Q- Learning Algorithm with Network Coding in Multi-Path Transfer Protocol for Wireless Mesh Network

S. Rajeswari, S. A. Arunmozhi, Y. Venkataramani

Abstract- In a wireless mesh network, the network coding algorithm used to improve network efficiency. In this paper, we have implemented the Q-learning algorithm with CSMA/CA as in distributed co-ordination function along with multi-path transfer protocol (MPTP). The functioning of CSMA/CA is based on physical carrier sensing. Q-learning algorithm, along with network coding, is implemented to achieve better throughput. Our proposed method has used to reduce the packet loss and to minimize the end to end delay of the network communication. Also, it will improve the possibility of receiver buffer blocking.

Keywords: Network Coding, Q-Learning Algorithm, Mptp, Ieee802.11 Dcf.

I. INTRODUCTION

The multi-hop wireless network has classified into mobile Ad-hoc network (MANET), wireless sensor network (WSN), wireless mesh network (WMN) and vehicular Ad-hoc network. In multi-hop wireless mesh networks (WMNs), there are one or more intermediate nodes (routers) along the path is used to receive and forward packets. In WMNs, several advantages are there since it extents coverage area of networks and also improves the connectivity due to the existence of several paths while it compared to single-hop networks. These parameters can be used to increases the robustness of the networks. In WMNs, dynamical routes have configured so that each node connected to several nodes. In the established communication path, even if one node drops out, its neighbours quickly found another route to reach the desired destination. WMNs consist of mesh router and mesh clients. Among the mesh clients, one node can act as a router. Mesh router is the essential component of the WMNs and considered as the backbone of the network. It transfers the packets using a multi-hop network in order to cover the large area with less cost. The router used to provide the best and efficient path for effective communication. Even though one path is a failure under any circumstances, the router used to provide continuity, since many routes are available to continue the network communication process. In a conventional network, if a routing node receives two packets from two distinct source nodes, it will forward them sequentially, even if both the packets addressed to the same destination. During queueing, the routing node may receive packets from other nodes in the network.

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The above one may end up with the node creating separate transmissions for every packet delivered to the appropriate destinations, which results in a decrease in network efficiency. In many real applications, the network throughput and end-to-end delay are the most challenging issues to overcome this problem by implementing a Q-learning algorithm in DCF with multi-path transfer protocol in multi-hop WMN.

II. BACKGROUND AND RELATED WORK

The maximum stable throughput in single-hop wireless networks [14] in which, a source multicasts data packets to several destinations directly and network coding applied to retransmit the packets which are not received by a subset of the destinations. In this paper, we developed a network coding based new queuing model on formulating a packet scheduling algorithm. Queuing model with many sub-queues designed and each packet in sub-queue is associated with an index set. Next, they have chosen a scheduling method for combining the packets from sub-queues and sending a network coded packet out to the desired receivers. They have formulated this problem as a linear programming problem with stability conditions as a constraint of each sub-queue. The scheduling maximizes throughput without any constraint on the delay and with a constraint to guarantee an inevitable average delay [13]. This paper explained bidirectional relay networks with half-duplex nodes and blocked fading the nodes with a fixed transmission rate. Furthermore, to analyze [5], the throughput and delay of network coding in two-hop networks with two unbalanced traffic cases (i.e., one-to-one and one-to-many bidirectional relay) employing slotted ALOHA. They also extended the model to single-relay multi-user wireless networks and provided the achievable region in throughput [6].

In another single-relay research [9], the throughput of network-layer and physical-layer network coding under IEEE 802.11 DCF with two groups of nodes communicating with each other through a relay node discussed. In a similar work, where again all nodes are in carrier sensing range of each other, they not only study the throughput under slotted ALOHA but also propose a hybrid network coding scheme it is the combination of physical-layer and network layer network coding to improve performance. Regarding multi-hop wireless networks, [7] collision-free scheduled access to formulate throughput for both saturated and non-saturated queues. However, in the case of a random access scheme, their analytical model is limited to saturated queues. [15]

In this paper, instead of limiting nodes to scheduled access, they studied the performance using the IEEE 802.11 MAC layer, where a collision can occur without assuming saturated queues. In an [1] analytical study of the arrival and departure of packets are stochastic, an average delay and throughput in a two-way relay network exploiting network coding to exchange source packets examined. Simulations confirmed the theoretical analysis that transmission probabilities depend on the coded/uncoded and destination of packets. The authors obtained stable throughput for multiple broadcast sessions in a multi-hop wireless tandem network with random access. Packets combination and packets multicasting are two fundamental processes of network coding. By solving the traffic equations with stability condition, they have obtained the maximum stable throughput [3]. The problem is challenging since the interaction among nodes and the issues of saturated mode where all nodes always have a packet to send, which results in infinite packet delay. They have considered two different control mechanisms, the deterministic system, contents of the receivers' buffers announced to the coding node via overhearing reports and stochastic system coding node makes decisions based on statistics, and the performance improved via NACK messages. Hence they proved the tradeoff between throughput and overhead. [10].

III. PROPOSED SYSTEM

The proposed model includes medium access protocol CSMA/CA as in IEEE802.11 DCF. The Q-learning algorithm implemented within the multi-hop multi-path transfer protocol. Q-learning algorithm used to control the number of redundant packets depending on the network dynamics and to reduce the possibility of receiver buffer blocking. To increase the throughput and to reduce the end to end delay of the multi-hop wireless mesh network, Q-learning algorithm in DCF with multi-path transfer protocol in multi-hop wireless mesh network used.

A learning algorithm:

In Q-learning, each mesh router (MR) makes the best path along with the gateway by calculating the parameter called path quality and connectivity. In this learning, the Q table is built for all possible combinations of state and action to store all possible Q values. It called Q-Learning because, within a provided space, it represents the action taken by an agent based on the quality of a specific action. To choose the best action which gives maximum reward to the agent, Q-table is used by the. So, conventionally the Q-Table acts as a source that lists all the critical points needed to know for a given state to the agent as it has all the possible combinations for the environment. It can also be called as model-free since the Q-value did not approximate using any function. It stored inside a table, with rows as states and actions as columns. Q- Learning algorithm is highly alleviating the loss of packets and also to reduce the possibilities of receiver buffer blocking. Collisions may occur due to more number of packet retransmissions which can predict by using Q-learning algorithm. All individual nodes will undergo a Q-learning process. Once the routing table has created, all the nodes in the network will check whether the routing path is properly working or not. If any problem identified, the sender re-route the path to transmit the packets. Hence this process is implemented to achieve the optimal throughput.

B Processing Steps For Q-Learning

1. Source node generates the packet with the process of encoding
2. The source node schedules the packets by FIFO to a destination to avoid the drop of packets
3. If any packets have been a loss in the intermediate node, router re-routes the packets, prevent the loss of packets, and thereby delay minimized.
4. Q learning will assign the maximum probability for the proper route, updates the Q matrix, to achieve better throughput.

The Q-learning method is an on-line scheme which is composed of two aspects for learning, namely strategy update and Q-value update.

Strategy updating: In order to arrive a best possible decision strategy, during each decision period the node will select a network randomly with probability ε ∈[0,1] and with probability (1 –ε) it will select a network based on the stored Q-values.

Q-value updating: Lookup table has formulated with the Q value for the corresponding state. The network would have associated with the state value. Q-values can obtain from the lookup table formulated for Q-value corresponding to state and the network will select with the maximum Q-value. After the transition to the next state, dynamically Q-values will be updated.

The algorithm procedure described as follows: $Q_{t+1}\,(s,a) = (1{-}\propto)\,Q_i\,(s,a){+}\propto[(s,a) + p_{max}\,a_0 Q_t\,(s_{0,}a_0)]$

$Q_{t+1}\,(s,a)$ - indicates the Q-learning rule where s is the source and “a” indicates the path

$(1{-}\propto)$ - indicates the total no of packets

$Q_i\,(s,a)$ – Number of packets transmitted through the path

$a_0 Q_t\,(s_{0,}a_0)$ The maximum probability of route

In Q- learning to assign the maximum probability level of the route and then update the Q matrix. Q matrix represents the column or sequence order to update the matrix. The main advantage of Q- learning is to alleviate the loss of packets and also to reduce the possibility of receiver buffer blocking.

IV. FLOW CHART:

A Encode

In network coding technique is used by the process of encoding. For an example, if source node two or more messages transmitted the intermediate node to composite two messages and destination to receive the two messages likewise XOR operation. In network, coding is a field of information theory and coding theory and then also to attain the maximum information to flow in a network, it is necessary to consider the encoding and decoding of the data, and it achieves the optimal throughput.

The encoding process to transmit the packet to an intermediate node if any packets are to be lost it takes re-route to transmit the packet hence this process to reduce end to end delay of the network.

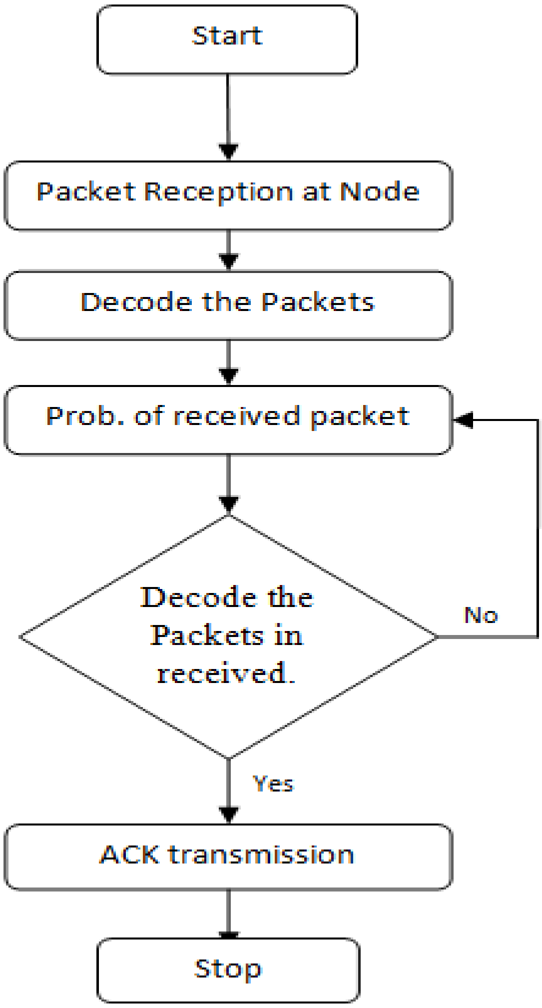

Figure 4.1.1 Encoding

The process of encoding and decoding used to reduce end to end delay of the network.

B Decode

In network coding technique is used by the process of decoding. Network coding is a field of information theory and coding theory and then also to attain the maximum information to flow in a network, and it is necessary to consider the encoding and to decode a data and it s the optimal throughput. Q learning used to assign the probability level for the route; it will assign (0 to 1). If maximum time consumed for packet transmission, it will be assigned with the probability nearby to 0 and where minimum time consumed for packet transmission, it will be assigned with the probability nearby to 1. Based on the number of packets flow Q matrix will be updated. If any problem occurs in that path, it will select the next possibility of the path to send the packets; hence this Q-learning process used to achieve better performance.

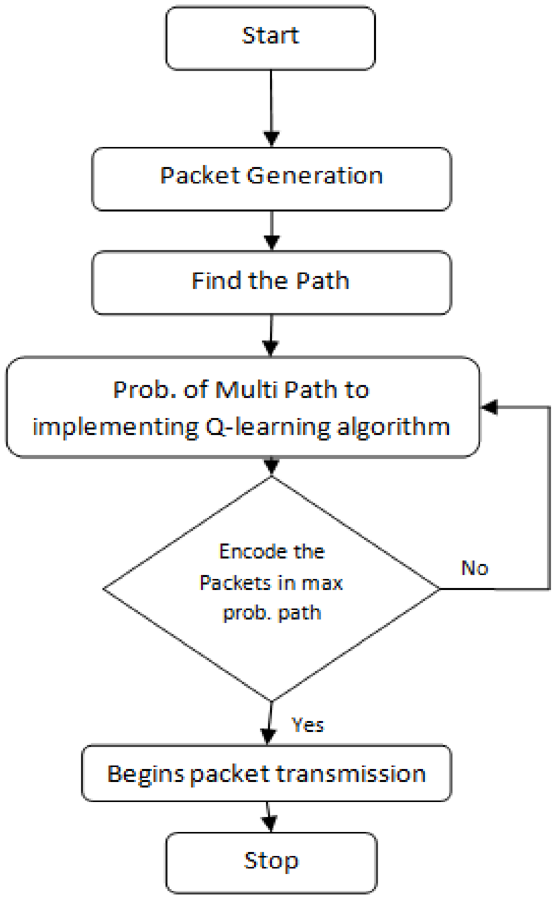

Figure 4.2.1 Decoding

V. MPTP

Multi-path transfer protocol diverts traffic in order to balance traffic from the more congested path to a less congested path. Multiple potential paths across the network used in order to balance a huge amount of traffic which will generate the congested network The recipient should reorder the packets which take a different path and also out-of-order delivery packets. The differences in maximum packet size among different paths generates few issues for specific protocols, namely TCP and its path MTU discovery.

VI. IEEE802.11 DISTRIBUTED COORDINATION FUNCTION:

DCF does not solve the hidden and exposed terminal problem completely, it only alleviates the problem through the use of RTS and CTS control signals and recommends the use of a broader carrier sensing range. IEEE802.11 DCF is a protocol which mainly used in carrier sensing and maximizes the throughput and preventing the packet collision. In IEEE802.11, RTS and CTS are used in wireless network protocol to reduce the frame collision and to increase the throughput. DCF includes a definite positive acknowledgement scheme, which means that if a frame is received by the destination successfully, the destination needs to send an ACK frame to notify the source of successful reception.

VII. ENCODING TECHNIQUE

A network coding:

The network coding is composite two or more messages. The network coding is a field of information theory and coding theory and is a method of attaining maximum information flow in a network.

In network coding out that it is necessary to consider encoding and decoding data on nodes in a network in order to achieve optimal throughput. Network coding is one of the networking technique in which the data is transmitted the data in an encode and decode to increase the throughput and reduce end to end delay of the network and then also network to make more robust. To accumulate the various transmissions of the data to apply the algebraic algorithms in network coding. The received transmission is decoding the data at their destination. In fewer transmissions to require all the data is to be transmitted, it requires more processing the intermediate and terminal nodes. In the network, coding used to merge the two messages and then the accumulate result forward to the destination. After receiving that message is decode at their destination by using the process of network coding.

VIII. RESULTS

A Throughput:

The throughput has defined as the rate of successful message delivery over a communication channel.

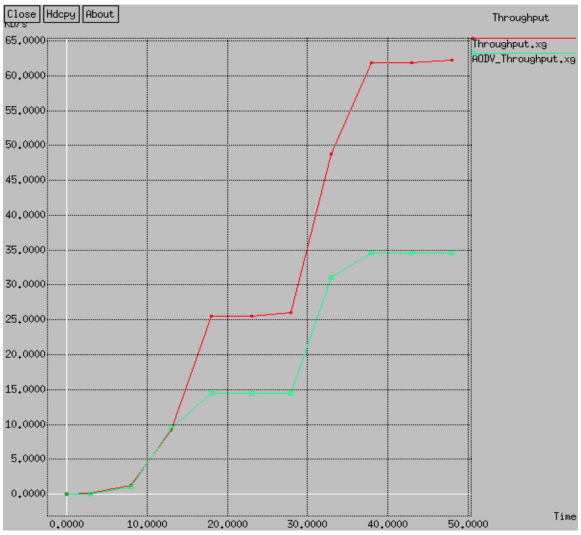

Fig 8.1.1Throughput

Figure 8.1.1 shows the comparison of network coding with Q matrix network coding without Q matrix for the maximum node speed 30 m/s in terms of throughput with simulation time. The graph proved that network coding with the Q matrix achieved significant achievement in throughput.

B Packet drop:

When packet losses occur if one or more packets travelling across a network and then reach to the destination. The packet loss causes the error in transmission. When it typically across a wireless network or network congestion. When one or more than packets is to fail to reach into the destination.

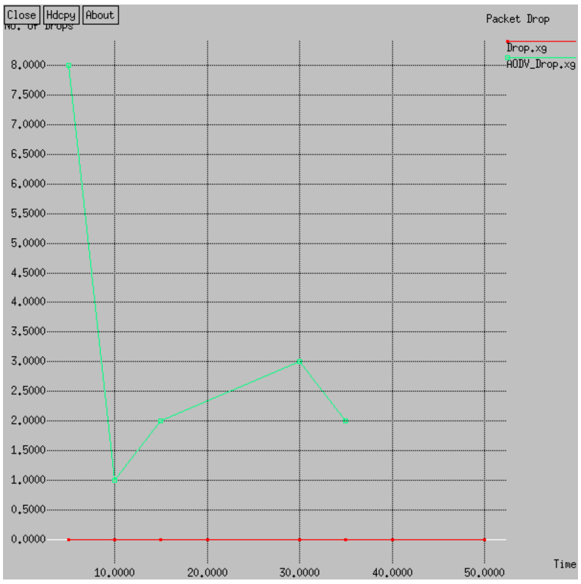

Fig 8.2.1 Packet drop

IX. CONCLUSION AND FUTURE WORK

This paper, the multi-path transfer protocol, is highly effective in alleviating the loss of packets. We consider retransmission, collision probability, link qualities and coding probabilities in calculating the throughput and an upper-bound of average end-to-end delay of the network. By using Q-learning algorithm, we can control the number of redundant packets depending on the network dynamics to reduce the possibility of receiver buffer blocking. Also, the validity of the analytical model is shown by simulations in NS-2.

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