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# Formal verification of a new version of AOMDV in ad hoc network

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**Abstract**

In ad hoc networks like MANET the topology change frequently and interferences problems are inevitable in many cases, as a result link failures can arise. Unfortunately, traditional routing algorithms are no more suitable for this kind of networks especially in case of using a single path routing schemes. In order to overcome this problem, multipath routing approach is proposed where in some cases as an extension of the traditional routing algorithms. Our aim in this paper is to propose a formal study based on model checking to formally verify an enhancement version of AOMDV. In this new version we have added new functionalities in ROUTE DISCOVERY and ROUTE MAINTENANCE to achieve energy efficiency, packet overhead minimization and latency reduction.


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*Keywords:* Ad-hoc networks; routing protocols; Formal verification; model checking;

## 1. Introduction

A mobile ad-hoc network or MANET is a collection of mobile nodes sharing a wireless channel without any centralized control. Each nodes act as both end systems and routers at the same time. In this kind of network with all nodes capable of movement or any other kind of network where the topology changes frequently, manage communication is very difficult especially on single path routing algorithm. We distingue tree types of routing algorithms: proactive protocol which continuously exchange routing information between the nodes; reactive

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protocol which built route on demand and hybrid protocol the combination of the two. The major drawback of proactive protocol is that the maintenance of unused paths may occupy an important part of the available bandwidth if the topology changes frequently[1]. Reactive routing protocols have some inherent limitations. First, since routes are only maintained while in use, it is usually required to perform a route discovery before packets can be exchanged between communication peers. This leads to a delay for the first packet to be transmitted. Second, even though route maintenance for reactive algorithms is restricted to the routes currently in use, it may still generate an important amount of network traffic when the topology of the network changes frequently. Finally, packets to the destination are likely to be lost if the route to the destination changes[1]. Several performance studies[2,3] of ad hoc network have shown that on demand protocols incur lower routing overheads compared to the proactive protocols. However, in dynamic network the performance will be reduced due to frequent route discovery (i.e. high route discovery latency and overhead). In order to overcome the limits of those protocols, multipath routing algorithm have been developed to overcome these limits by computing several path in a single route discovery attempt. In this case, whenever a route is broken the node will just skip to the alternative path without the need of a route discovery process, which is time intensive. An example of multipath routing algorithm AODVM[4] and AOMDV[5], both of these protocols are bases on the Ad hoc On demand Distance Vector AODV[6], which work on the principle of creating routes only if it is required between a source and destination. In spite of AOMDV which incurs more routing overhead and packet delay than AODV, many studies[7,8] has shown that AOMDV results is superior than AODV when there is mobility induced link break in distributed environment. The idea is to improve AOMDV in such a way to give better performances by reducing the routing overhead. To prove the good functioning of our new algorithm, we pass by a formal verification using the model checking[9]. This one has been successfully employed to detect ambiguities in the standard AODV and its implementations[10,11,12]. When model checking is applicable in large network protocol, such deep errors are found[13,14,15]. It consist first to build a model for the system then to verify it against specifications (expressed in a temporal logic), using a software tool called model checker. We use the tool UPPAAL instead others, due to its facilities to model the timed aspects[16,17] and especially the notion of broadcast communication that can be modeled in an easiest way[18]. Also, UPPAAL includes techniques to minimize and avoid falling into situations of explosion state[19].

The rest of this paper is organized as follows: in section 2 we review the AOMDV protocol and detailed the optimized version of AOMDV in section 3. Section 4 describes the modeling methodology under UPPAAL tool and presents the verification of model results compared to the properties. Finally, Section 6 concludes the paper.

## 2. The Ad hoc On Demand Multipath Distance Vector protocol

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) protocol is an extension to the AODV protocol for computing multiple loop-free and link-disjoint paths[7]. AODV is an IP routing protocol using distance vectors (measured with hops). It consists of two procedures:

- ***ROUTE DISCOVERY process****:* The source broadcasts the RREQ (ROUTE REQUEST) packet and waits the reception of RREP packet (ROUTE REPLEY). When a node receives RREQ, it first checks if it is not a RREQ that has received earlier or an old one. In case where it's a new one, a reverse route is built to the previous node, update the fields in the RREQ and forward it, otherwise it deletes. The RREP packet is sent to the source either by an intermediate node who knows the route to the destination, or by the destination node itself.
- ***ROUTE MAINTENANCE process*****:** This procedure allows a rollback to the source in case the route is broken in order to update it or to discover another. A node reports its status to the neighbors by sending a message called HELLO. In case where no HELLO message is received from a node, then a local route discovery is performed to discover an alternative path. If no route is found, an error message is diffused called RERR (ROUTE ERROR). All nodes receiving this packet invalid the route and the source node starts a new route discovery.