Providing internet access to mobile ad hoc networks

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Abstract: Mobile ad hoc networks (MANETs) are infrastructure-less dynamic networks allowing mobile nodes to communicate beyond transmission range by supporting multihop communication through IP routing. Typically routing protocols provide local connectivity within the reach of the ad hoc cloud. This paper describes a way to provide global internet access for MANETs. The main issues discussed are routing and addressing related to global address resolution, gateway discovery and communication through it.

1. Introduction

The Internet Protocol (IP) is constantly acquiring a dominant position in networking. All-IP based networks are being designed from the standardised bodies and will soon be widely available. An important area of IP research is wireless networking. The desire for mobile access to information available on the internet is stronger than ever, resulting in an increasing deployment of wireless local area networks (WLANs). In these, connectivity is provided at the edge of the network infrastructure by base stations.

However, it is also possible to utilise WLAN technology for the establishment of a mobile multihop architecture, the mobile ad hoc network (MANET). In a MANET, the participating mobile nodes (MNs) can move freely and communicate with each other directly or by using other intermediate MNs as communication relay points. For this purpose, no pre-installed infrastructure is required. Thus, costs, deployment duration and maximal transmission power can be reduced. Various research efforts have been concentrating mainly on the ad hoc networks stand alone. Several routing protocols have been proposed and can be roughly classified to proactive and reactive[1].

The network model of MANETs, while working well for local communications within the topological viscinity of the MANET cloud, fails to support any connectivity with the existing wired network infrastructure. However, for particular applications integration of the internet and MANET cloud is required. In order to realize such an interworking, an access point is required which has both wired and wireless interface. Recent approaches for such an internet gateway have been documented in [2], [3], [4]. Basically in order to be able to communicate with the internet, each MN within the MANET must configure globally routable IP address. The process to do that includes acquiring a temporary address once it enters the MANET, which allows only local communication, within the ad hoc cloud. Next it needs to discover and select one gateway to use its prefix and form a globally routable address.

This paper examines routing and addressing issues arising for such an interconnection in IPv6 networks. In particular a mechanism for providing a MANET node, with globally routable IPv6 addresses is described, through the use of a slightly modified version of the ad hoc on demand distance vector routing protocol (AODV [5]).

The remainder of the paper is organised as follows: In section 2 the AODV routing protocol is presented. Section 3 describes address autoconfiguration and gateway discovery problems. In section 4 routing and addressing mechanisms for global communication are discussed. Section 5 investigates utilisation of mobile IPv6 to further enhance mobility. Finally section 6 concludes the paper and suggests further work.

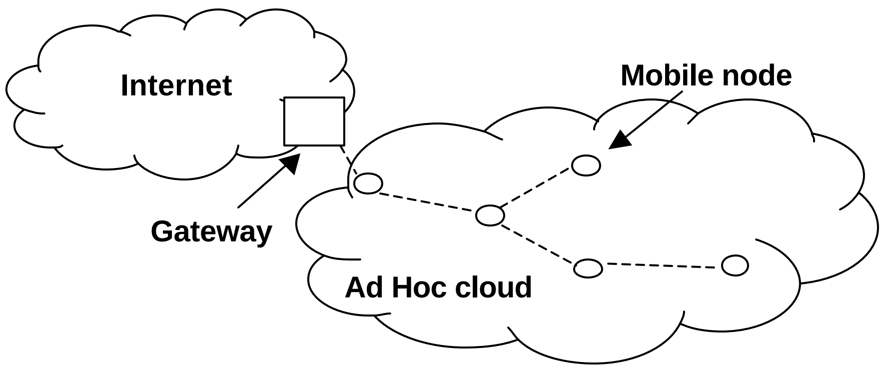

Fig. 1 - *Ad hoc cloud with internet connectivity*

2. AODV operation

Ad hoc on demand distance vector, as the name suggests is a routing protocol designed to build routes between nodes only when demanded by source nodes. Routes are maintained as long as they are needed by the sources. Sequence numbers are used in order to maintain the routes up to date. Routes are built using route request/reply messages. When a source node wishes to communicate with a destination for which it does not have a route, it broadcasts a route request (RREQ) packet across the network. A node receiving the packet updates the information about the source node and sets backward pointers to the source node in the route tables. A node will then unicast a route reply (RREP) if it is the destination or if it has a route to the destination with a greater or equal sequence number to that of the RREQ message. Otherwise the node rebroadcasts the RREQ packet. If it has already been processed it is then being discarded.

When a RREP propagates back to the source, nodes set up forward pointers to the destination. Once the source node receives the RREP which includes the sequence number of the destination and the hopcount to reach it, data packets can be sent to the destination using the forward route entries of the intermediate nodes. If a RREP is received later with a greater or equal sequence number and shorter hopcount, the better route can be used.

Timeouts are used in order to keep the routes active for certain periods of time. In the case a link breaks while a route is active, the node upstream of the breakage will propagate a route error (RERR) message to the source node to inform that the destination is unreachable. The source node can then reinitiate RREQ if desired. Additionally sequence numbers are used in order to maintain the freshness of routing information and loop avoidance.

3. Address autoconfiguration

In a MANET nodes should be able to enter and leave the network at will. Thus the nodes should be dynamically configured by the network upon their entry in to it. Stateful address autoconfiguration such as DHCP [6] could be considered. However, this requires the presence of a centralised DHCP server which maintains the configuration of all nodes in the network. Since a MANET is devoid of any fixed infrastructure or centralized administration, this approach would be inappropriate.

Alternatively stateless address autoconfiguration can be performed [7]. In this case the node initially forms a temporary address. This can be formed using a reserved non-link-local prefix (such as the MANET_INITIAL_PREFIX) in order to assure multihop communication. Further, duplicate address detection (DAD) has to be performed to guarantee that the selected address is unique. Using this temporary address the node can communicate with the other nodes in the ad hoc network.

Additionally it can be used to perform a gateway discovery. This is necessary in order to acquire a globally routable prefix and can be done in the following ways [8]:

- Actively, where the node broadcasts a modified route request AODV message, indicating the gateway (through a flag) to include its prefix in the (RREP) message
- Passively, where the node receives modified gateway advertisements according to the Neighbor Discovery Protocol (NDP) that include their prefix information.

It is possible that a node receives multiple replies or advertisements from different gateways. In this case it has to select one of them according to certain criteria such as hopcount, loading of gateway, capacity etc [9]. Once the node selects one of the gateways it uses its prefix to configure a globally routable IP address while at the same time the initial temporary address is deleted using route maintenance operations, such as RERR messaging.

4. Global communication

4.1 Mobile node to internet host

Considering a node wants to send a packet to an internet node, first it checks its routing table to see if a route to the destination is available. If a route exists the packet is sent to the desired destination. If not, AODV is utilized to perform a route discovery, as described in previous sections. Once a route to the destination is known, the node can send a packet using one of the following ways:

- One method is to use a routing header where the real destination address is inserted, while the gateway address is inserted in the destination address field of the IPv6 header. Hence the packets are tunneled to the gateway through the ad hoc network. Only the gateway node can examine what is in the routing header and route the packet to its final IP host destination.

- The second method is to send each packet to the global destination address relying in the next hop routing of the other nodes.

4.2 Internet host to mobile node

Considering an internet host wants to communicate with a MN, once the MN has acquired a globally routable IP address as described in previous section, the host can send packets through the available gateways which will forward them to the destination.

4.2 Mobile node to mobile node

Considering communication between nodes within the MANET, two methods can be used, similarly to the ones described in 4.1. In particular:

- Using a routing header where the mobile node destination address is inserted, while the gateway address is inserted in the destination address field of the IPv6 header. Hence the packets reach their destination through an internet gateway.

- The second method is to send each packet to the global destination address relying in the next hop routing of the other nodes. In this case if an intermediate node receives the packet and knows a route to the destination routes packets to it directly. However, the sender does not know whether the packets go directly or through a gateway.

Use of the routing header option is the preferable method, especially when considering that more than one gateways could be reachable. The mobile node can decide the best route by counting the dstance in hops or some other metric. In this case priority number could be assigned to each gateway. This could be realised by extending AODV RREP or the gateway advertisement messages to include a candidate gateway option in it [8].

5. Enhancing mobility

When a MN moves within the ad hoc cloud and selects a different gateway it has to configure a new IP address with the new prefix. With this configuration MNs attached to the same gateway could be considered as part of the same subnet. To make the mobility of MNs between different gateways transparent to higher layers, mobile IPv6 [10] can be utilised, (similarly to [3], [4]). This will be based on the assumption that each MN has a permanent IPv6 home address, which has the prefix of its home network and acts as a unique identifier for the MN. The location dependent address that is formed when the node registers with a new gateway can be used as a care of address (CoA). A binding message is used to register CoA with the home agent (HA). The HA stores the mapping between MN's home address and CoA in a binding cache. Traffic destinated to the MN's home address is received by the HA which tunnels it to the CoA according to the binding cache information. Now applying this operation, nodes belonging in the same ad hoc subnet could be assigned the same CoA. The gateway would then posses two IPv6 addresses having the same prefix: a home address identifying the gateway and a CoA assigned to each MN of the subnet. MN's home address could then be used for communication within the MANET whereas CoA would be used for communication with an internet host. Alternatively each MN could be assigned a different CoA, however this would result in more address wastage.

6. Conclusions

In this paper a way to provide global internet access for MANETS was described. The main issues discussed were routing and addressing related to global address resolution and gateway discovery. Different ways for communication through it, were considered. Routing header extension proves to be the more efficient method for route optimisation. Additionally utilisation of mobile IPv6 to provide transparency of node movement within the MANET was also investigated. Further work includes implementing the described protocol through a network model using the Network Simulator 2[11]. Possible metrics used will be packet delivery fraction, packet delivery latency and routing protocol overhead, for a wide range of scenarios.

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