Performance Analysis of Routing Protocols in MANETs checked	Phân tích hiệu suất của các giao thức định tuyến trong MANET

Wireless ad hoc network is a collection of mobile devices forming a network without any supporting infrastructure or prior organization. Nodes in the network should be able to sense and discover with nearby nodes. Due to the limited transmission range of wireless network interfaces, multiple network" hops" may be needed for one node to exchange data with another across the network. There are number of characteristics in wireless ad-hoc networks, such as the dynamic network topology, limited bandwidth and energy constraint in the network. Mobile ad hoc network is useful for different purpose e.g. military operation to provide communication between squads, emergency case in out-of-the-way places, medical control etc.	GIỚI THIỆU Mạng tùy biến không dây là một tập hợp các thiết bị di động hình thành nên một mạng mà không cần bất kỳ hỗ trợ gì về cơ sở hạ tầng hoặc tổ chức trước. Các nút trong mạng có thể phát hiện và truy cập vào các nút lân cận. Do khoảng truyền tải giới hạn của các giao diện mạng không dây, cần có nhiều "hop" mạng để một nút trao đổi dữ liệu với một nút khác qua mạng. Mạng tùy biến không dây có một số đặc trưng chẳng hạn như tô pô mạng động, băng thông giới hạn và năng lượng trong mạng hạn chế. Mạng tùy biến di động hữu dụng cho nhiều hoạt động chẳng hạn như trong quân sự, để truyền thông giữa các đội, trường hợp khẩn cấp ở những nơi xa xôi, điều khiển trong y tế, v.v…
Routing protocol plays very important part in implementation of mobile ad hoc networks. Due to the nature of mobile ad hoc networks it is non-trivial problem to find path from source to the destination and perform the communication between nodes for a long period of time.	Giao thức định tuyến đóng vai trò quan trọng trong việc triển khai các mạng tùy biến di động. Do bản chất của các mạng tùy biến di động, việc tìm đường từ nguồn tới đích và thực hiện truyền thông giữa các nút trong một khoảng thời gian dài không phải là vấn đề tầm thường.
A number of routing protocols using a variety of routing techniques have been proposed for use in MANETs. Adhoc On demand Distance Vector Routing (AODV) [1], Dynamic Source Routing (DSR) [2], Temporally Ordered Routing Algorithm (TORA) [3], Location Aided Routing (LAR) [4] (in which nodes search for or maintain a	[redacted]

route only when route is needed), and periodic (proactive) protocols suchas Destination Sequence Distance Vector (DSDV) [5], Distributed Bellman Ford [6] (in which nodes periodically exchange routing information and then can always know a current route to each destination). Also, several protocols use both reactive and proactive mechanism such as Zone Resolution Protocol (ZRP) [7], Cluster Based Routing Protocol (CBRP) [8].

The basic idea of on-demand routing protocols, is that a source node sends a route request and makes routing decision based on received route reply, which may be sent by destination or intermediate node. On-demand routing has several advantages, such as simplicity, correctness and flexibility. However, on-demand routing algorithms have the disadvantage of increasing per-packet overhead. This extra network overhead decreases the bandwidth available for transmission of data, increases the transmission latency of each packet, and consumes extra battery power in the network transmitter and receiver hardware. Due to manner of propagation route request (flooding), it is difficult to limit dissemination of unnecessary packets.

The basic idea of proactive routing is periodically updating routing table via exchanging routing information. According to routing table, source node knows path or next hop to destination anytime when route needs. In proactive routing, route information is available when needed, resulting in little delay

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prior to data transmission. However proactive routing protocols are likewise not appropriate for mobile ad hoc networks, as they continuously use a large portion of the network capacity to keep the routing information current. Proactive routing protocols tend to distribute topological changes widely in the network, even though the creation/destruction of a new link at one end of the network may not be significant piece of information at the other end.	[redacted]
The hybrid routing protocols pretends to inherit the best parts of both reactive and proactive routing protocols. The main idea of the hybrid routing protocols is the limiting the set of forwarding nodes and using the proactive routing algorithm for nearly placed nodes which usually forward data to far placed nodes.	[redacted]
This thesis work investigates how the clustering in ad hoc networks can result in time efficient and resource saving routing. It describes the structure and working of an on demand routing protocol that is cluster based routing protocol in detail. In CBRP the nodes of a wireless network are divided into several disjoint or overlapping clusters. Each cluster elects one node as the so-called cluster head. These special nodes are responsible for the routing process. CBRP is implemented using ns2 [9] as a simulation environment and its results are compared with the protocols AODV and DSR, the protocols which don't use clustering mechanism.	[redacted]

Advantages and disadvantages of CBRP are highlighted. Some suggestions are also made to overcome the limitations when cluster based routing is used in MANETs.

II. RELATED WORK

Traditional routing protocols based on the link-state [11] or distance-vector [11]algorithms are aimed at finding optimal routes to every host in the network, andtopological changes of the network can only be reflected through the propagation ofperiodic updates. These protocols are not suitable for ad hoc networks. Indeed,finding and maintaining routes to every host is too expensive and almost always notnecessary as each host only communicates with a subset of the hosts in the network.Furthermore, the periodic updates cannot promptly reflect the frequent topologicalchanges in ad hoc networks, which in turn will cause a lot of undelivered packets andundermine the quality of communication. As a consequence, a mobile ad hocnetworking (MANET) working group has been formed within the InternetEngineering Task Force (IETF) to develop a routing framework for IP-basedprotocols in ad hoc networks. Today, a number of routing protocols have beenproposed for ad hoc wireless networks, derived from distance-vector or link-staterouting algorithms. Such protocols are classified as proactive or reactive, dependingon whether they keep routes

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continuously updated or react on demand. While eachprotocol has its own advantages and disadvantages, none of them can be claimed asabsolutely better than the others. Routing in wireless mobile ad-hoc networks shouldbe time efficient and resource saving. One approach to reduce traffic during therouting process is, to divide the network into clusters.

The main aim of the project is to analyze, implement and perform comparative analysis of cluster based routingprotocol with the protocols that don't use clustering as a routing mechanism todemonstrate how the cluster based routing results in time efficient and resourcesaving routing as well as what are limitations of cluster based routing in mobile adhoc networks and how these limitations can be overcome by suggesting some of theimprovements in the existing protocol.

III. OVERVIEW OF ADHOC ROUTING PROTOCOLS

Since the advent of DARPA[19] packet routing networks in the early 1970s,numerousprotocols have been developed for ad hoc mobile networks, which include high power consumption, low bandwidth and high error rates. An Ad hoc protocol is aconvention or standard that controls how nodes come to agree which way routepackets between computing devices in a mobile ad-hoc network. Routing protocols in MANETs can be classified as:

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- > Proactive(Table driven)[11]
- > Reactive (On demand)[11]
- > Hybrid[11]

3.1 Proactive protocols

These are called table driven protocols. In these protocols, each node maintains routing information to every other node in the network. The routing information isusually kept in number of different routing tables. These tables are periodically updated if the network topology changes. Thedifference between these protocols existsin the way the routing information is updated, detected and type of information kept ateach routing. Some of these protocols are:

- > Destination Sequenced Distance Vectored (DSDV)[12]
- > Distributed Bellman- Ford (DBF)[12]
- > Wireless Routing Protocol (WRP)[13]
- > Cluster head Gateway Switch Routing (CGSR) [14]
- > Source Tree Adaptive Routing (STAR) [15]
- > Hazy Sighted Link State Routing ((HLSR) [16]
- > Hierarchical Stare Routing (HSR)[17]
- > Intrazone Routing Protocol (IZR)[18]

3.2Reactive Protocols

These are called on demand protocols. These are designed to reduce theoverhead by maintaining the information for active routes only at the expense of delay due to route search.

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This means that routes aredetermined and maintained for nodes that require send data to particulardestination. Route discovery occurs by flooding a route request through the network. This scheme is significant for Ad hoc environment since thebattery power is conserved both by not sending the advertisements and bynot needing to receive them(A host could otherwise reduce its powerconsumption by putting itself into sleep or standby mode when they arenot busy with other tasks.Some of the protocols are:

> Associativity Based Routing[(ABR) [19]

> Dynamic Source Routing (DSR)

> Temporary Ordered Routing Algorithm. (TORA)

> Adhoc On Demand routing protocol (AODV)

> Cluster Based Routing Protocol (CBRP)

> Relative Distance Micro discovery Adhoc Routing (RDMAR) [20]

> Signal Stability Routing (SSR) [21]

> Caching And Multipath Routing (CHAMP) [22]

> Ant-based Routing Algorithm (ARA) [23]

3.3 Hybrid Protocols

This method combines the merits of proactive and reactive routing protocols withsome additional features. The main idea of the hybrid routing protocols is the limitingthe set of forwarding nodes and using the proactive routing algorithm for nearlyplaced nodes which

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usually forward data to far placed nodes. While route to nearlyplaced nodes is available immediately, there is no waste of bandwidth due topropagation of the local information to the far placed nodes. Also with the flexibilityand correctness of the reactive routing, the overhead is greatly decreased caused bylimitation of number of forwarding nodes. This is especially noticeably for highdense network. However hybrid routing algorithm does not concentrate on the route maintenance against mobility. Also imperfect balance between proactive and reactiverouting causes decreasing of a data transmission performance, such as higher end-to-end delay, reduction of a packet delivery ratio. Protocol in this category is:

> Zone Resolution Protocol (ZRP)

A. Adhoc On Demand Distance Vector Routing (AODV)

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is arouting protocol designed for ad hoc mobile networks. AODV is capableof both unicast and multicast routing. It is an on demand algorithm,meaning that it builds routes between nodes only as desired by sourcenodes. It maintains these routes as long as they are needed by thesources. AODV uses sequence numbers to ensure the freshness of routes.It is loop-free, self-starting, and scales to large numbers of mobile nodes.AODV builds routes using a route request / route reply query cycle.

AODV maintains routes for as long as the route is active. This

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includesmaintaining a multicast tree for the life of the multicast group. Becausethe network nodes are mobile, it is likely that many link breakages alonga route will occur during the lifetime of that route.

B. Dynamic Source Routing (DSR): The DSR protocol is composed of two mechanisms that work together to allow thediscovery and maintenance of source routes in the ad hoc network. Route Discovery and Route Maintenance each operate entirely on demand. Inparticular, unlike other protocols, DSR requires no periodic packets of any kind at anylevel within the network.DSR allows such unidirectional linksto be used when necessary, improving overall performance and network connectivityin the system. DSR also supports internetworking between different types of wirelessnetworks [27], allowing a source route to be composed of hops over a combination ofany types of networks available For example, some nodes in the ad hoc network mayhave only short-range radios, while other nodes have both short-range and long-rangeradios; the combination of these nodes together can be considered by DSR as a singlead hoc network. In addition, the routing of DSR has been integrated into standard Internet routing, where a ’’gateway” node connected to the Internet also participatesin the ad hoc network routing protocols; and has been integrated into Mobile IProuting, where such a gateway node also serves

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the role of a Mobile IP foreignagent.

C. Cluster Based Routing Protocol (CBRP):

In recent years there have been some different approaches on cluster-based routing.The essential works that are taken into consideration here—apart from CBRP—arethose of Krishna [24], Chiang [25] and Gerla and Tsai [26]. The cluster-based routingprotocol (CBRP) was introduced by Jiang[8] in 1999. In CBRP the nodes of awireless network are divided into several disjoint or overlapping clusters. Each clusterelects one node as the so-called cluster head. These special nodes are responsible forthe routing process. Neighbours of clusterheads cannot be clusterheads as well. Butcluster heads are able to communicate with each other by using gateway nodes. Agateway is a node that has two or more clusterheads as its neighbours or— when theclusters are disjoint—at least one clusterhead and another gateway node. The routingprocess itself is performed as source routing by flooding the network with a routerequest message. Due to the clustered structure there will be less traffic, because routerequests will only be passed between clusterheads.

3.1.1 Cluster formation

There are two approaches of cluster formation one is identifier based clustering andother is connectivity based clustering. When using identifier-based clustering a nodeelects itself as the clusterhead if it has the

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lowest/highest ID in its neighbourhood, or aneighbour node if one has a lower ID. Connectivity-based clustering elects the node,which has the most neighbour nodes, as the clusterhead. So, whenever a clusterhead loses a neighbour node its connectivity decreases and it is most likely that anothernode has to be elected to act as clusterhead. While in the identifier-based approach, anew clusterhead has to be chosen only when nodes with lower/higher ID appear.The CBRP uses a variation of the lowest-ID algorithm specified by Gerla and Tsai. Which is an identifier-based algorithm? In order to support the cluster formationprocess each node uses a neighbour table, where it stores information about its neighbour nodes, such as their ID's, their role in the cluster (clusterhead or member node) and the status of the link to that node (uni-/bi- directional). The neighbour table is maintained by periodically broadcasting HELLO messages. A HELLO messagecontains information about one node's state, its neighbour table and its cluster adjacency table. The various states describe the clustering process depending on thecurrent node state. These states are:

Undecided

This means the node does not belong to any cluster: this usually occurs if anew node appears in the network. Thus, if it receives a HELLO message from a clusterhead and there is a bi-directional link between them it changes itsstate to be member of the cluster indicated by

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the clusterhead. Otherwise itlooks up in its neighbour table if it has any bi-directional links. If so, it becomes itself the clusterhead of a new cluster, if not, it remains in theundecided state and tries again.

Clusterhead:

If a clusterhead detects that it has a bi-directional link to another clusterhead for a time period, it changes its state to member if the other clusterhead has a lower ID. Otherwise it stays the clusterhead and the other node has to change its state. This is a special case which may result in clusterre-organization

Member:

If a member loses its clusterhead, it looks for bi-directional links to othernodes. If it detects any, it changes its state to clusterhead if it has the lowestID, otherwise it switches to the undecided state. Each member node belongs atleast to one clus

Fig.l. Clusterhead Movement

When clusterhead 5 moves intocluster 2 it gives up its role as clusterhead according to its higher ID. NodesA and B which lost their clusterhead form new clusters. Striking for the goal to minimize cluster re-organization, the structure of the clustersshould change as seldom as possible. That means" a non-cluster head never challenges the status of an existing cluster head", even if it has a lower ID.

Routing:

CBRP uses two data structures to support the routing process

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1. The cluster adjacency table (CAT) and

2. The two-hop topology database.

The CAT stores information about neighbouring clusters. This is, whetherthey are bi-directionally or unidirectionally linked. That means, a clusteris called

> bi-directionally linked, if there is a bi-directional link between two nodes ofthe clusters, or if there are at least two opposite uni-directional links betweentwo nodes

Uni-directionally linked, if there is just one unidirectional link between them.

reachthem—and the cluster address list which consists of the addresses of the clusterheads forming the route.

When a node N receives a RREQ it does the following:

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If the RREQ reaches the destination node D it contains the loose source route [S, C1, C2 Ck,D]. D sends a route reply message (RREP) back to Susing the reversed loose source route [D,CkC1, S]. Every time a clusterhead receives this RREP it computes a strict source route, which then consists only ofnodes that form the shortest path within each cluster.

Fig. 2. Linking Between Clusters: Clusters A, B and A, C are bi-directionallylinked, clusters C,D are unidirectional linked.

The two-hop topology database is build from the information received by HELLOmessages. It contains all nodes that are at most two hops away. The routing processworks in two steps.

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First, it discovers a route from a source node S to a destinationnode D, afterwards it routes the packets.

Route discovery

Route discovery is done by using source routing. In the CBRP only cluster heads are flooded with route request package (RREQ). Gateway nodes receive the RREQs aswell, but without broadcasting them. They forward them to the next cluster head. Thisstrategy reduces the network traffic.Initially, node S broadcasts a RREQ with unique ID containing the destination’s address, the neighbouring clusterhead(s)—including the gateway nodes to

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Fig.3. Source Routes: The loose source route (non-dashed arrows) and thestrict source route (dashed arrows) from S to D.

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Routing and route improvement Due to node movement, disappearance of nodes or failures, the CBRP includes twomechanisms to improve a route: The first is Local Repair and the second is RouteShortening.

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> Local Repair If a connection between two nodefails, the CBRP is able to repair theroute. Therefore one of the following nodes of the route has to be in the two hoptopology database of the node, that discovered the broken link. If the node isunable to repair the route, the route has to be recalculated.

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Fig. 4. Local Repair: The broken route between N and D (gray arrow) was repaired by using the clusterhead.

> Route shortening Sometimes a

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node may discover a connection between itself and anothersucceeding node of the route, that is not its direct successor or a connectionbetween two following nodes, respectively. This can be done by examining theinformation stored in the two-hop topology database. If so, it shortens the route byexcluding the redundant node(s) from the route.

Fig.5. Route Shortening

Node N discovered a new connection betweenitself and D (dashed line) and shortened the route.

In both cases, Local Repair and Route Shortening, the destination node is informed about the changes by receiving a gratuitous route reply packet from the node thatperformed the changes.

IV. EVALUATION

4.1 Simulation results We are implementing the results using NS2 simulator. We are comparing AODV, DSR and CBRP for performance metrics by throughput, delay and overhead by taking 10 nodes, 20 nodes, 30 nodes and 40 nodes

4.1.1 Throughput:

The two source routing protocols demonstrate high quality in delivering packets — more than 95% in the case of 50 nodes. AODV has difficultywhen the nodes are moving fast (corresponding to smaller pause time), with a throughput less than 80%. Source routing reveals moreinformation in one route discovery than AODV. Therefore, within thesame time, more routes are discovered and so

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more packets can bedelivered. AODV catches up when the mobility of the nodes gets lower.This is because routes become more stable, and so eventually everybodycan find all the routes it ever needs. Between DSR and CBRP, CBRP hasa better throughput for a larger network size. This better scalability comesfrom its largely reduced flooding for route discovery.

Among the three protocols, AODV has the shortest end- to-end delay of no more than0.05 seconds. Besides the actual delivery of data packets, the delay time is alsoaffected by route discovery, which is the first step to begin a communication session.The source routing protocols have a longer delay because their route discovery takesmore time as every intermediate node tries to extract information before forwardingthe reply. The same thing happens when a data packet is forwarded hop by hop.Hence, while source routing makes route discovery more profitable, it slows down thetransmission of packets. CBRP is even more time-consuming because of its two- phaseroute discovery. The task of maintaining cluster structure also takes a piece of eachhost’s CPU time.

Figure 5.4 Average data packet delay: 50 node model with various no of trafficsources.

4.1.3 Overhead:

both the packet overheadand the byte overhead of DSR are less than half of the overhead of CBRPand less than a quarter of AODV’s overhead. AODV has the largestroutingload (in the 50-

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node cases, as many as 6.5 routing packets perdata packet and 2 routing bytes per data byte) because the number of itsroute discoveries is the most, and the discovery is network-wide flooding.CBRP has a much smaller flooding range; the number of its routerequests and replies is constantly half that of DSR. But its hello messagesoutweigh this gain. And since the size of CBRP hello messages can belarge, its byte overhead is still more than DSR's (in the 50-node cases,more than twice as much as DSR's). When there are more connections,more routing is needed, and so the proportion of hello messages in thetotal overhead becomes smaller. As the result, CBRP and AODV get closer to DSR.

V. CONCLUSION

In this work, we focused on the routing problem in ad hoc networks. Routing inwireless mobile ad-hoc networks should be time efficient and resource saving. Oneapproach to reduce traffic during the routing process is, to divide the network intoclusters. We have seen the structure and the working of the cluster-based routingprotocol. We also described the working of two other routing protocols ad hoc ondemand distance vector and dynamic source routing. We have presented an extensivesimulation study to compare three on-demands ad hoc routing protocols (DSR, AODV,and CBRP), using a variety of workloads such as mobility, load, and size of the adhoc networks. Our results indicate that the

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two source routing-based protocols, DSRand CBRP, have very high throughputs while the distance-vector-based protocol,AODV, exhibits a very short end-to-end delay of data packets. Furthermore, despite its improvement in reducing route request packets, CBRP has a higher routingoverhead than DSR because of its periodic hello messages. DSR has much smallerrouting overhead than AODV and CBRP, and AODV have the largest overhead among the three protocols. We can further extend our work to often routing protocols such as CGSR. We can super cluster concept to CBRP.	[redacted] [redacted]