Gateway Migration Algorithm between Mobile Node and Gateway Node

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Abstract
Problem Statement: Multiple gateway selection schemes have been proposed that selects gateway nodes based on Quality of Service (QoS) parameters such as path load capacity and delay. Approach: I propose a Gateway Migration Algorithm (GMA) to select the gateway with multiple QoS path parameters such as path availability period, available load capacity and latency. If the traffic source node is moved on another gateway transmission range, then it transfers the traffic on that path via another gateway. To improve the overall network performance, it is necessary to select a gateway with stable path, a path with the minimum residual load capacity of path and minimum latency. Results: The proposed work is implemented in NS2 and the performance metrics like throughput, packet delivery ratio; delay and bandwidth are measured and compared with existing protocol. Conclusion/Recommendations: This System shows that our gateway selection to improve the quality of service, network throughput and packet delivery ratio with low energy power consumption per node.

Keywords
MANET, QoS, gateway selection, GMA

I. Introduction

Mobile Ad hoc NETworks (MANETs) consist of a number of mobile nodes that are free to move and communicate one with each other wirelessly. These mobile nodes have routing capabilities that allow them to create multi-hop paths connecting nodes which cannot directly communicate. These networks are extremely flexible, self-configurable, and do not require the deployment of any infrastructure for their operation. When a node in a MANET wants to connect to the internet, it is important for mobile nodes to detect gateways available to provide access to the Internet. I assume that the nodes in the MANET are moving and should change their IGW every now and then. In such a scenario, it is important for the mobile nodes (MN) to discover available IGWs to be able to perform hand-over between them, if required. Two main approaches can be distinguished: reactive and proactive. These two types of behavior are the same as for ad- hoc routing protocol:
Reactive discovery: A mobile node broadcasts a message throughout the MANET soliciting a connection to the Internet. A GW receiving this message will reply to the mobile node offering its services and an IP prefix address.
Proactive discovery: All Internet gateways periodically broadcast their services and IP prefix address throughout the MANET. When the MN is connected to an GW and receives an advertisement from another GW, it may decide to connect to the new GW, if it provides a better service. In our simulations, the MN always connects to the GW that is the fewest numbers of hops away.

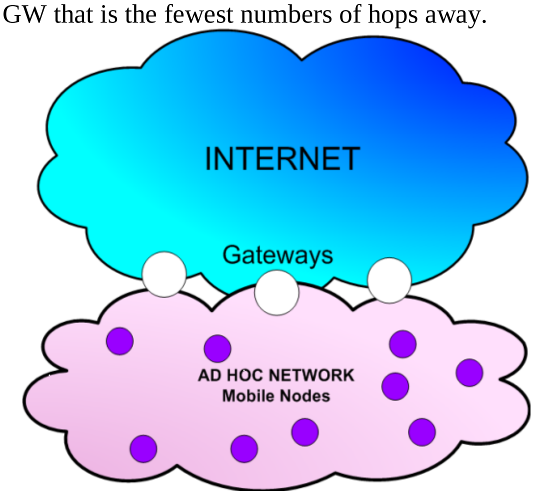

Fig 1: Gateway Selection on MANET

These gateway nodes provide a bridge between multiple networks and may be mobile or fixed, as shown in Fig. 1. An ad- hoc node must discover and select a suitable gateway node from a number of gateways before starting communication with the node in the infrastructure network. Hence, the gateway discovery and selection is an important factor to enable the integration between both networks. This research lies in the category of the gateway selection.
The objective is to design a new gateway migration algorithm that helps real-time flows in a wireless scenario to maintain their quality of service parameters. Some different approaches have been developed in literature, which propose different gateway discovery schemes. I have designed a new gateway migration algorithm that is able to select gateway under the condition of mobility

Manuscript received March 5, 2015
Manuscript revised March 20, 2015

prediction to improve and maintain their desired quality of service. This is the main contribution of this paper.
The paper is organized as follows. The Remainder of this paper is organized as follows: Related work about gateway selection methods and their performance is presented in Section II. Proposed system has been proposed in Section III. Section IV that describes the implementation & results. Finally conclusions and future work are given in section V.

II. related work

Gateway selection is a process that selects a potential gateway node out of multiple discovered gateway nodes based on network, link, and path or gateway node parameters. In the literature, several gateway selection methods [1]–[10] have been proposed that consider different QoS parameters to select a potential gateway node. Most of the gateway selection methods consider hop count, delay, mobility traces, link connectivity and residual load capacity of gateway nodes or a combination of these parameters.
The gateway selection schemes in [2], [3] select a prospective gateway based on hop count. A gateway discovery message is broadcasted by the gateway and based on that message each node calculates its distance to the gateway. The gateway with the shortest path in terms of hop count is selected for relaying traffic from MANET to the infrastructure network.
In [4], Congestion controlled adaptive multi-path routing protocol to achieve load balancing and avoid congestion in MANETs. The algorithm for finding multi-path routes computes fail-safe multiple paths, which provide all the intermediate nodes on the primary path with multiple routes to destination. The fail-safe multiple paths include the nodes with least load and more battery power and residual energy. When the average load of a node along the route increases beyond a threshold, it distributes the traffic over disjoint multi-path routes to reduce the traffic load on a congested link.
In [5], a weight based gateway selection algorithm is proposed. It calculates the weights of gateway nodes by considering residual battery power, speed of a gateway node and number of hops. The gateway with a higher weight is selected as a default gateway. This scheme slightly improves the network throughput; however, the end-to-end delay and packet drop ratio depends on the proper selection of the weighting factors, which is quite difficult in dynamic scenarios.
In [6], AOMDV to resolve the problem through dynamic route switching method. Based on the delay of the multiple paths, a source node selects its route dynamically and checks the quality of the alternative routes according to the change of the ad hoc network.

In [7], an adaptive QoS-aware Internet Gateway (IG) selection scheme is proposed that selects a gateway based on two parameters that are the maximum residual capacity of an IG and the minimum hop-count of a path between a mobile node and an IG. The residual capacity of an IG (δcurrent) is computed by subtracting the current traffic load of an IG from its total load capacity (C).

$$\delta current = C - \sum_{i=1}^{j} \lambda i K i \qquad (1)$$

where λ, K, and l are the average traffic arrival rate per second,the average packet size per second and number of nodes connected to IG, respectively. The second parameter that has been considered for gateway selection is the hop-count between a MANET node or source node (s) and an IG or destination node (d), denoted as H(s, d) and is computed as

$$H(s, d) = \begin{cases} \min\{H(p)\} : s \xrightarrow{p} d, & \text{if there is a path from } s \text{ to } d \\ 0, & otherwise \end{cases} \qquad (2)$$

An IG is selected based on the following criterion

$$IG = \alpha(\delta/ \delta max)+(\alpha\_ \delta)(Hmax/H) \qquad (3)$$

Where $\alpha (0 \leq \alpha \leq 1)$ is the weighting factor that is determined by the services and network status. The δ, δmax, H, and Hmax
are the residual IG capacity, hop-count, maximum residual capacity among all IGs, and the maximum hop-count among all paths to the IGs, respectively. A gateway node with the maximum *IG* is selected to forward traffic from a mobile node to the infrastructure network. n this IG selection criterion, the residual capacity parameter (δ/δmax) normalizes the residual capacity value between 0 and 1 for all path(s) to IG(s), however, the hop-count parameter (Hmax/H) fails to normalize the hop-count value and results in a value ≥ 1. In result, the hop-count parameter dominates the IG selection criterion.
In [8], Gateway discovery scheme suitable for real-time applications that adjust the frequency of gateway advertisements dynamically. This adjustment is related to the percentage of real-time sources that have quality of service problems because of excessive end-to-end delays. The optimal values for the configuration parameters (time interval and threshold) of the proposed adaptive gateway discovery mechanism for the selected network conditions have been studied with the aid of simulations. The scalability of the proposed scheme with respect to mobility as well as the impact of best-effort traffic load has been analyzed.
Another gateway selection scheme that considers Mobility-Tracing-Value (MTV) as a basic criterion to select a gateway is proposed in [9]. If a neighboring node does not receive a Hello message until its duration expires, then the MTV value increases. Hence, the larger value of

MTV denotes the higher probability of link failure. A gateway node on a path with the minimum MTV is selected. If two routes have the same MTV value, then the hop count is the second option to select a gateway.

III.PROPOSED SYSTEM

In this section I discuss the proposed gateway selection algorithm along with the gateway selection parameters and discovery process. The performance of the gateway selection algorithm depends on these gateway selection parameters, which directly affects the QoS that an infrastructure network provides to the MANET. Therefore, I consider multiple QoS path parameters in gateway selection algorithm that provide better QoS in MANET. These parameters compute the end-to-end (path between a MANET node and a gateway node) path availability period, available load capacity and latency of a path.

A. Gateway Selection Parameters

The detailed description of the gateway discovery parameters is as follows.

A.1 Path Availability Period

In MANET, nodes move at random speed and direction that result in a dynamic topology. Consider an example of a Random Walk mobility model where movement of each node is a sequence of random length intervals called epochs during which a node moves in a direction θ at the constant speed v. In this situation the link availability period between two nodes is varying at different time intervals. And the path availability period between two nodes that are not immediate neighbors of each other, is equal to the minimum link availability period between intermediate nodes in that path. The path availability period, Li, of a path i between a MANET node and a gateway node indicate the total time that a gateway is accessible by a MANET node through that path. Path availability period estimation is based on the link connectivity prediction method in [11], where Li represents the minimum link availability period and lu is the link availability period between two neighboring intermediate nodes in a path from a source MANET node (S) to the gateway node (G).

$$Li = \min\{lu\} \tag{4}$$

where u denotes the link between intermediate nodes in path i.

Link connectivity period, lu, of a link between node m and n is computed as follows. Let node m and n on path i are in the transmission range tr of each other and the current positions of nodes m and n are (xm, ym) and (xn, yn), respectively.

Suppose θm and θn are moving directions and vm and vn are speeds of node m and n, respectively. Then, lu of node m and n is computed as

$$lu = \left(-(\alpha\beta + \gamma\rho) + \sqrt{(\alpha^2 + \gamma^2)tr^2 - (\alpha\rho - \beta\gamma)^2}\right)/(\alpha^2 + \gamma^2) \tag{5}$$

where $\alpha = v_m cos\theta m - v_n cos\theta n$, $\beta = x_m - x_n$, $\gamma = v_m sin\theta m - v_n sin\theta n$, and $\rho = y_m - y_n$.

According to the link estimation time in (5),node m and n are estimated to be in the transmission range of each other till time t2, as movement of node n is shown by dashed line after time t1. However, epoch length of n(t1 − t0) is shorter than the epoch length of m (t2 − t0) and after time t1 node n randomly selects another direction and speed. In this situation, m and n are in the transmission range of each other till time period of (t1 − t0).

In proposed scheme, lu is estimated as follows. First, lu is computed as in (4). If lu is greater than epoch length of m(em),then lu = em, otherwise, if lu is greater than the epoch length of n (en), then lu = en. Conversely, if lu is less than em as well as en, then the link connectivity time is same as computed by (5).The overall path availability time period is computed in similar way by our proposed scheme as in (4).

A.2 Residual Load Capacity of a Path

In multi-hop MANET there can be multiple paths to the gateway node(s). Also, there is possibility that multiple paths may have some common node(s) in the paths between mobile nodes to the gateway nodes, as shown in Fig.2.

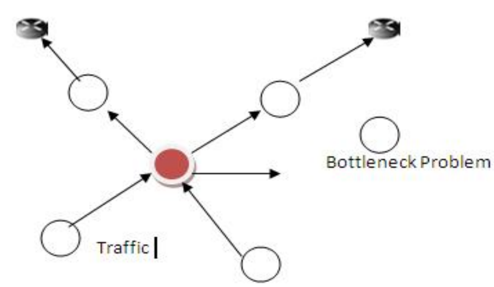

Fig.2: Bottleneck Problem

If traffic is forwarded through these nodes then the common node(s) in the end-to-end paths are overloaded and results in a bottleneck situation that will increase the delay and packet loss. Almost all previous proposals just compute the traffic load of a gateway node and based on that information they select gateways. On the contrary, in proposed scheme to select gateway nodes accessible through a path with maximum available load capacity. The residual load capacity of a path is the minimum available load capacity at any node, including intermediate nodes and the gateway node, in that path. Suppose the maximum load capacity of a node m is μ and the current traffic load handled by m is λm, then the residual load capacity, cm, at node m is computed as

$$cu = \mu - \lambda m, \text{ where } \lambda m = \sum_{j=1}^{s} r_j k_j \quad (6)$$

In (6), λm is the current traffic load on node m that is relaying traffic from s traffic sources, and rj and kj denote the average packet arrival rate and the average packet size of the traffic from source j, respectively. The overall residual load capacity Ci of path i is computed as

$$Ci = \min \{cj\}$$

where cj denotes the residual capacity of the intermediate nodes in the route including gateway node.

A.3 Path Latency

Latency is the propagation delay plus processing time of a packet from one node to another node. Latency can either be increased when the packet is relayed in a hop-by-hop fashion from sender to the receiver node or when the traffic load is high on any node in the path. Latency of path i, Yi, is the additive measurement of latency at each link on the path between the gateway and mobile node.
In last, the overall QoS value of a path i, δi, is computed as

$$\delta i = (Li/L\text{max}) + (Ci/C\text{max}) + (Y\text{min}/Yi) \quad (7)$$

where Lmax, Cmax, and Ymin are the maximum path availability period, maximum residual path load capacity, and minimum path latency from all the available paths between a MANET node and gateway node(s), respectively. After computing δi for every path to the gateway node(s), a gateway node is selected by the MANET node path with maximum δi is selected by the MANET node. A user can also set some preferences for individual parameter in δi to prioritize any of the parameters based on the network preferences.

B. Proposed Gateway Migration Algorithm

In this section, I discuss the Gateway Migration Algorithm along with the propagation mechanism of QoS parameters during the gateway discovery process. Analyze gateway selection scheme based on QoS in the gateway migration algorithm, where each node periodically advertises its parameters within a reactive region. The MANET node j in the reactive zone discovers the Gateway Node by sending the GW_DISC message. Node j sends GW_DISC with its own parameters, i.e., eu, vu, θu, xu, yu,time_stamp, cu, and other parameters, as shown in Algorithm 1. GW_DISC message is processed by each node at every hope and the minimum parameters of the path are forwarded until it is received by a gateway node or any node in the proactive region. If a node j in the proactive region receives GW_DISC message, it sends a unicast GW_ADV message to the sender of the GW_DISC message. Before sending a unicast advertisement message, the proactive region node finds the best available path to the gateway node from its routing table and it compares these path parameters (capacity and availability period) with the one in the GW_DISC message. The minimum of both the parameters along with the sum of path latency in the routing table and the latency of the GW_DISC message are added in the unicast advertisement message. On receiving the unicast advertisement message, the mobile node updates its routing table.

Algorithm 1 Gateway Migration Algorithm

Node *u* sends GW_DISC message:
GW_DISC (l_{GW_DISC} = *Null*, *eu*, *vu*, *θu*, *xu*, *yu*, time_stamp, TTL = 0, and c_{GW_DISC})
When node *j* receives GW_DISC message:
If (Node *j* is in *Reactive Zone*) **then**
Mobile node *j* computes *lj* as in (6);
if (l_{GW_DISC} = Null or $lj < l_{GW\_DISC}$) **then**
$l_{GW\_DISC} = lj$;
end if
Compute *cj* as in (7);
If ($c_j < c_{GW\_DISC}$) **then**
$c_{GW\_ADV} = c_j$;
End if
Replace *eu*, *vu*, and *θu* with *ej, vj, θj, xj* , and *yj* in GW_DISC message;
Update path parameters (*l*, *c*, *y*) in Node *j*'s Routing table;
TTL = TTL + 1;
Forward GW_DISC message;
End if
If (Node *j* is GW node or Node *j* is a node in *Proactive Zone*) **then**
Node *j* computes *δr*, as in (9), from its routing table;
where *r* = path(s) to GW node(s) ;
index = max(*δr*);
Generate GW_ADV message with updated *l*, *Y*, and *c* values:
$l = \min(l_{GW\_DISC}, l_{\textbf{index}})$,
$c = \min(c_{GW\_DISC}, c_{\textbf{index}})$, and
$Y = Y_{\textbf{index}} + \text{delay}_{GW\_DISC}$;
Send GW_ADV message to the GW_DISC originator;
End if

The MANET is a dynamic topology network where data traffic is generated and forwarded through dynamic routes. In result, the overall path capacity either increases or decreases at random. Therefore, it is necessary to propagate the current state of the path to the data traffic source node(s). The intermediate node on the active path sends the path update message to the data traffic source node(s) in a unicast manner when a new connection is established through this path or an old connection is terminated. In this manner, the data traffic source node(s) select a potential gateway by mobility prediction of node.

Algorithm 2 Gateway Selection

Node computes δr, as in (6), from its routing table;
where r = path(s) to GW node(s) ;
index = max(δr)
Select the **GW** with path **index;**

The QoS parameters of each path to the gateway node(s) along with the path entries are maintained by the MANET node in its routing table. If a MANET node wants to send data traffic to a host in the infrastructure network, it calculates the overall QoS value of each path (δi) in the routing table and selects the gateway that has a path with maximum δi, as shown in the Algorithm 2.

IV. Implementation & Results

I have run a simulation with the NS-2 tool to investigate the performance of proposed approach. A scenario where an ad-hoc network is connected via two gateways in a network has been selected. The chosen scenario consists of 20 mobile nodes, 2 gateways. The mobile nodes are uniformly distributed in a rectangular region of 1000 m by 500 m. The gateways are laced with x, y coordinates (150,250) and (850,250).Each mobile node selects a random destination within the area and moves toward it at a velocity uniformly distributed between 0 and 3 m/s. Energy consumption parameters are also defined where the transmission, receiving, idle, and sleep power are 0.316, 0.2, 0.05, and 0.001Watts, respectively. In the beginning of the simulation, all nodes are assigned with the equal amount of energy that is 1000 joules.
Data communication between MANET nodes and the infrastructure nodes is carried out in a Constant Bit Rate (CBR) manner. CBR packet size of 512 bytes and the CBR interval of 0.3, 0.15, to 0.009 s are considered in the simulations. The simulation results are the average of 3 randomly generated traffic models executed over each of the 5 randomly generated movement scenarios. The performance of the proposed gateway selection algorithm is compared with the gateway selection schemes proposed in [10] and [11], which are referred as conventional 1 and conventional 2, respectively, in this paper. Figs. 5–15 show the simulated performances of the proposed scheme and the conventional schemes.
I have run simulations with the aim of analyzing the impact of mobility and scalability of the proposed mechanism with respect to mobility. Fig. 3 shows the average end-to-end delay for VoIP traffic. This parameter is defined as the time it takes for data packets to arrive from the source to the destination node.
In both schemes the end-to-end delays for traffic are increased with higher mobility times, because when the mobility time is very high the routes of the existing flows break frequently and the routing protocol continuously does new route discovery processes that increase latency. On the contrary, when the mobility time is smaller, the average link duration is increased as well as the duration of the routes. The average end-to-end delay for sources is lower with our proposed scheme.

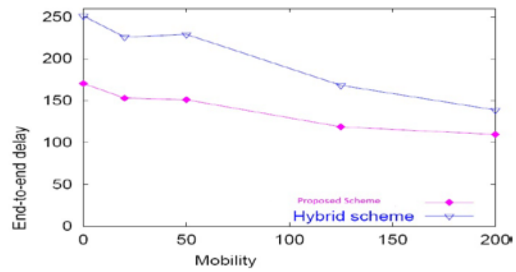

Fig.3: Mobility Vs End-to-end delay

Each gateway periodically checks if it has received QoS_LOST messages associated with sources having end-to-end delay problems. If the percentage of traffic sources having latency problems exceeds a predefined threshold (in this case this threshold is set to $\gamma = 0.15$), no GWADV messages are sent by the gateway. Therefore, no more traffic overload is introduced in the network and as a consequence the latency of the flows is diminished; hence with the proposed scheme the reduction of congestion is more effective in comparison with the hybrid scheme.

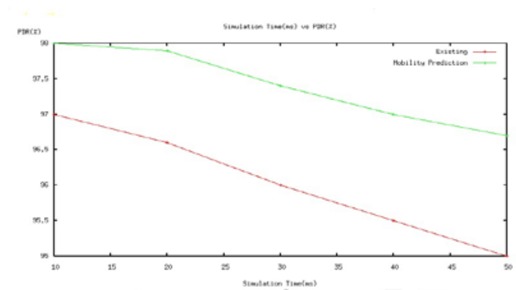

Fig.4: Simulation Time Vs Packet Delivery ratio

Moreover, the packet delivery ratio can be defined as the number of real-time packets successfully delivered over the number of real-time packets generated by the sources (Fig.4: simulation time Vs Packet delivery ratio) and this parameter is very significant to check the quality of service of real-time flows, too. This ratio is decreased when mobility is increased. However, in both mechanisms the values are always maintained over 98.5%, that is, the packet loss rate (See Fig.5) is always limited (lower than 1.5 %) and it is very acceptable for real-time traffic.

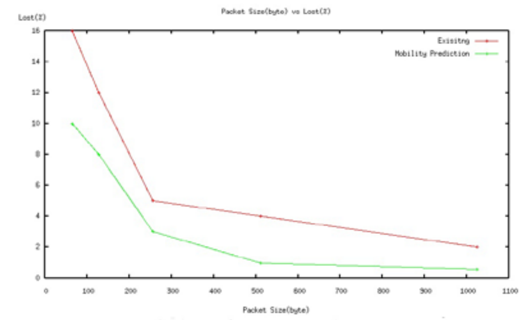

Fig.5: Packet size Vs lost

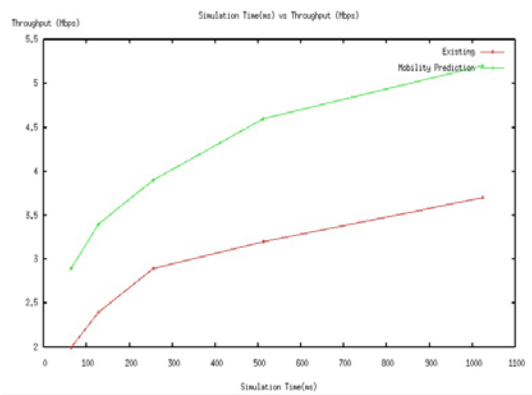

Fig.6: Simulation Time Vs Throughput

Average throughput versus simulation time is shown in Fig.6. It shows that the proposed scheme improves the throughput compared to the existing system. This improvement of the throughput by the proposed scheme is only because; it considers the normalized (values between 0 and 1) multiple QoS path parameters, i.e., path stability time period, maximum available load capacity and minimum path delay. It precisely computes the path stability by considering the epoch length of the individual nodes in the path, which reduces packet loss and improves the throughput.

The average energy consumption is shown in Fig.7. It is evident that existing system has more average energy consumption per node because it selects unstable paths and due to this instability. In result, our proposed scheme has less energy consumption per node, because the proposed scheme selects more stable and less congested path compared to conventional 2 that consequently improves the throughput and also reduces control energy consumption and control overhead.

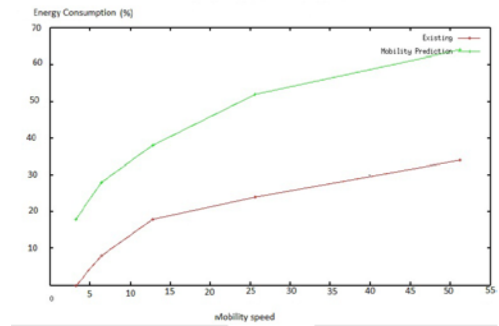

Fig.7: Mobility Vs Energy

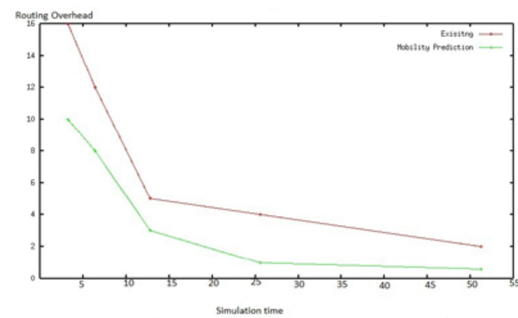

Fig.8: Simulation Time Vs Routing Overhead

Fig. 8 depicts the average control overhead in terms of total number of messages processed in the network during simulation time versus routing overhead. The proposed scheme produces less control overhead compared to existing system, because existing system selects the shortest and slightly less stable path. Conversely, the adaptive gateway selection scheme has slightly less control overhead because it selects the gateway based on multiple parameters and hop-count parameter dominates the gateway selection criteria. In result, existing system has high drop ratio and less throughput compared to the proposed scheme.

V. Conclusion

In this paper, I have described the design and implementation of the Gateway Migration Algorithm that select the gateway node based on mobility prediction and carried out a detailed ns2 based simulation. The simulation results show that the proposed scheme improves the Quality of Service (QoS), network throughput, success rate and increase the packet delivery ratio, end-to-end delay and reduce the energy consumption per node.

In our future work plan to study the performance of this gateway selection algorithm under other network scenarios by routing overhead, control overhead, mobility models and speed of mobile nodes etc.

References

[1] Mari Carmen Domingo,”An Adaptive Gateway Discovery Algorithm to support QoS when providing Internet Access to MANET”, Journal of Networks, vol. 2, No.2, 2007.

[2] B. Shen, B. Shi, B. Li, Z. Hu, and L. Zou, “Adaptive gateway discovery scheme for connecting mobile ad hoc networks to Internet,” in Proc. WiCOM, Sept. 2005, pp. 795–799.

[3] M. C. Domingo, “Integration of ad hoc networks with fixed networks using an adaptive gateway discovery protocol,” in Proc. IET International Conference on Intelligent Environments, July 2006, pp. 371–379.

[4] Soundararajan, S. and R.S. Bhuvaneswaran,”Adaptive Multi-Path Routing for Load Balancing in Mobile Ad Hoc Networks”, Journal of Computer Science, 2012.

[5] C. Shin, S. H. Kim, and S. An, “Stable gateway selection scheme based on MANET with Internet,” in Proc. IEEE ICCIT, Sept. 2006.

[6] Ducksoo shin,Jonghyup lee, Jaesung kim, and jooseok,” Aomdv : an adaptive ad hoc on-demand multipath distance vector routing protocol using dynamic route switching”,vol.4,No.2.2009.

[7] B. N. Park, W. Lee, C. Lee, and C. K. Shin, “QoS-aware adaptive Internet gateway selection in ad hoc wireless Internet access networks,” in Proc.IEEE BROADNETS, Oct. 2006.

[8] F. P. Setiawan, S. H. Bouk, and I. Sasase, “An optimum multiple metrics gateway selection mechanism in MANET and infrastructure networks integration,” IEICE Trans. Communication., vol. E92-B, No. 08, Aug. 2009.

[9] Dilli Ravilla,V.Sumalatha, Dr Chandra Shekar Reddy Putta,”hybrid routing protocols for ad hoc wireless networks”,Vol.2.No.4,2011.

[10] Safdar Hussain Bouk, Iwao Sasase, Syed Hassan Ahmed, and Nadeem Javaid, “Gateway Discovery Algorithm Based on Multiple QoS Path Parameters Between Mobile Node and Gateway Node”,Journal of Computer Networks,Vol.14,No.4,2012.