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Performance Analysis of V-AODV Routing Protocol for Intelligent Transportation System

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ABSTRACT: Vehicular Ad hoc Network (VANET) is a particular class of Mobile Ad hoc Network (MANET) where vehicles are taken as MANET nodes with wireless connections. The design of effective routing protocols in Vehicular routing protocols is a main problem for supporting the smart Intelligent Transportation System ITS. Available MANET routing protocols are not appropriate for VANET. In this paper we measure V-AODV a extended version of AODV (Ad-hoc On-demand Distance Vector) particularly produced for Vehicular Ad-hoc networks (VANETs). V-AODV is planned to operate with a complicated cross layered metric depending on both Bit Error Rate (BER) and delay from node to node coming from the physical layer. We also indicate that when utilizing a routing metric depending on BER and delay, the first parameter is more concerned in terms of QoS as compared to the second one.

KEYWORDS: VANETs, Realistic Propagation models, QoS, AODV

I. INTRODUCTION

Wireless communications between vehicles achieve the concentration of research in both of the automobile industry and academic research community. Many vehicles manufacturers have fitted their novel vehicles with global positioning systems (GPS), wireless interfaces. In addition to, in 1999, the US Federal Communications Commission (FCC) assigned 75 MHz of spectrum at 5.9 MHz to be utilized by DSRC (Dedicated Short Range Communications). DSRC is a short to medium range interaction facility that was formulated to support vehicle-to-roadside and vehicle-to-vehicle communications. These communications deal with a broad range of applications, involving traffic information, vehicle-to-vehicle safety messages, drive-through payment, toll collection and many others. DSRC is targeted at offering low communication latency and high data transfers in small communication zones. IEEE is also operating on the IEEE 1609 family of standards for wireless access in vehicular environments (WAVE), which describe architecture and a standardized, complementary collection of interfaces and services that collectively enable protected vehicle-to infrastructure (V2I) and vehicle to vehicle (V2V) wireless.

The primary objective of VANET is offering comfort and safety for travellers. Besides safety applications VANET also offer comfort applications to the road subscribers. For instance: mobile e-commerce, weather information, Internet access and other multimedia applications. VANET and MANET are featured by the self-organization and movement of nodes. The main difference of MANET and VANET is the specific mobility pattern and frequently changeable configuration of VANET. Also, MANET nodes cannot recharge their battery power where VANET has no power restraint for nodes. Because of particular features of VANETs, conventional routing protocols in wireless ad hoc networks may not be appropriate for vehicular interactions. The design of efficient vehicular interactions poses a series of technical issues. Ensuring a reliable and stable routing technique over VANETs is a significant step toward the realization of efficient vehicular communications. One of the serious problems contains the design of scalable routing algorithms that are robust to quick path interruptions caused by vehicles mobility. Available routing protocols, which are conventionally planned for MANET, do not make usage of the unique features of VANETs and are not appropriate for vehicle-to-vehicle communications throughout VANETs. Configuration based and position-based routing are two techniques of data forwarding generally followed for multi-hop wireless networks [1], [2]. Topology-based protocols utilize the information of existed network connections for packet transmission. Each node has to manage the routing table. Position-based protocols consider that each node is known of the location of itself, the location of the destination node and the location of neighboring nodes. With the increasing existence of GPS fitted vehicles, Position based

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Protocol is becoming more comfort. Since, the position-based protocols formulated for MANETs may not directly be used to vehicular atmosphere, because of the unique vehicular network features. One good way of data transmitting in VANET is to change MANET routing protocols and build it appropriate for vehicular atmosphere. There are several routing protocols for ad hoc networks [3], [4], [5]. One of the most well-famous is AODV [6], [7], [8], [9]. Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) protocol is an extended version of AODV protocol for calculating multiple loop-free and connection disjoint paths [10]. SD-AOMDV is an effective AOMDV-based VANET routing protocol with good average packet delivery fraction and delay [11].

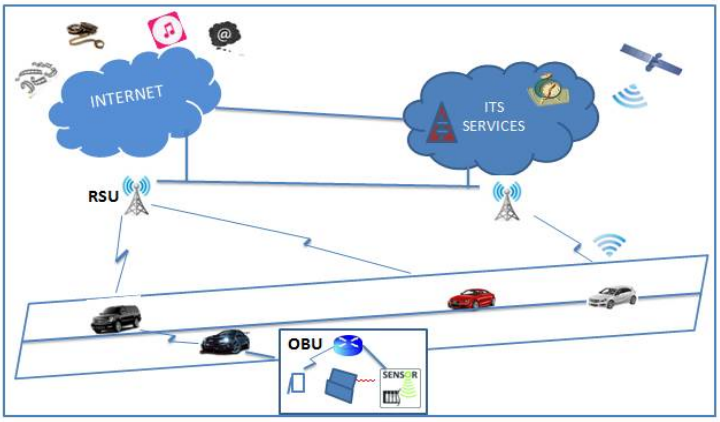

Figure 1: Vehicular Ad Hoc Network

But if there is no suitable radio connection, which can be viewed as a common resource in a *provided* neighbourhood, no interaction can occur. Time variation, fading, nodes mobility and multi-path impacts lead to rapid broken routes, particularly in the existence of high mobility nodes. Accordingly, offering end-to-end QoS support guarantee is even more challenging, because in a high speed mobility context, several data packets are dropped and the failure notifications together with the overhead because of route repairs increase importantly.

To take these two points together, we introduce VAODV, an improvement to the AODV routing protocol for VANETs. V-AODV can be viewed as a cross layer operating between the network layers and PHY layers. In VAODV we utilize a metric depending on the radio connection quality information integrated with delay information which is, as prior talked about, most relevant in the propagation of safety messages. Another significant point of this work is the usage of a realistic propagation model.

Taking into consideration of these elements in VANETMOBISIM based simulations, permits us to validate our method by indicating how our novel metric enhances the end to end delay and packet drop in realistic situations.

The remaining paper is presented as follows. Section II shows the realistic channel model we utilize for validation of the introduced improved routing protocol. In Section III we explain the improvements brought by the V-AODV routing protocol. Section IV shows to the performance measurements of V-AODV. At last Section V concludes the paper and highlights concepts for future work.

II. A REALISTIC PROPAGATION MODEL FOR VANETS

Numerous researchers in the area of wireless networking utilize the network simulator VANETMOBISIM for the measurement and validation of their routing protocols. Since, it is known that VANETMOBISIM does not model perfectly the radio propagation channel [4]. In fact, VANETMOBISIM Radio Propagation Models (RPM) do not permit describing complex atmospheres as such containing obstacles. This characteristic is however a serious problem in the VANETs. Besides the very simplistic RPMs conducted in VANETMOBISIM, the error model utilized by this network modeller is also a significant problem. In fact, the native VANETMOBISIM error model only examines if the obtained power of a packet is below or above the recipients threshold.

For overcoming the above specified restrictions we have combined into VANETMOBISIM a realistic RPM known as Communication Ray Tracer (CRT) which has been formulated at the SIC-XLIM laboratory [7]. This RPM depends on a ray-tracing technique and permits to model very accurately the propagation techniques included in a realistic atmosphere explained by a scene like the one depicted in Fig 1.

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III. ROUTING IN AODV

The deficiency of resources in VANETs has made the QoS routing technique a challenging issue. To overcome this issue, a simple and effective routing technique is needed to maintain the resource requests, while simultaneously it has to be adaptable to the rapid changing configuration conditions.
However, VANET communications should support minimum two types of messages, such as Alert and Comfort messages, the QoS routing require to offers minimum two levels of QoS to applications. The first level handles released parameters and the second deals with strained parameters. In the condition of the latter level, a mechanism is needed to offer link control to new flows by predicting their effect on the QoS of the flows already working in the network.

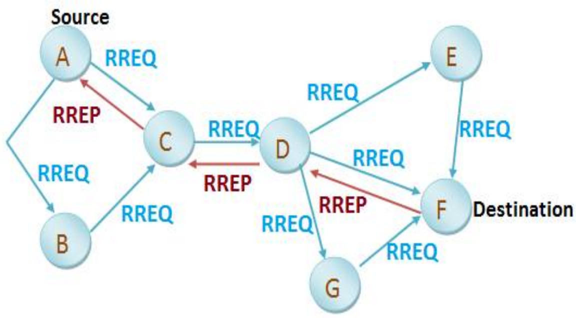

Figure: Route Discovery in AODV

A VANET can be simulated as an undirected graph *G(V,E)*, where *V* is the collection of nodes, and *E* is the set of connections. Inspired by the *coloured* sub-graphs formulation shown in [8], we divide every connection to sub-connections presented by elementary cost function for QoS metrics (such as delay, bandwidth, bit error rate (BER), energy, security, packet loss probability etc.) In this paper, we only concentrate on BER and delay parameters. In the future, we plan to analyse other metrics i.e. jitter, delay, security and packet loss probability.
Evaluating end-to-end delay in a VANET is very complicated because of the unsynchronized behaviour of the network. In V-AODV we utilize the "Hello" messages to evaluate the delay required to arrive every neighbour. By mean of this, we make existed a cross matrix of the network configuration consisting every node to neighbour delays. These computed delays show the Round Trip Time (RTT) between the node originator of the Hello message and their neighbours returning acknowledgements. Hence, the delay cost function of a provided node "i" can be shown as follow:

IV. PERFORMANCE METRICES OF AODV

To measure the performance of SW-AOMDV related to AOMDV and SD-AOMDV, we evaluate the following performance metrics: packet delivery fraction, end-to-end delay and normalized routing load against packet rate.
Normalized Routing load (NRL): ratio of total no. of routing control packets to the total no. of data packet obtained.
End to end delay: average delay in obtaining data packets created by all traffic sources. This involves all possible delays caused by retransmission delays at the MAC, storing ate time of route discovery, queuing delay at the interface, propagation and transfer times.
Packet delivery ratio (PDF): ratio of total no. of data packets obtained to the total no. of data packets forwarded by all traffic sources.

V. CONFIGURATION

VanetMobisim [17] is a legal vehicular traffic generator. Manhattan is utilized as Mobility Model. 802.11 is utilized as MAC layer protocol with transmission coverage range of 250 m of every node. Traffic pattern contains 20 CBR/UDP links between randomly selected source-destination pairs and Packet size of 512 Bytes. We take a square region of 4000 x 4000 m with 80 nodes for 1800 s simulation time. Vehicles speeds are changing from 10km/h to 90 km/h. in comparison of the routing performance with various traffic loads, packet generation rate is adjusted to 1 packet/s, 2

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packet/s, 4 packet/s, and 8 packet/s, respectively. The simulation results are averaged over five simulation runs. A mobility snapshot is depicted in Figure 1.

VI. V-AODV

The CRT RPM combined into VANETMOBISIM permits us to utilize either VANETMOBISIM built-in free space propagation atmosphere or realistic propagation atmosphere and, when required, to calculate the BER between two nodes. All simulations were carried out in an 1122 square meter region showing the core of the city of Munich (Germany) with streets and building. In this region 10 mobile nodes are moving. The nodes motion speed is adjusted to 4m/s. Hello messages are forwarded approximately each second by all nodes. At the time of the simulation three communications are organized. These communications, which are video flows, occurs in a first simulation set between randomly selected nodes and in a second set between static nodes. The data rate of these video flows is adjusted to a 6Mb/s rate. From the data delivery perspective, a higher PDR shows a lower packet loss rate and thus a most effective routing protocol. In real time interactions, the routing protocol with maximum PDR may not be considered better as compared to the one with minimum PDR, however packets which reach late could be waste although they arrive the destination node successfully. Real time traffic is delay sensitive.

Because the introduced V-AODV protocol can utilize a metric depending on BER, delay or both for routing computation, in the remaining paper we call VAODV delay the first, V-AODVBER the second and VAODV delay+BER the integration of the two. The standard AODV is known as AODV Hop. In a first simulation set, comparison of standard AODV protocol to the three versions of V-AODV (such as BER, delay and delay +BER) is performed in a free space and in a realistic propagation atmosphere. If we now take a view at both the AEED (Figure 2) and the PDR (Figure 3), we can view that in the free space atmosphere, both AODV and V-AODV delay protocols yields to always possible communications (AEED of 0,003s and PDR of 100%). In the realistic propagation atmosphere we can view that the proposed restraints lead to a development for AODV Hop of the AEED to 0,4s and due to more significant packets rejection, a reduction of the PDR to 80%.

When utilizing V-AODV delay the extra delay restraint when setting up routes decreases the PDR to 58%. But in the same time, the AEED reduces to 0,220s, showing better communication situations.

With V-AODVBER we notice that both the AEED and PDR stay at values close to the ones of AODV Hop. This implies that, in the condition of AODV Hop, when a connection is utilized for a communication between two nodes, its BER has a better value. Only a few hops are eliminated because of bad BER.

If we now utilize a metric taking into consideration both the BER and delay, we notice that the first results are ensured because the AEED reduces to 0,230s together with a value of 58% for the PDR, which is a value same as the V-AODV Delay one.

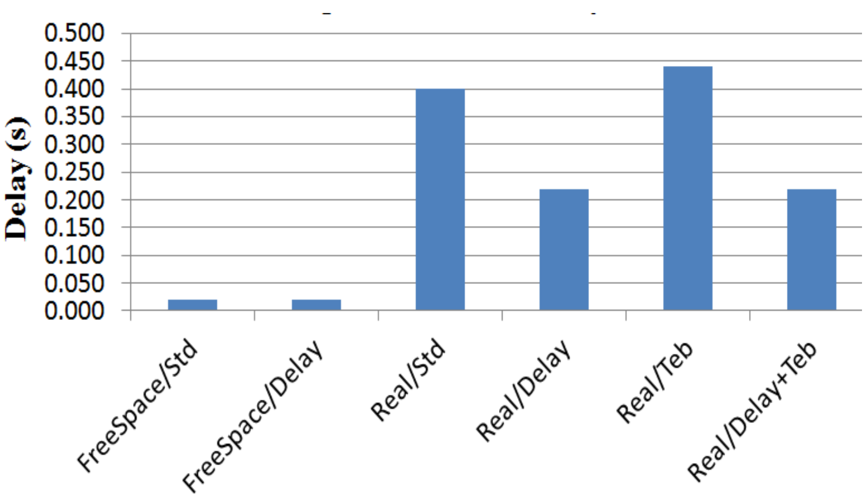

Fig. 2: Average end to end delay

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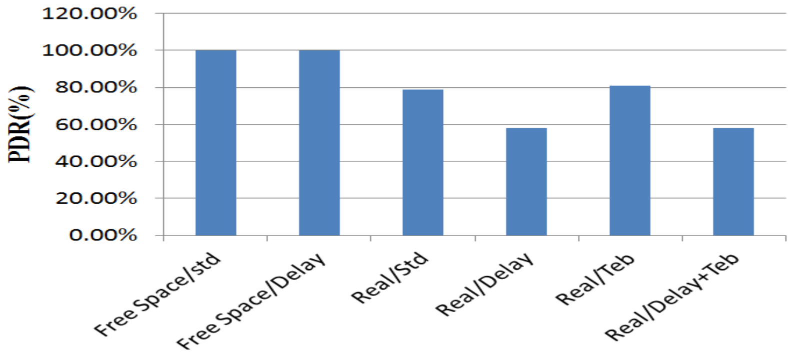

Fig. 3: Packet delivery ratio

For getting another idea about the protocol efficiency, we calculated the NOL (Figure 4). We can view here that in the realistic propagation atmosphere, the propagation restraints causes to an increase of the signalling overhead for AODVHop. When utilizing VAODVBER,. in agreement with the PDR and AEED results, the signalling overhead stays in the same range of values (resp. 11% and 12%).

When the delay parameter is involved in the metric, for staying under the maximal delay set between a source and a destination node, we obtain more broken routes, yielding to a signalling overhead increasing from 12% to 17%.

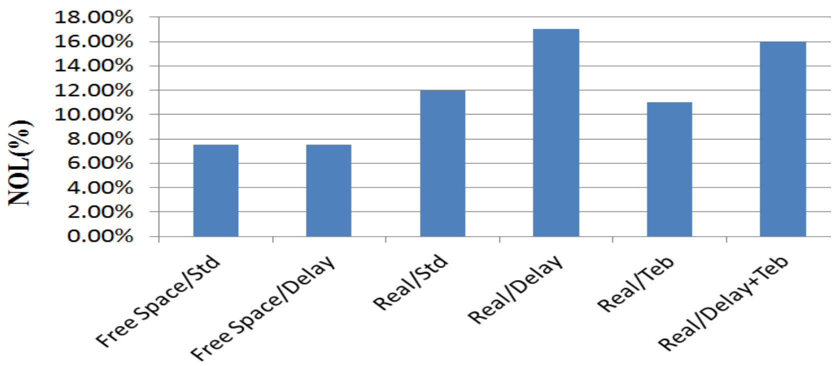

Fig. 4: Normalized overhead load

If we now have a look at the number of dropped packets (Fig. 5), we also observe that the main constraint is related to the delay parameter.

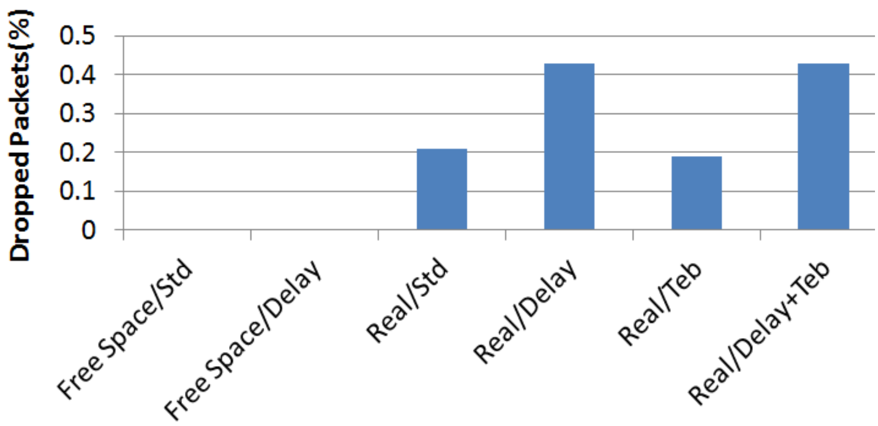

Fig 5: Dropped packets

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For completing our analysis, Figure 6 indicates that when the routing metric needs increase, so does the average no. of hops.

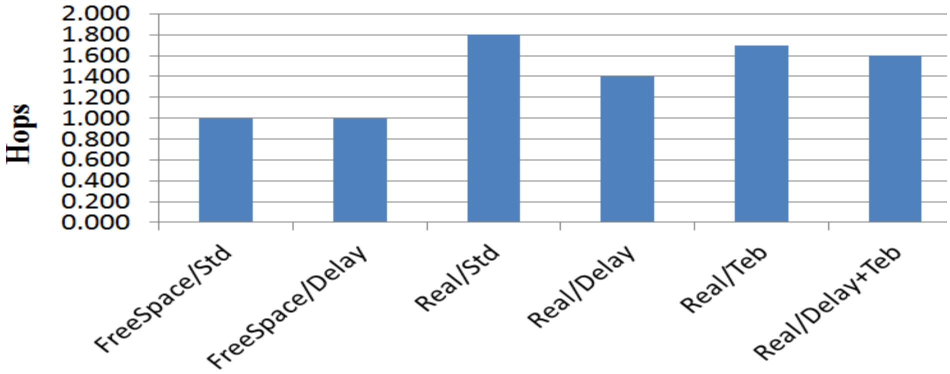

Fig 6: Number of hops

The prior results permit us to conclude that, whatever the propagation model utilized, when a connection between two nodes is appropriate for communication, the test of its BER yields to little extra packet rejection. To the contrary, the delay parameter appears to have more significance in route computation. This seems in every evaluated indicator. To view how the delay affects communications, we make extra simulations with static couples of receivers and sender. In these simulations we only vary the maximal delay permitted for setting up a communication.
As can be viewed in Figure 7, when the maximal delay reduce, there available a threshold over which the AEED is constant (over 10ms). At this threshold the AEED reduces in a fast manner, so there is no possible interaction when it is below or equal to 0,5ms. In Figure 8 we can view that with a maximal delay of greater than 5ms multihop communications are permitted while with a 1ms delay only one hop interactions are possible.

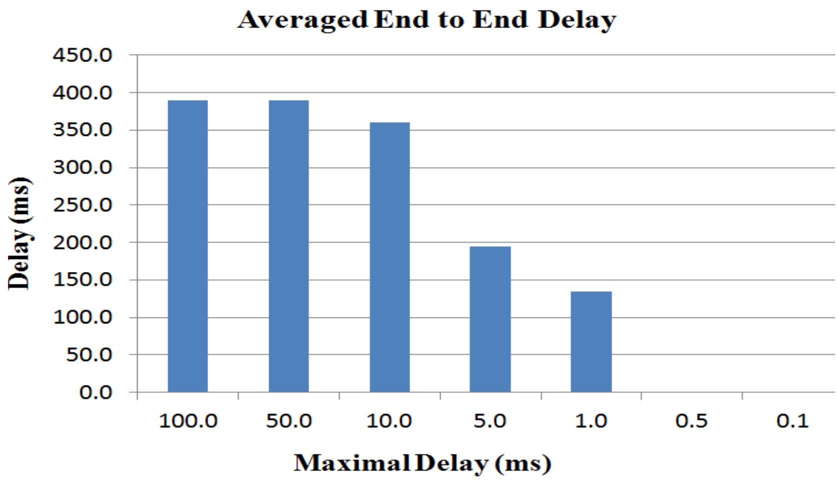

Fig. 7: Averaged End to End Delay

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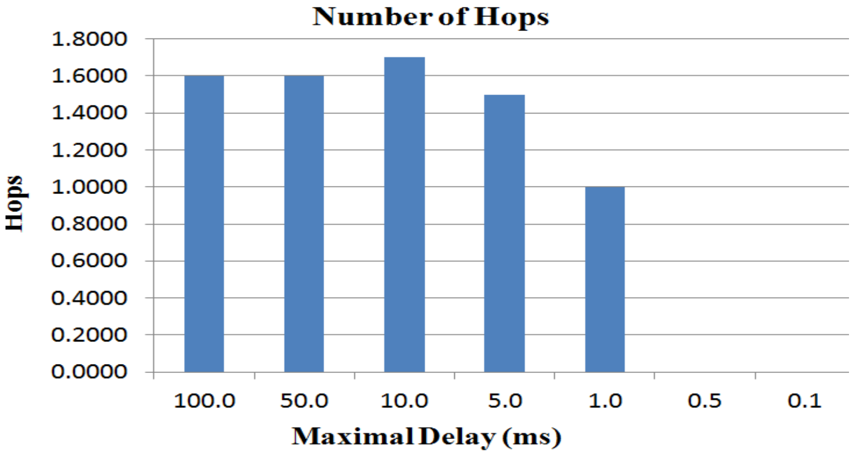

Fig. 8: Number of Hops

We also observe that the maximal delay is calculated at the beginning of a communication and then updated each second.
Thus, because of nodes movements, the evaluated end to end delay is more than the maximal delay.
This extra study ensures us that the maximal delay selected in the first simulation set (10ms) is not low enough to prevent interactions.

VII. CONCLUSION AND FUTURE WORK

In this paper we examined an improved version of AODV known as V-AODV planned for VANETs. The tests were carried out both in a free space propagation atmosphere and in a realistic one. The first results indicated that in the domain of VANETs, simulations must be carried out in realistic atmosphere for validating accurately the modification or improvements applied to a routing protocol. The measurements of the V-AODV protocol which routing metric depends on a source to receiver delay evaluation and a cross layered physical BER ratio both evaluated when setting up a route, indicates us that the delay parameter considers the precedence over the BER parameter. We achieved these interesting results in a realistic but restricted region. The no. of nodes was adjusted to 10 and the no. of communications to 3. Thus, every time a connection between two nodes was existed, its BER had a "good" value. In a future work, we will examine if in a larger atmosphere, the BER, because of reflections etc… can become a most relevant metric for route computation.

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