Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
June 2024 5(6), 1661–1667

DESIGN AND INVESTIGATE THE STATE-OF-THE-ART WSN SOLUTIONS FOR THE CONGESTION CONTROL

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ABSTRACT

Congestion in WSNs is an inescapable issue in today's reality, when data flow has exceeded the channel's aggregated capacity. Because retransmission of every unacknowledged packet is not an optimized solution in terms of energy for resource-restricted sensor nodes, the result is overflowing of the buffer at each receiving sensor node, which eventually reduces the packet delivery ratio, drops the packets, and degrades network throughput. Routing is one of the most popular ways for reducing node energy consumption and increasing throughput in WSNs since the routing issue has been proven to be NP-hard and it has been discovered that a heuristic-based approach outperforms their conventional equivalents. Therefore, it is need of optimized routing solutions for the future WSNs by considering the energy and traffic parameters. The scope of this study is limited to the WSNs.

Keywords: Investigate, Design, Congestion Control, WSNS, Optimized Solution

DOI
10.29121/shodhkosh.v5.i6.2024.2491

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

1. INTRODUCTION

The development of low-cost, compact, and minuscule sensor nodes plays a vital role in situations in which the sensor nodes have extremely desirable properties, such as detecting the circumstances of their surroundings and processing the data they have received. “The sensor nodes are able to be put in any accessible or inaccessible region for the purpose of gathering data for a variety of purposes, including monitoring of disaster zones, target field imaging greenhouses, combat inspections, and building inspections. Because the placement of sensor nodes is application-specific, it may either be arbitrary or predetermined. The wireless sensor network's (WSN) sensor nodes are responsible for sensing the data or event, collecting the data in accordance with the architecture, and processing the signals that are received. Even after significant progress has been made in wireless sensor networks, the technology still suffers from a number of drawbacks, including insufficient compute, limited memory, restricted bandwidth, and nodes that are powered by batteries. Because sensor nodes have a limited connection range, the intermediary nodes must work together to relay data packets. There are many different uses of WSN, all of which involve the deployment of sensor nodes inside an infrastructure-free network. The sensor nodes are able to detect an incident and communicate their findings to the closest base station in order to trigger the appropriate response. Congestion-free end-to-end data delivery and delay-free data transmission are two examples of the quality of service that may be achieved via the design of an effective and efficient network that takes into account the challenges posed by WSN in terms of energy consumption. Congestion may develop in a network when a node gets more data than it has the ability to handle, and this can result in the repetition of packets that have not been acknowledged. However, it is possible that the nodes' energy would be depleted as a result of the frequent retransmission of packets. Because the nodes in a WSN are powered by batteries, making choices that are efficient in terms of energy is the preferred strategy for maximizing the lifespan of the network. On wireless sensor networks (WSN), numerous classic methodologies, such as load balancing, duty cycling, and data aggregation, have been investigated and put into practice. The conventional method, on the other hand, is fraught with problems because of the exponential growth of sensor nodes. For residual energy usage nowadays, techniques such as trajectory-based data forwarding, mobility sink, and energy supply based on node selection are utilized.

2. LITERATURE REVIEW

Triad parameters that affect network performance, in general, are latency, loss and jitter metrics. Latency can be explained as the amount of time (in milliseconds) a data packet takes to journey to its destination and back again. This amount of time is known as the round-trip time (RTT). Even though latency can be measured in a one-way trip, it fetches more costs and requires advanced instrumentation compared to the round-trip measurement. Pertaining to the performance measure of QoS, latency falls under the Quality of Experience (QoE) metric. The variation of delay or latency from one point to another in a network depicts the jitter, which is the significant difference between the latency from one packet to another on a data path. Depending on the jitter buffer of networking equipment constitutes the amount of jitter bearable by the network. Packet Loss is the measure of packets misplaced during the journey of packets from a source point to a destination point. The network experiences packet loss when some of the packets are not received at the intended destination. This is very common in the real world of networks. The behaviour of networks to riffle or alternate occurs from time to time.

In the scenario of phone calls where a caller places a call to the receiver, latency will be the time it takes for the caller and receiver to have effective communication. The concept of queuing theory shows that when a link is busier or congested, more packets will have to wait in the queue. When there is a high latency in transmission, packet loss also increases contributing to some packets being discarded to reduce the congestion, especially on low-speed links. Also, there will be no or limited space in the TCP buffer. This will cause transfers of packets to halt until the lost frames have been retransmitted and received at the destination. Some UDP- based applications can show its response to packet loss by resending lost frames, corrupting the data or even terminating the active connection. Much of these effects are experienced in VoIP applications where one can hear feedback or echo as well as distorted audio. Other elements of the network and buffers try to fix the losses of packets which in turn cause delays which are easily seen in conversations. This depicts that when the latency is high, packet loss increases. There can be a solution around it but that will also cause TCP activities to slow down rapidly.

Some packets make it through to its destination even though some are lost on the way. The amount of data that travels or traverse through the network successfully is referred to as the throughput. “The effects and impact of latency in the network are not eradicated by bandwidth increment. The time it takes to transmit a packet between two nodes A and B, across a network and to receive a response back impacts the network as a whole. Since the speed at which the packet travels cannot be greater than that of light, the amount of data that can travel successfully (throughput) greatly depends on the distance between the nodes in the network.

The operation of TCP is such that when a packet is lost usually in wired networks as a result of congestion, the degree of packets sent is slimmed down to 50% of the prevailing size of the congestion window (cwnd). Assuming *cwnd* is 4, it will be lowered to 2 for the process of slow start in TCP to begin again. In order to find the appropriate and optimal throughput, the congestion window will be increased by 1 segment gradually. In situations of high packet loss, this will result in overall lower levels of throughput. The maximum size of packets or frames varies as a result of different networks that are connected via the internet. The maximum size otherwise the maximum transfer unit (MTU) of the data payload of 802.11 standard is normally 2312 bytes. Other forms of the 802.15.4 standard have 104bytes as the MTU. Fragmentation occurs when packets get onto a link with lesser maximum size than the packets arriving. Fragments of packets are then transmitted in packets independent of each other. At the end of the transmission, with all fragments received, they are reassembled at the end host.

MTU size puts a limit the maximum size of packets that traverses on a link. Fragmentation, however, helps to overcome that limitation but that can also affect the performance of the network negatively by incurring extra costs and complexity due to the reassembling of protocols and the fragmentation process. However, there is a high probability for packet loss to increase since more packets for each of the primary packets must be transmitted. In networks with limited resources, the repercussions of packets loss may be very critical. The network layer constitutes the building blocks for several applications and data that traverse on the network. Hence, problems arising from this layer will affect the other layers that operate on top of this layer negatively. Packet loss is one of the adverse effects networks suffer. The reasons why packets get dropped in a network includes link congestion, network device performance, software errors and issues on network devices and faults in cables and hardware.

3. RESEARCH METHODOLOGY

RESEARCH PURPOSE

Purpose of this study is to design the novel clustering-based solutions for energy and traffic aware congestion management in WSNs.

RESEARCH DESIGN

This study will cover title of the study, significance of the study, aims and objectives of the study, research hypothesis and research design. This research has designed based upon descriptive study as it aims an in-depth analysis on relationship standard methods in congestion management and clustering in WSNs. The research design contains the following steps:

THEORETICAL AND EXPERIMENTAL ANALYSIS.

Consequently, the following **hypothesis** will be invented:

H1: There is direct relationship between selection of clustering mechanism and energy efficiency.

H2: There is direct relationship between disease congestion management solutions and energy efficiency.

H3: There is direct relationship between the clustering designing and congestion management in WSNs.

DATA COLLECTION

This study is based on secondary research method. Thus, gathering and analyzing the data will be done on the basis of existing research.

4. TOOLS AND TECHNIQUES

In this research work we will use simulation tools to implement and evaluate the proposed models with existing methods.

(1) We will use a detailed simulation model based on NS.

(2) We will use the different metrics to compare the performance of proposed methods.

5. ANALYSIS AND INTERPRETATION

Every one of the models will undergo simulation and evaluation on a 64-bit version of Windows 11 equipped with an Intel I5 CPU and 8 gigabytes of random-access memory. The proposed and existing models will be implemented and evaluated using the different WSN network scenarios and conditions.

AVERAGE DELAY: This metrics calculates the average time between the packet origination time at the all sources and the packet reaching time at the all-destination nodes. It is computed as:

$$D = \frac{\sum_{i=1}^{N} d_t^i + d_p^i + d_{pc}^i + d_q^i}{N} \quad (1)$$

Where N is number of total transmission links, d_t^i is transmission delay of i^{th}link, d_p^i is propagation delay of i^{th}link, d_{pc}^i is processing delay of i^{th}link, and d_q^i is transmission delay of i^{th}link.

AVERAGE THROUGHPUT: This metrics calculates the total number of packets delivered per second i.e. total number of messages which are delivered per second. The average throughput in Kbps is:

$$T = \left(\frac{R}{T^2 - T^1}\right) \times \left(\frac{8}{1000}\right) \quad (2)$$

Where R is complete received packets at all destination nodes, T^2 is simulation stop time and T^1 simulation start time.

Average Energy Consumption: It computes the average energy consumption by entire network after the end of simulation by measuring the remaining consumed energy of all nodes. The total energy consumed $E^{tot}$is computed as:

$$E^{tot} = \sum_{i=1}^{N} E_i^{initial} - E_i^{consumed} \quad (3)$$

Where $E_i^{initial}$ and $E_i^{consumed}$ are initial and consumed energy of i^{th} node respectively. N is total number of nodes in network. The average consumed energy is computed as:

$$E^{avg} = \frac{E^{tot}}{N} \quad (4)$$

E. NETWORK LIFETIME

Lifetime (Rounds) = Total Remaining Energy/10

PDR: It is the calculation of the ratio of packet received by the destinations which are sent by the various sources of the different traffic patterns. It is computed as:

$$P = \left(\frac{P_r}{P_g}\right) \times 100 \quad (5)$$

Where, P_r is number of received packets and P_g number of generated packets.

Communication Overhead: It is computed as the ratio of total number of routing packets to the total number of data packets in network. It is computed as:

$$O = \sum_t \left(\frac{RT^t}{DT^t}\right) \quad (6)$$

Where, RT^t is total number of routing packets and DT^t is total number of data packets at time t.

6. DATA ANALYSIS

Several simulation tests were run using the Network Simulation program NS2 and the assumed simulation parameters (Table 1) in order to evaluate the efficacy of the proposed ETCCC technique. The performance of the well-known procedures LEACH and F-ETCCC is evaluated alongside the simulated results produced by ETCCC.

Table 1 Parameters considered for Experiment.

Parameters	Value
Sensing Field	100 m x 100 m
No. of nodes deployed	100
Sink Location	(50.50)
Initial Energy	0.5J
Sensing Range	20 m
Packet Size	500 bytes
Hello packet size	25 bytes
Aggregation Energy Consumption	50 pJ/bit
Transmission energy *(ETX)*	100 nJ/bit
Reception energy *(ERX)*	50 nJ/bit
Transmitter amplifier energy *(Eanp)*	100 pJ/bit/m^2

Under this section of the report, you will find comprehensive data as well as analyses pertaining to both the online drift detector and the HBBE. Memory and running time requirements for each drift detector are shown in Figure 1. Following SEED is TECP (Threshold-sensitive Energy-efficient Clustering Protocol), Moth Flame Optimization (MFO), and F-ETCCC & suggested ETCCC in terms of memory consumption, with MFO having the most significant impact. The ETCCC keeps track of the longest runtimes ever recorded. The reason for this is due to the fact that these finders need more memory in order to keep the anticipated results of the classifiers that are located beneath sliding windows or archives. As a consequence of this, more computing time is required due to the processes of sub-window pressure or supply inspecting. The internet-based drift identifier that we have developed has shown to be the most cost-effective of the three different locators that have been tested due to its low processing time and memory use. This is due, in part, to the fact that our live drift locator maintains a fixed set of factors, which results in less memory use as well as less runtime required to update these factors.

For the final point, in regard to the classification accuracy of each drift detector, Figs. 2 and 3 demonstrate how well the suggested Hybrid Model for Novel Concept Drift Classification through Streamlining Data performs in comparison to the

TECP (Threshold-sensitive Energy-efficient Clustering Protocol), Moth Flame Optimization (MFO), F-ETCCC, and proposed ETCCC. This comparison is made in light of the fact that each of these protocols is used to detect drift. in relation to the standard deviation of the accuracy of each drift detector.

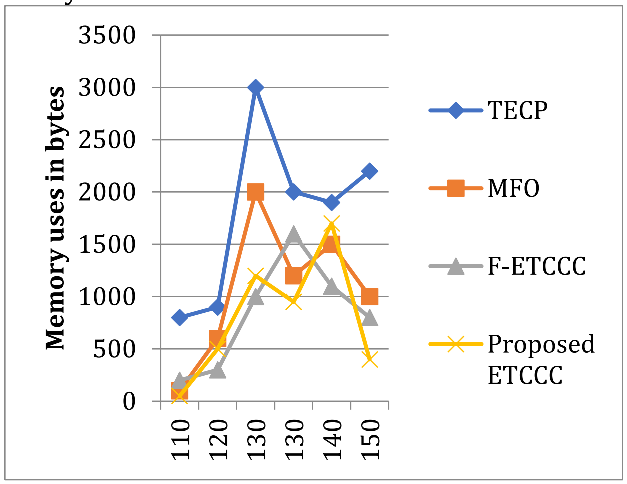

Fig.1. Memory Consumption of proposed ETCCC as compare to existing System

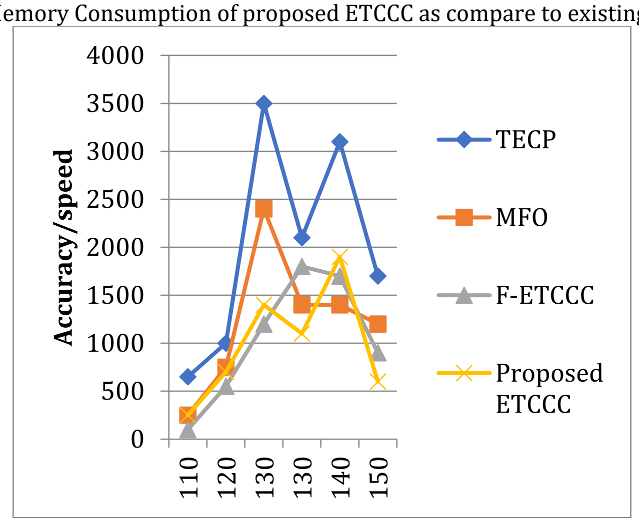

Fig.2. Average Accuracy & Delay Detection proposed ETCCC as compare to existing ADASYN, EACD, HLFRTEC, MFO, and F_ETCCC

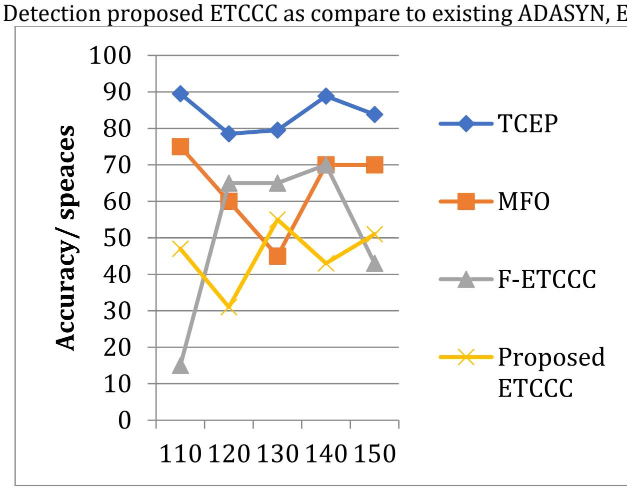

Fig. 3. Average Accuracy & Delay Detection proposed ETCCC as compare to existing ADASYN, EACD, HLFRTEC, MFO, and F_ETCCC

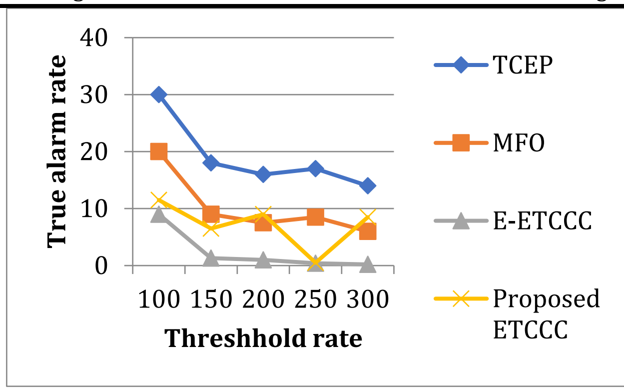

Fig.4 Effect of True alarm Rate of ETCCC as compare to existing ADASYN, EACD, HLFRTEC, MFO, F_ETCCC

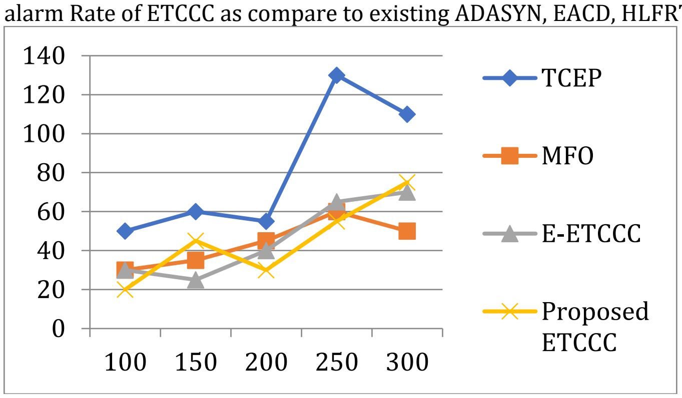

Fig.5. Effect of Delay detection Rate of ETCCC as compare to existing ADASYN, EACD, HLFRTEC, MFO, F_ETCCC

The effectiveness of ETCCC and a great number of other ideas are shown under the heading algorithms. As can be seen beneath the graph, the performance of each detector suffered a considerable setback as the noise ratio increased from 10 percent to 50 percent.

Moreover, the certainty of the data is employed as one of the assumptions that are utilized under this sector; nevertheless, recognizing drifts is the key concern due to the affect that it has on performance. During the process of data streaming, it is quite common to have uncertainty due to the presence of privacy protection, the loss of data, network problems, and other issues. However, every single publication that can be found beneath the literature, including the one that you're reading right now, was founded on the assumption that the facts are true and trustworthy.

7. CONCLUSION

The research objectives of this thesis have opened several challenging research directions, which can be further explored. To extend the network lifetime, the proposed protocol ETCCC divides the entire sensing field into several regions. Node distances from the BS are considered for constructing the regions in the network. In each region different number of clusters is formed. If the network area increases, number of clusters will also increase. To perform energy-efficient data transmission and to prolong the network lifespan, it is very important to determine the optimum number of regions that can be formed in the network. This may be explored for further research; also research may be extended to find the optimum amount of energy in each region to reduce the total energy consumption in the network. In order to overcome the difficulties of balancing the energy in the complete network, energy efficient clustering methods need to be proposed to limit the number of rounding processes and limiting the number of hop counts. The proposed Reliability based protocols and various scheduling algorithms have mostly focused on reducing energy consumption of nodes by creating various sized clusters and regions in the WSN. New protocols can be developed using Machine learning techniques to optimize the WSN performances like minimizing the energy, improving the scalability, increasing the packet counts and improving Reliability. Neural Networks, Artificial Intelligent Techniques such as Genetic Algorithms, Bee Colony Optimization etc., can be employed to determine the optimum number clusters in the different network regions to improve the performance of the protocols.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS
None.

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