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Design, Implementation and Analysis of Efficient - AODV Routing Protocol in MANETs

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Abstract: Mobile ad hoc network (MANET) is independent structure of mobile nodes connected by wireless links. Ad hoc wireless networks are illustrated by multi-hop wireless connectivity, infrastructure less and repeatedly changing structure. Each node operates not only is a host, but also as a router to forward the packets. Hence energetic routing protocol is required for these networks to function appropriately. Many Routing protocols have been developed to complete this task. AODV is one of the commonly studied on-demand ad hoc routing protocols. AODV and others of the reactive ad hoc routing protocols use single route-reply with reverse path. Quick changes in topology causes that the route-reply could not arrive to the desire node. The source node sends numerous route request messages to gain a reply message, specifically on high speed mobility. This increases in end to end delays and decreases both in packet delivery fraction and average throughput. To overcome these problems, an efficient AODV (E-AODV) is proposed. In E-AODV the destination node receives first route request message (RREQ), it generates turn around route request (TA-RREQ) message and floods it to neighbor nodes within transmission area. When the source node receives first TA-RREQ message, then it starts packet transmission, and late arrived TA-RREQs are saved for future use. It reduces route fail correction messages and gets good performance than the existing AODV. The performances of AODV and E-AODV protocols are evaluated based on varying density and mobility using NS-2 simulator. It is examined by the simulation results that the performance of E-AODV routing protocol is better than existing AODV routing protocol in the forms of packet delivery fraction, average throughput and end to end delay especially in high speed mobility as well as with density.

Keyword - AODV, E-AODV, MANETs, NS-2, RREQ, RREP, TA-RREQ, RERR, density, mobility.

1. INTRODUCTION

A MANET is a collection of wireless nodes that can enthusiastically structure a network to exchange information without using any fixed network infrastructure. These are generally mobile and that's why it is called as Mobile Ad hoc NETworks. MANETs are defined as a "mobile ad hoc network" is an autonomous system of mobile associated by wireless links the union of which built a arbitrary topology [1]. The routers are free to move arbitrarily and arrange themselves randomly, that's why the network wireless topology can be change rapidly and randomly such a network may operate in an impartial way. If two nodes are not within the transmission range of each other, other nodes are needed to serve as midway routers for the communication between sources to destination node.

Furthermore, mobile devices wander separately and communicate via enthusiastically changing network. Thus, numerous change of network topology is a hard challenge for many important issues, such as routing protocol robustness, and performance ruin resiliency. Proactive routing protocol requires nodes to exchange routing information occasionally and compute routes constantly between any nodes in the network, regardless of using the routes or not This means numerous network resources such as energy and bandwidth may be washed out, which is not desirable in MANETs where the resources are very important. On the other hand, on-demand routing protocols do not swap routing information occasionally [10][11]. Instead, they find out a route only when it is required for the communication between two nodes. Because of this dynamic change of network on ad hoc networks, links between nodes are not fixed. In occasions, a node can't send packets to the intended next hop node and this will lost the packets. Loss of packets may influence on route performance in many ways. Along with these packet losses, loss of route reply brings much additional problems, because source node needs to reinitiate route discovery procedure to send packets. A disadvantage of existing on-demand routing protocols is that their main route discovery systems are not well concerned about a route reply message loss. More specifically, most of today's on demand routing is based on single route reply message. The vanished of route reply message may cause an important waste of performance.
In this paper we proposed efficient AODV which has a new feature contrasted to other on-demand routing protocols on ad-hoc networks. In E-AODV, route reply message is not uni-cast, destination node uses turn around RREQ (TA-

RREQ) to find source node. It decreases route path fail modification messages and can improve the performance. Thus, success rate of route discovery may be increased even in high node mobility situation. The simulation results show our proposed algorithm improves performance of AODV [9] in most metrics, including packet delivery fraction, average end to end delay and average throughput especially in high speed mobility of nodes [2].

2. LITERATURE REVIEW

2.1 Ad-Hoc on Demand Distance Vector Routing Protocol (AODV):

Perkins et. al.[3] The Ad-hoc On-Demand Distance Vector routing Protocol (AODV), is one of most common routing algorithm in ad hoc networks and is based on the principle of find out routes as required. AODV is a reactive algorithm that has few capabilities like low processing, memory overhead, and small network utilization. AODV routing algorithm is a famous method for structure routes between network nodes. The request is made on-demand rather than in advance, to account for the continually changing network structure, which is likely to in update routing tables on time. The routing table kept information about subsequently hop to the destination and a sequence number which is obtained RREQ packet to its neighbors. When middle nodes receive a RREP packet, they update their routing tables for a reverse route to the source and similar to this process, when the middle nodes receive RREP, they update the forward route to the destination. AODV protocol uses sequence numbers to determine the timeliness of each packet and to avoid creation of loops. AODV algorithm uses Route Error Message route failures and link failures spread by a RERR from a broken down link to the source node of the equivalent route. When the next hop link breaks, RERR packets are sent by the starting node of the link to a set of neighboring nodes that converse over the broken link with the destination.

Royer et.al.[4] The Ad-hoc On-Demand Distance Vector routing Protocol (AODV), is one of more studied routing algorithm in ad hoc networks and is based on the rule of discover routes as required. AODV routing algorithm is a famous method for building routes paths between network nodes. The request is made on-demand not in advance, to account for the repeatedly changing network topology, which is probable to in validate routing tables over time. In AODV [10], when a source node desires to send packets to the destination but no route is available, it begins a route discovery operation. In the route discovery operation, the source transmits route request (RREQ) packets (Fig 1). The routing table stores information about next hop to the destination and a sequence number which is obtained route request packet to its neighbors. The RREQ has following fields: source address, source sequence number, destination address, broadcast ID, destination sequence number and hop count. When middle nodes obtain a RREQ, they revise their routing tables for a turnaround route to the source and like this process, when the middle nodes receive RREP they revise the forward route to the destination. The RREP contains the following fields: source address, destination address, hop count and lifetime. AODV protocol uses sequence numbers to identify the timeliness of each packet and to avoid formation of loops.

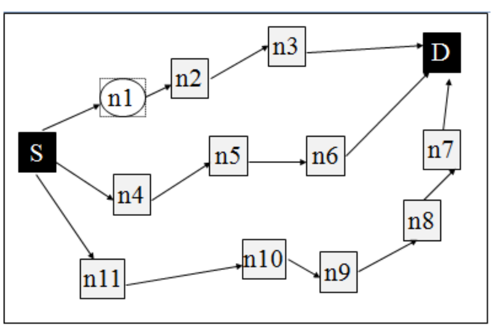

Fig 1: RREQ in AODV to find Route

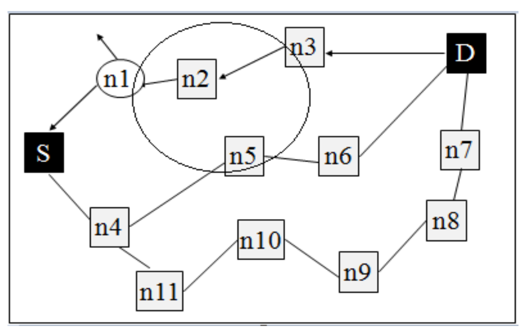

Fig 2: Path of RREP to the source in AODV

Once the RREQ reaches the destination, the destination or intermediate node responds by uni-casting a route reply (RREP) packet reverse to the neighbor from which it first received the RREQ (Fig 2).

As the RREP [8] is routed rear along the reverse path, nodes along this path set up forward route entries in their routing tables which point to the node from which the RREP came. These forward route entries indicate the present forward route. The route timer is used to deletion of the entry if it is not used within the particular lifetime. Since the RREP is forwarded along the path formed by the RREQ. Routes are maintained as follows. If a source node moves from its original position to other place, it is able to reinitiate the route discovery process to find another route to the destination. If a node along the route moves, its upstream neighbor observe the move and shows a link failure notification to each of its lively upstream neighbors to inform them of the removal of that part of the route. These nodes in turn propagate the link failure information to their upstream neighbors, and so on until the source node is reached. The source node may then choose to re-initiate route discovery for that destination if a route is still required. AODV algorithm uses Route Error Message (RERR) route failures and link failures propagated by using RERR message from a broken link to the source node of the matching route. When the next hop link fails, RERR packets are sent by the starting node of the link to a set of neighboring nodes that communicate over the failed link with the destination node [5].

Bharathi et.al.[7] proposed an optimized power reactive routing based on AODV protocol by using concept of cognitive function. It make sure data packet is transferred in the straight and most reliable scalability of network management and gives a way of broadcasting with an energy capable manner broadcasting with stability using a technique called Optimized Power Reactive Routing (OPRR) and for more superb performances. This proposed protocol avoids new route discovery process in AODV with low power consumption and maintain the stability of node and to get better scalability of the network.

3. PROBLEM STATEMENT

AODV and most of the on demand ad hoc routing protocols in MANETs use single route reply along reverse path. Quick change of network topology causes that the route reply could not arrive to the source node, i.e. after a source node sends numerous route request messages; the node obtains a reply message, especially on high speed mobility. This causes decrease routing performance, like, long end-to-end delay, low packet delivery fraction and average throughput. Therefore, we are considering how simply to decrease the failure of RREP messages. We can see a situation in Fig 2, where S is a source node, D is a destination node and others are intermediate nodes. In traditional AODV, when RREQ is broad D-n3-n2-n1-S is built [6].

This reverse path is used to deliver RREP message to the source node S. If node 1 moves towards the arrow direction and goes out of range of node 2, RREP lost will occur and the route discovery process will be hopeless. We can easily know that several alternative paths built by the RREQ message are ignored.

4. PROPOSED EFFICIENT-AODV (E-AODV)

4.1 PROPOSED PROTOCOL OVERVIEW

We propose the E-AODV to avoid RREP loss and improve the performance of routing in MANET. E-AODV uses exactly same procedure of RREQ of AODV to deliver route reply message to source node. We call the route reply messages turn around route request (TA-RREQ). E-AODV protocol can reply from destination to source if there is at least one path to source node. In this manner, E-AODV prevents a large number of retransmissions of route request messages, and hence diminishes the congestion in the network. Moreover, E-AODV will improve the routing performance such as packet delivery fraction, throughput and end-to-end delay especially in high speed mobility.

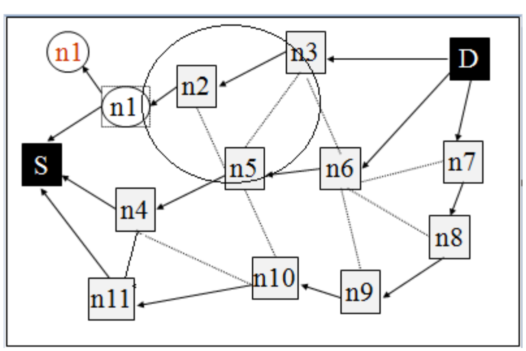

Fig 3: TA-RREQ in E-AODV

Let's see the same case of AODV, we have mentioned, in Fig 3. In E-AODV, destination does not uni-cast reply along pre-decided shortest reverse path D-n3-n2-n1-S. It floods TA-RREQ to find source node S. And forwarding path to destination is built through this TA-RREQ. Following paths might be built: S-n4-n5-n6-D, S-n11-n10-n9-n8-n7-D, and etc. Node S can choose best one of these paths and start forwarding data packet. So RREP delivery fail problem on AODV does not occur in this case, even though node 1 moves from transmission range.

4.2 IMPLEMENTATION

AODV and efficient AODV are tested on NS-2.34 which is a discrete event simulator targeted at networking research work. It provides considerable support for simulation of TCP, routing and multi-cast protocols on wired and wireless networks both. It consider of two simulation tools. The ns-2 simulator has several features that make it suitable for experimental result.

Ns-2 is an object-oriented simulator which is written in C++ and OTcl. The simulator supports a class hierarchy in C++ and a similar class hierarchy within the OTcl interpreter. There is a one-to-one association between a class in the interpreted hierarchy and one in the compile hierarchy. The reason to use two different programming languages is that OTcl is suitable for the programs and configurations that demand frequent and fast change and C++ is suitable for the programs that have high demand in speed. Ns-2 is highly extensible. It not only supports most commonly used IP protocols but also allows the users to extend or implement their own protocols. It also provides powerful trace functionalities, which are very important in our research since lot of information need to be logged for investigation.

4.3 ALGORITHEM FOR PROPOSED E-AODV PROTOCOL

The efficient AODV (E-AODV) routing protocol find out routes on-demand using a turnaround route discovery mechanism. In E-AODV the destination node receives first route request message (RREQ), it generates turn around route request (TA-RREQ) message and broadcasts it to neighbor nodes within transmission area. When the source node receives first TA-RREQ message, then it starts packet transmission, and late arrived TA-RREQs are saved for future use. It reduces route fail correction messages and gets good performance than the existing AODV.

STEP 1: In E-AODV Route request message contain following fields like source IP address, destination IP address, hop count, broadcast ID, source sequence number, request time and destination sequence number to uniquely identify this route request message.
STEP 2: When the destination node obtains initial route request message, it generates turn around route request (TA-RREQ) message and transmits it to neighbor nodes within transmission area.
STEP 3: In E-AODV turn around route request message contain following fields like broadcast ID, destination IP address, Destination Sequence Number, Source IP address, Reply Time and hop count.
STEP 4: When transmitted TA-RREQ packet arrives to middle node, it will check for duplicate messages.
STEP 5: If it previously received the similar message, the message is dropped, else forwards the message to subsequent nodes.
STEP 6: When the source node obtains first TA-RREQ message, then it starts sending packet.
STEP 7: Late arrived TA-RREQs are kept for further use.
STEP 8: The alternate routes can be used when the main route breaks communications.

4.4 IMPLEMENTATION CODE FOR PROPOSED E-AODV PROTOCOL

The following modification is done in original AODV code for implementing efficient AODV routing protocol in Route reply, small proposed code snippet is shown below:

```
recvMultiRoutes(Packet *p) {
struct hdr_ip *ih = HDR_IP(p);
struct hdr_aodv_reply *rp = HDR_AODV_REPLY(p);
```

```
char suppress_reply = 0;
double delay = 0.0;
aodv_rt_entry *rtc;
#ifdef DEBUG
 fprintf(stderr, "%d - %s: received a RQREP\n", index , __FUNCTION__);
#endif // DEBUG
if (rp->rp_src == index) {
#ifdef DEBUG
    fprintf(stderr, "%s: Got my own RQREP\n", __FUNCTION__);
#endif // DEBUG
    Packet::free(p);
    return;
  }
aodv_rt_entry *rt0; // it is reverse path
rt0 = rtable.rt_lookup(rp->rp_src);
if(rt0 == 0) {
   rt0 = rtable.rt_add(rp->rp_src);
 }
if (rp->rp_dst != index)
              {
  if ((rt0->rt_seqno < rp->rp_dst_seqno ) ||
       (( rt0->rt_seqno == rp->rp_dst_seqno) &&
       ( rt0->rt_hops > rp->rp_hop_count ))) {
      rt0->rt_expire = max(rt0->rt_expire, (CURRENT_TIME+REV_ROUTE_LIFE));
      rt0->pc_insert(ih->saddr());
      rt_update(rt0, rp->rp_dst_seqno, rp->rp_hop_count,ih->saddr(), max(rt0->rt_expire, (CURRENT_TIME +
REV_ROUTE_LIFE)));
     if (rt0->rt_req_timeout > 0.0 ) {
        rt0->rt_req_cnt = 0;
        rt0->rt_req_timeout = 0.0;
        rt0->rt_req_last_ttl = rp->rp_hop_count;
        rt0->rt_expire=CURRENT_TIME + ACTIVE_ROUTE_TIMEOUT;
         }
      }
  if (id_lookup(rp->rp_src, rp->rp_bcast_id))   {
   Packet::free(p);
   return;
    }
id_insert(rp->rp_src, rp->rp_bcast_id);
    ih->saddr() = index;
    ih->daddr() = IP_BROADCAST;
    rp->rp_hop_count += 1;
    if (rt0) rp->rp_dst_seqno = max (rt0->rt_seqno, rp->rp_dst_seqno);
    forward((aodv_rt_entry*) 0, p, NO_DELAY);
}
else {
              if ( (rt0->rt_seqno < rp->rp_dst_seqno ) ||
       (( rt0->rt_seqno == rp->rp_dst_seqno) &&
       ( rt0->rt_hops > rp->rp_hop_count )) && (rt0->rt_nexthop==ih->saddr()) ) /* and from same source */ {
    #ifdef MDEBUG
 fprintf(stderr, "Adding new router or updating excisting route: %i\n",rt0->rt_order);
#endif // DEBUG
      rt0->rt_expire = max(rt0->rt_expire, (CURRENT_TIME+REV_ROUTE_LIFE));
      rt_update(rt0, rp->rp_dst_seqno, rp->rp_hop_count,ih->saddr(), max(rt0->rt_expire, (CURRENT_TIME +
        rt0->rt_req_last_ttl = rp->rp_hop_count;
```

```
        rt0->rt_expire=CURRENT_TIME +
       }
    }
  }
}
```

5. EXPERIMENTAL SETUP

The performance is analyzed against parameters such as mobility, density. For the performance analysis of the protocol extensions, a usual well-behaved AODV network is used as a reference. The investigational results are being studied under NS-2 Simulator. Research has been carried out in order to evaluate performance of MANETs.
The aim is to reduce end to end delay and increase PDF and throughput. AODV and Proposed E-AODV are simulated in same settings of parameters and scenarios. Experiments are run on 6 different mobility speeds and also on different number of nodes. The mobility model is Random Waypoint model of 1000 * 1000 meters area size. It has focused more attention on the evaluation of network performance in terms of throughput, and packet delivery fraction and end to end delay of a mobile ad-hoc network. Following parameters are set for experiments on network simulator ns2.

Parameter	Values
Number of Nodes	10,20,30,40
Simulation Time	900sec
Pause Time	20s
Environment Size	1000*1000 meter^2
Traffic type	CBR
Packet Size	512 bytes
Maximum Speed	10,20,30,40,50,60 m/sec
Simulator	NS-2.34
Mobility Model	Random Waypoint
Packet Rate	2.0 packet/sec

Table 5.1: Simulation Scenario Setup

6. RESULT ANALYSIS OF MOBILITY BASED AODV AND E-AODV

In this section the experimental results is shown for mobility based performance of AODV routing protocol and proposed E-AODV. We compare them using three metrics:
The end to end delay: is defined as the time a data packet is received by the destination minus the time the data packet is generated by the source.

Average End-to-End Delay of 1st Data Packet = (T_DataR – T_DataS)
Where, T_DataR = Time 1st data packets received at destination node
T_DataS = Time 1st data packets sent from source node
Packet delivery fraction: The ratio of the data packets delivered to the Destinations to those generated by the constant bit rate sources. Packets delivered and packets missing are taking in to reflection.
PDF = (DataR / DataS) * 100
Where, DataR = Data packets received by the CBR agent at destination node
DataS = Data packets Sent by the CBR agent at source node
Throughput: There are two symbols of throughput; one is the amount of data transferred over the period of time expressed in kilobits per second (Kbps).

Figure 4 shows the average end-to-end delay of each protocol. It should be noted that the delay is considered for the packets that actually arrive at the destinations. We can see that E-AODV has lower delay than AODV. The reason is that AODV chooses route earlier, E-AODV chooses recent route according to turn around request. Especially E-AODV gives lower delay in high speed mobility it is clearly shown in the figure. Figure 5 shows packet delivery ratio of each protocols on varying node speed. In almost all cases, E-AODV shows better performance in packet delivery ratio. From Figure 6 it is clear that at 10m/s onwards E-AODV outperforms than AODV because as the throughput of AODV decreases with node velocity.

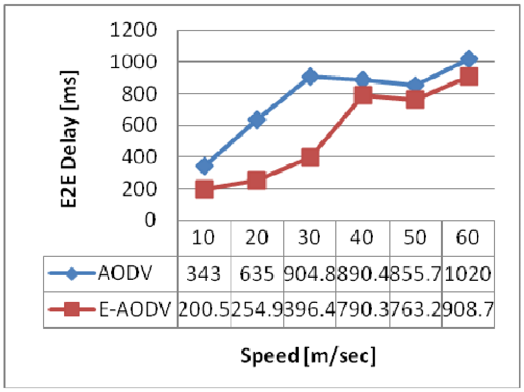

Fig 4: Mobility Vs end to end delay

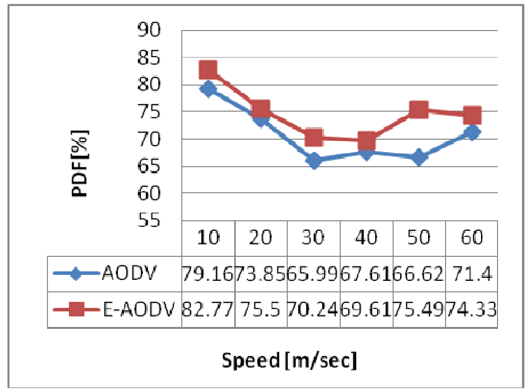

Fig 5: Mobility Vs packet delivery fraction

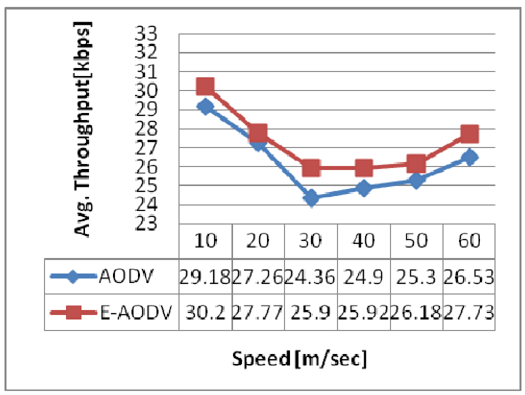

Fig 6: Mobility Vs average throughput

7. DENSITY BASED PERFORMANCE EVALUATION OF AODV & E-AODV

Figure 7 shows that the average end-to-end delays of each protocol. It should be noted that the delay is considered for the packets that actually arrive at the destinations. It is clearly shown in the figure at node size 10 onwards E-AODV has lower end to end delay than AODV. The lowest delay of E-AODV is 50.32 at node size 40. The reason is that AODV chooses route earlier, E-AODV chooses recent route according to reverse request.

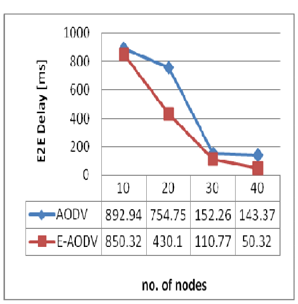

Fig 7: Density Vs end to end delay

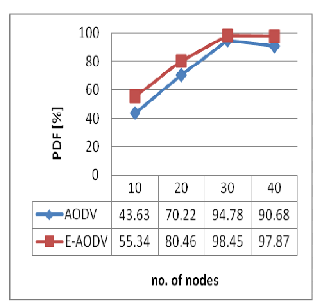

Fig 8: Density Vs Packet Delivery Fraction

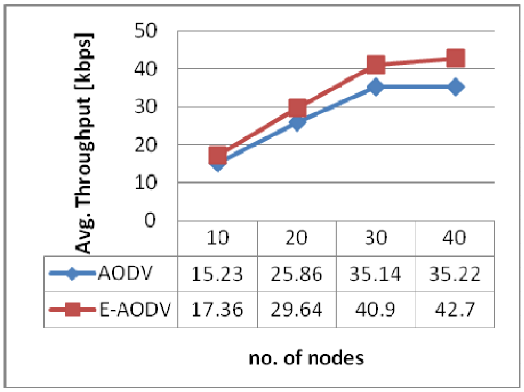

Fig 9: Density Vs average throughput

8. **CONCLUSION**

In AODV routing protocol route reply messages are very important for ad hoc networks for send messages. The loss of route replies causes serious destruction on the routing performance. This is because the rate of a route reply is very high. If the route reply is lost, a large amount of route discovery effort will be washed out. Furthermore, the source node has to re-initiate another route discovery to establish a route to the destination.

In this paper it is proposed that the idea of efficient AODV, which attempts turn around route request (TA-RREQ). E-AODV route discovery succeeds in fewer tries than AODV. We conducted extensive simulation study to evaluate the performance of E-AODV and compared it with that of existing AODV using NS-2 simulator. The results show that E-AODV improves the performance of AODV in most metrics, as the end to end delay, packet delivery fraction and average throughput especially in high speed mobility of nodes as well as in density.

Our Future work will be to evaluate the performance of AODV and E-AODV routing protocols by taking different metrics like by varying pause times and traffic source. The proposed algorithm would be used and tested on different routing protocols like DSR and Hybrid protocols.

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