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Review Techniques and Fundamentals of Adaptive gateway discovery mechanism in an integrated internet MANETs (IIM)

Md. Misbahuddin
Research Scholar, Computer Science Department, BS Abdur-Rahman University, Chennai-600048, Tamilnadu, India.

Orcid ID: 0000-0002-9733-7077

Dr. Muneer Ahmed Rabbani
Professor, Computer Application Department, BS Abdur-Rahman University, Chennai-600048, Tamilnadu, India.

Dr. Syed Raziuddin
Professor & HOD, Computer Science Department, Deccan college of engg and technology, Hyderabad, Telangana, India.

Abstract

An interconnection of wired internet and mobile Adhoc network is called integrated internet MANET. This interconnection is achieved through gateways. Gateway may be a fixed gateway or mobile gateway. The gateway works as the router for all the nodes of the MANET through which all the incoming/outgoing packets are routed between the MANET and the internet. Discovery of the efficient internet gateway and mobile gateways is very challenging task. In this review paper we are discuss about integration of internet MANET, internet gateway discovery approaches and power consumption in an integrated internet MANET(IIM). In this review paper concludes with future work on power consumption in IIM using different algorithms.

Keywords: MANET, AODV, TTL,FA, Gateway Discovery, Internet, Routing Protocols, IIM.

INTRODUCTION

A mobile ad hoc network (MANET) facilitates people to communicate without the need for pre existing infrastructure. The Internet and mobile ad hoc network offer a complimentary set of communication features. We define the interconnection of the Internet with a mobile ad hoc network as an Integrated Internet-MANET. The Internet is based on a worldwide infrastructure, whereas the infrastructure less mobile ad hoc network offers the benefit of communication on the move. To let mobile devices within an ad hoc network to communicate with any other device connected to the Internet, anywhere in the world, the mobile ad hoc network is connected to the Internet. Several strategies exist which define various architectures for Integrated Internet-MANET . A general architecture of Integrated Internet-MANET is shown in figure 1. In this interconnection, various issues arise. One of the issue is power consumption in Integrated internet MANETs.

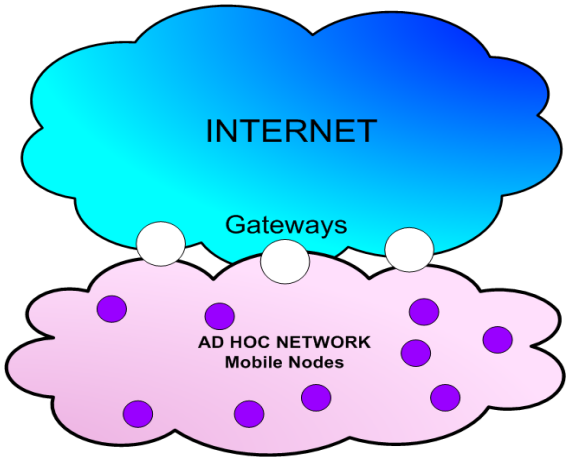

Figure 1: Architecture of Integrated Internet MANETs

Communication has become very important for exchanging information between people from, to anywhere at any time. MANET is group of mobile nodes that form a network independently of any centralized administration. Since those mobile devices are battery operated and extending the battery lifetime has become an important aim. Most of the researchers have recently started to consider power-aware development of efficient protocols for MANETs. As each mobile node in a MANETs performs the routing function for establishing communication among different mobile nodes the ``death'' of even a few of the nodes due to power exhaustion might cause disconnect of services in the entire MANETs.

Power consumption is a crucial design concern in mobile ad-hoc networks (MANETs), since the nodes are powered by batteries with limited battery power. The mobile hosts in MANETs are constrained by the battery power for their operation. Hence, the battery power of a node is a precious resource that must be used efficiently in order to avoid early.

Applications of MANETs.

- **Military Scenarios:** MANET supports tactical network for automated battle fields and military communications.
- **Rescue Operations:** It provides Disaster recovery, means replacement of fixed infrastructure network in case of environmental disaster.
- **Data Networks:** MANET provides support to the network for the exchange of data between mobile devices.
- **Device Networks:** Device Networks supports the wireless connections between various mobile devices so that they can communicate.
- **Free Internet Connection Sharing:** It also allows us to share the internet with other mobile devices.
- **Sensor Network:** It consists of devices that have capability of sensing, computation and wireless networking. Wireless sensor network combines the power of all three of them, like electricity, gas ,smoke detectors and water meters.

PRELIMINARIES

MANET-INTERNET INTEGRATION PROTOCOL STACK:

Comparison of the basic protocol stack for mobile ad hoc network with OSI model and TCP/IP suite, presents a better understanding of the differences in their protocol architecture. Figure 5 shows these protocol stacks [12].

OSI model provides a layered framework for communication between networked computers. TCP/IP suite was designed before the OSI model. The lower four layers are same as the OSI model. The top most layers, i.e. the application layer is a combination of the application, presentation and session layer of the OSI model. The MANET protocol stack is similar to the TCP/IP suite. Only the network layer differs for these two protocol stacks. In case of MANET protocol stack, this layer is divided into two parts – network and ad hoc routing.

Standard Internet routing protocols are used in the network part. MANET nodes use an ad hoc routing protocol for handling the routing within the ad hoc network. Mobile nodes run protocols that have been designed for the wireless channels and are capable of decentralized direct mode operation in the physical and data link layers.

Figure 3 shows the protocol architecture needed for interconnection between the MANET and the Internet. The Internet nodes use the TCP/IP suite and the MANET nodes use the MANET protocol stack discussed above. Whenever a mobile node wants to send a data packet to the Internet, it has to forward it to the gateway. The gateway then transmits the packet to the corresponding node in the Internet. Thus the gateway functions as a bridge between the MANET and the Internet. It has to translate between these two different protocols and must understand both. Therefore, it needs to implement both the MANET protocol stack and the TCP/IP suite.

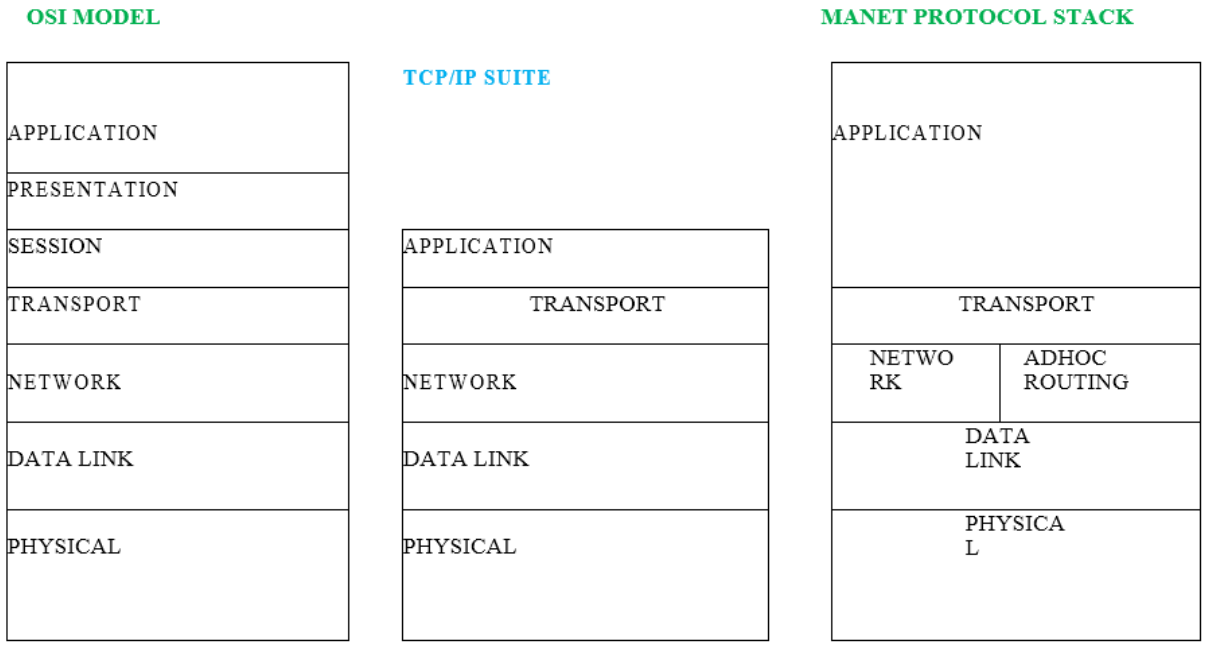

Figure 2: Basic Protocol Stack of Network Routing

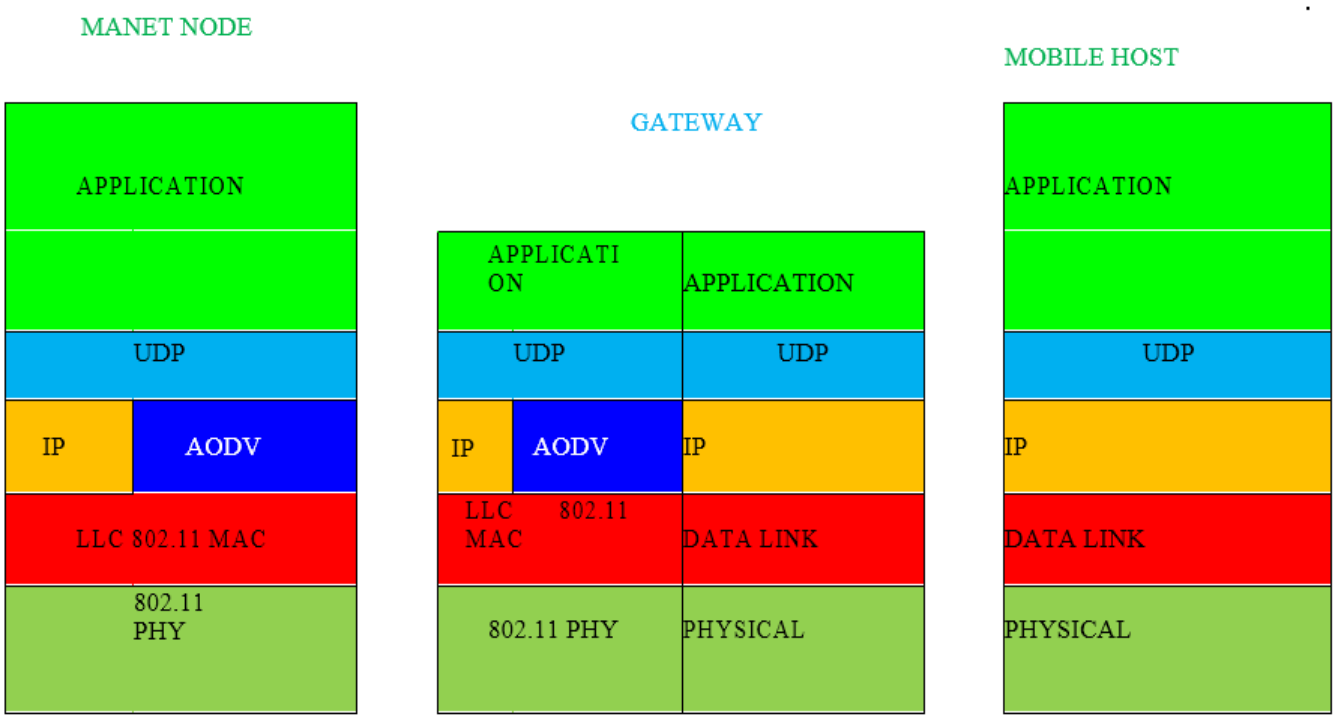

Figure 3: Gateway Protocol Stack: MANET-INTERNET Integration

INTERNET GATEWAY DISCOVERY APPROACHES:

A mobile node which wants to communicate with a wired node located in the wired Internet first needs to discover the presence and then connect with an Internet gateway. This interconnection can be facilitated in different ways, a few of which are present in the literature [S3] and are briefly discussed below.

A. Proactive Gateway Discovery:

In this approach, the gateway periodically broadcasts gateway advertisement messages (GW_ADV). The GW_ADV message contains relevant information like control information and the address of the gateway like the transmission range of the GW_ADV message. The transmission range is express in terms of number of hops and is called the Time to Live (TTL) value. The TTL value is decremented at each hop, and is finally discarded when it reaches zero. The TTL value defines the range of the proactive zone. A mobile node which wants Internet connectivity responds to the GW_ADV message and gets connected to the gateway. All the internet bound traffic emanating from this mobile node is routed though the gateway to which it is connected. Mobile nodes outside the proactive range do not receive the GW_ADV message as you see in th fig 4.

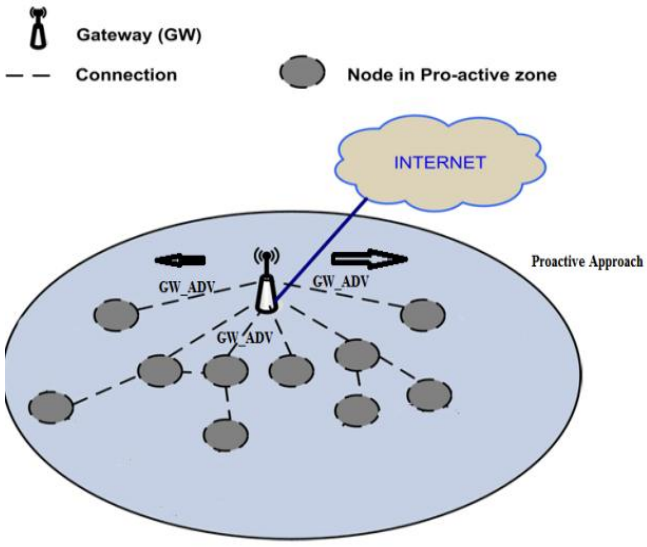

Figure 4: Proactive Gateway Discovery

B. Reactive Gateway Discovery:

The reactive gateway discovery mechanism is the opposite of the proactive approach. In this approach, the gateway does not send periodic gateway advertisement message. A mobile node initiates the gateway discovery process by broadcasting a gateway solicitation (GW_SOL) message. When a gateway receives a GW_SOL message, it responds with a GW_ADV message to the requesting mobile node as you see in fig 5.

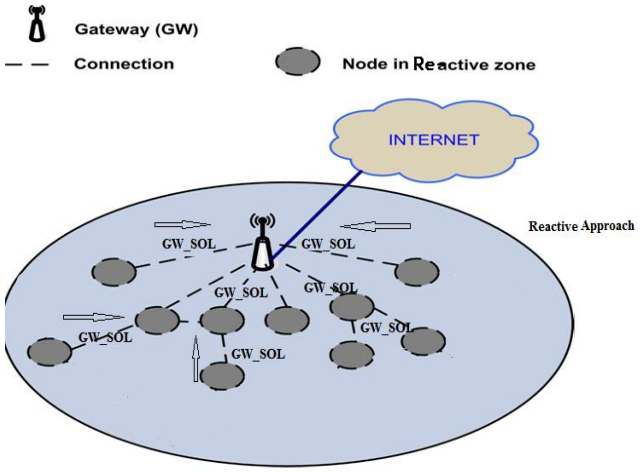

Figure 5: Reactive Gateway Discovery

C. Hybrid Gateway Discovery:

The proactive and reactive gateway discovery mechanisms can be combined into a hybrid gateway discovery mechanism. In this approach, the proactive gateway discovery is followed in a part of the MANET whereas; the reactive gateway discovery approach is followed in the rest of the MANET as you see in the fig 6.

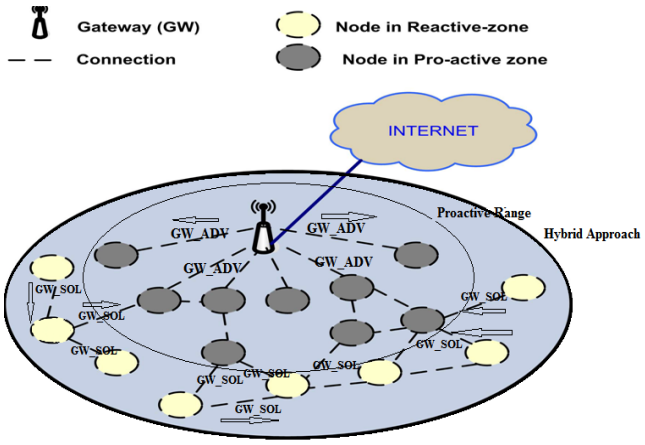

Figure 6: Hybrid Gateway Discovery

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REVIEW OF EXISTING INTERNET MANET SOLUTIONS

To access the internet application through MANET nodes, it needs the access point to provide bridge between MANET and internet called gateway. It requires mapping the flat addresses of the mobile node to the global topological address to communicate with the host located in the IP network. It is also paramount requirement of the mechanism to deal with the mobility of the visiting node, especially when node moves from one network to the other networks. Due to leaving and joining the networks the problem of duplicate addresses encounters most frequently for the reason of network partitioning and merging. For this reason efficient scheme is required to duplicate address detection, its resolution and care-of-address visiting node. Several solutions have been proposed to deal with the integration of MANETs to the Internet. Most of the proposed solutions require the addition of gateways and differ in the design and functionality of the gateways, number of occurrences, and the routing protocols used within the Ad Hoc network. Since Internet gateways have two interfaces they are part of the Internet and the Ad Hoc network simultaneously. They understand the Internet protocol (IP) as well as a MANET routing protocol (e.g. AODV). Mostly, the existing approaches consider only static gateways to connect MANET nodes to the wired Internet and very few have considered dynamic approaches. This paper briefly discusses solutions for both static Internet gateways and dynamic Internet gateways [19, 20].

Static gateway discovery solutions:

Royer E.M. [18], it is capable of packet routing using default routing of FA. However, this proposal does not consider the selection between multiple FAs. Also, it delays the connection setup time because this proposal first need to conclude that the destination is not within the ad hoc network before a mobile node can use the FA.Proposed Mobile IP which was supported by IPv4 ad hoc networks with AODV routing protocol. The proposed scheme has a proactive agent solicitation procedure with AODV route search to register to Mobile IP. It distinguishes the location of destination nodes using FRREP of FA, when a packet is sent to the Internet. In addition,

Ratanchandani *et al*. [21], describe a hybrid solution within the context of Mobile IP. Foreign agents (FA) proactively send advertisements to their closest nodes, while farthest ones operate on demand. To control the scope of the advertised messages the Time to Live (TTL) field of the IP header is set to a fixed value. The problem is that there is not a best TTL for a range of scenarios and network conditions.

Shin [22], proposed NAT-based MANET-INTERNET integration access. Periodic gateway discovery mechanism is used based on periodic HELLO message. HELLO scheme is extended as e-HELLO to contain the RGS (Reachable Gateway Sets) information over the ad hoc networks to inform its neighbor node when HELLO message is broadcasted and updates route entries for the gateways. NAT-based table for source node and proxy RREP (P-RREP) scheme is used to maintain the connectivity with the gateway. Mobile node can change its current gateway only when current session is over when node moves away the range of the default gateway.

Ruiz. P.M [23], the authors propose an adaptive gateway discovery mechanism based on the hybrid discovery approach that modifies the scope of the GWADV (Gateway Advertisement) messages sent by the gateways to obtain the maximal benefit in terms of overhead savings by avoiding sources to flood the network asking for gateways. The same authors propose in [24] an adaptive gateway discovery mechanism based on the hybrid discovery approach that modifies the scope of the GWADV messages sent by the gateways to reach the maximal number of active sources. A comparison between these gateway discovery schemes with already existing ones is done in [25], where both adaptive approaches have been evaluated with similar results and it has been demonstrated that they outperform existing schemes.

Khaleel [26], described extension of approach for gateway selection scheme. The path is updated to the gateway on the request of mobile node which facilitates handoff from one gateway to another gateway. This scheme also maintains continuous connectivity to the fixed host. Another extension is that routing queue length and minimum hop count metric not only used to discover the routes to the gateway but also for routing in the local ad hoc domain among ad hoc host. The occupancy level of each of node is updated after a short interval of time. This reduces the delay and increase packet delivery ratio.

Bin et al. [27], proposed an adaptive gateway discovery scheme that can dynamically adjust the TTL value of Agent Advertisements (GWADV messages) according to the mobile nodes MANET Internet traffic and their related position from Internet Gateways with which they registered. This protocol provides Internet access to MANET mobile nodes using mobile IP.

Hamidian [28], the authors extended the AODV routing protocol to the Internet to achieve the interconnection between the MANET and the Internet. The paper discusses and evaluates three approaches for gateway discovery. The authors implement these three schemes in network simulator 2 (ns-2) and compare them by means of simulation study. They also discuss the advantages and disadvantages of the three approaches. The gateway discovery method follows a similar approach based on. However, those approaches have a fixed TTL for proactive gateway advertisements and do not reflect dynamic network conditions.

R. Wakikawa [29], the authors proposed an approach to global Internet connection over the IPv6 MANET environment, where mobile nodes in the ad hoc network are configured with new globally routable IP addresses based on the neighbor discovery protocol (NDP) of IPv6 or route searching procedure of on-demand routing protocol. This paper defines two different mechanisms to discover Internet gateways: periodic flooding of gateway advertisement (GWADV) messages from the gateways and reactive flooding a gateway solicitation (GWSOL) message from nodes. The periodic flooding using GWADV is completely proactive, whereas the reactive flooding using GWSOL is completely reactive. GWADV and GWSOL messages can be implemented by simply adding an "I" flag to existing route request (RREQ) and route reply (RREP) messages. However, this proposal does not give any metric to select a gateway.

The optimization of the timing of MRA messages was studied in R.Kumar [30]. In this study, the authors suggest that the appropriateness of broadcasting a MRA message depends on the number of active sources that communicate to external hosts as well as the number of intermediate nodes that forward the packets to the internet gateway. With these two parameters, the so-called Regulated Mobility Degree (RMD) is defined. When this factor overpasses a pre-established threshold, the MRA message is sent.

Trujillo [31, 32], proposed process optimized adaptive gateway discovery approach to provide internet connectivity in multi-hop ad hoc networks. Modified router advertisement (MRA) message scheme is used to discover the gateway. Claims that mechanism can be implemented using either scheme, reactive, proactive or hybrid. Time interval T is defined for MRA advertisement as beacon interval. Control system function is defined to adjust that is proportional to MRA massages received from the gateway neighbors and also real mobile node close to the gateway. It is also defined that the probability p that a node is near a gateway, regardless of the model chosen for mobility can be given by binomial distribution.

Carman [33], proposed hybrid gateway discovery scheme with modified AODV routing protocol for routing in ad hoc domain. Scheme differentiates between the best-effort and real- time services. QoS are also discussed for real time services. Threshold is discussed for end-to-end delay to improve the QoS for real time services. QoS model named DS-SWAN is proposed to improve the real time flows. QoS _LOST parameter is defined to assume packet lost is end-to-

end delay cross the threshold. Ratio between the number of real time sources having latency problem and total number of real time sources using gateways and a threshold parameter is also discussed. Destination keeps track of the lost messages and inform to real time source traffic. Also suggest that to reduce the end-to-end delay of the lost message the message will be forwarded as broadcast packet.

Ruiz *et al*. describe in [34], an adaptive algorithm which selects the TTL of the gateway advertisements according to the number of hops between the traffic sources and the gateways. This approach tries to limit the huge overhead which is provoked by the reactive scheme when there are many traffic sources in the network. At the same time, the overhead of the proactive algorithm when the number of gateways increases is also reduced. The same paper performed an analytical study where it is shown how the reactive gateway discovery has a big impact on the overall performance when there are many traffic sources.

R. Kumar [3], discussed about minimum hop metric. A Mobile node uses minimum hops to communicate to a fixed host using gateway. Sometimes, a minimum hop path is not sufficient if there are some waiting packets in the queue. The Authors analyzed existing load aware routing protocols in MANET and devise a proactive load aware routing scheme. This scheme uses the interface queue occupancy and min hop metrics. The Handoff from one gateway to other gateway is also discussed. When a mobile node receives gateway advertisements based on interface queue interface queue and minimum hop, the node updates its default route to the gateway.

Geetha [35], described the Protocols used in Mobile Ad hoc Network. The gateway is used to communicate MANET nodes with Internet. The Authors surveyed the AODV and DSDV protocols. The Protocols are analyzed and Performance of AODV is better as compared to DSDV Protocol.

Zhuang [36], proposed adaptive algorithm for MANET-INTERNET integration. Scheme uses the usual approach to route discovery and gateway discovery with new approach to remove the unidirectional links to avoid unnecessary control overheads. Each node in MANET maintain a neighbor node list (NNL) by sending HELLO messages to record its set of neighbors, with information about the node like neighbor IP address and its life time. RREQ (RREQ-I) is broadcasted along with this information. Nodes receiving the RREQ check for its presence in received RREQ, it it is there then between this node and broadcasting node link is bi-directional otherwise RREQ is discarded and it is not broadcasted further. Same scheme is adopted for gateway advertisement with additional information attached with GWADV message. Scheme adjusts broadcast range, GWADV interval and TTL value.

Majumdar [6], analyzed that users require huge amount of resources and services from the internet and for increasing the coverage area of MANET. So there is a need for integration ad hoc networks to the internet. The gateways are used which acts as bridges between these two protocol architectures. The gateway discovery scheme in hybrid network is a complicated task. The complexity increases due to greater number of sources. So AODV reactive routing protocol is extended to provide communication between MANET and Internet. The number of received packets increases with more number of sources, so traffic increases. The number of sources and number of gateway discoveries results the increase in traffic. These further results in higher routing load. The hybrid approach is a combination of proactive and reactive approaches, the routing load lies between these protocols.

Shahid [37], proposed the hybrid scheme for gateway discovery and selection based on on-demand gateway advertisement. Interface queue length and the total number of neighbors along a route are also considered in addition to the hop count to bypass the loaded and dense route to the gateway in order to reduce the delay and packet loss. It is proposed in discovery scheme that the mobile node want to internet access should first search its routing table for the available gateway and if available then set default route to the gateway, otherwise start solicitation process by broadcasting the GWDSC message with initial TTL value. Gateway advertisement process is initiated only when the gateway is triggered by the GWDSC message to reduce the routing overhead. The proposal states that the intermediate nodes to update two additional field interface queue length and total number of neighbors of the nodes along a route from a gateway while forwarding the message to the next nodes.

Erik [16], has designed the robust and flexible MANET-INTERNET integration approach using AODV routing protocol. Indirection approach is integrated using tunnels with the AODV routing protocol. Default route forwarding is also integrated to compare the two approaches. Similar gateway discovery and route setup mechanism is used for both default route and tunneling. Proxy RREP solution is used. The scheme use RREQ to determine the route in the MANET as normal process. A gateway replies by RREP to determine locality of destination. The address locality check at gateway is implemented through a prefix check or using a visitor list. Flag G is used to mark gateways to indicate backup tunnels for faster hand off and I flag to distinguish internet host entry from normal MANET route entry. Internet routing protocol. The mobile router sets up tunnels to every mobile node for which it is serving as gateway, and another tunnel to the HA using second interface.

Khan et al. [40], proposed a new approach for integrating MANET with the Internet by devising a protocol named Efficient DSDV (Eff-DSDV). The proposed framework uses one of the Ad Hoc mobile nodes as a Mobile Internet Gateway (MIG), which acts as a bridge between the connectivity

scheme has been implemented into the AODV-UU implementation. These code runes in both the ns-2 simulator and Linux with IPv4.

Dynamic gateway discovery solutions:

In [38], Ammari et al. 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 connectivity to MANET nodes and, thus to help establish interaction between MANET nodes and the 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 integration framework considers using some border MANET nodes to connect the rest of MANET nodes to the Internet. These MANET nodes are referred as mobile gateways. A mobile gateway selects a closest and/or a least loaded foreign agent based on the distance and the load criteria. MANET nodes select a closest and/or least loaded mobile gateway.

Kock [39], integration between cellular system (GPRS) and ad hoc networks is presented using Mobile IP. The basic idea in the integration is using mobile routers as a gateway between the HA and ad hoc mobile nodes. It is assumed that gateways (mobile routers) in the ad hoc network are multi-interfaced. One interface is connected to the cellular system and the other connected to the ad hoc network using the ad hoc two networks. The MIG runs the Eff-DSDV protocol and takes care of the addressing mechanisms to ensure the transfer of packets between MANET and Internet. This strategy does not require the flooding of the gateway advertisements for registration of mobile nodes with MIG. Ad Hoc routing protocol EFFDSDV and Mobile IP coordinate with each other to provide the connectivity. Eff-DSDV follows the conventional DSDV; however it reduces the packet loss due to broken links.

COMPARATIVE SUMMARY OF THE CURRENT PROPOSALS

Table 1: Comparative Summary of the Current Proposals

Scheme/ Author(s)	Ad-hoc Domain Routing Protocol	Gateway Discovery Scheme	Mobile IP Used	Multiple Gateway Support	Significant Features of the Scheme
R. Kumar [3]	AODV	Proactive	YES	YES	Load aware gateway selection
Erik [16]	generic	Reactive with proxy RREP	YES	YES	Flexibility to work with any MANET routing protocol
Royer E.M. [18]	AODV	Proactive	NO	NO	Distinguishes the destination node location using FRREP of FA
Ratanchandani *et al*. [21]	AODV	Hybrid	YES	YES	Fixed TTL value to control advertised messages
Shin et al. [22]	AODV	Proactive	NO	YES	Proxy- RREP maintains connectivity to Gateways.
Ruiz. P.M [23]	AODV	Hybrid	NO	NO	Reduces control overheads
Khaleel [26]	AODV	Proactive	YES	YES	Reduce delay and increase PDF

Bin et al. [27]	AODV	Reactive	YES	YES	TTL adjustment according to network scenario
Hamidian [28]	AODV	Proactive, Reactive, Hybrid	NO	YES	AODV is extended and performance of three gateway discovery schemes is analyzed with ns-2
R. Wakikawa[29]	generic	Proactive, Reactive	IPv6	YES	Mobile node's global address is configured using neighbor discovery protocol (NDP)
R.Kumar [30]	AODV	Proactive	YES	YES	Periodic and adaptive advertisement are combined that improve PDF and reduces overhead messages
Trujillo [31, 32]	AODV	Proactive	YES	YES	Decrease control traffic without increasing packet lost rate and delay time
Carman [33]	Modified AODV	Hybrid	IPv6	YES	QoS support for real time services
Ruiz *et al*. [34]	AODV	Proactive	YES	YES	Reduces gateway message advertisement overheads
Zhuang [36]	AODV	Proactive	YES	YES	Reduces control overheads by removing unidirectional Links
Shahid [37]	AODV	Hybrid	YES	YES	Bypass loaded and dense route to gateway to reduce delay and packet loss
Ammari et al. 38]	DSDV	Reactive	YES	YES	Load and distance aware selection of the foreign agent
Kock [39]	DSDV	Reactive	YES	YES	Support mobile gateway and provide interface between GPRS & Ad-hoc Networks
Khan et al. [40]	Eff-DSDV	Proactive	YES	YES	Does not require flooding of gateway advertisement for registration of mobile node with mobile internet gateway

IMPLEMENTATION ISSUSES

Network Simulator (NS):

Network Simulator (NS) is an object-oriented, discrete event simulator for networking research. NS provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. The simulator is a result of an on-going effort of research and development. Even though there is a considerable confidence in NS, it is not a polished and finished product yet and bugs are being discovered and corrected continuously. NS is written in C++, with an OTcl[1] interpreter as a command and configuration interface. The C++ part, which is fast to run but slower to change, is used for detailed protocol implementation. The OTcl part, on the other hand, which runs much slower but can be changed very quickly, is used for simulation configuration. One of the advantages of this split-language programming approach is that it allows for fast generation of large scenarios. To simply use the simulator, it is sufficient to know OTcl. On the other hand, one disadvantage is that modifying and extending the simulator requires programming and debugging in both languages simultaneously.

Network Animator (NAM):

Network Animator (NAM) is an animation tool for viewing network simulation traces and real world packet traces . It supports topology layout, packet level animation and various data inspection tools.Before starting to use NAM, a trace file need to be created. This trace file is usually generated by NS. It contains topology information, e.g. nodes and links, as well as packet traces.

CONCLUSION AND FUTURE DIRECTIONS

This paper has presented a review of solutions for integration MANETs with Internet. Most of the solutions proposed are based on Mobile IP mobility protocols. Solutions are investigated systematically and their limitations have also been dealt with. Maximum solutions presented are based on the fixed gateways, only very few solution proposed are based on mobile gateways. We have also presented fundamentals of MANET-INTERNET integration for better understanding of the solutions like, different connectivity issues & challenges, care-of-address for the mobile nodes at micro and macro level mobility.

This paper conclude that although much exercise has been extended by the different authors in this area and the solution provided are network scenario based and no unique and standard solution is discovered so far. Hence a deep investigation is required to be exercised to provide network scenario independent, robust & flexible solution that can be operated independently of routing protocols and other network conditions.

Hence there is the future scope to work in the areas like, optimization of the control overheads occurred due to the nodes solicitations and gateways advertisements, selection of the optimal gateway from the multiple gateways available, multi-homing or load balancing means maintaining consistent forwarding states with the multiple gateways simultaneously, and also consumption in the communication of mobile nodes with gateways.

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