MANET Routing: An enhanced simulation-based analysis of MANET Routing Protocols

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ABSTRACT

Mobile Ad hoc Network (MANET) is an innovative and dynamic network architecture which constitutes a set of mobile nodes without any support of central authority. The mobile nodes in these networks moves dynamically which can change in network topology at any time. Due to this dynamic nature of mobile nodes, routing has become a challenging task. There are different MANET routing protocols available which are implemented and analyzed based on the application environment. In this paper, we have thoroughly studies both proactive and reactive MANET routing protocols and analyzed Dynamic Source Routing (DSR), Destination-Sequenced Distance Vector (DSDV) and Ad Hoc On-Demand Distance Vector (AODV) protocols based on different performance metrics. These performance matrics are throughput, packet delivery ratio (PDR), average end-to-end delay, and Energy consumption (EC). We have used NS-2 simulation tool for the implementation and analysis of MANET routing protocols. We performed different simulation tests with random number of nodes (41, 81 and 121) and achieved better results on small number of nodes as well as on large number of nodes. It is depicted from the results that throughput of DSDV is consistently well as compare to AODV. AODV protocol outperforms DSR and DSDV protocols with reference to end-to-end delay at random number of nodes and at different pauses time. Moreover, DSDV gives best PDR results on large number of nodes whereas AODV and DSDV consume less energy.

Keywords: *MANET, DSR, AODV, DSDV, Throughput, Delay, Energy Consumption*

1. INTRODUCTION

In 21st century, the mobile communication systems and networks are becoming popular due to their usability and mobility which provides information access in an efficient and fast way. These networks have many innovative research areas including routing protocols for maintaining and establishing the ad hoc network. The ad hoc networks do not use existing network infrastructure or require a specialized one. Instead, every participating node forward data to the other participating nodes which is responsible to forward data to the destination as per requirements. This requires routing of data to a specific route or flooding of information.

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Internet based MANETs are networks that link mobile nodes and fixed Internet gateway nodes. Although there are large numbers of routing protocols available in this area, this paper considers DSR, DSDV and AODV routing protocols for the implementation and analysis due to their recognition among all other protocols. These protocols are studies using performance metrics such as, PDR, EC, average end to end delay, and throughput. The results are represented with the help of simulations via NS-2 simulator.

In this paper, we have performed different simulation tests with random numbers of nodes. It is evident through the simulation results that the throughput of DSDV is better compared to AODV. In addition, by comparing the results of DSR, DSDV and AODV protocols with the reference to end-to-end delay at random number of nodes and at different pause time, AODV shows better performance. Besides, AODV and DSDV consume less energy and DSDV gives best Packet delivery ratio results on large number of nodes.

2. LITERATURE REVIEW

Fengying et al. [1] described a comparative study of MANET routing protocols. It shows that presently there are some research groups which are doing numerous investigations on system conventions by utilizing OPNET and NS2 simulation tools. Their research focus is on routing efficiency, power control and load balancing in ad hoc wireless networks. The research states that ad hoc wireless network routing protocols consume less energy and improve communication quality in case of high data rates. It compares two on-demand routing protocols performance simulation results which are, DSR and AODV. The research work demonstrates that the DSR conventions are better than AODV. Talooki et al. [2] introduced execution examinations of AODV, DSDV and DSR. In this paper four grids are utilized which are, Weighted Way Optimality, System's heap deviation, Normal end-to-end postponement and Jitter. It defines jitter value for Temporally Ordered Routing Algorithm (TORA), DSR, AODV and DSDV protocols for performance analysis. Soni et al. [3] investigated the MANET multicast routing protocols and analyze these according to different performance metrics by discussing their functionalities and properties along with their advantages and disadvantages. Royer et al. [4] discussed different ad hoc routing protocols by describing the complete history of these protocols. The main goal of a MANET protocols is to find the correct and efficient route for the communication between different nodes for the timely delivery of messages. The existing routing protocols define AODV routing protocol which is actually the mixture of DSDV and DSR. AODV is the improved version of DSDV and it reduces number of routes that are needed for transmission via on-demand routing instead of maintaining a complete list of routes. This research work investigates MANET routing protocols according to different set of parameters by comparing them with respect to their advantages and disadvantages.

Putta et al. [5] illustrated the survey on ad hoc network routing performance. They compare both reactive and proactive protocols, traffic model, mobility models, impact of mobility

models and impact of traffic load. The research work shows that the mobility models affect protocols performance. By using the probe walk mobility model, the following results are calculated:

- AODV routing protocol performs better compared to DSR for parcel conveyance proportion.
- Optimized Link State Routing (OLSR) performs better as compared to AODV protocol, however, when the traffic load increases, then little variations are occurred.
- In case of light load, all protocols perform in same manner, however, if load increases then OLSR gives better results.

In case of higher routing load, it sends routing packets periodically for maintaining the routing table up-to-date. DSR produces higher data rates in case of File Transfer Protocol (FTP) sources and results in higher delay. Pandey et al. [6] reported the research work based on performance analysis of AODV for various environments of mobility. According to its specifications, this protocol is carefully implemented, and they applied basic methodology for simulation of network with specific intervals by sending data packets from the sender. In addition, tests in different mobility conditions are also performed for the simulation environment. The four different types of mobility conditions are used for cooperative analysis of average jitter in the network. With the increase in simulation time, the jitter value also increases linearly. In addition, it also explains routing protocols along with their advantages and disadvantages. Abushiba et al. [7] illustrated the performance comparisons of reactive routing protocols in ad hoc network and discuss results based on its performance metrics. In case of end to end delay, AODV Protocol provides 0 to 1400 ms delay and in case of addition of more nodes, this delay is not increased. The packet delivery rate in medium number of nodes is always greater than 40%, it may be 310 nodes or higher under CBR traffic. In experimental traffic, the delivery of packets on both protocols (DSR and DSDV) does not perform very well. However, AODV under CBR traffic provides better results with respect to PDR which is in the range of 70% to 80%.

M. Bansal et al. [8] discussed comparison of two on-demand routing protocols, AOVD and DSR. According to this paper, the major difference between DSR and AODV is the transmission of data packets from source to its destination. In AODV, there are source and intermediate nodes which store the information of next hop for transmission of every packet. However, in DSR, a data packet follows the whole path from source to the destination. In on-demand routing protocols, if route for the desired destination is not available then the source node transmits the route request packet in the network. May be there are many routes for different destinations in the result of a single route request. AODV shares DSR on-demand characteristics to discover the route if necessary, through a similar route search process. It uses different technique that maintains the routing information based only on destination address on which routing table is built. For a single destination, DSR maintains many route cache entries which is against the AODV. When AODV does not have source

routing then it depends on the entries of routing table to find its source. After that, it finds a route to transmit data packets to the destination. Sequence numbers normally used by AODV to maintain each destination for the determination of new routing information and to save routing loops. According to the results, AODV performs better compared to DSR in case of high mobility. However, the performance of DSR increases with the increase in pause times as well as under low mobility conditions.

Nasipuri et al. [9] proposed a hybrid routing mechanism which is the combination of proactive and reactive routing protocols. This mechanism helps to reduce average end-to end delay with the same routing overhead for data transmission. It uses a pre-emptive route discovery which helps to replace existing route by a shorter route over a specific interval of time. This pre-emptive route discovery time is calculated by using link statistical distribution and route life time. Finally, the performance analysis of the proposed scheme is presented via comparing existing routing protocols. Mbarushimana et al. [10] analyzed the performance of proactive (OLSR) and reactive (AODV and DSR) MANET routing protocols with diverse network constraint via CBR traffic. The results state that the proactive protocol performs well as compared to reactive protocols under higher traffic load. Marinoni et al. [11] described the ad hoc routing protocols and analyzed the performance in realistic environments with specific topological properties. The various diverse properties (obstacles, buildings and/or mountains) affect the performance of routing protocols. This research proposes a realistic Urban Mobility Model (UMM) which is based on users' movement as well as radio signals propagation in an urban like environment. The results of research suggest that realistic scenarios affect the performance of routing.

Arain et al. [12] analyzed the performance of MANET routing protocols like, OLSR, Dynamic MANET On-Demand (DYMO), AODV and DSR on the basis of Packet Delivery Ratio (PDR) and end-to-end Delay. The results suggest that load offered on the system is more important in comparison with mobility to measure the performance of MANET routing protocols. Asokan [13] provided a comprehensive review of MANETs which states networks are getting popular day by day due to their dynamic nature, mobility, support of multimedia and real time applications. However, the focus is on Quality of Service (QoS) provisioning at network layer. The aim is to find an appropriate path to maintain QOS parameters like bandwidth requirements, end-to-end delay, jitter, energy etc. Chengetanai et al. [14] discussed different reactive, proactive and hybrid routing algorithms for MANETs. In addition, a new routing algorithm namely, AntHocNet, is proposed which is based on the concept of Swarm Intelligence and Ant Colony Optimization (ACO). This algorithm uses both reactive and proactive functionalities to meet the issues of MANETs in an efficient and effective manner. The comparison is made with AODV protocol on basis of different performance metrics. The results suggest that AntHocNet algorithm provides better results compared to the traditional AODV protocol.

Draz et al. [15] discussed different characteristics and properties of ad hoc routing protocols. DSR and AODV protocols are considered for different routing issues and their real time network performance. In this paper, real time TCP and UDP environment is considered to measure the packet delivery ratio of these protocols. Results show that packet delivery ratio of AODV is not good under TCP as compared to DSR. While the packet delivery ratio of DSR is efficient under TCP and UPD environment. Reddy et al. [16] provided the performance analysis of different MANET routing protocols. Authors consider several MANET protocols like DSR, AODV, and DSDV. In addition, different other protocols like DYMO, DSR, Temporally-Ordered Routing Algorithm (TORA) are also analyzed. The comparison of these protocols show that some protocols perform better in one condition while others perform better in second condition. We should use the protocols according to environments that are considered for implementation of these protocols.

3. SIMULATION AND MODELING

This section includes simulation and modeling. We have used network simulator 2 (NS-2) for simulation, because it provides dynamic nature due to its event driven ability which is useful in communication networks. Using NS-2 simulator, the protocols and functions of wired as well as wireless networks can be implemented. We utilized a Linux platform (UBUNTU 15.10) due to the fact that it provides different programming development tools which are helpful during the implementation and analysis of simulation.

3.1 Simulation Scenario

In this simulation scenario, we have analyzed three protocols which are DSR, DSDV and AODV. The purpose is to find the application environment where these protocols can perform better. For this purpose, we choose an area with 400 x 500 meter under the two-ray ground propagation which has a wireless channel. Every node has same distance from each other. In this scenario, one node is selected as intermediate node and other nodes are chosen for route traffic through this intermediate node. When simulation started, it generates a trace file which has description of different events. We analyze the experimental outcomes by applying the AWK command on the output trace files (.tr).

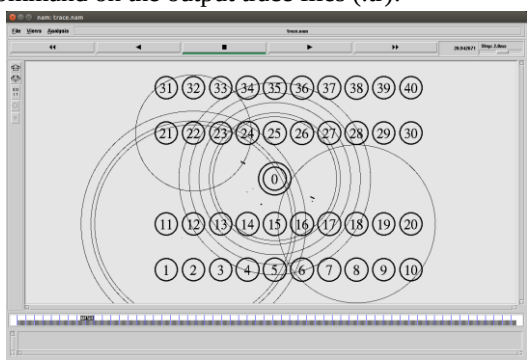

Fig. 1. Simulation at 41 Nodes

There are three different simulations according to the number of nodes. In Fig. 1, 2, and 3, total number of nodes are 41, 81, and 121, respectively. In this simulation setup, 0 node is known as intermediate node, which is used for transmission between different nodes. This intermediate node is connected to other nodes for transmission and has a TCP agent

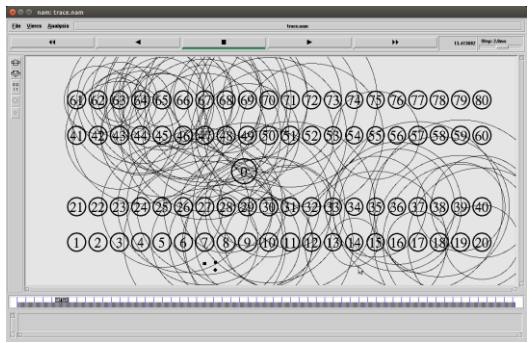

Fig. 2. Simulation at 81 Nodes

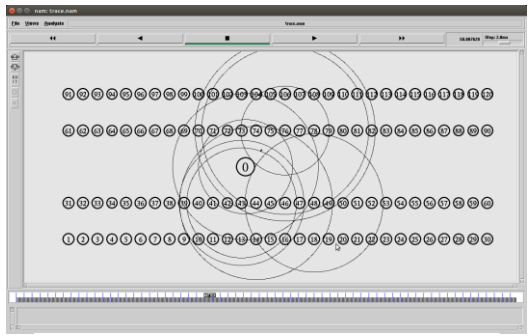

Fig. 1. Simulation at 121 Nodes

Basically, nodes are not connected, the agents are attached with them and the agents are connected. The other nodes have TCPSINK agent and are connected via TCP agent. The FTP agent is attached with TCP agent for transmission of packets. When simulation starts, the communicating node spreads a circle which means that it sends or receives some data. The data is transmitted using intermediate node which is a common way between two nodes. A pause time is defined for simulation, when this value reaches then simulation gets stop. When simulation is stopped, the simulation generates a trace file (.tr) which records all the transmission between nodes. This trace file is used for calculation of performance parameters.

4. PERFORMANCE ANALYSIS

This paper analyses the performance of MANET routing protocols such as DSR, DSDV and AODV based on performance measures such as throughput, end to end delay, and energy

consumption with dissimilar number of nodes, different pause time and along with the parameters described in Table 1.

4.1 Throughput

A throughput is the ratio of transmission of data from the sender in the time it takes to acquire the last packet that a receiver is received. In this simulation, throughput at 41 nodes (Fig. 4) on different pauses time, DSR has a high starting value and it decreases with the increase in pause time. At 81 nodes (Fig. 5), DSR has a low initial starting value but it increases slowly with the increase in pause time. However, at 121 nodes (Fig. 6), DSR maintains a certain level with low values. The pause time does not vary at 121 nodes. So, we can say that at maximum nodes, the pause time is not effective and DSR has lowest throughput at this stage. AODV starts from a low value when number of nodes are 41 (Fig. 4), and increases this value slowly. At 81 nodes (Fig. 5), AODV acts like 41 nodes and it starts from a low value and increases time to time. When no of nodes are 121 (Fig. 6), AODV gives performance as it has in 41 and 81 nodes. So, we can say that AODV performance is always same at different pause time. AODV performance is same at different nodes like DSDV, however, DSDV maintains a certain level. At different pause time, the value is same as the starting value which is a high value among others. We can see, when number of nodes are; 41, 81 and 121 (Figures 4, 5 and 6), DSDV performance is better than others. It means that, DSDV gives same performance at different nodes and at different pause time, so, DSDV is the best choice.

Table 1: Performance parameters

Parameter	Value
Radio propagation model	Two Ray Ground
Area	400 x 500
Antenna	Omni Antenna
Channel	Wireless
No of nodes	41, 81, 121
Mac	Mac 802.11
Protocols	DSR, DSDV, AODV
Pause time	30, 60, 90, 120, 150

4.2 Average End-to-End Delay

End-to-End delay is a transmission time of packets from source to destination. In Fig. 7, DSR starting with a value and as pause time increases, the values are also increased. At every pause time the graph goes up, so here DSR gives worst performance. DSDV and AODV give better performance, however, AODV has nearly less values than DSDV. Both (AODV and DSDV) maintain a level with less values. According to these two protocols, the performance is not affective, it does not depend on the number of nodes, nor at different pause time.

At 81 nodes (Fig. 8), DSR starts from a high value and goes down with the increase in pause time, so, again DSR has worst performance. AODV and DSDV again have better performance, as they again have almost same values. At 121 nodes (Fig. 9), DSR has worst performance because end-to-end delay has much high values which is not good. But AODV and DSDV have better values. The values of both (AODV and DSDV) once again are almost same but the only difference is that AODV have less values than DSDV at 30 pause time. Comparing the protocols according to the end-to-end delay at different nodes and at different pause time (Fig. 7, 8 and 9), AODV shows better results. So AODV is the best choice but we cannot ignore DSDV which also provides good results.

4.3 Energy Consumption

The energy consumption presents the energy level of nodes in network. In the beginning of simulation, a value is defined as an initial energy value. Node loses a particular amount of energy for every packet which is received and transmitted. In this simulation, nodes are 41, 81 and 121 (Fig. 10, 11 and 12) respectively. Initially DSR, DSDV and AODV have a defined energy value but DSR have high energy consumption. DSDV has a low value which is good, and it also decreases slowly. AODV has value which is much varied from DSR but near to DSDV. At these three stages, DSDV gives best performance, and it is not dependent on nodes and pause time. The performance is same in every case, it shows less consumption of energy as compared to other protocols.

4.4 Packet Delivery Ratio (PDR)

It is the successful packet delivery ratio of packets which are transmitted from source node and successfully received at destination node. PDR measures loss rate and characterizes the efficiency and correctness of ad hoc routing protocols. The high PDR is desired in every network. When nodes are 41 (Fig. 13), DSR and DSDV give worst performance because these have less PDR values than AODV. All these protocols start with some initial value and go up as pause time increases. When number of nodes are 81 (Fig. 14), DSDV enhances itself than DSR and gives performance like AODV but the only difference is that AODV value is very less than DSDV. DSR also improves itself but not as DSDV. The value is lower than DSDV and AODV which is not a better result. After increasing the nodes to 121 (Fig. 15), AODV and DSDV again has best performance. But at 120 pause time AODV has less value than DSDV. DSR again has worst performance among DSDV and AODV. So, AODV shows better PDR values because at different nodes and at different pause time, it has best performance among others. DSDV has little high PDR values from AODV but at 41 number of nodes it becomes worst.

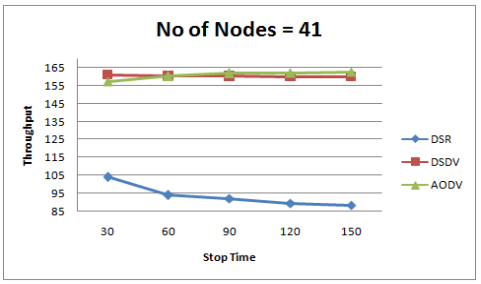

Fig. 2. Throughput at 41 Nodes

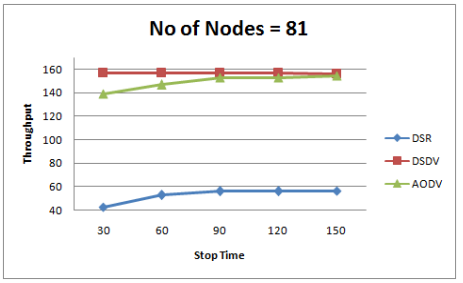

Fig. 3. Throughput at 81 Nodes

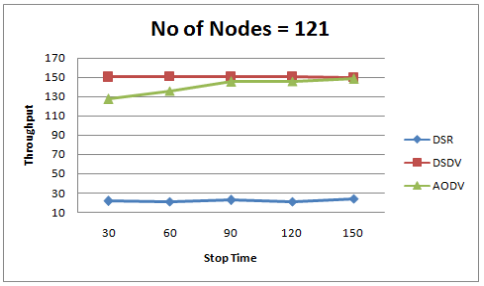

Fig. 6. Throughput at 121 Nodes

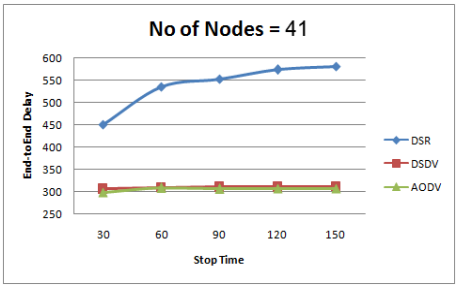

Fig. 7. End-to-End Delay at 41 Nodes

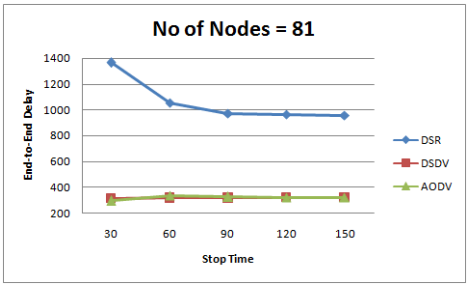

Fig. 8. End-to-End Delay at 81 Nodes

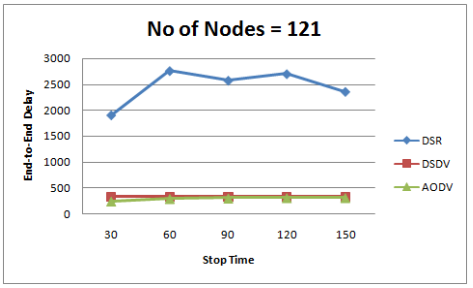

Fig. 9. End-to-End Delay at 121 Nodes

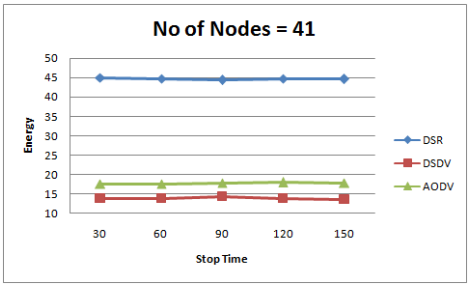

Fig. 10. Energy Consumption at 41 Nodes

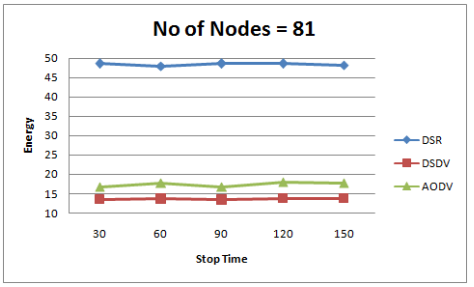

Fig. 11. Energy Consumption at 81 Nodes

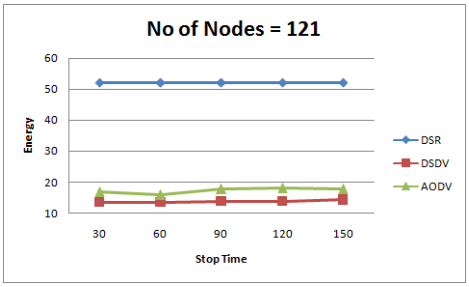

Fig. 12. Energy Consumption at 121 Nodes

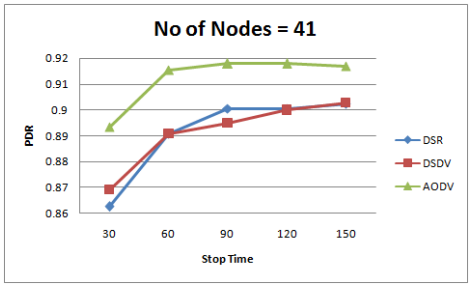

Fig. 13. PDR at 41 Nodes

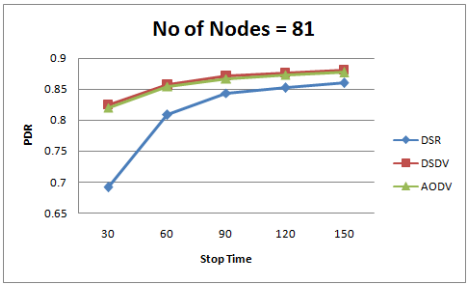

Fig. 14. PDR at 81 Nodes

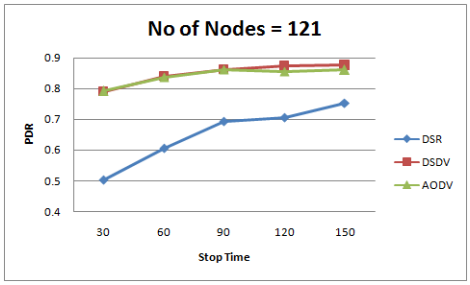

Fig. 15. PDR at 121 Nodes

5. CONCLUSION

The literature studies suggest that AODV protocol is known as a best choice in MANETs. However, it provides good results only with small number of nodes. Our simulation results suggest that DSDV protocol performs best even on large number of nodes. In addition, our simulation based on DSDV has high throughput, less end-to-end delay, less packet loss rate and consumes less energy as compared to AODV on maximum number of nodes. In addition, we calculated the energy consumption during the ad hoc mobile network communication process. The results show that DSDV gives best performance, and it is not dependent on nodes and pause time. Consequently, DSDV is best choice in ad hoc mobile networks.

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