Congestion and SINR Evaluation for Improving Traffic Capacity in Ad Hoc Wireless Networks

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Abstract. More than the several years, multi-hop wireless ad hoc network shave obtained significant attention. This network is usual to have pervasive pertinences for the intention of transactions as well as disseminated calculation. Generally, the ad hoc network uses the hybrid routing protocols to handle the traffic flow in the network. However, the hybrid protocols did not consider the congestion related problems. Therefore, we propose Congestion and Signal to Interference Noise Ratio (SINR) Evaluation for Improving Traffic Capacity in Ad Hoc Wireless Networks (CETC) aiming to maximize the throughput and improve the energy efficiency. In this scheme, the congestion measurement is used to evaluate demanding time for determining a route with an expected lower level congestion. In addition, the SINR measurement is used to determine the node link performance. Thus, it improves the energy-efficiency and network throughput. The Simulation results show that the proposed CETC improves the network performance and reduce the delay as well as energy consumption.

Keywords: Ad Hoc wireless Networks, Congestion Measurement, Energy Efficiency, Network Simulation, Signal to Interference Noise Ratio.

1. Introduction
Wireless ad-hoc networks (WANETs) comprise a numerous of mobile wireless nodes which can travel in an arbitrary manner with the ability to connection otherwise depart the network. It can origin congestion which ensues in enhancing communication latency as well as loss of packets. This problematic is extra simple in greater networks by additional traffic as well as extraordinary motion which applies active topography [13]. The straight pathway routing cannot equilibrium the routing capacity on the connections based their capability therefore some connections involvement extra traffic than they can adapt that congests the system. Therefore, there is an essential to stability the traffic load on entirely connections based on their capabilities [14]. Congestion Control is additional significant dispute when leading for QoS attainment precisely with extremely movable mobile stations. The congestion control effects introduce an raised traffic method in Transmission Control Protocol (TCP) utilizing the token bucket traffic shaping method through packet transmitting at the middle nodes [9].AD-hoc Transmission Control Protocol, the receiver notices the feasible current condition as well as communicate this details to the sender as response [10]. However wireless networks necessity effective energy controlling, because communication energy is a valuable reserve. A wireless system is associated
to an energy channel, energy is yet significant as it straight involves the amount of interfering formed in the network, as well as accordingly affects the entire throughput that the network. Hence, power control is a significant element in a wireless network [12]. To diminish the energy utilization in a wireless network, several methods for example power management, congestion minimization and energy efficient routing techniques have been studied. Energy-efficient techniques discover the path which diminishing the entire energy utilization. Routing as well as congestion control at the network layer to fulfill quality-of-service (QoS) necessities otherwise diminish the energy depletion.

2. Related work
The Delay-based load-balancing routing (DLBR) algorithm is utilized for evaluating the congestion level. This scheme select the node has less congestion and offer high capacity [1]. A bandwidth aware routing scheme (BARS), which can evade congestion based on supervising remaining bandwidth capability. The sum of present as well as utilized bandwidth together with remaining accumulation necessity be functioned out earlier communicating messages. This scheme operates the response method to close the traffic for correcting the data rate by the present bandwidth as well as queue in the route. However, this scheme cannot control the transmission energy in Ad Hoc Wireless Networks [2]. History based scheme applies modern effective communication factors for the present communication effort where Priority based controls every node's transmitting time period. The Priority based approach endures from a largest communication latency owing to priority, however attains a greater packet received rate. Instead, the History-based approach accomplishes a least queuing delay at the expenditure of fewer effective communication efforts per part time [3]. An iterative double auction regard to energetically divest the traffic of their mobile employers. Every mobile node (MN) can apply several access points (Aps) as well as every AP can simultaneously assist traffic from several MN. This scheme provides effectual function whereas MN can exploit their discharging gains and APs diminish their offloading costs [4]. Multicast tree construction is used to diminish the multicast traffic. The NP-hard as well as effective heuristic technique for minimizing the multicast traffic [5]. Fast Lin Q (FLQ) Device-to-Device (DtD) transaction Scheme can recover operation of wireless medium through creating a DtD link. Communication power control system for FLQ that operates every DtD link's communication power regarding its forces to the FLQ's medium access method [6]. A delay-guaranteed geographic routing which can endure several end-to-end delay levels. This scheme alertness of the existence of a routing hole as well as it evades the hole [7]. A hybrid multipath energy as well as QoS-aware enhanced routing scheme which is established to handle with the disputes accessible with imperfect energy resourcefulness, nodes mobility, as well as traffic congestion through data communication. It employs a node rank rate based on multi criteria node rank metric (MCNR). It combines several metrics associated to QoS as well as energy into a complete metric to intensely diminish the difficulty of several reserved concerns as well as evade the control overhead. The MCNR parameter is applied with a link quality valuation operation for several route calculations [8]. Framework and implementation agent for controlling the congestion in the network. This technique, the nodes are categorized into four classes depend on its traffic. It measures acquire in extent of the numerous traffic modules as well as the channel difference also approximates the congestion parameter to discover the least congestion level in the network. This parameter is utilized for electing the least congested path [11]. Agent based congestion control method that the details about congestion is gathered as well as disseminated by mobile agents (MA). This method is utilized for choosing the least congested path [12]. Modified Russian Peasant Multiplier based on Divide as well as conquer method is utilized for multiplication procedure. Minimizing the chip size, enhancing the quickness as well as minimizing the energy depletion are key critical issues in System strategy [15]. The Resource Aware and Link Quality (RALQ) routing strategy [16] formed the route by link quality and energy utilization for data transmission and receiving. It improves the routing efficiency. Modified Russian Peasant Multiplier based on Divide as well as conquer method is utilized for multiplication procedure. Minimizing the chip size, enhancing the quickness as well as minimizing the energy depletion are key critical issues in System strategy [17]. An opportunistic routing by responsiveness of energy to accept by dynamic environment. While the sender transmits the information
to a multicast group, the sender transmits the information via greater energy between vicinity thus enhance the life span [18].

3. Congestion and SINR Evaluation for Improving Traffic Capacity in Ad Hoc Networks
A Generally, the ad hoc network uses the hybrid routing protocols to handle the traffic flow in the network. However, the hybrid protocols did not consider the congestion related problems. Therefore, we propose Congestion and SINR Evaluation for Improving Traffic Capacity in Ad Hoc Networks (CETC) aiming to maximize the throughput and improve the energy efficiency. The congestion evaluation of a node connected with a given receiver offers evaluate the best probable demanding time period of a packet incoming at that node till it reaches the receiver. Every node is accountable to inform its congestion evaluation as well as communicate this information to its neighbors. Also every node compute the SINR value is used to improve the energy efficiency.

3.1. Congestion Measurement
We consider a network of D nodes labelled by \( \Omega = \{1, \ldots, D\} \). While a node obtains extra data than its presented capability, congestion occurs. If the node’s queue is complete, the extra packets have to be lost. Here, \( N(m) \) represented as a set of neighbours and the node \( n \) denoted as the neighbour node of \( m \). The routing table is updated using a “virtual routing table” at the end of every computation cycle: an interval of \( T_c \) units of time. More specifically, node \( m \) at regular intervals calculates its congestion and subsequently updates its neighbours by control packets at intervals of \( T_s < T_c \) sec. Finally, the actual routing table is updated using the entries in the virtual routing table after every seconds.

The congestion calculates from node \( m \) to receiver \( R \) at time \( t \) is given below.

\[
V_m^R(t) = L_m^R(t) + D_m^R(t)
\]  

Where,

\( L_m^R(t) \rightarrow \) Local demanding time

\( D_m^R(t) \rightarrow \) Demanding time since its next hop to the receiver

In order that calculate \( L_m^R(t) \) as well as \( D_m^R(t) \), node \( m \) relies on the subsequent measures

\( P_{mn} \) represented as Probability that a packet transmitted via node \( m \) is obtained by node \( n \).

\( S_{mn}(t) \) represented as neighbour nodes obtained the packet from node \( m \) at time \( t \).

\( \overline{Q}_m^R(t) \rightarrow \) Denoted as average number of packets at node \( m \) intended for \( R \) on the final calculation cycle,

\( \overline{Q}_m^R(t) \) that is informed as

\[
\overline{Q}_m^R(t) = \frac{T_s}{T_c} \sum_{m=0}^{T_c-1} Q_m^R(T(t) - l)
\]  

Note that \( \overline{Q}_m^R(t) \) is a constant on a single computation cycle, that is,
\[ \overline{Q}_m^R(t) = \overline{Q}_m^R(t') \quad \text{for } \forall t, t' \text{ s.t. } T(t) = T(t') \]

\( N_k^{(m,R)}(t) \) is mentioned as a Neighbours of node m whose sensed congestion evaluates are smaller than that of node k, that is
\[ N_k^{(m,R)}(t) = \left\{ n \in N(m) : \overline{V}_{n}^{(m,R)}(t) < \overline{V}_{k}^{(m,R)}(t) \right\} \quad (3) \]

\( N^{(m,R)}(t) \): Neighbours of node m that are utilized by node m to route packets intended for node R, i.e.,
\[ N^{(m,R)}(t) = \left\{ \begin{array}{l}
N_m^{(m,R)}(t) \\
\arg\min_{n \in N(m) - \{m\}} \overline{V}_{n}^{(m,R)}(t) 
\end{array} \right. \begin{array}{l}
\text{if } N_m^{(m,R)}(t) \neq 0 \\
\text{if } N_m^{(m,R)}(t) = 0 \end{array} \quad (4) \]

\( P_{\text{succ} \rightarrow k}^{(m,R)}(t) \): possibility that node k is chose as the next hop for a packet intended for node R and communicated by node m such as
\[ P_{\text{succ} \rightarrow k}^{(m,R)}(t) = p_{mk} \prod_{n \in N_k^{(m,R)}(t)} (1 - p_{mn}) \quad (5) \]

Note that, between the neighbours of the packet node k is chose as then next hop, if and only if none of the other higher priority nodes \( N_k^{(m,R)}(t) \) received the packet.

\( P_{\text{acc}}^{(m,R)}(t) \): Possibility that a packet transmitted by node and intended for node moves on the way to the receiver,
\[ P_{\text{acc}}^{(m,R)}(t) = \sum_{k \in N^{(m,R)}(t)} P_{\text{succ} \rightarrow k}^{(m,R)}(t) \quad (6) \]

With these parameters and assuming a FIFO discipline, we proceed with the relay selection rule. In particular, for each packet, the next hop \( K_{CM}^{(m,R)}(t) \) is selected as
\[ K_{CM}^{(m,R)}(t) = \left\{ \begin{array}{l}
\text{arg min}_{k \in N^{(m,R)}(t)} \overline{V}_{n}^{(m,R)}(T(t)) 
\end{array} \right. \quad (7) \]

Then we offer the calculation details of \( L_m^R \), as well as \( D_m^R \). The local demanding time, \( L_m^R \), relies on the fact that, while a packet gets at a node m, its awaiting time is equivalent to the time expended in demanding the packets that have arrived earlier plus its own transmission time. The required communication time at node m for the packet can be estimated by \( \frac{1}{P_{\text{succ}}^{(m,R)}(t)} \), the local demanding time for node m to receiver R at time t is
\[ L_m^R(t) = \frac{1}{P_{\text{succ}}^{(m,R)}(t)} + \sum_{e \in \Omega} \frac{Q_m^R(T(t))}{P_{\text{succ}}^{(m,R)}(t)} \quad (8) \]
This scheme calculates the expected congestion $D_m^R(t)$ for every node $k \in \Omega$ using the latest congestion measures $\overline{V}_n^{(m,R)}(t)$ received from nodes $k \in \Omega$ with lower congestion measure. More specifically, the accepted congestion $D_m^R(t)$ can be given as

$$D_m^R(t) = \frac{1}{p_{suc}^{(m,R)}(t)} + \sum_{k \in N^{(m,R)}(t)} p_{suc^k}^{(m,R)}(t) \overline{V}_n^{(m,R)}(t)$$  

(9)

### 3.2. Data Transmission

When a sender wants to transmit the data to the receiver through the relay nodes, it first broadcasts a Route Request (RREQ). This message comprises the broadcast id, receiver id, receiver sequence number, sender id, sender sequence number, accepted congestion, and count of hop. When a node obtains this RREQ, it then sends the RREP message back to the source node. This RREP message contains receiver id, receiver sequence number, SINR value, with accepted congestion.

This SINR has been used as a link quality as follows.

$$SINR = \beta \times SINR + (1 - \beta) \times SINR_{new}$$  

(10)

Where $\beta \rightarrow 0.75$

$SINR_{new} \rightarrow$ Most recent $SINR$ value

The lower acceptance congestion value and less SINR value based select the relay node for determining the best route path selection in the network. Finally, the data is sent through the better relay node. Therefore, it increases the energy efficiency and enhances the network throughput.

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**Figure 1. SINR and Congestion based Route Selection**

In this figure, the route from sender to receiver is s-a-e-d. But the node e link quality is low. Therefore, the proposed scheme finds the new route s-a-f-i-d. The a-e-d path is replaced by a-f-i-d, thus the packets are received successfully. This established path is enhancing the network performance. The figure 1 indicates the working flow of the proposed scheme. The link quality is measured based on the SINR value. The highest link quality node is selected as the next hop node. Finally, the source sends the data to receiver through the highest link quality nodes. Figure 2 illustrates the CETC Approach.
4. Performance evaluation
To execute simulation examination, we utilized the NS-2.35 that incorporates the 802.11 MAC protocol. This protocol is functioning on the 2.4 GHz physical layer and each sensor node transaction range is pre-set to 250 meter. In this simulation topology, every node plays an owner of complete network as well as every wireless node function is data forwarding as well as obtaining the data. The packet traffic is yielded with variable bit rate (VBR). This simulation examination, we measured the following metrics namely Packet Obtained Rate, Latency, Loss Packet Rate, Average Remaining Energy, Throughput.

4.1. Packet Obtained rate
It is defined as the ratio among the amount of data packets perfectly obtained by the receiver and the amount of data packets yielded by entire wireless nodes. This metric mutually constitutes the less congestion and energy efficiency of the data gathering procedure.
From this figure 3, the proposed method CETC is greater compared to the existing method BARS. Because, the CETC picks the route by the energy efficient path. Thus, enhances the routing efficiency.

4.2. Packet Drop Rate

PDR is denoted as the distinction among the forward packets and obtained packets in the communication WANET per particular time. PDR is measured by Equation 12.

\[
PDR = \frac{\sum^{n}_{0} \text{Forward Packets} - \text{Obtained Packets}}{\text{Time}}
\]  

From figure 4 illustrate the PDR of CETC as well as BARS. The CETC method selects the relay node by link consistency factor. Thus, reduces the network PDR in the system.
4.3. Latency
It is defined as the time period from while the data packet communication is initiated at the source to while the data packet is perfectly obtained by the receiver. We evaluated both its usual value and its allotment.

\[ \text{latency} = \sum_{n}^{\theta} (\text{Packet Obtained Time} - \text{Packet Forward Time}) \]  

(13)

The figure, 5 illustrates the latency of CETC as well as BARS. The data traverse via link consistency factor nodes. Thus minimizes the routing latency.

4.4. Throughput
It is the vital parameter for measuring the operations of network. In this protocol, the throughput is specified as the amount of data packets effectively obtained at the receiver.

\[ \text{Throughput} = \sum_{n}^{\theta} \frac{\text{Packets Received}(n) \times \text{Packet size}}{\text{Time}} \]  

(14)
The figure 6 proves the CETC scheme has higher throughput. Because of, BARS scheme concentrate the congestion based on the bandwidth. But, CETC focuses the less congestion and energy efficiency path thus CETC has provide better performance in WANET.

4.5. Average energy
It is defined as the whole energy exhausted by every sensor node divided by the amount of data packets perfectly distributed to the receiver. This metric evaluates the energy efficiency of the WANET.

Figure 7 explains the residual energy of CETC as well as BARS. The CETC has highest throughput since the energy is an important parameter during compute the congestion factor. Thus CETC raises the residual energy in the network.

5. Conclusion
In this paper, we introduced Congestion and SINR Evaluation for Improving Traffic Capacity in Ad Hoc Networks aiming to maximize the throughput and improve the energy efficiency. In this scheme,
the congestion measurement is used to evaluate demanding time for determining a route with an expected lower level congestion. In addition, the Signal to Interference Noise Ratio measurement is used to determine the node link performance. The node ink quality is measures based on the SINR to guarantee optimal path selection. Thus, it improves the energy-efficiency and network throughput. The simulation results demonstrate that the CETC provide guarantee packet delivery rate and increases the Residual energy in wireless ad hoc network.

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