A Novel Approach to Find an Optimal Path in MANET Using Reactive Routing Protocol

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Abstract- **If there is no communication between the nodes in MANET, reactive protocols don't preserve routing information in the network node level. Reactive protocol determines a route to a specific destination when a particular packet intends to send. We propose a reverse reactive routing based Route discovery approach, which is used to find an optimal route to the destination with lower overhead, than the flooding based reverse route discovery. We also showed that the process of the reverse reactive protocol performance for finding an optimal path to the destination. The discussion is based on the optimal path, which is obtained through three steps; those are reverse route calculation in route request (RREQ), reverse route calculation in route reply (RREP) and reverse route calculation in route error (RERR). Experiments have been carried out using NS2 as network simulator and results show that performs better than reactive routing protocol (AODV).**

Keywords: **Mobile Ad-Hoc Networks, Reactive Routing Protocol, Route Discovery, Ns2, RAODV**

I. INTRODUCTION

1.1 Mobile ad-hoc network

In the next generation of wireless communication systems, there will be a drastic need for the rapid deployment of independent mobile users for rescue operations, disaster relief, and military operations. Such type of network scenarios can not rely on centralized connectivity, and can be conceived as applications on Mobile Ad Hoc Networks. The design of network protocols for these networks is really a complex issue. Regardless of the application, MANETs need efficient distributed algorithms to determine network organization, link scheduling and routing. However, determining variable routing paths and delivering messages in a decentralized environment where network topology fluctuates is not a well-defined problem. While the shortest path (based on a given cost function) from a source to destination in a static network is usually the optimal route. But this idea can not be easily extended to MANETs.

Mobile ad-hoc networks are self-organizing and self configuration of multi-hop wireless networks, where to interpret the network changes dynamically due to mobility of nodes [1]. The reactive routing protocol algorithm creates routes between nodes on request of source nodes with network flexibility, to allow the nodes to enter and leave the network at any point of time. The newly created routes remain active only as long as data packets are travelling along the paths from the source to the destination. A routing procedure always needs to find an optimal path to send the packets between the source and the destination [2]. Therefore the requirements of the protocol for mobile ad hoc networks are path (source, destination), hop count and sequence number, to make sure the freshness of the routes.

1.2 Reactive Routing Protocol

Reactive routing protocol is an on-demand routing protocol for mobile ad-hoc networks, which uses routing tables to store routing information. During routing, all route information maintain in tables, for unicast routes as well as for multicast routes. These routing tables hold information like destination address, next-hop address, hop-count, destination sequence number and life time. Instead of keeping static route information from one node to every other node, any reactive routing protocol can discover the route as and when required and these routes are maintained as long as necessary. The protocol comprises of three main functions like *route discovery*, *route establishment* and *route maintenance*.

In routing protocol, on request of source node, route discovery function is responsible for the discovery of new routes. Route establishment function is responsible for detection of the link of discovered routes by route establishment function. Finally route maintenance function is responsible for detection of the link failures and repair of an existing route. Reactive routing protocols, such as the AODV [3] nodes have four types of message to communicate between each other. These are Route Request, Route Reply, Route Error and Hello messages with a key feature that doesn't require any distribution routing information and then, keep the routing information about the failure links [4]. During packets transmission, every intermediate node in the discovery route create routing table to store the information regarding neighbour node and the destination node information. The routing table information updated for every packet transmission during the message transmission. When communication between two nodes completes, the nodes discard all these routing and neighbour information.

II. RELATED WORK

Numerous frameworks have been proposed in mobile Ad-hoc network for performance-based routing protocol. Few of them are frameworks are simulated. This framework uses the concept of reverse reactive routing to find an optimal path between source and destination.

khan et al. [5] conclude that when the MANET setup, for a small amount of time, then AODV is better because of low initial packet loss. DSR is not preferable because of its packet loss. On the other hand if we have to use the MANET for a longer duration so we can use both protocols, because after sometimes both have the same behavior. AODV have very good packet receiving ratio in comparison to DSR. At the end, they concluded that the combined performance of both AODV and DSR routing protocol could be the best solution for routing in MANET. In [6], OPNET 14.5 was used for simulation. The simulation study for MANET network under five routing protocols AODV, DSR, OLSR, TORA and GRP were deployed using FTP traffic analyzing. These protocols were tested with three QoS parameters. From their analysis, the OLSR outperforms others in both delay and throughput. In [7], Barakovic et al. compared performances of three routing protocols: DSDV, AODV and DSR. They analyzed these routings with different load and mobility scenarios with Network Simulator version 2 (NS-2). They concluded that in low mobility and low load scenarios, all three protocols react in a similar way, but when mobility or load is increasing, DSR outperforms AODV and DSDV. In [8], Bindra et al. evaluate the performance of AODV and DSR routing protocol for a scenario of Group Mobility Model such as military battlefield. They used Reference Point Group Mobility (RPGM) Model for their scenario. They concluded that in Group mobility model with CBR traffic sources, AODV is better than DSR but when TCP traffic used, DSR perform better in stressful situation like high load or high mobility. DSR routing load is always less than AODV in all type of traffic. Average end-to-end delay of AODV is less than DSR in both type of traffic. Over all the performance of AODV is better than DSR in CBR traffic and real time delivery of data. But DSR perform better in TCP traffic under limitation of bandwidth. In [9], Kaushik et al. compared three routing protocols DSDV, AODV and DSR. They concluded that AODV performs predictably because it delivers the data at node with low mobility virtually, and it has problem when node mobility increases. But DSR was very good in situation that node has mobility and DSDV performs almost as well as DSR, but it needs many routing overhead packets. As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. So for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DSDV's performance is better. In [11] Performance of AODV, TORA and DSDV protocols is evaluated under both CBR and TCP traffic pattern. Extensive Simulation is done using NS-2. Simulation results show that Reactive protocols perform better in terms of packet delivery ratio and average end-to-end delay.

III. ROUTING PROTOCOL

Mobile ad-hoc networks, also well-known as short-term networks, are autonomous systems of mobile nodes forming network in the absence of centralized access point. Absence of fixed infrastructure poses several types of challenges for this type of networking. Among these challenges routing is one of them. Routing protocols of mobile ad-hoc network lean to need different approaches from existing protocols, since most of the existing Internet protocols were proposed to support routing in a network with fixed structure. The proposed routing protocol for find an optimal path in MANET using the following route discovery approaches.

3.1 Random way point mobility model

In mobility management, the random waypoint model is a random model for the movement of mobile users, and how their location, velocity and acceleration change over time. Mobility models are used for simulation purposes when new network protocols are evaluated. It is one of the most popular mobility models and the "benchmark" mobility model to evaluate other Mobile ad hoc network (MANET) routing protocols, because of its simplicity and wide availability. In random-based mobility models, the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes. We have taken this model to model a real life simulation.

3.2 Optimal Path Finding Approach:

We study the problem of selecting an optimal route in terms of transition probability and link available time. Finally we calculate optimal path between source and destination node by three steps, which execute and forwarding RREQ (route request) packets, RREP (route reply) packet and RRER (route error) packets. Experiments have been carried out using NS2 as network simulator ware and results encouraging.

3.3 Computation of reverse route in RREQ

In mobile ad-hoc network each node will create a reverse route table when it receives a RREQ (route request), the RREQ is discards if it has already been processed. It records and indicates the route to the source node; otherwise the source address and the broadcast ID from RREQ resolve is there buffered to prevent it from being processed again. Furthermore, each node will calculate the distance every time, and most importantly, this distance is the key reason to choose the shortest path from the source node. Initially, when a node receives RREQ, it will create a reverse route entry which indicates the next hop (forwarding the RREQ) of the source node and calculate the distance between the next hop node and the source node. Second, each node will also make the similar decision when it receives RREQ and update reverse route table or discard RREQ [12].

In this case, we have use two variables (Exit and new) to indicate how to make reverse route calculation in RREQ. The Exit is distance the node calculates at the first time when it receives RREQ or the distance at current time. The new is distance the node calculates when it receives RREQ again. Once an intermediate node receives a RREQ, the node sets up a reverse route entry for the source node in its reverse route table. Reverse route entry consists of <Source IP address, Source seq. number, number of hops to source node, Destination IP address, Destination seq. Number>.

Fig. 1 Structure of Mobile Ad hoc Network

By using the reverse route a next node can send a RREP to the source node. Reverse route entry also has life time field. RREQ reaches to the destination, In order to respond to RREQ a next node should have in its route table unexpired entry for the destination and sequence number of destination at least as great as in RREQ (for loop prevention). If both conditions are meet & the IP address of the destination matches with that in RREQ the node responds to RREQ by sending a RREP. If conditions are not satisfied, then node increments the hop count in RREQ and broadcasts to its neighbors. Ultimately the RREQ will make to the destination.

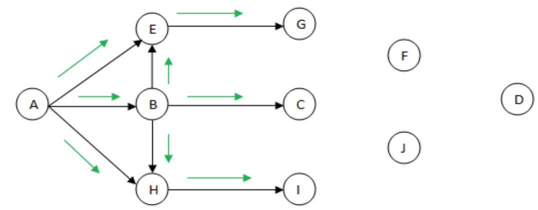

Fig2: Node RREQ Broadcasting

In Fig. 2, when node A broadcasts RREQ to node B and E, node B and E will create a reverse route entry which indicates the next hop to the source node when packet arrives at node B and E. Besides, node B and E would calculate the distance between forwarding node and source node. In this situation, the next hop to source node for node B and E is node A and the first for node B and E is 0, because node A is both the forwarding node and source node. And then, when node B forwards the RREQ to node E, node E will calculate the new which is the distance between forwarding node (node B) and the source node (A). Then, node E will compare the new with Exit (the first distance when node E receives RREQ from node A).Since new > Exit, the node discard this RREQ.This reverse route entry table Update route table in RREQ.

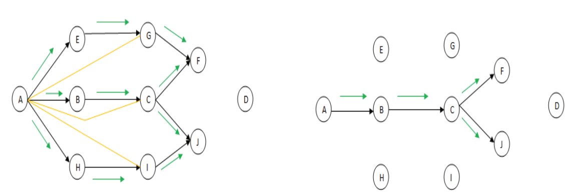

Fig.3 (a) Update Reverse route Table in RREQ. Fig.3 (b) The Result of Updating Reverse route tables in RREQ

As shown in Fig. 3(a), node F create reverse route entry when it receives RREQ from node G and select node G as the next hop to the source node (A). The same process happens when node F receives the same RREQ again from node C. Node F calculates the new between the forwarding node (node C) and the source node (A). Since new < Exit, node F updates the route table and select node C as the next hop to the source node. Fig.3 (b) is the finally route after node C broadcasts RREQ.

3.4 Computation of reverse route in RREP

We have used the similar calculation mechanism to find the optimal path in forwarding RREP. The simply difference is that the distance we calculate in RREP is from the node forwarding RREP to the destination node

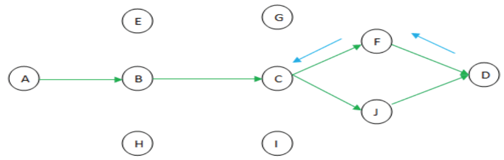

Fig 4: Reverse route entry and Calculates distance in RREP

As shown in Fig. 4, the destination node (node D) receives the RREQ from node F and then creates the RREP and unicasts it to node F. Node F forwards this RREP to node C according to the reverse route table created by forwarding the RREQ.

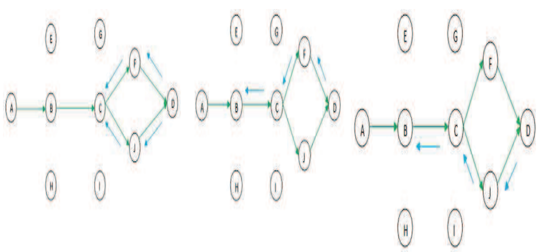

Fig 5(a): Update reverse route table in RREP. 5(b) and 5(c) Optimal Path between source and destination

When node C receives the RREP from node F, it creates the reverse route entry and calculates the Exit, which indicates the next hop is node F when the message whose destination node is node D arrives at node C. And then, when node C receives RREP from node D, it will calculates the new and finds that new<Exit, as shown in Fig. (a), (b)And (b), node C updates the route table, and then finally optimal path is found.

3.5 Computation of reverse route in RERR

We have used the similar calculation mechanism to find the optimal path in forwarding RERR. The simply difference is that When a node detects a link break (for example, receives a link layer feedback signal from the MAC protocol, does not receive passive acknowledgments, does not receive hello packets for a certain period of time, etc.), it performs a one hop data broadcast to its immediate neighbours.

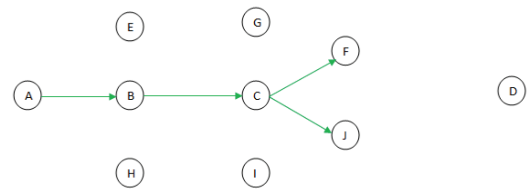

Fig 6: Reverse Route Entry and Calculates distance in RERR

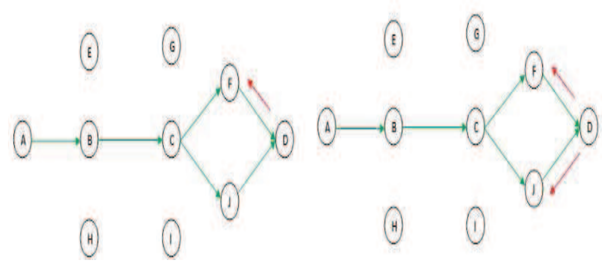

Fig 7(a): Update reverse route table in RERR. 7(b) Reverse Route Error Entry and Calculates all distances in RERR

As shown in Fig. 7(a), the destination node (node D) moves out of a range and does not receives the RREQ from node F and then creates the RERR and unicasts it to node F. Node F forwards this RERR to node C according to the reverse route table created by forwarding the RREQ. As shown in Fig 7 (b), the destination node (node D) specifies in the data header that the link is disconnected from F and thus the packet is candidate for alternate routing. Upon receiving this packet, neighbor nodes that have an entry for the destination in their alternate route table, unicast the packet to their next hop node. Node D receives the RREQ from node J and then creates the RERR and unicasts it to node J. Node J forwards this RERR to node C according to the reverse route table created by forwarding the RREQ.

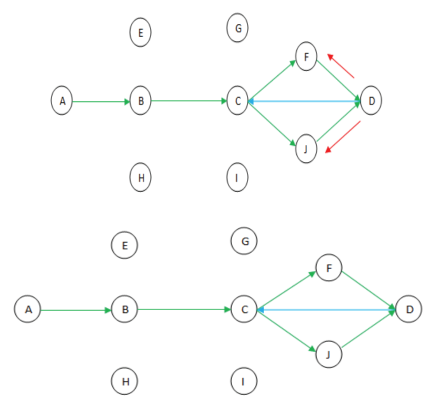

Fig 8(a) Route Discovery and (b) Update Reverse Route tables in RERR

As shown in Fig 8, the destination node (node D) specifies in the data header that the link is disconnected from F and J. Therefore the packet is candidate for alternate routing. Upon receiving this packet, neighbor nodes that have an entry for the destination in their alternate route table, unicast the packet to their next hop node. Node D broadcasts ROUTE REQUEST (RREQ) through Route Discovery and then creates the RREP and unicasts it to node C. Node C forwards this RREP to node B according to the reverse route table created by forwarding the RREQ. Each intermediate node (node C and B) updates the route.

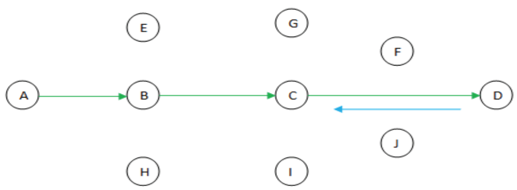

Fig 9: Optimal path communication between A to D

As shown in Fig 9, the destination node (node D) receives RREQ and count hops, when node C receives the RREP from node D; it creates the reverse route entry and calculates the exit, which indicates the next hop is node B when the message whose destination node is node C arrives at node B. And then, when node C receives RREP from node D, it will calculates the new and finds that new < exit and calculate the minimum length of hops, shows that Fig. 9, node C updates the route table, and then finally choose lower hop count get the optimal path between A to D. Therefore data packets can be delivered through one or more alternate routes and are not dropped when route breaks occur.

IV. PERFORMANCE EVALUATION

We have performed simulations to evaluate several performance metrics of our schemes. First, we would like to see how obtained optimal path of route discovered by reverse route calculation reduced. Then we compare our schemes with DSR in terms of packet delivery ratio, routing overhead and end-to-end delay.

Simulation environment

To evaluate and compare the effectiveness of these routing protocols with existing proposed models [13], we performed extensive simulations in NS2. Each simulation is carried out under a constant mobility. The simulation parameters are listed in table1.

Table 1: Simulation Parameters

Expt Parameter	Simul-time	Terrain Dimension	No. of mobile nodes	Node Placement	Mobility Speed	Mobility Model	Routing Protocol	MAC Protocol
Expt Value	400 S	(1500 * 1500) m	10	Random Waypoint	0-10 mps	Random	RAODV,DSR	
Descriptio n	Simul duration	X,Y Dimension s	No of nodes in a network	Change Direction in a randomly	Mobility of nodes	Mobility directions	Optimal Path-finding	Wireless Protocol

4.1 Simulation Results and Analysis

- *No of nodes Vs Bandwidth:*

The number of nodes was varied each time and the throughput was calculated at destination node during entire simulation period whose amount was as in fig. 2.

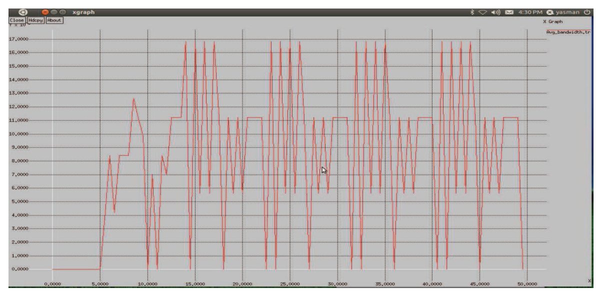

Figure 10: Bandwidth variation

RAODV shows higher throughput compare to DSR and AODV. The RAODV has much more routing packets than DSR because the RAODV avoids loop and freshness of routes while DSR uses stale routes. Its throughput is higher than other two routing protocols at high mobility.

- *No. of nodes Vs Packet Drop:*

A packet is dropped in two cases: the buffer is full when the packet needs to be buffered and the time that the packet has been buffered exceeds the limit. Packet dropping was observed for several nodes and varied the nodes each time and the dropped was counted at destination node during entire simulation period.

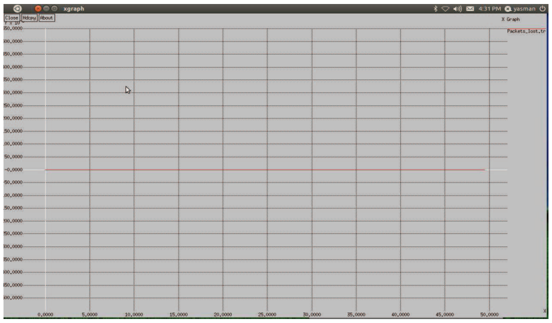

Fig. 11 Packet Lost variation

Efficient protocols can wisely find out routing direction thus packets dropping rate reduces for them. The packet dropped for DSR is less than that of AODV and RAODV as it outperforms with fewer nodes and no periodic update is maintained in DSR.

- *Packet Received Vs Propagation Delay:*

Packet receiving statistic were performed for several propagation delays in case of all MANET protocols, whose nature of packet variation becomes as in fig 4. DSR perform better when the propagation delay of nodes increases because nodes become more stationary will lead to more stable path from source to destination. DSR is superior to AODV as well as RAODV especially when the node's propagation delay begins to rise.

For RAODV, it shows significant dependence on route stability, thus its packet received rate is lower. Although, the amount of packet received is inversely proportional to propagation delay, DSR has the best performance than AODV and RAODV.

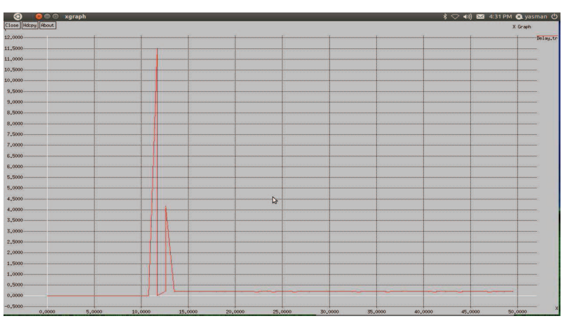

Fig. 12(a) Packet delay variation

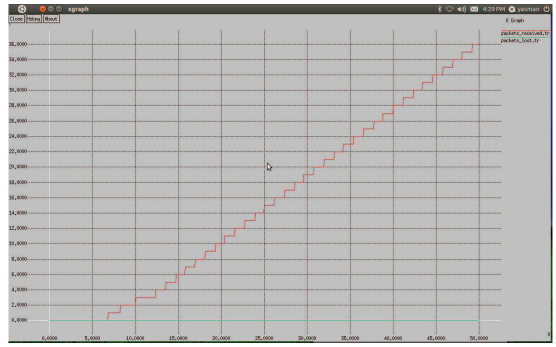

Fig. 12 (b) Packet received variation

- *Throughput Vs Simulation Time:*

Throughput was gained at destination node against various dimension of networks and varied the simulation time uniformly for each protocol whose measure was as in fig 5.Throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is usually measured in bits per second (byte/sec), and sometimes in data packets per second or data packets per time slot. This is the measure of how soon an end user is able to receive data. It is determined as the ratio of the total data received to required propagation time. A higher throughput will directly impact the user's perception of the quality of service (**QoS**).

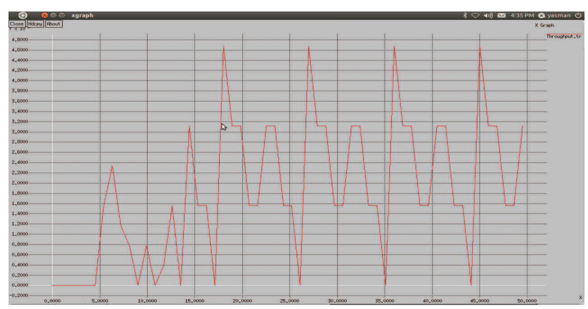

Fig 13: Throughput variation

Based on the fig 13, it is shown that AODV perform better when the time increases because nodes become more stationary will lead to more stable path from source to destination. AODV has higher throughput than RAODV and DSR because of avoiding the formation of loops and it uses stale routes in case of broken links. The rate of packet received for RAODV is better than the AODV because this periodic broadcast also add a large overhead into the network. For RAODV, the routing overhead is not likely affected as generated in AODV. For RAODV, it shows significant dependence on route stability, thus its throughput is lower when the time decreased.

Path Optimality:

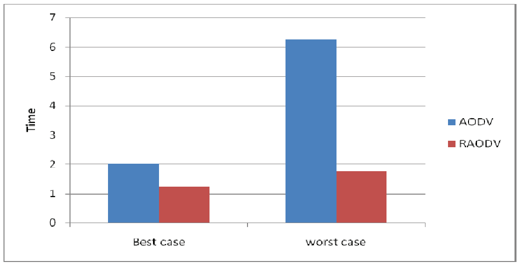

Fig.14 Optimal Path

The above displayed graph clarifies the fact that the proposed protocol is superior to the basic AODV protocol in both best cases as well as in worst case. But in worst case the performance of the proposed protocol is very indebted. From the calculation it was found that the newly proposed protocol is almost 85% fast as compare to the other reactive routing protocols. The ratio between the numbers of hops of the shortest path is to the number of hops in the actual path taken by the packets.

V. CONCLUSION

This study was conducted to propose a reactive routing protocol, consists of three steps to find the optimal path. Initially, we calculated the shortest path to the source node and created reverse route table. Then, we filtered these paths to obtain optimal path for communication in the mobile ad-hoc network by calculating distance to the destination node. Then in third step, a comparative analysis conducted in between three different protocols in terms of packet delivery ratio, routing overhead, throughput and average end to end delay, by using NS2 simulator. Finally, according to the average end to end delay, we have shown that DSR is lower than AODV, where the number of nodes we have used in our experiment is 10. We anticipate that our simulated results can be helpful for the future work for finding the optimal path in MANETs.

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