Optimized Use of Battery Power in Wireless Ad hoc Networks

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***Abstract*--Wireless network is an emerging area for researchers. Wireless network can be deployed either in infrastructure mode or in Ad hoc mode. In an Infrastructure mode, mobile stations communicate with each other with the help of Base Station or Access Point (AP). It is similar to star topology of wired network. This Access Point makes communication easier between the nodes. In an Ad hoc mode there is no access point or base station that helps in communication between nodes. All nodes in wireless Ad hoc network directly communicate with each other in peer-to-peer fashion. The topology of wireless Ad hoc network is dynamic in nature therefore routes are changed frequently. Wireless Ad hoc network has no routers. Each node act as an intermediate node for other node and intermediate node forwards data towards destination node. An intermediate node is also a sender for other nodes and acts as a router in the network. The major factors, which affect the data transmission of an Ad hoc network, are battery power, bandwidth, delay, speed, type of data and cost. The data transfer rates in a wireless Ad hoc network are not static but are dynamic. The availability of these resources at any node, either during data transmission or forwarding of data to other node is not certain. The resources available at any node are in scarce. The optimized use of any of these resources is a big question. Battery power is one of the major factors in a wireless Ad hoc network. A node can transmit data to a longer distance only if it has sufficient battery power. Area covered by a node in an Ad hoc network plays an important role during data transmission. In this paper our main focus is on utilization of battery power available at any node for data transmission. Here we propose two algorithms for optimization of battery power that find out nodes which wants to transmit the data and the total power consumption in wireless Ad hoc network.**

***Keywords*- Ad hoc networks, battery power, resource, vicinity, data transmission, total power consumption.**

I. INTRODUCTION

Wireless Ad hoc network now a days gaining popularity in research area. Wireless network can be created with the help of Access Point (AP) or without AP. A network with AP is called infrastructure network [1]. AP performs node selection and route selection in the network. This type of network calculates route selection in advance. Ad hoc mode can be deployed anywhere easily without requiring major infrastructure. It is a decentralized network. Users are mobile in this network they can access data from anywhere. Data transmission, in wireless Ad hoc mode, from source node to destination node requires help of other nodes presents in the vicinity of a node. As a node they behave as a source and destination and as a router or intermediate node they forward data for other nodes.

The major characteristics of wireless Ad hoc network are: Dynamic topology, easy deployment, limited bandwidth, limited battery power, lower data rates, higher error rates, higher delay etc. The resources available at a node in wireless Ad hoc network are in scarce [2]. Topology of wireless Ad hoc network changes rapidly and re-organizes them-selves in an arbitrary fashion [3][4]. There may be many possible routes available between two nodes over which data can flow, and each path may have different available capacity that may or may not meet the quality of service requirements of the desired service [5]. For a wireless Ad hoc network we can consider many factors which affect the overall working of it. These factors are bandwidth, battery power, memory, speed, cost, type of data, delay etc [6]. As the network topology changes the distance between source and destination may vary time to time. If a wireless Ad hoc network deployed in such area where power is not available in ample amount then optimized use of battery power and resources is essential. The battery power required to transmit the data from source to destination may also vary as topology changes. A node can easily transmit data to a distant node, if it has sufficient battery power. A node transmits its data to other node without any interference, if node lies in its vicinity. A large battery power is required to transmit the data to a node which is situated too far from source node. After few transmissions a node reaches to its threshold battery level and it may exclude from network path. After some time all the nodes may not be available during data transmission and the overall life time of the network may decreases.

II. RELATED WORK

Many researchers have concentrated their work in the area of resources available in the wireless Ad hoc network. Das Sudipto and Rajesh Roy have discussed about the high mobility and link failure in mobile Ad hoc network and require frequent route discoveries [7]. Wireless Ad hoc network follows many approaches for routing to save resources [8] [9]. Marc Mosko and J.J. Garcia-Luna-Aceves has discussed about multi path routing instead of single path routing. Short life of these routes, which resulting in decreased throughput and high end to-end delay in wireless Ad hoc network [10]. Catherine Rosenberg and Aditya Karnik discussed different types of data flow and also considered link capacity [11]. Peter Key and Don Towsley proposed a combined multipath routing and congestion control architecture that can provide performance improvements to the end user and simplifies network dimensioning for operators [12]. Krishna Ramachandran et al. has discussed route stability in a wireless Ad hoc network [13]. For the resources which are available in scarce in wireless Ad hoc network lot of works have been done by many researchers. Ajoy navin et al. emphasized on over all transmission power for each connection request [14]. Jing Deng et al. discussed on the transmission range of wireless Ad hoc networks [15]. Wonseok Baek et al. have given a concept of power efficient topology control technique that minimizes the total power consumption [16]. Ioannis C. et al. have given that how much power required at reception end to detect a signal. Data transmission can be done with the help of intermediate nodes [17]. Lamia Kaddar et al has given a transmission and reception energy saving model which increases life time of network [18]. Allon Rai et al. discussed the location of a node to save the power consumption [19]. Gui Wei Hua et al has given a power minimization algorithm for throughput enhancement [2].

III. Proposed Work

Wireless Ad hoc network is infrastructure less network. Communication in such type of network is either single hop or multi hop. A node can transmits or receive data to /from a node which lies in its vicinity. A node can transmit data to a longer distance if it has sufficient energy level. In wireless Ad hoc network a node is not only transmitting its own data but it also forward data of other nodes. Resources available in scarce at a node may halt the data transmission either temporarily or permanently. All the nodes in the wireless Ad hoc network are battery operated and the life time of the network is depends upon the available battery power of a node. A node after data transmission may reach to a threshold level. If the battery power of a node reaches to threshold value, then node is not in position to either accept the data or send the data to other nodes in the network [15]. In this situation a node is excluded from the available path. Similarly if such types of nodes are in large number then more number of paths will not be available to send the data to other nodes and it may be possible that network is of no use [14]. The position of a node in wireless Ad hoc network is not fixed. Mobility of nodes are very high. The range of data transmission of every node is not fixed it changes according to the position of node. The coverage area is different for different node. Consider a node 'i' wants to transmit data to a node 'j'. Node 'i' can transmit data directly to 'j' if and only if they are in transmission range of each other and node 'i' has sufficient battery power for data transmission. Source node can also send its data with the help of other intermediate nodes, which lies in its vicinity, If the destination node not in a range of source node [15].

In Figure-1 the total area of a network is 'r' and let say the transmission range of inner circle node is 'r1'.Where (r1<r). The nodes which are situated 'r1' distance from each other can transmit data directly to each other without any interference.

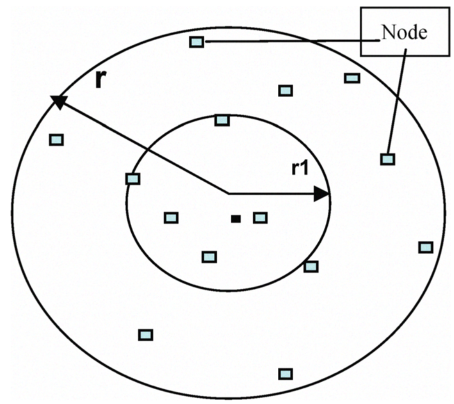

Figure-1 Transmission Area

The node situated at the periphery i.e. the distance between two nodes is 'r' then it is the maximum distance between 2 nodes. Here two cases arises either a node transmit data directly to destination, if it has sufficient battery power or it can send the data with the help of intermediate nodes [20]. Whenever a node wants to transmit data beyond its range, data may collide due to interference problem. If node 'i' transmits data to a node 'j' with the help of intermediate node 'k' then the power required during data transmission from node 'i' to 'j' via 'k' should be less as compare to transmit data directly from 'i' to 'j' i.e.

$$P(i, k) + P(j, k) < P(i, j)$$

$$\text{Minimize} \sum_{i,j=1}^{n} P(i, j)$$

Where P is power required to transmit data between two nodes. Here we want to minimize the total power consumption of the network. Power requirement during data transmission from source node to destination:

$$Pt / d(i, j)^{\alpha} >= \gamma[17]$$

Where Pt is power at transmitter, d (i, j) is the distance between node i and j, α is constant depends on the environment and γ is the signal strength at receiving end. If a node transmits data then the minimum strength of signal required at receiving end is γ [17]. As earlier it is mentioned that if a node directly transmit its data to a distant node then there may chance that node reach to threshold of battery power. For the optimization of battery power for the entire network we propose two algorithms they are: Select_Node and Total_Minimum_Power.

Algorithm 1: Select_Node

```
Variables
a: two dimensional array  // for representing power strength at
                          // receiving end.
p: one dimensional array // for representing power strength of
                         // transmitting node
d: two dimensional array // for representing distance between
                         // nodes
 i, j, s: temporary variables

Begin
        for i=1 to k
                for j=1 to n
        {
                        S= strength (p_i , d_ij)
                        if s ≥ γ  then a_ij = s
                        else  a_ij =0
        }
end for
//End of Select_Node
```

Function definition of Strength

```
float strength (p , d)
{
        return   p / d^α
// α is a constant depends on environment of ad hoc network
}
 // End of strength
```

Algorithm 2: Total_Minimum_Power

```
// calculate total minimum power consumption in network at
//any instance of time

// Assumptions-
//        -Total number of nodes in the network= 'n'
//        -Number of nodes wants to transmit data='k'

Variables
min_p, i:  temporary variables
Begin
        min_p=0
        for i=1 to k
        min_p += find_min(i);
end for
//End of Total_Minimum_Power
```

Function definition of find_min

```
Variable
 a: two dimensional array // for representing power strength
                          // at receiving end.
float find_min (i)
{
                min=10000;
                for j=1 to n
                if a_ij < > 0 and a_ij < min then
                min = a_ij ;
                return min;
} // End of find_min
```

In Select_Node algorithm we select all those nodes who want to participate in data transmission. We consider here that number of nodes are "n" in network and number of nodes wants to transmit are 'k' ($k<n$). When a node has sufficient battery power, it can transmit to a distant node and to detect signal at receiving end the minimum strength required at the receiver end is γ. We calculate the strength 'S' of signal to transmit data between node i and j who are situated at a distance'd' of each other by:

$$S= P / d^{\alpha}$$

Where S is signal strength which should be equal or greater then γ, P is power, d is the distance between two nodes and α is a constant depends on environment of Ad hoc network. Total_Minimum_Power algorithm calculates total minimum power consumption in network at any instance of time. This algorithm finds the minimum energy required to transmit the data from node 'i' to node 'j'. This algorithm compares the power required to transmit the data between two nodes. These values are stored in a two dimensional array. After calculating these value algorithms also sum up the minimum consumption of energy to calculate total consumption of energy in the network at any instance of time. By applying these two algorithms it can be evaluate that at any instance of time how many nodes are transmitting data and during this data transmission a node can be selected among the nodes which requires less energy for data transmission. Proposed algorithms also get the total minimum power consumption of a network.

Methodology

For performing simulation we have taken a hypothetical model of five nodes A, B, C, D, and E. The power of nodes can be between 1 to 750 mW. With the help of random function we have generated five random values which are defining the power of the nodes from node A to E respectively. The power matrix P is P= [636 700 509 568 557] which defines P_A=636, P_B=700, P_C=509, P_D=568, P_E=577. With respect to node A, we have taken random distance for B, C, D and E. The value of α is 2.Similarly we have calculated the distance of other nodes from a node with the help of distance and angle using cosine rule. Angles between nodes are generated randomly. The network generated is as shown in Figure 2.

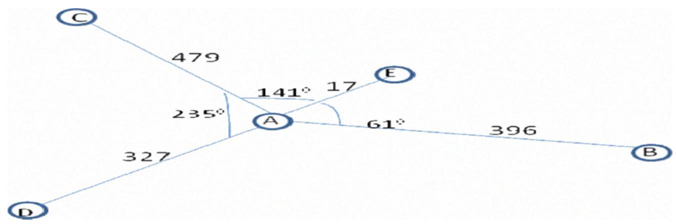

Figure-2 Network Model

The distance calculated between various nodes of the network is shown in Table-1 the distance matrix 'D'.

TABLE- 1: DISTANCE MATRIX

	A	B	C	D	E
A	0	396	479	327	17
B	396	0	823.6	642	388.12
C	479	857.4	0	598.3	476.4
D	327	642.09	598.39	0	336
E	17	388.12	476.12	336	0

With the help of power and distance using the formula

$$Pt / d\,(i, j)^{\alpha} >= \gamma$$

We have calculated the strength matrix 'S' which as shown in Table-2

TABLE- 2: STRENGTH MATRIX

	A	B	C	D	E
A	INF	0.0041	0.0028	0.0059	2.2007
B	0.0045	INF	0.0010	0.0017	0.0046
C	0.0022	0.0007	INF	0.0014	0.0022
D	0.0053	0.0014	0.0016	INF	0.0050
E	1.9273	0.0037	0.0025	0.0049	INF

With the help of these two matrices we can find the optimal path for transmitting the data from any source node to any destination node by considering battery power.

CONCLUSION

Resource optimization plays vital role in wireless Ad hoc network since such type of network are not having resources in ample amount. Working with limited resources like bandwidth, battery power, buffer space etc. create problems during data transmission in the network. Battery power may decrease the overall life time of a network. In this paper we have proposed two algorithms Select_Node. Select_Node find out how many nodes want to participate in data transmission and Total_Minimum_Power calculates the total power consumption in wireless Ad hoc network. These two algorithms help to minimize the consumption of large battery power as well as increases the overall life time of the network.

FUTURE ENHANCEMENT

The major characteristics of wireless Ad hoc network are: Dynamic topology, easy deployment, limited bandwidth, limited battery power, lower data rates, higher error rates, higher delay etc. The resources available at a node in wireless Ad hoc network are in scarce. This paper has discussed one of the resource of wireless ad hoc network i.e. battery power. Future scope may include other parameters to develop an optimized model to measure the performance of wireless Ad hoc networks.

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