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Survey on Path Optimization in Ad Hoc Networks

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Abstract

Ad hoc networks are useful in various fields due to their various characteristics. There are various applications which require immediate transmission of messages. Therefore routing is the main problem faced by ad hoc networks. There are various existing routing algorithm that are used for path optimization but these all protocols have some pros and cons. This paper gives a comparative study of various routing protocols which can be useful in developing a new protocol which can be more efficient than existing protocols to optimize the paths in an ad hoc network.

1. Introduction

Ad hoc networks are wireless and infrastructure less networks with no central support device. In this network all nodes are independent of each other and can move in any direction any time. Due to this mobile nature of nodes ad hoc network have dynamic topology. Any node can send or receive message from any other node in the network. To receive or send messages nodes must be in transmission range of each other. Each node in the network has limited energy and limited storage capacity so to enhance the network life routing in ad hoc networks must be done carefully and in controlled manner. Due to mobility of nodes the network has dynamic topology, so ad hoc networks can be used anywhere and in any situation. As the nodes in the network are independent of each other so each can act as a router and forward data for communication without the need of any central device. These networks supports multihop routing i.e. transmission of message takes place through various intermediate nodes between source and destination. The nodes in ad hoc network are mobile. They can leave or enter the network anytime. Due to this mobility of nodes determination of a stable path between source and destination is very difficult , hence, routing is the main problem in ad hoc networks. Apart from routing there are various other challenges faced by ad hoc networks like hidden terminal problem due to which security in the networks can decrease. There is also a problem of packet loss during the transmission, so reliability is reduced. Due to dynamic topology of network and mobility of nodes ad hoc networks are being used in various fields like military, collaborative applications, short range transmission like Bluetooth devices and in various commercial areas.

2. Related Work

As most of the reactive protocols (like AODV) uses blind flooding techniques for routing between source and destination nodes, this creates a huge amount of routing overhead. In [1] a new type of protocol is proposed which is in improvement of traditional AODV called Tactical Ad Hoc on Demand (TAODV) protocol that uses a new technique called query localization technique to reduce the network traffic as well as to select the most efficient path between source and destination.

Classical algorithm (like dijikstra algorithm) had a very small search space to find distance between two points in a graph. In [2] a new algorithm called the Quantum Search Algorithm has been developed to find the shortest path in a graph. In this algorithm we first start with the Dijikstra algorithm and then integrate the Quantum Algorithm to it which makes the search for paths faster.

Due to dynamic nature of a hoc networks the shortest path (SP) problem is very difficult to handle in MANET's. In [3] a Genetic Algorithm is developed that uses immigrants and memory schemes to solve the SP problem in MANET's which is difficult to solve due to dynamic topology of the networks. This new algorithm can easily adapt the new environmental changes and can produce good solutions after any change in the environment. This algorithm aims at solving Dynamic SP Routing problem in MANET's.

The Ant Colony algorithm is very useful and efficient to find shortest path in an ad hoc network. But it is difficult for ant colony algorithm to find shortest path when the input is prone to some kind of noise. In [4] a new algorithm that is the slight improvement to original ant colony algorithm is developed to deal with the cases in which we find some noise in the input parameters. In this algorithm the metric used to find the shortest path is expected path length (under mild conditions

In single path on-demand routing protocol it is very difficult to cope up with disconnected routes which in turn increases end to end delay. The Split Multipath Routing (SMR) overcomes this problem but has a disadvantage that it has large routing overhead because it uses more control packets in order to build multiple routes between source and destination. To overcome this problem of SMR in [5] an algorithm called Simple Split Multipath Routing (SSMR) has been introduced. This protocol restricts the number of RREQ packets to 4 at each node and if they are greater than 4 then that node will drop those packets.

In [6], a matrix games framework is used for both routing optimization and network coding under conflict free scheduling for multi-source wireless ad-hoc networks. The effect of multicasting on scheduling is restricted by using a compressed multicast topology matrix. A new environment is designed by partitioning the network into small parts with different topologies using network graph coloring algorithm which is link conflict free. For each part of the network a coloring scheme and priority is assigned. For all these topologies a sub matrix is build which acts as a payoff matrix for matrix game. Such a game is referred to as Asymmetrical Matrix Game, where 2 indicate two dimensional games.

Due to mobility of nodes the topology of ad hoc networks is dynamic in nature because of which it is difficult to determine various factors about the network like its lifetime, which routing algorithm to use and also its capacity. In [7] author studied about various signal propagation models and their effect on routing. An algorithm that uses two metrices i.e. hop count and distance between the nodes is also introduced. The results showed that routing is better when we use hop count as a metrics.

In [8], the author looked at the problem of simultaneous optimization of routing, bandwidth and power allocation at each node in a MIMO-based ad hoc network. A mathematical solution is introduced in [8], that combines various processes like cutting plane, Lagrangian decomposition, gradient projection and sub gradient methods.

Multiple paths exists between two end nodes in an ad hoc networks. But there are some applications that do not require any interruption during a particular session. In [9] the author developed algorithms which are based on two performance metrices:1)that the selected path will meet the target residual path time and 2)the selected path is the best path from all other existing paths. These two performance metrices were also selected in order to compare these algorithms among themselves as well as with a baseline algorithm.

In [10] the author has focused on the expected duration of the paths to make the decision of path selection and also investigated the relationship between the path's expected duration and the links along that path. [10] shows that the path with the longest expected path duration is the best path. This path also increases the reliability and lifetime of the network.

.[11] shows an algorithm that finds the shortest path by optimizing the shortest path node and also uses its data structure and storage organization. This algorithm is named as optimized dijikstra algorithm and removes various shortcomings of classical dijikstra algorithm.

[12] uses a heuristic algorithm that is applied on dynamic networks to find the shortest path as it is very difficult to find shortest path in dynamic networks because the size of the networks increases anytime. Due to this increase in the size of the networks the performance of various classical algorithm reduces. This algorithm uses a pruning technique. can be used in hierarchical as well as non-hierarchical networks.

Now a days various routers are used to find the Shortest Path Tree (SPT) between the nodes but these computes the shortest path from scratch. [13] introduces new algorithm called Optimized SPT to find the shortest path. This algorithm does not compute shortest path from scratch rather computes it based on the available information of previous SPT.Due to this path stability is also maintained.

3. Comparison of Various Routing Protocols

Protocol	Technique Used	Routing Overhead	Network Lifetime	End to End Delay	Packet Delivery Ratio
TAODV[1]	Query localization	Less	Increases	Less	Increases
Quantum algorithm[2]	Wave-like properties	Less	Increases	Less	Increases
Genetic algorithm[3]	Memory scheme	Increases under mild conditions	Depends on topology	Less	Depends on topology
Improved ant colony [4]	Ants technique	Less	Increases	Depends on phoremone concentration	Depends on phoremone concentration
SMR[5]	Uses less control packets	Less	Increases	Less	Increase
Asymmetric game matrix algorithm[6]	Topology compression	Increases with long network division	Increases	More with more load	Increase
Improved AODV[7]	Distance and hop count	Less	Increases	Less with less number of hops	Increase
Algorithm for MIMO[8]	Optimizing power	Less	Increases	Less with high mobility of nodes	Increases with mobility
Homogeneous network's algorithm[9]	Residual path lifetime	Less	Increases with path set-size	Increases with path set-size	Decreases with path set-size
Path duration algorithm[10]	Long path duration	More with large path duration	Increases with expected path duration	Decreases with path duration	Increase

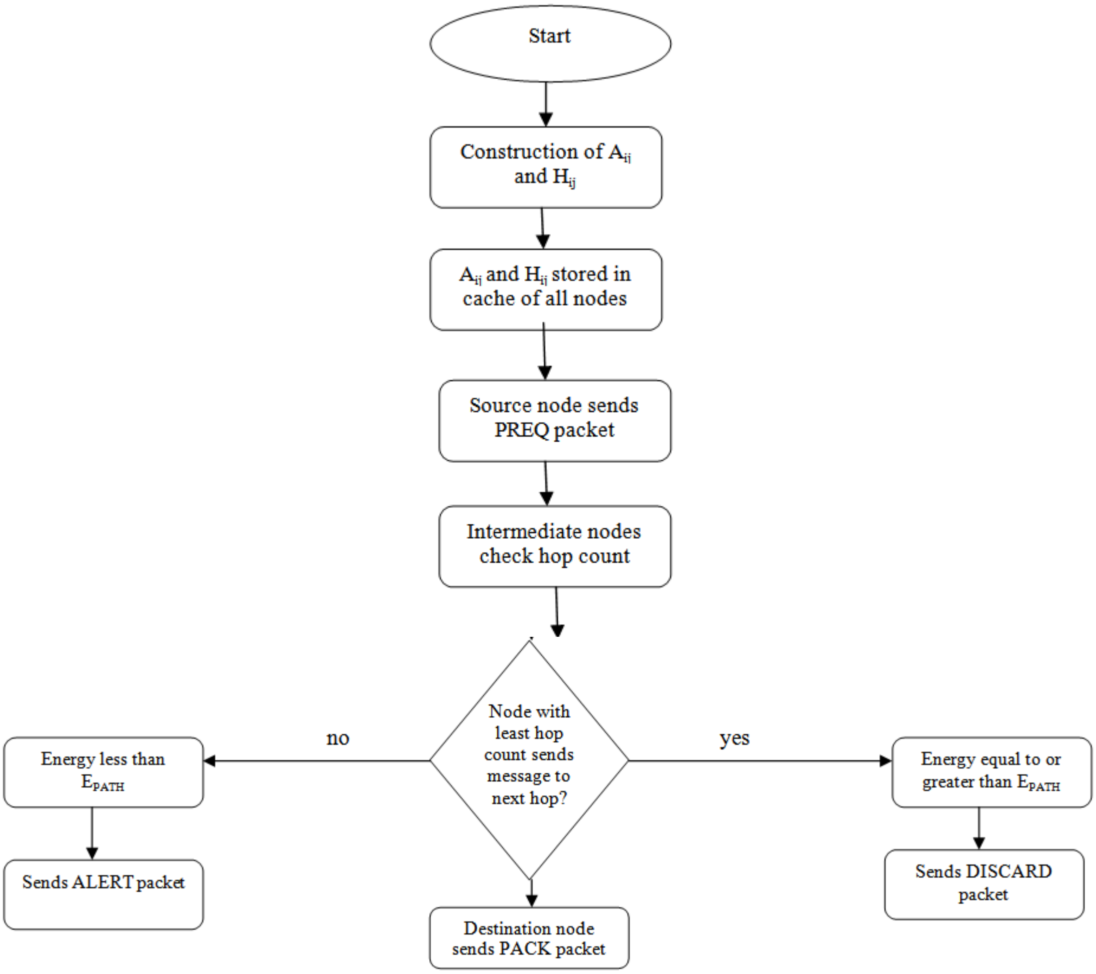
4. Proposed Algorithm

This scheme can be used for the ad hoc networks that have a large number of nodes and all the nodes know each others status. We assume that there is an ad hoc network with N nodes which can move freely in any direction. Each node is assigned a value v such that v lies between 1 and N. We select an energy parameter E_{PATH} by taking average of the energies of all the nodes in the network. The main aim behind this scheme is to improve the existing protocols like AODV so that we can get an optimized path between source and destination in an ad hoc network. In this algorithm we use following parameters:

- Transmission range of the nodes
- Energy of the nodes
- Hop count

1. We construct two matrices
   a) Adjacency matrix: A_{ij} = 1 ,if nodes are within transmission range of one another 0,otherwise
   b) Hop matrix: H_{ij} ,that gives the number of intermediate nodes between two nodes.
2. These matrices will be stored in cache of all the nodes in the network.
3. When a source node wants to send a message to destination node, it sends a PathRequest (PREQ) packet to all the nodes in its transmission range.
4. The packet consists of source id, destination id and id's of all the intermediate nodes.
5. All the nodes receiving the PREQ packet will check the hop matrix stored in their cache to see the number of hops between it and the destination node.
6. The node having the least hop count will send the packet to the next hop writing its id in the packet.
7. then we will check energy of that next hop:
   a) if it is equal or greater than E_{PATH} then the selected node in step 5 will send a DISCARD packet to all the nodes that received PREQ packet in step 3.after receiving the DISCARD packet these nodes will drop the PREQ packet.
   b) If it is less than E_{PATH} then it will send an ALERT packet to all the nodes who received PREQ packet to notify them so that another node with least hop count is selected.
8. Steps 3 to 7 will be repeated till we reach the destination node.
9. When destination node receives the message it will send a Path Acknowledge (PACK) packet back to the source node through the same path (in reverse order) by using the intermediate node's id's in PREQ packet to notify the source node about reception of the message.

The above algorithm can be better described using the following flowchart



5. Conclusion

This paper shows study of various algorithm developed to find the shortest path between source and destination nodes in an ad hoc network. We studied about various protocols and come across their shortcomings. We developed a new protocol using some assumptions and keeping in mind all the shortcomings of existing protocols to develop a more efficient protocol that can be used for routing in ad hoc networks. Efforts are being put for obtaining the simulation results and the results will be compared with AODV. This proposed algorithm takes various factors like energy of the nodes, transmission range of the nodes and op count. We hope that after simulation we get better results with this protocol so that we can optimize the paths in ad hoc networks.

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