JOINT SCHEDULING AND POWERCONTROL FOR WIRELESS ADHOC NETWORKS AGAINST MULTIPLE ACCESS INTERFERENCE.

Oladimeji T.T[1], Alake T.J[2],
[1,2]Department of Electrical/Electronic Engineering,The Federal Polytechnic, Ado-Ekiti, Nigeria
Email: tolulopett@yahoo.com, +2348030896393 alaketope@yahoo.com, +2348035652087

Abstract

This paper is aimed at the application of power control to addressing the problem of multiple access interference (MAI) of Code division Multiple Access (CDMA) networks. Our approach accounts for multiple access interference (MAI) at the protocol level, thereby addressing the notorious near-far problem that undermines the throughput performance in MANET (Mobile Adhoc Network) collision avoidance information is inserted in the clear-to-send (CTS) packets and broadcast over an out of band control channel. This information is used to dynamically bound the transmission power of possible interfering nodes to the vicinity of a receiver. Data were collected based on area of coverage and flow chart is shown to itemized each stage of the joint scheduling and power control. Initial routing table was designed in order to impose initial network connectivity and to know nodes that should be able to communicate with each other and simulation was carried out using a network of different nodes randomly distributed over different grids to know the effectiveness of the designed network. Findings show that multiple access problem can be solved by the use of scheduling algorithm to coordinate the transmission of independent users for the elimination of interference or by the use of power control in a distributed fashion for schedule users to satisfy single- hop transmission requirements.

Index Terms: Clear-To-Send (CTS), Code division Multiple Access (CDMA),MANET (Mobile Adhoc Network), Multiple Access Interference (MAI),Thorough put, Nodes.

1.0 Introduction

There are two distinct types of wireless networks: the infrastructure-based wireless networks and mobile adhoc networks (MANETS). In infrastructure-based wireless networks, the mobile nodes rely on stationary nodes, usually called access points, with ample alternating current power to route their packets through the network.In this wise, the access point coordinates and routes traffic between nodes. In MANETs, the mobile nodes rely on each other for packet delivery and traffic coordination. This type of coordination forms what is called multi-hop connections. In adhoc networks, the task of packet delivery and traffic coordination puts a lot of stress on the individual nodes' energy sources. As the nodes consume energy from their power sources, the network can become partitioned hastening its "death", i.e. the point at which the network can no longer fulfill its intended functions (Perkin,2002).

Wireless networks have expanded and their technology has advanced considerably, there are still issues that need to be looked at more closely. These issues include throughput, delay, channel capacity, and power consumption; The throughput and delay in wireless networks lag behind that of wired ones. There are many reasons for this including node mobility which increases the likelihood that destination nodes become reachable. Another factor limiting throughput is the long delay that networks incur due to channel interference and underutilization of channel capacity because hidden and exposed node problems. ***[Perkins(2002);Frankling and Irwin (1985)].***

Limiting multiuser interference to increase single-hop throughput and reducing power consumption to prolong battery life of transmitter is achieved with the method of next neighbor transmissions where nodes are required to send information packets to their respective receivers subject to a constraint on signal-to-interference-and-noise ratio. The multiple access problems can be solved via two alternating phases namely scheduling and power control. The scheduling algorithm is always essential to coordinate the transmissions of independent users in order to eliminate strong levels of interference (self-interference) that cannot be overcome by power control [***Carlor and Karl (2007),***].

Power is also crucial in wireless networks especially in mobile adhoc networks as it is the “fuel” that keeps the network alive. The two most popular power sources for wireless networks are regular alternating current (AC) outlets and batteries. Power control is executed in a distributed fashion to determine the admissible power vectors that can be used by the scheduled users to satisfy their single-hop transmission requirements.***[Lyas (2002)].***

Methodology

In order to bring to focus the aim of this study, a method of imposition of initial network connectivity through the provision of initial routing table is utilized as reflected in Table 1. The routing table performs power control in such a way that transmission is to a minimum .When transmission power is determined the routing table can subsequently change as soon as unnecessary hops are detected along the path. However enhanced power conservation when a node can reach another node in the path to destination by decreasing with each iteration the number of hops whenever possible. And this usually brings about an overall improved efficiency of the routing system. Figure 1,depicts the imposed actual transmission links for the initial connectivity routing. Solution to MAI was achieved through the use of closest next neighbor routing approach. Simulations were run using a network of different nodes randomly distributed over a 2500m by 2500m grid.

Table 1. Initial Routes using initial network connectivity Approach.

ROUTES USING INITIAL NETWORK CONNECTIVITY	NO OF HOPS
1-19-11	2
2-14-10-1-19-12	5
3-5-15-13	3
4-20-16-2-14	4
5-15	1
6-12-19-1-10-14-2-16	7
7-17	1
8-18	1
9-17-7-4-20-16-2-14-10-1-19	10
10-14-2-16-20	4

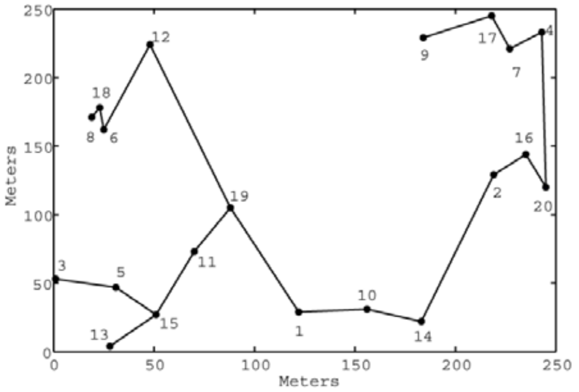


Figure 1: Actual Transmission links for initial connectivity approach.

Initial network connectivity based on the Closest Next Neighbour Approach

This approach assumes a link between a node and its closest neighbor in the forward X coordinate's cycle within the initial network connectivity. If no such neighbor exists, then it connected to the closest neighbor in any direction to maintain full network connectivity. Initial network connectivity for this approach can be constructed as follows: ***[D.Mitra (1994)]***:

The closest Neighbour Approach Algorithm

```
Begin
F i ⟶ 1 to total. No. of. Nodes
        Find j = Closest next neighbor of 1 in forward X
Axis direction from node I,
If j found
        Link (I,j) = link exists;
Else
        Find j = Closest neighbor of I in any direction
        From node I:
Link (I,j) = link exists;
End for:
End
```

With the algorithm (Mitra ,1994) ,the final routing with the elimination of unnecessary hops on the routing is obtained in table 1 while the actual transmission link is shown in figure 2

Table 2 Final Routes using the Closest Next Neighbor Approach.

FINAL ROUTES FROM SOURCE TO DESTINATION	NO OF HOPS
1-11	1
2-14-10-1-19-12	5
3-5-15-13	3
4-2-14	2
5-15	1
6-12-19-1-10-14-2-16	7
7-17	1
8-18	1
9-4-20-16-2-14-10-1-19	8
10-14-2-16-20	4

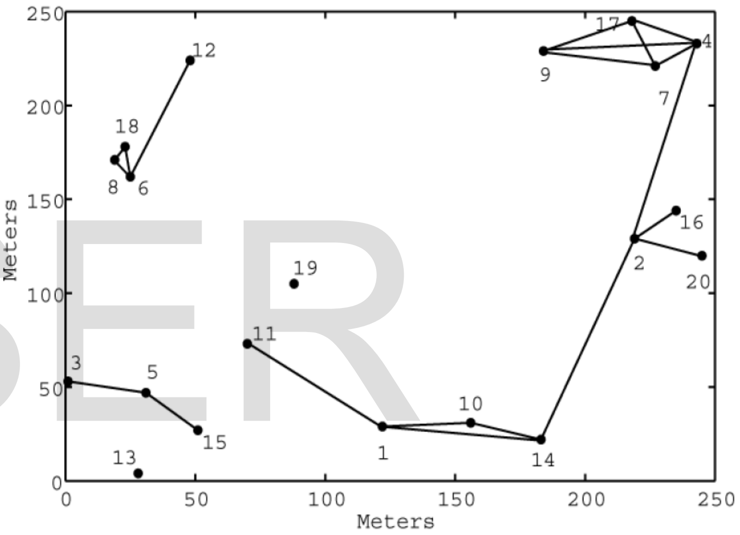


Figure 2: Actual Transmission Links for slot 1 using the closest Next Neighbour Approach

Analysis of Illustration on The Scenario And Simulation Results

A random network scenario is considered as an example to illustrate the working principle of our proposed routing algorithms. ***(Tang and Garcia-Luna-Aceves 1999)***

Step 1

The initial connectivity and the initial route table for the closest next neighbor approach is shown in the table1 and figure 1. The route table consists of route from each source to destination for each time slots on the connectivity plan.

Step 2

Transmission power for each transmitter is calculated through the energy optimization problem. After deriving the powers and spreading gain that minimizes the energy consumption, each transmitter checks others nodes with SNR> β along the routes. If such node exists the route are shortened by eliminating the unnecessary intermediate hops. The complete network connectivity for the closet next neighbor approach is shown in figure2:

STEP 3

For network scenario ***(Figure 1)*** used to illustrate our proposed approach, the output route table of the 2nd iteration is the same as the route table achieved in the 1st iteration.

In other words, we conclude that after the first iteration, routes for all source and destination nodes remain the same. The final route table is generated from the actual network connectivity for the Closest Next Neighbor approach and it is shown in ***Table 2 .***

Initial network connectivity and actual connectivity for the minimum spanning Tree Approach is shown in ***figure 2.*** final route table for this approach is shown in ***Table3*** Looking at the Figures for initial and actual network connectivity for different approaches, it is clear that, although initially we imposed a particular link from one node to another, but once our iterative Algorithm has converged other links can be chosen if fewer hops are feasible.

Table3 Final Routes using the Minimum Spanning Tree Approach

ROUTES USING INITIAL NETWORK CONNECTIVITY	NO OF HOPS
1-11	1
2-14-10-1-11-19-6-8-18-12	9
3-5-15-13	3
4-7-16-2-14	4
5-15	1
6-11-19-1-10-14-2-16	7
7-17	1
8-18	1
9-17-7-16-2-14-10-1-11-19	9
10-14-2-16-20	4

TABLE 4: Simulation Results after each iterations

ITERATION	ENERGY CONSUMED	COMMENT
1	8.952	Energy consumption minimized Route table conversed
2	6.354	
3	6.354	

In fact, this is the key to our proposed approach to minimize number of hops between a source and it its intended destination.

We observe from ***Table 1*** and ***Table 2*** that through our proposed iterative routing algorithm, the number of hops for some routes decreases significantly. As an example, ***Table 1*** shows that according to our proposed initial network connectivity, source node 1 routes through node 19 to its destination node 11. This route path simplifies to a direct path from source node 1 to its destination 11 applying our proposed routing algorithm and using same transmits power.

This is shown in ***Table 3*** which clearly indicates that route path obtained after the second iteration consume less network energy that rate path obtained after the 1st iteration due to the decrease in the number of hops.

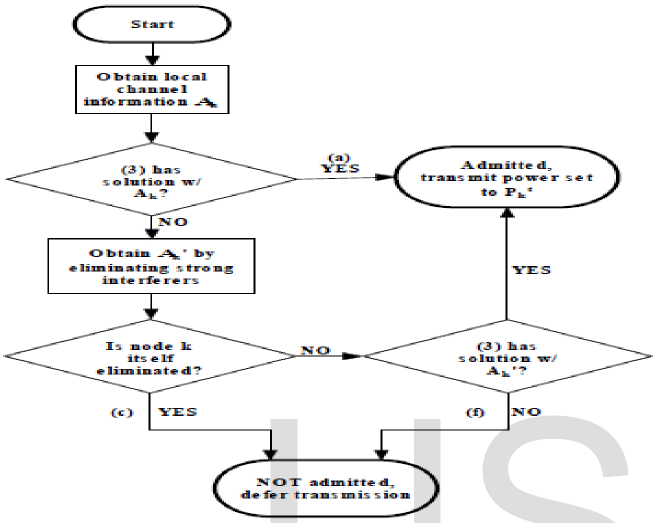


figure 3. Flow chart of joint scheduling and power control algorithm

The description of the flow chart shown figure 3 is as follows:

i. Each node in S sends a test packet with power equal to $P_{max.}$

ii. Each receiver detects the test packets from all transmit nodes nearly, and estimates the corresponding channel attenuation. The receiver then sends a packet including all the estimated attenuation factors. As an example, consider the net shown in ***fig4***, where transmitters are connected to the intended receivers by solid lines and not to the intended receivers by dotted lines. In this case, receiver r_3 estimates factors a_{31} such information to S_1 and S_2.

iii. The generic node K, K ∈ S, detects the packets from the receivers within its transmission ranges from each of these receivers K obtains the list of all possible interfering transmitters and their attenuation factors toward the receiver's looking at ***fig4***, we have that transmitter S_1 gets a packet from the intended receivers $r_1$and r_2, as well as from r; therefore, 8. Is aware also of the signal attenuation from δ_2 toward r_1 and r_3

iv. The generic node K, K ∈ S, transmits a packet with power level equal to lmax including the attenuation factors corresponding to all the receivers in its transmission range.
    a. In the example in ***fig4*** shown below δ_2 sends a packet including the channel attenuation factors related its transmissions toward r_1, r3 and r.

v. Each receiver re-transmits such a packet, thus every node K, K ∈ S, can acquire information related to all the transmission range. Referring to the example in fig 2, as thus point S_1 knows all the channel attenuation factors but the one related to the transmission from δ_3 to r_4.

vi. The generic node K, K ∈ S, can construct its own copy of the channel attenuation, matrix. Matrix k is based on 'local' information and include the channel attenuation related to transmissions toward nearby receivers only, Hence its dimension is expected to be small.

vii. The generic node K, K ∈ S, tries to find the optimal transmit power vector by plugging A_K for solving the power vector control problem

(a). If there is a solution to the power control problem, node K is allowed to transmit, and it s transmit power is set to P_k^t.

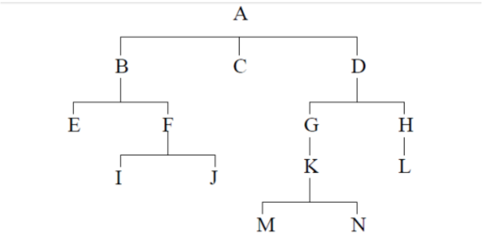
(b). Else, for each transmitter for which a row in matrix A_K exists, node K computes the so-called Maximum Interference to Minimum Signal Ratio (MIMSR), which is defined as the ratio of the maximum absolute value of negative entries in row j to the minimum positive entry's in row j. the MIMSP's are compared to a preset threshold β. If $MIMSR_j$>1, then the jth row is eliminated from ^ and a new A_j^t is obtained.

(c). If by doing this, the row corresponding to node K is removed, K will not participate in the current round of scheduled transmissions and defer its transmission to the next round.

(d). Otherwise, node K tries to solve the power control problem again by using A_j^t.

(e). If a solution exists, node K transmits at power 1/K.

(F). Else if defers is transmission attempt to the next round



Sender	Receiver
A	B, C, D
F	I, J
G	K
H	L

Sender	Receiver
B	E, F
D	G, H
K	M, N

Simulation Results

Simulations were run using a network of different nodes randomly distributed over a 2500m X 2500m grid. The simulations use a cost-231 propagation model at 1.9 GHz between the mobiles. The values for γ_o and K and 10rB respectively. The chip bandwidth W is 1.2 MHz, the thermal noise density N_o is -179 ∝BmHz, and the pilot rate R_b is 4.8 Kbps. The values for X and T are 6 and 7, respectively. The initial choices for slot and rate assignments were chosen at random.

The slot assignment algorithm was run on a random node at each iteration. In other words, the actual random access of the control channel was approximated by time. ***Figure 5*** below shows a faulty network configuration (i.e some nodes are transmitting in the same slot as their neighbors, or have too few neighbors) for a 10-mobiles subset of the network. ***Figure 6*** shows the firaj network configuration for the same subset after the neighbor discovery/time-slot assignment algorithm has been run. The links in which neighbors had the same slot assignment have been fixed, and all nodes have enough neighbors.

The rate assignment algorithm was run for a single time-slot at each iteration. ***Figure 7 shows*** the number of infeasible links at each iteration. It can be seen that this function is decreasing and stabilized at "O". finally the ***figure 8*** shows the system throughput using a street threshold model, in which a given mobile. Is assumed to have perfect reception of condition C_3 is satisfied, and no reception of it is violated.

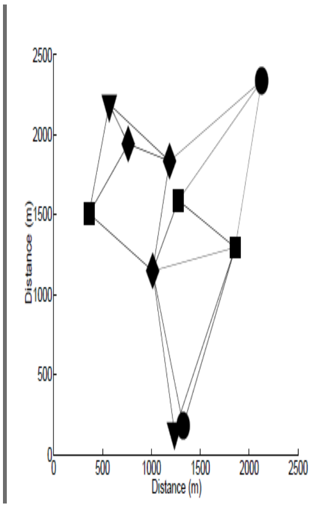


Fig.5

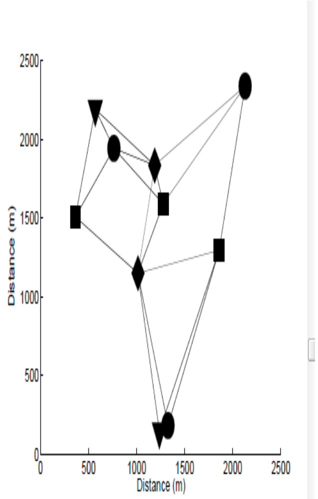


Fig.6

Figure 5 showing a faulty network configuration (i.e some nodes are transmitting in the same slot as their neighbors, or have too few neighbors) for a 10-mobiles subset of the network.

Figure 6 showing the firaj network configuration for the same subset after the neighbor discovery/time-slot assignment algorithm has been run

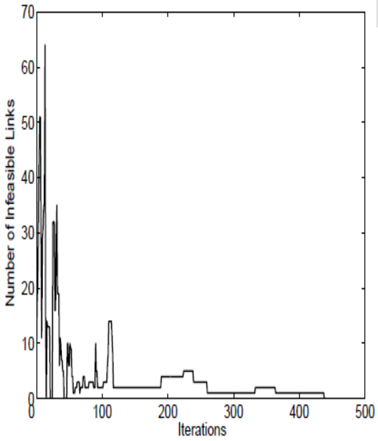


Fig.7.

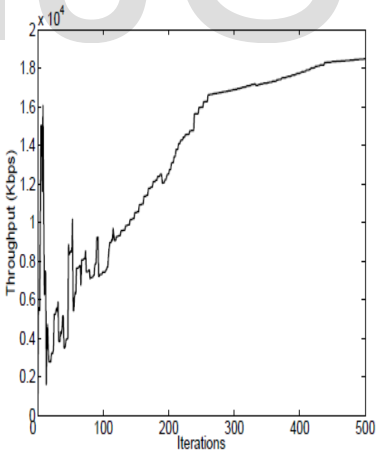


Fig.8

Figure7 showing the number of infeasible links at each iteration.

Figure 8 Shows the system thourghput using a street threshold model

Summary

The motivation for this study is twofold, limiting multiuser interference to increase single-hop throughput and reducing power consumption to prolong battery life. We focus on next neighbor transmission where nodes were required to send information packets to their respective receivers subject to a constraint on the signal-to-interference and noise ratio. The multiple access problem is solved via two alternating phases, namely scheduling and power control. The scheduling algorithm is essential to coordinate the transmissions of independent users in order to eliminate strong levels of interference typically self-interference that cannot be overcome by power control.

On the other hand, power control is executed in a distributed fashion to determine the admissible power vector, that can be used by the scheduled users to satisfy their single-hop transmission requirements. This is done for two types of networks, namely time-division multiple-access (TDMA) and TDMA/Code division multiple-access wireless adhoc networks.

Conclusion

The result solutions developed an integrated routing, link scheduling and power allocation policy for a general multi hop network that minimizes the total average rate requirements per link. This solution can support higher throughputs than with conventional approaches to ratio resource allocation at the expense of decreased energy efficiency. Schedule and power control requires time synchronization between transmitters and requires that channel conditions remain constant over several time slots.

REFERENCE

Carlor .A.F and Karl H.J :(2007) Energy Consumption of Minimum Energy Coding in CDMA. (K. Langendoen and T. Voigt (Eds.): EWSN 2007, LNCS 4373, pp. 212–227, 2007.c_Springer-Verlag Berlin Heidelberg 2007)

Chlamtac , I. and Farago,A (1994): “Making transmission schedules immune to topology changes in multi-hop packet radio networks,” *IEEE/ACM Trans. Networking*, vol. 2, pp. 23–29,

Lyas M.L (2002): The Handbook of Adhoc Wireless Network . CRC Press LLC, N.W. Corporate Blvd., Boca Raton, Florida.

Mitra,D. (1994): An Asynchronous Distributed Algorithm for power control in cellular radio systems.

Perkins C.E (2002): Adhoc Networking, in Addison professional. Addison-Wesley Professional ,USA.

Sousa E.S. and Silvester,J.A.: "Spreading code protocols for distributed spread spectrum packet radio networks," *IEEE Trans. on Communications* , vol. 36, No. 3, pp. 272-281, March 1988.**)**

Steven Low and David Lapsley(1999): Optimization flow control I : Basic algorithm and convergence. IEEE/ACM TRANSACTIONS ON NETWORKING, 7(6).

Tang, Z. and Garcia-Luna-Aceves J.J.:(1999) “: A protocol for Topology-dependent-transmission scheduling In proceeding of: Wireless Communications and Networking Conference, 1999. WCNC. 1999 IEEE *IEEE INFOCOM*, 1999.