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Design, Model, and Analyze Traffic-Aware Clustering-Based Congestion Control Mechanism for WSNS

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Abstract - This study is to introduce the novel solutions for traffic and energy aware congestion control in future WSNs. In this study, we make an effort to present a congestion management method for wireless sensor networks. The proposed algorithms should be applicable to a wide variety of applications, including those dealing with agricultural, monitoring, and health care systems. The NGBC is examined using the results acquired by earlier algorithms like LEACH, HEED, and IDCA in order to provide justification of the efficacy of the proposed mechanism. This analysis's goal is to provide justification of the effectiveness of the suggested mechanism. The comparison was carried out with the objective of determining measures like as throughput, packet loss, energy usage, packet delivery ratio, and end-to-end latency. The suggested approach makes use of optimization algorithms that are based on artificial intelligence in order to discover more than one path for data routing in networks that are clustered.

Keywords: LEACH, HEED, IDCA, approaches, methods, Wireless Sensor Network

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INTRODUCTION

During previous decade, Wireless Sensor Network (WSN) applications such primary observation, military reconnaissance, mechanical estimates, and medical care have been allowed. Wearable biomedical sensors improve smart medical care testing and enable specialists view vital physiological data from remote locations. IoT (Internet of Things) is a proven concept, and WSN aims to improve services and devices that eliminate human mediation and improve human life. An IoT-powered wireless sensor network provides access to wearable sensor data. A massive information vault is needed to monitor human boundaries. The GSMA predicts 15 billion linked wearable devices by 2015 and 24 billion by 2020. A coordinated processing device with an Internet connection in a home clinic improves patient care. WSN tests security, sensor position, neatness, and caring information in medical clinics. All WSN applications transmit aggregated data down the base slowly [1]. The present WSN can incorporate approved and network-coded communication.

WSN research and data computing are growing fields. WSN send deployed area data to the base station concurrently. WSN were first used in military and heavy industrial applications, then in consumer uses. Battery-powered WSN nodes make power conservation the primary difficulty. “Low-power hardware is needed to miniaturize the sensor node due to its battery capacity. Code optimization (algorithm complexity), running operating systems, and supporting applications can extend sensor node lifetime. Due to battery capacity, computational, and transmission limits, these sensor nodes must coordinate and collectively submit data to the Base Station (BS) analyzed wireless sensor network for detection and tracking by conducting high-level information processing. Well-defined task detection, false/missing alarms [2], classification errors, and track quality were evaluated to evaluate network performance. Sensor networks are categorized by application, deployment technique, sensing modality, power supply, and heterogeneity. Wireless sensors cost less and deploy faster than wired sensors, which make up 90% of WSNs. Wiring budget and insulation dominate deployment cost. Building, repairing, and placing take longer [3]. Wired sensors are impractical for several applications. Battlefields, enclosed regions (radioactive monitoring), and automobile systems necessitate fast deployment and mobility. Wireless sensor deployment reduces installation cost and time, eliminating these limitations. Demand and research will boost wireless sensor manufacture at cheap cost.

LITERATURE REVIEW

During a trip across a network, data traverse through several devices and links. When a link has utilized its capacity fully, incoming data arriving on that link must wait in a queue for its turn to be given access to travel on the link. Depending on the length of the queue, when the buffer space of the network device is full, the incoming data will have to be dropped and discarded. However, several applications are able to handle it in such a way that it will be unnoticeable by the end user. The transfer speed of packets is slowed down in any stage a lost packet is encountered, which initiates a process to re-transmit the missing packets again. If packet loss does not occur continuously or consistently, legitimate time applications like email retrievals and downloading of files normally experience minimal effects of it. On the other hand, applications which include phone and audio calls, video messaging and chats have its users noticing the effects of the lost packets such as missing parts of audio and video distortion. Increasing the bandwidth of congested links can help reduce congestion to a certain level. Also, configuring QoS to give much priority to some of the real-time applications like audio and video will not eliminate but can go a long way to reduce the congestion on links.

Network Devices includes switches, routers, and firewalls. Each device has its working performance as to how much traffic it can keep up with. Bandwidth increase can help to reduce packet loss to a certain level in that when the network device is not able to process the traffic that comes to it, packet loss can still occur. This can result because the network device has reached the maximum throughput that it can allow for. The device's memory has exhausted its capacity or CPU processing capacity, therefore dropping the packets when the traffic reaches the device. It is required to replace the device with a new one or add another device to an existing one to keep up with the incoming traffic and handle the throughput to its maximum.

Bugs in software can cause device malfunction and make the device not behave the usual way it is supposed to. Due to the complexity of network devices, it takes time for one to detect these bugs. Furthermore, some features do not work well or might even not work entirely. Since it takes some time to detect it might cause performance issues. Most of these performance issues are mostly found in packet captures and system logs. Frequent upgrade and updates of the device software are required for the devices that have been affected. Another common cause of packet loss is faults with the physical components such as cables (e.g. fibre optic and copper cables), pinched cables, corrosions, poor crimping and faulty connectors. Hardware malfunction can generate errors in system logs and the device console. The best remediation is to replace faulty hardware or repairing faulty links if detected.

When computer components, systems, and devices connect in order to share or transfer resources through media or communication channels, it can be termed as a network [146]. A simple example of an existing network can be a couple of computers in connection to each other by a wired media, with the two being able to send or access information (files and documents) between each other. Networks can also be more robust and complicated such as several networks linked together to formulate a larger network. The type of network can be defined by the geographical area the network covers. With respect to that, network types can be grouped into three major groups namely Wide Area Networks (WANs), Local Area Networks (LANs), and Metropolitan Area Networks (MAN) [65]. Other varieties include Personal Area Network (PAN) and Campus Area Networks (CANs). The type of media used in the network can also define network types such as Passive Optical Local Area Network (POLAN). Depending on the type of devices connected to the network for communication, a network can be also grouped into Homogeneous or Heterogeneous.

A LAN usually connects devices, workstations, and computers in a setting or buildings closer to each other or covering a small geographical area. Switches, Hubs, and Ethernet cables are some of the hardware devices used in LANs. Routers are used to connect LANs to bigger networks and other LANs together to share resources, data, and information. Twisted pair and coaxial cables are examples of transmission media used in LANs. When devices are linked by wireless technology in a LAN, it can be referred to as a Wireless LAN (WLAN). This is made possible by using wireless access point devices to serve as a bridge between the computer devices and networks.

RESEARCH METHODOLOGY

It should be noted that, while designing a protocol for clustering, the cluster' size along with confirmed connectivity throughout the lifetime of the network. When there is no need for its active contribution, the sensors must be able to sleep, and it increases the longevity of the network. Therefore, every node's working cycle must also be researched and analyzed while design of a clustering mechanism. Traffic-aware Clustering for Congestion Control (TCCC) is a mechanism presented in this thesis, with all those concerns.

Traffic-aware Clustering for Congestion Control (TCCC)

A new algorithm called Traffic-aware Clustering for Congestion Control (TCCC) comes up in this chapter to select excellent CHs in WSN by concluding the previous discussions. Due to the frequent selection of CH, the mechanism helps to prolong the lifetime of the sensor network, thereby reducing communications overheads, which helps to increase energy consumption on nodes, then those to other approaches. It is now possible to carry out selection appropriately and replace CH, based on current energy levels of the sensor nodes and the distance calculated between corresponding nodes. The number of rounds evaluated to be served by the specific CH before its replacement along with the energy threshold utilization is also incorporated in the algorithm. Apparently, with the help of this approach, the position (P,) of nodes with respect to the BS, in perspective with the existing energy level, the nodes even within cluster are disbursed by grade points (Ey). Effective CHs are selected and sorted in to the levels through strict compliance with its position from the respective sink and its Euclidean distance. Hence, grades are assigned in the networks for every node and are represented with Gy (Ey, Py). Showing the likelihood of it being appointed as the CH.

Steps in the TCCC algorithm

The steps to be taken in developing the TCCC algorithm are as follows:

- In compliance with pre - defined communication ranges of that same sensor nodes algorithm their positions, the base station identifies the covered area in to the smaller regions termed as clusters
- Tt should be ensured with none of the nodes outside the area of coverage.
- During set-up phase, each node transmits a message about their present energy level and location, to its neighbouring nodes.
- Hence, a data table about its neighbours is maintained by every node. Tt is advertised again to the neighbourly nodes until the data concerning those sensor nodes approaches the sink.

Energy and Traffic-aware Clustering for Congestion Control (ETCCC)

Most software systems and companies use the ETCCC method. F-ETCCC picks the alternate attributes according to the concept of compromised solutions. Negative Ideal Solution (NIS), is chosen as the longest Euclidean distance and Positive Ideal Solution (PIS) is chosen as the shortest Euclidean distance. The PIS is created on the basis of best criteria values achievable, and the NIS is created based on the worst criteria values achievable. Using the concept of ETCCC Fuzzy Positive Ideal Solution (FNIS) and Fuzzy Negative Ideal Solution (FPIS) are defined. The approach contains an M x N matrix, where M indicates a wide range of alternatives and N is the range of attributes to each alternative.

Experimental Environment

"According to the word reference, the Simulation can be characterized as —reproduction of fundamental elements of something is help to learn or preparing." Under basic words, the cycle where we can develop the one model of mathematic is called as reproduction to tackle the framework issue. Such interaction regularly uses to duplicate the qualities of the complicated work. To recreate the network like portable impromptu networks called MANET or VANET, number test systems are accessible, for example, OPNET, Qualnet, and NS2 and so on. First part of this section, will take the overview of all such networks with their usage, advantages and disadvantages of using it. For our simulation, we have to finalize the one out of them depending on their availability and problem compatibility under order to simulate the work.

DATA ANALYSIS

The NGBC is examined using the results acquired by earlier algorithms like LEACH, HEED, and IDCA in order to provide justification of the efficacy of the proposed mechanism. This analysis's goal is to provide justification of the effectiveness of the suggested mechanism. The comparison was carried out with the objective of determining measures like as throughput, packet loss, energy usage, packet delivery ratio, and end-to-end latency. In contrast, with its initial parameter presumptions, as shown in Table 1, the alleged work i performance of the evaluated utilizing the Network Simulator (NS2) tool was found to be satisfactory. The simulation area that will be used here will be 500 m × 500 m, and each node will be given a beginning energy of 5 Joules. Additionally, it is essential that the consumption of 5 nJ each bit throughout the process of data collection be taken into consideration.

According to the methodology, the CHs in each cluster are determined to be the nodes that are located in the closest proximity to the BS. In line with our hypotheses, the number of nodes may range anywhere from one to one hundred, the simulation length can be set to eight hundred seconds, and the mobility speed can be set to meters per second. The payload size will be 512 bytes, and the transmission range will be 250 meters. The frequency will be 9 megahertz. Figure 4.1 illustrates the cluster creation that takes place inside the Node-Grade Based Clustering (NGBC) Algorithm. The value of K is found by conducting experiments with a number of different test scenarios, such as K=5, K=10, K=15, K=20, K=25, K=30, K=35, and K=40. Experiments are performed using real-world examples of cluster formation generated by the Node-Grade Based Clustering (NGBC) Algorithm. Figure 4.1 displays the results of an analysis done on the average F-measure to determine the optimal value of K.

Table 1. List of simulation parameters

PARAMETERS	INITIAL VALUES
Simulator	Matlab
Sensing area	500m x 500m
No. of Nodes	Varies from 1-100
Simulation time	800s
Mobility Model	Random waypoint
Traffic Type	CBR
Mac Type	IEEE 802.11
Mobility speed	5 m/s
Payload size	512 bytes
Pause time	0 s
Transmission Range	250m
Frequency	9Mhz
Initial Energy	5Joules per Node
Simulation end time	50.0

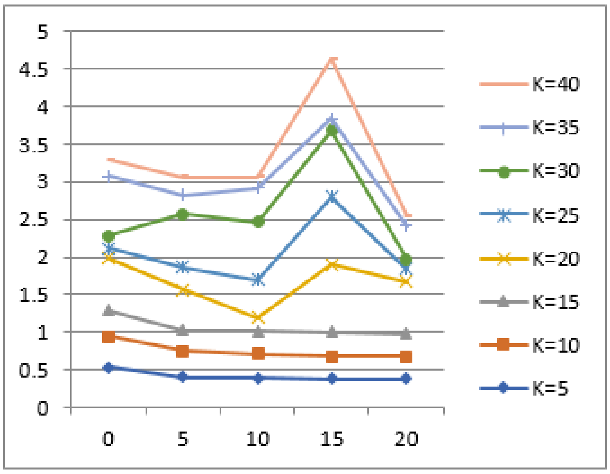

Figure 1: Analysis of optimum 'K' value using F-Measure

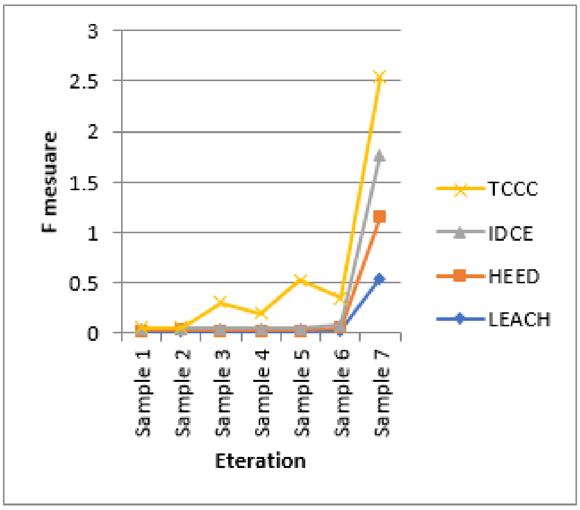

Figure 2: F-Measure Analysis of Various Proposed Algorithms

To compare the performance of proposed TCCC, IDCE and HEED algorithms, traditional Cluster head (CH) algorithm has been implemented using simple Leach clustering technique. Recommendation of web pages with query match with neighbouring users is given to active user. The following Figures 2 to 4 represent the analysis of various evaluation metrics. Based on the results obtained for traditional CH and proposed TCCC algorithms, F-Measure value is analyzed for various sample datasets.

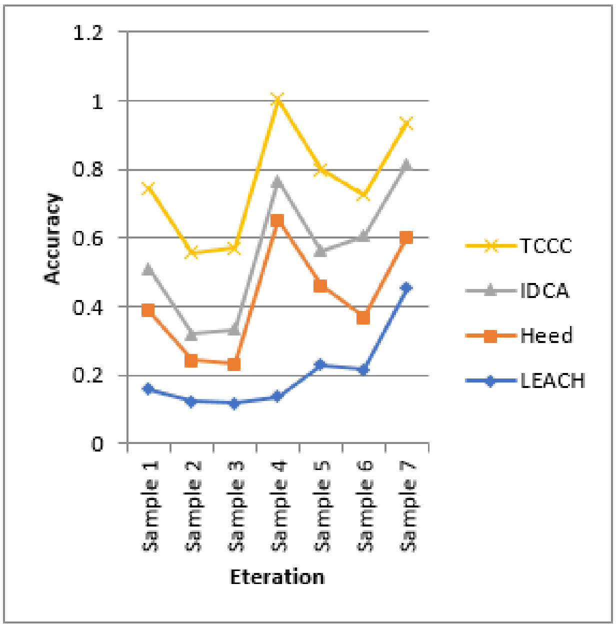

Figure 3: Number of iterations vs. average computation time

Figure 4 states that on average, compared to CH method, the proposed TCCC algorithm yields 5% of improvement while TCCC algorithm has provided 12% of improvement. IDCA algorithm outperformed all other algorithms with 76.63% of F-Measure value. Performance has been improved by 21% when compared to traditional Leach algorithm.

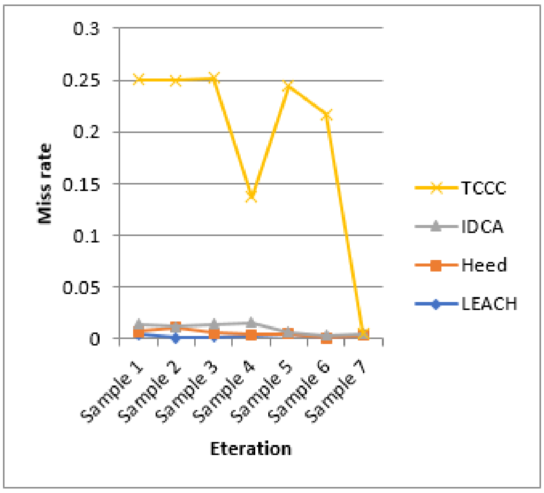

Figure 4: Miss Rate Analysis of various Proposed Algorithms

MR results are visualized in Figure 4.5 respectively. Negligible MR and FR reduction have been found to be achieved by TCCC algorithms. Analysis of Matthews Correlation (MC) is also examined to verify the performance of proposed algorithms.

CONCLUSION

A traffic-aware clustering for congestion control (TCCC) algorithm-based structured CH selection mechanism is described. Just after the construction of the cluster, the CH selection is established in order to calculate the residual energy of the candidate nodes and their Euclidean distance to the BS. In addition, the Threshold Energy Rate (TER) for each cache node is figured out, and if it turns out to be required, the CHs are switched out for other nodes at the beginning of each cycle in an effort to save the nodes from unnecessary or excessive energy consumption. This leads in a reduction in the amount of energy that is used, which in turn increases the lifetime of the network. The performance assessment demonstrates that the suggested algorithm is superior to other algorithms that are already in use, such as IDCA, HEED, and LEACH. In addition, it has been discovered that the use of TER in the process of cluster head replacement results in an increase in the overall network's lifetime. The results of the simulations demonstrate conclusively that the proposed TCCC algorithm is capable of improving throughput while simultaneously lowering energy consumption, improving the ratio of packet deliveries, and shortening end-to-end latency. In compared to the methods that came before, there is a significant decrease in the number of packets that are lost.

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