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An Extended AODV Protocol to Support Mobility in Hybrid Networks

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Abstract— **This paper deals with a model of communication that supports the mobility of the users in hybrids networks. This suggestion is based on the AODV (Ad hoc On demand Distance Vector) protocol that exploits both opportunistic routing techniques and handover between different access points to manage mobility in hybrid networks. Opportunistic routing techniques that operate on the principle of "store, carry and forward" are considered. With Network Simulator 2 (NS2) package, the traffic of control, the packet delivery ratio and the end to end delay are measured in the original version of AODV and compared with the modified version.**

Keywords-component; AODV, mobility, hybrid networks, «store, carry and forward», handover, NS2

I. INTRODUCTION

Hybrid networks are networks that combine two types of wireless networks: networks with infrastructure and networks without infrastructure or ad hoc networks [1]. In this type of network, the user mobility implies sometimes a change of Access Point (AP). This fact is generally known as a handover, and more precisely a handover of layer 2. Several works were done to manage mobility in the hybrid networks. Among these, we can mention: MCIP protocol [2], the Extended DSR protocol [5] , and the AODV+ protocol [6]. However, these works are subject to limitations because of the metric of the access point selection. This metric is based on the number of hops between the node (PDA or laptops) and access point [3], which is not always optimal. In addition, in the absence of end to end path between the source and the recipient of a packet, the packet is not transmitted to the recipient because the techniques of the "opportunistic communication" are not implemented in these works. The term "opportunistic communication" is used in the literature to refer to the fact that a node temporarily stores messages in transit in the network before retransmitting. This article aims to overcome the shortcomings of these works.

II. OVERVIEW OF THE EXTENDED AODV PROTOCOL

Our proposal named Extended AODV is an improvement of AODV protocol by adding the following mechanisms: discovery of access points, metric for access point selection, registration by an access point, mechanism of handover, opportunistic communication.

The following sections are devoted to the description of these mechanisms.

A. Discovery of access points Review

This mechanism's role is to know all the access points reachable in one or several hops. In Extended AODV, we chose to implement the proactive and reactive methods. The choice of a reactive or proactive method depends on the number of hops separating the mobile node from the access point. Indeed, for nodes located in a certain zone around the access point, the proactive method is used. For the other nodes, it is the reactive approach that is used.

Proactive method

It is initiated by the access point itself that broadcasts periodically the APADV (Access Point ADVertisement) message (Fig. 1) with a period determined by an attribute: ADVERTISEMENT_INTERVAL.

0	8	19	24 31
Type	Reserved	Pref.Sz	Hop Count
APADV_ID			
Destination IP Address			
Source IP Address			
Lifetime			
traversed way			
F			
V			

Figure 1. Format of APADV Message

identification of RREQ (Route REQuest) has not been already received during the last seconds. If such a message has been received, this message is no longer distributed, otherwise the node receiving the message creates or updates an entry in its table of access points and rebroadcast the message after adding its own address to the field "traversed way", size of its queue to the field "F" and the total number of neighbors whom it has on the level of the field "V".

Reactive method

It is initiated by a mobile node which wishes to enter communication with an access point. The mobile node broadcasts an APSEARCH (Access Point SEARCH) message (Fig. 2) to a special address: ADR_ALL_GW (IP addresses of all the network access points). When an Access point receives this message, it responds by sending a unicast mobile node requesting a Post ANNPA containing between another IP address.

0	8				12	24 31
Type	J	R	G	P	Reserved	Hop Count
APSEARCH_ID						
Destination IP Address						
Originator IP Address						
traversed way						

Figure 2. Format of APSEARCH Message

B. Metric for access point selection

The metric of access point selection named SPA allows selecting the best access point when a mobile node receives multiple messages of requests from several access points. This metric is composed of three factors: the number of hops, the size of queue and the total number of neighbors. The expression of this metric is given by (1):

$$SPA_q = ns_q + \frac{F}{F+1} + \frac{V}{V+1} \qquad (1)$$

Avec $\theta \in E_{AP}$ $\quad F = \sum_{i=1}^{ns_q} int\_f\_size \quad V = \sum_{i=1}^{ns_q} v_i$

where E_{AP} is the set of access points in the network, ns_q is the number of hops from q to p, int_f_size represents the size of the queue of node i along the road from access point q to node p, V_i represents the number of the neighbors of node i along the road from access point to the node.

When a mobile node receives many APADV messages from several access points, it selects the access point having the lowest SPA. Our SPA metric selects the access point whose way is not only less charged and less dense, but also the shortest.

C. Registration of a node by an access point

The mechanism of registration of a node by an access point allows a mobile node to be localized on the network by an access point [4]. It consists in recording a mobile node by the access point that it would have selected, and to notify this registration to other access points of network. The APREG message is used for the purpose (Fig. 3).

0	8			11	19	24 31
Type	R	A	E	Reserved	Pref.Sz	Hop Count
Destination IP Address						
Originator IP Address						
traversed way						
Lifetime						

Figure 3. Format of APREG Message

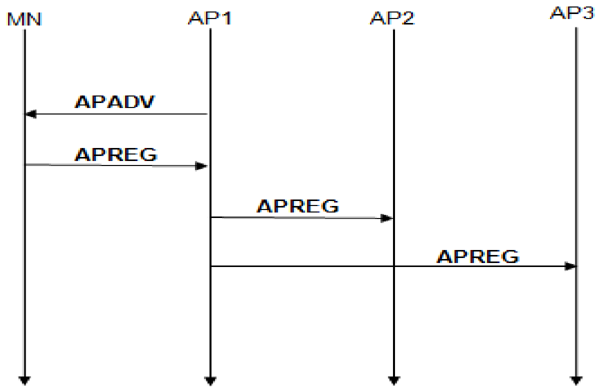

Figure 4. Registration of a mobile node towards the access points at the time of the reception of a message APADV with a proactive discovery

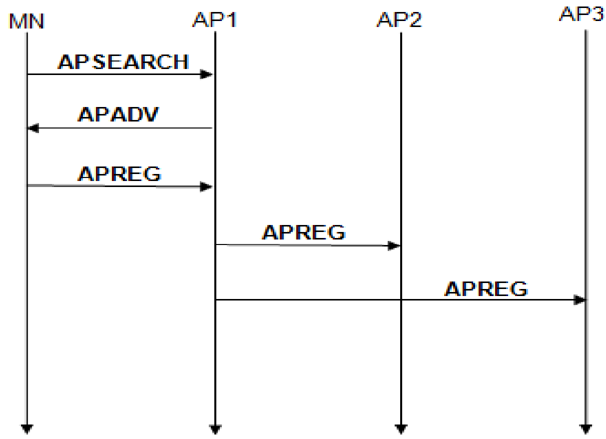

Figure 5. Registration of a mobile node towards the access points at the time of the reception of a message APADV with a reactive discovery

Fig. 4 and Fig. 5 show the registration of a mobile node towards the access points at the time of the reception of an APADV message with a proactive discovery and the registration at the time of the reception of an APADV message with a reactive method, where the mobile node broadcast an initial APSEARCH message.

D. Process of handover

The handover is the process allowing a mobile node to continue its communication while changing access point during its movement. It takes place also in the following cases: the quality of the bond with the current AP is degraded, the node loses connection with the current AP, the quality of the bond with the new AP increases.

The mechanism of handover in our proposal goes as follows: on receipt of an ANNPA message, the node checks if the issuer belongs to the score table access. If this is not the case, AP adds this to the table of access points after calculating the SPA. Once this addition is done, it will test whether to perform handover: if the packet received (ANNPA message) is from an AP different from that with which the node is currently connected, then the values of their SPA are compared. If the SPA of the new AP is higher than that of the current AP's, the handover can be done. Once the handover is accepted, the node is associated to the new AP.

E. Route discovery

In Extended AODV, when a node u wants to communicate with a node v, three modes of route discovery can be used:

- Infrastructure mode: Node u sends the packets to the access point which it is connected (denoted AP (u)), which forwards them to access point is connected node v (denoted AP (v)). This last will dispatch the packages in its turn with v.
- Ad-hoc mode: Node u sends the packets directly to v, using other mobile nodes as relays without going through an access point.
- Opportunistic mode: Node u sends a copy of the message intended for recipient v to his neighboring nodes. The latter also proceed in the same way until the message is received by recipient v.

In Extended AODV, for determining which mode to use, the node u first asks the value ns of *v* (Number of hops between the node *v* of the access point to which it is connected with) to AP(*u*). When the node *u* does not retrieve this value, it would mean that the node *v* is totally disconnected from the network and that there is not an end to end path to reach it, and the opportunistic mode is employed, but if the node *u* reaches retrieve the value, the node *u* broadcast a RREQ with a lifetime (TTL) equal to ns_v + ns_u -1 to find a route ad-hoc mode using the pure method of route discovery AODV protocol. If *v* does not return a RREP before the expiration of the life of the RREQ (TTL), it would mean that the between these two nodes ad-hoc mode is longer than that in infrastructure mode, that is to say ns that $ns_{(u,v)} > ns_u + ns_v$ or that there not a path between end the two nodes. If there is no one path from end to end between nodes u and v, the opportunistic is used. But if there is a path end to end between the two nodes and if $ns_{(u,v)} > ns_u + ns_v$, is the infrastructure mode which will simply used. If the node v sends a RREP before the expiry of the life of the RREQ, that is to say $ns_{(u,v)} < ns_u + ns_v$, is the ad hoc mode is used.

As shown in Fig. 6, it is the ad-hoc mode to be used for routing packets of mobile node u to node v because $ns_{(u,v)} < ns_u + ns_v$ with $ns_{(u,v)} = 2$, $ns_u = 2$ and $ns_v= 2$. On Fig. 7, it is the opportunist mode which is used to establish a road between node 13 and one unspecified node of the network, because node 13 is completely disconnected from the network.

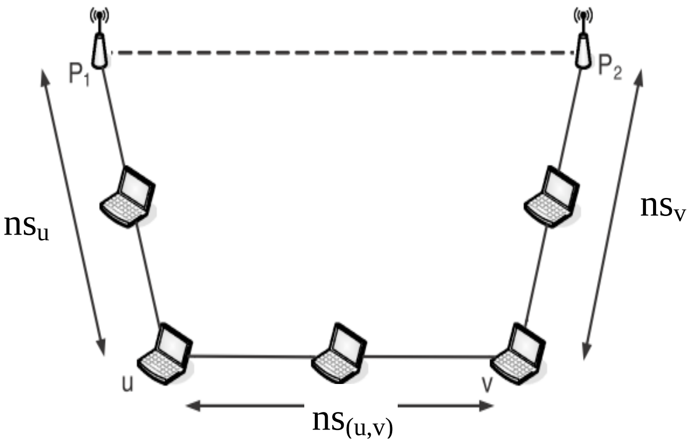

Figure 6. Example of route discovery in Extended AODV

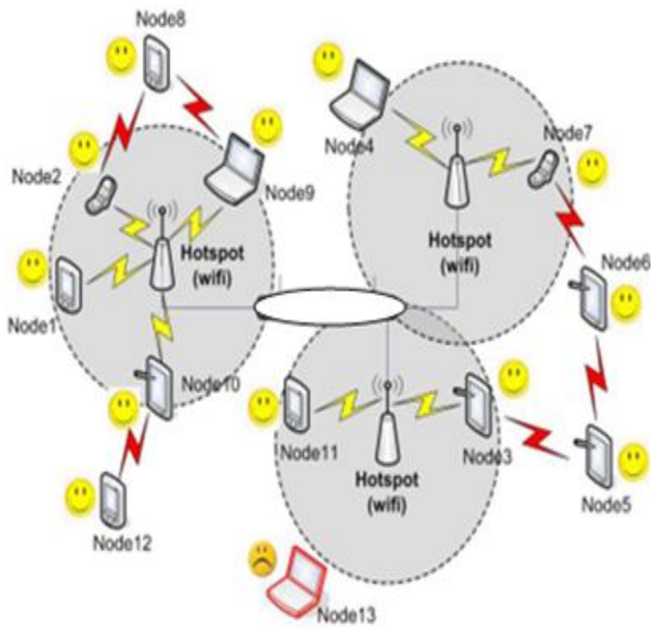

Figure 7. Example of hybrid network discontinuous

F. Mobility Management

Regarding the management of mobility in the Extended model AODV, it mostly occurs when a node u moving away from the AP to which it is registered and loses the connection with it. Indeed, as the present value of the metric is better SPA node u uses the route discovery model presented below for communication. But when this metric is not better, then we go to the handover procedure that will allow the node u to register with another AP. Once the handover process is completed that is to say when the node u manage to record his new AP, we use the model route discovery presented below for communication. Another aspect of mobility is important to note is out of data during mobility. This is ensured by the previous model maintenance road below.

G. Route maintenance

In Extended AODV, the route maintenance depends on mode of route discovery employed: ad hoc mode, infrastructure mode.

- In ad hoc mode, the road maintenance of AODV protocol that is used to maintain the roads. Indeed, the maintenance of roads in the AODV protocol is using the RERR message: when a packet does not reach the next node when the node sees the link as dead. It then sends a RERR message to the source. The source and the intermediate nodes update their cache receiving this message. The source must find another route by sending a RREQ.
- In infrastructure mode, there are two possible scenarios broken connection in the exchange of data between a source and a destination is a way to link the current AP (AP1) of the source (MN1) (is to say the AP to which the node is registered MN1) is broken (Figure 8) or it is a link to the current AP (AP2) of the destination (MN3) is broken (Figure 9). In the first case, the source will re-register with a path contained in the table of access points if it exists, then initiate a new search path. In the second case, the source receives a RERR, indicating that the data packet could not reach the destination. But this is not a link in the path to the current access point source is at stake, so the source does not initiate a new record, but just a path search. By cons, destination, noting a failure to send a HELLO message, initiates a new record to an accessible access point (here AP3). Registration is propagated to the AP1 to the source node (MN1) to relocate the destination.

III. SIMULATIONS AND RESULTS

- In ad hoc mode, it is the route maintenance of the AODV protocol that is employed to maintain the roads.
- In infrastructure mode, there are two possible scenarios of rupture of connection during the data exchange between a source and a destination. Fig. 8 and Fig. 9 respectively illustrate the route maintenance in the case of a rupture of way between the source and the AP to which it is connected and in the case of a rupture of way between the destination and the AP to which it is connected.

Extended AODV, we used the Network Simulator NS2 installed on Debian GNU / Linux. Simulations were made to measure traffic control (quantity of control packets generated by the protocol), the rate of packets receipts (percentage of packets delivered to their destinations by compared to the transmitted packets in network) and the average end- end (average time for a packet to leave the data source to the destination) in the original AODV protocol and Extended AODV. Simulation parameters are given as follows:

- Topology: simulation for an environment of 1500mx300m. The time of simulation is 1200s
- Traffic: Traffic of CBR with a frequency of consignment of 5 packets/s
- Nodes and APs: 50 nodes are expanded in the network. There are 5 APs. The time of pause of nodes in their movement is 0s.

Fig. 10 shows that the load of control generated by the AODV protocol is higher than that generated by Extended AODV. This is justified by the fact that with protocol AODV, the requests of search for way are broadcasted on the whole of the network, whereas Extended AODV broadcasts these requests only in the ad hoc small island.

Fig. 11 shows the rate of packets received (PDR) in two protocols. We note an average improvement of 35% of the PDR between AODV and Extended AODV. This improvement is explained by the addition of the mechanism of opportunistic communication in Extended AODV.

The average end to end packet delay is slightly lower in the AODV protocol in relation to Extended AODV (Fig. 12). That can be explained by the use of opportunistic communication mechanism implemented in Extended AODV.

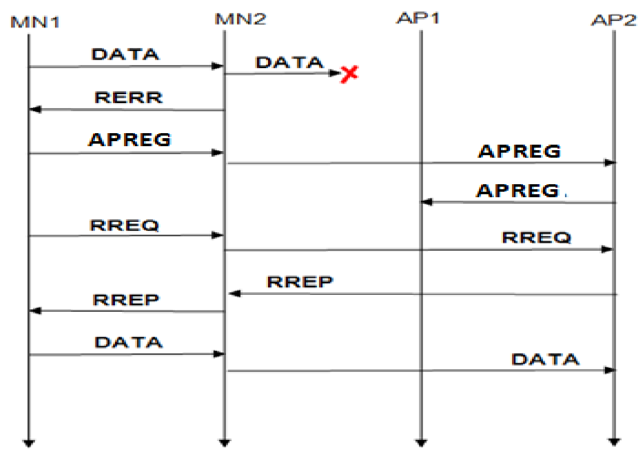

Figure 8. Example of route maintenance in infrastructure mode: rupture of way between the source and the AP to which it is connected

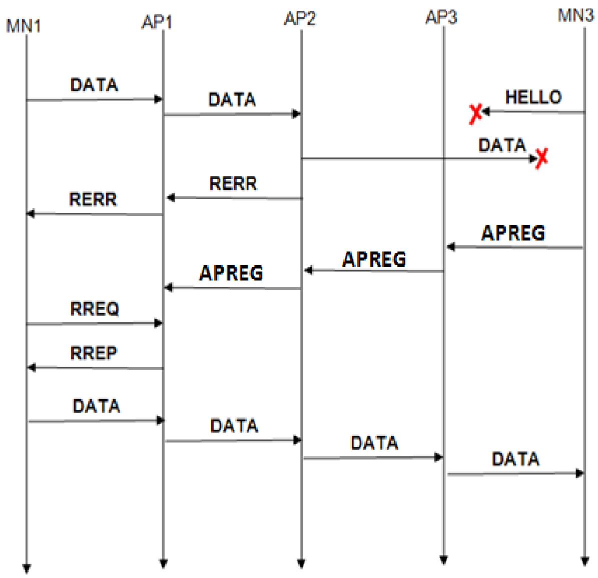

Figure 9. Examples of route maintenance in infrastructure mode: rupture of way between the destination and the AP to which it is connected

IV. Conclusion

Within the scope of this article, we proposed a modification of AODV protocol in order to support the mobility of the nodes in hybrid networks. Our proposal called Extended AODV shows notable improvement in the delivery of the packages in a rise of 35% compared to the AODV protocol, but with a high time of transmission. In continuation of this work, we plan to expand the number of users to evaluate our proposal in the context of high load with high mobility.

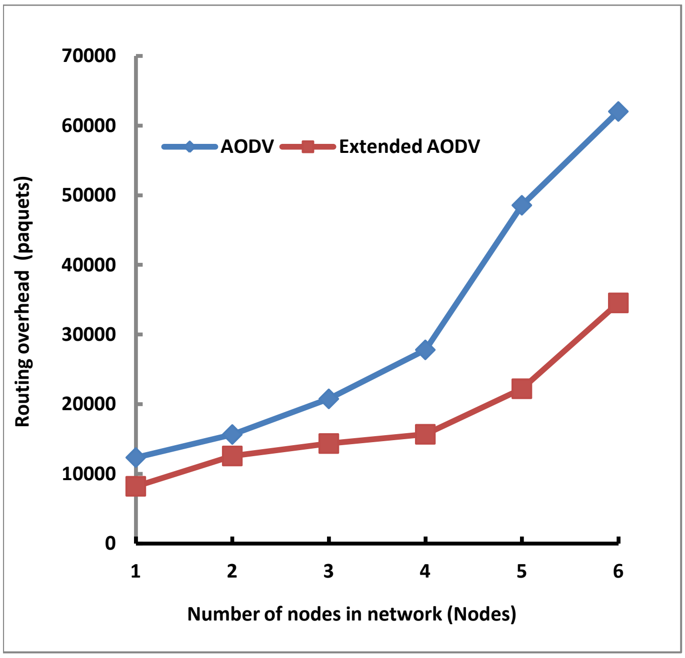

Figure 10. Comparison between Extended AODV and AODV: Routing overhead

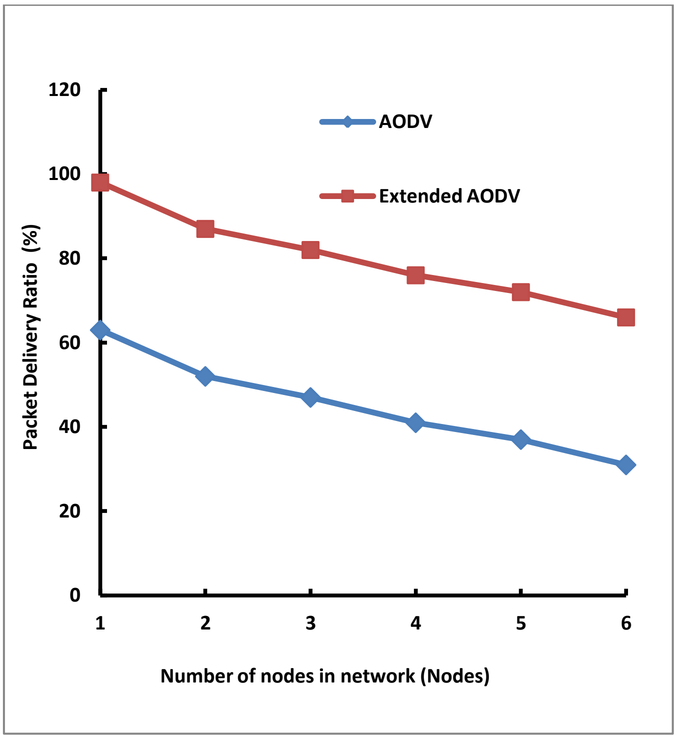

Figure 11. Comparison between Extended AODV and AODV: PDR

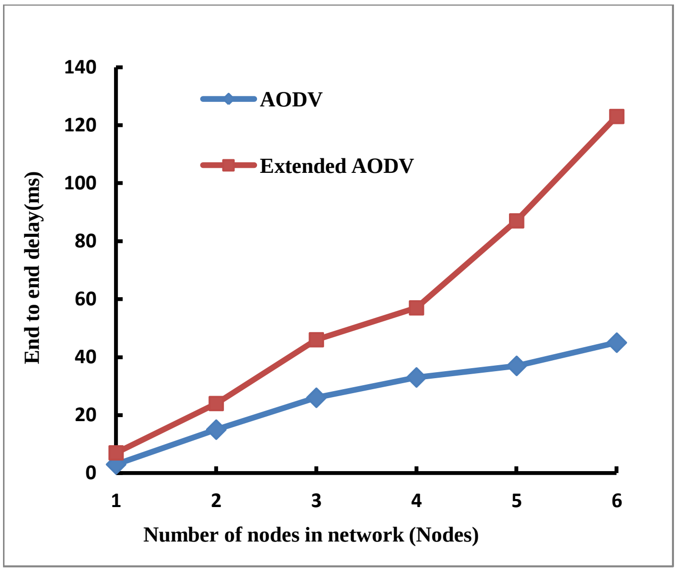

Figure 12. Comparison between Extended AODV and AODV: End to end delay

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