Active gateway switching in hybrid ad hoc networks

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A possible solution to provide access to ad hoc terminals to the Internet through conventional WLAN networks is described in the mobile multi-gateway support. Reported is a simple scheme that has been developed to decrement the gateway switching times that are present under this IETF Internet Draft. By reducing these periods, the method clearly eases the integration of ad hoc communications into external networks.

Introduction: Ad hoc networks (MANETs) were initially conceived as standalone entities without connection to any external infrastructure. However, in most practical applications of ad hoc networking, a connection to the Internet is required. Most of the proposed mechanisms that integrate MANETs into the Internet utilise a dedicated entity acting as the Internet Gateway. This demand prevents the MANET from operating in scenarios prepared for one-hop Wireless LAN where a gateway is not pre-installed. One possible solution is described in the mobile multi-gateway support [1], which sequentially configures a terminal of the MANET to play the role of the gateway. However, this algorithm shows a main drawback as the transfer of the gateway functionalities between the nodes provokes the existence of periods during which no gateway is configured so that the MANET remains isolated and thus the network performance degrades. To reduce these intervals, a new technique has been developed. By means of simulations, the benefits of the modified mechanism have been demonstrated in terms of packet delay and protocol overhead.

![Diagram](image)

Fig. 1 Comparison of conventional and active gateway switching

a Operation without gateway switching
b Conventional gateway switching
c Active gateway switching

Mobile multi-gateway support: This mechanism is based on the temporal transfer of gateway functionalities to a mobile node residing in the coverage area of an Internet Access Router (AR). An AR can announce its presence by means of broadcasting one-hop RA (Router Advertisement) messages periodically. Among all the devices that receive these RA messages, only one is self-configured to play the role of the Internet Gateway. This element is called the Default Gateway (DG). The rest of the nodes that are potentially valid to operate as gateways are referred as the Candidate Gateways (CG).

The DG is responsible for propagating the prefix information that nodes require for global connectivity. This task is accomplished by the regular emission of MRA (Modified Router Advertisements) messages which are similar to the periodic RA packets generated by the AR but without the one-hop limitation [2]. CGs must be alert to the evolution of this process since, if they stop receiving these periodical MRAs, they will assume that the DG has escaped from the coverage area of the AR and, therefore, is unable to operate as a gateway any longer. Under these circumstances, a new DG is configured among the resting CGs.

The change in the gateway that is operating as the DG is called gateway switching. Fig. 1 illustrates the differences between the conventional gateway switching and the proposed active strategy. In both schemes, the DG notices that its role (and corresponding functionalities) has expired when no RA message is received after the corresponding period for the RA emission (RA interval). However, under the conventional method, the CGs will not initiate the distributed process for selecting the new DG until they detect that no MRA message has been collected during the MRA emission interval, which is defined (and updated) in a field of the last received MRA message. By following this ‘passive’ strategy, the DG does not interact with the rest of the nodes after assuming to be out from the coverage area of the AR.

On the other hand, the active switching takes advantage from the detection that the DG automatically performs when one expected RA message is not received. At that moment, not only the DG will cease its role as gateway but it will also inform the MANET about the expiration of its former state by the broadcasting of a ‘switching’ MRA. The idea is that this special MRA message sets the timer defining the MRA emission interval to zero, so that all nodes that receive it will presume that no DG is configured. Therefore, those CGs that acquire this information will not have to wait for the expiration of any timer. Thus, they will trigger the gateway self-configuration process earlier compared to the conventional strategy. This procedure could also be applied as soon as the DG predicts that it will not be operative shortly (e.g. because of lack of power or when it detects that it is going to be turned off).

Results: To analyse the active gateway switching, extensive simulations have been performed under the Network Simulator (NS-2) tool. Simulations considered a typical 1500 x 300 m² space, placing the access router in the centre of the area. The ad hoc network was formed by 50 simulated mobile nodes, the movements of which were based on the popular Modified Random WayPoint model with a minimum speed of 1 m/s. Owing to their popularity, AODV and 802.11 were chosen as the ad hoc routing protocol and MAC layer, respectively. Ten random sources were programmed to send uplink traffic at a rate of 4 packets/s with a packet size of 512 B. Basing on different practical recommendations, we set the RA and MRA intervals to 2 and 5 s, respectively. Similar results were obtained employing other parameters for network and protocol configurations.

![Graph](image)

Fig. 2 End-to-end delay against maximum speed

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Figs. 2 and 3 show the results of the simulations considering diverse mobility conditions of the nodes. The results of conventional global connectivity mechanism (where a fixed node is programmed to act as the unique network gateway) have also been included as the theoretical limit that the mobile multi-gateway support could reach under a completely seamless switching [2]. Fig. 2 illustrates the reduction of the gateway switching due to the application of the proposed technique. This effect is significant since, during this interval, mobile nodes are unable to communicate to exterior hosts and therefore they should keep packets in their internal queues. As a consequence, the decrement of the gateway switching time clearly improves the performance of the MANET, i.e. the end-to-end delay, the percentage of lost packets (not shown) as well as the normalised overhead (see Fig. 3). Overhead is reduced up to 20% since those nodes without a configured route to the Internet broadcast a special message of route solicitation to find the gateway. Since the proposed scheme reduces the periods where this action can take place, the overhead is also diminished, especially in the case of high mobility of the nodes.

**Conclusions:** Proposed is a simple scheme to decrement the gateway switching times that are present under the IETF multi-gateway support to interconnect MANETs and the Internet. The proposal permits a drastic increase in the ad hoc network performance both in terms of packet delay (and losses) and protocol overhead without augmenting the complexity of the IETF recommendation.

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**References**
