Journal of Academia and Industrial Research (JAIR)
Volume 2, Issue 7 December 2013

ISSN: 2278-5213

RESEARCH ARTICLE

Genetic Algorithm based Dynamic Approach for Routing Protocols in Mobile Ad hoc Networks

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Abstract

MANET stands for mobile adhoc networks. Mobile networks are the most wide spread networks with no fix infrastructure. This widely distributive property of MANET has made them very useful in the fields of wars, telecommunication etc. But at the same time has rendered them without a fix infrastructure. This means that nodes in MANET do not have any central server to control their mobility. Any node could be in range of any server as per its location at that point of time. Since the nodes in MANET are battery powered the energy levels decrease as the nodes become a part of transmission. This study proposes a technique where the nodes in the network use the concept of feed forward and recurrent networks to notify the neighbouring nodes about their residual energy and route traffic to enable them decide whether to choose the same path for transmission. This will help the cluster head to save its energy thereby saving retransmissions and multiple transmissions. This study also uses the selection operator of Genetic Algorithm to select the cluster head.

Keywords: Genetic algorithm, MANET, certificate authority, cluster head, residual energy, routing protocol.

Introduction

The mobile networks are the most efficient for communication because of their widespread reach and distributivity. The nodes in the network are mobile and hence have no particular fixed location all the time. There is no central infrastructure to control the mobility of these nodes although every node is registered with some or the other server. The cluster heads play the role of these servers. Cluster heads are the nodes from the group of nodes and are selected on the basis of some parameters that could be weight (Rezaee and Yaghmaee, 2008) or operators of GA (Turgat *et al.,* 2002). Here, we have used the selection operator of GA to select the most stable node for from a group of nodes to become the cluster head. Cluster based routing works upon selecting a cluster head. The cluster head has the responsibility of inter and intra cluster transmissions. The nodes that want to send a packet to the nodes in other clusters send it to their respective cluster heads which then transmit it to the cluster head of the other destination node. These cluster heads upon receiving these packets forward it to the nodes to which they are destined to. Similarly if any node wants to send a packet to the node in the same cluster they first send it to the cluster head of that cluster and the cluster head forwards it to the node it is meant for. However, due to the lack of a central infrastructure and a central server there is no fixed position of the nodes ever. There could be multiple transmissions and retransmissions that lead to the decrease in the energy of the nodes.

The nodes in MANET are battery powered and thus, to stay in clusters have to preserve their energy. Changing the batteries is not a suitable option as there are cost constraints on this method. Here, we have proposed a technique to combat this loss of energy where each node of the cluster notifies its next neighbour on the transmission path about its residual energy using feed forward network and the destination node with the acknowledgement sends this summed up amount of residual energies of nodes on that path to the source. This enables the source to decide whether to route the packets from the same path again. Our scheme also makes use of the selection operator of GA to decide which node has to become the cluster head. The base station decides the cluster heads. This decision is based upon the weight parameters that are computed (Rezaee and Yaghmaee, 2008). The head is the node that has maximum number of neighbours. All the other nodes are called the member nodes. All the nodes are members of some or the other cluster. This depends upon the range of the cluster head in which the nodes fall. The nodes that fall within the range of a particular cluster head are the members of that cluster. Sometimes nodes may move out of the transmission range of their cluster heads. In this case either they become the members of some other clusters or themselves become the cluster heads and nodes falling in their transmission range become members of these clusters.

In this study, we aim to propose a technique that would save the energy of the cluster head by preventing the multiple transmissions and retransmissions. The use of recurrent networks to notify the traffic on the route and use of feed forward networks to notify about the residual energies would enable the head to decide whether to choose same transmission path thereby saving the energy and network resources and bandwidth. The saving in the energy of the cluster head would also enable it to add more nodes to its network. This will lead to minimum number of cluster heads in the network but with more energy because they will not have to check again and again about their member nodes. The minimum number of heads means less execution of head selection procedure that consumes most of network energy. Hence, this technique would both conserve the network and head energy and will thus increase the transmission range of cluster heads leading them add more nodes in their network and not forming new clusters of their own. New nodes will join the existing clusters as members. Many research works have been directing their effort to conserve the energy of the nodes in the adhoc networks. Recent research is very much focused on increasing the efficiency of the MANET. MANET consists of nodes that are battery powered and hence they need to preserve their energy so as to remain in transmission for long time and to stay alive. One such scheme has been proposed by Chang and Ju (2012) where, k means algorithm has been modified to create cluster heads. The information about the residual energies is used by the base station to create cluster heads. Apart from this, in the steady phase the aggregation and compression is also done by the cluster heads that saves network energy. S-MAC protocol has been designed by Mercy and Balamurugan (2013) that enhance the reliability and scalability of the network. It uses a contention scheme to avoid collisions in the network. This proposed protocol makes use of the sleep/active methodology that greatly reduces the energy consumption.

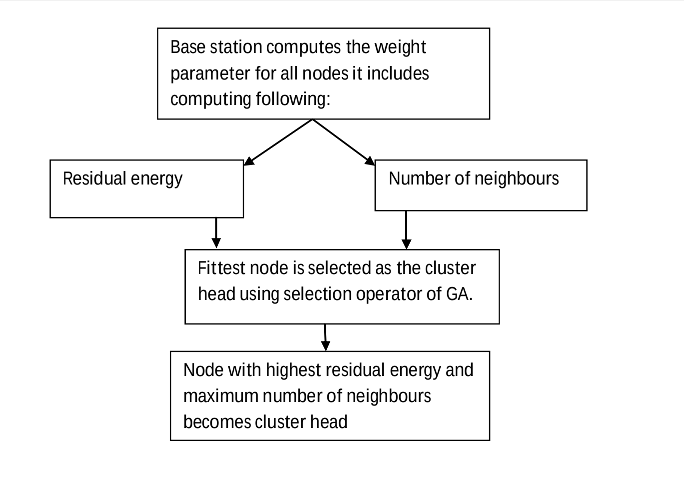
CIDR protocol achieves great efficiency and scalability in network as it assigns unique ids to all nodes in the network (Zhou *et al.,* 2009). These ids are their physical addresses. This assignment of unique ids helps avoiding the routing loops in case of domain splits. The problem of energy conservation in MANET has been the major research topic for the past few years. The nodes being battery powered suffer energy loss continuously as they become part of transmission. Cluster head election algorithm when initiated consumes most of energy of the network. A novel security architecture for information retrieval in MANET focuses on electing a cluster head that serves as a local DNS for nodes (Pradeep Kumar and Vatsa, 2011). All nodes obtain certificates from CA before entering into a cluster. This ensures network security because it uses the public private key pairs for purpose of authentication and confidentiality.

Nodes in MANET suffer energy loss due to continuous and random movement. This calls for an urgent scheme to design energy efficient protocols for MANET. Due to excessive transmission the nodes are always engaged in packet transmissions that results in a decrease in their battery power. The random movement of nodes also results in loss of data packets and acknowledgements in case, the nodes move out of the transmission range of their cluster heads. The nodes that move out of the range of their cluster heads either join some other clusters or become cluster heads themselves. When a new node enters a cluster its weight parameter is computed (Rezaee and Yaghmaee, 2008) and if its weight parameter is greater than that of the existing cluster head then this new node becomes the cluster head (Pradeep Kumar and Vatsa, 2011). The cluster heads have the responsibility of compressing the data received from other nodes and send it to base station. The head also performs data aggregation. Thus, the energy of cluster head reduces. A novel trajectory scheme for conserving the network energy has been proposed by Munaga *et al.* (2009). This technique uses rotation strategy among cluster heads to preserve the energy of the nodes. Cluster heads are selected upon the basis of the traffic. This scheme results in a higher network lifetime and better message delivery. A survey about routing protocols for MANET has been discussed by Vijaya Kumar *et al*. (2010), where routing algorithm is described along with some of the drawbacks. An enhanced novel security scheme has been discussed by Patil *et al*. (2012) that uses less complex calculation consumes less power and provides better security in packet delivery. A scheme to cause lower overheads in case of changes in network topology has been discussed by Krishna *et al.* (1997). Overlapping clusters are formed that preserve network energy in case of topology changes. Keeping the above facts in mind, this study proposes a technique where the nodes in the network use the concept of feed forward and recurrent networks to notify the neighbouring nodes about their residual energy and route traffic to enable them decide whether to choose the same path for transmission.

Materials and methods

Architecture for Cluster Head Selection: The architecture for proposed scheme has been shown in Fig. 1. There are many nodes in the MANET that move randomly always. There is no central server to control the movement of these nodes. The nodes move randomly and thus may move out of the transmission range of their respective cluster heads. This would result in loss of data packets and acknowledgements. This would further lead to multiple transmissions of data packets hence consuming more energy and resources of the network. The nodes in MANET are battery powered and so cannot afford such loss of energy in multiple transmissions and packet losses.

Fig. 1. Architecture for Cluster Head Selection.



We thus, propose a scheme here that uses an efficient methodology to reduce the energy loss in multiple transmissions. This will increase the energy of the cluster head thereby increasing its range and enabling it to add more nodes in its range. This will ensure less execution of cluster head election algorithm that consumes much of network resources. Our scheme also reduces the bandwidth use by preventing the multiple transmissions. Firstly, we use the concept of Darwin's theory of GA for cluster head selection. The head is a member of the same cluster and is one among the many nodes of that cluster. The base station has this responsibility of computing the weight parameter of all the nodes (Rezaee and Yaghmaee, 2008). To compute this parameter following equation is used:

Weight = N + R

Where, N is the number of neighbours of a particular node and R is the residual energy of the nodes. Residual energy is the remaining energy of the nodes. The base station finds out that which node has the highest number of neighbours and the nodes with highest value of residual/remaining energy. After this computation the node with the highest number of neighbours and highest value of residual energy is appointed the cluster head. We propose the use of selection operator of the GA to appoint this cluster head. The theory of 'Survival of the Fittest' is applied to these nodes and the most stable node that is one with maximum number of neighbours and highest residual energy is appointed the cluster head. The criteria for cluster head selection considers highest number of neighbours because it covers most number of nodes in the network that is the node with maximum number of neighbours if appointed the head will cover maximum area for transmission and thus we will need less number of cluster heads to be selected. This is important because the process of selection of cluster heads that is cluster head election algorithm uses much of network resources.

The proposed scheme of using a GA selection operator would hence contribute in selection of the best node as the cluster head out of the population of many nodes.

Algorithm for Cluster Head Selection:

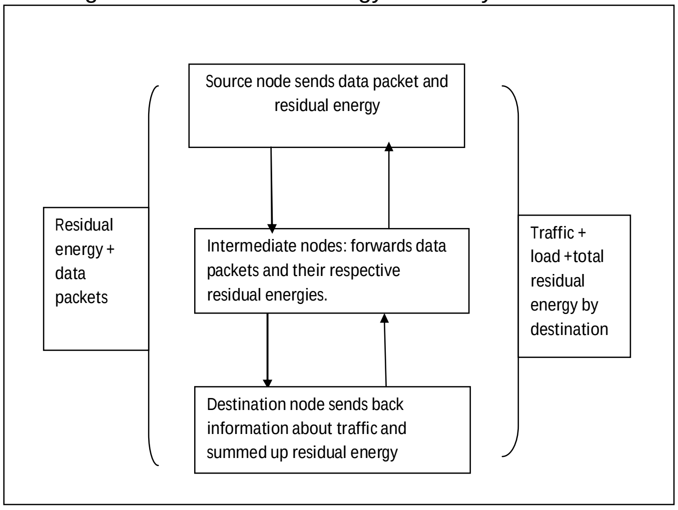
1) Count the number of nodes in network and let it be s.
2) Base station computes weight parameter of all nodes.
3) Using selection operator of GA select from node population a node S with highest number of neighbours and maximum residual energy.

   For (i=0;i<N;i++)
   {
   Weight W[i]= N+R
   N→number of neighbours of node
   R→residual energy of nodes
   }
4) If W[i]{S} = highest
   Then S= cluster head
   Else
5) repeat steps 2 to 4

The node selected from this process will ensure the selection of the fittest node as the cluster head. Two parameters that are considered here for cluster head selection are number of neighbours and residual energy. The node with maximum residual energy will be able to serve the network the most efficient way and being the one with maximum number of neighbours will enable easy transmission covering most number of nodes.

Architecture for Energy Efficiency of Network: Architecture for Energy Efficiency of Network is shown in Fig. 2. Nodes in MANET have no fixed position at any time but all the nodes are always registered with some or the other cluster head all the time. These cluster heads serve as the DNS. The mobility of these nodes is a problem for the network that could result in the loss of data packets in case nodes move out of the range of their cluster heads. This loss will trigger multiple transmission or retransmission of data packets thus, consuming more energy, resources and bandwidth of the network. Multiple transmissions in a network will occur in case the acknowledgment is not received within a certain time period and retransmission will occur in case the packets are lost. This situation needs to be avoided to prevent node's energy. Here we have proposed a scheme that makes use of the feed forward networks where all nodes notify the next neighbour nodes on the transmission path about their residual energies and load. This residual energy of all the nodes is forwarded to the destination. The destination node will compute the sum of the residual energy of all the nodes in that path that has been received in that packet.

Fig. 2. Architecture for Energy Efficiency of Network.



This summed up amount of residual energy will be then sent to the source node by using recurrent networks that will help it decide whether to choose the same path for transmission again or not. If the energy of the nodes on that path does not cross a threshold value then it will not be chosen for transmission again because the nodes on that path may die out and this will result in loss of data packets. The scheme also uses the recurrent networks where the destination nodes on transmission path notify the source node about the network traffic and load. The path with more traffic and load will not be selected again for transmission. The acknowledgement packet that is sent back from destination node to the source node contains the summed up amount of residual energy of all nodes on that path and the load and traffic information of that path. The transfer of such information will reduce the burden of the cluster head. The nodes will now be aware of the condition of the paths and thus they will choose more reliable paths. The reliability of the paths will be decided on the basis of traffic and load on the path. So, the cluster head that performs all the transmissions in cluster based routing will now route packets on the reliable paths only. This will conserve the energy of the cluster heads and will increase their range. Thus, the new nodes will now be able to join the existing clusters and will not have to initiate the cluster head election algorithm again. The new nodes joining the clusters if have a greater weight parameter W[i] then they will not immediately trigger the head selection process. They will wait for the cluster head to die out and then again the selection process will be initiated (Pradeep Kumar and Vatsa, 2011). Using this scheme less number of cluster heads will be required thereby saving the resources and energy of the network and new nodes will be able to join existing clusters. The increased power of cluster head will also enable it retain the existing member nodes. Hence, will reduce the use of bandwidth also which is a scarce resource. The traffic and load information is also sent to the source node.

The path with more load and traffic will not be chosen again in order to avoid collisions and avoid data loss. The traffic could result in collisions and these collisions further lead to jams in the network and this jam cause packet delay and packet loss. Our scheme that uses recurrent networks to notify nodes about the traffic will help in preventing collisions and data loss.

Algorithm for Energy Efficiency of Network:

1) Select a source node S and a destination node M.
2) Choose a path P for transmission.
3) S transfers data packets D[i] to its neighbour S+1.
4) D[i] = data packets + residual energy(R)
 For(i=0;i<M;i++)
 {
 S→S+1......-->M (// forwards packet till it reaches destination)
 }
5) Packet reaches destination.
6) Destination sends back V[i] that is acknowledgment and load and traffic information back to source.
 V[i]= Load information + traffic information+ Total residual energy of path
 Total residual energy(R)= R(S)+R(S+1)+........R(M)
7)If V[i] >= threshold then path P is chosen again for transmission else chose another path P' for further transmission.

Results and discussion

Energy conservation has been a great issue in mobile adhoc networks. Nodes tend to lose their energies as they become a part of the transmission. Moreover, the cluster head routing is also a much energy consuming process where the cluster head election procedure consumes most of the energy sources. The cluster heads are also elected more in number and this process is thus initiated many times for selection of clusters so that all the nodes can be put into the range of some cluster head that can serve as a DNS for them. Our scheme proposed here uses the selection operator of GA to elect the cluster head and for that it considers nodes with highest number of neighbours and maximum residual energy to be elected as the head. This scheme thus, chooses the best nodes and contributes to less execution of the head selection procedure. Hence, it conserves the sources of the network that is bandwidth and node energies. Hence, it is an efficient solution to conserve network resources. Figure 3 represents the relation between the uses of GA's selection operator. This is an inverse relationship. When this technique is used, the need to execute the head selection process decreases as the fittest node that is the one with maximum number of neighbours and maximum residual energy is selected as the head. Thus, there is less overhead in network. Apart from this, the use of recurrent and feed forward networks also lets the nodes to notify the previous nodes about load information and residual/remaining energies.

Fig. 3. Less overhead with use of GA's selection operator.

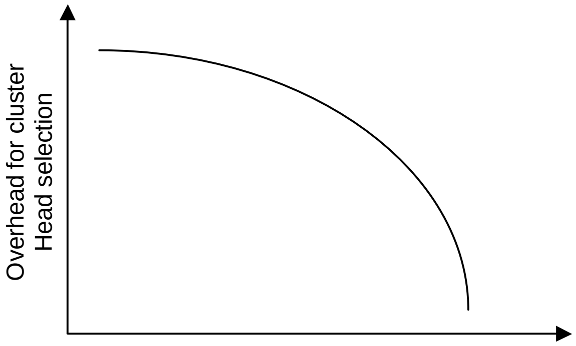
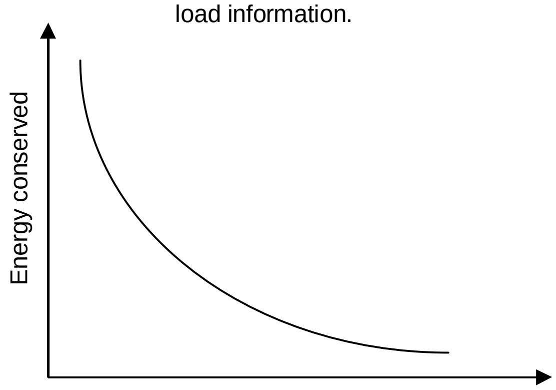


Fig. 4. More energy conservation with transfer of load information.



The summed up amount of residual energy of a path sent to source by destination lets it decide whether to route the packets again via the same route or not. Hence, the packets will be routed through a path again only if the threshold value is crossed for residual energy. This will lead to routing via a more reliable path with nodes that will not die out thereby saving the acknowledgment loss and preventing retransmissions. Figure 4 shows that when the traffic and load information and information about residual energy is sent back to the source it helps the source decide whether to choose the same path for transmission again. If the residual energy crosses the threshold the path can be chosen again without any fear of loss of data packets and loss of acknowledgement packets. Hence, this is an efficient way to conserve network energy and resources.

Conclusion

Nodes in MANET suffer from energy loss and this loss in energy of nodes needs to be minimized because, the nodes are battery powered. Changing the batteries always is not a feasible option because of the cost constraints. Hence routing protocols should be designed in such a way that the maximum energy is conserved and bandwidth is least utilised. Our proposed scheme prevents both bandwidth usage and enhances the network performance and preserves the energy of nodes as well as the cluster head. The scheme requires less execution of head selection process thereby conserving the network resources and uses GA's selection operator for cluster head selection to elect the fittest node to become the cluster head. The cluster head's range is increased and now it can accommodate more nodes and retain existing member nodes. New nodes will not form clusters of their own. This scheme allows new nodes to join existing clusters and do not form clusters of their own. This has increased the range of cluster heads by conserving their power.

Acknowledgements

This research work has been completed under the esteemed guidance of my guide Mr. Mohammad Asim. He has guided me throughout and supervised the complete work and has extended his support in devising the proposed methodology. I would also like to thank him for explaining me the core concepts of the techniques used for proposing the algorithms and helping me to complete the whole work under his supervision and reviewing my work.

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