NS-3 Simulation of DSDV and AODV

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Dr. Marnel Peradilla

College of Computer Studies

Department of Computer Technology

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Submitted by

Chua, Judy P.

Telosa, Arwyn Gabrielle A.

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I. ABSTRACT

This study demonstrates the application and assessment of the Ad-hoc On-Demand Distance Vector (AODV) and Destination-Sequenced Distance-Vector (DSDV) routing protocols in mobile ad-hoc networks (MANETs) using the ns-3 simulation tool. The study concentrates on important performance parameters, including packet delivery ratio (PDR), routing overhead, and end-to-end delay. The simulation parameters consist of varying simulation durations, diverse packet sizes, and a combination of stationary and moving nodes. The results illustrate the effectiveness and constraints of both the AODV and DSDV protocols in various network settings, providing insights for optimal protocol selection in different scenarios.

II. INTRODUCTION

Mobile ad-hoc networks (MANETs) are a class of wireless networks characterized by a dynamic topology and lack of fixed infrastructure. These networks depend on effective routing protocols to manage communication between nodes. Two prominent routing protocols used in such contexts are the Ad-hoc On-Demand Distance Vector (AODV) and Destination-Sequenced Distance-Vector (DSDV). AODV is a reactive protocol that establishes routes to destinations on demand, using route discovery and maintenance processes to reduce control message overhead (Perkins & Royer, 1999). Conversely, DSDV is a proactive protocol that maintains a complete routing table, periodically updating it to reflect network topology changes, ensuring that routes are free from loops and that routing information is timely updated (Perkins & Bhagwat, 1994). The objective of this study is to utilize the ns-3 platform to build both the AODV and DSDV protocols and assess their performance using a predefined set of metrics.

III. METHODOLOGY

A. Simulation Environment

The simulations were performed with ns-3, a discrete-event network simulator extensively employed for research in network protocols and communications (Riley & Henderson, 2010). The selected protocol stack consists of TCP/IP over WLAN 802.11, and the mobility types employed are Static and RandomWaypoint.

Parameter	Value
Data Flow	Constant Bit Rate (CBR)
Network Size	300 x 1500 m
Number of Nodes	30, 50, 100
Static-Mobile Ratio	1:1
Transmission Range	25 meters
Traffic Pattern	TCP/UDP
Protocol Stack	TCP/IP
Medium	WLAN 802.11
Packet Size	64, 128, 256, 512 bytes
Mobility Model	Static and RandomWayPoint

Table 1: NS-3 Parameters and Settings

B. NS3 Helpers

The following helpers were used for the simulation to generate nodes, configure the following parameters to match the given values, create packets for transmission, simulate the process, and produce the desired results.

- ns3/core-module.h

  This helper offers the essential classes and tools to create NS-3 simulations, such as simulation events and logging.

- ns3/network-module.h

  This helper provides the basic structure needed to build and operate network simulations, like data structures for network components, interfaces, and addresses.

- ns3/internet-module.h

This helper is used to install the internet stacks on the nodes and configure them with IP addresses and TCP/IP protocols.

- ns3/wifi-module.h

  This helper is responsible for setting the WiFi standard to WLAN 802.11, transmission power to 25 meters, and channel models to use AdHoc wifi Mac. These configurations will be installed on the nodes.

- ns3/mobility-module.h

  This helper manages the physical positions and movements of nodes within a simulation and provides a range of mobility models, which, in this case, are static and random way points used to simulate different types of node movements and placements.

- ns3/dsdv-module.h

  This helper is used to set up and configure the DSDV routing protocol for the nodes in the simulation when the user picks DSDV as their routing protocol.

- ns3/aodv-module.h

  This helper is used to set up and configure the AODV routing protocol for the nodes in the simulation when the user picks AODV as their routing protocol.

- ns3/applications-module.h

  This helper configures and installs OnOff and PacketSink helpers to help generate UDP traffic and handle received packets between nodes.

- ns3/flow-monitor-module.h

  This helper offers tools for tracking and examining network traffic flows inside a simulation, installing flow monitors on nodes, and gathering information about the nodes for performance analysis. This is used to get the packet delivery ratio, end-to-end delay as well as transmission packets for the routing overhead.

- ns3/netanim-module.h

This helper includes tools for recording and exporting simulation data in a way that is compatible with NetAnim for visualization purposes. It sets up the animation XML file, node descriptions, and colors for visualization.

C. **Performance Metrics**

1. **Packet Delivery Ratio (PDR):**

The calculation is performed by dividing the number of packets received at the destination by the number of packets generated by the source application layer, specifically the Constant Bit Rate (CBR) source. The statement indicates the rate at which packets are lost, which in turn restricts the maximum data transfer rate of the network (Perkins & Royer, 1999).

$$\text{PDR} = \frac{total\ number\ of\ received\ packets}{total\ number\ of\ transmitted\ packets}$$

2. **Routing Overhead:**

Specifies the quantity of routing packets transmitted to facilitate the process of identifying and preserving routes. The purpose of this study is to assess the scalability of the protocol and evaluate its performance in both congested and low-bandwidth scenarios (Johnson et al., 2001).

$$\text{Routing Overhead} = \frac{routing\ packets}{routing\ packets + data\ packets} \times 100$$

3. **End-End Delay:**

It is the duration it takes for a packet to go from the Constant Bit Rate (CBR) source to the application layer of the destination. The term refers to the mean data latency encountered by programs or users (Broch et al., 1998).

$$\text{End-to-End Delay} = \sum \frac{\text{all packet transmission times}}{\text{total number of received packets}}$$

IV. RESULTS & ANALYSIS

A. Simulation Results

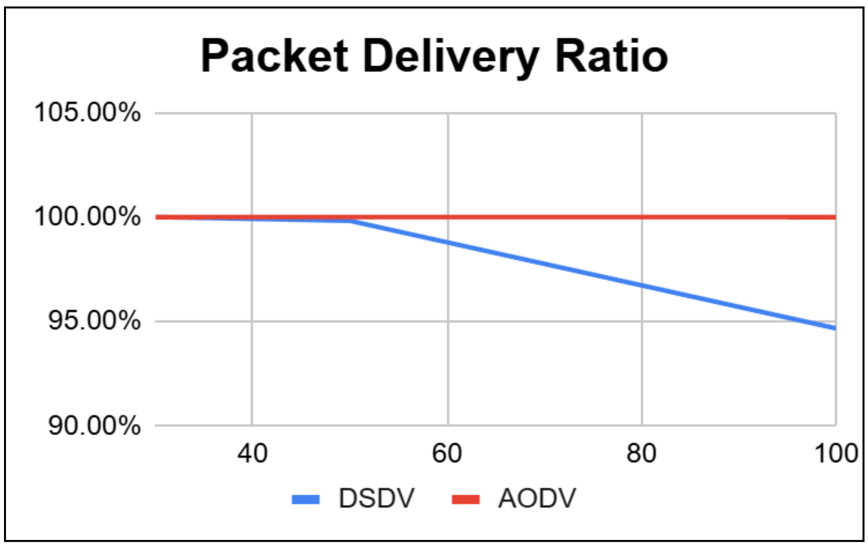
Number of Nodes	Packet Size	PDR	Routing Overhead	End-to-End Delay
30	64	100.0000%	61.9692%	0.00295324
	128	100.0000%	69.33565	0.00260853
	256	100.0000%	77.8497%	0.00274658
	512	100.0000%	85.7745%	0.00206397
50	64	99.7993%	73.3893%	0.00984748
	128	99.8971%	81.8870%	0.00910792
	256	99.9177%	88.9676%	0.00909553
	512	99.6706%	93.7665%	0.00975112
100	64	94.8953%	88.9451%	0.00996976
	128	94.9876%	93.7983%	0.0103451
	256	94.3598%	96.6981%	0.0105234
	512	94.4833%	98.2885%	0.0111882

Table A: *DSDV Simulation Results*

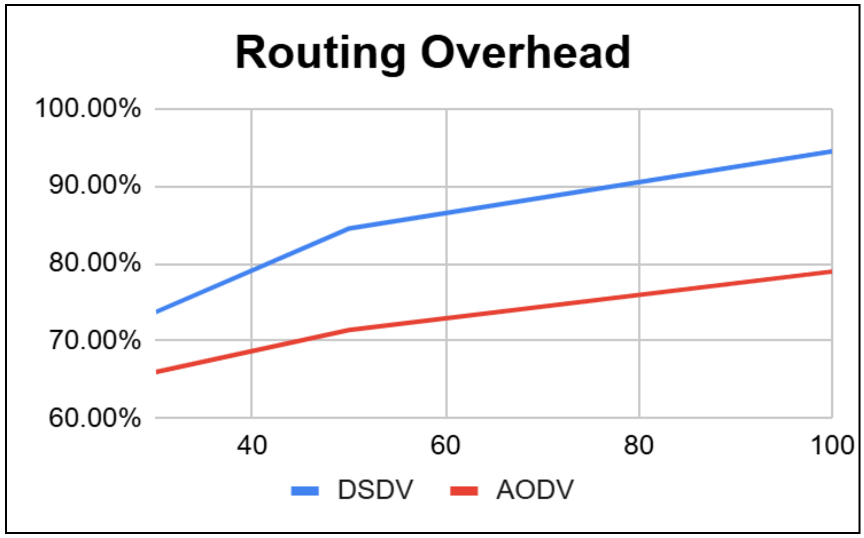
Number of Nodes	Packet Size	PDR	Routing Overhead	End-to-End Delay
30	64	100.0000%	56.5109%	0.000132975
	128	100.0000%	61.5461%	0.000622683
	256	100.0000%	68.6924%	0.000147453
	512	100.0000%	77.2117%	0.000190983
	64	99.9949%	60.1178%	0.000152902

50	128	100.0000%	66.8282%	0.000163707
	256	100.0000%	75.1711%	0.000194934
	512	100.0000%	83.4782%	0.000252076
100	64	100.0000%	66.8758%	0.000173142
	128	100.0000%	75.2351%	0.000178812
	256	100.0000%	83.5417%	0.000194985
	512	100.0000%	90.1496%	0.000234581

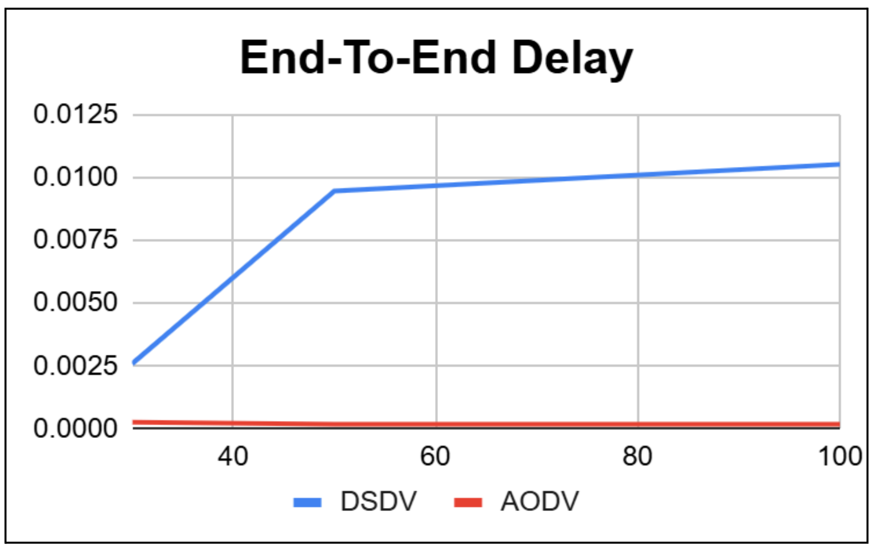
Table B: *AODV Simulation Results*



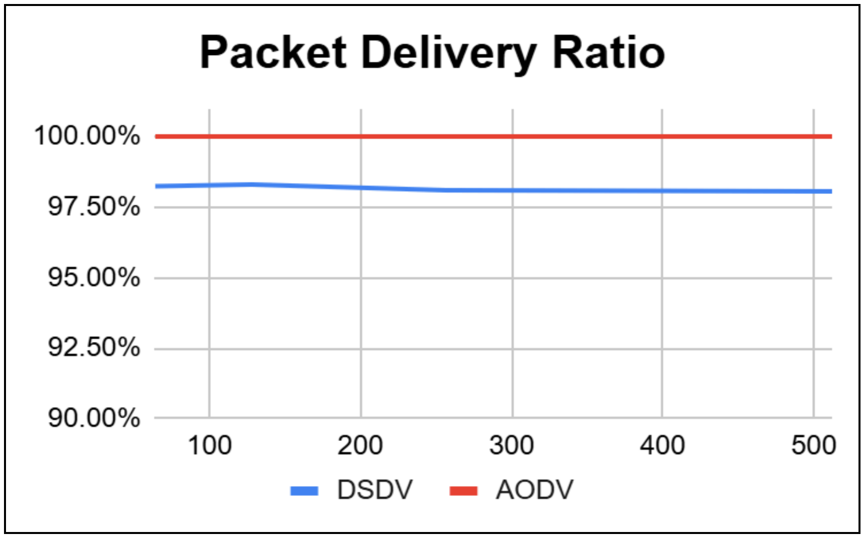
Graph A: *PDR vs. # of Nodes*



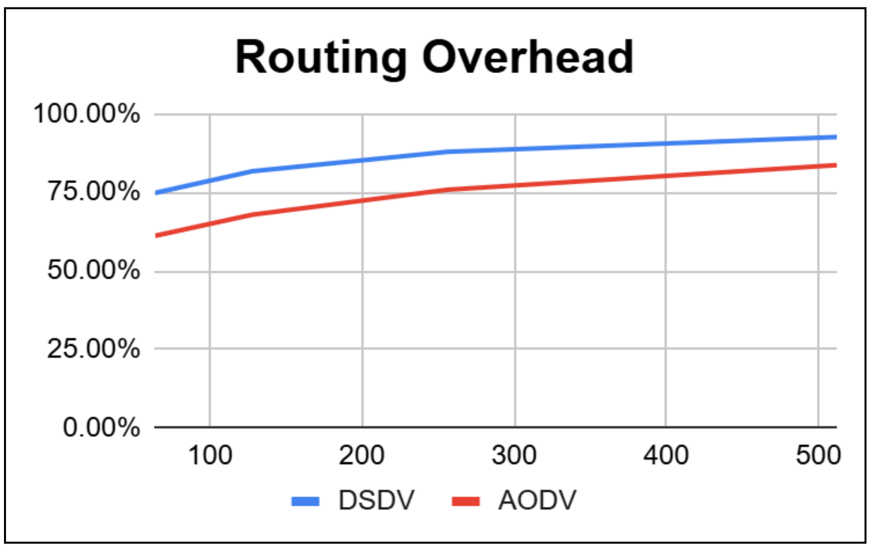
Graph B: *Routing Overhead vs # of Nodes*



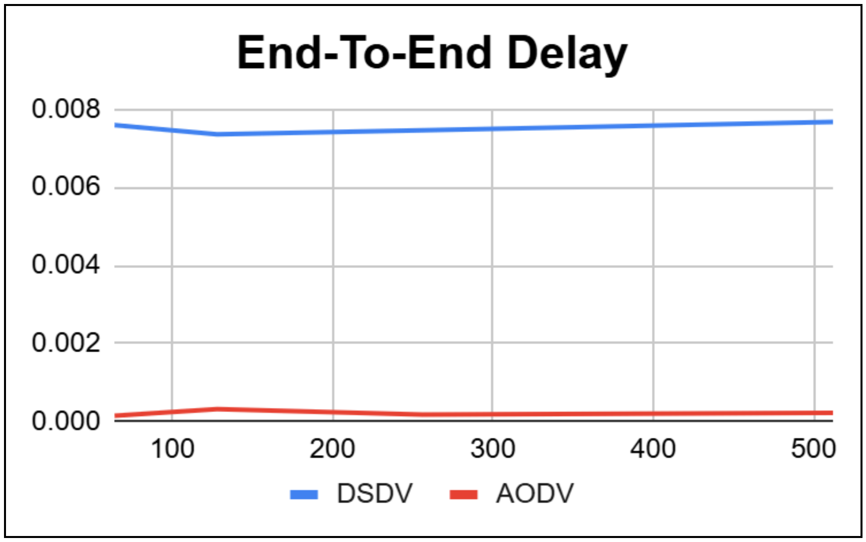
Graph C: *End-to-End Delay vs. # of Nodes*



Graph D: *PDR vs. Packet Size*



Graph E: *Routing Overhead vs. Packet Size*



Graph G: *End-To-End Delay vs. Packet Size*

The simulation results clearly highlight the trade-offs between AODV and DSDV protocols. DSDV is more adaptive to network topology changes, making it suitable for environments where nodes frequently move. However, this adaptability comes at the cost of increased routing overhead and end-to-end delay due to the proactive nature of ensuring that routes are always available, but it may not scale as efficiently in highly dynamic environments due to the periodic routing table updates. AODV, on the contrary, offers high reliability and lower delays, making it relatively stable networks with less frequent topology changes. Its reactive approach allows route discovery for every change in the network topology, needing lesser sending of packets than DSDV.

B. Impact of Network Size

The settings are configured with a transmission range of 25 meters. Both static and random mobility of nodes are used. Graphs A, B, and C display the results of the packet data ratio, end-to-end delay, and routing overhead in proportion to the number of nodes. The packet size is not taken into account. On AODV, it is evident that the packet delivery ratio remains constant and there are no instances of packet loss, regardless of the number of nodes. This is because AODV only transmits the data packet when there is a modification in the topology, rather than doing it regularly. In the case of DSDV, the ratio demonstrates a falling trend as the number of nodes increases, indicating a higher susceptibility for packet loss. Due to the ongoing updates between nodes, even when there is no change in topology, these packets can cause congestion in the network, resulting in packet collisions and ultimately packet loss.

Graph B demonstrates that both routing systems experience an increase in routing overhead as the number of nodes grows. This is due to the increased number of packets being transmitted to the nodes for the purpose of updating packets, determining the optimal routing, and modifying routes. AODV has lower routing overhead compared to DSDV. This is due to the fact that with AODV, packet requests and transmissions only occur when there are changes in the network's topology. The on-demand technique decreases the total amount of routing updates and control messages, resulting in a lower routing overhead compared to DSDV, which uses a periodic update mechanism. Conversely, DSDV leads to increased routing overhead as the network expands, as every node consistently communicates routing information even in the absence of any alterations in the network configuration.

Concerning end-to-end delay, Graph C demonstrates no variation in AODV as the number of nodes grows. However, for DSDV, the delay noticeably increases. This demonstrates that as the routing tables of each node grow in size and complexity, the time required for route lookups and updates would inevitably increase. Due to its proactive nature, the DSDV routing protocol has a gradual rise in delay in discovering routes or forwarding packets, mostly because it requires constant updates with new information. However, AODV is more efficient in managing end-to-end latency as it consistently reduces the delay as the number of nodes increases. This is because it refrains from sending updates needlessly.

C. Impact of Packet Size

Graphs D, E, and G illustrate the impact of different packet sizes on the packet delivery ratio, end-to-end delay, and routing overhead, respectively. The findings are averaged across various numbers of nodes for each packet size to offer a full understanding of how packet size affects each measure. The link between packet size and each statistic, as well as the difference between the DSDV and AODV routing protocols, varies compared to the impact of network size.

It is evident that AODV consistently does not experience any packet loss, regardless of the packet size. In contrast, DSDV likewise shows a decrease in packet loss as the packet size grows. The reason for this is mostly because the DSDV protocol requires the constant maintenance of accurate tables at every node, resulting in network congestion, particularly when the packet size is larger. Although AODV is an on-demand protocol, it effectively minimizes control traffic and promptly adjusts to network changes, resulting in improved efficiency in terms of routing maintenance and scalability.

Furthermore, the routing overhead escalates proportionally with the packet size in both protocols, while AODV exhibits a lower overhead compared to DSDV. The rise in cost for DSDV is a consequence of its persistent update method, which leads to a higher frequency of exchanges, contributing to network congestion and packet loss. On the other hand, AODV's routing method that is activated only when needed decreases the quantity of routing messages, resulting in improved utilization of bandwidth and reduced overhead. Consequently, AODV's capacity to sustain stable routes and reduce control traffic plays a significant role in its consistent performance and minimum packet loss, even when packet sizes increase. Due to the continuous transmission of updates, the quantity of routing packets in DSDV will inherently be greater than that in AODV, which only initiates requests when a change takes place.

The disparity in end-to-end delay between AODV and DSDV may be observed in Graph G. The disparities between the two are notable, as AODV exhibits lower latency due to its limited packet modifications and routing, which only occur when new routes are necessary, hence decreasing the overall delay. However, DSDV experiences a growing delay as the size of packets increases. This is because DSDV uses a proactive routing system that necessitates regular updates and ongoing maintenance of routing tables. These activities contribute to the total delay, particularly as packet sizes become larger. When comparing, it appears that AODV experiences a decrease in delay as packet sizes increase. This is likely due to its efficient processing, which eliminates the need for frequent route changes and lessens the influence of larger packets on the total transmission time.

V. DISCUSSION of DIFFERENCES

A. Packet Delivery Ratio

DSDV maintained a high PDR across different packet sizes and node densities, though slightly lower than AODV in larger networks. The PDR also decreased marginally as the number of nodes increased, indicating potential challenges in maintaining route consistency under higher loads. On the other hand, AODV achieved 100% in nearly all scenarios, showcasing its reliability in delivering packets. The reactive nature of AODV ensures consistent route availability, leading to zero packet loss under the simulated conditions.

B. Routing Overhead

Higher routing overhead was demonstrated by DSDV, which increased significantly with the number of nodes and packet sizes. This is due to the constant update of routing information even without changes in the network topology, resulting in a substantial number of control packets. AODV, however, maintained a lower routing overhead compared to DSDV, despite increasing node density and packet sizes. The periodic updates of routing tables in DSDV reduce the need for frequent route discoveries, minimizing control message overhead.

C. End-to-end Delay

Likewise, DSDV also experienced higher end-to-end delays, which increased with its node density and packet size. The proactive maintenance of routing tables in DSDV ensures that routes are immediately available, contributing to the additional delay in establishing routes before packet transmission. AODV demonstrated significantly lower end-to-end delays across all scenarios. The reactive nature of AODV, which requires route discovery on demand, reduces the time packets spend waiting for route discovery.

VI. SUMMARY ANALYSIS

The simulation findings demonstrate clear advantages and disadvantages of the AODV and DSDV routing protocols in wireless ad hoc networks. DSDV exhibited a consistently high PDR for different packet sizes and node density. However, there was a minor decrease in PDR as the network size increased, suggesting that while packet delivery was efficient, there may be difficulties in maintaining consistent routes under heavier loads. In contrast, AODV demonstrated a flawless PDR in almost all situations, highlighting its dependability as a result of its proactive approach that guarantees continuous route availability and prevents any loss of packets.

DSDV demonstrated more routing overhead, which escalated notably with the growth in the number of nodes and packet sizes, primarily because of frequent route discovery procedures. The AODV protocol reduces routing overhead by regularly updating routing tables, thus lowering the amount of control messages sent. AODV exhibited elevated end-to-end delays that escalated with the density of nodes and the size of packets, primarily due to its reactive route discovery mechanism. On the other hand, AODV exhibited notably shorter delays in all situations due to its proactive maintenance of routing tables, which guarantees instant availability of routes and reduces the time that packets wait for route discovery. Therefore, DSDV is better suited for smaller, dynamic networks that require a high level of adaptability, while AODV is well-suited for bigger, stable networks that prioritize dependable packet delivery and low latency.

VII. CONCLUSION

This study employed the ns-3 simulation tool to evaluate the efficiency of the Ad-hoc On-Demand Distance Vector (AODV) and Destination-Sequenced Distance-Vector (DSDV) routing protocols in mobile ad-hoc networks (MANETs). The researchers assessed important performance measures, such as packet delivery ratio (PDR), routing overhead, and end-to-end delay, by conducting simulations under different network scenarios. The results indicated that AODV is well-suited for larger and more stable networks, since it offers dependable packet delivery and little delay owing to its reactive routing approach. On the other hand, DSDV, due to its proactive routing characteristics, consistently maintained available routes and experienced minimum packet loss. This makes it well-suited for smaller, dynamic networks that need to be very adaptable. Both protocols provide unique benefits and constraints, indicating that the selection of a protocol should be determined by the specific demands and attributes of the network environment. This study provides significant insights for optimizing the selection of protocols in various circumstances of Mobile Ad hoc Networks (MANETs), hence improving the overall performance of the network.

VIII. ACKNOWLEDGEMENTS

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