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Review of Gateway Selection Schemes for MANET to Internet Connectivity

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***Abstract*– Nowadays, MANETs becomes a most types of the networks used in many applications, which support a communications between several sources and destinations without using infrastructure mode. Since these networks are infrastructure free, so it required a mechanism to route the information from the sources to destinations and the routing protocols has been studied deeply. Other consideration that becomes a most important issue is how to connect the MANET to the Internet and the most important parameter is how to interface between these networks. Gateways are most important mechanism to interface between these networks and it must be stable to ensure good quality of services for MANET and Internet connectivity. The main challenges in MANET-Internet connectivity are gateway discovery and gateway selection. Many solutions are proposed and implemented by the different authors/researchers to discover the gateway to the internet so that gateway discovery as we know has been deeply investigated. The second challenge is how to select an optimal gateway and a few different mechanisms have been proposed to select gateways. In this paper we present a review of various gateway selection schemes which are used in MANET to Internet connectivity.**

***Index Terms*– MANET, Internet, Gateway Discovery, Gateway Selection, QoS, SAW and Generic Algorithm**

I. INTRODUCTION

MOBILE Ad-Hoc Network (MANET) is a recent developed part of wireless communication and becomes an important part of the future generation architecture [1]. One of the major issues that becomes most important is how to MANET interfaced with Internet. Since modern Networks support an accessing to Internet, and MANET becomes one the modern networks used in many applications today needs to accessing to the Internet.

Gateways play an important role in MANET- Internet connectivity and used as an interface between MANET and Internet and mobile nodes may access several Gateways as shown in Fig 1. Under these circumstances, the device should decide the gateway to employ when it is going to establish communications with external hosts [2].

Several parameters could be considered to take the decision of gateway selection as the number of hops in the route to the Gateway, the traffic load, the delay, the gateway's stability and so on. Due to these parameters and high dynamic nature of the mobile nodes in MANET, a mechanism of an optimal gateway selection scheme is required to reduce the amount of packets loss and end to end delay at each link between mobile nodes to the gateways, also to ensure the optimizing link and stable network against the high mobility to support efficient connectivity between MANET and Internet. Also multiple routing to gateways discovery protocol is required to achieve backup routes and gateways to the network to frequent handoff to other selected reserve gateway [3].

Many Protocols can be used to discover a route to the gateway and studied extensively in many researchers. Gateway discovery mechanism also has been studied in many researches and the studies were reviewed in many papers. A new issue is how to select a most stable and efficient gateway as an interface between MANET and internet. A lot of study has been done on selecting gateways for Internet-MANET architecture.

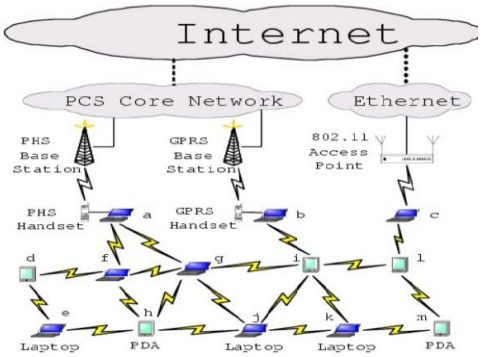

Fig. 1: MANET - Internet Architecture

II. MANET– INTERNET CONNECTIVITY

In NAMET nodes belonging to an ad-hoc network can only communicate among themselves, using multi-hop wireless transmission and each node has a unique address since there is no external connectivity. However, there are some solutions which extend this architecture providing Internet access for ad-hoc nodes. This means that more than one node or all the nodes has at least two network interfaces, one making it part of the ad-hoc network, and another connecting to the Internet [4]. This node becomes a gateway and provides Internet access for the wireless-only nodes. The gateway must capable to interface between MANET and Internet carrying the two networks stack layers features as shown in Fig. 2.

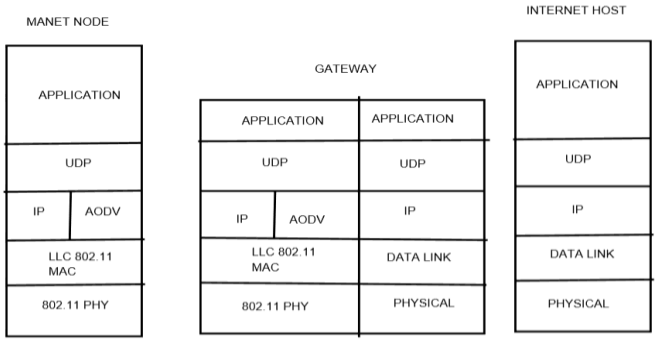

Fig. 2: MANET to Internet gateway protocol stack

There are two general approaches for providing Internet Connectivity they are; with and without tunneling. In both approaches, a mobile node needs to know the gateway address and have a route to it. Mobile nodes also need to know their network prefix and compare it with the destination address.

In tunneling approach, if the destination lies outside the mobile network, mobile nodes encapsulate the packets directed to the Internet and put the gateway address as a destination. When such a packet is received by the gateway, it de-capsulate its contents and forwards the packet to the desired destination. In non-tunneling approach if the destination lies outside the mobile network, mobile nodes send the packet with the 'real' destination address and direct the packet to the next hop for the gateway. Each of the nodes needs to keep a default route, as in standard Internet connectivity. The next hop for such route is the next hop to the gateway [5].

III. GATEWAY DISCOVERY SCHEMES

The Gateway discovery scheme is an important to discover a route to the gateway , since the structure of MANET is infrastructure free , so it requires a way to discover a route to the gateway to have accessing the Internet. The gateway schemes based on three types of discovery proactive, reactive and hybrid schemes [3].

In proactive scheme the gateway itself initiates the gateway discovery process by broadcasting gateway advertisement message (GWADV). The nodes inside the range of the gateway accept the advertisement and generate a new route entry or renew the existing route entry in their routing table for the gateway [6].

The reactive gateway scheme initiates the route discovery by a source mobile node. If a source mobile node wants to communicate with an internet node, it first performs the expanding ring search techniques to find the destination within the ad hoc network. When it obtains no corresponding route reply even after a network-wide search, the source mobile node broadcasts a RREQ-I message to the All-MANET-GW-Multicast address. This is the IP address for group of all gateways. Thus only the gateways receive and reply to this message. The intermediate mobile nodes receiving this message simply rebroadcast it after checking the RREQ ID field to avoid any kind of duplicate broadcast. After receiving the RREQ-1, the gateway unicast back RREP-1 message to the source node. The source then selects one of the hop counts and forwards the data packets to the selected gateways [7].

Hybrid gateway discovery is the combination of proactive and reactive approaches. In hybrid gateway approach the gateway periodically broadcasts the GWADV message. The TTL is set to Advertisement zone so that the advertisement message can be forwarded only up to this minimal number of hops through the ad hoc network. The mobile nodes within this receive this message and set according to the proactive approach. The node outside this region discovers the default routes to the gateways using the reactive scheme [8].

IV. GATEWAY SELECTION SCHEMES

In the MANET to the Internet connectivity, the communication with external host requires the use of a MANET node acting as the Gateway that is not controlled by the telecommunication operator and the gateway can freely move. Single gateway or multi-gateway is supported and must be selected carefully since the gateway is last end of MANET route to the internet. The method of selecting the node to operate as gateway as well as the treatment associated to its mobility is the main characteristics of this mechanism. In the following section we present a review of gateway selection schemes for MANET to Internet connectivity that was collected from several researches based on topics and mechanisms used during years from 2004 to present.

A. Hop Count Based Schemes

Changui shin, [11] studying and investigation on integration between MANET and Internet using an algorithm known as mobility tracing value (MTV) to calculate the mobility of the mobile nodes in ad-hoc mode to internet gateway for selecting best path to the gateway. The proposed scheme considering the specific character of node mobility makes possible to increase the throughput of the whole network and to construct

more stable route. The study depends on the mobility of the nodes in path based on hop count only.

Mari Carmen Domingo et al [14] proposed an adaptive gateway discovery and selection approach that has been mainly designed to reduce congestion problems in an ad hoc network and that helps real-time applications to maintain their QoS parameters even in the presence of high traffic. This approach defines a transmission range where the gateways periodically send advertisement messages and they are propagated around a limited zone (a certain number of hops away from the gateway). If a mobile node wants Internet connectivity and it is outside the gateways transmission range and the propagation zone of the gateways advertisements, it should broadcast a message to the group of gateways in the ad hoc network. The gateways should respond sending back a reply and the routing protocol of the mobile node selects the reply of the gateway which offers the best route towards internet in terms of number of hops accordingly to the normal functioning of the AODV routing protocol.

B. Gateway Load Balancing Based Scheme

Bok-Nyong Park et al [13] proposed an adaptive gateway discovery and selection approach for ubiquitous connectivity of ad hoc network with internet. This approach improves the load-balancing feature. After the routes are discovered to gateways, ad hoc mobile nodes should be able to select one Internet gateway providing the best internet connection. In the Internet gateway selection, this approach uses method to distribute data packets into different gateways while keeping low offered load.

C. Secured Gateway Based Scheme

Takeshi Matsuda [18] proposed a novel gateway selection protocol in hybrid Mobile Ad hoc Networks focusing on the situation that occurs when specialized, sensitive data is sent to the Internet from MANET nodes. These special data types are especially susceptible to security risks such as information leak and data falsification. Therefore, it is necessary for such special data to be forwarded by a secure (trusted) GW which is controlled by a trusted network administrator. The proposed scheme to intentionally deliver such special data described above to a fully-secure GW, this achieved by enabling the MANET routing protocol to allow selection of GW depending on the sensitivity of data from multiple GWs provide Internet connectivity, and only trusted GW scan be used to forward sensitive data to the Internet, this selection mechanism done by a modification in DYMO protocol to discover routes to appropriate GW depending on the type of application data. The proposed study ensures that advanced and important data are handled securely by a GW that is under the control of a trusted network administrator.

D. Path Quality Based Scheme

Palanik [24] ; the study investigate the quality of services on adaptive gateway discovery for MANET , the study focusing on how packet delivered ratio PDR becomes 100% taking calculation of contention and congestion metrics. The contention is calculated by packet dropped so sender retransmit RTS or data frame or both together and each retransmitted RTS or DF detect a contention. The congestion calculated by queue metric QM depends on queue length and queue size. The self-metric SM for each node measures its CM and QM together. This scheme is focusing on quality of the path by calculating the route congestion and contention of the path to the gateway.

C. Jelger et al [9] proposed a proactive gateway discovery and selection approach in which internet gateways periodically advertise their presence by flooding information (GW_INFO) messages. This proposal uses a restricted flooding scheme, to limit the overhead of the proactive gateway discovery. The prefix continuity ensures that every node shares the same prefix and each gateway only receives IPv6 data packets belonging to its prefix. A mobile node chooses one of the GW_INFO messages according to some metrics. Then the node configures an IPv6 address based on the advertised prefix and sends only the GW_INFO message including the selected prefix. However, if the approach is unified with a reactive routing protocol, then a node in the network must discover a route otherwise it causes a break of the connection because of the property of the reactive routing protocol. It uses a stateless auto-configuration mechanism, which is based on network prefixes advertised by gateways. The nodes concatenate interface identifier to one of those prefixes to generate the IP address. A mobile node selects the optimal route towards the gateway using one of the metrics such as distance, stability, or delay from all the gateway information messages received.

E. Path Load Based Scheme

Shailesh kumar [26] investigate on how to improve the network performance based on select a gateway with Stable path, minimum packet loss rate between two neighbor nodes, a path with the maximum residual load capacity and the minimum latency. The gateway selection scheme considers multiple quality of service path parameters such as path availability period, available capacity latency and link quality to select a potential gateway node to ensure improvement in throughput and packet delivery ratio with less per node energy consumption. The gateway selected depends on three parameters updated; they are path availability period, residual capacity of nodes and path latency .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 using the updated path parameters. The proposed gateway selection algorithm considers multiple end-to-end QoS attributes which improves the network throughput, success rate and reduces the packet drop ratio.

F. Multi-Metrics Based schemes

Ammari et al [10] proposed a mobile gateway based on three-layer approach using both Mobile IP protocol and DSDV Ad Hoc routing protocol. The first layer contains Mobile IP foreign agents; the second layer includes mobile gateways and mobile Internet nodes, which are one-hop away from Mobile IP foreign agents; the third layer has all MANET nodes and visiting mobile Internet nodes that are at least one-hop away from mobile gateways. The second layer is to provide Internet. Mobile gateways are powerful MANET nodes and are designed in a way to use both Mobile IP protocol when they communicate with the Internet. The DSDV protocol is used for routing within the MANET.

The MANET nodes in Ammari et al scheme are referred as mobile gateway and other MANET nodes select a closest and least loaded mobile gateway. The study based on distributes the functionality of haul network nodes MANET to Internet Integration with support a selectivity of gateway depends on closest gateway to the SMN and least loaded one.

Alicia Triviño [12] proposed that the gateway selection is depends on two factors; the first is Minimum Hop Count Criterion in which gateway is selected for connection if the number of hops between the MANET node and the gateway is minimum. The second factor is maximum gateway utilization criterion which a node utilizes the selected gateway until it becomes unreachable for the ad hoc node because of the network mobility. This fact is detected by the node when it stops receiving the corresponding MRA (Modified Router Advertisement) messages. The study focusing on minimum number of hops and the maximum gateway usage for gateway selection. The results show that utilization of shorter routes is recommended even if the number of gateway switching increases.

The study of Fudhiyanto Pranata Setiawan, [15] focusing on weighting the node mobility, energy required for nodes and number of hops to select the gateway using SAW calculation as one of MCDM technique is used to optimize the selection mechanism . The scheme can enhance performance of throughput, Packet Delivery Ratio (PDR), and gateway lifetime.

Wenbo Ma [16], investigate over interworking of MANET and Internet by selecting gateway using improved generic algorithm. This scheme select the gateway based on hop count, gateway load and path quality, uses a hybrid search approach which based on orthogonal generic algorithm and sensitivity analysis and the gateway elected through performance analysis. The generic algorithm ensures selecting best gateway quickly in multi gateway situation.

Khaleel Ur Rahman Khan [17], study an effective gateway discovery mechanism in integrated Internet-MANET, the algorithm depends on a proactive gateway discovery based on length of routing queues account addition to minimum hop count metric to select an efficient gateway by calculating the load along a path and updating the routing entry as a route request process from one mobile node to another, allows to update route without waiting for the gateway advisement for update routing entry. The algorithm depends on AODV routing protocol with path load calculations measuring the all load in mobile nodes in the path to the gateway. This study is investigated over minimum hop count to gateway, path load and timer to reduce the end delay. The mechanism reduces the congestion in the network and thereby improves the overall performance in terms of packet delivery ratio, end-end delay and the routing protocol overhead.

Iqbal [19] presents a novel solution for connecting nodes in ad hoc network to the Internet. Here the gateway replies with an advertisement message which is broadcasted to the whole network instead of sending a unicast reply to the requestor. The proposed scheme takes into account the traffic load along a path in addition with minimum hop count to select an efficient gateway and the AODV routing protocol has been used for routing in the MANET domain. The scheme ensures better performance having lower delay but fewer packets drop.

R. Manoharan, [20], investigating on integration of MANET with Internet, the scheme is based on load capacity of route and trusted route only .the residual route (load capacity) calculated based on packet size and packet arrival rate, each node calculate it's residual load capacity and compare its residual load with the residual load received from previous node and so on until arrive the gateway. The route trust calculated by assigned a value of residual load between 1 , -1, node m in route from node n gives trust value 0 represent normal node , trust value 1 represent trusted node and if trust value is -1 represent a malicious node. The route in this scheme establishing to the gateway depends on two metrics route capacity and trusted route only

Shahid Md [21] investigate over internet gateway discovery and selection scheme in MANET, the scheme depends on three factors to select the gateway; hop count, interface queue size and total number of neighbors of nodes along route from gateway to mobile node, and these three metrics used to calculate the gateway cost (GC), this calculation done when the gateway discovery message (GWDSC) triggered the gateway, the gateway then broadcast the gateway advisement (GWADV) depending on TTL. The hop count used to ensure shortest path, interface queue size of each node along the route used to ensure low congestion in the route. Gateway with lowest GC is selected, the number of neighbors calculated to help mobile node to select the gateway whose path is least dense to ensure low contention.

Yogesh Chaba et al [22] proposed a gateway selection protocol that is used for hybrid MANETs ensures multipath extension in case one of the path fails the data can be routed through another path .the scheme consists of two phases. One is the request phase and the other one is the reply phase. In request phase the source node broadcasts a route request (RREQ) packet to its neighbors until it reaches for the destined node. In the

Reply phase the route reply (RREP) is sent to the source by the destination. By this way the route to the gateway cutoff problem is solved. The study based on hops count (shortest distance between MANET node and gateway) also inter/intra traffic load and all energy at the IGW are used to select the gateway.

Safdar Hussain [23] proposed a gateway discovery and selection scheme in which movement of each node is considered as a sequence of random length intervals called epochs during which a node moves in a direction θ at a 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 scheme based on the minimum link availability period and the link availability period between two neighboring intermediate nodes in a path from a source MANET node to the gateway node. Almost all protocols just compute the traffic load of a gateway node and based on that information they select gateway. 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. The overall residual load capacity of path is computed and used beside the link availability periods to select the gateway.

Yonghang Van [25], this study investigate on gateway selection in MANET with internet connectivity based on the concept of quality of services GoS, depends on load traffic of gateway, path quality and hop count for gateway selection by using simple additive weight (SAW) to compute the above three metrics together. The study focusing on three metrics only, hop count, path quality and gateway traffic load, to ensure good connectivity b/w MANET and Internet.

The study of Amit Kumar [27] focusing on a secure hybrid gateway selection and authentication scheme to select a trusted secure gateway and authenticate it, which can be reached via trusted and uncongested route and trusted node. The scheme based on normalized metric computed from multiple security metrics they are; node trust, route trust, residual route load capacity and hop count to ensure tight security in the network. The mechanism select the gateway depends on trusted route to the gateway. A gateway node calculates its parameters Route Trust and Residual Route load capacity before soliciting a GWADV (RREP_I) message to the GWSOL sent by a MN. After that, gateway node updates these parameters in RREP_I message and broadcast in a proactive region of the MANET by using the Time to live value. The mobile node computes its own parameters of Route Trust and residual route load capacity when it receives a GWADV message. Now the intermediate MN compares its residual route load capacity value with that of the one arrived from its previous neighbor and assigns of the comparative values of the new Residual Route load capacity. SMN calculates the trust route selection value TRSV of all routes available to the gateway, gateway selected according to highest TRSV value.

V. PROPOSED SCHEMES COMPARISON

The comparison of different proposed schemes discussed above is illustrated in Table 1.

Table 1: Proposed GW Selection Schemes comparison

Proposed Scheme	Gateway Discovery Scheme	Ad-hoc Routing Protocol	Gateway Selection Scheme	Results
C. Jelger [9]	Proactive	IP based	Path Quality Based	Limiting Flooding
Ammari [10]	Reactive	DSDV	Hop count, Gateway Load Based	Efficient Gateway
Changui Shin [11]	Reactive	AODV	Hop Count Based	Stable route and increase throughput
Alicia [12]	Reactive	AODV	Hop count and Gateway Load Based	Utilization of shorter routes
Bok Nyong [13]	Adaptive	DSR and DSDV	Gateway Load Balancing	Efficient Gateway
Mari [14]	Adaptive	AODV	Hop count Based	Improve End Delay and PDR, Reduce Overhead
Setiawan [15]	Reactive	AODV	Hop Count and energy Based	Improve throughput and gateway lifetime
Wenbo Ma [16]	Hybrid	Generic Algorithm	Hop Count , Path Quality and Gateway Load Based	Better Performance in PDR and packets delay
Khaleel Khan [17]	Proactive	Extended AODV	Hop Count and Path Load Based	Reduce Congestion
Takeshi [18]	Reactive	DYMO	Secured gateway Based	Secured Data Handling
Iqbal [19]	Reactive	AODV	Hop Count and Path Load Based	Lower Delay, Few Packet Drop
R.Manoharan [20]	Hybrid	AODV	Secured path and Path Load Based	Controlled Overhead
Shahid [21]	Hybrid	AODV	Hop Count , path Load and Path quality Based	Less Load and Dense Route
Yogesh [22]	Reactive	Modified AODV	Hop Count , path Load and Energy Based	Improve PDR and delay
Safdar [23]	Hybrid	DSR and DSDV	Path Load and gateway Load Based	Improve Throughput and End Delay
Palani [24]	Adaptive	Cross Layer Algorithm	Path Quality Based	High PDR
Yonghang [25]	Reactive	AODV+	Hop Count , path Load and gateway Load Based	Improve PDR and End Delay
Shailesh kumar [26]	Hybrid	Extended AODV	Path Load Based	Improve Throughput and reduce packet drop
Amit Kumar[27]	Hybrid/ Adaptive	NA	Hop Count , path Load and secured quality Based	secure data transmission

IV. CONCLUSION

The aim of the gateway selection is to provide the connectivity of mobile nodes in MANET to the Internet. Various schemes have been proposed for this network structure. Each of them tries to improve the efficiency of the internet access through the gateway node with different mechanism of gateway selection. Proposed schemes work in gateway selection based on various parameters but one or two parameters taken together to select a gateway, now study based on the haul parameters together to select an optimal gateway to the Internet to improve the packet delivery ratio and minimize the drops of data that transmitted from between MANET and Internet. In near future various enhancements to this approach will be done and we are working to improve the efficiency of gateway selection process to select an optimal gateway from various gateways candidates to improve the network throughput , packet delivered ratio and ensure minimum packets drop with minimum delay and stable connectivity between MANET and Internet.

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