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Performance Analysis of Adaptive Approach for Congestion Control In Wireless Sensor Networks

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Abstract: *WSN consists of hundreds / thousands of wireless nodes distributed within the geographical area. The wireless nodes gather information and supply towards the central node for further processing. There are different factors that affect the WSN design like transmission media, power consumption, routing protocols etc. Congestion in WSNs can lead to packet losses and increased transmission latency. Different type of congestion is present like node level, Link level, etc. Lot of work is performed by the different researchers to detect the congestion and remove or decrease the effect of congestion. The congestion gives the energy loss and packet drop over the communication. In this work, an improvement to the traditional routing algorithm is defined by generating a distance and energy based priority path. In this work adaptive algorithm is suggested to generate the effective communication route and analyze the work under different parameters. The analysis of work is done under the parameters like packet loss, throughput, bit rate etc. The network simulator NS-2 is used. The obtained results show that the proposed algorithm gives the better results than the existing algorithm.*
Keywords: *Wireless Sensor Network, Congestion, NS-2, Adaptive Approach, Routing.*

I. Introduction

The emerging field of wireless sensor networks combines together the features like sensing, computation of sensed data and communication into a single tiny device. Wireless networks are broadly divided into infrastructure and infrastructure less network where infrastructure network consists of wireless node with a network backbone and infrastructure less network consist of independent, distributed, low-power, dynamic topology and task-oriented wireless node. Cellular wireless network falls under the category of infrastructure network whereas ad-hoc and wireless sensor network (WSN) are the part of infrastructure fewer networks. In ad hoc mode, the wireless devices integrated and communicated to each other by making an on-support dynamic wireless link [1]. WSN consists of hundreds/thousands of wireless nodes distributed within the geographical area. A sensor network consists of a many sensor nodes, which are placed at very short distances either inside the phenomenon or at a place very near to it [1] [2]. There can be several different types of sensors that sense different kinds of things like some can be used to sense temperature, others sensing humidity, some sensing the vibrations, composition of soil, movement of vehicles, levels of noise etc. [3][4].

A. Network Design Objectives

Sensor networks depend on the type of application that we need to develop and also have different requirements as per the application. For example if we are developing an application for ground level then we need a GPS to keep a track of the location of the nodes whereas if the application is underwater then it would be entirely different as there would not be any GPS for underwater applications and the position of nodes is calculated in a different way. So we keep into mind these few or all design objectives for designing a sensor network [7], [4]

1. Small node size: Sensor nodes are placed in an inconsiderate environment that too in large numbers. So smaller is the size of the nodes easier it will be to place the sensors and the total energy consumed by the sensors will also be reduced leading to a cost effective network.

2. Low node cost: We need to deploy a large number of sensors placed very close to each other and these cannot be used again and again. So more the sensors greater will be their cost. So for decreasing the cost of the whole network we need to decrease the cost of individual sensors.

3. Low power consumption: Sensor networks suffer from the biggest problem that is power. The power is limited and it cannot be replenished easily. So it is important to decrease to amount of power utilized during communication between sensor nodes so that the life of the entire network improves and it lasts longer.

4. Scalability: The protocols that are made for sensor networks have to be scalable so that they can work on any sensor network regardless of its size. The size of the network varies as per the application as well as the number of nodes that vary from tens to thousands.

5. Reliability: There must be methods with the protocols to control the errors and correct them whenever required so that there is trustworthy transfer of data over the wireless channel that consist of noise, varies with time and is prone to errors.
6. Self-configurability: The sensor nodes ones must by themselves organize to form a sensor network for communication and should regain their connectivity whenever there is change in the topology of the network or any of the nodes fails. In case of both these things the network must not stop its functionality.
7. Adaptability: The size of a sensor network keeps on changing. There can be addition of a new node in the network, any of the nodes may fail and removed. So the structure and size of the network is not static. The protocols designed should be able to adapt as per these changes.
8. Channel utilization: The bandwidth in case of sensor networks is limited and hence should be used resourcefully. This is the responsibility of protocols to make use of the channel in an efficient way.
9. Fault tolerance: There can be faults in the sensors as well as the readings collected by them due to the conditions under which they are kept and the operations that are not attended in time. They suffer from failures too. Thus the nodes must be able to tolerate the fault, perform testing on their own, repair themselves and recover after a failure.
Security: In a sensor network there can be attacks by the malicious users who can gain access to the network and perform unauthorized works. Hence there should be methods to keep the data of the network secure and save it from harm from the unauthorized users.

B. Power
A node in a wireless sensor network is very small in size and has some fixed amount of energy that in some cases cannot be replenished easily. So the life of a node relies on the life of the battery [15].

C. Routing Protocols
The process of routing in wireless sensor networks is entirely different form that of the existing routing schemes in the fixed networks. There is need to save the energy, the links are not trustworthy and there can be a failure in some of the nodes in the network [11]. The routing protocols are Location-based Protocols [18], Data Centric Protocols [19], Hierarchical Protocols [11], Mobility-based Protocols [11] , Multipath-based Protocols, Heterogeneity-based Protocols, QoS-based Protocols [11] etc. It is very difficult to design routing protocols for WSNs because in WSNs there is limited energy, lesser bandwidth, slow processor and less memory. Some of them are Limited energy capacity, Sensor locations, Limited hardware resources, Massive and random node deployment, Network characteristics and unreliable environment, Data Aggregation, Scalability etc. [19].

D. Congestion Control
Congestion control is an important issue that should be considered in transport protocols. Congestion is an essential problem in wireless sensor networks. Congestion in WSNs can lead to packet losses and increased transmission latency has a direct impact on energy efficiency and application QoS, and therefore must be efficiently controlled.
Congestion occurs in WSN due to
i). Radio channel interference,
ii). Addition and removal of sensor nodes
iii). lastly sensed event cause bursts of messages.
Congestion not only wastes the scarce energy due to a large number of retransmissions and packet drops, but also hampers the event detection reliability [15].
This paper is divided in five sections. In section I the Introduction is given about the Wireless Sensor Network. In section II, the Literature Review is discussed. In section III, the Problem associated with WSN and the proposed solution is given. In section IV, result analysis is discussed. At last in section V, the conclusion and future work is described.

II. Literature Review
A lot of work is done in the congestion control. Different researchers try to solve congestion problem.
Kamal Kumar Sharma, Dr. Harbhajan Singh and Dr. R.B Patel in their work, to detect congestion, each node calculates its node rank based on the parameters buffer Size, hop count, channel busy ratio and MAC overhead. When the node rank crosses a threshold value T, the sensor node will set a congestion bit in every packet it forwards. If the congestion bit is set, the downstream node calculates the Rate Adjustment Feedback based on the rank and propagates this value upstream towards the source nodes. The source nodes will adjust their transmission rates dynamically based on this feedback. [2]
Basaran, Kyoung-Don Kang, Mehmet H. Suzer in their work “Hop-by-Hop congestion control technique and load balancing in Wireless Sensor Networks”, used the Effective Queue Length (EQL) is measured. EQL is

used to determine whether the congestion is occurred or not. The technique called CONSEQ (CONtrol of Sensor Queues) is used to control the congestion. The CONSEQ aims to reduce congestion and, thereby, decrease the delay and energy consumption due to packet losses and retransmission in WSN. [3]

Chieh-Yih Wan, Shane B. Eisenman,Andrew T. Campbell In “Energy efficient COngestion Detection and Avoidance in sensor networks, CODA, propose it as an energy efficient congestion control scheme for sensor networks was proposed. CODA (COngestion Detection and Avoidance) comprises three mechanisms: (i) receiver-based congestion detection; (ii) open-loop hop-by-hop backpressure; and (iii) closed-loop multi-source regulation. CODA detects congestion based on queue length as well as wireless channel load at intermediate nodes. Furthermore it uses explicit congestion notification approach and also an AIMD rate adjustment technique. [4]

Muhammad Monowar, Obaidur Rahman, Al-Sakib Khan Pathan, and Choong Seon Hong in “Prioritized Heterogeneous Traffic-oriented Congestion Control Protocol in Wireless Sensor Networks”, proposes a Prioritized Heterogeneous Traffic-oriented Congestion Control Protocol (PHTCCP) to control congestion. It uses packet service ratio to detect congestion. Packet service ratio is defined as the ratio of average packet service rate and packet scheduling rate in each sensor node. PHTCCP uses hop-by-hop rate adjustment for controlling the congestion. The output rate of a node is controlled by adjusting the scheduling rate. [5]

Rekha Chakravarthi, C.Gomathy in “IPD: Intelligent Packet Dropping algorithm for congestion control in Wireless Sensor Networks”, the congestion is detected by measuring the length of the queue. The queue length increases when the Packet inter-arrival time is more than Packet inter-service time. Using queue length, the Buffer Occupancy is calculated. When the Buffer Occupancy increases, the congestion increases. Congestion is controlled by assigning priority to the data packets. When the Buffer Occupancy increases, the data packets are dropped depending on priority assigned to the data packets i.e., Intelligent Packet Dropping. [6]

Hull B., Jamieson K., and Balakrishnan H. assumed that congestion is detected by measuring the queue length. The congestion is controlled by using three techniques i) hop-by-hop flow control , ii) source rate limiting, and iii) prioritized MAC. Even in high offered load it claims to achieve good throughput and fairness. [7]

Ee C. and Bajcsy R. in hop-by-hop congestion control technique, Congestion Control and Fairness (CCF), which uses packet service time to infer the available service rate and therefore detects congestion in each intermediate sensor node. CCF ensures simple fairness. However, it lacks efficient utilization of the available link capacity when some nodes do not have any traffic to send or nodes remaining in sleep mode or the nodes whose flows do not pass through the congested area. [8]

R.Then Malar work PCCP is a recent congestion control protocol for WSNs which uses hop-by-hop approach for rate control. PCCP is a node priority based congestion control protocol which allows sensor ndes to receive priority-dependent throughput. However, PCCP does not have any mechanism for handling prioritized heterogeneous traffic originated from a single node. In [10], congestion is detected by calculating depth of congestion at the sink node. To calculate depth of congestion service and arrival rate are used. It"s the ratio of local packet inter-service rate and local packet inter-arrival rate. Hop-by-Hop Rate control Technique (HRCT) is implemented to control congestion. The sensor/transmission rate of the node is adjusted based on depth of congestion and overall sensor priority. [9]

B. Hull in his work Fusion is another congestion mitigation technique that uses queue lengths to detect congestion. Fusion uses three different techniques to alleviate congestion, viz, hop-by-hop flow control, rate limiting, and a prioritized MAC. [10]

C. Y. Wan, A. T. Campbell and L. Krishnamurthy, proposed the PSFQ (Pump Slowly, Fetch Quickly) mechanism is proposed for reliable retasking / reprogramming in WSN. PSFQ is based on slowly injecting packets into the network, but performing aggressive hop-by-hop recovery in case of packet loss. The pump operation in PSFQ simply performs controlled flooding and requires each intermediate node to create and maintain a data cache to be used for local loss recovery and in-sequence data delivery. [11]

ESRT was proposed by **Yogesh Sankara subramaniam Özgür B. Akan Ian F. Akyildiz** which is based on an event-to-sink reliability model and provides reliable event detection without any intermediate caching requirements. ESRT also seeks to achieve the required event detection accuracy using minimum energy expenditure and has a congestion control component.

III. Problem and Proposed Solution

The congestion control mechanisms all have the same basic objective: they all try to detect congestion, notify the other nodes of the congestion status, and reduce the congestion and/or its impact using rate adjustment algorithms. There are several congestion control protocols for sensor networks. They differ in the way that they detect congestion, broadcast congestion related information, and the way that they adjust traffic rate.

A. Need for new congestion control protocol

Although TCP and UDP are the popular transport protocols and deployed widely in the internet, neither may be a good choice for Wireless. Sensor Networks. For the most part, there is no interaction between TCP or UDP and the lower layer protocols. In WSNs the lower layers can provide rich and helpful information to transport layer and enhance the badly needed system performance.[20]

Problems that make TCP or UDP unsuitable for implementation of WSNs:-

1. TCP is connection oriented. Data sensed for event-based application in Wireless Sensor Networks is usually very small. The three-way handshaking process required in TCP may be a overhead for such a small volume of data.
2. In TCP, segment loss can trigger window-based flow and congestion control. This will reduce the transmission rate when the packet loss may have occurred as a result of link error and there may not be congestion. This will lead to low throughput under multiple wireless hops.
3. TCP uses end to end acknowledgement and retransmission when necessary. This will result in much lower throughput and longer transmission time when RTT (Round Trip Time) is long.
4. Sensor nodes may be in different hop count and RTT from the sink. TCP operate unfairly in such environments. The sensor nodes near the sink may receive more opportunities to transmit; this may result in a disconnection between more distant nodes and the sink. As a connectionless transport control protocol, UDP is also not suitable for WSNs.
5. Because of lack of flow and congestion control mechanism in UDP, datagram loss can result in congestion. UDP is not energy efficient for WSNs.
6. UDP contains no acknowledgement mechanism therefore; the lost datagram can be recovered only by lower or upper layers.

For WSNs, one should consider carefully how to detect congestion and how to overcome it, because sensor nodes have limited resources. These protocols must consider simplicity and scalability to save energy and ways to prolong the life of sensor batteries

B. Problem Definition

A sensor network is the most required private and public area network used by many applications. The main advantage of this network is its dynamic topology. This kind of network is defined in different ways for different kind of nodes. These network types actually differ respective to network size, shape, protocol, battery power and the criticality. These all parameters get affected because of the real time scene in which the network is composed or established. As the network formation is done under any scenario or the scene, the analysis of the work is done under different parameters such throughput, loss rate etc. One of the critical network parameter is battery specification. According to this battery adaptive node network is critical because some amount of energy is lost with each communication. One of the common problems in such network is bulk of data communication that results the network congestion. The congestion gives the energy loss and packet drop over the communication.

C. Proposed Work

The presented work is the generation of effective communication in congested sensor network. In this work, the work is presented an improvement to the traditional routing algorithm is defined by generating a distance and energy based priority path. The work is here presented in the form of analytical comparison on these networks so that effective results will be derived from the system. The analysis of work is done under the packet loss, throughput, bit rate etc. In this present work an improvement to the existing route generation algorithm is done under the energy parameter specification. In this work, distance and energy adaptive algorithm is suggested to generate the effective communication route and analyze the work under different parameters.

D. Algorithm

The proposed algorithm to present the proposed work is given below:-

Design a sensor network with N number of stationary sensor nodes and energy vector.

Perform the bulk transmission over network to represent congestion.

Define source and destination nodes to perform effective communication. Set S as source node and perform the communication.

While S<> DestNode

Build the list of neighboring nodes to Node S called Ne1,Ne2…Nem

For i=1 to M

{

Analyze the neighboring nodes under throughput, energy, packet loss and delay parameters.

```
If (PacketLoss(Node(i))>Threshold)
{
            Set Priority(Node(i))=Low
 }
If (Energy(Node(i))<Threshold )
{
            Set Priority(Node(i))=Low
            }
 If(Communication(Node(i))>Threshold)
            {
 Set Priority=High
            }
 }
 Identify High Priority Neighbor Node and Set it as Current Node
```

IV. Result Analysis

A. Simulation

In simulation, we can construct a mathematical model to reproduce the characteristics of a phenomenon, system, or process often using a computer in order to information or solve problems. The mobile adhoc network comprising of 50 mobile nodes is constructed in the NS-2 simulator with the use of TCL script in the topological boundary area of 670 m x 670 m. The position of the mobile nodes is defined in terms of X and Y coordinates values and it is written in the movement scenario file. A NS2 application will be used to generate sample data.

B. Result Analysis

The experiments performed and results obtained

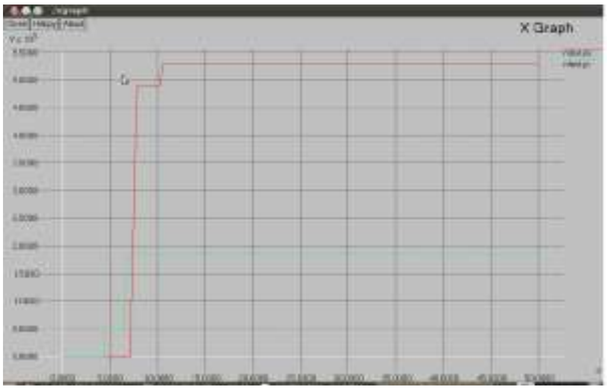

Fig. 1 Packet Loss Analysis (Existing Vs. Proposed)

In this fig.1, the comparison between the Existing and proposed approach is defined. The existing approach defines the loss in congested network and Proposed is the solution with parametric prioritized routing scheme. In the fig.1, the Packet loss is presented. As we can see the packet loss is reduced in the proposed system.

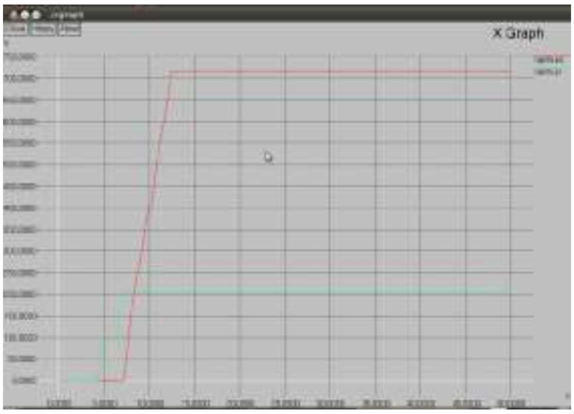

Fig. 2 Packet Transmission Analysis (Existing Vs. Proposed)

In the fig. 2, the comparison between the Existing and proposed approach is shown. The existing approach defines the system with congestion and proposed is the solution with parametric prioritized routing scheme. In fig. 2, the Packet Received is presented. As we can see the Packet Received is increased after the implementation of algorithm in the system.

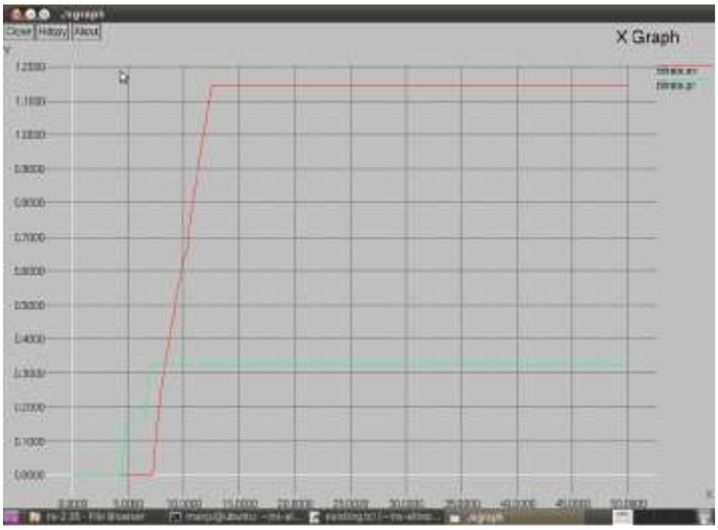

Fig. 3 Bit rate Analysis (Existing Vs. Proposed)

In the fig. 3, the comparison between the existing and proposed approach is defined. The existing approach defines the system with congestion. Proposed scheme is the solution with parametric prioritized routing scheme. In the fig.3, the Bit Rate is presented. As we can see that the Bit Rate is increased after the implementation of algorithm in the system

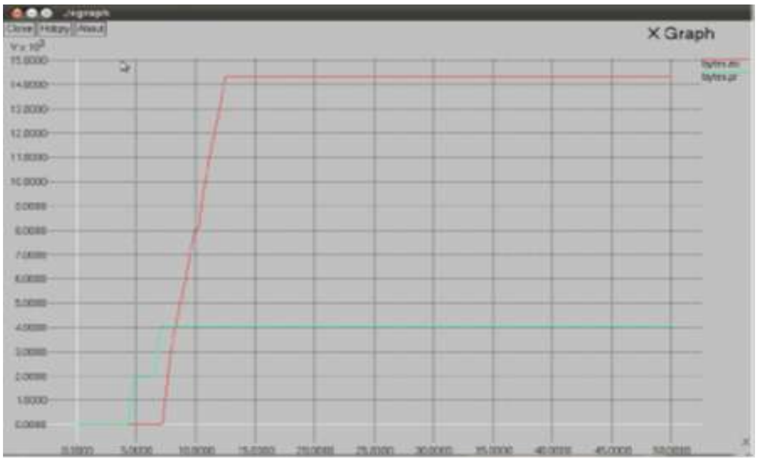

Fig. 4 Bytes Transferred Analysis (Existing Vs. Proposed)

In this fig.4, the comparison between the existing and proposed approach is defined. The existing approach defines the system with congestion and proposed is the solution with parametric prioritized routing scheme. In the fig.4, the Bytes Transferred is presented. As we can see the Bytes Transferred is increased after the implementation of algorithm in the system In this fig. 5, the comparison between the Existing and proposed approach is defined. The existing approach defines the system with congestion and Proposed is the solution with parametric prioritized routing scheme. In this fig. 5, the Time of Last Packet is presented. As we can see in the proposed system the packets are transferred more constantly.

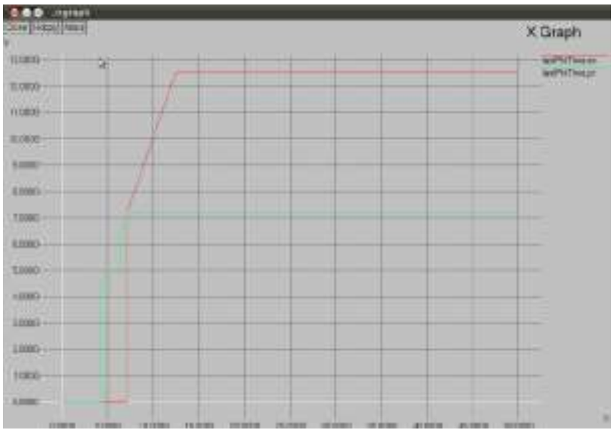

Fig. 5 Time of Last Packet Analysis (Existing Vs. Proposed)

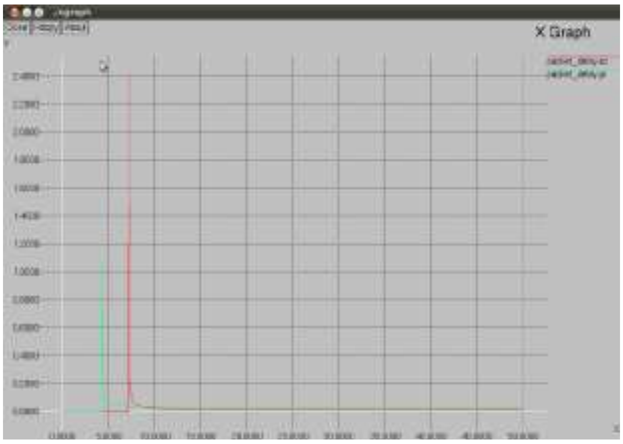

Fig. 6 Delay Rate Analysis (Existing Vs. Proposed)

In this fig. 6, the comparison between the existing and proposed approach is defined. The existing approach defines the system with congestion and Proposed is the solution with parametric prioritized routing scheme. In the fig. 6, the Delay Rate is presented. As we can see the Delay Rate is decreased after the implementation of algorithm in the system.

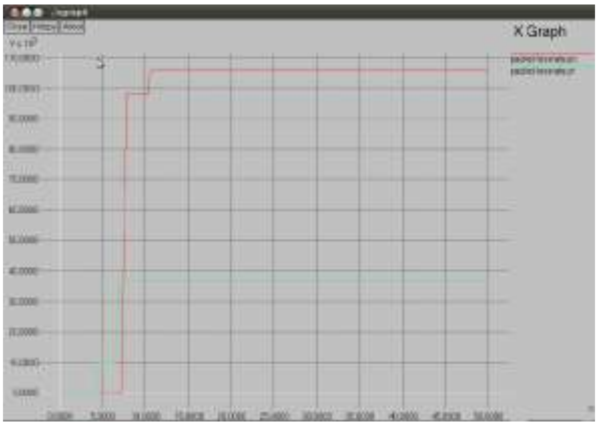

Fig. 7 Packet Loss Analysis (Existing Vs. Proposed)

In the fig.7, the comparison between the existing and proposed approach is defined. The existing approachdefines the system with congestion and proposed is the solution with parametric prioritized routing scheme. In the fig. 7, the packet loss analysis is presented. As we can see the packet loss is decreased after the implementation of algorithm in the system.

V. Conclusions and Future Work

In this present work, an effective parameter based prioritization approach is suggested to perform reliable communication over the network. The parametric check is here performed while selecting the next communication hop. Once the neighbour node analysis is performed, based on the loss and energy analysis, the priority to the neighbouring nodes is performed. The work is about to perform the safe communication over the priority nodes. The analysis results show that the presented work has reduced the communication loss and communication delay over the network.

In this present work, an effective communication approach is suggested in congested network communication to reduce the network loss and to improve the network communication. The work can be improved in future under different aspects. The work is here tested random scenarios, in future some other real time scenarios can also be implemented. The work is tested under the energy and packet loss constraints, in future some other vector can also be considered.

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