congestion in wireless sensor networks by making alternative paths to the sink. [14] As per the nature of the network, the probability of appearance of congestion is too high. Higher amount of traffic is observed when event takes place and then this traffic leads to congestion. Network congestion occurs when too many sensor nodes carrying so much data tries to send at a same time. It also give rise to drop of packets and retransmission of packets at the MAC layer events which affects the limited power of WSNs. Congestion causes packet loss, delay, blocking of new connections, and degradation of the Qos. To avoid aforementioned problem a relevant congestion control protocol is proposed to relieve the congestion from congested areas. This protocol is named as Token Bucket and Multiplexing based congestion control clustering protocol. In this, first sensor nodes are deployed. Base station(sink) is responsible for the distribution of tokens and cluster head(CH) selection is done on the basis of threshold function. A node can become CH iff, it has token. Then, intra-cluster data aggregation is done. In multiplexing, first of all Root cluster head node is to be found. The node which is considered as Root cluster head node is the one which lies nearby the base station(sink) and it sends data to BS in one-hop manner. This paper is structured into five sections. In Section II, related work of congestion control, detection and mitigation protocols used to refine the objectives of clustering protocol. The protocol supports congestion control and multiplexing of packets. Section III defines about how the existing system. Section IV of this paper presents a brief overview of our proposed approach. Section V provides experimental results of our proposed scheme based on comparison with an existing priority based application specific congestion control clustering protocol. Finally Section VI concludes the paper.

II. RELATED WORK

In this section, an overview is provided of various congestion detection and mitigation techniques and protocols, cluster-based hierarchical routing protocols, as well as multiplexing technique for the better transmission of data to base station and utilization of quality of service (QoS) of network. Heinzelman et al. [1] proposed the low energy adaptive clustering hierarchical (LEACH), a clustering-based protocol that enhances the system lifetime and reduces energy dissipation by dividing the load to all nodes at different time. LEACH is completely distributed. In order to operate LEACH, no control information from the base station is required as well as the nodes do not require knowledge of the global network. D.S. Kim, Y.J. Chung [2] proposed an improved protocol named "LEACH-Mobile". This protocol announces membership of the nodes with its cluster head on the move in order to check whether the sensor nodes are able to communicate to its cluster head within a time slot according to its TDMA schedule. It also provides better data transfer success rate as a mobile nodes as compared to the non-mobility centric LEACH protocol. A. Manjeshwar, D.P. Agrawal has introduced a new energy efficient protocol for reactive networks, TEEN (Threshold sensitive Energy Efficient sensor Network protocol). [3] This protocol reduces duty cycle because nodes always stay in sleep mode and when specific criteria are met only then transmitters are triggered. TEEN is well fitted for time critical applications and is also acts efficiently in energy consumption and response reaction. It allows user to control energy consumption and accuracy to suit the application. C.Y. Wan, S.B. Eisenman, A.T. Campbell has evolved an energy efficient congestion control scheme for WSN called CODA (Congestion Detection and Avoidance). It comprises of three mechanisms (i) Receiver-based congestion detection (ii) open-loop hop-by-hop backpressure and (iii) closed-loop multi-source regulation.[4] CODA lowers the level of congestion but it retransmits packets again and again, which imposes an extra burden sensor nodes. Y. Sankarasubramaniam, Ö.B. Akan, I.F. Akyildiz has introduced a new reliable transport scheme for WSN named ESRT (Event-to-sink reliable transport) protocol. It provides to reliable event detection with nominal energy consumption and congestion resolving functionality. [5] ESRT is used to configure the network with the optimum operating point where the reliability of the network is achieved with minimal energy consumption and without network congestion. Omar Banimelhem and Samer Khasawneh [6] have proposed an efficient QoS routing protocol for grided sensor networks named GMCAR (Grid-based Multipath with Congestion Avoidance Routing) protocol. In this, a sensor network field is divided into grid, where one sensor node is selected as a master node in each grid. It is responsible for delivering the data and for transferring the received information from master nodes to the neighbor grids. Mari Carmen Domingo [7] has proposed a biologically-inspired congestion control protocol for UWSNs which has power to terminate with phytoplankton flowers and maintain the system back to equilibrium between species. Dirk Abendroth, Martin E. Eckel, Ulrich Killat [8] has presented two weighted fair queuing (WFQ) scheduling algorithms based on token bucket and leaky bucket shaping/policing algorithms. This algorithm provides a better equity at lower implementation Complexity while achieving network utilization than WFQ schedulers. E. Vayias, J. Soldatos, G. Kormentzas has proposed an technique named ETBF (exponential token bucket filtering) in routers which works on Linux operating system. It describes the traffic-shaping scheme which can be fit in this architecture as a mechanism applied to the traffic that is transmitted from the edge routers to the core of a domain, so traffic can be multiplexed at the core routers adapt to the M/G/1 model.[9] Yongbo Dai, Peng Li, Yanju Liu, Anand Asundi, Jinsong Leng [10] has proposed a FBG (fiber Bragg grating) sensor multiplexing system. It monitors both two- dimensional strain and temperature field. Large capacity multiplexing technology with mixed TDM and WDM is presented, using semiconductor optical amplifier (SOA) resonant cavity technology. 1000 sensors can be multiplexed in one single fiber. C.M.S. Negi, Irfan A. Khan, Gireesh G. Soni, Saral K. Gupta, Jitendra Kumar has formulated orthogonal wavelength division multiplexing with Coherent detection (Co-OWDM) and Quadrature phase shift keying (QPSK). [11] It increases the system throughput and enhances the efficiency with higher delivery ratio, greater tolerance to transmission impairment and secured data transfer. HEED protocol ensures that there is only one CH within a certain range, so there is uniform distribution of the cluster heads in the network which will result in minimum energy consumption thereby enhancing the network lifetime.

III. NETWORK MODEL AND PROBLEM DESCRIPTION

Network model is based on a densely deployed WSN, Where nodes are initially deployed randomly; each node has some energy (E), probability (p) and sensor position etc. Sink node (BS) is located at a specific point in the network topology and all the number of source nodes is variable. Each node in the topology knows its position and the position of the sink node. Nodes forwards the data to CH and it further transmit data to the base station. In our network, it is considered that all the nodes another than sink are similar and CSMA/CA is deployed as the MAC protocol. The problem that we seek to perform in this paper is the behavior of the queue has been neglected for coverage fidelity, queuing thresholds, number of queues, blocking probabilities etc. The nature of the traffic arrival process exhibits a bursty and correlated behavior, which totally degrade the network performance. This means that proposed technique should be able to detect possible congestion and avoid it. To remove the congestion further multiplexing is employed which multiplexes the data of CH and send it to the BS.

IV. EXISTING SYSTEM

A priority based application specific congestion control clustering (PASCCC) protocol incorporate the mobility and heterogeneity of the nodes to detect congestion in a network.[1] PASCCC is an energy efficient application

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specific clustering protocol using a queuing model. The results of PASCCC indicate that the approach significantly improves the lifetime, energy consumption and data delivery to CH and BS. The existing method has used priority based queuing model, it curtails the performance of the congestion control protocol. The results of PASCCC indicate that the approach significantly improves the lifetime, energy consumption and data delivery to CH and BS.

Disadvantages of Existing system

- The use of congestion prevention has been neglected in majority of existing research of WSNs.
- The behavior of the queue is also neglected for all time connectivity, queuing thresholds, number of queues, etc.
- The use of token bucket algorithm has also ignored in congestion control in WSNs.
- Most of the existing congestion control protocols have not used multiplexing to prevent the congestion further.

V. PROPOSED TECHNIQUE

This section provides the various steps required to successfully accomplish the objectives of the paper.

1. **Deployment of sensor nodes:** Initialize WSNs with respective characteristics like initial energy (E), probability (p), sensor positions and number of nodes. Sensor nodes are randomly deployed in a wireless sensor network and distribution of these nodes is done in a square region.
2. **Apply token bucket algorithm to given nodes:** In this algorithm token bucket keeps token that are generated at regular intervals. BS distributes tokens to all sensor nodes. Token will be allocated to that sensor node which has some energy and which have not been cluster head in last 1/p rounds.

$$Token = \begin{cases} 1 & if\ W_{(i)}.E > 0\ and\ W_{(i)} \in G \\ 0, & otherwise \end{cases} \quad (1)$$

3. **Apply Threshold $T_{(n)}$ function to evaluate CHs iff, node has token:** Threshold function $T_{(n)}$ is applied to the sensor nodes for the election of cluster heads(CHs). Each node chooses a random number $R_{(n)}$ or value between 0 & 1. If the number is less than the present threshold $T_{(n)}$, then the node becomes cluster head for the current round else the node becomes cluster member and the label of cluster head will attach to it. The threshold is defined as:

$$T(n) = \begin{cases} \dfrac{p}{1 - p\left(t mod \frac{1}{p}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \quad (2)$$

Where *p* is desired CHs number, t represents the current round, *G* represents the number of nodes that have not become cluster heads in the last $\frac{1}{p}$ rounds. At this threshold each node gets a chance to become a cluster head within $\frac{1}{p}$ rounds. Nodes that are not elected as cluster heads are still act as normal nodes.

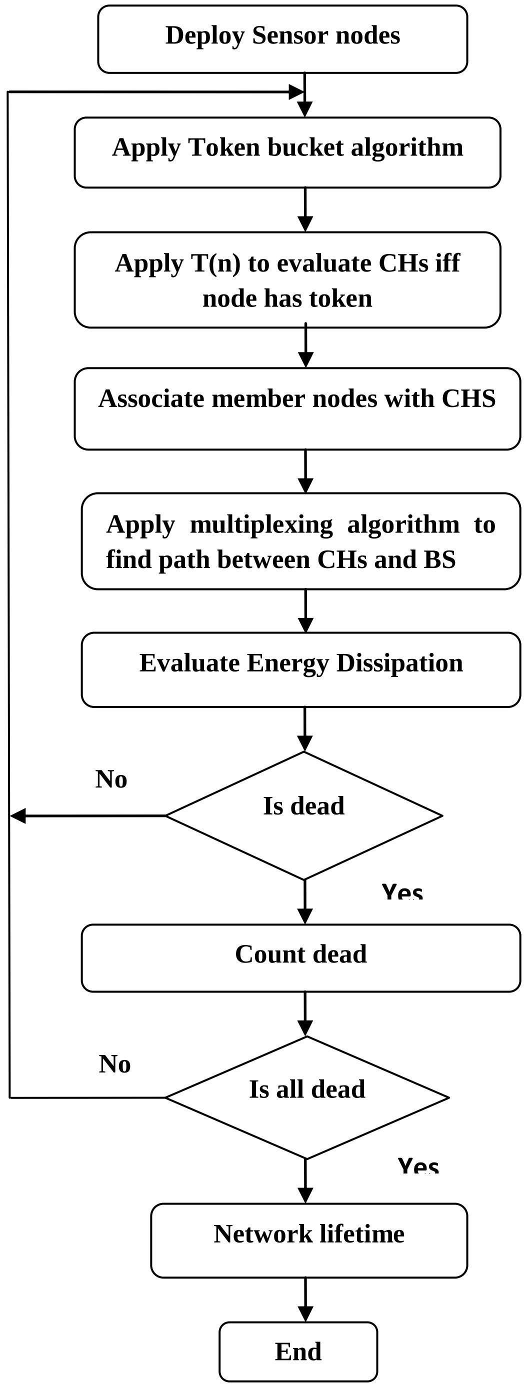

Fig.1 Flowchart of Proposed Technique

4. **Associate member nodes with Cluster Heads**: Elected CH broadcast the advertisement message to all the sensor nodes and waits for join-request message Cluster heads use the CSMA protocol to send the advertisement message. All the nodes depending upon the distance to the cluster head decides to which cluster it belongs.
5. **Apply Wavelength Division Multiplexing:** Wavelength division multiplexing is applied on each cluster head. Each cluster head collects data from its cluster members, performs data aggregation, and forwards the results to a sink in a single-hop manner. The node that is closest to the base station will act as a Multiplexer. Wavelength division multiplexing act as a middleware between sink and cluster head as it collects data from CHs and send it to base station. Root CH use multiplexing to make this packet as individual one to utilize quality of service (QoS) of network on more proficient manner and send data to its base station.
6. **Evaluate energy dissipation:** After multiplexing phase, dissipation of the energy is evaluated. This evaluation is done by calculating the energy consumption in various operational states. The energy consumption during processing and transmission are calculated using Eq. (3) [1]:

$$W_{(i)}.E = \begin{cases} nkE_{elec} + nkE_{DA} + kE_{fs}d^2, & d < d_0 \\ nkE_{elec} + nkE_{DA} + kE_{Two-Ray}d^4, & d \geq d_0 \end{cases}$$

If d is less than d_0 then free space model is used. If d is greater than d_0 then Two-Ray ground propagation model is used.

$$\text{where } d_0 = \sqrt{\frac{E_{fs}}{E_{amp}}}$$

W(i).E is the energy of i^{th} node, n is the number of nodes, E_{elec} is energy consumed by electronic component, K is the size of packet, E_{DA} is effective data aggregation, E_{fs} represents the free space model and d is the distance between cluster head and its node, d_0 is the minimum allowed distance.

7. **Check whether the nodes are dead or not**: If the energy of i^{th} node is less than 0 then the node is considered as dead and the nodes which are not dead will start sending the data again.
8. **If the nodes are dead, count the dead nodes:** If all the nodes are dead then the network lifetime is end and if some nodes are alive they will have to again start the process from applying threshold function $T_{(n)}$ and then network lifetime will be returned

VI. EXPERIMENTAL RESULTS

A MATLAB simulation of Token Bucket and Multiplexing algorithm is done to evaluate the performance. In this section we have evaluated the performance of the proposed token bucket and multiplexing algorithm and compare it with the existing PASCCC on the basis of Stable period, half node dead, network lifetime and packet send to CH at different energy levels ranging from 0.1 to 1. In the comparison graphs x-axis represents the initial energy and y-axis represents the rounds. Blue color bars in the graph represent the Existing technique (PASCCC) and red color bars represent the proposed technique (TBMCCCP).

A. Remaining Energy: The remaining energy of all sensors nodes at the end of simulation has been plotted in Fig.2. The graph shows that TBMCCCP has better overall remaining energy over the entire network in a more balanced way. From Table 1, it has been clearly shown that the TBMCCCP outperforms over the PASCCC.

Initial Energy	PASCCC	TBMCCCP
0.1	0.001	0.002
0.2	0.009	0.011
0.3	0.021	0.024
0.4	0.037	0.043
0.5	0.060	0.068
0.6	0.086	0.100
0.7	0.118	0.135
0.8	0.152	0.177
0.9	0.194	0.223
1	0.237	0.275

Table 1. Remaining Energy Analysis

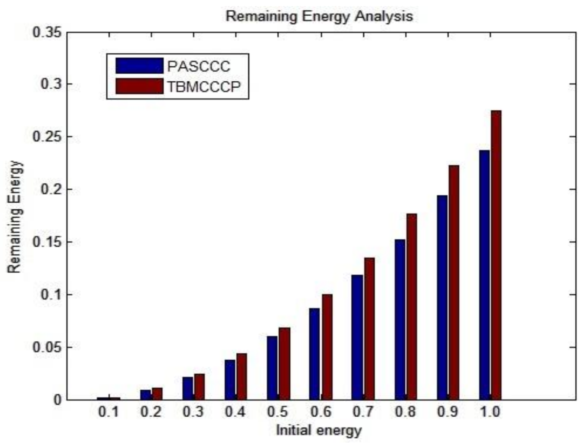

Fig.2 Remaining energy of nodes after simulation

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B. Stability period: Stability period of a network is the time when first node dies in the network. Below Table 2 and Fig.3 shows the results. In the proposed scheme first node dies much later than the first node dead in PASCCC protocol on the basis of different energy levels.

Initial Energy	PASCCC	TBMCCCP
0.1	166	221
0.2	351	403
0.3	508	637
0.4	733	887
0.5	908	1130
0.6	1060	1396
0.7	1210	1563
0.8	1354	1874
0.9	1695	2043
1	1678	2291

Table 2. Stability period Analysis

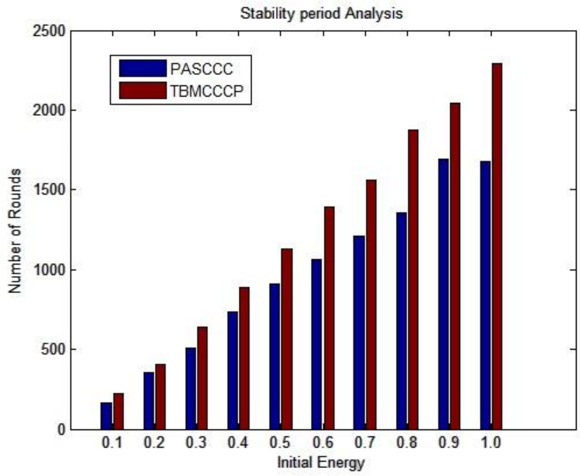

Fig.3 Graph shows stability period comparison of PASCCC and TBMCCCP

C. Half node dead: This metric defines the round at which half of the nodes die in the network. Table 3 and Fig.4 shows the comparison. In proposed technique, the delay in death rate of half node is even more as compare to the PASCCC. It shows that proposed protocol has better results as compare to the existing one.

Initial Energy	*PASCCC*	*TBMCCCP*
0.1	241	279
0.2	488	537
0.3	737	801
0.4	955	1073
0.5	1223	1352
0.6	1458	1607
0.7	1734	1888
0.8	1954	2116
0.9	2230	2429
1	2426	2722

Table 3. Half Node dead Analysis

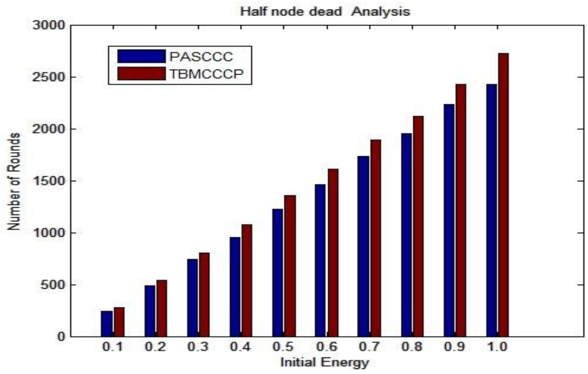

Fig.4 Graph shows half node dead comparison of PASCCC and TBMCCCP

D. Network lifetime: Network lifetime of a network is the time when all the nodes are dead in the network. Below Table 4 and Fig.5 shows the comparison between PASCCC & TBMCCCP on the basis of network lifetime at different energy levels. he lifetime of the network increases very rapidly as the energy levels are increased.

Initial Energy	PASCCC	TBMCCCP
0.1	258	350
0.2	521	675
0.3	780	930
0.4	1039	1285
0.5	1298	1565
0.6	1560	1959
0.7	1820	2344
0.8	2078	2930
0.9	2343	2822
1	2598	3089

Table 4. Network lifetime Analysis

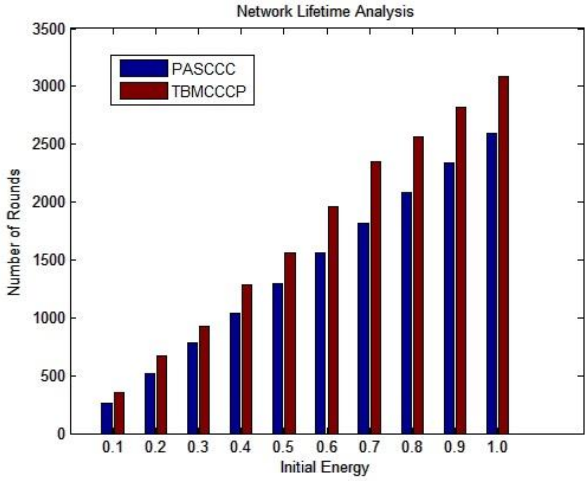

Fig.5 Graph shows network lifetime comparison of PASCCC and TBMCCCP

E. Throughput: It is the rate which defines the successful delivery of a packet over a communication channel. Table 5 and Fig.6 shows the better transmission of packets in Token Bucket & Multiplexing based congestion control clustering

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protocol in comparison to Priority-based application-specific and on the basis of throughput at different energy levels.

Initial Energy	PASCCC	TBMCCCP
0.1	2300	2716
0.2	4588	5131
0.3	6659	7430
0.4	8547	9669
0.5	10590	11663
0.6	12288	13791
0.7	14029	15385
0.8	15524	17127
0.9	16945	18470
1	18095	19778

Table 5. Throughput Analysis

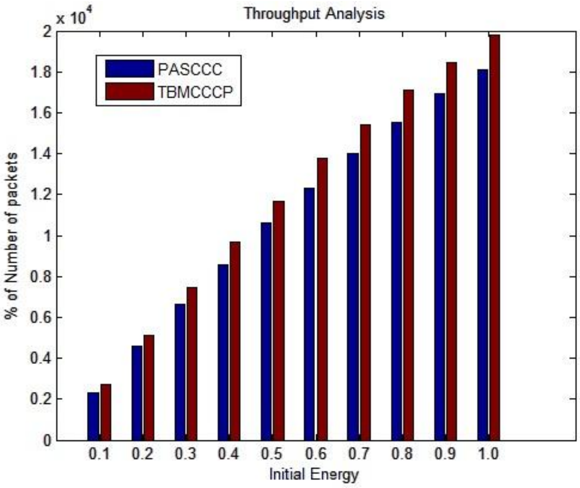

Fig.6 Graph shows throughput comparison of PASCCC and TBMCCCP

VII. CONCLUSION

In this study, we have proposed an energy-efficient Token bucket and multiplexing based congestion control clustering protocol for detecting congestion in a network and mitigate it. Although numerous numbers of congestion control clustering protocols in WSNs have been proposed in the literature, yet they need to consider, delay guarantee, multiplexing and handling of traffic support and congestion. This protocol maintains the flow of data and ensures that the available bandwidth is utilized efficiently. Moreover, simulation results have shown that the proposed protocol have better performance in terms of metrics compared.

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