# PERFORMANCE EVALUATION & COMPARISON OF ROUTING PROTOCOLS FOR AD HOC WIRELESS NETWORKS

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## Abstract

The recent advances and the convergence of micro electro-mechanical systems technology, integrated circuit technologies, microprocessor hardware and nano technology, wireless communications, Ad-hoc networking routing protocols, distributed signal processing, and embedded systems have made the concept of Wireless Networks. Wireless network nodes are limited with respect to energy supply, restricted computational capacity and communication bandwidth. Most of the attention, however, has been given to the routing protocols since they might differ depending on the application and network architecture. To prolong the lifetime of the wireless network nodes, designing efficient routing protocols is critical. Even though wireless networks are primarily designed for monitoring and reporting events, since they are application dependent, a single routing protocol cannot be efficient for ad hoc wireless networks across all applications. In this chapter, we analyze the design issues of wireless networks and present a classification and comparison of routing protocols. This comparison reveals the important features that need to be taken into consideration while designing and evaluating new routing protocols for ad hoc wireless networks.

***Key words:*** AD HOC wireless network, reactive and proactive routing protocols.

## Comparison between Table Driven Routing Protocols :

As we have discussed that DSDV routing protocol is modification of BF routing protocol. In DSDV there are no routing loops and this is a simple routing protocol in comparison of BF routing protocol. DSDV provides only a single path from any source to the destination and selects the shortest path which is based on the number of hops of the destination. DSDV provides two types of update messages and one message is smaller than other. The smaller update message can be used for incremental updates so that the entire routing table needs not br transmitted for every change in the network topology. DSDV is inefficient because of the requirement of the periodic update transmissions regardless of the number of changes in the network topology.

In CGSR, DSDV is used as the underlying routing protocol. Routing in CGSR is done with the help of cluster heads and gateways or we can say that a cluster head table is necessary in addition to the routing table. One advantage of the CGSR is that the performance of the protocols is high in comparison to other routing protocols.

As we know that WRP is different routing protocol from the other routing protocols. In WRP each node will maintain four routing tables but there is a disadvantage of WRP that when the number of nodes in the network is more then this can lead the memory requirements. WRP routing protocol uses the hello packets for transmission from a given node then this hello packet will consume the bandwidth. Although, WRP uses the path finding routing algorithm and WRP has an advantage over other path finding algorithms that it avoids the problem of creating temporary routing loops. The complete comparison between table driven routing algorithms have been shown in the table 1.

| **PARAMETERS** | **DSDV** | **CGSR** | **WRP** |
|---|---|---|---|
| **Loop Free** | Yes | Yes | Yes |
| **Uses of Hello Messages** | Yes | No | Yes |
| **Table required** | 2 | 2 | 4 |
| **QoS Support** | No | No | No |
| **Multiple path** | No | No | Yes |
| **Multicast capability** | No | No | No |
| **Security** | No | No | No |
| **Sequence No used** | Yes | Yes | Yes |

| | | | |
|---|---|---|---|
| **Routing Philosophy** | Flat | Hierarchical | Flat |
| **Cluster Head & Gateway** | No | Yes | No |
| **Distributed** | Yes | Yes | Yes |

***Table 1: Comparison between table driven routing protocols***

## Comparison between On-Demand Routing Protocols:

AODV uses a route discovery procedure similar to DSR; there are two most important differences between the two that the overhead of DSR is potentially larger than that of AODV because each DSR packet must carry full routing information where as in AODV packets need only destination address. Similarly, the route replies in DSR are larger because they contain the address of every node along the route where as AODV route replies carry only the destination IP address and sequence number. This is the reason to AODV due to remember full nodes as opposed to only next hop information in AODV .The main advantage of AODV is that it supports multicast and none of the other algorithms considered currently incorporate multicast communication. On the other hand AODV requires symmetric links between nodes and hence can not utilize routes with asymmetric links, but DSR is good in this aspect because it does not require the use of such links and DSR can utilize asymmetric links when symmetric links are not available.

The advantage of DSR over other On demand routing protocols is that it does not make use of periodic routing advertisements but they save the bandwidth and reduce the power consumption and DSR has a multiple routes from source to destination in their cache. Hence when a link on a route is broken, then it can use another route to reach at destination, but there are no additional routes to the destination in the source node’s cache, route discovery must be reinitiated as in AODV.

TORA is also a popular on-demand routing protocol which is best suited for the network which contain a lot of nodes. Like DSR, TORA also supports to the multiple routes. Route reconstruction is not necessary until all known routes to a destination are deemed invalid, and hence bandwidth can potentially be conserved because of the necessity for fewer route re buildings. TORA also supports to the multicast. Although unlike AODV, TORA does not incorporate multicast into its basic operation. Furthermore, In TORA the route rebuilding may not occur as quickly as in other algorithms due to the potential for oscillations during this period.

ABR is also a popular On-demand routing protocol which uses the connection oriented packet forwarding approach. The main advantage of ABR is that like the other routing protocols it is guaranteed to be free of packet duplicates. The reason of this is that only the best route is marked as valid while all other routes are marked as invalid. As we know that ABR uses the beaconing and this beaconing requirement may result in additional power consumption. ABR does not utilize the route cache.

As we have discussed about ABR that the path selected by ABR are not necessarily shortest in hop count so the new algorithm SSR utilizes a new technique of selecting routes based on the signal strength and location stability of nodes along the path. The drawback of SSR routing protocol is that unlike in AODV and DSR intermediate nodes can not reply to route requests sent forward a destination. In DSR when a ink failure occurs along a path, the route discovery algorithm must be invoked from the source to find a new path to the destination. No attempt is made to use partial route recovery that is to allow intermediate nodes to attempt to rebuild the route themselves. So we can say that SSR do not specify intermediate node rebuilding. Thus it remains to be seen whether intermediate node route rebuilding is more optimal that source node route rebuilding.

| **Parameters** | **AODV** | **DSR** | **TORA** | **ABR** | **SSR** |
|---|---|---|---|---|---|
| **Loop Free** | Yes | Yes | Yes | Yes | Yes |
| **QoS Support** | No | No | No | No | No |
| **Multiple path** | No | Yes | Yes | No | No |
| **Multicast capability** | Yes | No | No | No | No |
| **Security** | No | No | No | No | No |

| | | | | | |
|---|---|---|---|---|---|
| **outes are maintained in** | oute table | oute Cache | oute table | Route table | oute table |
| **Routing Philosophy** | Flat | Flat | Flat | Flat | Flat |
| **uster Head & Gateway** | No | No | No | No | No |
| **Use of Beaconing** | No | No | No | Yes | Yes |
| **Sequence No. Used** | Yes | Yes | Yes | Yes | Yes |
| **Distributed** | Yes | Yes | Yes | Yes | Yes |

***Table 2 : Comparison between On-demand routing protocols***

## Reactive Vs Proactive Ad hoc Routing Protocols:

Most routing protocols in mobile ad hoc networks derive from distance vector or link state algorithms. In distance vector routing, each router maintains a table containing the distance from itself to all possible destinations. Each router periodically transmits this table information to all its neighbour routers, and updates its own table by using the values received from its neighbours. Based on the comparison of the distances obtained from its neighbours for each destination, a router can decide the next hop as the shortest path from itself to the specified destination. When each router has a packet to send to some destination, it simply forwards the packet to the decided next hop router. When the routing table is frequently updated, the algorithm speeds up the convergence to the correct path. However, the overhead in CPU time and network bandwidth for flooding routing updates also increases. Perkins and Bhagwat [46] devised a Destination-Sequenced Distance Vector (DSDV) protocol based on the classical Bellman-Ford routing algorithm to apply to mobile ad hoc networks. DSDV also has the feature of the distance-vector protocol in which each node holds a routing table including the next-hop information for each possible destination. Each entry has a sequence number. If a new entry is obtained, the protocol prefers to select the entry having the largest sequence number. If their sequence number is the same, the protocol selects the metric with the lowest value. Each node transmits advertisement packets using increasing sequence numbers [46]. A study of performance evaluation on DSDV shows that DSDV is able to deliver virtually all data packets when each node moves with relatively low speed. However, when the mobility of each node increases, the speed at which the system converges to the correct path decreases [5].

While DSDV is a proactive protocol that always tries to maintain the correct information regarding network topology, Ad hoc On-demand Distance Vector (AODV) [55] is a reactive protocol to perform Route Discovery only when a new route needs to be found. Thus, AODV does not maintain any routing information nor transmit any periodic advertisement packets for exchanging routing tables. i.e., only when two nodes need to communicate with each other, will they forward routing packets to maintain connectivity between the two nodes. Usually, when there is a need for communication between two nodes, each mobile node transmits a local broadcast packet known as a hello message. Routing tables of the nodes within the neighborhood are organized for the optimization of response time to local movements and the support of rapid response time for requests to establish a new route. AODV is similar with the Dynamic Source Routing (DSR) protocol, which will be explained with more details in the following sections, in terms of the nature of on-demand. However, while DSR is based on source routing, AODV is dependent upon dynamically establishing route table entries at intermediate nodes.

The proactive ad hoc routing protocols 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 reactive routing protocols. When a node using a reactive 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 maintained in proactive 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.

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.

The numerical comparison of reactive and proactive ad hoc routing protocols by assuming five routing protocols which are DSDV, AODV, DSR, TORA, ABR has been shown in the following table 3, and here "1" is for the best up to "5" is for the worst and the comparison of the characteristics of source-initiated on demand ad hoc routing protocols and proactive protocols has been shown in the table 4:

| METRICS | DSDV | AODV | DSR | TORA | ABR |
|---|---|---|---|---|---|
| *Scalability* | 5 | 2 | 3 | 1 | 1 |
| **Delay** | 1 | 4 | 2 | 5 | 3 |
| **Routing Overhead** | 5 | 2 | 1 | 3 | 2 |
| **Packet Drop** | 5 | 1 | 2 | 3 | 1 |
| **Route Acquisition time** | 1 | 2 | 4 | 3 | 3 |
| **Throughput** | 3 | 1 | 2 | 4 | 1 |
| **Adaptability to dynamic environment** | 5 | 2 | 4 | 1 | 1 |
| **Bandwidth conservation** | 5 | 1 | 2 | 2 | 2 |
| **Energy Conservation** | 5 | 2 | 1 | 3 | 3 |
| **Optimal Path** | 1 | 1 | 1 | 3 | 2 |

*Table 3: Numerical comparison of the reactive and proactive routing protocols*

| RFORMANCE PARAMETERS | AODV | DSR | TORA | ABR | DSDV |
|---|---|---|---|---|---|
| *Time Complexity (Route Construction)* | O(2d) | O(2d) | O(2d) | O(d + z) | O(d) |
| Time Complexity (post failure) | O(2d) | O(2d) | O(2d) | O(/ + d) | O(d) |
| ommunication Complexity (Initialization) | O(2N) | O(2N) | O(2N) | O(N + y) | O(x=N) |
| Communication Complexity (post failure) | O(2N) | O(2N) | O(2x) | O(x + y) | O(x=N) |
| Routing Philosophy | Flat | Flat | Flat | Flat | Flat |
| Loop-free | Yes | Yes | Yes | Yes | Yes |
| Multicast Capability | Yes | No | No** | No | No |
| Beaconing Requirements | No | No | No | Yes | No |
| Multiple Route possibilities | No | Yes | Yes | No | No |
| Routes maintained in | Route Table | oute Cache | oute Table | Route Table | oute Table |
| Jtilizes route cache/table expiration timers | Yes | No | No | No | Yes |
| Route reconfiguration methodology | e route; notify source | route; notify source | reversal; route repair | alized broadcast query | route; notify source |
| Routing metric | hest & Shortest path | ortest path | ortest path | iativity & Shortest path | ortest path |

***Table 4: Characteristics comparison of the reactive and proactive routing protocols***

Where N= Number of nodes in the network, d= Network Diameter

h= Height of the routing tree, x= No. of nodes affected by a topological change

l=Diameter of the affected network segment

y= Total number of nodes forming the directed path where the REPLY packet transits

z= Diameter of the directed path where the REPLY packet transits * Cache hit

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