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Integration of protocols FHAMIPv6/AODV in Ad hoc networks

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Abstract

This paper presents the integration of protocol Fast Hierarchical Ad-Hoc Mobile IPv6 (FHAMIPv6) and the Ad hoc On Demand Distance Vector (AODV). The paper shows the effects of FHAMIPv6/AODV on QoS. The simulation was realized in NS-2 version 2.32. The traffic used is TCP. We analyzed the delay, jitter and throughput in an end to end communication. The metrics from the ACN perspective are presented in the paper. The FHAMIPv6/AODV integration is a step forward to the FHAMIPv6/MPLS/AODV integration in order to provide quality of service in MANET networks. We can consider FHAMIPv6/AODV and the future FHAMIPv6/MPLS/AODV integration as part of development Long Term Evolution standard (LTE) included in the all-IP concept that allows us to meet some requirements of LTE, such as end to-end quality of service. We test it MANET (Mobile Ad hoc Network) networks with different number of nodes. The paper shows the scenarios with 25 nodes as shown. The results of all simulations are displayed in a table.

Keywords: QoS, AODV, AMN, ANAR, APAR, FHAMIPV6, Integration, MAP.

1. Introduction

The overcrowding of wireless technologies and the rise of mobile devices made to support mobility for Internet hosts necessary. They require a host IP address to connect to a network with success, for this reason when a host moves a new IP address should to be assigned; this causes the loss of any established connection. MIPv4 protocol emerges as a solution to the problem of mobility on the Internet. This protocol introduces two new entities, the Home Agent (HA), which is responsible for routing the packets of mobile host (mobile node or MN) and the Foreign Agent (FA),which act on behalf of the mobile host when is moving outside their home network. However, this approach has a high delay in the handover, because of the registration process with the home network and the time obtaining the foreign network address (CoA). To solve these problems, two main proposals were developed. The first one is based on a hierarchical scheme, known as HMIP that aims to reduce the overhead and delay in the registration process with the home network. In order to achieve this goal, it adds a new entity on the edge of the network called Mobile Anchor Point (MAP) and the mobility is divided into micro-mobility (mobility within the domain of MAP) and macro-mobility (mobility outside the domain of MAP).[1][2][3][4][5][6]

With this new entity, when a host moves within the domain of MAP, only their MAP network is required to be updated, by optimizing the registration process with the home network, because the MN does not need to inform the change of the HA address. Thus, the MAP will receive packets that are directed to the MN and will send them to its new address. However, the latency does not decrease when the MN gets its new CoA in the handover process. The second approach seeks to reduce the handover delay due to the above procedure. It is called F-MIP. It uses Mobile Internet Protocol (MIPv4) pre-registration and post-registration methods to decrease due to handover latency.

A subsequent proposal known as FHMIPv6 integrated these two approaches to take both advantages, FHMIPv6 [3][7][8] hierarchical scheme to reduce the overhead of the updates to the home network and a fast handover scheme to reduce the latency due to the handover. This scheme reduces 18 times the latency delay in comparison with MIPv6.

However, the advantages of FHMIPv6, work well in wired infrastructure networks. Because there is a need of a protocol with these features in Ad-hoc mobile environments, we created FHAMIPv6. In the beginning although FHAMIPv6 allowed the registration process, it failed to establish a TCP session between the AMN (MN in Ad-hoc network) and some ACN (Correspondent Node in Ad-hoc Network). For this reason we used the modified NOAH routing agent to support routing in FHAMIPv6. This gave rise to AHRA (Ad-hoc Routing Agent) [9].

With AHRA allows establishing TCP sessions. This paper shows the quality of service metrics of FHAMIPv6 with AODV routing protocol. We present the advantages of FHAMIPv6/AODV with respect to throughput and low packet loss rate and also its disadvantages in relation to delay and jitter.

2. Background

2.1 FHMIPv6

Fast Handover for Mobile IPv6 (FMIP) is a Mobile IP extension that allows the MN to set up a new CoA before a change in the network. This is possible because it anticipates the change of the access router when an imminent change of the point of access is detected. This anticipation is important because it minimizes the latency during the handover, when the MN is not able to receive packets.

F-HMIPv6 was initially proposed by Robert Hsieh [5][6] as a way of integrating Fast handover and HMIPv6 and shows why this integration is a better option than only HMIPv6[10][11][7][8]

2.2 AODV

AODV (Ad-hoc On Demand Distance Vector) routing is a protocol that provides multi-hop routing between mobile nodes in MANETs. This protocol is based on the Distance Vector (DV) algorithm. AODV is reactive, while DV is proactive. This means that AODV only requests routes when needed, while DV continuously sends routing messages to discover and update routes. AODV operates as follows:

When a node wants to find a route to another node, it broadcasts a Route Request (RREQ) to all its neighbors. This message is spread all over the network until it reaches the destination node or a node that has a path to it. The discovered route is enabled by sending RRER messages back to the source. Furthermore, AODV uses hello messages (a special type of RREP) that are continually sent to its neighbors in order to confirm its location. If a node stops sending hello messages, its neighbors may assume that it has left the network and they will consider the link broken. Then, the affected nodes will be notified. [4]

Route Discovery: The route discovery refers to the fact that if node A wants to send packets to node B, it must previously obtain a route. When a node needs to learn a route to a destination and it has not one available (it does not know a route, or its former route expired), it broadcasts RREQ messages and waits for a RREP message. If after some time there is no answer, it will keep sending RREQ messages or will assume that there is no route to the destination.

RREQ type message forwarding occurs when a node receiving this message knows no route to the destination, so it will send it to its neighbors and keep a temporary reverse path to the source. Next hop would be the neighbor's IP of the one that sent the RREQ. This temporary route is created in order to send back through it an eventual RREP from the destination. This route is considered temporary because its expiration time is much shorter than normal routes.

When a RREQ type message reaches its destination or a node that has a valid route to it, a RREP message is created and sent to the node that produced the RREQ request. In the RREP forwarding process from the destination to the source, and via intermediaries, a path to the destination is also created, so when the RREP reaches the source, a complete route between it and the destination is established.

Route keeping: This refers to the mechanism used by the source node in order to detect whether the network topology has changed making it impossible to send packets along previously discovered routes. This occurs when a node moves out of the transmission radius of others or when a node is turned off.

When a node detects that a route to another node is no longer valid, it will remove it from its routing information and will send a link failure type message. This message is directed to the neighbors that could be constantly using that route to inform them that it is no longer valid. These ones will also send the message to their neighbors. In order to fulfill this task, each AODV node has the record of the routes used by its neighbors. When the link failure notification reaches any affected node, each AODV node can decide between sending information via this route or sending RREQ requests to discover a new one.

2.3 FHAMIPv6

IPv4 protocol was enough for a long period of time to satisfy the needs of internet users regarding to the network layer. However, given the current massive use of wireless technologies and the arise of mobile computing, this protocol began to be insufficient for the new users demands, mostly the necessity of staying connected in a mobility environment. In order to solve this inconvenient, MIPv4 appeared. It provides the mobile capacity that users were starting to demand. Moreover, this protocol produced a very high delay when a mobile node changed from an access point to another in an external network. To amend this problem, some protocol extensions were designed.

The first one is, known as HMIP. It tried to decrease network overload by introducing a hierarchical scheme. The second proposal, known as F-MIP, seeked to reduce the transfer delay through methods well defined in [2] In the same way, a third extension was created by merging the best HMIP and F-MIP: F-HMIPv6 [3], which delivered a low delay transfer hierarchical scheme that supports mobility in infrastructure networks. FHAMIPv6 then comes up as an extension of F-HMIPv6 for Ad-Hoc mobile networks (MANETs). Figures 1, 2 and 3 illustrates the exchange of messages for the registration process, the messages sequence process when the AMN moves from the APAR towards the ANAR area and the registration process between the AMN and its AHA from the ANAR area respectively.

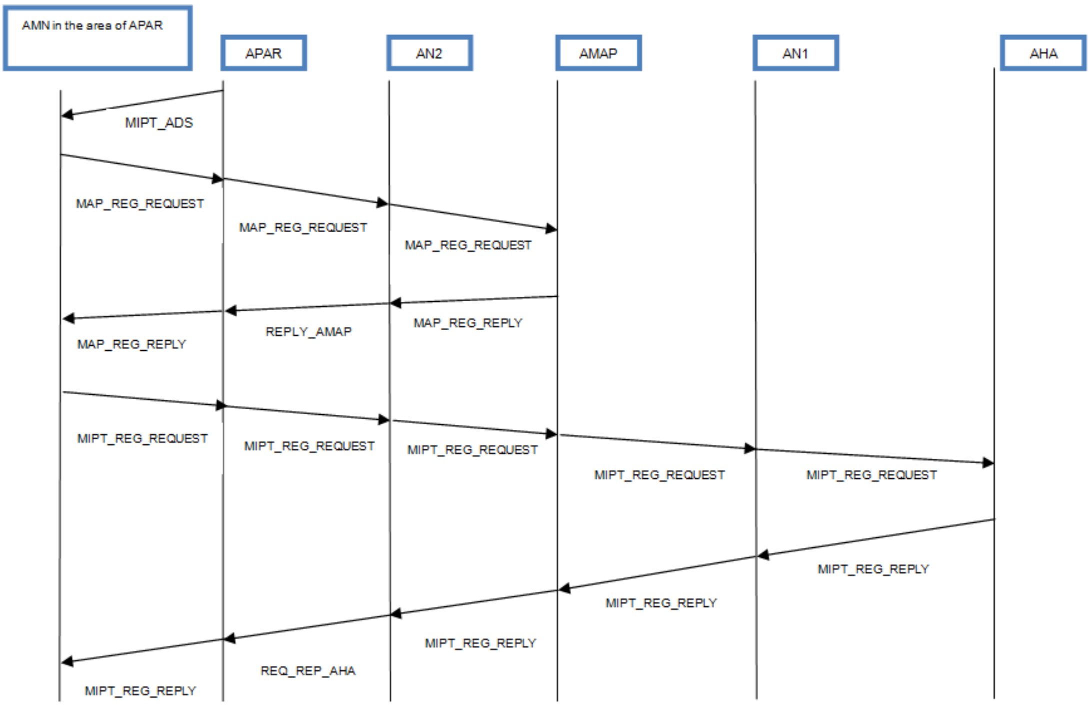

Figure 1. Register process: AMN in the APAR area

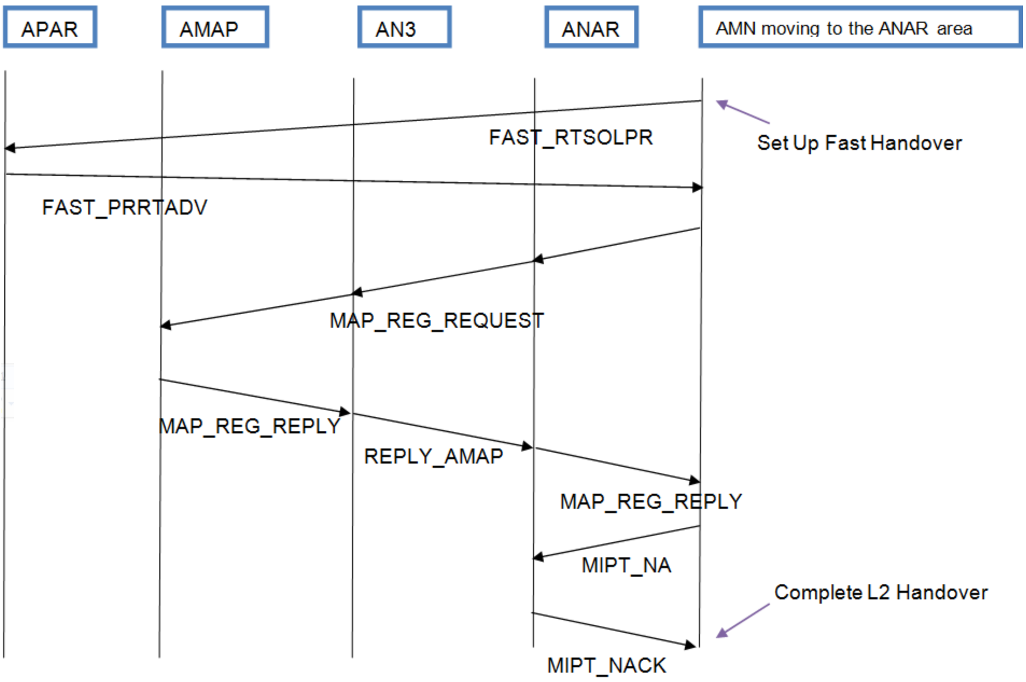

Fig 2. Register process: AMN moving to the ANAR area

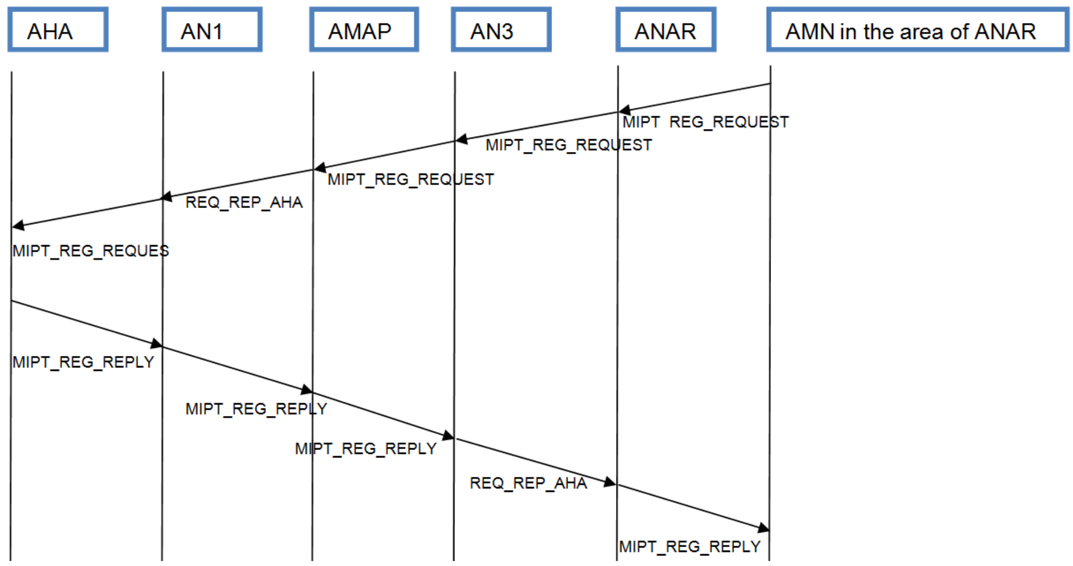

Fig 3. Register process: AMN in the ANAR area

3. Analysis of FHAMIPv6/AODV integration

3.1 Description:

The main objective of the simulation was to observe the effects of FHAMIPv6/AODV integration on QoS parameters. The metrics analyzed were: delay, jitter, packet loss and throughput. The simulated scenario was a MANET networks with different nodes numbers. Ns-2.32 is the version of the simulator used in this work.

The following Figures illustrate the simulation scenario. The first scenario has nine nodes. In this scenario we analyze the delay, jitter and throughput. Similarly, we analyze scenarios with 15, 20, 25,30,35,40 and 45 nodes. Figure4 shows a scenario with 25 nodes.

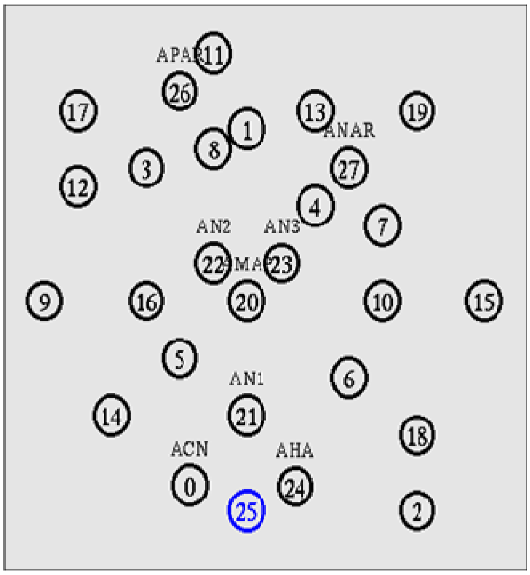

Fig 4. Scenario of simulation with 25nodes.

The AMN (blue node in figure 4) is initially in the area of the ACN. Here, the communication between nodes is carried out without any intermediary. At t=2s, the ACN starts sending TCP packets towards the AMN. This transfer has the lowest delay of the entire simulation. Then, at t=5s the AMN starts moving to the APAR (figure 5) and remains in this area until t=20s. Figure 5 shows the AMN in the area of the APAR. Subsequently, it begins moving towards the ANAR and maintains the communication from that area with the ACN until the end of the simulation at t=30 s. Figure 6 shows the AMN in the area of the ANAR.

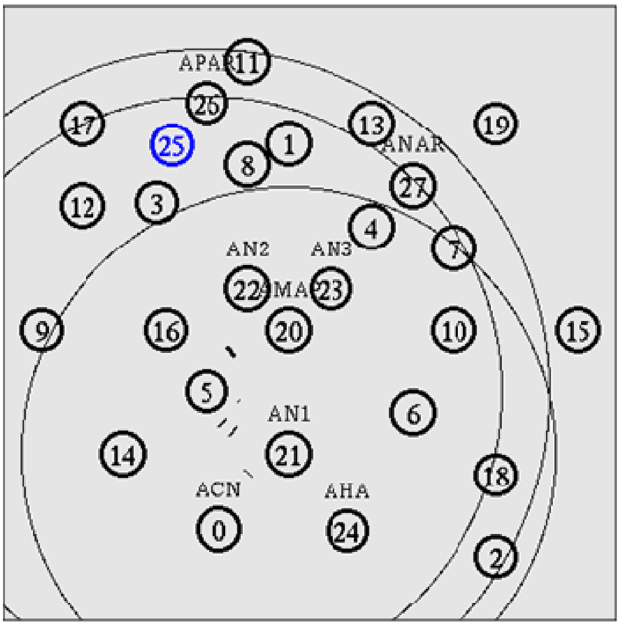

Fig 5. AMN in the area of the APAR.

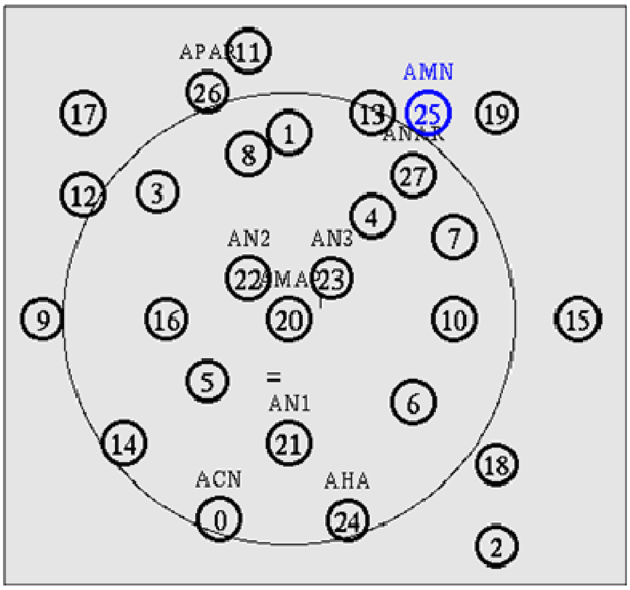

Fig 6. AMN in the area of the ANAR.

4. Delay analysis

Between the 2nd and 5th seconds of the simulation, the delay is kept below 350 ms. When the AMN moves to the area of the APAR, the delay increases slightly, reaching a peak of about 1 s. Later, when the AMN moves to the area of the ANAR at t=20 s, the delay decreases but it, shows a peak of about 1.2 s at the end of the simulation. This causes the average delay to reach 331.209 ms. Figure 7 illustrates it.

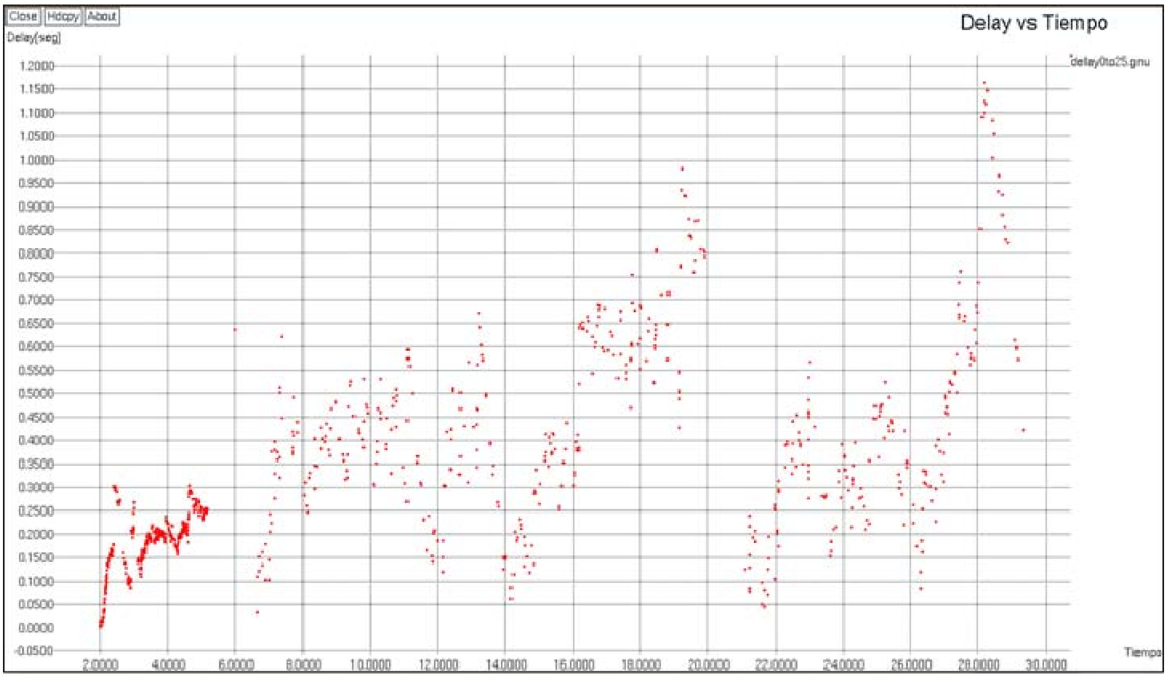

Fig 7. Delay vs. time.

5. Jitter analysis

Note that between the 2nd and the 6th seconds after the start of the simulation, the jitter remains below 300 ms. Later, when the AMN is in the area of the APAR, the jitter has peaks of about 650 ms, although sometimes it stays below 50 ms. At t=20 s, the AMN is in the area of the ANAR and the jitter decreases, but later it obtains a peak of more than 750 ms, probably due to the network overload. Fig 8. Jitter vs time.

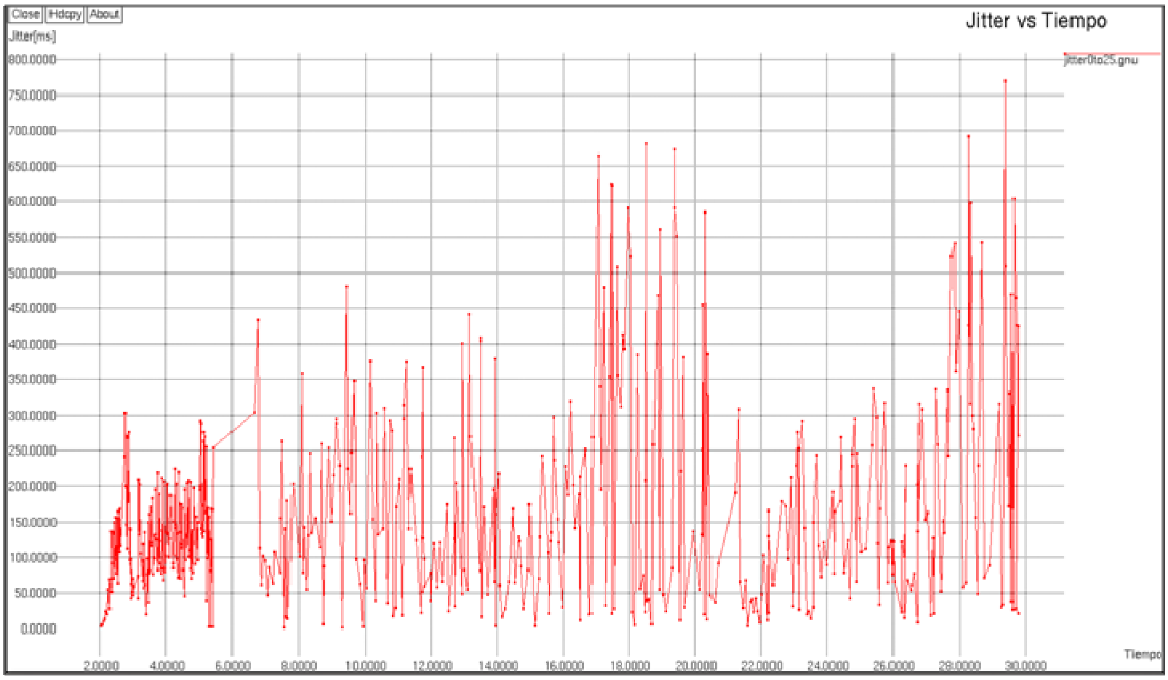

Figure 8 shows the behavior of the jitter from the ACN's point of view.

6. Throughput analysis

The throughput experienced by the traffic going from ACN to AMN is shown in figure 9. It is remarkable that, when the AMN is in the area of ACN, the throughput remains close to 450 Kbps. When the AMN is in the area of the APAR or the ANAR, the throughput is more or less steadily close to 100 Kbps. The average throughput was 107,644 Kbps.

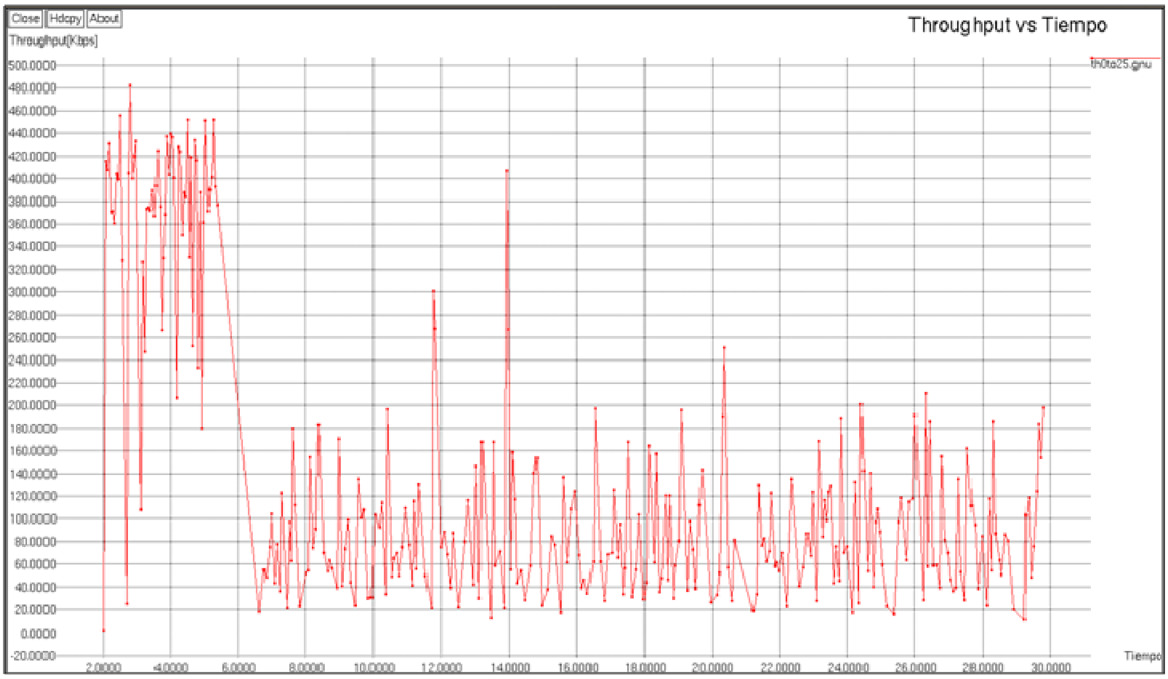

Fig 9. Throughput vs time.

7. Results comparison

Table 1 shows the results in the integration of FHAMIPv6/AODV with different number nodes.

Table 1. Summary of the average metric values for each scenario

Scenario\Metric	Delay[s]	Jitter[ms]	Throughput [Kbps]	Sends Packets	Receive Packets	Lost Pakects (%)
15 nodes	320.933	52.7631	136.32	655	615	6.10687
20 nodes	308.033	46.918	136.891	658	617	6.231
25 nodes	330.343	58.046	126.038	608	571	6.08553
30 nodes	314.552	59.6723	99.4551	460	450	2.17391
35 nodes	263.931	50.6464	111.681	539	505	6.30798
40 nodes	214.359	62.7909	75.7101	354	332	6.21469
45 nodes	309 .761	104.533	56.2325	267	255	4.49438

From the results obtained in the simulation FHAMIPv6/AODV we can conclude that the delay does not show a significant change when the number of nodes and the traffic flow vary. We can also say that the jitter has a significant increase when the number nodes are 45, but we consider that it is a normal result. In general, the throughput decreases when the number nodes increases.

The metrics (sent packets, received packets and lost packets) decline as the number of nodes grows.

Therefore, the FHAMIPv6/AODV integration shows a good performance in mobile ad-hoc networks and the quality of service (QoS) is not affected by changing the number of nodes and the flow of network traffic.

8. Conclusions

This work presents the study of the effects of FHAMIPv6/AODV integration on QoS metrics. The simulation showed that the average delay was about 330.343 ms and was adversely affected by AODV signaling, which is necessary to update the status of the routes. On the other hand, the jitter introduced different behavior depending on the area where the AMN was located. Regarding to packet loss, 37 out of 608 never reached their destination. It is 6.08% of total packets sent. The transfer rate exceeds 126 Kbps on average. In general, delay and jitter suffered a big impact due to the routing updates performed by AODV. Sometimes, some nodes stopped sending TCP packets to transmit

AODV signaling instead, which was useful for recalculating routes. This circumstance delayed significantly the TCP session. One possible solution for this inconvenience (assuming that only one node moves to the AMN) would consist of modifying AODV to prevent routing updates until the APAR or the ANAR receives a MAP_REG_REQUEST from the AMN, suggesting that AMN is their area.

In general, the integration FHAMIPv6/AODV optimizes the QoS metrics such as delay, throughput, jitter, etc. or at least, maintains a minimum level of quality standards that guarantees and meets the requirements of IP packet traffic in the network.

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