Extended Multi-Class Approach for Improvement in Overall Throughput Efficiency of Mobile Adhoc Networks

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Abstract—**The techniques and possibilities for Adhoc networks designed in general are always attracted by only a minority division of applications, the reason being the varied application environments. One of the imperative scenario covers applications where we have a lone sender, one or multiple end receivers and of course a number of intermediate nodes. The above scenario(Application specific) provides us the luxury of classifying nodes on the basis of various transmission states(Sender ,intermediate ,End-receiver).This node classifying strategy thus makes node state as a performance tuner for the whole network. The sender node consequently dictates the impact on the performance of whole transmission. Here we show that by eliminating almost all the transmission overheads at the sender node alone makes the whole transmission much more effective and efficient. The above scenario makes a ripple effect (improvement) on the overall transmission performance. Taking into consideration the aggregate throughput as the performance indicator across the nodes for transmission efficiency, we generate results for the throughput across the nodes, which help us to analyze the efficiency ratio of the various nodes for the current standard. Our analysis reveals that the proposed scheme works on all the standard bandwidths, moreover we found that at higher bandwidths the approach is showing more acceptance. The comparison of our scheme is done with existing (IEEE-802.11b) standard. Finally, we show the efficiency of the proposed scheme with respect to increase in bandwidth.**

Index Terms— **Network-Overhead, Bandwidth, Throughput.**

I. Introduction

As the wireless Adhoc is getting mature in its application and development aspects, the real world applications still strive for the dynamic, realizable, and efficient technologies. These techniques need to be embedded as such, that the power of mobile Adhoc networks on real world's day to day applications can be felt, which may lure the industrial manufactures and hence after help in improving the living standards of the common people.

There are still many areas where mostly some uncooked techniques still dwell. One of the areas of the Adhoc wireless communication where more effective techniques or algorithms need to be deployed is the bandwidth efficiency. The world is getting more and more involved in wireless technology and in particular about distributed on the fly networks. In the industrial data communications (telecommunication, Personal Area Networks, Campus LANs) wireless local area network (WLAN) technology is seamlessly attracting kind attention. The wireless local area networks can effectively be realized by wireless Adhoc-environment. Of course, trendy wireless systems (point-to-point and networked) have been around for a while, but cost, lack of homogeny and performance limitations have been a holdup to their range of implementation. As the cost/performance ratio of IEEE 802.11 wireless has improved, manufacturers and users have begun to develop products and systems specifically for industrial applications. Now users are looking to WLANs for solutions to a wider range of commercial and domestic needs. Economical, unflagging wireless networks allow industrial users to enhance data collection rate, human-machine interfaces (HMI) and web-based system monitoring. The ability to project adhoc-environment without the time and expense of installing fixed (AP) access points is a compelling force for Adhoc-network candidature for future world of business and development areas. The proposed scheme presented in this paper, take advantage of transmission scenario to make the service more bandwidth efficient. The proposed scheme allows the nodes to communicate without concerning about the next hop or the neighboring node.

II. Related Work

In the wireless technology till date, several studies dealing with analysis and behavior of DCF protocols have been done. CSMA/CA algorithm is the most thoroughly studied one. Bandwidth and battery power are key constraints for efficient and continuous operation of mobile computers [1]. Bandwidth efficiency is the most important aspect of the above two. The bandwidth efficiency expresses the quality of modulation that is used to modulate the signal over a specific bandwidth while respecting the required bit rate in term of time occupancy among the contending nodes instead of ensuring fair access probability. Also to achieve efficiency, we give different access priority to different hosts according to their transmission bit rate classes (11, 5.5 or 1 Mbps) [3]. To deploy the protocol that dynamically changes the window size according to the transmission rate is complex in implementation, as we need to take in consideration all the contending nodes in the whole network. Thus the development of a more dynamic scheme more suitable for a distributed environment is desired. Here we propose a novel method which keeps well with the distributed nature of the ad hoc environment. The proposed scheme classifies the various nodes according to the state of transmission (sender, receiver

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and intermediate). Also the scheme is simple in its design and implementation.

III. IEEE-802.11B

The strength of a signal decreases proportionally to the square of the distance to the sender, and obstacles attenuate the signal further (free space loss). Further on the few existing problems like hidden terminal, exposed terminal, and near far terminal like problems still aren't eradicated completely from wireless scenarios. One of the most generic problems is with the sharing of common channel in an unfaired fashion. Unlike cellular networks, there is a lack of centralized control and global synchronization in ad hoc networks. Thus the existing schemes shown in table1 below are not quite suitable for the Adhoc environment. The Mac protocols need to be in distributed fashion to best suit with the ad hoc networks scenarios.

TABLE 1

Protocol	**Mechanism**
CSMA	CSMA
MACA	PSMA/RTS/CTS
FAMA	CSMA/RTS/CTS
IEEE 802.11DCF	CSMA/CA/RTS/CTS/ACK

Ad-Hoc mode (IEEE 802.11 DCF) is a set of 802.11 wireless stations that communicate directly with each other without using an access point or any connection to a wired network. This basic protocol is useful in order to quickly and easily set up a wireless network anywhere a wireless infrastructure does not exist such as a hotel room, a convention center, or an airport. Ad-Hoc Mode is also called peer-to-peer mode or an Independent Basic Service Set (IBSS). In the IEEE 802.11b protocol, the fundamental mechanism is called Distributed Coordination Function (DCF), which is random access scheme based on carrier sense multiple access with collision avoidance (CSMA/CA) protocol. A station which has a packet queued for delivery monitors the channel activity. If the channel is idle for a duration equivalent to a distributed inter-frame space (DIFS), the station waits for a random amount of time dictated by binary exponential back-off rules, and then transmits its packet. If the channel is found busy, the station persists to monitor the channel until it is found to remain idle for the duration of a DIFS. DCF employs a discrete-time back off scale. The time immediately following the DIFS is slotted, and a station is allowed to transmit only at the beginning of such slots. The duration of these slots is equal to the maximum time needed for a station to detect a packet from another station. Every new development is making the link transmission more efficient and smooth.

IV. Throughput Factor as Performance Indicator

Early simulation experience with wireless ad hoc networks suggests that their capacity can be surprisingly low, due to the requirement that nodes forward each other's packets. The achievable capacity depends on network size, traffic patterns, and detailed local radio interactions [4]. The properties of wireless networks are determined by means of large number of factors such as frequency band, channel bandwidth, number of channels used, bit rate, signal range, bandwidth efficiency, modulation used and so on. The bit rate quantity determines the number of information units transferred over a transmission path in basic time unit. The bit rate is often referred to as transfer rate, channel capacity, maximum throughput, digital bandwidth capacity or connection speed. The bandwidth efficiency expresses the quality of modulation that is used to modulate the signal over a specific bandwidth while respecting the required bit rate. While maximum theoretical throughput assumes only data packets on a channel, maximum achievable throughput takes into account handshake and control packets, which reduce the amount of channel space available for data packets, also the considerations such as reduced data packet length. Additionally, this value takes into account hardware limitations of the systems on both ends of the channel, within the channel itself, and normally includes the additional overhead related to the specific control requirements of the system, and sometimes assumptions about the behavior of a system as a whole, such as maximum achievable throughput is typically an optimistic assumption of network performance, but provides more useful insight into expected system performance than maximum theoretical throughput and is often an active area of research. Most simulations of systems based on certain assumptions can be described using this number. The Peak measured throughput is throughput measured by a real, implemented system, or a simulated system. The value is the throughput measured over a short period of time mathematically, this is the limit taken with respect to throughput as time approaches zero. This term is synonymous with "instantaneous throughput". This number is useful for systems that rely on burst data transmission, however, for systems with a high duty cycle this is less likely to be a useful measure of system performance Throughput is sometimes normalized and measured in percentage, but normalization may cause confusion regarding what the percentage is related to. Channel utilization and packet drop rate in percentage are less ambiguous terms. The channel utilization, also known as bandwidth utilization efficiency, in percentage is the achieved throughput related to the net bit rate of a digital communication channel In general efficiency formula is:

$$\text{Efficiency} = \text{data} / (\text{data} + \sum \text{overhead})$$

V. Proposed Solution

The adaptation of network overheads (contention window, DIFS and EIFS) on the basis of the transmission rate classes does provide efficient bandwidth utilization and a comparable fairness [3]. The above approach but has a limitation that the higher transmission rate nodes may lead to the unfairness and lesser aggregate throughput, and also limits the faster nodes to transmit at their will.

The scheme which we propose here is that, we classify nodes into three main categories. Classification will be done on the basis of transmission state. The classes are:

Class A	Class B	Class C

38 - 40 %	25 – 30 %	15 – 20 %

In a network transmission whether it is unicast transmission or broadcast transmission there generally exists a lone sender and many intermediate nodes and a few end receivers. So at a particular time instant the node interested in sending the data, sends RTS which defines the sender in the transmission, and the destination address defines the receiver (if not broadcasted). Now as we have simulated the basic IEEE-802.11b standard (DCF), the simulations depict the efficiency for different node classes. Now the efficient bandwidth utilization can be achieved by two means. One , to upgrade the throughput of class B and class C type nodes, but this method is complex and isn't suitable for the distributed control scenario (DCF), the method also has bottleneck of limiting the overall throughput of the network, as here we need to limit the capacity of the class A type nodes. The Second method, if we increase the efficiency of sender node, we need not to limit the sender's capacity. Now by increasing the capacity (sender efficiency can be increased by minimizing the overhead at the sender only). Scenarios like where a lone sender exists, the contention window is reduced to minimum. The impact of overhead reduction on the performance can be dealt in (figure 2a, 2b, 2c, 2d). As by simulating the existing standard (802.11b), we can see that the efficiency decreases across the network in decreasing order on the standard bandwidths (1, 2, 5.5, 11.0 Mbps).

Now the proposed scheme will reduce the overhead at the sender nodes, which in turn will increase the efficiency of the class A and class B type nodes. The effect can been taken analogous to ripple effect. Thus we can term the new approach as the ripple approach to upgrade bandwidth efficiency. The scheme is simple to develop and keeps well with the distributed control nature of the Adhoc networks (DCF), as we only need to minimize the overhead dynamically at the sender. The protocol will then take care of the rest node classes in turn.

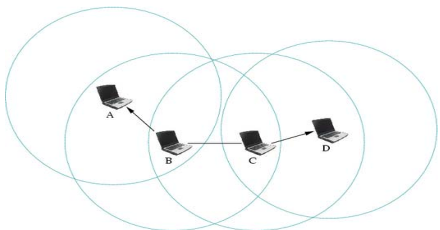


Figure 1. Node A is sender, node B, C are intermediate nodes and node D is the receiver node.

Here now, if the efficiency of node A is 40 %, then if we increase the node A efficiency by some degree, then we can see that, efficiency of node B, C and D will in turn increase, Because the decrease in overhead at sender node will reduce overhead at other nodes also. Thus an overall improvement in network throughput will occur. After simulating the results for the new scheme we see an increase in overall throughput of network. Also we found that as we deploy the proposed scheme at higher bandwidths, the scheme shows better performance in terms of bandwidth efficiency (Figure 3.a).

VI. Performance Evauluation

Here we will discuss the mathematical analysis of the proposed scheme, which takes into consideration the results taken from the simulation of the basic IEEE-802.11b protocol. Assuming that we have a chain network of seven nodes, traffic was generated at the very first node of the chain, and was sent to last node of the network, through intermediate nodes. The results were firstly taken under the basic IEEE-802.11 standard protocol. After that each node's efficiency was calculated (achieved throughput). The results show us the decreasing trend in efficiency across nodes. Now, assuming the total theoretical efficiency of the sender = 'X'**.** Now the actual achieved throughput of node1 is 40 percent of the 'X' i.e.

Efficiency of node 1 = 0.40X

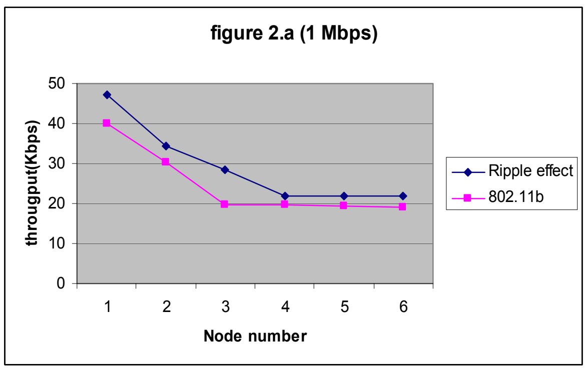
Now, if we increase the efficiency of the sender node, by reducing the overhead, the ripple effect will take effect on the efficiency of others. As shown in figure 2.a and 2.b. Class B and class C node overhead is directly proportional to overhead of class A node (if senders are waiting for long, thus increasing intermediate and receiver overhead). As contention window is a prime overhead, we should minimize the contention window for the sender node. So we suggest a minimum contention window for the sender nodes, which will lessen the overhead of the sender node. Thus we are with a scheme which upgrades overall efficiency of the whole network.

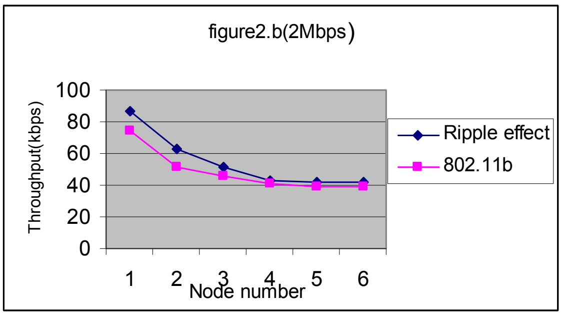
VII. Conclusion

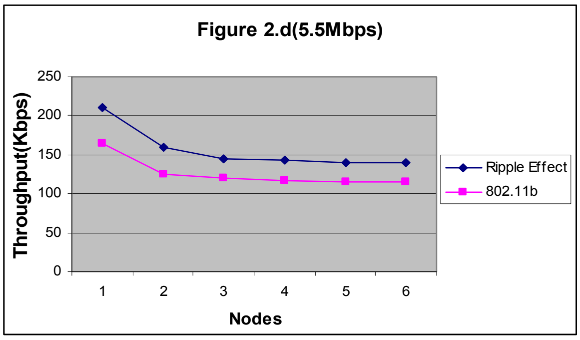
We have presented a new approach to improve ad hoc network performance, by simply making use of the general scenarios and the basic distributed nature of the Distributed Coordination Function. The impact of the new approach is just like the ripple, as performance improvement fades across the network.

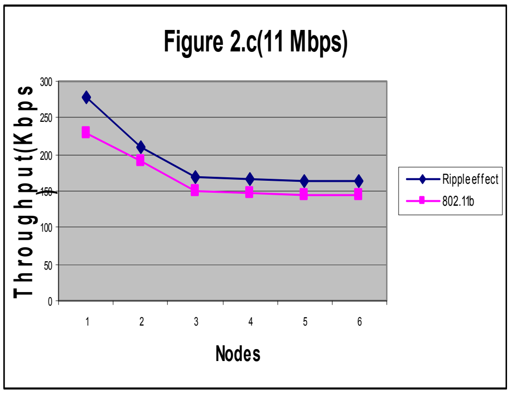
VIII. Sugested Future Work

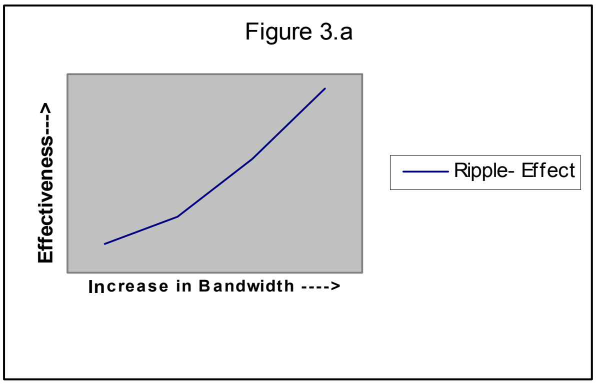
Further on we can make the scheme more efficient by taking advantage of the multiple back off window principle [2], thus deploying both the schemes.











REFERENCES

[1] [1]. Ing. Milan Šimek, ING. Ivan Míča, Ing. Jan Kacálek, Ing. Radim Burget " Bandwidth Efficiency of Wireless Networks of WPAN, WLAN, WMAN and WAN", elektro-revue 2007/30 – 28.8.2007

[2] Yassine Chetoui and Nizar Bouabdallah, " Adjustment mechanism for the IEEE 802.11 contention window: An efficient bandwidth sharing scheme ", Computer Communications, Vol. 30, No. 13, September 2007.

[3] Yassine Chetoui, Nizar Bouabdallah and Jalel Ben-Othman "Improving the Bandwidth Sharing in IEEE 802.11", Proceedings of the 32nd IEEE Conference on Local Computer Networks, 2007.

[4] Douglas S. J. De Couto, Daniel Aguayo, John Bicket, and Robert Morris," A High - Throughput Path Metric For Multi-Hop Wireless Routing", Proceedings of the 9th ACM International Conference on Mobile Computing and Networking (MobiCom '03), San Diego, California, September 2003.

[5] Jinyang Li, Charles Blake, Douglas S. J. De Couto, Hu Imm Lee, and Robert Morris, Capacity of Ad Hoc Wireless Networks , Proceedings of the 7th ACM International Conference on Mobile Computing and Networking", (MobiCom '01), Rome, Italy, July 2001.

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