Study of the Performance and Limitations of a Reactive Ad hoc Protocol (AODV)

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Abstract—**The domain of mobile networks ad-hoc (MANET) has won an important part of the interest of researchers and become very popular in recent years. MANET can operate without a fixed infrastructure and can survive rapid changes in the network topology. They can be formally considered as graphs in which all edges varies over time. The main method for assessing the performance of MANET is the simulation. This article is subject to routing protocols on demand with identical loads and environmental conditions and to assess their performance relative to the six performance criteria are following: rate, flow Numhops, energy, end-to-end delay and the collision rate.**

Keywords— A**d hoc, NS2, Throughput, Numhops, Energy, End-to-End Delay, Collision Rate and Mobility**

I. INTRODUCTION

An ad-hoc network is a collection of wireless mobile nodes (or routers) dynamically forming a temporary network without using any existing network infrastructure or centralized administration. The routers are free to move randomly and organize themselves arbitrarily, so the topology of the wireless network may change rapidly and unpredictably.

Such a network may operate in a stand-alone fashion, or may be connected to the Internet. Multi-hop, mobility, large network size combined with device heterogeneity, bandwidth, and battery power constraints make the design of adequate routing protocols a major challenge. Some form of routing protocol is in general necessary in such an environment, because two hosts that may wish to exchange packets might not be able to communicate directly, as shown.

Mobile users will want to communicate in situations in which no fixed wired infrastructure is available. For example, a group of researchers en route to a conference may meet at the airport and need to connect to the wide area network, students may need to interact during a lecture, or firefighters need to connect to an ambulance en route to an emergency scene. In such situations, a collection of mobile hosts with wireless network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration.

Because nowadays many laptops are equipped with powerful CPUs, large hard disk drives, and good sound and image capabilities, the idea of forming a network among these researchers, students, or members of a rescue team, who can easily be equipped with the devices mentioned above, seems possible. Such networks received considerable attention in recent years in both commercial and military applications, due to the attractive properties of building a network on the fly and not requiring any preplanned infrastructure such as a base station or central controller.

A mobile ad hoc network (MANET) group has been formed within IETF [11]. The primary focus of this working group is to develop and evolve MANET specifications and introduce them to the Internet standard track. The goal is to support mobile Ad hoc networks with hundreds of routers and solve challenges in this kind of network.

Some challenges that ad hoc networking faces are limited wireless transmission range, hidden terminal problems, and packet losses due to transmission errors, mobility-induced route changes, and battery constraints. Mobile ad hoc networks could enhance the service area of access networks and provide wireless connectivity into areas with poor or previously no coverage (e.g., cell edges).

Connectivity to wired infrastructure will be provided through multiple gateways with possibly different capabilities and utilization. To improve performance, the mobile host should have the ability to adapt to variation in performance and coverage and to switch gateways when beneficial.

To enhance the prediction of the best overall performance [14], a network-layer metric has a better overview of the network. Ad hoc networking brings features like easy connection to access networks, dynamic multi-hop network structures, and direct peer-to-peer communication. The multi-hop property of an ad hoc network needs to be bridged by a gateway to the wired backbone. The gateway must have a network interface on both types of networks and be a part of both the global routing and the local ad hoc routing.

- ✓ Users could benefit from ubiquitous networks in several ways.
- ✓ User mobility allows users to switch between devices, changing sessions, as the same personalized service.
- ✓ Host mobility allows user devices to move around the network and maintain connectivity and accessibility.

MANETs have several salient characteristics:

- ✓ Dynamics topologies
- ✓ Bandwidth constrained, variable capacity links
- ✓ Energy-constrained operation
- ✓ Limited physical security.

II. ROUTING PROTOCOLS

Routing protocols are classified in several categories (see Fig. 1, you'll be interested in the reactive category, reactive category or on-demand routing protocols.

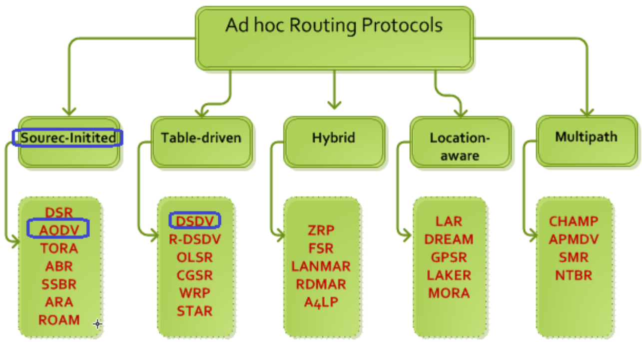

Fig. 1: Routing Protocols Classifications

A. Destination-Sequenced Distance-Vector (DSDV) [1]

The Destination-Sequenced Distance-Vector (DSDV) is a table-driven routing protocol based on Bellman–Ford routing algorithm. Every mobile node maintains a routing table that contains all of the possible destinations in the network and each individual hop counts to reach those destinations. Each entry also stores a sequence number that is assigned by the destination. Sequence numbers are used to identify stale entries and avoidance of loops. In order to maintain routing table consistency, routing updates are periodically sent throughout the network. Two types of update can be employed; full dump and incremental. A full dump sends the entire routing table to the neighbors and can require multiple network protocol data units (NPDUs).

Incremental updates are smaller updates that must fit in a packet and are used to transmit those entries from the routing table since the last full dump update. When a network is stable, incremental updates are sent and full dump are usually infrequent. On the other hand, full dumps will be more frequent in a fast moving network. The mobile nodes maintain another routing table to contain the information sent in the incremental routing packets. In addition to the routing table information, each route update packet contains a distinct sequence number that is assigned by the transmitter. The route labeled with the most recent (highest number) sequence number is used. The shortest route is chosen if any of the two routes have the same sequence number.

B. Ad Hoc On-Demand Distance-Vector Protocol (AODV)[1]

AODV routing protocol is developed as an improvement to the Destination-Sequenced Distance-Vector (DSDV) AODV today has many successes and is used in many systems. The Zigbee and the Wi-Fi mesh networks use an adapted version of AODV. AODV belongs to the class of distance vector routing protocols. In these protocols, to reach a destination, the mobile node uses the next hop allowing the smallest distance in number of hops between it and the destination. AODV is a reactive protocol; hence mobile nodes do not retain any information for nodes not concerned by the active traffic information.

The aim of AODV is to reduce the number of broadcast messages sent throughout the network by discovering routes on-demand instead of keeping complete up-to-date route information.

There following four classes represent the different AODV [2] messages:

- ✓ RouteRequestMessage (RREQ) is a route request message used whenever a new route to a destination is required.
- ✓ RouteReplyMessage (RREP) is a reply message for a route request.
- ✓ RouteErrorMessage (RERR) is a route error message.
- ✓ Periodic HELLO messages are broadcast to check the presence of immediate active neighbors.

A source node seeking to send a data packet to a destination node checks its route table to see if it has a valid route to the destination node. If a route exists, it simply forwards the packets to the next hop along the way to the destination. On the other hand, if there is no route in the table, the source node begins a route discovery process. It broadcasts a route request (RREQ) packet to its immediate neighbors, and those nodes broadcast further to their neighbors until the request reaches either an intermediate node with a route to the destination or the destination node itself. This route request's packet includes the IP address of the source node, the current sequence number, the IP address of the destination node, and the sequence number.

An intermediate node can reply to the route request packet only if they have a destination sequence number that is greater than or equal to the number contained in the route request packet header. When the intermediate nodes forward route request packets to their neighbors, they record in their route tables the address of the neighbor from which the first copy of the packet has come from. This recorded information is later used to construct the reverse path for the route reply (RREP) packet. If the same RREQ packets arrive later on, they are discarded. When the route reply packet arrives from the destination or the intermediate node, the nodes forward it along the established reverse.

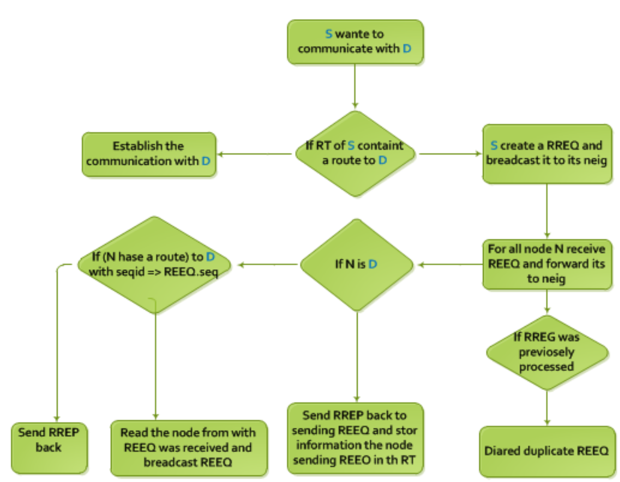

Fig. 2: The following flow chart illustrates this process [1]

III. CHOICE OF THE SIMULATOR [2]–[6]

We will choose the tool ns2, based on the following comparative Table 1.

Table 1: Choice of the simulator NS2

	GLOMOSIM	OPNET	OMNet++	NS2	NS3
802.15.4	No	Yes	Not th whole	yes	Not yes
Support	Last version december	yes	yes	yes	yes
Free of use	yes for academic	yes but ther are heavy	yes	yes	yes
use friendly		graphic UI	graphic UI	No graphic UI	No graphic UI

Table 2: Environment of the simulation [3]

set	val(chan)	Channel/WirelessChannel	# channel type
set	val(prop)	Propagation/TwoRayGround	# radio-propagation model
set	val(ant)	Antenna/OmniAntenna	# Antenna type
set	val(ll)	LL	# Link layer type
set	val(ifq)	Queue/DropTail/PriQueue	# Interface queue type
set	val(ifqlen)	50	# max packet in ifq
set	val(netif)	Phy/WirelessPhy	# network interface type
set	val(mac)	Mac/802_11	# MAC type
set	val(nn)	20 30 40 50 60 70 80 90 100 110 120 130 140 150	# number of mobilenodes
set	val(rp)	AODV	# routing protoco
set	val(energymodel)	EnergyModel	# Energy Model
set	val(initialenergy)	40.0	# value

I've performed 100 simulations per each set of mobile nodes. I've 14 sets including 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, and 150 mobile nodes, separately.

A. Definitions

The metric [13]: we define a metric m denoted as a feature that may be associated with a station or a bond in the mobile ad hoc network. We denote by M the finite set of all metrics considered in a performance of a MANET. Any metric must be defined explicitly, and the set of metrics considered in the context of a solution must be clearly specified.

The value of a metric: We define the value of a metric M m any real function as a subjective val noted that, in any station or connection between two stations characterized by the metric m, associates a real value:

$$\forall m \exists val : M \rightarrow IR, m \rightarrow val(m)$$

For each metric must therefore provide a clear and reproducible that would allow to calculate the value of this metric to the station or the route in question. A level playing field, this method should provide the same value.

Reference interval [12]: In mathematics, a confidence interval to define a margin of error between the a poll and a comprehensive record for total population. More generally, the confidence interval is used to evaluate the accuracy of the estimation of a parameter on a statistical sample.

Let a and b two real numbers such that a <b. We define an interval of IR reference value associated with a MANET a subset of real numbers between a and b included such that for any metric m we can find an increasing function linking the value of m to a real number in IR:

$$I_{IR} = \{x, a \le x \le b, \forall\, m \in M, \exists\, f: IR \rightarrow [a,b], val(m) \rightarrow f(val(m))\}. \quad \text{Eq.2}$$

- ✓ The natural values of different metrics may exhibit impressive differences.
- ✓ We studied different scenarios, in exchange for a number of nodes considering their dynamic mobility.

Mobility: Johansson, Larsson and Hedman et al. [7] took a further step and proposed the Mobility metric to capture and quantify this nodal speed notion. The measure of relative speed between node i and j at time t is:

$$RS(i,j,t) = |\bar{V}_i(t) - \bar{V}_j(t)|$$

Then, the Mobility metric is calculated as the measure of relative speed averaged over all node pairs and over all time. The formal definition is as follow

$$\bar{M} = \frac{1}{|i,j|} \sum_{i=1}^{N} \sum_{j=i+1}^{N} \frac{1}{T} \int_0^T RS(i,j,t)dt$$

where |i,j| is the number of distinct node pair (i,j), n is the total number of nodes in the simulation field (i.e., ad hoc network), and T is the simulation time.

B. Results for V-graph

From the simulation results and detailed analysis, we classify the metric criticality and those that must be optimized to improve the performance of AODV protocol.

Table 2: Number of drop per collision & Total 100 lost during the simulation

NbreNode	NbrDroParCOL
20	5722
30	36791
40	33491
50	198183
60	323455
70	478148
80	551814
90	699400
100	772718
110	933383
120	1061641
130	1265918
140	1373713
150	1650750

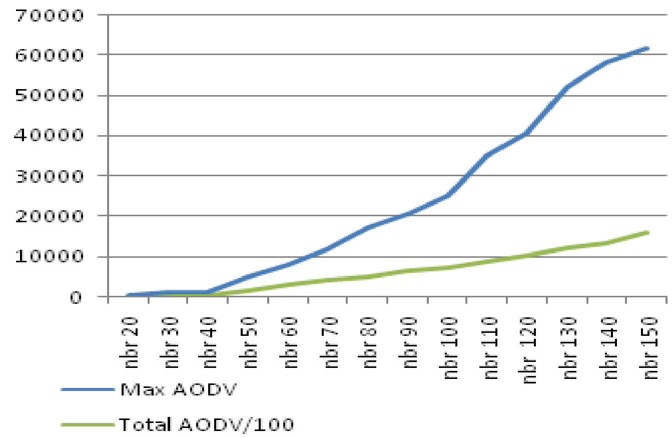

Fig. 3: Graph Total 100 lost during the simulation. The rate of frames lost due to collisions augmented with a linear function based on the number of node 50

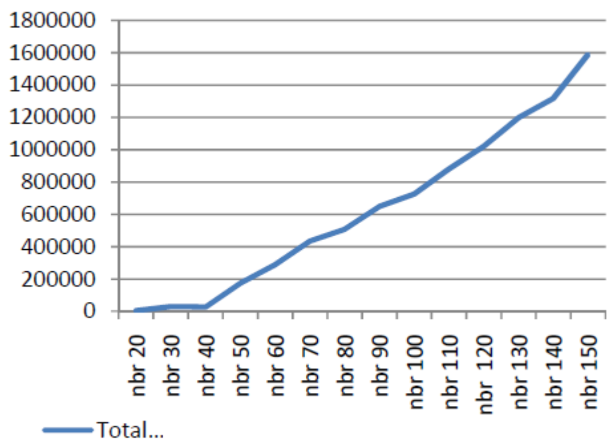

Fig. 4: Graph of the max of packet loss and average

The collision rate increases relative to the max AODV more than the average total divided by 100. Therefore, we can reduce the average packet loss if we reduce the maximum packet loss rate for each simulation.

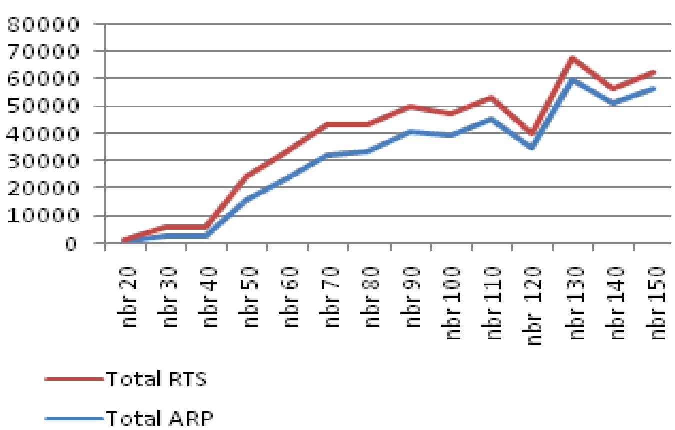

Fig. 5: Average number of packets lost during sending queries RTS/ARP

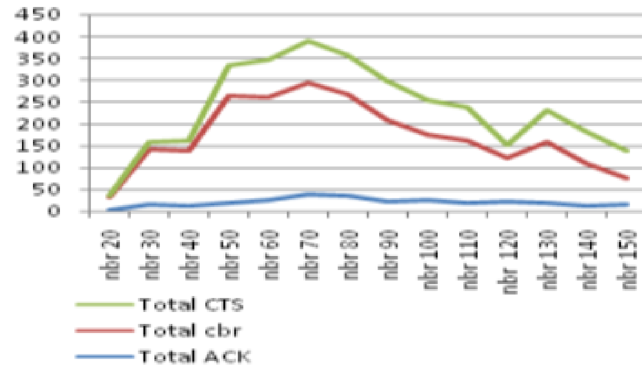

Fig. 6: Graph of the average number of packets lost during sending requests CTS/CBR/ACKII; we have a fairly high rate of packet loss between the simulations, the number of nodes is 40-120, CTS packets and CBRW are the best touch and it peaked at 70 nodes

Table 3: State of the lost packet by node number

Packet of nodes	Loss rate AODV	Loss rate RTS / ARP	Loss rate CTS / CBR	Loss rate ACK
40-120	high	high	low	low
20-40	low	low	low	low
120-150	high	high	low	low

Average time from beginning to end: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer time. It can be defined as follows:

$$D = 1/N \sum_{i=1}^{s} (ri - si)$$

Eq.3

Where N is the number of packets successfully received, I is uniquely identifying package ri is time at which a packet is received with unique id, if the time at which a packet with unique id is sent and Dest ENMS measured. It must be less for a great performance.

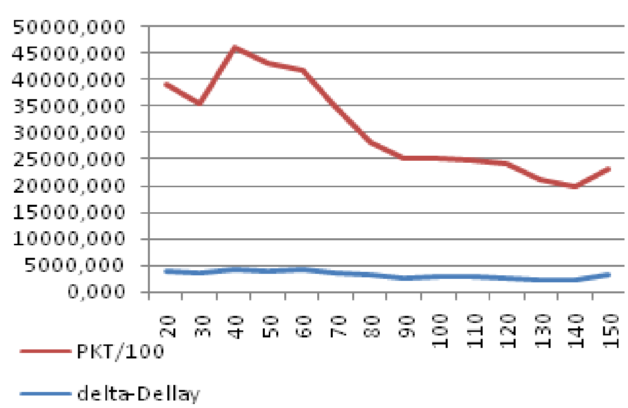

Fig. 7: Graph of the average number of packet sent and the average delay of End To End. This graph shows that the amount of packet sent and is very high in an environment of nodes between 20 and 80

Table 4: The sum of the number of packet each End to End Delay & the average number of packet sent and the average delay of End To End

Nbre Node	delta-Delay	NbrePKT Envoyé/100
20	3820,777	35461,76
30	3585,655	31733,45
40	4108,298	42039,33
50	3649,535	39344,36
60	4016,332	37658,88
70	3577,611	31267,36
80	2980,822	25202,79
90	2380,957	22869,22
100	2728,826	22306,29
110	2816,339	21868,44
120	2455,203	21523,41
130	2070,472	19169,49
140	2202,305	17546,63
150	3160,387	19995,73

Table 5: Representation of the average min / max / average consumption of energy

Nbre Node	AVG-AVG	AVG-MIN	AVG-MAX
20	819,101	629,381	2667,058
30	910,382	845,051	1867,889
40	877,821	797,638	2175,047
50	918,339	878,881	1781,484
60	917,141	881,351	1643,670
70	897,607	863,543	1812,067
80	832,959	804,557	1633,982
90	682,283	656,533	1355,083
100	635,385	614,321	1204,852
110	593,077	576,681	960,723
120	617,022	597,671	1338,882
130	538,802	522,909	1156,029
140	537,850	522,587	1185,716
150	582,440	564,281	1480,252

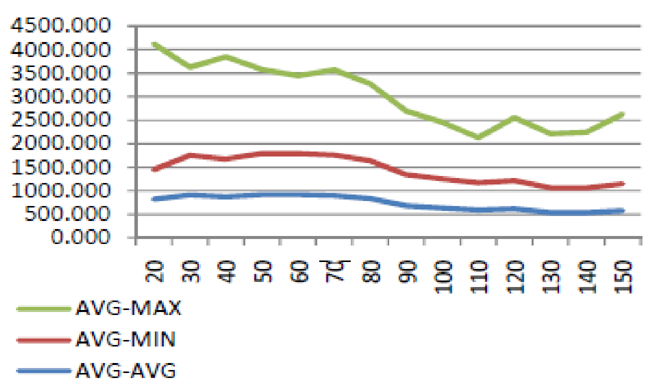

Fig. 8: Graph of the average min / max / average consumption of energy

We found that the average energy lost during the simulations using a node number between 20 and 80 is higher compared to that lost during simulations using a number of nodes between 90 and 150.

According the Fig. 8, the metric of the energy is large enough to study in such an environment where the number of node is between 20 and 90.

Table 6: Representation of the average flow during the sending and receiving

Nbre NODE	"RATE/100"	"THROUGPUT/100"
20	131666,854	15014,257
30	129097,591	26235,838
40	129588,845	24632,278
50	128889,136	27516,212
60	128677,046	30247,670
70	129321,446	27560,010
80	118851,258	22138,204
90	97609,573	17964,324
100	89693,846	16121,376
110	84630,968	15987,899
120	89990,267	16957,203
130	77597,289	15254,190
140	79567,671	14197,457
150	87838,421	12816,543

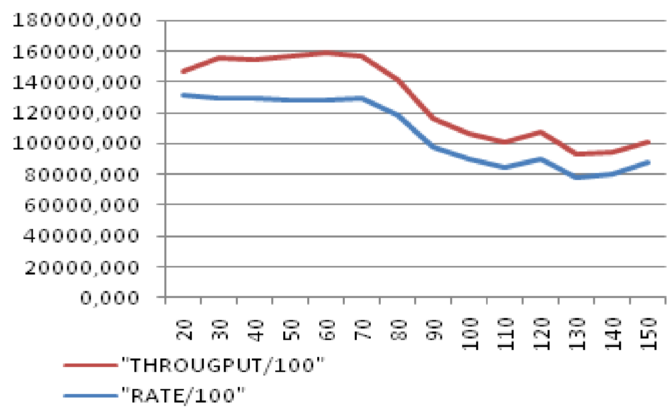

Fig. 9: graph the average flow during the sending and receiving

We note that the consumption rate for sending and receiving mobility is important in my condensed (20-90).

Challenges of MANET: The following list of challenges shows the inefficiencies and limitations that have to be overcome in a MANET environment [7]:

1- Limit wireless networks.

- ✓ Packet losses due to transmission errors [2].
- ✓ Variability of link capacity.
- ✓ Limited bandwidth.
- ✓ Disconnections / partitioning frequent
- ✓ Security (total circulation!)
- ✓ Limited wireless transmission range: [2]
- ✓ Routing Overhead

2- Due to limited mobility.

- ✓ Topology / routes dynamically changing
- ✓ Lack of recognition of mobility by applications / systems (transparency).
- ✓ Broadcast nature of the wireless medium [2], [5].
- ✓ Mobility-induced route changes [8].
- ✓ Time-varying wireless link characteristics [2].

3- Limit due to equipment / mobile computers:

- ✓ Battery life limited.
- ✓ Capacity (computing and storage) limited.
- ✓ Battery constraints [8].

IV. CONCLUSION

The figures below represent the parametric analysis of AODV routing protocol on mobility, the density variable node, the consummation of energy and packet loss caused by the phenomenon of collision.

The loss of frame (simulation nodes from 40 to 90), which is due to the collision between the nodes is caused by receptions requests like RTS / CTS to the source, once she's influence on energy consumption.

We note that, as the number of collision leads directly to energy consumption and therefore the time to wait for the destination via a path very short.

My next job is to design an algorithm that reduces the number of frames that are lost due to requests sent and received to or from the source or destination.

This future work we'll solve the energy consumed during shipping to and from the source and destination also provided a significant rate of data sent to a destination.

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