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A REVIEWON CURRENT ROUTING PROTOCOLS FOR AD HOC MOBILE WIRELESS NETWORK

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ABSTRACT: *An ad hoc mobile network is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. In order to facilitate communication within the network, a routing protocol is used to discover routes between nodes. The primary goal of such an ad hoc network routing protocol is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be done with a minimum of overhead and bandwidth consumption. This article examines routing protocols for ad hoc networks and evaluates these protocols based on a given set of parameters. The article provides an overview of eight different protocols by presenting their characteristics and functionality, and then provides a comparison and discussion of their respective merits and drawbacks.*

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Wireless networks is an emerging new technology that will allow users to access information and services electronically, regardless of their geographic position. Wireless networks can be classified in two types:-infrastructure network and infrastructure less (ad hoc) networks. Infrastructure network consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed. In contrast to infrastructure based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Ad hoc networks are very useful in emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain. This article discusses proposed routing protocols for these ad hoc networks. These routing protocols can be divided into two categories: table-driven and on-demand routing based on when and how the routes are discovered. In table driven routing protocols consistent and up-to-date routing information to all nodes is maintained at each node whereas in on demand routing the routes are created only when desired by the source host. Next two sections discuss current table-driven protocols as well as on-demand protocols..

2.Existing Ad Hoc Routing Protocols

Since the advent of Defense Advanced Research Projects Agency (DARPA) packet radio networks in the early 1970s [1], numerous protocols have been developed for ad hoc mobile networks. Such protocols must deal with the typical limitations of these networks, which include high power consumption, low bandwidth, and high error rates. As

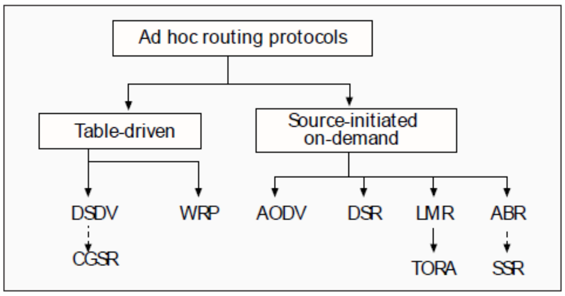

Figure 1. Categorization of ad hoc routing protocols.

shown in Fig. 1, these routing protocols may generally be categorized as:

- Table-driven
- Source-initiated (demand-driven)

Solid lines in this figure represent direct descendants, while dotted lines depict logical descendants. Despite being designed for the same type of underlying network, the characteristics of each of these protocols are quite distinct. The following sections describe the protocols and categorize them according to their characteristics.

2.1 Table-Driven Routing Protocols

Table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating pdates throughout the network in order to maintain a consistent network view.

The Destination-Sequenced Distance-
Vector Routing protocol(DSDV) described in [2] is a table-driven algorithm based on the classical Bellman-Ford routing mechanism [3]. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables. Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded Cluster head Gateway Switch Routing —
The Cluster head Gateway Switch Routing
(CGSR) protocol differs from the previous protocol in the type of addressing and network organization scheme employed. Instead of a "flat" network ,CGSR is a clustered multi hop mobile wireless network with several heuristic routing schemes [4]. The authors state that by having a cluster head controlling a group of ad hoc nodes, a framework for code separation (among clusters), channel access, routing, and bandwidth allocation can be achieved.

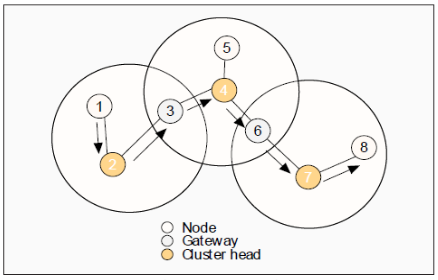

Figure 2. CGSR: routing from node 1 to node 8.

Figure 2 illustrates an example of this routing scheme. Using this method, each node must keep a "cluster member table where it stores the destination cluster head for each mobile node in the network. These cluster member tables are broadcast by each node periodically using the DSDV algorithm. Nodes update their cluster member tables on reception of such a table from a neighbor .In addition to the cluster member table, each node must also maintain a routing table which is used to determine the next hop in order to reach the destination. On receiving a packet, a node will consult its cluster member table and routing table to determine the nearest cluster head along the route to the destination. Next, the node will check its routing table to determine the next hop used to reach the selected cluster head. It then transmits the packet to this node.

2.2 Source-Initiated On-Demand Routing

A different approach from table-driven routing is source-initiated on-demand routing. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined.
Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired.Ad Hoc On-Demand Distance Vector Routing — The Ad Hoc On-Demand Distance Vector (AODV) routing protocol described in [7] builds on the DSDV algorithm previously described. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm. The authors of AODV classify it as a pure on-demand route acquisition system, since nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges [7].When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. It broadcasts a route request (RREQ) packet to its neighbors, which then forward the request to their neighbors, and so on, until either the destination or an intermediate node with a route to the destination is located. Figure 3a illustrates the propagation of the broadcast RREQs across the network. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node's IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ .During the process of forwarding the RRE Q, intermediate nodes record in their route tables the address of the neighbor from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination/intermediate node responds by unicasting a route reply (RREP) packet back to the neighbor from which it first received the RREQ (Fig. 3b). As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables which point to the node from which the RREP came. These forward route entries indicate the active forward route. Associated with each route entry is a route timer which will cause the deletion

of the entry if it is not used within the specified lifetime. Because the RREP is forwarded along the path established by the RREQ, AODV only supports the use of symmetric links.

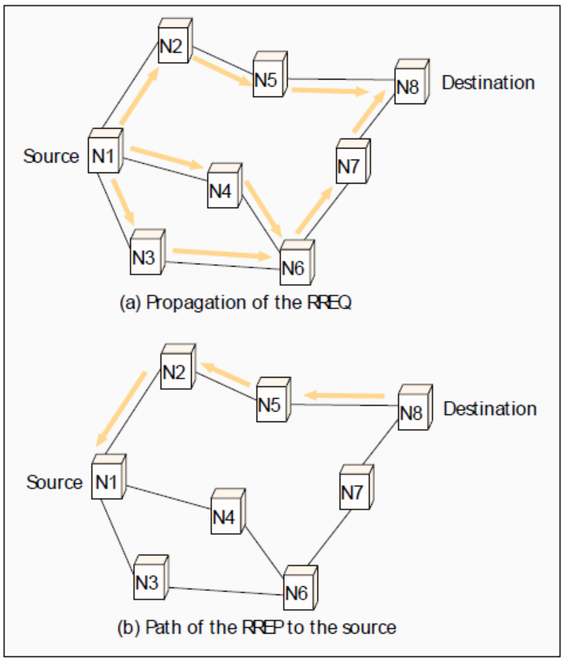

Figure 3. AODV route discovery.

Routes are maintained as follows. If a source node moves, it is able to reinitiate the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbor notices the move and propagates a link failure notification message (an RREP with infinite metric) teach of its active upstream neighbors to inform them of the erasure of that part of the route [7]. These nodes in turn propagate the link failure notification to their upstream neighbors, and so on until the source node is reached. The source node may then choose to reinitiate route discovery for that destination if a route is still desired. An additional aspect of the protocol is the use of hello messages, periodic local broadcasts by a node to inform each mobile node of other nodes in its neighborhood. Hello messages can be used to maintain the local connectivity of anode. However, the use of hello messages is not required. Nodes listen for retransmission of data packets to ensure that the next hop is still within reach. If such a retransmission is not heard, the node may use any one of a number of techniques, including the reception of hello messages, to determine whether the next hop is within communication range. The hello messages may list the other nodes from which mobile has heard, thereby yielding greater knowledge of network connectivity.

Dynamic Source Routing — The Dynamic Source Routing(DSR) protocol presented in [8] is an on-demand routing protocol that is based on the concept of source routing Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are learned. The protocol consists of two major phases: route discovery and route maintenance. When a mobile node has a packet to send to some destination, it first consults its route cache to determine whether it already has a route to the destination. If it has an unexpired route to the destination, it will use this route to send the packet. On the other hand, if the node does not have such a route, it initiates route discovery by broadcasting route request packet. This route request contains the address of the destination, along with the source node's address and a unique identification number. Each node receiving the packet checks whether it knows of a route to the destination. If it does not, it adds its own address to the route record of the packet and then forwards the packet along its outgoing links. To limit the number of route requests propagated on the outgoing links of a node, a mobile only forwards the route request if the request has not yet been seen by the mobile and if the mobile's address does not already appear in the route record. A route reply is generated when the route request reaches either the destination itself, or an intermediate node which contains in its route cache an unexpired route to the destination[9]. By the time the packet reaches either the destination or such an intermediate node, it contains a route record yielding the sequence of hops taken. Figure 4a illustrates the formation of the route record as the route request propagates through the network. If the node generating the route reply is the destination, it places the route record contained in the route request into the route reply. If the responding node is an intermediate node, it will append its cached route to the route record and then generate the route reply. To return the route reply, the responding node must have a route to the initiator. If it has a route to the initiator in its route cache, it may use that route. Otherwise, if symmetric links are supported, the node may reverse the route in the route record. If symmetric links are not supported, the node may initiate its own route discovery and piggyback the route reply on the new route request. Figure 4b shows the transmission of the route reply with its associated route record back to the source node. Route maintenance is accomplished through the use of route error packets and acknowledgments. Route error packets are generated at a node when the data link layer encounters a fatal transmission problem. When a route error packet is received, the hop in error is removed from the node's route cache and all routes containing the hop are truncated at that

point. In addition to route error messages, acknowledgments are used to verify the correct operation of the route links. Such acknowledgments include passive acknowledgments, where a mobile is able to hear the next hop forwarding the packet along the route.Temporally Ordered Routing Algorithm — The TemporallyOrdered Routing Algorithm (TORA) is a highly adaptiveloop-free distributed routing algorithm based on the conceptof link reversal [10]. TORA is proposed to operate in a highlydynamic mobile networking environment. It is source-initiatedand provides multiple routes for any desiredsource/destination pair. The key design concept of TORA isthe localization of control messages to a very small set ofnodes near the occurrence of a topological change. Toaccomplish this, nodes need to maintain routing informationabout adjacent (one-hop) nodes. The protocol performs three basic functions:

- Route creation
- Route maintenance
- Route erasure

During the route creation and maintenance phases,nodes use a "height" metric to establish a directed acyclicgraph (DAG) rooted at the destination. Thereafter, linksare assigned a direction (upstream or downstream) basedon the relative height metric of neighboring nodes, asshown in Fig. 5a. This process of establishing a DAG issimilar to the query/reply process proposed in LightweightMobile Routing (LMR) [11]. In times of node mobility theDAG route is broken, and route maintenance is necessaryto reestablish a DAG rooted at the same destinationa node generates a new reference level which results in thepropagation of that reference level by neighboring nodes,effectively coordinating a structured reaction to the failure.Links are reversed to reflect the change in adapting to thenew reference level. This has the same effect as reversingthe direction of one or more links when a node has nodownstream links.Timing is an important factor for TORA because the"height" metric is dependent on the logical time of a link failure;TORA assumes that all nodes have synchronized clocks(accomplished via an external time source such as the GlobalPositioning System). TORA's metric is a quintuple comprisingfive elements, namely:

- Logical time of a link failure
- The unique ID of the node that defined the new referencelevel
- A reflection indicator bit
- A propagation ordering parameter
- The unique ID of the node

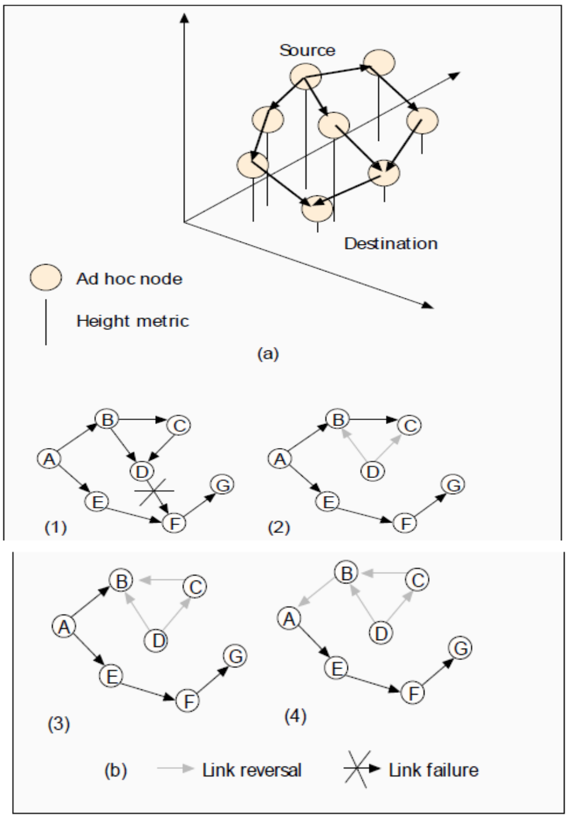

Figure 5. a) Route creation (showing link direction assignment); b) route maintenance (showing the link reversal phenomenon) in TORA.

The first three elements collectively represent the referencelevel. A new reference level is defined each time anode loses its last downstream link due to a link failure.TORA's route erasure phase essentially involves flooding abroadcast clear packet (CLR) throughout the network toerase invalid routes.In TORA there is a potential for oscillations to occur,especially when multiple sets of coordinating nodes are concurrentlydetecting partitions, erasing routes, and buildingnew routes based on each other. Because TORA uses intermodal coordination, its instability problem is similar to the"count-to-infinity" problem in distance-vector routing protocols,except that such oscillations are temporary and routeconvergence will ultimately occur.

Associativity-Based Routing — A totally different approachin mobile routing is proposed in [12]. The Associativity-Based Routing (ABR) protocol is free from loops, deadlock,and packet duplicates, and defines a new routing metric forad hoc mobile networks. This metric is known as the degreeof association stability. In ABR, a route is selected based onthe degree of association stability of mobile nodes. Eachnode periodically generates a beacon to signify its existence.When received by neighboring nodes, this beacon causestheir associativity tables to be updated. For each beaconreceived, the associativity tick of the current node withrespect to the beaconing node is incremented. Associationstability is defined by connection stability of one node withrespect to another node over time and space. A high degreeof association stability may indicate a low state of nodemobility, while a low degree may indicate a high state ofnode mobility. Associativity ticks are reset when the neighborsof a node or the node itself move out of proximity. Afundamental objective of ABR is to derive longer-livedroutes for ad hoc mobile networks.The three phases of ABR are:

- Route discovery
- Route reconstruction (RRC)
- Route deletion

The route discovery phase is accomplished by a broadcastquery and await-reply (BQ-REPLY) cycle. A nodedesiring a route broadcasts a BQ message in search ofmobiles that have a route to the destination. All nodesreceiving the query (that are not the destination) appendtheir addresses and their associativity ticks with their neighborsalong with QoS information to the query packet. Asuccessor node erases its upstream node neighbors' associativitytick entries and retains only the entry concerned withitself and its upstream node. In this way, each resultantpacket arriving at the destination will contain the associativityticks of the nodes along the route to the destination. Thedestination is then able to select the best route by examiningthe associativity ticks along each of the paths. Whenmultiple paths have the same overall degree of associationstability, the route with the minimum number of hops isselected. The destination then sends a REPLY packet backto the source along this path. Nodes propagating theREPLY mark their routes as valid. All other routes remaininactive, and the possibility of duplicate packets arriving atthe destination is avoided.RRC may consist of partial route discovery, invalid routeerasure, valid route updates, and new route discovery, dependingon which node(s) along the route move. Movement by thesource results in a new BQ-REPLY process, as shown in Fig6a. The RN[1] message is a route notification used to erasethe route entries associated with downstream nodes. Whenthe destination moves, the immediate upstream node erasesits route and determines if the node is still reachable by alocalized query (LQ[H]) process, where H refers to the hopcount from the upstream node to the destination . Ifthe destination receives the LQ packet, it REPLYs with the best partial route; otherwise, the initiating node times out and the process backtracks to the next upstream node. Here an RN[0] message is sent to the next upstream node to erase the invalid route and inform this node that it should invoke the LQ[H] process. If this process results in backtracking more than halfway to the source, the LQ process is discontinued and a new BQ process is initiated at the source. When a discovered route is no longer desired, the source node initiates a route delete (RD) broadcast so that all nodes along the route update their routing tables. The RD message is propagated by a full broadcast, as opposed to a directed broadcast, because the source node may not be aware of any route node changesthat occurred during RRCs.Signal Stability Routing — Another on-demand protocol is the Signal Stability-Based Adaptive Routing protocol (SSR) presented in [13]. Unlike the algorithms described so far, SSR selects routes based on the signal strength between nodes and a node's location stability. This route selection criteria has the effect of choosing routes that have "stronger" connectivity.SSR can be divided into two cooperative protocols: the Dynamic Routing Protthe destination receives the LQ packet, it REPLYs with the best partial route; otherwise,the initiating node times out and the process backtracks to the next upstream node. Here an RN[0] message is sent to the
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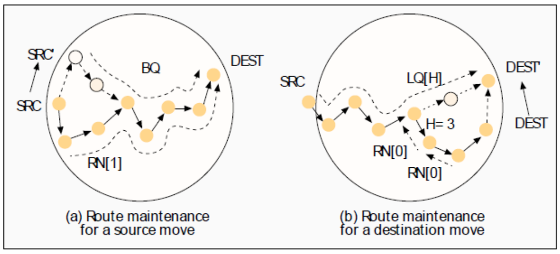

Figure 6. Route maintenance for source and destination movement in ABR.

The DRP is responsible for the maintenance of the Signal Stability Table (SST) and Routing Table (RT). The SST records the signal strength of neighboring nodes, which is obtained by periodic beacons from the link layer of each neighboring node. Signal strength may be recorded as either a strong or weak channel. All transmissions are received by, and processed in, the DRP. After updating all appropriate table entries, the DRP passes a received packet to the SRP.The SRP processes packets by passing the packet up the stack if it is the intended receiver or looking up the destination in the RT and then forwarding the packet if it is not. If no entry is found in the RT for the destination, a route-search process is initiated to find a route. Route requests are propagated throughout the network, but are only forwarded to the next hop if they are received over strong channels and have not been previously processed (to prevent looping). The destination chooses the first arriving route-search packet to send back because it is most probable that the packet arrived over the shortest and/or least congested path. The DRP then reverses the selected route and sends a route-reply message back to the initiator. The DRP of the nodes along the path update their RTs accordingly. Route-search packets arriving at the destination have necessarily chosen the path of strongest signal stability, since the packets are dropped at a node if they have arrived over a weak channel. If there is no route-reply message received at the source within a specific timeout period, the source changes the PREF field in the header to indicate that weak channels are acceptable, since these may be the only links over which the packet can be propagated. When a failed link is detected within the network, the intermediate nodes send an error message to the source indicating which channel has failed. The source then initiates another route-search process to find a new path to the destination. The source also sends an erase message to notify all nodes of the broken link.

3. Comparisons

The following sections provide comparisons of the previouslydescribed routing algorithms. The next section comparestable-driven protocols, and another section compares ondemandprotocols. A later section presents a discussion ofthe two classes of algorithms. In Tables 1 and 2, time complexityis defined as the number of steps needed to perform a
protocol operation, and communication complexity is thenumber of messages needed to perform a protocol operation[11, 14]. Also, the values for these metrics represent worstcasebehavior.

Table-Driven Protocols

As stated earlier,DSDV routing is essentially a modification of the basic Bellman-Ford routing algorithm. The modifications include theguarantee of loop-free routes and a simple route updateprotocol. While only providing one path to any given destination,DSDV selects the shortest path based on the numberof hops to the destination. DSDV provides two types ofupdate messages, one of which is significantly smaller thanthe other. The smaller update message can be used forincremental updates so that the entire routing table neednot be transmitted for every change in network topology.However, DSDV is inefficient because of the requirementof periodic update transmissions, regardless of the numberof changes in the network topology. This effectively limitsthe number of nodes that can connect to the network sincethe overhead grows as O(n2). In CGSR, DSDV is used asthe underlying routing protocol. Routing in CGSR occursover cluster heads and gateways. A cluster head table is necessaryin addition to the routing table. One advantage ofCGSR is that several heuristic methods can be employed to improve the protocol’s performance. These methods includepriority token scheduling, gateway code scheduling, andpath reservation [4].The WRP protocol differs from the other protocols inseveral ways. WRP requires each node to maintain fourrouting tables. This can lead to substantial memory requirements,especially when the number of nodes in the networkis large. Furthermore, the WRP protocol requires the useof hello packets whenever there are no recent packet transmissionsfrom a given node. The hello packets consumebandwidth and disallow a node to enter sleep mode. However,although it belongs to the class of path-finding algorithms,WRP has an advantage over other path-findingalgorithms because it avoids the problem of creating temporaryrouting loops that these algorithms have through theverification of predecessor information, as described in anearlier section.Having discussed the operation and characteristics ofeach of the existing table-driven routing protocols, it isimportant to highlight the differences. During link failures,WRP has lower time complexity than DSDV since it onlyinforms neighboring nodes about link status changes. Duringlink additions, hello messages are used as a presenceindicator such that the routing table entry can be updated.Again, this only affects neighboring nodes. In CGSR,because routing performance is dependent on the status of specific nodes (cluster head, gateway, or normal nodes),time complexity of a link failure associated with a cluster head is higher than DSDV, given the additional time needed to perform cluster head reselection. Similarly, this applies to the case of link additions associated with the cluster head. There is no gateway selection in CGSR since each node declares it is a gateway node to its neighbors if it is responding to multiple radio codes. If a gateway node moves out of range, the routing protocol is responsible for routing the packet to another gateway. In terms of communication complexity, since DSDV CGSR, and WRP use distance vector shortest-path routing as the underlying routing protocol, they all have the same degree of complexity during link failures and additions

Source-Initiated On-Demand Routing Protocols

Table 2 presents a comparison of AODV, DSR, TORA,ABR, and SSR.AODV employs a route discovery procedure similar toDSR; however, there are a couple of important distinctions.The most notable of these is that the overhead of DSR ispotentially larger than that of AODV since each DSR packetmust carry full routing information, whereas in AODV packetsneed only contain the destination address. Similarly, theroute replies in DSR are larger because they contain theaddress of every node along the route, whereas in AODVroute replies need only carry the destination IP address andsequence number. Also, the memory overhead may be slightlygreater in DSR because of the need to remember fullroutes, as opposed to only next hop information in AODV. Afurther advantage of AODV is its support for multicast [17].None of the other algorithms considered in this article currentlyincorporate multicast communication. On the downside,AODV requires symmetric links between nodes, andhence cannot utilize routes with asymmetric links. In thisaspect DSR is superior, since it does not require the use ofsuch links and can utilize asymmetric links when symmetriclinks are not available.The DSR algorithm is intended for networks in whichthe mobiles move at moderate speed with respect to packettransmission latency [8]. Assumptions the algorithm makesfor operation are that the network diameter is relativelysmall and that the mobile nodes can enable a promiscuousreceive mode, whereby every received packet is delivered tothe network driver software without filtering by destinationaddress. An advantage of DSR over some of the other ondemandprotocols is that DSR does not make use of periodicrouting advertisements, thereby saving bandwidth andreducing power consumption. Hence, the protocol does notincur any overhead when there are no changes in networktopology. Additionally, DSR allows nodes to keep multipleroutes to a destination in their cache. Hence, when a linkon a route is broken, the source node can check its cachefor another valid route. If such a route is found, routereconstruction does not need to be reinvoked. In this case,route recovery is faster than in many of the other ondemandprotocols. However, if there are no additionalroutes to the destination in the source node's cache, routediscovery must be reinitiated, as in AODV, if the route isstill required. On the other hand, because of the smalldiameter assumption and the source routing requirement,DSR is not scalable to large networks. Furthermore, as previouslystated, the need to place the entire route in bothroute replies and data packets causes greater control overheadthan in AODV.TORA is a "link reversal" algorithm that is best suitedfor networks with large dense populations of nodes [10]. Partof the novelty of TORA stems from its creation of DAGs toaid route establishment. One of the advantages of TORA isits support for multiple routes. TORA and DSR are the onlyon-demand protocols considered here which retain multipleroute possibilities for a single source/destination pair. Routereconstruction is not necessary until all known routes to adestination are deemed invalid, and hence bandwidth canpotentially be conserved because of the necessity for fewerroute rebuildings. Another advantage of TORA is its supportfor multicast. Although, unlike AODV, TORA does notincorporate multicast into its basic operation, it functions asthe underlying protocol for the Lightweight Adaptive MulticastAlgorithm (LAM), and together the two protocols providemulticast capability [18]. TORA's reliance onsynchronized clocks, while a novel idea, inherently limits itsapplicability. If a node does not have GPS or some otherexternal time source, it cannot use the algorithm. Additionally,if the external time source fails, the algorithm will ceaseto operate. Furthermore, route rebuilding in TORA may notoccur as quickly as in the other algorithms due to the potentialfor oscillations during this period. This can lead topotentially lengthy delays while waiting for the new routes tobe determined.ABR is a compromise between broadcast and point-topointrouting, and uses the connection-oriented packet forwardingapproach. Route selection is primarily based on theaggregated associativity ticks of nodes along the path. Hence,although the resulting path does not necessarily result in thesmallest possible number of hops, the path tends to be longerlivedthan other routes. A long-lived route requires fewerroute reconstructions and therefore yields higher throughput.Another benefit of ABR is that, like the other protocols, it isguaranteed to be free of packet duplicates. The reason is thatonly the best route is marked valid, while all other possibleroutes remain passive. ABR, however, relies on the fact thateach node is beaconing periodically. The beaconing intervalmust be short enough to accurately reflect the spatial, temporal,and connectivity state of the mobile hosts. This beaconingrequirement may result in additional power consumption.However, experimental results obtained in [19] reveal that theinclusion of periodic beaconing has a minute influence on theoverall battery power consumption. Unlike DSR, ABR doesnot utilize route caches.The SSR algorithm is a logical descendant of ABR. It utilizesa new technique of selecting routes based on the signalstrength and location stability of nodes along the path. As inABR, while the paths selected by this algorithm are not necessarilyshortest in hop count, they do tend to be more stableand longer-lived, resulting in fewer route reconstructions. Oneof the major drawbacks of the SSR protocol is that, unlike inAODV and DSR, intermediate nodes cannot reply to routerequests sent toward a destination; this results in potentiallylong delays before a route can be discovered. Additionally,when a link failure occurs along a path, the route discoveryalgorithm must be reinvoked from the source to find a newpath to the destination. No attempt is made to use partialroute recovery (unlike ABR), that is, to allow intermediatenodes to attempt to rebuild the route themselves. AODV andDSR also do not specify intermediate node rebuilding. Whilethis may lead to longer route reconstruction times since linkfailures cannot be resolved locally without the intervention ofthe source node, the attempt and failure of an intermediatenode to rebuild a route will cause a longer delay than if thesource node had attempted the rebuilding as soon as the brokenlink was noticed. Thus, it remains to be seen whetherintermediate node route rebuilding is more optimal thansource node route rebuilding.specific nodes (cluster head, gateway, or normal nodes), time complexity of a link failure associated with a cluster head is higher than DSDV, given the additional time needed to perform cluster head reselection. Similarly, this applies to the case of link additions associated with the cluster head. There is no gateway selection in CGSR since each node declares it is a gateway node to its neighbors if it is responding to multiple radio codes. If a gateway nodemoves out of range, the routing protocol is responsible for routing the packet to another gateway.In terms of communication complexity, since DSDV,CGSR, and WRP use distance vector shortest-path routing as the underlying routing protocol, they all have the same degree of complexity during link failures and additions.

4.Table-Driven vs. On-Demand Routing

As discussed earlier, the table-driven ad hoc routing approach is similar to the connectionless approach of forwarding packets, with no regard to when and how frequently such routes are desired. It relies on an underlying routing table update mechanism that involves the constant propagation of routing information. This is not the case, however, for on demand routing protocols. When a node using an on demand protocol desires a route to a new destination it will have to wait until such a route can be discovered. On the other hand, because routing information is constantly propagated and maintainedin table-driven routing protocols, a route to every other node in the ad hoc network is always available, regardless of whether or not it is needed. This feature, although useful for datagram traffic, incurs substantial signaling traffic and power consumption. Since both bandwidth and battery power are scarce resources in mobile computers, this becomes a serious limitation. Table 3 lists some of the basic differences between the two classes of algorithms. Another consideration is whether a flat or hierarchical addressing scheme should be used. All of the protocols considered here, except for CGSR, use a flat addressing scheme. In [20] a discussion of the two addressing schemes is presented. While flat addressing may be less complicated and easier to use, there are doubts as to its scalability.

6.Conclusion

In this article we provide descriptions of several routingschemes proposed for ad hoc mobile networks. We alsoprovide a classification of these schemes according to therouting strategy (i.e., table-driven and on-demand). Wehave presented a comparison of these two categories of Table 3 Overall comparisons of on-demand versus table driven routing protocols.highlighting their features, differences, and characteristics. Finally, we have identified possible applications and challenges facing ad hoc mobile wireless networks. While it is not clear that any particular algorithm or class of algorithm is the best for all scenarios, each protocol has definite advantages and disadvantages, and is well suited for certain situations. The field of ad hoc mobile networks is rapidly growing and changing, and while there are still many challenges that need to be met, it is likely that such networks will see widespread use within the next few years.

7.References

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