ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, Vol 8(24), DOI: 10.17485/ijst/2015/v8i24/79462, September 2015 ISSN (Online) : 0974-5645

An Energy Aware Congestion Controlled Cross Layered Approach in MANETS

A. Sumathi* and B. Vinayaga Sundaram

Department of Information Technology, MIT Campus, Anna University - 600025, Chennai, Tamil Nadu, India; sumisolay@yahoo.com, bvsundaram@annauniv.edu

Abstract

In the proposed Energy Aware Congestion Controlled Cross Layered protocol, a cross layered approach is handled using adhoc on demand distance vector routing protocol for attaining a congestion controlled network. At the Medium Access Control layer, the nodes which possess signal to noise interference ratio requirements are only selected in the network and Shannon's capacity is found for those selected nodes. Hence at the Medium Access Control layer, only energy constrained nodes are selected. These selected nodes are moved to transport layer using the proposed cross layered approach. At the transport layer, if any congestion is found it can be detected using congestion threshold rate which is calculated using packet loss rate. Based on the congestion threshold rate, a congestion fewer routes can be found out that improves the throughput. Simulation results using NS2 shows improvement in the packet delivery ratio.

Keywords: Capacity, Congestion Control, Cross Layer, Energy, NS2, Signal to Noise Interference Ratio

1. Introduction

In Mobile Adhoc Networks (MANETS), due to mobility of nodes, there is no predefined infrastructure[1,2]. Since it is a dynamic environment, nodes may join or leave the network at any time without taking part in the data transmission which makes it difficult in constructing routes[3]. All nodes must coordinate with each other to enable communication which requires each node to be more intelligent so that it can function not only as a network host for transmitting and receiving data but also network router for routing packets from other nodes.

A critical issue for MANETS is congestion control and handling power control across all the layers. In order to address these issues in the proposed cross layered approach, the different layers of protocol stack inter communicate with each other. The congestion causes the disadvantages such as high delay, high overhead and more number of packet losses.

Consider an Adhoc network with n nodes, connection will be established between source node S and destination node D so that data can be transferred between intermediate nodes. When multiple senders compete for link bandwidth in a shared network, the data rate has to be adjusted to avoid overloading in the network. If the router is unable to forward a packet, it is dropped leading to packet loss. This dropped packet may travelled many intermediate nodes which consumes significant network resources such as bandwidth, energy etc. This lost packet also triggers retransmission which increases the network traffic. Thus, the network congestion severely affects the network throughput. To avoid this network congestion problem, an effective congestion detection method has to be considered and the nodes used in the network should be of energy constrained to avoid such packet losses.

2. Related Works

The solution for congestion avoidance should consider the limited availability of network resources[4]. In a cross layered model of congestion detection and a congestion control mechanism the following methodology is discussed. It

* *Author for correspondence*

includes energy efficient congestion detection, Zone level Congestion Evaluation Algorithm (ZCEA) and Zone level Egress Regularization Algorithm (ZERA), which is a hierarchical cross layer based congestion detection and control model and is referred as Energy Efficient Congestion Detection and Control (ECDC)[5]. In a Delay aware Multipath Source Routing (DMSR) protocol accumulation delay is considered as the admission metric to choose the paths. Using node delay best routing path is determined. The other metric such as the number of neighbor nodes, the channel busy time and the number of packets in the send buffer is also discussed in DMSR protocol[6]. A congestion aware protocol is discussed here through bypassing the affected links[7].

A reliable protocol is presented to cross layer congestion control where the video coding is aware[8]. A congestion avoidance framework is proposed which is designed for multi tree overlays in mobile adhoc networks with high node density and stringent constraints on delay. This algorithm detects a node movement that can predict failures because of false route and prevent unnecessary route reestablishments by referring the changes in its neighborhood. Now every node can determine whether to retransmit a failed packet or to discover an alternate route[9].

An algorithm is proposed where the source is informed of the route failure with the help of a Route Failure Notification (RFN) by using a single bulk data transfer session, where a source mobile host is sending packets to a destination mobile host. As soon as the disruption of a route is detected, RFN packet is explicitly sent to the source and this event is recorded. The network parameters like data rate and failure rate have been discussed[10]. A cross layer scheduling method by combining network layer and MAC layer is proposed in which a deterministic schedule based energy conservation scheme is proposed which drives its power efficiency from eliminating idle listening and collisions[11].

3. Need for Cross Layered Design

A traditional layered design is not flexible enough to cope with the dynamics of the mobile Adhoc networks[12]. Hence a modified layered approach called cross layer design is proposed that maintain the layered architecture and captures the important information that influences other layers and also exchanges the necessary information across the various layers and implement effective protocols and algorithms at each layer to optimize the performance.

In a mobile adhoc network, since the nodes are battery constrained, there is a need for energy conservation between nodes. Also due to mobility, the nodes should also be of congestion controlled to avoid packet loss. Hence a cross layered approach using AODV routing protocol EACCCL is proposed to overcome this problems in a MANET network. The overview of proposed cross layered protocol EACCCL is shown in Figure 1.

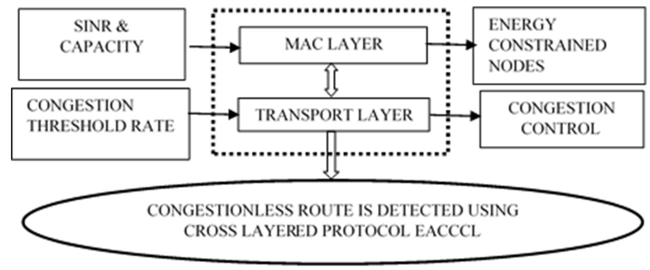

Figure 1. Overview of proposed cross layered protocol EACCCL.

3.1 MAC Layer

Consider a MANET with N nodes. Now the signal to interference to noise ratio of the link L is given by the following equation (1) as,

$$SINR(L) = \frac{P_k G_d}{\sum_{d \neq k} P_0 G_{k0} + n_k} \qquad (1)$$

here, P_k - Transmission Power on the link K.
G_d - Path Gain on the link K.
G_{k0} - Path gain of the node on link K to another node on link 0.
n_k - Thermal noise on the link k.

Now the nodes which possess SINR values are selected from the network and Capacity values are calculated for those selected nodes. A capacity definition for reliable communication under energy constraints has been proposed, as the maximum number of bits per unit energy that can be transmitted, so that the probability of error goes to zero with energy[13]. This is obtained by examining the minimum energy per bit required to transmit at the normalized Shannon capacit[14]. The normalized capacity is given in equation (2) as,

$$C_B = \frac{C}{B} \qquad (2)$$

here, C_B – Normalized capacity.
C – Capacity of the channel measured in bits per second.
B – Bandwidth of the channel in hertz.

Specifically, for transmission at rates approaching the Shannon capacity C, the received energy per bit (E_b) equals the ratio of received power to data rate. This is given by equation (3) as,

$$\hat{x} = \begin{cases} \max(a,b) \text{ if } c \le \min(a,b) \\ \min(a,b) \text{ if } c \ge \min(a,b) \\ a+b-c \quad \text{otherwise} \end{cases} \tag{3}$$

here, P - Received power.
R - Data rate/net bit rate.
C - Capacity.

Using this expression, the Shannon capacity can be calculated as per the following equation (4) as,

$$C = B\log_2\left(1+\frac{P}{N_o B}\right) = B\,log_2\left(1+\frac{E_b C}{N_o B}\right) \tag{4}$$

Inverting Shannon capacity C in above equation yields the energy per bit required to transmit at rates approaching the normalized capacity $C_B = C/B$ which is shown below in equation (5).

$$\frac{E_b}{N_o}(C_B) = \frac{2C_B - 1}{C_B} \tag{5}$$

As the channel bandwidth B increases, C_B approaches zero, yielding the minimum energy per bit in the wideband limit which is shown in equation (6).

$$\frac{E_b}{N_o}(C_B) = \frac{2C_B - 1}{C_B}$$

$$= \ln 2 = -1.59\text{dB} \tag{6}$$

At the MAC layer, the maximum number of bits per unit energy that can be transmitted is defined as capacity is evaluated using a Shannon capacity C. Using this, the minimum energy per bit required to transmit is calculated that gives an acceptable E_b/N_o value which is minimum. Using SINR values and the evaluation of capacity per unit energy at the MAC layer provide an energy constrained network environment. After this, the energy constrained nodes are moved to the transport layer.

3.2 Transport Layer

The source node sends the data packet to destination node via intermediate nodes to establish the route discovery process. Now let us consider the interval between two adjacent packets as T_n. The arrival time of first data packet is t_s and the arrival time of the last data packet is t_d. The average processing time of data packet in a node is T_k and this value is updated whenever a data packet is sent out.

Let us assume the transmission time of data packets to be t_e and q is an adjustable parameter which is set to be 0.7. Now the packet loss of a node ($N_{PL}(t_1, t_2)$) can be calculated as shown in equation (7) as,

$$N_{PL}(t_1 t_2) = \frac{\int_{t_1}^{t_2} 1_{\{c(t)=D_1\}} dF(t)}{\int_{t_1}^{t_2} dF(t)} \tag{7}$$

here F (t) – Arrival process for user packets.

Denominator $\left[\int_{t_1}^{t_2} dF(t)\right]$ – number of user packets sent in.

Numerator $\left[\int_{t_1}^{t_2} 1_{\{G(t)=D_1\}} dF(t)\right]$ - Number of lost user packets.

The Congestion Threshold Rate (C_{TR}) is given in equation (8) as shown below,

$$\left[\int_{t_1}^{t_2} 1_{\{G(t)=D_1\}} dF(t)\right] \tag{8}$$

where $T_n = (1 - q) \times T_n + q \times (t_s - t_d) - N_{PL}(t_1 t_2)$,
$T_k = (1 - q) \times (t_s - t_d) + q \times t_e - N_{PL}(t_1 t_2)$,

Here the value of packet loss of the node is calculated. Using this value Congestion Threshold rate, C_{TR} is evaluated. If the value of $C_{TR} > 1$, it indicates the arrival rate of the data packets is larger than the outgoing rate of data packets, which means congestion may possibly happen in the future route.

3.3 Proposed EACCCL Protocol Procedure Algorithm

Input: A MANET Network with N Nodes.
In MAC Layer,
For each node do
a. Calculate SINR value.
b. If nodes possess SINR Requirements, then:
- Nodes are selected for data transmission.
- Calculate Shannon capacity for the selected nodes.
- Now the selected nodes are of energy constrained.
- Selected energy constrained nodes are moved to Transport layer using cross layered approach.

else,
Discard nodes,

In Transport layer,
For each node do:
a. Calculate Packet loss of the selected nodes.
b. Calculate Congestion Threshold Rate(C_{TR}).
c. If $C_{TR} < 1$, then:

- Congestion less Route is selected for data transmission.
- Congestion Controlled Network is attained.
  else,
  Congestion based Route is detected and discarded.

4. Simulation Setup

Network Simulator 2 tool is used to simulate the various existing protocols such as Trust-based Cross Layer (TCLS) protocol[15], Cross Layer Adhoc On Demand distance Vector (CLAODV) protocol[16] and the proposed EACCCL protocol and the results were compared. Fifty nodes arranged in a MANET topology of network area 2000 meter × 2000 meter are selected for this work. Using the nam simulator trace files, the various parameters such as packet delivery ratio, delay and overhead are analysed with the node speed parameters. The various parameters used are shown in Table 1.

Table 1. Parameters used in the proposed EACCCL protocol

Parameters	Assumptions
Simulator Tool	NS2
No. of nodes	50
Minimum delay required	2 CBR units
Maximum delay required	7 CBR units
Minimum bandwidth rquired	4 CBR units
Network Area	2000 meters × 2000 meters
Transmission range	250 meters
MAC layer protocol	IEEE 802.11
Protocol	EACCCL
No. of packets	1000

5. Performance Metrics of EACCCL

Using the parameters discussed in Table, the results obtained for packet delivery ratio, delay and overhead for the EACCCL protocol have been found and compared with the TCLS and the CLAODV protocol.

5.1 Packet Delivery Ratio vs. Speed

The TCLS protocol did not discuss about nodes energy consumption and capacity for each node whereas CLAODV uses contention window mechanism, so that each time the window size is adjusted for data transmission. Here in EACCCL protocol by using SINR, Shannon capacity which is found at the MAC layer and congestion control which is found at the transport layer yield congestion less route that increases the packet delivery ratio even though the node speed increases as shown in Figure 2.

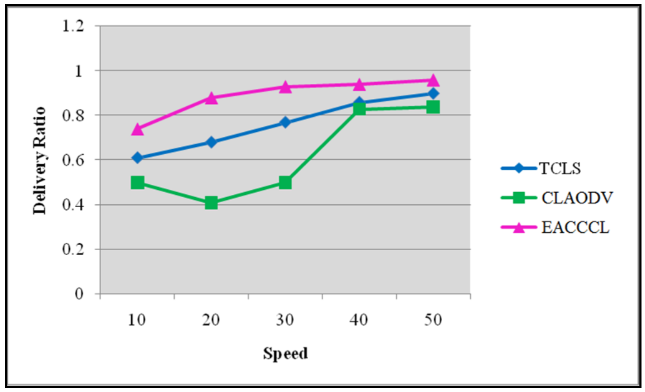

Figure 2. Variation in delivery ratio with varying speed for the proposed EACCCL protocol in comparison with TCLS and CLAODV protocols.

5.2 Delay vs. Speed

Here only energy constrained nodes are selected for data transmission. By evaluating a congestion threshold rate at the transport layer, a congestion based route is avoided and congestion less route is selected. Hence the delay found is reduced in EACCCL protocol when compared to the other protocols. The comparison of variation in delay is shown in Figure 3.

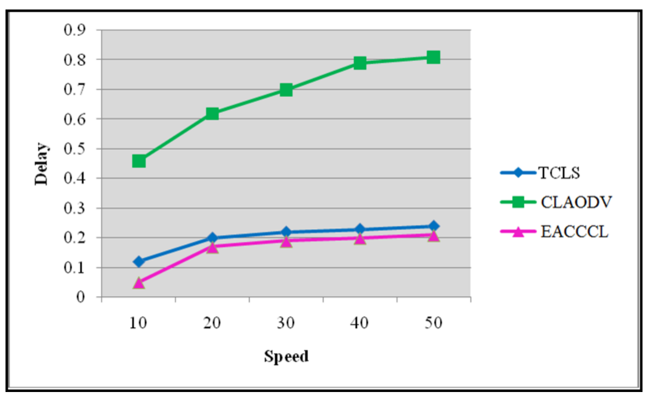

Figure 3. Variation in Delay with varying speed for the proposed EACCCL protocol in comparison with TCLS and CLAODV protocols.

5.3 Overhead vs. Speed

Here using a cross layered architecture, SINR value, Shannon capacity value at the MAC layer, and congestion control at the transport layer are interconnected and hence overhead is reduced in the proposed EACCCL protocol when compared to the other TCLS and CLAODV protocols. The variation in overhead with varying speed is shown in Figure 4. Here TCLS discusses only about link and MAC layer and CLAODV use exponential back off mechanism for packet loss. Hence the overhead is high in TCLS and CLAODV protocols.

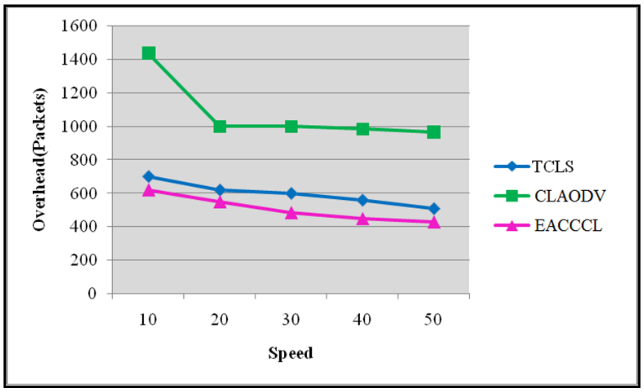

Figure 4. Variation in Overhead with varying speed for the proposed EACCCL protocol in comparison with TCLS and CLAODV protocols.

6. Conclusion

The proposed EACCCL protocol using MAC and the Transport layer is discussed in this work. At the MAC layer, the nodes which possess SINR requirements are only selected in the network and Shannon's capacity is found for those selected nodes. Hence only energy constrained nodes are selected at the MAC layer. These selected nodes are moved to transport layer using the cross layered approach. At the transport layer, using congestion threshold rate, a congestion less route is detected and a congestion controlled network is attained which improves the throughput. Simulation results also shows significant improvement in the packet delivery ratio with reduced delay.

7. References

1. Sivaram Murthy C, Manoj BS. Adhoc wireless networks India. 2nd edition. Pearson Education; 2001.
2. Freedman M, Morris R. Tarzan: A peer-to-peer anonymizing network layer. ACM Conference on Computer and Communications Security; 2002 Nov 18–22; New York, NY, USA. p. 193–206.
3. Rennhard M, Plattner B. Morph Mix: Peer-to-peer based anonymous internet usage with collusion detection. Proceedings of the 2002 ACM workshop on Privacy in the Electronic Society (WPES '02); 2002 Aug; New York, NY, USA; p. 91–102.
4. Kliazovich D, Granelli F. Cross-layer congestion control in ad hoc wireless networks. Ad Hoc Networks. 2006; 4:687–708.
5. Srinivas K, Chari AA. ECDC: Energy efficient cross layered congestion detection and control routing protocol. International Journal of Soft Computing and Engineering. 2012 May; 2(2):316–22.
6. Liu S, Liu J. Delay-aware multipath source routing protocol to providing QoS support for wireless ad hoc networks. Proceedings of the 12th IEEE International Conference on Communication Technology; IEEE Xplore; 2010. p.1340–3.
7. Chen X, Jones HM, Jayalath ADS. Congestion-aware routing protocol for mobile Ad Hoc networks. IEEE 66th Vehicular Technology Conference; IEEE 66th Vehicular Technology Conference;2007 30 Sep- 3 Oct; Baltimore, MD; p. 21–5.
8. Greco C, Cagnazzo M, Pesquet-Popescu B. A low-latency video streaming with congestion control in mobile ad-hoc networks. IEEE Trans Multimed. 2012; 14(4):1337–50.
9. Yu H, Ahn S. Node movement detection to overcome false route failures in mobile ad hoc networks. IEEE International Conference on Information Science and Security ICISS; IEEE; 2008. p.137–40.
10. Chandran K, Raghunathan S, Venkatesan S, Prakash R. A feedback based scheme for improving TCP performance in ad hoc wireless networks. IEEE Pers Comm. 2001; 8(1):34–9.
11. Sichitiu ML. Cross-layer scheduling for power efficiency in wireless sensor networks. IEEE INFOCOM 2004: Twenty Third Annual Joint Conferences of the IEEE Computer and Communications Societies. 2004 Mar 7–11; 3:1740–50.
12. Senthil Kumaran T, Sankaranarayanan V. Congestion free routing in adhoc networks. J Comput Sci. Science Publications. 2012; 8(6):971–7.
13. Gallager RG. Energy limited channels: Coding, multi access and spread spectrum. 1987 Nov. Technical Report LIDS, MIT. p. 1714.
14. Verdu S. On channel capacity per unit cost. IEEE Trans Inform Theor. 1990 Sep; 36(5):1019–30.
15. Rajaram A, Palaniswami S. Malicious node detection system for mobile ad hoc networks. Int J Comput Sci Inform Tech. 2010; 1(2):77–85.
16. Gowada R, Havinal RS. Cross layer energy Improvement in MANET. International Journal of Engineering Science and Innovative Technology. 2013 Mar; 2(2).