

# The Effect of the Multi-Objective Dynamic Metric on the QoS and the Energy in Networks Manets

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**Abstract**—The first aim of this article is to find a Intelligent parameter which is based on mobility and Clustering. This metric will be integrate in the selection process of MPRs to improve QoS in Manets networks. The unpredictable mobility and the large quantity of generated traffic by each node interface make communication in network increasingly difficult to manage. Thus, routing protocols need to be adapted to such conditions. In order to make OLSR protocol more robust, piercing and more adaptable to the conditions dictated by the environment of each node, this work proposes a polymorphic metric that changes depending on the network behavior. This metric aims to make the OLSR protocol best suited to each zone. The second objective of this article is to know the behavior of the new OLSR protocol version (SPEED OLSR) in environments with high mobility (pause time = 0). To know the effectivity of the speed of the parameters have several criteria. Many simulations would be undergone by NS2 to test and prove the validity of this new metric in environments with high mobility and quantity of traffic

**Keywords**—Ad hoc Network, Routing, OLSR, density, Quality of Service, Clustering, Metrics, Mobility

## 1 Introduction

The Communication in MANETs [1] (Mobile Ad hoc Network) is becoming more difficult because of the large number of nodes and their limitations in resources, unpredictable mobility, the number of interfaces per node and also the amount of traffic that is becoming increasingly important. Thus, routing protocols need to be more robust and more efficient to take into account all these changes and these new changes and constraints. One solution adopted by a vast majority of researchers is providing metrics calculated from the information extracted from the network. Then, they are introduced in the process of road construction in order to select those that best respond to a number of requirements and to improve the performance of routing protocols. But most of these metrics have the disadvantage of being standard: they use the same way of calculating

at each node and are applicable in the same way on all the nodes. Therefore, it is proposed in this work a polymorphic metric. It means a metric that changes depending on the area where it is applied. Indeed, the objective is to introduce a dynamic multi-objective metric in the routing process and more particularly in the construction process all MPRs (MultiPoint Relays) specific to OLSR [2] (Optimized link state protocol Routing). This is a metric that changes in its way of being calculated from one area to another. Thus, in this approach, our metric is calculated according to the degree of mobility and the amount of traffics for each area represented by clusters. Each representative of each zone (cluster head) will evaluate its environment depending on the speed of movement of nodes and the amount of transient traffic, and propose a different metric which should be used by the nodes in its domain. As a result, according to the information retrieved his representative, each node will decide how it will combine multiple metrics to form the method (or Advanced monocriterion) is most suited to the environmental conditions of the area to which it belongs.

## 2 Related Works

In this paper,[3] a loop may occur in the procedure of managing the topology-tree for mobility management of mobile nodes in infrastructure-based on mobile ad hoc networks. The creation of a loop degrades an effective bandwidth of the wireless network by passing an identical message repeatedly within the same loop. Thus, the loop should be resolved to restore the system to its usual state. In this work, the researcher suggests a simple and new mechanism that quickly detects and resolves a loop by tracking the depth of trees. The mobility management approach that uses the loop resolution method is evaluated comparatively with the original tree-based one and the hybrid one. It is shown that this approach is better than the other approaches, and it is strong against the rapid changes in network topology.

In this paper [4]In mobile ad hoc networks, there are numerous applications in which mobile users share information. , developing data availability is an important matter for such applications, so different studies have been done with this aim. Although, each of these conventional works assumed a particular mobility model and did not completely examine the effect of the mobility on the proposed approach. In this paper, the aim of the researcher is to measure the effects of mobility on data availability from different perspectives. They also report results of some experiments that measure the suggested metrics assuming several typical mobility models.in this work[5], the researcher studies the connectivity for large-scale clustered wireless sensor and ad hoc networks. They study the effect of mobility on the critical transmission range for asymptotic connectivity in k-hop clustered networks and compare to existing results on non-clustered stationary networks. By introducing k-hop clustering, all packets from a cluster member may be able to reach a cluster head within k hops, and thus the transmission delay is bounded as  $\Theta(1)$  for any finite k. firstly, the researcher characterizes the critical transmission range for connectivity in mobile k-hop clustered networks where all nodes move under either the random walk mobility model with nontrivial velocity or the i.i.d. mobility model. Then, they compare with the critical transmission range for stationary

k-hop clustered networks. In addition to that, the critical number of neighbors is studied in the same manner for both stationary and mobile networks. They also study the transmission power in opposition to delay tradeoff and the average energy consumption per flow among different types of networks. They demonstrate that arbitrary walk mobility with nontrivial velocities augments connectivity in k-hop clustered networks, and thus significantly decreases the energy consumption and improves the power-delay tradeoff. The decrease of energy consumption per flow is shown to be  $\Theta(\frac{\log n}{nd})$  in clustered networks. These results provide insights on network design and fundamental guidelines on building a large-scale wireless network.

This paper [6] studies a practical restricted random mobility model. For more explanation, Throughput capacity in mobile ad hoc networks has been studied extensively under many different mobility models. However, most previous researches assume global mobility, and the results show that a constant per-node throughput can be achieved at the cost of very high delay. Thus, there has been a very big gap here. In this paper [7], the researcher analyzes asymptotic delay-throughput tradeoffs in mobile ad hoc networks comprising heterogeneous nodes with restricted mobility. They show that node spatial heterogeneity has the ability to drastically improve upon existing scaling laws established under the assumption that nodes are identical and uniformly visit the entire network area.

In this paper [8] Opportunistic mobile ad hoc networks (MANETs) are a particular category of sparse and disconnected MANETs where data communication uses sporadic contact opportunities among nodes. In this work, the researcher takes into consideration opportunistic MANETs where nodes move independently at random over a square of the plane. Nodes exchange data if they are at a distance at most  $r$  within each other, where  $r > 0$  is the node transmission radius. The flooding time is the number of time-steps required to broadcast a message from a source node to every node of the network, and it's an important measure of how fast information can spread in dynamic networks. They get the first upper bound on the flooding time, which is a decreasing function of the maximal speed of the nodes.

This research [9] studies the problem of joint topology transparent scheduling (TTS) and quality-of-service (QoS) routing in ad hoc networks and presents a joint scheme for the problem. TTS is chosen as the underlying medium-access-control (MAC) protocol because of its ability to guarantee single-hop QoS support. By being built on top of TTS, this paper first designs methods for bandwidth estimation and allocation (BWE and BWA, respectively) to provide QoS support without knowledge of slot status information, and then, estimates and allocates no assigned eligible bandwidth for best effort (BE) flows. This paper suggests a QoS routing protocol for a mixture of QoS and BE flows with these bandwidth management methods.

And this paper [10] develops a theoretical model for estimating the available bandwidth of a path based on interference from both background traffic and traffic along the path. The researcher shows that the clique constraint widely used to construct upper bounds does not hold any more when links are allowed to use different rates at different time. In this model, traditional clique is coupled with rate vector to more properly characterize the conflicting relationships among links in wireless ad hoc networks where time-varying link adaption is used. They also investigate the problem of joint

optimization of QoS routing and link scheduling. Several routing metrics and a heuristic algorithm are proposed. The newly proposed conservative clique constraint performs the best among the studied metrics in estimating available bandwidth of flows with background traffic.

This paper [11] proposes a QoS-Oriented Distributed routing protocol (QOD) to enhance the QoS support capability of hybrid networks. A wireless hybrid network that integrates a mobile wireless ad hoc network (MANET) and a wireless infrastructure network has been proven to be a better alternative for the next generation wireless networks. QOD transforms the packet routing problem to a resource scheduling problem. QOD incorporates five algorithms. simulation results based on the random way-point model and the real human mobility model show that QOD can provide high QoS performance in terms of overhead, transmission delay, mobility-resilience, and scalability. The researcher in this paper [12] suggests an optimal scheduling policy which uses stream control schemes. They also present a medium access control (MAC) protocol to implement the optimal scheduling policy so as to exploit multiuser diversity and achieve QoS requirements in MIMO ad hoc networks. This paper [13] introduces two new stability-driven clustering algorithms for pseudo linear highly mobile ad hoc networks. The aim of the new algorithms is establishing stable clusters, where cluster-head reelection is reduced, and cluster membership periods are increased in the targeted system. The first algorithm is used for scenarios where the position information of nodes is not available, and the second one is aimed at scenarios where position information is available. The algorithms engage dynamic clusterhead election, and the scheme incorporates cluster maintenance to make changes in network topology as time progresses. Simulations demonstrate that the suggested clustering algorithms give highly stable clusters with several advantages over previous one-hop clustering schemes.

This paper[14] suggests a new technique of clustering for large multihop vehicular ad hoc networks. The cluster structure is decided by the geographic position of nodes and the priorities have a relation with the vehicle traffic information. Each cluster chooses one node to be its cluster head. The cluster size is controlled by a predefined maximum distance between a cluster head and its members. Clusters are separately controlled and vigorously reconfigured when nodes are moving. This paper has as aim, presenting the stability of the proposed cluster structure, and communication overhead to maintain the structure and connectivity in an application context. The simulation is performed with comparative studies using CORSIM and NS-2 simulators.

New k-hop compound metric based clustering (KCMBC) scheme is the theme of this research[15]. It uses the host connectivity and host mobility jointly to select cluster-heads. KCMBC is described as a fast convergent and load balancing clustering approach that can offer significant development on scalability for large-scale ad hoc networks. Additionally, the clusters constructed by KCMBC are more stable than many other schemes, because the host mobility has been taken into account in terms of the average link expiration time. Simulation results show that the clusters created by using the KCMBC approach keep modest but more uniform cluster size, and cluster-head lifetime can be increased by KCMBC up to 50%. In addition to that, the control overheads for cluster formation using the KCMBC scheme are kept relatively low if compared to other clustering schemes.

In this paper[16], the researcher presents a new k-hop cluster-based location service (KCLS) protocol in mobile ad hoc networks. This protocol can well balance the tradeoff between the communication overheads and the accuracy of location information. Scalability and tolerance of link breakage are extra advantages of the proposed KCLS protocol that can significantly reduce communication overheads and the latency caused by route path recovery. According to the numerical results obtained from both theoretical analysis and simulations, the cost of location management using the KCLS protocol is less than 2% of the location-management cost using the link-state protocol. Especially for a large value of k, in addition to its ability to suppress the increasing rate of the total cost when the number of hosts in the network increases, the suggested KCLS protocol increases the hit probability of location service and reduces the passive effect of host mobility on control overhead. The proposed KCLS protocol is adaptable to accommodate most applications in ad hoc networks because of its good scalability and the capability of self-discovery.

This work[17] suggests a new medium access control (MAC) protocol entitled three-phase multiple access with continual contention resolution (TPMA-CCR) for wireless multi-hop ad hoc networks. The motivation of this research is the three-phase multiple access (TPMA) scheme of Hou and Tsai, which is the appropriate MAC protocol for clustering multi-hop ad hoc networks owing to its beneficial attributes. The new TPMA-CCR allows all competing nodes participate in contentions for a medium access more aggressively than the original TPMA and with continual resolving procedures as well. Through the systematical performance analysis of the proposed protocol, it is also shown that the maximum throughput of the new protocol is not only superior to the original TPMA, but also improves on the conventional slotted carrier sense multiple accesses (CSMA) under certain circumstances. As a result, TPMA-CCR can give an attractive option to other contention-based MAC protocols for multi-hop ad hoc networks.

This research[18] presents a new Tiered Authentication scheme for Multicast traffic (TAM) for large scale dense ad-hoc networks. TAM mixes the advantages of the time asymmetry and the secret information asymmetry paradigms and uses network clustering to decrease overhead and ensure scalability. Multicast traffic within a cluster uses a one-way hash function chain in order to authenticate the message source. Cross-cluster multicast traffic contains message authentication codes (MACs) that are based on a set of keys. Every cluster utilizes a unique subset of keys to search for its distinct combination of valid MACs in the message so as to authenticate the source. The simulation and analytical results show the performance advantage of TAM in terms of bandwidth overhead and delivery delay.

This research[19] deals with key management in cluster-based mobile ad hoc networks (MANETs). Ensuring secure communication in an ad hoc network is very difficult because of the dynamic nature of the network and the lack of centralized management. Hence, key management is not easy to implement in such networks. The researcher presents a fully-distributed ID-based multiple secrets key management scheme (IMKM). This scheme is implemented via a combination of ID-based multiple secrets and threshold cryptography. It eliminates the need for certificate-based authenticated public-key distribution and gives an efficient mechanism for key update and key

revocation schemes, which leads to more suitable, economic, adaptable, scalable, and autonomous key management for mobile ad hoc networks.

This work[20] suggests the development of an improved ILP formulation of the Clustering Problem. Moreover, different enhancements are implemented in the form of extensions to the improved formulation, including the establishment of intra-cluster communication, multihop connections and the enforcement of coverage constraints. The improved formulation and enhancements are implemented in a tool designed to visually create network topologies and cluster them using state-of-the-art Generic ILP and SAT solvers. With this tool, feasibility of utilizing the suggested formulation and enhancements in a real-life practical environment is assessed. It is observed that the Generic ILP solvers, CPLEX, and SCIP, are able to deal with large network topologies, while the 0-1 SAT-based ILP solver, BSOLO, is effective at dealing with the smaller scale networks. It is also observed that while these enhanced formulations enable the generation of complex network solutions, and are suitable for small scale networks, the time taken to generate the corresponding solution does not meet the strict requirements of a practical environment.

The researcher in this paper[21] suggests an optimal asymmetric and maximized adaptive power management protocol, called OAMA, for 802.11-based clustered MANETs, which has the following attractive features. 1) Given the length of schedule repetition interval (SRI), the duty cycles of both clusterheads and members reach the theoretical minimum. 2) Under the minimum duty cycle constraints, the numbers of tunable SRIs for clusterheads and members reach the theoretical maximum. 3) By means of factor-correlative coterie-plane product, OAMA ensures bounded-time neighbor discovery between the clusterhead and its member, and between all clusterheads, regardless of stations' individual SRIs and the schedule offset between neighboring stations. 4) The time complexity of OAMA neighbor maintenance is  $O(1)$ . 5) OAMA adopts a cross-layer SRI adjustment scheme such that stations can adaptively tune the values of SRI to maximize energy conservation according to flow timeliness requirements.

This work[22] proposes a new joint clustering and multi-channel medium access control (MAC) protocol for mobile ad hoc networks, based on a scalable two-phase coding scheme. It uses the first-phase codes to differentiate the clusters and the second-phase codes for distinguishing the nodes in a specific cluster. The suggested protocol effectively integrates the procedure of code assignment with dynamic clustering and henceforth substantially decreases the control overhead of code assignment in a code division multiple access (CDMA) based multi-channel MAC protocol while simultaneously combating the hidden terminal problem. Additionally, the conflict detection and resolution mechanism for the allocation of the first-phase codes as well as the collision avoidance mechanism for the allocation of the second-phase codes in the control channel are also introduced. Analytical framework and extensive simulation results are provided and compared to the traditional distributed CDMA based multichannel MAC algorithms with or without clustering.

This paper[23] proposes an Asymmetric Cyclic Quorum (ACQ) system. The ACQ system guarantees the neighbor discovery between each member node and the clusterhead in a cluster, and between clusterheads in the network. The researcher shows that by taxing slightly more energy consumption on the clusterhead, the average energy

consumption of stations in a cluster can be reduced substantially than by traditional QPS protocols. Simulation results show that the ACQ system outperforms the previous studies up to 52% in energy efficiency. In the Prior works, there are several works that address the problem of clustering in MANETs (Ad Hoc Network). To form clusters and select cluster headers, each solution has a different criterion. In this case[24,29] it is based on the density of HELLO messages. In other words, the researcher proposes a clustering mechanism represented by a density parameter HELLO messages for each cluster. This new metric is considering in the selection process of Multipoint Relays to improve Quality of Service in Mobile Ad Hoc Networks, think that made to a new version of the protocol OLSR named Clustering OLSR

There are a lot of researches that addresses the bandwidth, among them we could cite:

This research[10], which develops a theoretical model to estimate the available bandwidth of a path taking into consideration the interference from both background traffic and traffic along the path. It shows that the clique constraint does not hold any more when links are allowed to exploit different rates at different time. In this model, traditional clique is joined with rate vector to more properly characterize the conflicting relationships among links in wireless ad hoc networks where time-varying link adaption is used. With the help of this model, the researcher studies the problem of joint optimization of QoS routing and link scheduling. Additionally, numerous routing metrics and a heuristic algorithm are suggested. The last proposed conservative clique constraint performs the best among the studied metrics in guessing available bandwidth of flows with background traffic.

With the analysis of research that addresses the various constraints and MANETs network problems such as: bandwidth, clustering technique, and mobility. For that, our work seeks a dynamic parameter that will represent these problems, in order to inject this new parameter in the MPRs selection process so as to improve the quality of service in the MANETs.

### **3 Our Contribution**

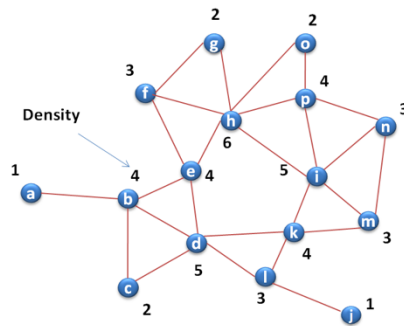
In addition to limited bandwidth, restricted capacity energetic, low security, disorder and high number of nodes are source of many other problems, specially, in networks with high mobility where nodes position changes all the time. To better manage density, improve QoS and enhance the routing performances, we are seeking in this paper to organize the MANET by using the clustering technique based on the density of nodes neighboring. Thus, in our approach, we focus, first, on the network distribution into clusters by choosing, at any time, the most representative node as a representative of each cluster. It is defined based on the density of its neighborhood. Then, each cluster head evaluate the degree of mobility of the neighborhood by calculating the average speed of all the nodes belonging to its cluster based on their speed of movement. Furthermore, the average speed of each cluster head evaluates the amount of data traffic exchanged in its neighborhood and passed it. Of this information, the next step is to

send a different code for each cluster head to inform its neighboring nodes of the metric should be used.

### 3.1 Clusters creation:

For the construction of clusters and as shown in Figure 1, Table 1, and Figure 2, the most important steps of the algorithm adopted in this respect are the following:

- Calculating the neighborhood density of each node.
- Choosing as head of the cluster, the node that has the largest density.

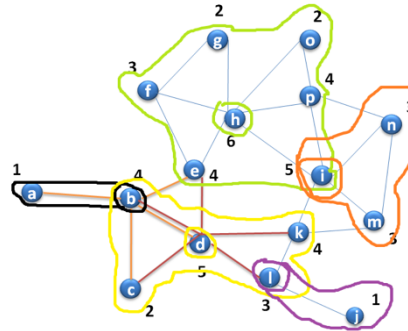


**Fig. 1.** Cluster head selection and Clusters formation (Nodes and their neighborhood density)

**Table 1.** Selected Cluster heads (candidate cluster head Nodes and their density)

Ni	Nbr-set	D	CH	CH_D
A	b1	1	b	4
B	a1, c2, e4, d5	4	d	5
C	b4, d5	2	d	5
D	b4, c2, e4, l3, k4	5	d	5
E	b2, d5, f3, h6	4	h	6
F	e4, h6, g2	3	h	6
G	e4, f3, h6	2	h	6
H	e4, f3, g2, o2, p4, i5	6	h	5
I	h6, k4, m3, n3, p4	5	h	6
J	l3	1	l	3
K	d5, l3, m3, i5	4	d	5
L	d5, k4, j1	3	d	5
M	i5, k4, n3	3	i	5
N	m3, i5, p4	3	i	5
O	p4, h6	2	h	6
P	h6, i5, n3, p4	4	h	6





**Fig. 2.** Cluster head selection and Clusters formation (Clusters construction and cluster head)

**Evaluation of the clusters environment:** To calculate the degree of mobility of the neighborhood, each cluster head computes the average moving speed of the nodes belonging to its neighborhood. If this value is greater than a given threshold (defined as a percentage of the average of all the average speeds calculated by each cluster head), a code is sent to force all nodes belonging to this cluster to consider mobility building as multi-objective metric. Mobility is calculated using the metric speed mobility [28] calculated by Equation 1 It has the advantage to combine the changes undergone by the neighborhood of a node in its speed.

$$mob(t) = \frac{OUT+IN}{nf} * (t) \tag{1}$$

Or:

**IN:** The number of nodes used in a neighborhood.

**OUT:** The out number of nodes in a neighborhood.

**nf:** The number of simulation nodes

**Calculation of each cluster metric:** To evaluate the amount of traffic transient data in the cluster, each cluster head calculates the sum of the amount of traffic of neighboring nodes and through Him for a time. He then divides the value of the largest amount of recorded from all nodes in the network traffic. In effect, Equation 2 shows how the head cluster node evaluates the degree of shared data about its neighborhood.

$$traf(t + \Delta t) = \frac{\sum_{\Delta t} Traffic\_Quantity}{Max\_Traffic\_Quantit} \tag{2}$$

This is the case that the mobility of the neighborhood, if the value of  $traf(t+\Delta t)$  is greater than a given threshold, a different code is sent to force all nodes of this cluster belonging to take into account the available bandwidth [25] in the construction of our multi-objective metrics. It is noted that the available bandwidth is calculated by the following equation:

$$ABW_t = (1 - \bar{u}_t) B \tag{2}$$

With the average utilization of a link is:

$$\bar{u}_i = \frac{1}{T} \int_{t-T}^t S_i(t) dt \tag{3}$$

The state of a given link at time  $t$  is:

$$S_i(t) = \begin{cases} 0, & \text{link is id} \\ 1, & \text{link is bu} \end{cases} \tag{4}$$

Bandwidth of link.

$$BW = \frac{L}{t_q + (t_s + t_{CA} + t_{over}) \times R + \sum_{r=1}^R B_r} \tag{5}$$

Knowing that  $t_q$  is the Mac layer queuing time,  $t_s$  is the transmission time of the  $L$  bits,  $t_{CA}$  is the collision avoidance phase time,  $t_{over}$  is the control overhead time such as *ACK*, *RTS/CTS* etc.,  $R$  is the necessary retransmissions and  $B_r$  the back-off time for a retransmission  $r$ .

**Construction of a multi-objective dynamic metric:** After receiving the codes defining the metric used to their heads of clusters, each node builds a multi-objective metrics to the values received. The following algorithm shows the response of each node in the network.

Depending on the value of the received code with his head cluster to which it belongs:

If set to 0: the degree of mobility and the amount of traffic both remain below predefined thresholds. While no metric is used and it is the behavior of the standard OLSR protocol to be used in the construction of all MPR.

If equal to 1: this means that the degree of mobility in the cluster remains below. Thus, it is only the available bandwidth metric that will be used in our dynamic metric and then can be introduced in the construction of all MPRs in OLSR.

If equal to 2: This is the reverse of the previous case. Indeed, the amount of traffic and it is still below the level of mobility neighborhood metric calculated by the speed of mobility that will be considered in the construction of our dynamic metric.

If equal to 3: it means that the degree of mobility and the amount of traffic are both higher in the cluster governed by the head that sent the code. Thus, the speed of mobility and bandwidth to be used in our multi-objective metrics.

The following figure (Figure 3) shows more about the principle of calculating this new metric.

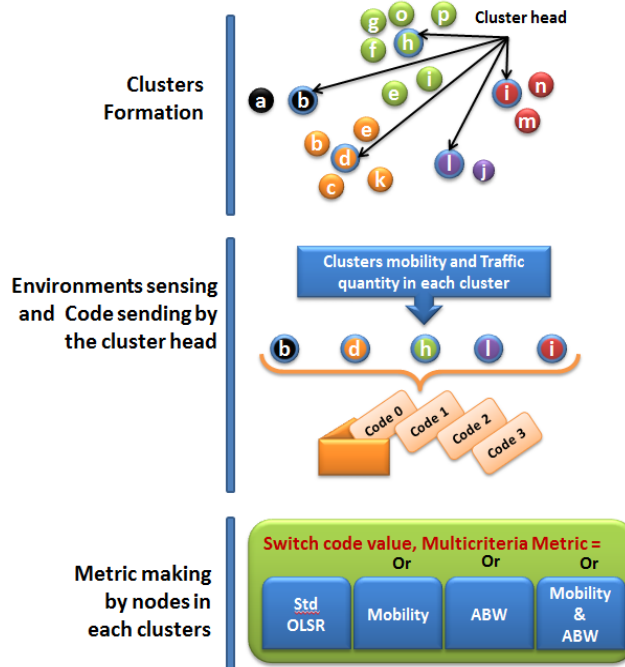


Fig. 3. Multi-objective metric computation process.

## 4 Simulations and Results

### 4.1 In the simulation environment

NS2 (Network Simulator)[26, 27] is a network simulation software implemented in C++ and has an interface OTCL (Object Tool Command Language). It is characterized by the availability of its source code (open source) which makes changes and the addition of new performance. The NS2 simulator has a very wide range of tools for the study of a large number of protocols from different layers of the network architecture (routing protocol, transport protocols, etc.). It has also mechanisms to integrate and manage the nodes mobility in the court's time. In our study, we used a standard version of OLSR[2] for NS2 developed by MASIMUM organization (MANET Simulation and Implementation at the University of Murcia) that we have integrated into NS2 (version 2.35) and we amended by taking into account the density metric and obtain the Clustering OLSR.

In the Simulations Parameters definition, our networks consist of 100 mobile nodes distributed in an area of 1000 x 1000 m. Each node moves according to the RWP mobility model (Random Way Point) with a no pause time (0 seconds) and a max speed

varied between 5m/s and 30 m/s. The scenario that defines the movement of nodes is changed for all simulations. In each simulation, 30 nodes were randomly selected to be sources of CBR traffic (Constant Bit Rate) on UDP (User Datagram Protocol) connections. Communications were made by sending packets with 512-bytes every 2.5 seconds the table II below summarize all pertinent parameters used in all simulations.

**Table 2.** Simulation Parameters

Parameter	Values
Simulation Time	300 s
Network area	1000 m x 1000 m
Node Numbers	100
Mobility Model	RWP (Random Way Point)
Pause Time	0 s
Maximum Speed	5, 10, 15, 20, 25 and 30 m/s
Traffic Type	CBR
Packet Size	512 B
Rate	2,5 S
Connection Numbers	30

## 4.2 Results

The main purpose of those experiments made with the NS2 simulator is to analyze the performance of standard routing protocols OLSR and our version Clustering OLSR according to performance indicators. We will start with the results that represent the successful packet delivery ratio depending on the density for different value of the speed.

### Studies of clusters:

*The lifetime of clusters:* This parameter represents the time interval during which the cluster exists. As this term is large, clusters are stable and last longer.

We can say that the system may become unstable after receiving several HELLOs messages. A node can change its state each time that the density of the received message is greater than its own density. This may give some instability in the system clustering. For a node remains in its state decided (head or member of clustering) for longer than the transmission interval of a HELLO message. The period we have undertaken for the simulations is equal to three times the emission HELLOs messages interval. This duration which we call interval clustering is the interval at which each node starts calculating, stocking and symbolizing the minimum lifetime of a cluster.

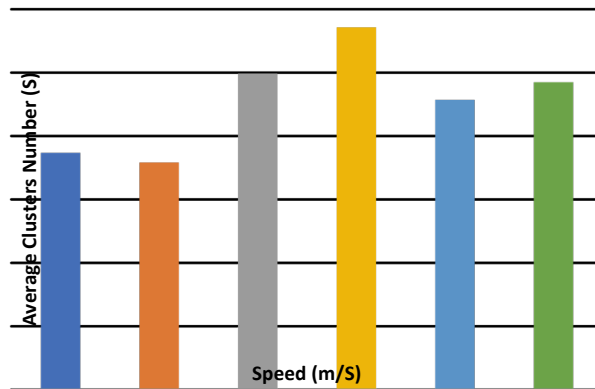


Fig. 4. The number of formed clusters.

The average number of clusters formed (Figure 9) during the entire simulation time is in most cases between 11 and 7. Given that the total number of nodes used for simulation is 100, then the number of valid built clusters stays (acceptable) and indicates that we have a good crawling nodes on which to rely.

### 4.3 The successful packet delivery ratio (PDR)

As a definition to the PDR, it is the total number of data packets successfully delivered and divided by the total number of data packets transmitted in the network. This metric gives an idea of the guarantees of the protocol in terms of packet delivery (Figure 4).

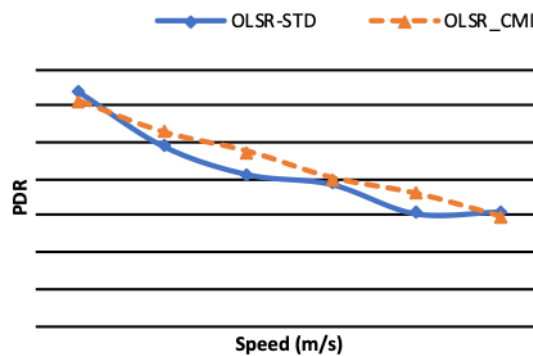


Fig. 5. PDR depending on the nodes speed (m/s)

For the majority of speeds we notice that the curve of the OLSR\_CMI is below the standard version of OLSR Protocol, so it is important to mention that the OLSR\_CMI

protocol performs well in comparison with the standard OLSR protocol. Thus, this metric shows that our protocol OLSR\_CMI gives us a very favorable result on the reliability of data in terms of guarantees packet delivery. So our protocol is more suitable for all levels of mobility 5m / s (environment with less mobility) at 30m / s (environment with very high mobility).

#### 4.4 The Throughput

As definition to the Throughput, it is the volume or quantity (per unit time) of in-bound on a communication channel data.

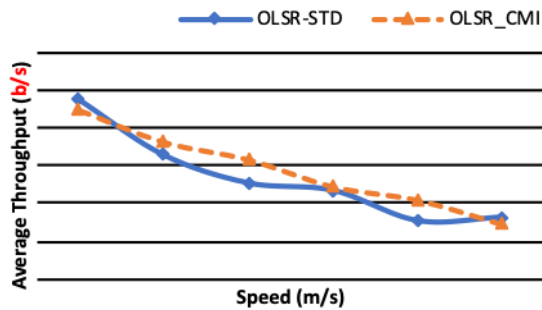


Fig. 6. Throughput depending on the nodes speed (m/s)

In Figure 6 we observe the behavior of the average flow rate versus Speed of nodes in the network. We note that the new version of OLSR provides better than that offered by the standard rate.

#### 4.5 The average Delay

This is the average time for data packets transmitted from source to destination.

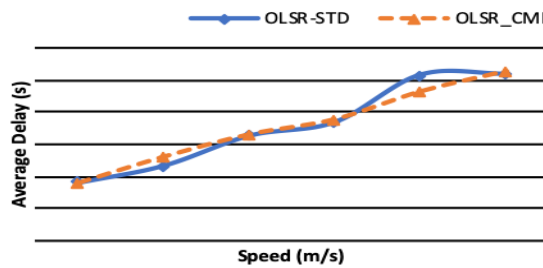


Fig. 7. Average Delay depending on the nodes speed (m/s)

This curve (7) shows the average propagation delay of messages based on the speed of the nodes in the network. For moderately mobile and mobile environments, we find that the delay OLSR\_CMI protocol is improved compared to the other version of the protocol (standard). This proves that our version gives a change in transmission delays and especially in environments that are characterized by more agitation nodes.

#### 4.6 The successful packet delivery ratio (PDR) of speed OLSR

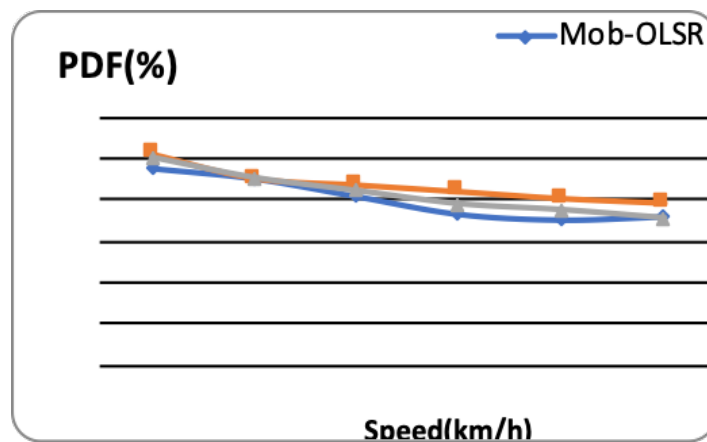


Fig. 8. PDR depending on the nodes speed (Km/h)

Fig. 8 illustrates the performance indicator (pdf) evolution for the speed values 40, 60, 80, 100, 120 and 140 km / h. For each value of the speed, the Performance of the modified protocol with those recorded by the standard protocol OLSR and Mob OLSR

In addition, we can say that Speed OLSR behaves well in terms of PDF, compared to the other proposed protocols (MobOLSR and OLSR) for all The maximum speeds. Precisely 120 and 140km / h.

We notice that Speed OLSR behaves better than MobOLSR and OLSR. Therefore Speed OLSR is more suitable for environments with high mobility (pause time = 0).

#### *The energy consumption of the new version of the OLSR protocol (Speed OLSR)*

Exhaustion of node batteries during operation has adverse effects on optimal network performance. Thus, a MANET should reduce unnecessary or excessive power consumption in order to extend the service life of the network (figure 9).

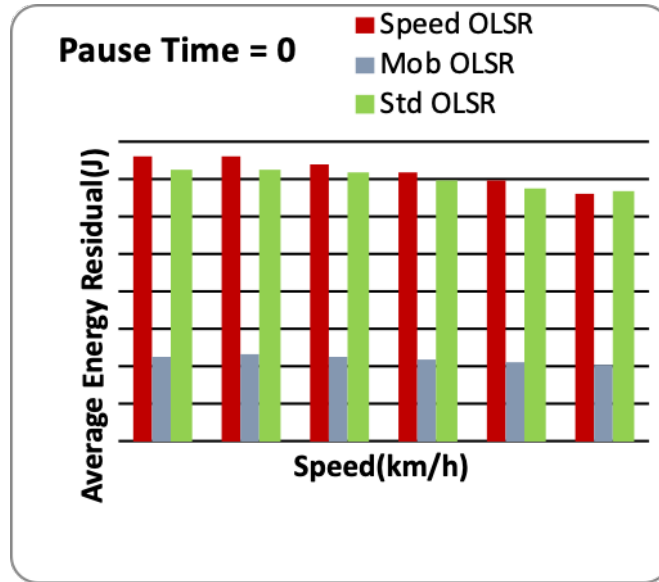


Fig. 9. Average Energy Residual(J) depending on the nodes speed (Km/h)

We observe, for all the higher values of the speed and especially 100 120 and 140 km / h that the energy consumed by our version (Speed OLSR) is more optimized compared to the other version of the protocol OLSR.

## 5 Conclusion

The objective of this article is the combination between a clustering technique, a metric for calculating the mobility and another metric to measure the amount of traffic carried in the neighborhood to be able to implement a multi-objective metrics and polymorphic.

The implied physical difficulties of real experiments are still the cause of restrictions on the NS2 simulator. Thus, simulations nevertheless allow to clearly show the gain provided by our approach. Indeed, the improvements (shown by the simulation results compared to the standard version) are saved when it was decided to choose to develop a new version of OLSR that takes into account parameters of mobility and amount of traffics allowed to confirm better adaptation in any mobile ad hoc environment of our metric. In summary, the simulation results show that the modified protocol OLSR\_CMI provides good performance compared to the standard version of OLSR, for the majority of speed values. The simulations show that as well OLSR\_CMI managed to achieve better adaptations in any environment.

The integration of speed in the measurement of mobility gives a great improvement of the OLSR Protocol, whether at the level of energy consumption or at the level of PDF (The rate of successful packet delivery), then the new version of OLSR speed has



a better performance especially in environments with high mobility (pause time = 0), which makes the speed among the most intelligent parameters. Therefore the integration of the speed in the multi-objective metric is more efficient.

As perspectives, in OLSR, building clusters can be extended to reach the second neighborhood of nodes. , In addition to the speed of mobility of the neighborhood and the bandwidth available, the multi-objective metrics may be enhanced by other metrics such as those used by other OLSR (OLSR-ETX, ETT-OLSR protocol, etc) or new metrics.

## 6 References

- [1] J Ferronato, M Antonio and STrentin, Analysis of Routing Protocols OLSR, AODV and ZRP in Real Urban Vehicular Scenario with Density Variation, IEEE Latin America Transactions, Volume: 15, Issue: 9 Pages: 1727-1734, 2017. <https://doi.org/10.1109/tla.2017.8015079>
- [2] Optimized Link State Routing Protocol (OLSR): RFC Editor, 2003.
- [3] H. Trung-Dinh and O. Hoon, "A looping problem in the tree-based mobility management for mobile IP supported ad hoc networks," Communications and Networks, Journal of, vol. 13, pp. 385-392, 2011. <https://doi.org/10.1109/jcn.2011.6157458>
- [4] L Rivoirard, M Wahl, P Sondi, M Berbineau and D Gruyer, Performance evaluation of AODV, DSR, GRP and OLSR for VANET with real-world trajectories, 15th International Conference on ITS Telecommunications (ITST) 2017. <https://doi.org/10.1109/itst.2017.7972224>
- [5] W. Xinbing, L. Xiaojun, W. Qingsi, and L. Wentao, "Mobility Increases the Connectivity of Wireless Networks," Networking, IEEE/ACM Transactions on, vol. 21, pp. 440-454, 2013.
- [6] L. Pan, F. Yuguang, L. Jie, and H. XiaoXia, "Smooth Trade-Offs between Throughput and Delay in Mobile Ad Hoc Networks," Mobile Computing, IEEE Transactions on, vol. 11, pp. 427-438, 2012. <https://doi.org/10.1109/tmc.2011.54>
- [7] M Alshamrani, H Cruickshank, Z Sun and B Elmasri; Vahid Fami, Evaluation of SIP Signalling and QoS for VoIP over OLSR MANET Routing Protocol 2013 UKSim 15th International Conference on Computer Modelling and Simulation. <https://doi.org/10.1109/uksim.2013.89>
- [8] A. Clementi, F. Pasquale, and R. Silvestri, "Opportunistic MANETs: Mobility Can Make Up for Low Transmission Power," Networking, IEEE/ACM Transactions on, vol. 21, pp. 610-620, 2013. <https://doi.org/10.1109/tnet.2012.2204407>
- [9] S. Yi-Sheng, S. Szu-Lin, and L. Jung-Shian, "Joint Topology-Transparent Scheduling and QoS Routing in Ad Hoc Networks," Vehicular Technology, IEEE Transactions on, vol. 63, pp. 372-389, 2014. <https://doi.org/10.1109/tvt.2013.2274806>
- [10] C. Feng, Z. Hongqiang, and F. Yuguang, "Available bandwidth in multirate and multihop wireless ad hoc networks," Selected Areas in Communications, IEEE Journal on, vol. 28, pp. 299-307, 2010. <https://doi.org/10.1109/jsac.2010.100402>
- [11] L. Ze and S. Haiying, "A QoS-Oriented Distributed Routing Protocol for Hybrid Wireless Networks," Mobile Computing, IEEE Transactions on, vol. 13, pp. 693-708, 2014. <https://doi.org/10.1109/tmc.2012.258>
- [12] Z. Jialing and M. Maode, "QoS-aware cooperative medium access control for MIMO ad-hoc networks," Communications Letters, IEEE, vol. 14, pp. 48-50, 2010. <https://doi.org/10.1109/lcomm.2010.01.091549>

- [13] F Semchedine, A Moussaoui, K Zouaoui and S Mehamel, CRY OLSR: Crypto Optimized Link State Routing for MANET 2016 5th International Conference on Multimedia Computing and Systems (ICMCS). <https://doi.org/10.1109/icmcs.2016.7905578>
- [14] W. Zhigang, L. Lichuan, Z. MengChu, and N. Ansari, "A Position-Based Clustering Technique for Ad Hoc Intervehicle Communication," *Systems, Man, and Cybernetics, Part C: Applications and Reviews*, IEEE Transactions on, vol. 38, pp. 201-208, 2008. <https://doi.org/10.1109/tsmcc.2007.913917>
- [15] L. Supeng, Z. Yan, C. Hsiao-Hwa, Z. Liren, and L. Ke, "A novel k-hop Compound Metric Based Clustering scheme for ad hoc wireless networks," *Wireless Communications, IEEE Transactions on*, vol. 8, pp. 367-375, 2009. <https://doi.org/10.1109/icc.2005.1495051>
- [16] N Patel and R Patel, Optimizing Performance of OLSR Protocol Using Energy Based MPR Selection in MANET Sefali Prajapati; 2015 Fifth International Conference on Communication Systems and Network Technologies. <https://doi.org/10.1109/csnt.2015.280>
- [17] C. Yeongyoon and A. Nosratinia, "Analysis of three-phase multiple access with continual contention resolution (TPMA-CCR) for wireless multi-hop ad hoc networks," *Communications and Networks, Journal of*, vol. 13, pp. 43-49, 2011. <https://doi.org/10.1109/jcn.2011.6157250>
- [18] M. Younis, O. Farrag, and B. Althouse, "TAM: A Tiered Authentication of Multicast Protocol for Ad-Hoc Networks," *Network and Service Management, IEEE Transactions on*, vol. 9, pp. 100-113, 2012. <https://doi.org/10.1109/tmsm.2011.113011.100139>
- [19] L. Lung-Chung and L. Ru-Sheng, "Securing Cluster-Based Ad Hoc Networks with Distributed Authorities," *Wireless Communications, IEEE Transactions on*, vol. 9, pp. 3072-3081, 2010. <https://doi.org/10.1109/twc.2010.080610.090759>
- [20] S. Z. H. Zahidi, F. Aloul, A. Sagahyroon, and W. El-Hajj, "Optimizing Complex Cluster Formation in MANETs Using SAT/ILP Techniques," *Sensors Journal, IEEE*, vol. 13, pp. 2400-2412, 2013. <https://doi.org/10.1109/jsen.2013.2254234>
- [21] C. Zi-Tsan, L. Yu-Hsiang, and J. Rong-Hong, "Optimal Asymmetric and Maximized Adaptive Power Management Protocols for Clustered Ad Hoc Wireless Networks," *Parallel and Distributed Systems, IEEE Transactions on*, vol. 22, pp. 1961-1968, 2011. <https://doi.org/10.1109/tpds.2011.92>
- [22] Z. Lili, S. Boon-Hee, and X. Wendong, "An Integrated Cluster-Based Multi-Channel MAC Protocol for Mobile Ad Hoc Networks," *Wireless Communications, IEEE Transactions on*, vol. 6, pp. 3964-3974, 2007. <https://doi.org/10.1109/twc.2007.06038>
- [23] W. Shan-Hung, C. Chung-Min, and C. Ming-Syan, "Collaborative Wakeup in Clustered Ad Hoc Networks," *Selected Areas in Communications, IEEE Journal on*, vol. 29, pp. 1585-1594, 2011. <https://doi.org/10.1109/jsac.2011.110908>
- [24] N. Lakki, A. Habbani, and J. E. Abbad, "QoS and Energy with Clustering in MANETs," *Far East Journal of Electronics and Communications*, vol. 13, pp. 1-16, 2014.
- [25] A. Moussaoui, A. Boukeream, "A survey of routing protocols based on link-stability in mobile ad hoc networks", *Journal of Network and Computer Applications*, vol. 47, pp. 1-10, 2015. <https://doi.org/10.1016/j.jnca.2014.09.007>
- [26] K. F. a. K. Varadhan, *The ns Manual: The VINT Project*, UC Berkeley, LBL, USC/ISI, and Xerox PARC, 2010
- [27] T. Issariyakul and E. Hossain, *Introduction to Network Simulator NS2*: Springer US, 2009.
- [28] Lakki N., Ouacha A., Habbani A. And El Abbad J. "The Integration of the Speed of Mobility in the Selection of MPR to Improve the QoS in Ad Hoc Networks" *Journal of Theoretical and Applied Information Technology (JATIT)*. February 2012. Vol. 36 No.2 [http://www.jatit.org/volumes/Vol36No2/thirtysixth\\_volume\\_2\\_2012.php](http://www.jatit.org/volumes/Vol36No2/thirtysixth_volume_2_2012.php).

- [29] Lakki N., Ouacha A., Habbani A. And El Abbadi J. "New Metric Density Based on the Clustering for the Improvement of Quality of Service in Manet" *Advances in information Sciences and Service Sciences(AISS)* Volume6, Number1, February 2014.

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