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Improved Network Lifetime in Mobile Wireless Sensor Networks using Adaptive Algorithms

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Abstract*: *Mobile Wireless Sensor Networks (MWSNs) have gained a lot of attention because of their applicability in different types of applications such as environment, healthcare, agriculture, industry automation, public safety, security and military surveillance. MWSNs are suffered from poor network lifetime because of the continuous disconnections between the mobile sensor nodes as they have limited battery power. This paper proposed and implement an adaptive algorithm(d-DSR) (implemented in DSR routing protocol) using ns-2.34,that handles the continuous disconnections because of low battery power of the mobile sensor nodes and improves the performance of the network in terms of throughput, packet delivery fraction, delay and network lifetime.

Index Terms*: *d-DSR, MWSNs, Network Lifetime, PDF, Throughput

I. INTRODUCTION

Due to the versatile applicability of wireless sensor networks in different areas, researchers are more focused on the issues related with the performance of these networks. Mobile Wireless Sensor Networks (MWSN) are the networks in which sensor nodes are mobile and form a network autonomously without any centralized administration, though forwarding packets to each other in a multi-hop mode. Routing is one of the most fundamental tasks that significantly affects the overall performance of the networks because of their mobile nature. Also these mobile sensor nodes rely on battery-power for their existence, enhancing the lifetime of battery has become a key objective of many researches. Therefore, continuous attention is being paid on power-aware design of protocols for MWSNs.

It is well known, that each mobile sensor node in such networks has to carry out the functions related to routing for setting up the communication among diverse sensor nodes. As the sensor nodes process this information, the energy of the node can get exhausted. Even if a few of the sensor nodes in the network die out, it could lead to the disruption of services in the whole network.

Though the nodes communicating in MWSN lie within the common communication region, the communication range shows signs of high variability therefore in this regard, retransmissions become essential to compensate for the link errors and to attain assured packet delivery using reliable communication. Generally the anticipated energy for packet delivery does not consider this potential retransmission cost; however it must be taken into account as retransmission can crucially affect the overall performance**.**

It is possible to monitor the local rate of energy consumption based on application such as audio, video, or word type of data being transferred. The estimation of battery life remaining (residual energy in a node) can also be found out based on the application type (rate of consumption). Thus early detection of depleting battery and thereby avoidance of disconnections is possible. This makes energy-aware routing protocols behave adaptively in the network.

The problem of energy-efficient data transfer in relevance to MWSN has been dealt by a large group of researchers. Two categories have been identified for these existing protocols-

- Based on minimum-power routing algorithms and try to minimize the power requirements over end-to-end paths.
- Based on maximizing the *network lifetime* routing algorithms and seek to achieve this by distributing the load related to forwarding over numerous diverse paths.

A typical criterion in case of first category is to choose a source to destination routing path with minimum total energy consumption related to transmission of a fixed number of packets over that path. The energy requisite for transmitting one packet of data across a link is considered as cost metric. In this way they continually choose the least-power cost routes between source-destination pairs due to which nodes along these least-power cost routes are likely to "die" quickly as they are the one being used again and again and thus drain out their battery energy in this processing. However these are the nodes that are most desirable to sustain the network connectivity.

The number of nodes involved in forwarding of packets, are reduced to distribute the load in second category sometimes. This is done in order to let a subset of nodes to sleep over different periods of time. In other cases, the load is distributed by using heuristics that takes into consideration the residual battery power at different nodes. At the core the idea is to thus avoid nodes that have a low level of remaining battery energy in the route.

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This way the nodes with better lifetime carry the traffic and balance the network load, ultimately providing prolonged life to the network. This class of protocol seems promising in power-aware network routing protocols and will be the focus of this paper.

This paper devises and assesses an adaptive energy efficient routing algorithm applied on DSR (Dynamic Source Routing) protocol resulting in d-DSR that optimizes the

operational lifetime along with avoiding and handling disconnections due to battery depletion.

II. RELATED STUDY

The conventional routing protocols for the wired Internet do not give a thought to battery and therefore often do not consider any energy-related parameters. Recently, a number of studies in the MWSN community have dealt with diverse facets of wireless link properties. Since in this paper we chose to modify DSR to accommodate energy aware feature, therefore literature was reviewed for the applicability of DSR in MWSN. Studies performed by [1]-[3] have shown that DSR performed best among other routing protocols in the different applications of WSN.

Authors in [4] in their work not only consider the energy efficiency but also security aspect of MWSN. In this study, simulation results show that the proposed ETARP can keep the same security level while achieving more energy efficiency for data packet delivery. [5] addressed the issue of energy balancing in multi-hop wireless sensor networks to optimize their operational lifetime. The proposed algorithm dynamically clusters the network to balance energy distribution resulting in a k-means-based algorithm. The simulations in NS-2.34 shows longer network lifetime than famous algorithms like LEACH, GAEEP and GABEEC protocols.

Problem of Limited power expenditure of sensor nodes to prolong network lifetime has been addressed in [6]. Here Clustering is used as a solution to fix the problem. Each region independently selects cluster heads based on the residual energy of nodes. Proposed routing protocol performance is compared with LEACH and simulation results shows better results in terms of network energy consumption, lifetime and packet transmission. However, in case of the energy consumption aspect, the majority of the research to date has talked about the analytical or experimental categorization of the energy consumption of the wireless sensor network. Authors of [7]-[10] have proposed different algorithms for energy efficiency optimization with some modification in existing protocol such as DSR and results verifies the proposed work.

In application based networks such as Delay-tolerant WSN, Simulation results of the work proposed by [11], shows that the proposed protocol i.e. novel energy aware routing using DSR has better ratio of alive nodes, overhead ratio, and finally good delivery probability in most of the considered parameter. Also work done by [12]-[13] shows some recent studies and technologies for optimal energy utilization in WSN.

III. PROPOSED WORK

As discussed by [14], in standard DSR protocol, after route establishment source and destination starts communication. According to the proposed work done, each node continuously keeps a track on its battery level before forwarding or sending the packet. For this an optimum value of threshold was also identified as 0.45. In the current work some modification are further done in standard DSR in order to handle the further disconnections between the mobile sensor nodes or nodes. Rather than working on a fixed threshold value, two different thresholds values i.e. 0.2 and 0.6 are chosen and then take appropriate steps instead of taking actions on one fixed threshold value and thus behave adaptively in the network. These upper and lower threshold values are chosen on the basis of the results obtained in previous work done by [14], where results for various parameters were obtained for different threshold values. These results showed that 0.2 and 0.6 threshold values are also giving better results. Therefore we consider these values as upper and lower thresholds. This modification is an extension to our heuristic approach especially to handle disconnections due to battery power draining. Rather than taking decision of route deletion, when the current energy level of the node goes beyond the threshold value (taken as 0.45) as done in previous work[14], in the proposed work two threshold values are taken into account. One upper threshold value (0.6) will serve as an apprehension for the sensor node. It indicates that now the node's energy level has become so low that it should not indulge in any new routing decision process or route discovery, as now it is not able to become a part of any new data communication path. By doing so, the disconnections are avoided that may occur in any new connections because of continuous exhaustion of the energy level of the node. Second value of lower threshold (0.2) will serve as a final action taking parameter. It signifies that current energy level of the node is reaching to a critical value such that it will die out soon, so some other routes should be searched in order to maintain the connectivity of current data communication path. In this way, by maintaining two threshold values, the proposed work will be able to handle as well as avoid disconnections due to battery power exhaustion during data communication in wireless sensor networks and adapt to the network condition accordingly.

Formal Description of Algorithm:

Variables used in present algorithm :

th1 = upper threshold value
th2 = lower threshold value
ns = source node
pe = current energy level of the battery
Ie = initial energy level of the battery
msg = message received by a node

This algorithm is executed at every sensor node when it receives a route request and before sending or forwarding a packet.

Algorithm:

```
Begin
{
Set th1 = 0.6 * Ie
Set th2 = 0.2 * Ie
node i checks value of pe for itself
{
 if (node i receives new route request)
  {
       if (pe <  th1)
        {

         discard new RREQ
        }
        Else
          {
            Handle
new route request
          }
   }
   Else
   {
    if (node i receives a data packet to send or forward)
     {
      if ( pe <  th2)
        {
        if (node i= ns)
             {
       stop application running on node i
             Broadcast  lowenergybroadcast( ) msg to neighbors
             }
          Else
          {
            Broadcast  lowenergybroadcast( ) msg to neighbors
          }
      }
      Else
      {
       Sends or forward data packets
        }
      }
   }
 }
}end
//action taken by neighboring node when receive lowenergybroadcast( )
if (msg received by node j = lowenergybroadcast( ))
   {
       set timer=10 seconds
       Search route cache for new route
       If (status=found)
        {
         Continue sending packets
        }
       Else
       {
         initiate new route discovery
        }
       if (timer expires)
        {
         delete route from the route cache containing the node from which
         lowenergybroadcast ( ) msg is received.
         }
     Else
      {     Continue data sending
       }
   }
```

IV. SIMULATION AND RESULTS

The simulations are performed using ns-2.34 network simulator. The total numbers of nodes participating in the network are varied from 20 to 140 for the simulation. The nodes move inside a simulation area of (500×500) m2.The simulation time is kept at 100 seconds. The nodes move with a maximum velocity of 10m/s and in accordance with the random waypoint mobility model. TCP traffic patterns are used with FTP application. The network contains variable TCP traffic connections and packet size of 512 bytes. We consider energy model and energy is kept fixed at 50 J. Transmit power consumption is kept at 2.5 J. Receiving and sleep power consumptions are taken as 1 J and .05 J respectively. The simulation is performed for different runs with different number of traffic flows or source-destination pairs varied from maximum connection 8.Figures discussed below shows the network lifetime, packet delivery fraction, throughput, and average delay against number of nodes ranging from 20 to 140 for number of connections 8.

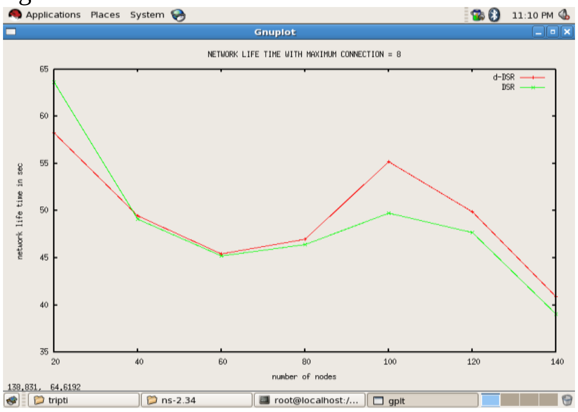

Fig 1: Network Lifetime Vs Number of Nodes for comparison of d-DSR and DSR

From the Fig 1 it can be observe that network lifetime in d-DSR is almost equal to or less than normal DSR in case of low node densities or when numbers of nodes are less. There is a sudden improvement in the network lifetime after the number of nodes 80. At 100 numbers of nodes it is maximum, after that it again decreases but is higher than that of DSR , means d-DSR is exhibiting good network lifetime in case of high node density.

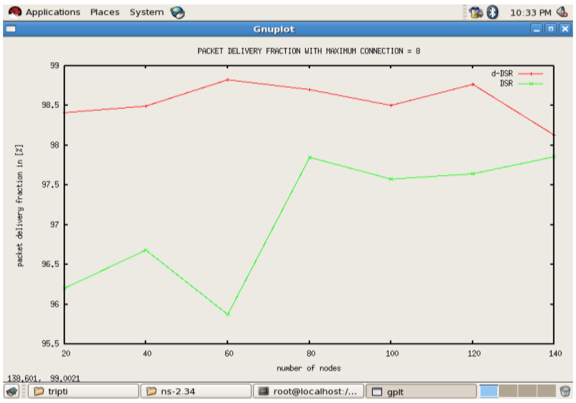

Fig 2: Packet Delivery Fraction Vs Number of Nodes for comparison of d-DSR and DSR

In Fig 2 the maximum value of PDF is very good in d-DSR; it is achieving around 98.7 %. There is a considerable difference in PDF value of d-DSR and standard DSR. PDF value in standard DSR is very much fluctuating also as compared to d-DSR which is almost stable.

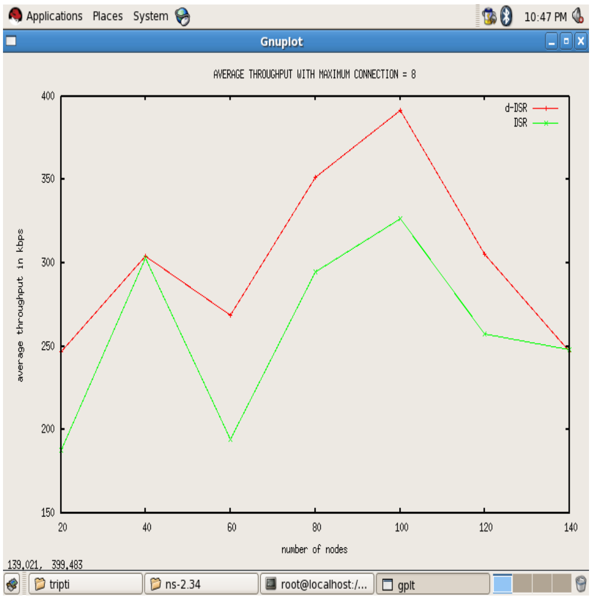

Fig 3: Average Throughput Vs Number of Nodes for comparison of d-DSR and DSR

Above graph shown in Fig 3 compares average throughput of d-DSR with DSR. From the figure it is clear that average throughput is higher in d-DSR as compared to DSR and it is highest at number of nodes 100 and then it again starts decreasing but is still more than normal DSR at all number of nodes starting from 20 to 140.We can observe that d-DSR is showing good behavior in terms of throughput in addition to handling disconnections, that will be an added advantage.

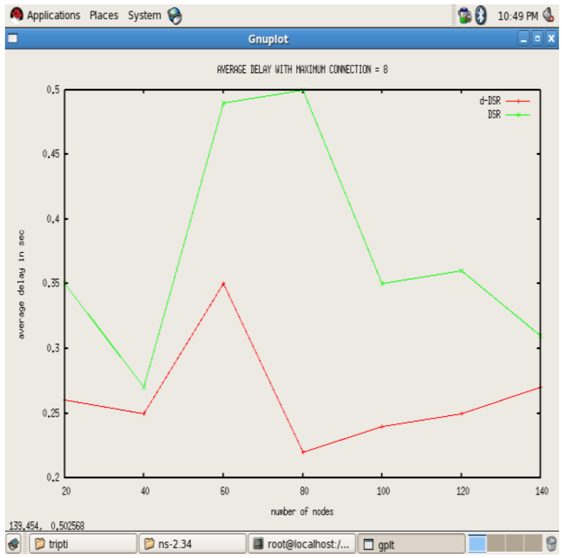

Fig 4: Average Delay Vs Number of Nodes for comparison of d-DSR and DSR

Fig 4 shows the average delay. From figure we observe that the average delay in d-DSR is less as compared to normal DSR.The lowest value of delay in d-DSR is achieved at number of nodes 80 but still lower than that of normal DSR. It indicates that average delay is showing reduction with increasing traffic, which is an indication of its good performance.

V. ANALYSIS AND DISCUSSION

The proposed work handle early disconnections caused due to high rate of depletion of battery. From the above results it can be concluded that the disconnections handling DSR or d-DSR performs better than standard DSR in terms of network life time in low node density as well as high node density conditions by handling the disconnections in the networks with the appropriate actions taken at the right time. In addition to it, average throughput and PDF is also better in d-DSR as compared to standard DSR. Average throughput is also good in d-DSR. Our main concern is to increase network lifetime to maintain connectivity. One of the advantages of d-DSR is that its average delay is less than standard DSR. Since all the performance metrics evaluated so far shows the betterment and consistent behavior of d-DSR, it is suggested that the proposed work can be used in the applications where the consistency of the data transfer is to be maintained with high traffic rate and lesser delay. Hence, it is established that d-DSR is working adaptively in the network to improve the overall performance of the network.

VI. CONCLUSION

The main aim of proposed work is to explore the problem of disconnections in mobile sensor networks. Several strategies have been proposed to tackle with the problem of disconnections resulting in poor network lifetime.

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In this work d-DSR (disconnection-handling DSR) is proposed which deals with disconnections caused due to battery depletion in Mobile wireless sensor networks, by first avoiding and finally handling them if there are any chances of further disconnections. Above results and discussion shows that d-DSR in addition to increase the network lifetime, improves overall performance of the network and that too with it's adaptive functionality. The network lifetime of d-DSR is showing further improvement from m-DSR proposed in previous work[14]. The Packet Delivery is also improved along with lower delays. The future work can also be done in future for mathematical verifications of the observed results, which is obtained with two battery thresholds 0.2 and 0.6 only through simulations in this work.

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