International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 3 (2015) pp. 5765-5780

http://www.ripublication.com

Interference-free Cross-layer based Routing Protocol in MANET

G.Mathiyalagan[1] and Amitabh Wahi[2]

[1]Research scholar, Anna University, Coimbatore
mathiyalagan0666@gmail.com
[2]Professor, Dept. of Information Technology,
Bannari Amman Institute of Technology, Sathyamanagalam.

Abstract

In Mobile Ad Hoc Networks (MANET), cross layer routing technique may result in overhead and interference. In order to overcome these issues, in this paper, we propose to develop an interference free cross-layer based routing protocol in MANET. In this technique, a cross-layer based routing is performed based on the signal to interference plus noise ratio (SINR) constraint in the MAC layer and throughput constraint in the application layer. The SINR constraint helps the receiving nodes to adjust the transmission power before forwarding it to the other nodes. In order to minimize the interference, a minimum interference method is used. This technique selects the links that have long connectivity duration, and then builds the least interfered route which is based on a new routing metric. This routing metric consists of interference along with the link connectivity duration. By simulation results, we show that the proposed technique minimizes the overhead.

1. Introduction

1.1. MANET

A mobile ad hoc network (MANET) is a collection of geographically distributed wireless mobile nodes which self configs themselves. It is an infrastructure-less multi hop network where each node communicates with other nodes directly or indirectly through intermediate nodes. Thus, all nodes in a MANET basically function as mobile routers participating in some routing protocol required for deciding and maintaining the routes.

The lack of an infrastructure and the limited battery power in ad hoc networks pose design challenges at all layers of the protocol stack. MANET requires new technologies for the mobility management, service discovery, and energy efficient information routing of the network. Significant research has been done towards implementing application-dependent Quality of Service (QoS) requirements. These researches mainly addresses the adaptive techniques in the link layer, interference in the Medium Access Control (MAC) layer, and energy and delay constrained routing in the network layer [1] [2].

1.2. Routing in MANET

Routing is the process of selecting paths in a network along which to send network traffic. Nodes in traditional wired networks do not route packets, while in MANET every node is a router. Nodes transmit and receive their own packets and also forward packets for other nodes. Due to mobile nodes, topologies are dynamic in MANET, but are relatively static in traditional networks. Connectivity and interference are indicated by link layer information. A traditional router has an interface for each network to which it connects, while a MANET "router" has a single interface [3] [4].

1.3. Cross-layer based routing in MANET

In order to achieve the desired vertical optimization goal, the useful information is inter-communicated by the different layers of the network protocol stack which is considered as cross-layer or inter-layer networking. The requirements of the quality of service may vary with applications and hence the network or higher layers function should directly rely on the information from the lower physical and MAC layers. Different layers can share locally available information by using interlayer interaction. This will significantly improve the performance. There are many cross-layer designs for different optimization purpose. Different cross-layer design focuses on different optimization purpose, different QoS metric, one or more of the followings: interference, delay, priority handling, security, etc. Obviously every system needs more than one cross-layer design to achieve overall QoS optimization [3].

Issues

- The cross-layer designs provide individual solution for congestion control, fault tolerance, power conservation, energy minimization and flow control. There is no complete and combined solution for the above issues.
- Expensive and High Overhead
- Packet error
- Node failure
- Network survivability [1] [3]

1.3. Interference free cross-layer routing in MANET

The cross-layer design of routing protocols based on interference in MANETs pay less attention to channel contention than to the number of the neighbor nodes. This will bring two problems such as (i) for a node in the network only the neighbors that send or forward packets (i.e. the active neighbors) will interfere with it. So, it's inappropriate to use the number of neighbors to indicate the strength of the interference: (ii) In most cases, nodes collect the neighbor information by periodically broadcasting the HELLO packets, which will not only increase the node workload but also deteriorate the network performance. So there is a need for interference free cross-layer based routing protocol for MANET [5].

Issues

- Route breakage
- Routing overhead
- Wastage of resources
- Performance degradation[5] [7]

1.4. Problem Identification

In our previous paper [14], Adaptive shrinking mechanism as a route optimization technique is proposed. Initially using EGD metric, route discovery and link quality prediction is made. Next while sending data packets shrink packets were also sent along with them.

As an extension to these works, we propose to develop an interference free cross-layer based routing protocol to reduce the interference or collision.

2. Literature review

Khoriba Ghada et al [1] proposed a cross-layer design that jointly considers routing and topology control taking mobility and interference into account for MANETs. This is called to be as Mobility-aware Routing and Interference-aware Topology control (MRIT) protocol. The main objective of the proposed protocol is to increase the network lifetime, reduce energy consumption, and find stable end-to-end routes for MANETs. The proposed protocol reduces energy consumption rate, end-to-end delay, interference while preserving throughput and network connectivity.

R.Venkatachalam and Dr.A.Krishnan [3] proposed to design multiple cross-layer design based architecture to provide a combined solution for link failure management, power conservation, congestion control and admission control. The average end-to-end delay, average energy consumption and the packet loss are considerably reduced with the increase in high throughput and good delivery ratio. However the packet drop increases after a particular stage with the increase in the nodes.

Chao Gu and Qi Zhu [5] have proposed a cross-layer routing protocol called (Minimum Interference Routing) MIR. By means of predicting the duration of the interference imposed by the neighbors at every hop along the route, a new routing metric is presented which guarantees that the established routes will not break frequently while having the minimum interference. MIR can significantly improve the network performance. However there occurs packet loss ratio and routing overhead.

M.A. Razzaque et al [6] have presented a routing scheme for proactive management for disconnections, by fusing and leveraging information derived from multiple levels of the network protocol stack using cross-layering. In addition to the disconnectivity information, this routing scheme utilizes node’s service level information and data/service replication to provide service from an alternate source (if there is one) even in the absence of the targeted source. There are significant improvements in route maintenance and service availability over other similar schemes. However at lower velocities, once the route is broken, retransmissions may occur because the delay in forming a new route is higher.

Zhixiang CHEN and Qi ZHU [7] presented a new routing protocol called CL-IAOR based on cross-layer design for multiple interfaces multiple channels (MIMC) mobile ad hoc networks, which utilizes a new channel assignment strategy to improve performance. In their protocol, each host equips with 2 or more transceivers or interfaces, which is equal to the number of available channels. The proposed routing protocol performs well in multi-hop mobile ad hoc networks. However the route overhead increases with the increase in the packet rate.

Fuad Alnajjar and Yahao Chen [8] proposed a cross-layer design to achieve a reliable data transmission in MANET. A key challenge is to create a mechanism that can provide good delivery performance and high quality of service in intermittent networks. The key components of our approach include a cross-layer design (CLD) to improve information sharing between different protocol layers. In order to improve the end-to-end performance of MANET, a mechanism is presented that allows the network layer to adjust its routing protocol dynamically based on SNR and Received Power along the end-to-end routing path for each transmission link. This model achieves better performance than traditional DSR protocol in terms of delivery rate, delay, throughput over intermittent network.

V. Haghighatdoost and M. Espandar [9] presented an algorithm which suggests the best sub graph for the input distribution of the nodes in the plane how the maximum interference of the proposed graph has the minimum value. The proposed algorithm is not only for one dimensional known distribution like exponential node chain, but also for two dimensional distributions.

Fredrick Awuor et al [10] proposed a coupled interference network utility maximization (NUM) strategy (i.e. CIN) for rate adaptation in WLANs that is solved using “reverse-engineering” based on Karush-Kuhn-Tucker (KKT) conditions. The users determine data rates based on their local observations (i.e. coupled interference). Both pricing and limited message passing mechanisms are employed in the NUM wherein pricing restrict users from self-interest behaviors while limited message passing assist users to announce their prices and transmit powers. It is demonstrated theoretically that CIN satisfies the conditions of the super-modular games and that its solution is optimal. The adapting data rates based on the link conditions can improve the performance of ad hoc networks.

Nouha Jaoua et al [11] proposed a method for the joint estimation of the multicarrier signal and the noise parameters. The proposed scheme is based on Bayesian estimation using SMC methods. They propose a sequential approach to remove interference without adding delays in the signal processing and therefore in the transmission. Based on sequential Monte Carlo (SMC) methods, the proposed scheme allows the online estimation using a Rao-blackwellized particle filter. However there occurs degeneracy problem.

Salam Akoum et al [12] presented a zero forcing beam forming at the transmitter, and analyze the corresponding network throughput and transmission capacity. Assuming a network with Poisson distributed transmitting nodes and spatially independent Rayleigh fading channels, they apply mathematical tools from stochastic geometry to derive a lower bound on the probability of outage. The network throughput achieved by interference nulling at the transmitter is comparable to that achieved by interference cancellation at the receiver. However the network throughput decreases with the increase in the number of antennas.

Guinian Feng et al [13] have proposed a topology control algorithm - minimum interference algorithm (MIA) – to minimize the overall network interference. MIA minimizes network interference it is optimal and has better performance than other algorithms in that respect. At the same time, compared with Gabriel Graph and k-NEIGH algorithms, MIA also has good spanner property.

3. Proposed Solution

3.1. Overview

In this paper, we propose to develop an interference free cross-layer based routing protocol in MANET. In this technique, a cross-layer based routing is performed based on the signal to interference plus noise ratio (SINR) constraint in the MAC layer and throughput constraint in the application layer. The SINR constraint helps the receiving nodes to adjust the transmission power before forwarding it to the other nodes. In order to minimize the interference, a minimum interference method is used. This technique selects the links that have long connectivity duration, and then builds the least interfered route which is based on a new routing metric. This routing metric consists of interference along with the link connectivity duration. By simulation results, we show that the proposed technique minimizes the overhead.

3.2. SINR and Throughput Constraint

3.2.1. SINR constraint

Let S and D be the source and destination respectively.

The SINR constraint is applied in MAC layer in order to reduce the overhead of messages.

Let N_i and N_j be the neighbor nodes

Let TP_{ij} be the transmission power of N_i and N_j

Let TP_{ij}/ d_{ij}^{δ} be the received power of N_j

Let $Pmax_i$ be the maximum allowed transmission power of N_i

Let Pm be the maximum transmission power of network nodes

Let λ_{ij} be the minimum threshold value of SINR.

Let η be the transmission quality parameter

Let d_{ij} be the Euclidean distance between N_i and N_j

Let δ be the distance power gradient.

If there is a link between N_i and $N_{j,}$

Then

Boolean variable $Z_{ij} = 1$

Else
$Z_{ij} = 0$
End if
Minimize $\{Pm_i = \max \{TP_{ij} | 0 \le i < n\}\}$
Subject to
$Z_{i,j} = Z_{j,i},\ \forall\, i, j \in N$ (1)

Eq (1) reveals that there is a bidirectional link between N_i and N_j.
$Z_{i,j} \le Z_{i,k}$, if $d_{i,k} \le d_{i,j},\ \forall\, i, j, k \in N$ (2)

Eq (2) reveals that the nodes have broadcast ability. The data transmitted by a node will be received by all the nodes within the transmission range.

$Pmax_i \ge TP_{ij} \ge \eta \,.\, d_{ij}^{\delta} \,.\, Z_{i,j},\ \forall\, i, j \in N$ (3)

Eq 3 reveals that the transmission power from any N_i to N_j is less than or equal to the maximum allowed transmission power and more than or equal to $\eta \,.\, d_{ij}^{\delta}$

$$SINR_{ij} = \frac{TP_{ij}/d_{ij}^{\delta}}{\sum_{(k,j)\in W, k\neq i} TP_{kj}/d_{kj}^{\delta} + \mu} \ge \lambda_{ij} \qquad \forall i, j, k \in N, \tag{4}$$

$Z_{i,j} = 0$ or $1,\ \forall i, j \in N,$
Eq (4) ensures minimum SINR for successfully reception at N_j from N_i.

3.2.2. Throughput Constraint

The network lifetime need to be maximized in order to enhance the throughput requirement.

Let t_i be the lifetime of N_i i.e. the time taken for N_i's battery to drain out.

Let $t_i(F)$ be the lifetime of the node i under flow F_{ij}., where $(i,j) \in Q$

Let E_{ini} be the initial energy of N_i

Let E_{tot} be the total energy needed to transmit the flow from N_i to its neighbors.

$t_i(F)$ is defined as the ratio between E_i and E_{tot}.

Let R_i^c be the rate at which the bits are generated at N_i per second belonging to commodity $g \in G$, where G is the set of all commodities.

The lifetime of the network (NL) under flow F is defined as the minimum battery lifetime over all nodes:

$$t_{NL}(F) = \text{Min}_{i\in N}\, t_i(F) = \text{Min}_{i\in N} \frac{E_{ini}}{\sum_{\substack{\forall j\in N,\\ (i,j)\in L}} e_{ij} \sum_{g\in G} f_{ij}^{(g)}} \tag{5}$$

The maximum network lifetime problem for MANETs is formulated as a nonlinear optimization problem as follows:

$$\text{Maximize}_f\ t_{NL}(F) = \text{Min}_{i \in N} \frac{E_{ini}}{\sum_{\substack{\forall j \in N, \\ (i,j) \in Q}} e_{ij} \sum_{g \in G} f_{ij}^{(g)}} \quad (6)$$

Subject to

$$\sum_{(i,j) \in Q} f_{ij}^{g} - \sum_{(k,i) \in Q} f_{ki}^{g} = \begin{cases} R_i^{(g)}, if\ i \in S^{(g)} \\ -R_i^{(g)}, if\ i \in D^{(g)}, \forall g \in G \\ 0, \quad Otherwise \end{cases} \quad (7)$$

3.3. Interference

It is defined using the following equation

$$M_i = \sum_i \min(t_{br}^{(i,j)} - t_c, t_d^i\ )$$

Where

i = interference of N_i active neighbors

t_c = current time of the system

T_d^i = duration that active N_j is in N_i's transmission range.

3.4. Cross -Layer Based Routing

In the route discovery process the network utilizes the direction information about the destination node, which makes the process of route discovery makes easy for the network. Initially the network utilizes the estimated geometrical distance (EGD) during the route discovery [14]. The EGD based on the received signal strength and the signal strength of the two nodes at the contact time. With this EGD, the future direction of nodes when they have parted from each other can be estimated. Using this EGD, network can evaluate the quality of link between nodes and then exclude the weak links in the network. By the exclusion of weak links network can easily turn the propagation direction of RREQ packets in the general direction of the destination.

Since the node is moving, we consider the times T_0, T_1 and T_2 for calculating the EGD. The node N_1 receives the packets with the signal strengths S_0, S_1 and S_2. D_0, D_1 and D_2 are the distances that N_2 moving from the N_1 at times T_0, T_1 and T_2. We calculate the D_0, D_1 and D_2 by using the following the equations

$$D_0(t) = D_0 + (S_0 * t_0) \quad (8)$$

$$D_1(t) = D_0 + (S_1 * t_1) \quad (9)$$

$$D_2(t) = D_1 + (S_2 * t_2) \quad (10)$$

Using the equations (8), (9) and (10) we will calculate the D_0, D_1 and D_2 values. Finally EGD is given by

$$EGD = D = \sqrt{xt^2 + yt + z} \quad (11)$$

In equation (11), x, y and z values are given by

$$X = A*D_0 - B*D_1 + C*D_2 \quad (12)$$

$$Y = -(c)*D_0 + t_2*B*D_1 - t_1*B_1*D_2 \quad (13)$$

$$Z = D_0 \quad (14)$$

Using the equations (12), (13) and (14) we calculate the value of EGD and in that equations A= $1/(t_1*t_2)$, B= $1/(t1(t_2-t_1)$, B_1= $1/(t2(t_2-t_1)$ and C= $((1/t_1)+(1/t_2))$. Here the D and T values are iteratively calculated. Each node stores information such as T_i and D_i i = 0, 1, 2. The EGD values are represented as a function of time t and t is the difference between the current time and the time of the third to the last packet received from the N_2.

Let R_REQ and R_REP be the route request and reply messages respectively

The steps involved in cross-layer based routing are as follows:

1. S broadcasts RREQ for all neighboring nodes.
2. For all route existing among S and D, the following actions are performed:
   i) N_i estimates the new power (NP_{ij}) based on which the transmission power TP_{ij} is adjusted by considering the SINR and throughput constraints (estimated in section 3.2)
   ii) N_i forwards RREQ message to the neighbor node based on the updated TP_{ij} value.
3. D chooses the RREQ message from S which has maximum power.
4. Then D transmits the RREP message to S using the similar power TP_{ij}.

While transmitting the message, if SINR is more than or equal to λ_{ij}, then message is transmitted without interruptions. Otherwise, a constant x is increased by a random variable more than zero and less than until SINR $\geq \lambda_{ij}$ or message lifetime ends.

3.4. Minimum Interference Method

In order to minimize the interference, minimum interference method is implemented. In this technique, the link with long connectivity duration is selected and least interfered route is build based on new routing metric. The routing metric consists of interference along with the link connectivity duration.

For node N_i and next hop node N_j in a path, link L_{ij} lasts for a long time if the link connectivity duration is greater than a certain threshold, i.e.

$$t_{br}^{(i,j)} - t_c > Th_{br}$$

where

$t_{br}^{(i,j)}$ = link broken time.

t_c = current time of the system

Th_{br} = pre-defined threshold value based on the network condition.

If the corresponding link connectivity duration is less than Th_{br}, then the relevant link is ignored.

Let V= {V_1, V_2, V_3, …,V_n}be a set that contains n paths from S to D.

Let H_v = {h_0, h_1,…, h_t} be the node sequences on path V.

Based on the interference defined in section 3.3, routing metric is defined using following equation (8)

$$\text{Metric} = \min_{V_i}\left(\sum \frac{\dfrac{M_j}{C(M_j)}}{t_{br}^{(j-1,j)} - t_c} \right) \quad (8)$$

where

$C(M_j)$ = total number of interference nodes surrounding N_j,

$\dfrac{M_j}{C(M_j)}$ = mean duration of interference imposed on N_j

$t_{br}^{(j-1,j)} - t_c$ = connectivity duration of current communication link.

Thus the path with minimum interference and long connectivity duration will be selected.

4. Simulation Results

4.1 Simulation Model and Parameters

The Network Simulator (NS-2) [15], is used to simulate the proposed architecture. In the simulation, 50 mobile nodes move in a 1250 meter x 1250 meter region for 50 seconds of simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR).

The simulation settings and parameters are summarized in table.

No. of Nodes	110
Area Size	1250 X 1250
Mac	IEEE 802.11
Transmission Range	250m
Simulation Time	50 sec
Traffic Source	CBR
Packet Size	512
Rate	100,200,300,400 and 500kb
Initial Energy	7.1J
Transmission Power	0.660
Receiving Power	0.395
Flows	2,4,6,8 and 10

4.2 .Performance Metrics

The proposed Interference free cross-layer based routing protocol (IFCLRP) is compared with the Mobility-aware Routing and Interference-aware Topology control (MRIT) protocol [1]. The performance is evaluated mainly, according to the following metrics.

- **Packet Delivery Ratio:** It is the ratio between the number of packets received and the number of packets sent.
- **Packet Drop**: It refers the average number of packets dropped during the transmission
- **Energy Consumption**: It is the amount of energy consumed by the nodes to transmit the data packets to the receiver.
- **Delay**: It is the amount of time taken by the nodes to transmit the data packets.

4.3. Results

1) Based on Flows

In our first experiment we vary the number of flows as 2,4,6,8 and 10.

Fig 1 shows the delay of IFCLRP and MRIT techniques for different number of Flows scenario. We can conclude that the delay of our proposed IFCLRP approach has 36% of less than MRIT approach.

Fig 2 shows the delivery ratio of IFCLRP and MRIT techniques for different number of Flows scenario. We can conclude that the delivery ratio of our proposed IFCLRP approach has 14% of higher than MRIT approach.

Fig 3 shows the drop of IFCLRP and MRIT techniques for different number of Flows scenario. We can conclude that the drop of our proposed IFCLRP approach has 93% of less than MRIT approach.

Fig 4 shows the energy consumption of IFCLRP and MRIT techniques for different number of Flows scenario. We can conclude that the energy consumption of our proposed IFCLRP approach has 26% of less than MRIT approach.

Fig 5 shows the throughput of IFCLRP and MRIT techniques for different number of Flows scenario. We can conclude that the throughput of our proposed IFCLRP approach has 14% of higher than MRIT approach.

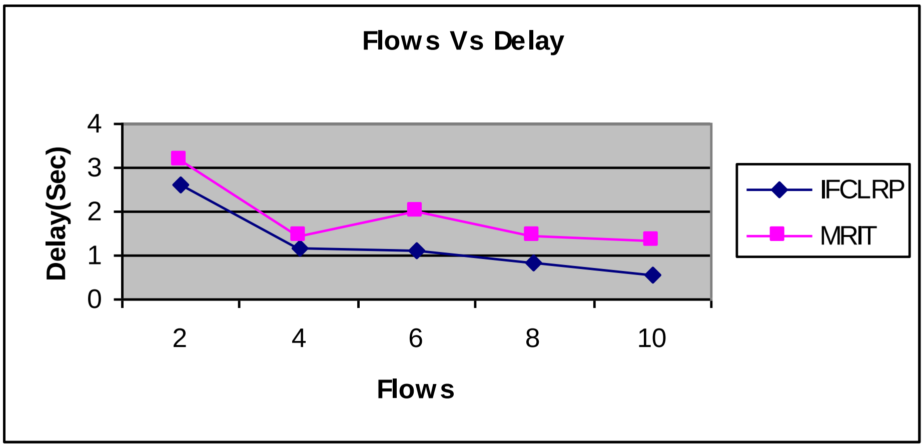

Fig 1: Flows Vs Delay

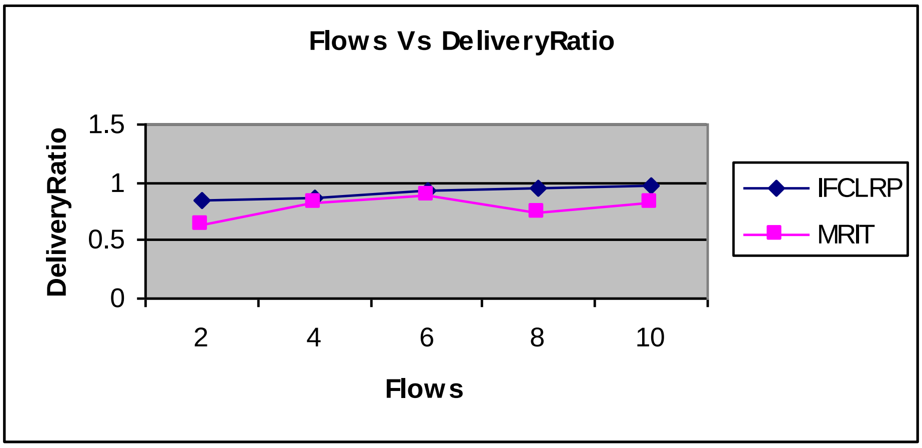

Fig 2: Flows Vs Delivery Ratio

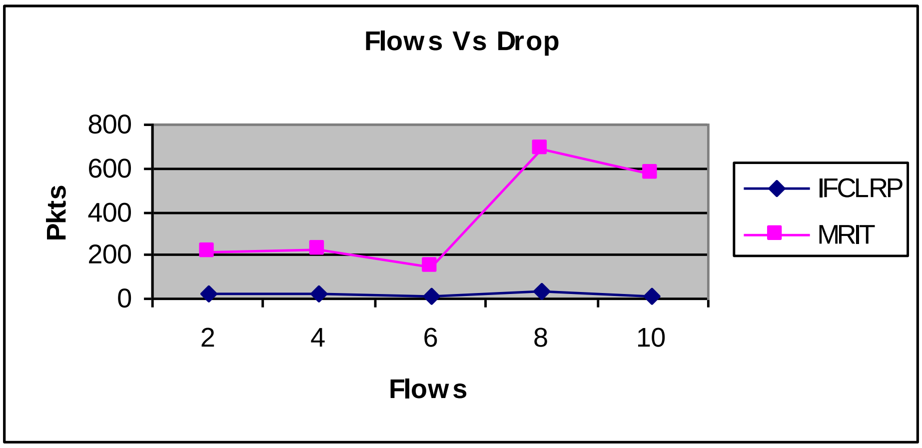

Fig 3: Flows Vs Drop

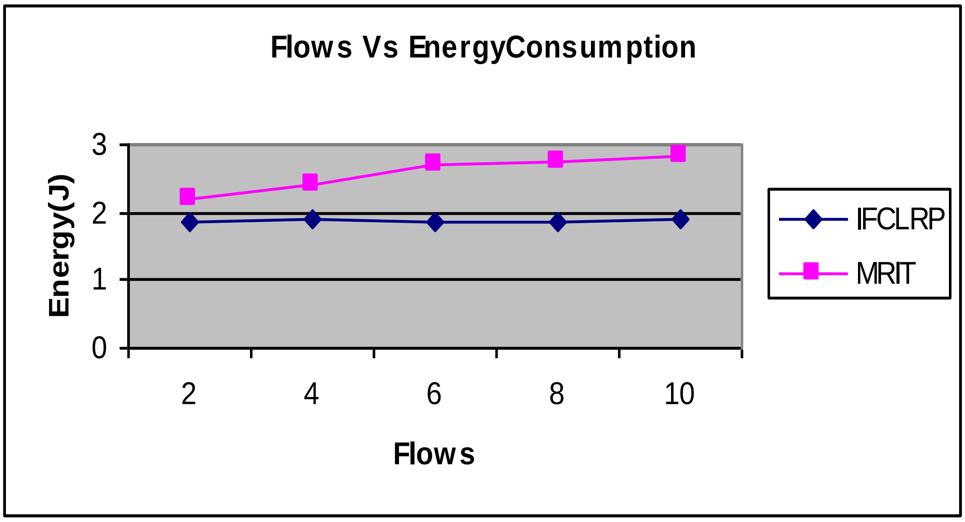

Fig 4: Flows Vs Energy Consumption

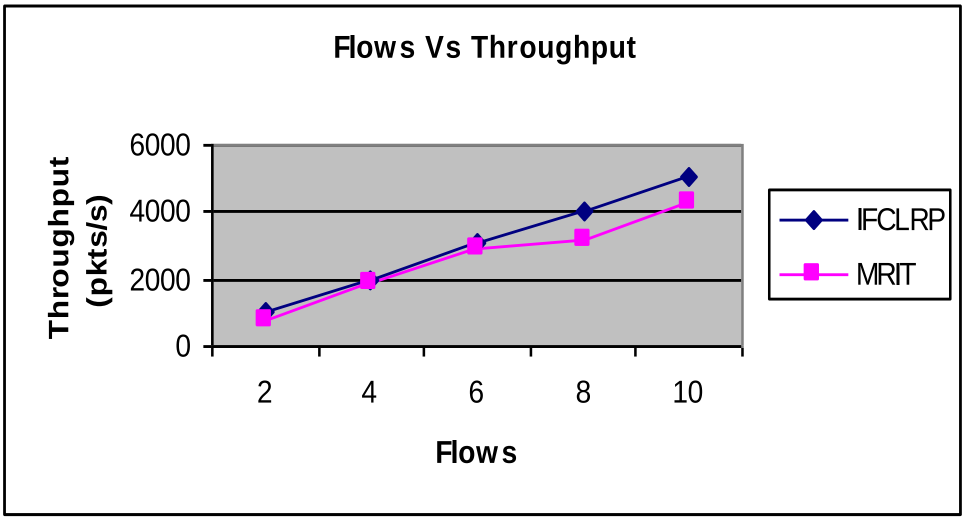

Fig 5: Flows Vs Throughput

2) Based on Rate

In our second experiment we vary the transmission rate as 100,200,300,400 and 500Kb.

Fig 6 shows the delay of IFCLRP and MRIT techniques for different rate scenario. We can conclude that the delay of our proposed IFCLRP approach has 65% of less than MRIT approach.

Fig 7 shows the delivery ratio of IFCLRP and MRIT techniques for different rate scenario. We can conclude that the delivery ratio of our proposed IFCLRP approach has 46% of higher than MRIT approach.

Fig 8 shows the drop of IFCLRP and MRIT techniques for different rate scenario. We can conclude that the drop of our proposed IFCLRP approach has 90% of less than MRIT approach.

Fig 9 shows the energy consumption of IFCLRP and MRIT techniques for different rate scenario. We can conclude that the energy consumption of our proposed IFCLRP approach has 41% of less than MRIT approach.

Fig 10 shows the throughput of IFCLRP and MRIT techniques for different rate scenario. We can conclude that the throughput of our proposed IFCLRP approach has 37% of higher than MRIT approach.

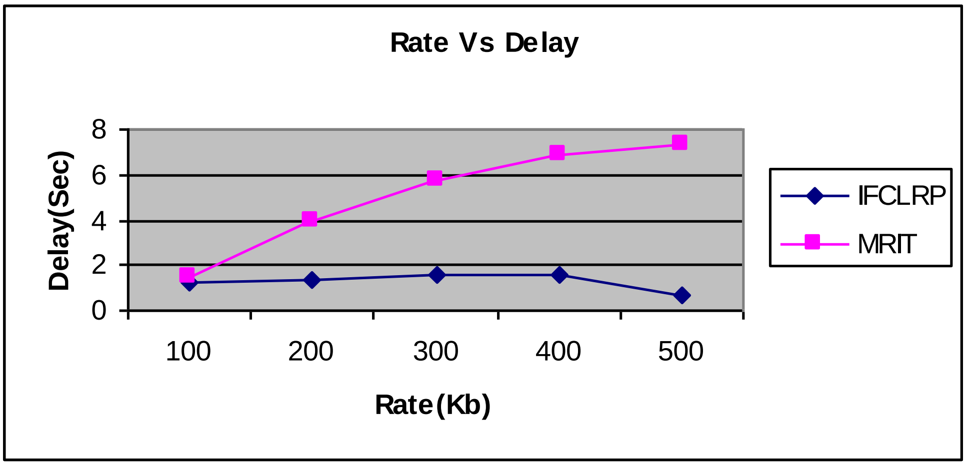

Fig 6: Rate Vs Delay

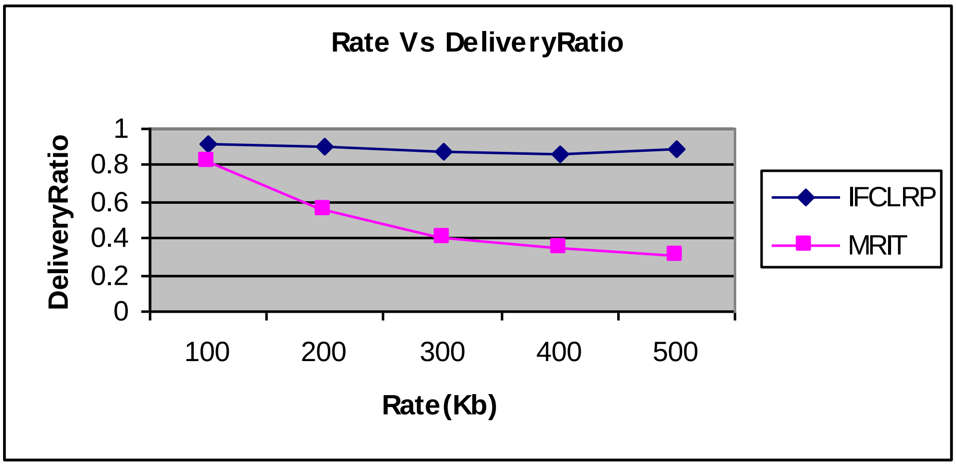

Fig 7: Rate Vs Delivery Ratio

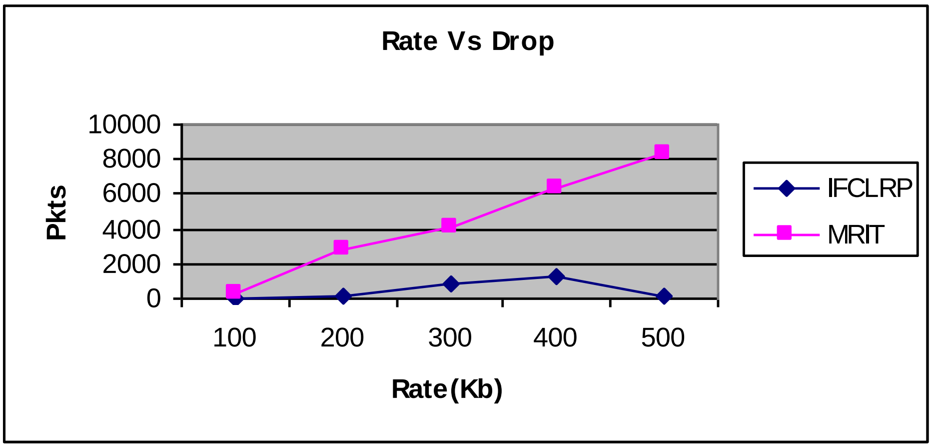

Fig 8: Rate Vs Drop

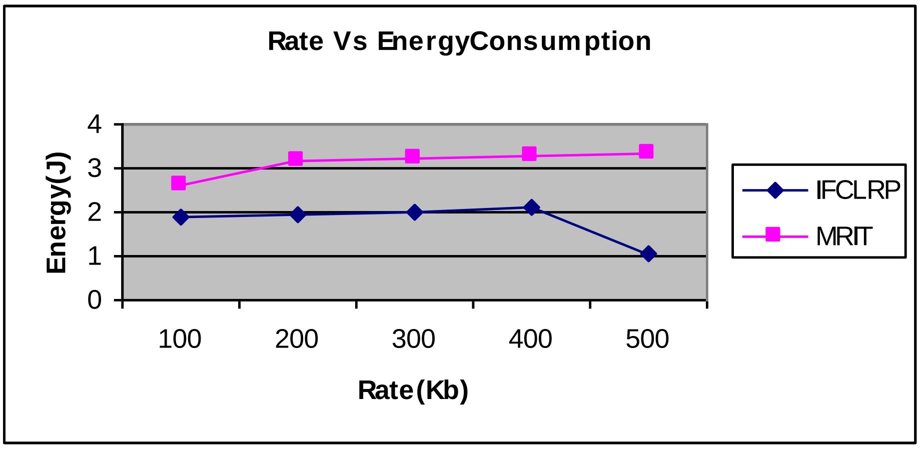

Fig 9: Rate Vs Energy Consumption

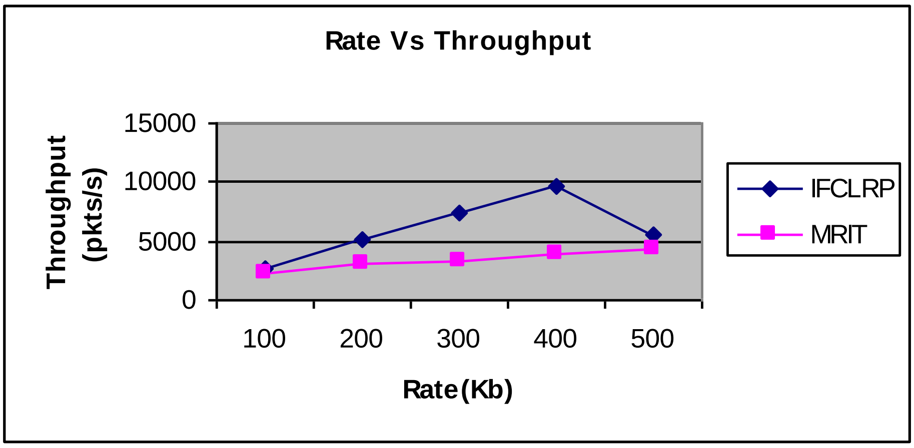

Fig 10: Rate Vs Throughput

5. Conclusion

In this paper, we propose to develop an interference free cross-layer based routing protocol in MANET. In this technique, a cross-layer based routing is performed based on the signal to interference plus noise ratio (SINR) constraint in the MAC layer and throughput constraint in the application layer. The SINR constraint helps the receiving nodes to adjust the transmission power before forwarding it to the other nodes. In order to minimize the interference, a minimum interference method is used. This technique selects the links that have long connectivity duration, and then builds the least interfered route which is based on a new routing metric. This routing metric consists of interference along with the link connectivity duration. By simulation results, we show that the proposed technique minimizes the overhead.

References

[1] Khoriba Ghada, Jie Li1and Yusheng Ji, "Cross-layer design for topology control and routing in MANETs", Wireless Communications and Mobile Computing 2012.

[2] T.Manimekalai, Dr.M.Meenakshi and P.Saravanaselvi, "RA-SPAN Protocol for Improving QoS Performance in Wireless Ad Hoc Networks", Internet AH-ICI 2009, First Asian Himalayas International Conference on IEEE 2009.

[3] R.Venkatachalam and Dr.A.Krishnan, "Multiple Cross-Layer Design Based Complete Architecture for Mobile Adhoc Networks", International Journal of Computer Science and Information Security, Vol. 5, No. 1, 2009.

[4] V. Thilagavathe and Dr. K. Duraiswamy, "Cross Layer based Congestion Control Technique for Reliable and Energy Aware Routing in MANET", International Journal of Computer Applications 2011.

[5] Chao Gu and Qi Zhu, "A Cross-Layer Routing Protocol for Mobile Ad Hoc Networks Based On Minimum Interference Duration", Applied Mechanics and Materials 2013.

[6] M.A. Razzaque, Simon Dobson and Paddy Nixon, "Cross-Layer Self Routing: a self-managed routing approach for MANETs", Networking and Communications WIMOB'08, IEEE International Conference on Wireless and Mobile Computing, IEEE 2008.

[7] Zhixiang CHEN and Qi ZHU, "Interference Aware On-demand Routing Protocol Based on Cross-layer Design for Ad Hoc Network", Journal of Computational Information Systems 2012.

[8] Fuad Alnajjar and Yahao Chen, "SNR/RP Aware Routing Algorithm: Cross-Layer Design for Manets", International Journal of Wireless & Mobile Networks (IJWMN), Vol 1, No 2, November 2009.

[9] V. Haghighatdoost and M. Espandar, "A General Approach for Minimizing the Maximum Interference of a Wireless Ad-Hoc Network in Plane", Int. J. of Computers, Communications & Control,Vol. VII (2012).

[10] Fredrick Awuor, Karim Djouani, Guillaume Noelz and Thomas Olwal, "Coupled Interference Based Rate Adaptation in Ad Hoc Networks", AFRICON IEEE, 2011.

[11] Nouha Jaoua, Emmanuel Duflos, Philippe Vanheeghe, Laurent Clavier and Francois Septier, "Impulsive Interference Mitigation In Ad Hoc Networks Based On Alpha-Stable Modeling And Particle Filtering", International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2011.

[12] Salam Akoum , Marios Kountouris , M´erouane Debbahz and Robert W. Heath, "Spatial Interference Mitigation for Multiple Input Multiple Output Ad Hoc Networks: MISO Gains", Signals, Systems and Computers (ASILOMAR), 2011 Conference Record of the Forty Fifth Asilomar Conference on IEEE, 2011.

[13] Guinian Feng, Soung Chang Liew and Pingyi Fan, "Minimizing Interferences in Wireless Ad Hoc Networks through Topology Control", Communications, 2008. ICC'08 IEEE International Conference on IEEE, 2008.

[14] G.Mathiyalagan and Amitabh Wahi," Route Optimization Using Adaptive Shrink Mechanism for MANET", International Review on Computer and Software (IRECOS), 2013.

[15] Network Simulator: http:///www.isi.edu/nsnam/ns