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RESEARCH ARTICLE

Cross Layer Based Energy Aware Routing and Congestion Control Algorithm in MANET

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Abstract: In a Mobile Ad hoc Network, the mobility of a node is unpredictable. The mobility is considered as one of the characteristics of a wireless network. In addition, the energy limit of the nodes must also be taken into consideration when designing routing protocols. This is an essential issue since energy consumption reduces the wireless network connection lifetime. In mobile link packet are often more significant than congestion losses. Congestion avoidance results in a very low utilization of the link when there is an appreciable rate of losses due to link errors. This issue is very significant for wireless links. In this paper to overcome network performance problems, a cross layer design which helps in allotment the information while the layers separation at the design level is still maintained is proposed. This minimizes data retransmissions and losses by analyzing and reacting appropriately to different events occurring at lower layers. This not only helps to sustain the communication with the lowest chance of interruption, but also prolongs the network lifetime due to the lowest possible consumption of energy for a given communication. This article also evaluates the performance of different adhoc routing protocols such as DSDV, AODV, DSR, TORA and AOMDV in terms of energy efficiency and it also proposes a new routing algorithm that modifies AOMDV and it provides better performance compared to all the above protocols.

Keywords: Energy constraint, energy consumption, Congestion, node selection, MANET, Cross Layer

I. INTRODUCTION

A mobile ad hoc network (MANET) is a dynamic distributed system of mobile formed by means of multi-hop wireless communication without the use of any existing network infrastructure. MANET routing protocols can be classified into two classes. Proactive protocols, they requires the nodes to periodically exchange the table information to update the pre-determine routes between any pair of source destination nodes. Reactive protocols can establish routes only when they require. MANET routing protocols can be classified on the bases of the methods of delivery of data packets from source to destination. Single Path routing protocols learn routes and select a single best route to each destination. These protocols are incapable of load balancing traffic. Multi-path routing protocols learn routes and can select more than one path to a destination. These protocols are better for performing load balancing[1].

II. LITERATURE REVIEW

Cross layer is like the revolution in the area of Wireless sensor networks. A lot of work has already been done on it but some aspects still need to be covered. MMSPEED [1] works on the network and the MAC layer. It promised to provide the reliable and timeliness delivery. In routing layer it performs the task of selecting the next node in the route based on the speed of the next neighbor node. It has adopted the idea of virtual separation of the speed layers so that the higher speed data do not experience the delay because of the low speed data. This work is carried on the routing layer. And to provide the reliability to access the shared channel based on the priority and to measure the average delay MAC support has been taken. But this paper does not consider the power consumption by the nodes which is the greatest threat for the wireless sensor networks

K. Srinivas et.al [2] have proposed A MAC layer level congestion detection mechanism, that 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 in short we refer this protocol as ECDC(Energy Efficient Congestion Detection and Control). ECDC derived a cross layered congestion detection mechanism with energy efficiency as primary criteria that included as congestion detection mechanism to "Two step cross layer congestion routing". The proposed algorithm aims to deliver an energy efficient mechanism to quantify the degree of congestion at victim node with maximal accuracy[3,4]. Packet loss in network routing is primarily due to link failure and congestion. Most of the existing congestion control solutions do not possess the ability to distinguish between packet loss due to link failure and packet loss due to congestion[5,6,7].

In HCR[11] the cluster head set is used to route the data. Rotation of cluster heads is done to send the data of other nodes. This protocol improves the energy efficiency but nothing has been said about the reliability, about route maintenance etc. All the work is done on the routing layer which can be further extended by inclusion of MAC and the Physical layer. QUATTRO[11] works on the routing and the MAC layer. This protocol has been divided into seven phases. If for any reason the selected route fails then all the phases have to be repeated depending upon the type of failure. But this can be avoided if Physical layer is also included in its working. The path between the nodes can be switched to the new path if the problem of the path is distinguished beforehand.

Zeng (2008) described Opportunistic Routing in Multi-hop Wireless Networks: Capacity, Energy Efficiency, and Security studied geographic opportunistic routing (GOR), a variant of OR which makes use of nodes' location information.

Wang (2005) presented p-MANET: Efficient Power Saving Protocol for Multi-Hop Mobile Ad Hoc Networks proposes an efficient power saving protocol for multi-hop mobile ad hoc networks, called p-MANET. Our design is expected as a new foundation MAC layer power saving protocol.

The authors of [10] have proposed a general framework for multi path routing scheme for ad hoc network. The framework provides high reliability of routing for the mobile nodes. A multi path routing protocol for ad hoc networks using directional antenna is proposed by the authors of [11].

III. Characteristics of Nodes with Constrained Energy

Each node in a Mobile adhoc Networks serves as a host and/or router generate, consuming or forwarding information. These nodes are fitted with and power-driven by batteries. The weakening of participating nodes' battery power in a routing path will shorten the network lifetime. As charging or replacing batteries on site is a difficult operation, it is essential to use the available energy resourcefully to extend the lifetime of the nodes. Developing an energy efficient routing method is one way of achieving optimized performance of nodes.

Nodes consume energy while transmitting beacon signals to neighboring nodes for the purpose of detecting their survival or transmitting data to a different node. When an intermediary node has been selected as a router, it consumes more energy than an idle node as it is dynamically involved in communication[7,8,9]. Thus, the nodes' residual energy is important in determining the path to successfully completing data transfer without interruption. Hence a routing protocol that considers the nodes' residual energy will perform better than the protocols that do not.

Advantages of Mobile Ad hoc Networks

(a) Low cost of deployment: Mobile Ad-Hoc Networks can be deployed on the fly, thus it not requires any expensive infrastructure such as copper wires, data cables, etc or not any central administration to support the network.

(b) Fast deployment: ad hoc networks are very convenient and easy to deploy, when it compared to WLANs because it requires less manual intervention.

(c) Dynamic Configuration: Configuration of Mobile Ad-Hoc Network can changes dynamically with time. Mobile Ad-Hoc Networks has various potential applications in various fields. In Civilian environments it includes taxi cab network, meeting rooms, sports stadium and boats, small aircrafts. In emergency operation it includes search and rescue, policing and fire fighting. The other applications of MANET includes sensor Networks, Collaborative computing, Communications in disaster recovery and areas battlefields.

IV. CROSS LAYER IN MANET

There is straight combination between the lower layer and the upper layers in the traditional protocol stack which is not sufficient for mobile networks. Cross-layer design method is an active research area to improve mobile network performance, where the information is exchanged between different protocol layers dynamically. In a MANET physical layer, MAC layer and routing layer together compete for the network resources. MAC and routing, transport layers are affected by transmission power and rate of the physical layer. Scheduling and allocating the wireless channel is responsibility of the MAC layer which finally determines the available bandwidth of the transmitter. Bandwidth also affects the decision at the routing layer to select the link. The links are selected by the routing layers to transfer the packets to the destination. Contention level at the MAC layer, and the physical layer parameters are affected by the routing decision at the routing layer. Congestion at the transport layer is controlled by the proper information of the percentage of redundancy at the routing layer which is possible when the aggregation is performed at the routing layer. Channel errors are avoided by the proper modulation and demodulation of the data. Signal to noise ratio can decrease total transmit over the links. Cross-layer design can therefore play an important role for the upcoming systems designed for the various applications, featured by all IP-based protocol stack, various access networks, and multimedia data traffic. One obvious shortcoming of the two classical network reference models, OSI and TCP/IP, is the lack of information sharing between the protocol layers. This does not allow optimal performance of the networks, because sharing of information between different layers can lead to the optimization of the MANET. Cross layer allows us to design new kinds of applications [12]. A major difference lies between the working of wired architecture and the wireless. The protocols defined for the wired are not suitable for the proper working of the wireless network which causes the problems like packet loss, delay etc.

V. Energy Efficient Congestion Detection Mechanism

The aim of the proposed congestion detection mechanism is to capture degree of congestion at relay hop level node with maximal accuracy. In proposed model, the detection mechanism is decoupled from other activities of the MAC layer such as link reliability analysis and buffer size analysis. The detection model extended to detect the congestion at traffic level, which is based on the degree of congestion measurement at relay hop level node.

Measuring degree of congestion at Relay hop level node:

Unlike traditional networks, nodes in the ad hoc network exhibit a high degree of heterogeneity in terms of both hardware and software configurations. The heterogeneity of the relay hop nodes can reflect as assorted radio range, maximum retransmission counts, and buffer capacity. Hence the degree of channel loading, packet drop rate, and degree of buffer utilization at relay hop level node is minimum combination to find the degree of congestion[13,14]. The usage of these three functional values supports to decouple the congestion measuring process from other MAC layer activities.

The degree of channel loading, packet drop rate and degree of buffer utilization together provide a scope to predict the congestion due to inappropriate ratio between collision and retransmission count. When retransmissions compared to collision rate are significantly low then egress delay of relay hop node will increase proportionally, which leads to congestion and reflected as congestion due to buffer overflow.

Minimize Energy consumed/packet

This is one of the more obvious metrics. To conserve energy, we want to minimize the amount of energy consumed by all packets traversing from the source node to the destination node. That is, we want to know the total amount of energy the packets consumed when it travels from each and every node on the route to the next node. The energy consumed for one packet is thus given by the equation:

$$E = \sum_{i=1}^{k-1} T(n_i, n_{i+1})$$

where n_1 to n_k are nodes in the route while T denotes the energy consumed in transmitting and receiving a packet over one hop. Then we find the minimum E for all packets.However, this metric has a drawback and that is nodes will tend to have widely differing energy consumption profiles resulting in early death for some nodes.

Minimize Cost/Packet

For this metric, the idea is such that paths selected do not contain nodes with depleted energy reserves. In other words, this metric is a measurement of the amount of power or the level of battery capacity remaining in a node and that those nodes with a low value of this metric are not chosen (unnecessarily) for a route. This metric is defined as the total cost of sending one packet over the nodes, which in turn can be used to calculate the remaining power. It is given by the equation:

$$C = \sum_{i=1}^{k-1} f_i(x_i)$$

where x_i represents the total energy expended by node i so far and f is the function that denotes the cost. Then we find the minimum C for all packets.

This metric is by far one of the more deployed metric as it can incorporates the battery characteristics directly into the routing protocol as shown in the introduction of MMBCR and CMMBCR [17][8]. These two protocols are discussed in more details in the next section.

Minimize Maximum Node Cost

The idea here is to find the minimum value from a list of costs of routing a packet through a node. The costs themselves are maximized value of the costs of routing a packet at a specific time. The equation for this metric is:

Minimize $\hat{C}(t)$, for all $t > 0$,

Where $\hat{C}(t)$ denote the maximum of the $C_i(t)$s and $C_i(t)$ is the cost of routing a packet through node i at time t.

Algorithm for Modified AOMDV

Step 1 If the Source node S wants to send data to the destination node D, it will first send REQ messageto all its neighbor nodes.

Step 2 When neighbor nodes receive REQ message they will check their Route_Cache, if this packet's ID is already in their Route_Cache then packet will be discarded.

Step 3 Otherwise, node will calculate its power by using: Pnew = Ptx - Pr + Pth + Pm + Power and send this value as a reply to source node.

Step 4 Source node will calculate the mean value of all the values of Pnew of all the nodes and send a RREQ message to the node whose Pnew value is nearest to the mean value.

Step 5 When the node receives a RREQ message it will send REQ message to its own neighbors and this process will be continued till the destination node reaches.

Step 6 When destination node will receive the RREQ message it will send the RREP message back with the same route.

Step 7 RREP process is same as in Modified AOMDV.

VI. SIMULATION ENVIRONMENT

A Simulation, is the procedure of designing a model of a real system and conducting experiments with this model for the purpose either of accepting the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system" [15]. Therefore Modeling & Simulation was the main part of this research in which application of different simulations techniques was developed using the NS-2 (Network Simulator) simulator. The entire simulation tests were conducted by using a very well known simulator by the research community NS2, by applying topologies and approaches.

Power Consumed/ Packet

The power consumed by the network interface when a host sends, receives or discards a packet can be described using a linear equation Power = m × size + b

Fig 1 shows the power consumption by single node to transfer a packet. It is the minimum power consumption using multihoping concept in the MANET system. The loss of energy in nodes can affects the communication activities in network. For MANETs, optimization of power consumption has greater impact as it directly corresponds to lifetime of networks and hence the creation of an energy efficient system.

Response Time

The response time of data packets is the interval between the data packet generation time and the time when the last bit arrives at the destination. Fig 3 shows the average response time which shows that as the traffic increases, system response also increases.

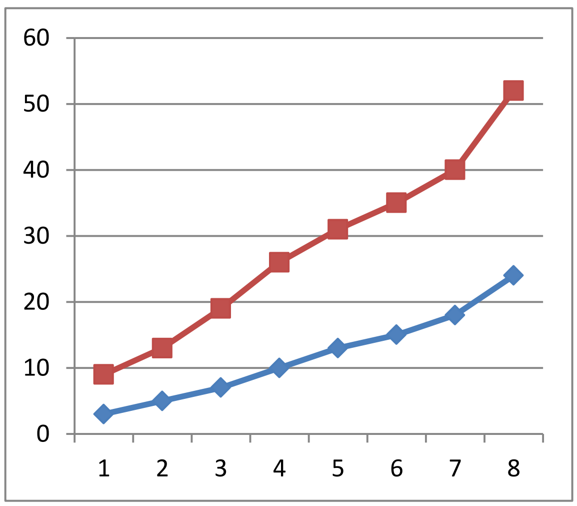

Fig:1 **Comparision of AODV vs AOMDV**

Average end-to-end delay

This is the overall average delay required by a packet to travel from source node to its destination node. The average total path end-to-end results given by simulation observe that Efficient TAODV packet delay is less delay than TAODV in all of the scenarios considered for the simulations in Figure 6. The delay is significantly lower in the 16 node network configuration where there is a considerable network traffic load. In both, the high mobility and the low mobility scenario sets, the delay shown by Efficient TAODV is at least 200 ms lower.

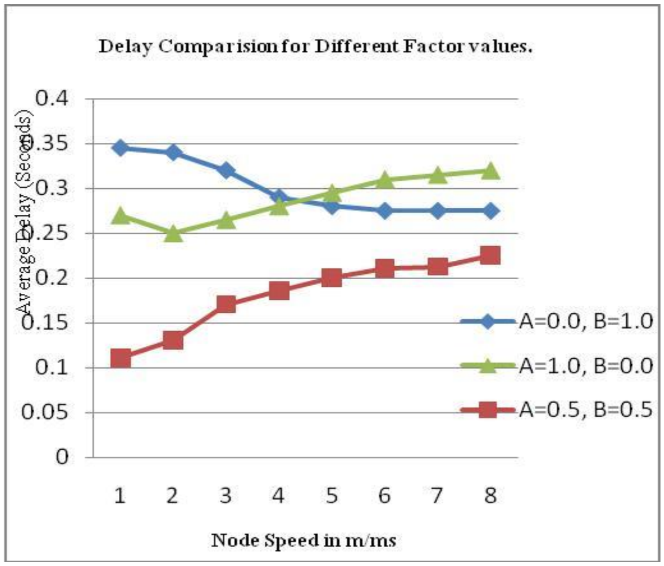

Fig:2 Delay comparison

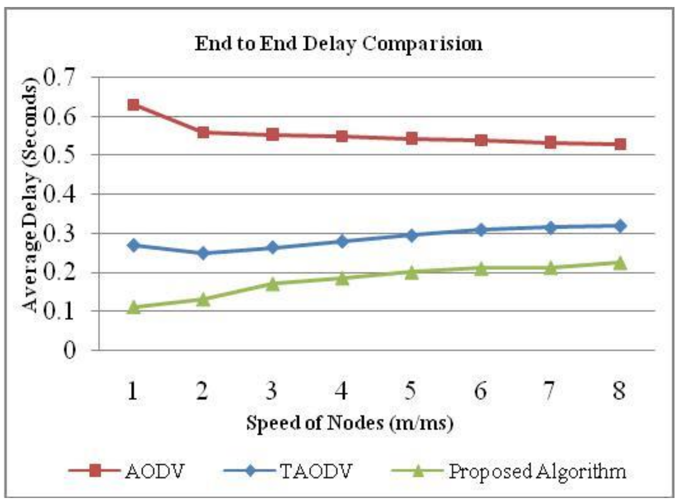

Fig:3 Delay performance with TAODV scheme.

VII. CONCLUSION

This article is an effort to review the cross layer protocols and their need in today's era.MANETs have additional many improvements to many fields, still this area is facing many challenges to operate properly. The major concerns of applications for MANET are regarding limited energy capacity of sensors, reliability, time. So, communication between nodes must introduce the minimal possible overhead to focus energy on data transfer, and thus the medium access method and the routing protocol must be chosen carefully. Adaptive modulation, opportunistic transmission and coding should be done in this way so that it could avoid the loss of data due to channel, which will save energy also. Many energy harvesting techniques have been studied in order to give importance to the sensors energy, even though they are not very efficient. Despite these solutions for the energy problem, violating the layered communication stack has proven to result in better gains for MANETs. This technique is called cross-layer design and it has been used to overcome not only energy limitations, but also to increase network throughput and to improve quality of service. Protocols can be developed which can deal both delay and the reliability together which are contradict to each other.

During low mobility, the average delay is dominated by network congestion due to data traffic. During high mobility, it is dominated by route changes in the simulation results. Our scheduling algorithms that give higher weight to data packets with smaller numbers of hops or shorter geographic distances to their destinations reduce average delay significantly without any additional control packet exchange. The weighted-hop scheduling algorithm is used for modified AODV. Result show considerably smaller delay than the other scheduling algorithms.

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