Performance Comparison of AODV, DSDV and ZRP Routing Protocols

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Abstract: Mobile Ad Hoc Networking (MANET) is a group of independent network mobile devices that are connected over various wireless links. It is relatively working on a constrained bandwidth. The network topologies are dynamic and may vary from time to time. Each device must act as a router for transferring any traffic among each other. This network can operate by itself or incorporate into large area network (LAN). In this paper, we have analyzed various Random based mobility models: Random Waypoint model, Random Walk model, Random Direction model and Probabilistic Random Walk model using AODV,DSDV and ZRP protocols in Network Simulator (NS 2.35). The performance comparison of MANET mobility models have been analyzed by varying number of nodes, type of traffic (CBR, TCP) and maximum speed of nodes. The comparative conclusions are drawn on the basis of various performance metrics such as: Routing Overhead (packets), Packet Delivery Fraction (%), Normalized Routing Load, Average End-to-End Delay (milliseconds) and Packet Loss (%).

Keywords:

Mobile Ad hoc, AODV, DSDV,ZRP, TCP, CBR, routing overhead, packet delivery fraction, End-to-End delay, normalized routing load.

1 Introduction:

Wireless technology came into existence since the 1970s and is getting more advancement every day. Because of unlimited use of internet at present, the wireless technology has reached new heights. Today we see two kinds of wireless networks. The first one which is a wireless network built on-top of a wired network and thus creates a reliable infrastructure wireless network. The wireless nodes also connected to the wired network and these nodes are connected to base stations. An example of this is the cellular phone networks where a phone connects to the base-station with the best signal quality.

The second type of wireless technology is where no infrastructure [1] exists at all except the participating mobile nodes. This is called an infrastructure less wireless network or an Ad hoc network. The word Ad hoc means something which is not fixed or not organized i.e. dynamic. Recent advancements such as Bluetooth introduced a fresh type of wireless systems which is frequently known as mobile Ad-hoc networks.

A MANET is an autonomous group of mobile users that communicate over reasonably slow wireless links. The network topology may vary rapidly and unpredictably over time because the nodes are mobile. The network is decentralized where all network activity, including discovering the topology and delivering messages must be executed by the nodes themselves. Hence routing functionality will have to be incorporated into the mobile nodes. Mobile ad hoc network is a collection of independent mobile nodes that can communicate to each other via radio waves. The mobile nodes can directly communicate to those nodes that are in radio range of each other, whereas others nodes need the help of intermediate nodes to route their packets. These networks are fully distributed, and can work at any place without the aid of any infrastructure. This property makes these networks highly robust.

In late 1980, within the Internet [1] Engineering Task Force (IETF) a Mobile Ad hoc Networking (MANET) Working Group was formed to standardize the protocols, functional specification, and to develop a routing framework for IP-based protocols in ad hoc networks. There are a number of protocols that have been developed since then, basically classified as Proactive/Table Driven and Reactive/On-demand Driven routing protocols, with their respective advantages and disadvantages, but currently there does not exist any standard for ad hoc network routing protocol and the work is still in progress. Therefore, routing is one of the most important issues for an ad hoc network to make their existence in the present world and prove to be divine for generations to come. The area of ad hoc networking has been receiving increasing attention among researchers in recent years. The work presented in this thesis is expected to provide useful input to the routing mechanism in ad hoc Networks.

2 Protocol Descriptions

2.1 Ad hoc On Demand Distance Vector (AODV)

AODV routing algorithm is a source initiated, on demand driven, routing protocol. Since the routing is "on demand", a route is only traced when a source node wants to establish communication with a specific destination. The route remains established as long as it is needed for further communication. Furthermore, another feature of AODV is its use of a "destination sequence number" for every route entry. This number is included in the RREQ (Route Request) of any node that desires to send data. These numbers are used to ensure the "freshness" of routing information. For instance, a requesting node always chooses the route with the greatest sequence number to communicate with its destination node. Once a fresh path is found, a RREP (Route Reply) is sent back to the requesting node. AODV also has the necessary mechanism to inform network nodes of any possible link break that might have occurred in the network.

2.2 Destination Sequenced Distance Vector (DSDV)

The Destination Sequenced distance vector routing protocol is a proactive routing protocol which is a medications of conventional Bellman-Ford routing algorithm. This protocol adds a new attribute, sequence number, to each route table entry at each node. Routing table is maintained at each node and with this table; node transmits the packets to other nodes in the network. This protocol was motivated for the use of data exchange along changing and arbitrary paths of interconnection which may not be close to any base station.

2.3 Zone Routing Protocol (ZRP)

ZRP is designed to address the problems associated with proactive and reactive routing. Excess bandwidth consumption because of flooding of updates packets and long delay in route discovery request are two main problems of proactive and reactive routing respectively. ZRP came with the concept of zones. In limited zone, route maintenance is easier and because of zones, numbers of routing updates are decreased. Nodes out of the zone can communicate via reactive routing, for this purpose route request is not flooded to entire network only the border node is responsible to perform this task. ZRP combines the feature of both proactive and reactive routing algorithms. The architecture of ZRP consists of four elements: MAC-level functions, Intra-Zone Routing Protocol(IARP),Inter-Zone Routing Protocol (IERP) and broadcast Routing Protocol(BRP). The proactive routing is based within limited specified zones and beyond the zones reactive routing is used. MAC-level performs neighbour discovery and maintenance functions. For instance, when a node comes in range a notification of new neighbour is sent to IARP similarly when node losses connectivity, lost connectivity notification is sent to IARP. Within in a specified zone, IARP protocol routes packets. IARP keeps information about all nodes in the zone in its routing table. On the other hand, if node wants to send packet to a node outside the zone, in that

case IERP protocol is used to find best path. That means IERP is responsible to maintains correct routes outside the zone. If IERP does not have any route in its routing table, it sends route query to BRP. The BRP is responsible to contact with nodes across Ad Hoc networks and passes route queries. Important thing in bordercasting mechanism of BRP is it avoids packets flood in network. BRP always passes route query request to border nodes only. Since only border nodes transmit and receive packets

3 Simulation

Both routing techniques were simulated in the same environment using Network Simulator (ns-2). AODV, DSDV & ZRP were tested by the traffic i.e. TCP. The algorithms were tested using 50 nodes. The simulation area is 1000m by 1000m where the nodes location changes randomly. The connection used at a time is 30. Speed of nodes varies from 1m/s to 10m/s. by using TCP traffic we calculate performance of these two protocols for different random based mobility model. i.e.:

(i)   Random Waypoint (RWP)
(ii)   Random walk(RW)
(iii)   Random direction(RD)
(iv)   Prob. Random Walk(PRW)

4 Simulation result

The results of our simulation will be presented in this section. First we will discuss the results of both AODV, DSDV & ZRP protocol for different matrices and after that we make the comparison between the two protocols.

4.1 Pause Time Model Result

This test studied the effects of increasing pause time on the performance of three routing protocols. As pause time increases, mobility in terms of change in directions (movement) decreases. When a pause time occurs, node stops for a while and select another direction to travel. If speed is deifned as constant then for every occurance of pause time, speed of node remains constant. In this model pause time changes from 0s to 400s while other parameters (nodes=50, speed=10 m/s, data sending rate=16kbps and no. CBR flows=10) are constant.
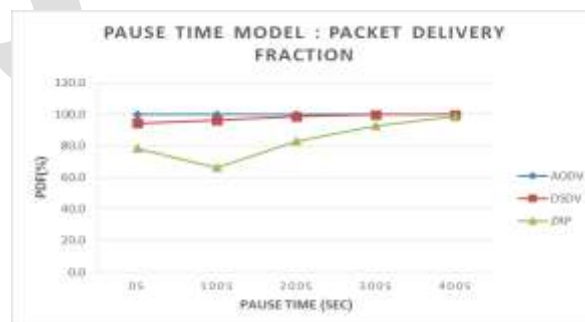

Fig.3(a): Varying pause time vs packets delivery fraction (%)

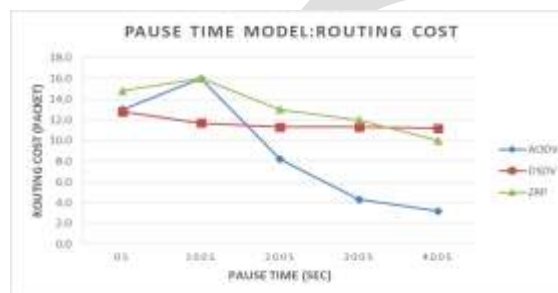Fig. 3(b) Varying pause time vs average network end-to-end delay (in seconds)

Fig. 3(c): Varying pause time vs routing cost(in packets)

The figures 3(a),3(b) and 3(c) demonstrate packets delivery fraction, avg. Network delay and routing cost when pause time varies from 0s to 400s. Figure 3(a) shows difference in packets delivery fractions of protocols. The performance of AODV is almost 100%. We recorded an average of 99% packets delivery for AODV during the whole simulation. DSDV was closed behind to AODV and showed second best performance. With smaller pause time (higher node's movement) DSDV delivered 90% of data packets successfully. As pause time increased (node's movement decrease d)DSDV packets delivery ration also increased and during pause time 300s and 400s DSDV gave similar performance as AODV. Same happened with ZRP. At pause time0s, 80 % of packets delivery fraction is recorded. We observed slightly low packets delivery fraction value of ZRP at pause time 100s. Although the value of packets delivery at this point should have been higher than the previous one. We check the NAM file but didn't find anything going wrong. One possible reason could be the far placement of sources and destinations before the pause time 100s occurred.

Figure 3(b) shows average end-to-end network delay. In high nodes movement , delay of ZRP is recorded 0.1s. As node's movement slowed down till pause time 400s, delay offered by ZRP also moved down and approached to near AODV as shown in fig. 3(b). DSDV and AODV showed nearly similar performance in terms of delay. But DSDV is bit smoother and offered lower delay compare to AODV. An average of 0.011s is recorded for DSDV, AODV possessed the second best position with an average delay of 0.014 s. While ZRP offered an average delay of 0.4 s.

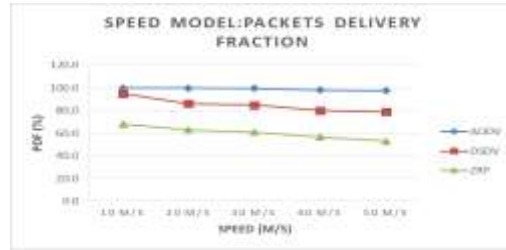## 4.2 Speed Model Simulation Results

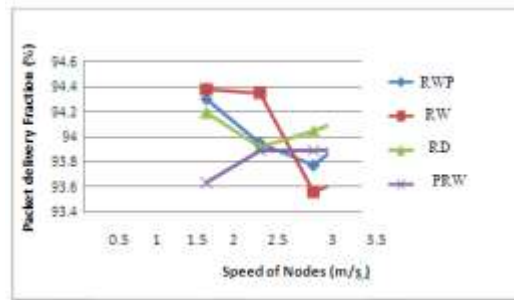Fig. 4(a) Varying speed vs packets delivery fraction (%)

Fig. 4(b) Varying speed vs average network end-to-end delay (in seconds)

Figure 4(b) shows tha average end-to-end network delay. We didn't see much difference between the delay values of AODV and DSDV. But DSDV performed slightly better than AODV and showed a constant performance with and average delay of 0.01s. Although AODV showed similarity with DSDV but at maximum speed of 50 m/s delay increased from 0.017 to 0.05s. Comparatively, ZRP showed high delay values. At speed 20 m/s delay slightly went down and again increased as node's speed increased. ZRP maintains an average of 0.1s delay.

Fig. 4(c) Varying speed vs routing cost (in packets)

Figure 4 (c) illustrates routing cost introduced in network. DSDV maintained an average of 12 control packets per data packets throughout the simulation. As speed increased, routing overhead of AODV also increased and reached up to 54 control packets per data packets. ZRP showed a high routing overhead. The maximum recorded routing load at high mobility was 2280 control packets.
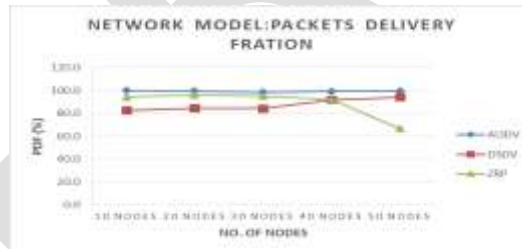

4.3 Network Model Simulation Results

Fig.5(a) Varying nodes vs packets delivery fraction (%)

Figure 5(a) 5 (b) and 5(c) show protocols performance in network model. We recorded consistent packets delivery fraction values of AODV in different network seize. In contrast, ZRP achieved consistent packet delivery till network size of 30 nodes. An average of 96% delivery ratio is recorded. In network size of 40 nodes, ZRP packets delivery fraction fell down from 95% to 91%. While in network size of 50 nodes the lowest value of packets delivery fraction is recorded (69%).DSDV showed the 3rd best performance in network model in terms of packets delivery fraction. As size of network increased , packets delivery fraction value of DSDV also increased and reached up to 91%. Packets delivery fraction comparison of protocols can be seen in figure 5(a). In terms of delay, figure 5(b), DSDV showed slightly consistent performance with an average delay of 0.01s. But delay of AODV varies in between 0.012s and 0.026s during whole simulation. ZRP, on the other hand, gave lowest delay as compared to AODV and DSDV until network size of 30 nodes. From network size of 30 nodes to 40 nodes, we saw slight increase in delay value of ZRP
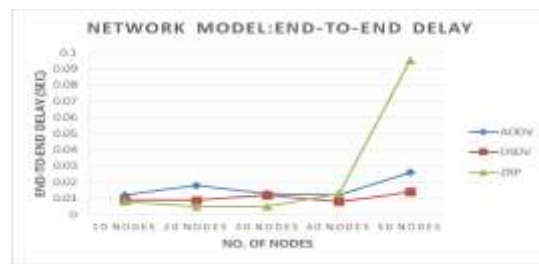
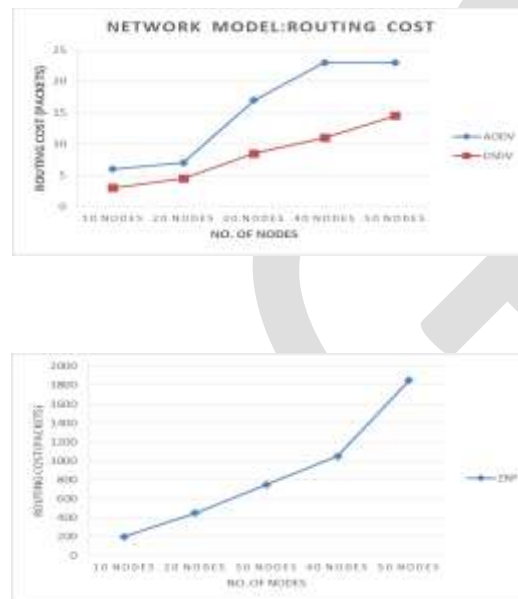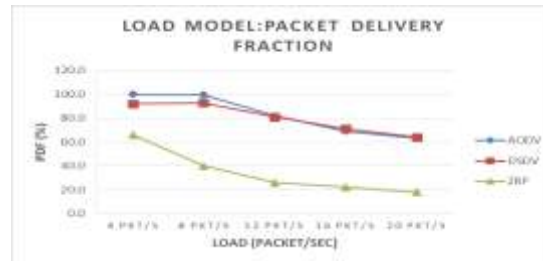Fig. 5(b) Varying nodes vs average network end-to-end delay

Fig. 5 (c) Varying nodes vs routing cost (in packets)

Figure 5(a) 5(b) and 5(c) show protocols performance in network model. We recorded consistent packets delivery fraction values of AODV in different network seize. In contrast, ZRP achieved consistent packet delivery till network size of 30 nodes. An average of 96 % delivery ratio is recorded. In network size of 40 nodes, ZRP packets delivery fraction fell down from 95% to 91%. While in network size of 50 nodes the lowest value of packets delivery fraction is recorded (69%).DSDV showed the 3rd best performance in network model in terms of packets delivery fraction. As size of network increased, packets delivery fraction values of DSDV also increased and reached up to 91%. Packets delivery fraction comparison of protocols can be seen in figure 5(a). In terms of delay, figure 5(b), DSDV showed slightly consistent performance with an average delay of 0.01s. But delay of AODV varies in between 0.012 and 0.026s during whole simulation. ZRP, on the other hand, gave lowest delay as compared to AODV and DSDV until network size of 30 nodes. From network size of 30 nodes to 40 nodes, we saw slight increase in delay value of ZRP and from nodes 40 to 50, there was a drastic increase in delay value. The maximum delay we calculated for ZRP at this point is 0.095s.
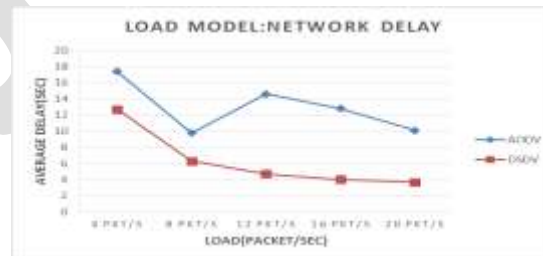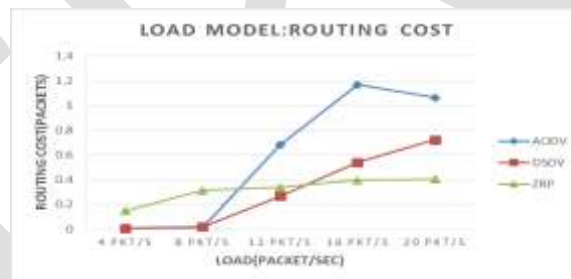
Figure 5 (c) demonstrates routing cost offered by protocols. From the figure , it is quite visible that routing load of ZRP is much higher than of AODV and DSDV. As network became fully dense the routing load of ZRP reached up to 1915 control packets per data packets. AODV and DSDV also showed the same behaviour . However, DSDV comparatively gave low routing load and an increased of 3 to 4 control packets are calculated as network size increased. AODV seemed to approach to DSDV when network size was 20 nodes but just after this point the load raised and reached up to 22 control packets. After the network size of 40 nodes we saw a consistent performance of AODV.
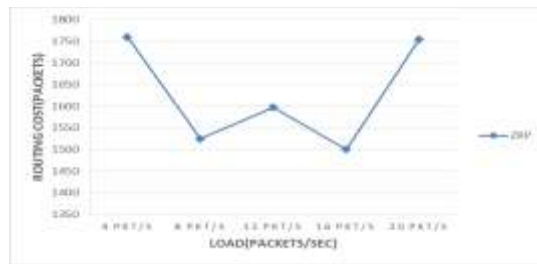
4.4 Load Model Simulation Results

In this testing model, varying parameter is data sending rate. With 10 CBR sources we offered different workload. Load increased from 4 to 20 data packets/second while pause time is null, node's speed is 10 m/s and number of nodes are 50.

Figures 6(a), 6(b) and 6(c) highlight relative performance of three protocols on load model. As seen in figure 6(a) packets delivery fraction of all protocols are affected as data sending rate increased. DSDV looked closer to AODV. Both maintained consistent delivery ratio till rate of 8 data packets/s. As sending rate increased from that point both protocols started droping data packets. At sending rate of 20 packets/s, AODV and DSDV gave lowest packets delivery fraction i.e 63% and 66% respectively. ZRP suffered badly when load increased and gave worst packets delivery fraction at sending rate of 8,12,16 and 20 packets/s.
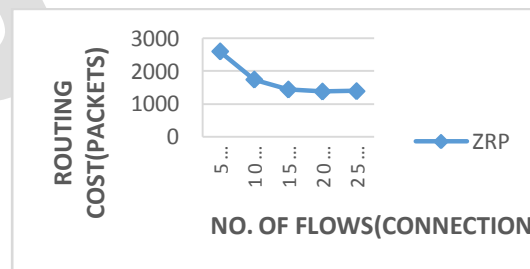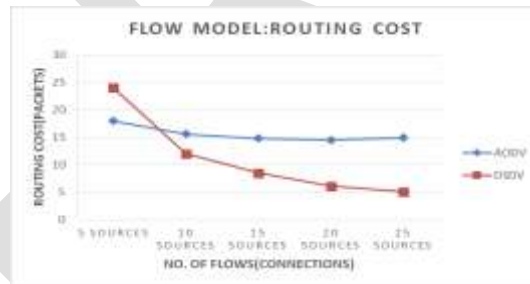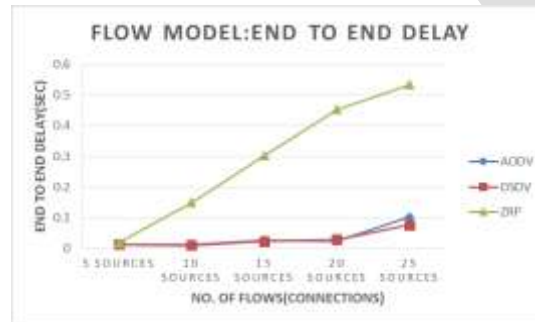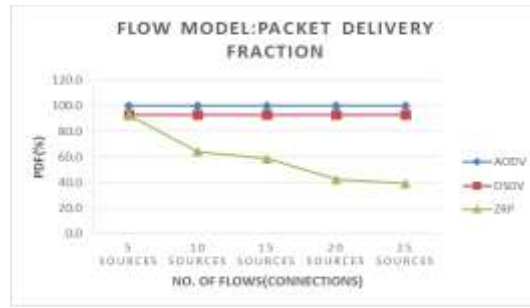
ZRP delivered only 18% f data packets at sendinf rate of 20 packets/s. Network delay can be found in figure 6(b). As figure highlights , ZRP maintained an average delay of 0.3s against increasing load. AODV and DSDV initially showed small delay value under low sending rate. As offered load increased from 8 packets/s to on ward, both AODV and DSDV reported high delay values.AODV however showed a rapid increased in delay and reported highest delay value of 1.064s when transmission rate was 16 packets/s Routing cost of protocols in load model is presented in fugure 6(c). As shown in figure the routing cost of DSDV is lower than AODV. As load in the network increases DSDV generates less routing packets. AODV gave slightly higher overhead than DSDV. For AODV, from offered load of 4 packets/s to 8 packets/s.

Finally at maximum applied load AODV generated 10 control packets. ZRP in this model again generated high number of control packets But this time as compare to figures 5(c) and 4(c). ZRP showed variation in routing load. From the sending rate of 8 to 16 packets/s. ZRP generated an average of 1540 control packets. At highest sending rate of 20 packets/s ZRP generated 1756 control packets.

4.5 Flow Model Simulation Results

In this testing model each CBR flows generated 16 kbps of traffic. Number of flows (connections) varied from 5 to 25. This model evaluates the strength of protocols in various source connections.

Figure 7(a), 7(b) and 7(c) show results we drawn after simulation. As shown in figure 7(a) packets delivery fraction of ZRP is lower than other two protocols. As number of flows increased from 5 to 25 sources, packets delivery fraction of ZRP also suffered and moved down fastly. For 5 sources both ZRP and DSDV delivered almost same number of packets to destination. But as number of CBR sourcesincreased DSDV maintained its packets delivery (an average of 90%) continuously till the end of simulation while ZRP started dropping packets. Finally for 25 number of CBR sources ZRP only delivered 38% of data packets to destination. AODV outperformed here and delivered 99% of data packets against increasing number of CBR sources. Average network delay is shown in figure 7(b). AODV and DSDV , both showed small delay values and almost same values till 20 number of CBR sources. Only a slight increase in delay (near to 0.1s) of both protocols happened for 25 number of CBR sources. From the start till end, delay of ZRP countinuesly moved up as number of CBR sources increases and reached up to highest value fo 0.543s. ZRP offered high delay as compared to AODV and DSDV.

Routing cost of all the protocols reduced when number of CBR sources increased as shown in figure 7(c). If we see AODV and DSDV, initially for 5 number of sources AODV generated 18 control packets while DSDV generated 23

control packets. As CBR sources changed from 5 to 25, both protocols generated small number of control packets. Although performance of DSDV is more satisfactory as it generated an average of 9 control packets, while AODV generated an average of 15 control packets. For ZRP the value of routing cost is very high (figure 7c). As we can see for 5 number of CBR sources ZRP generated the maximum routing packetsthat is 2646. Although , routing overhead decreased as number of sources increased and reached up to its lowest value of 1364 routing packet for 24 CBR sources. But still the routing load of ZRP is very much higher than DSDV and AODV

6 Future works:

In this paper four Random mobility models have been compared using AODV, DSDV and ZRP protocols. This work can be extended on the following aspects:

☐ Investigation of other MANET mobility models using different protocols under different types of traffic like CBR.

☐ Different number of nodes and different node speeds.

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