Exploitation of MIMO Based Wireless Networks by Novel Scheduling Algorithms

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Abstract- *MIMO system has attracted considerable attention recently for its potential to increase the system capacity. In this paper, we aim to design practical user scheduling algorithms to maximize the system performance. Various MAC scheduling policies have been implemented, in order to provide distributed traffic control and robustness against interference. Further, in order to increase the efficiency of resource-utilization, the scheduling policies have been modified, and those have also been implemented. MATLAB simulations have been used throughout and the various policies have been compared with each other in order to draw important results and conclusions. This paper ends with a few suggestions for future improvements.*

Keywords- MIMO, MAC, Scheduling, Resource utilization

I. INTRODUCTION

Multi antenna system has been researched intensively in recent years due to their potential, to increase the channel capacity in fading channel. It is shown that MIMO systems can support higher data rates under same transmit power and BER performance requirements. Such system finds wide applications in WLAN networks. The conventional collision avoidance (CSMA/CA) approach described in the 802.11 standard [9] makes use of control messages (RTS/CTS) to mitigate the hidden terminal problem, thus preventing collisions that would result in loss of data and waste of resources. In a MIMO wireless network, however, this is not always the best solution. Specifically, the receiver structure is able to separate incoming PDUs, which would then not result in a collision, but could instead be detected separately. The networking protocols may then choose how many and which channels to estimate, taking into account that the limited receiver capabilities allow locking onto at most N sequences simultaneously. While doing this, trying to detect too many destinations oriented data packets could leave limited resources for Interference cancellation, leading to data loss. Even with channel estimation and spatial de-multiplexing, the MIMO receiver itself is still vulnerable to “hidden terminals” in some sense: if the receiver is not aware of interfering nodes nearby, it cannot estimate their channel and cancel them.

Hence in this paper we propose different scheduling algorithm in which the awareness about interference has been incorporated. The receiver node first schedule all the requests contained in every correctly decoded RTS packet send by many senders for performance improvements. By enabling proper scheduling in the Medium Access Control layer (MAC), the system level performance has been improved by canceling the interference in Priority scheduling which we have proposed in MAC layer. Also we have analyzed the data rates and interference cancellation capability for the different scheduling policy which we have proposed in the MAC layer on RTS/CTS packets.

This paper has been organized as follows:

In the next three sections, the theory about System Model, MAC layer Scheduling, Class and MAC layer policies has been described. The simulation results, using MATLAB, have been included in Section-5. Comparisons of the different MAC layer scheduling using the simulation results, and related discussions have also been included in the same sections.

II.SYSTEM MODEL

Traditionally, the growing demand of capacity has been met by increasing the bandwidth and/or by inventing more spectrally efficient communication protocols. However, since the introduction at Bell Labs about 10 years ago, the concept of MIMO (Multiple Input Multiple Output) shown in figure 1 has received an increasing attention. The main observation is that if both the transmitter and the receiver are equipped with n antennas, the capacity (bit rate) can be increased by up to a factor of ‘n’, depending on the richness of the wireless channel. In principle, one can form ‘n’ parallel channels, which can transmit independently of one another. In general, this is not possible for line-of-sight (LOS) channels, since the multiple channels cannot be independent and will therefore interfere. However, in a rich scattering environment, the capacity can increase by a factor up to ‘n’. The transmission of data in parallel streams is usually referred to as spatial multiplexing.

Many detection algorithms have been proposed in order to exploit the high spectral capacity offered by MIMO channels. One of them is the V-BLAST (Vertical Bell-Labs

Layered Space-Time) algorithm which uses a layered structure. This algorithm offers highly better error performance than conventional linear receivers and still has low complexity.

2.1. Proposed System Model

In the system being implemented the MAC layer takes decisions based on received power levels. Hence there is a need for scheduling in the MAC layer for performance improvements.

2.1.1. Transmitting Nodes

Any node splits the transmit data into sub-packets called Packet Data Units or PDUs. We suppose ‘uj’ PDUs are sent through spatial multiplexing i.e., ‘uj’ antennas, one per PDU, where ‘j’ is the node index. Power of the ith antenna, given that it belongs to user ‘j’ is given as Ptot/uj, the maximum total power of any node is constrained to Ptot.

2.1.2. Receiving Nodes

Any receiver, say node ‘j’, uses all its available antennas NA. Thus, the received signal can be denoted using the NA-length column vector

$$r(j) = \hat{H}(j)s' + \nu'(j)$$

Here ν’(j) represents channel noise, and $\hat{H}$ (j) is the NA × U channel gain matrix. Under a Rayleigh fading assumption, $\hat{H}$ (j), ‘m’ is a circularly Gaussian complex random variable, including fading gain and path loss between the mth transmit and the nth receive antenna. We assume that the nodes’ channel knowledge is limited, i.e. at most NSmax channels related to as many transmit antennas can be estimated at the beginning of each reception. The set N(j) = {n1, . . . , nNSmax} contains the indices of such known antennas (KAs), for which we assume perfect channel estimation.

2.1.3 The Blast Receiver (Zero Forcing Algorithms with Optimal Ordering)

We take a discrete-time baseband view of the detection process for a single transmitted vector symbol, assuming symbol-synchronous receiver sampling and ideal timing. Letting a = (a1 , a2 , . . . ,aM)T denote the vector of transmit symbols, then the corresponding received N vector is

$$r1 = Ha + \nu \quad (1)$$

Here ν is a noise vector. One way to perform detection for this system is by using linear combinational nulling. Conceptually, each sub-stream in turn is considered to be the desired signal, and the remaining are considered as "interferers". Nulling is performed by linearly weighting the received signals so as to satisfy some performance-related criterion, such as Zero-Forcing (ZF). When symbol cancellation is used, the order in which the components of a are detected becomes important to the overall performance of the system. We first discuss the general detection procedure with respect to an arbitrary ordering.

Let the ordered set

$$S \equiv \{k1 , k2 , . . . , kM\} \qquad …….(1)$$

Be a permutation of the integers 1, 2, . . . , M specifying the order in which components of the transmitted symbol vector a are extracted. The detection process proceeds generally as follows:

Step 1: Using nulling vector wk1 , form decision statistic yk1 :

$$yk1 = wk1T\ r1 \qquad …..(2)$$

Step 2: Slice yk1 to obtain âk1:

$$\hat{a}k1 = Q(yk1) \qquad ……..(3)$$

Here Q(.) denotes the quantization (slicing) operation appropriate to the constellation in use.

Step 3: Assuming that âk1 = ak1, cancel ak1 from the received vector r1, resulting in modified received vector r2:

$$r2 = r1 - \hat{a}k1\ (H)k1 \qquad ……..(4)$$

Here (H)k1 denotes the k1-th column of H.

Steps 1 -3 are then performed for components k2, . . , kM by operating in turn on the progression of modified received vectors r2, r3, . . . , rM. The specifics of the detection process depend on the criterion chosen to compute the nulling vectors wki , the most common of these being ZF.

The kith ZF-nulling vector is defined as the unique minimum norm vector satisfying

$$\begin{array}{lll} WkT\ i(H)kj = 0 & j \geq i & \\ \quad 1 & j = i & \text{-------}\ (5) \end{array}$$

Thus, wki is orthogonal to the subspace spanned by the contributions to ri due to those symbols not yet estimated and cancelled. It is not difficult to show that the unique vector satisfying (5) is just the kith row of Hki − 1 where the notation Hki denotes the matrix obtained by zeroing columns k1, k2, . . . , ki of H and + denotes the Moore-Penrose pseudo inverse.

III.MAC LAYER SCHEDULING

A well-designed MAC protocol can offer much help to solve the channel estimation problem. In designing such a protocol, the concurrent channel access typically found in ad hoc networks can be exploited, instead of being suppressed. Collision avoidance schemes, such as 802.11, try to avoid concurrency by blocking the nodes that receive an RTS or CTS. Instead of blocking, simultaneous transmissions have to be encouraged. It is also desirable to make the receivers aware of potential interferers, and to exploit the spatial de-multiplexing capabilities of MIMO processing. To this aim, an assessment of the receiver performance when receiving data PDUs and signaling packets has to be done.

Figure 2 shows the MIMO system with scheduler. Here priority based scheduling, Partially Fair Scheduling with and without interference cancellation is proposed. In Priority scheduling, the scheduler receives many RTS packets and schedule according to the priority namely destination oriented (D) packets and non destination oriented (ND) packets. The Performance of all kind of scheduling is analyzed in the section IV.

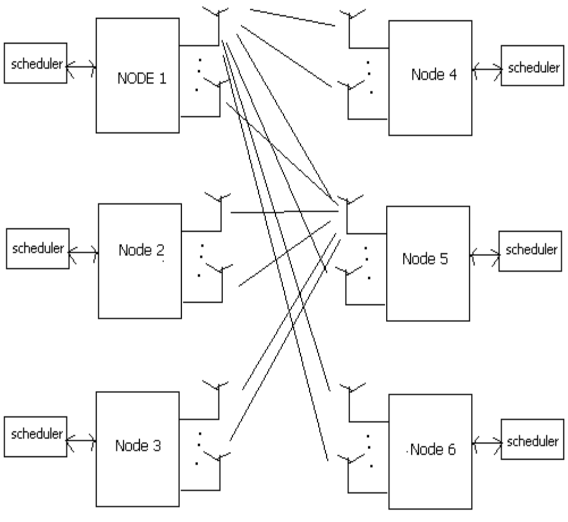

Fig2. MIMO with Scheduler

3.1 MAC Layer Design

We have framed communication structure, with four phases. For this scheme to work correctly, all nodes have to share the same frame synchronization. These phases are designed according to the standard sequence of messages in a collision avoidance mechanism, and are summarized as follows.

3.1.1 RTS phase—In this phase, all senders look into their backlog queue, and if it is not empty they compose transmission requests and pack them into a single RTS message. Each packet in the queue is split into multiple PDUs of fixed length, such that each PDU can be transmitted through one antenna. For this reason, any request has to specify the number of PDUs to be sent simultaneously, in addition to the intended destination node. Any RTS may contain several such requests. Moreover, an RTS is always sent with one antenna and at full power.

3.1.2 CTS phase—During the RTS phase, all nodes that were not transmitters themselves receive multiple simultaneous RTSs, and apply the reception algorithm as described in the previous section, to separate and decode them. In the CTS phase, when responding to the correctly received RTSs, nodes have to account for the need to both receive intended traffic (thus increasing throughput) and protect it from interfering PDUs (thus improving reliability). The constraint in this tradeoff is the maximum number of trackable channels, *i.e.*, the maximum number of training sequences a node can lock onto. CTSs are also sent out using one antenna and at full power.

3.1.3 DATA phase—All transmitters receive superimposed CTSs and, after BLAST detection, they follow CTS indications and send their PDUs. Each PDU has a fixed predefined length and is transmitted through one antenna, but a node can send multiple PDUs simultaneously, possibly to different receivers.

3.1.4 ACK phase—After detection, all receivers evaluate which PDUs have been correctly received, compose a cumulative PDU–wise ACK, and send it back to the transmitters. After this last phase, the data handshake exchange is complete, the current frame ends and the next is started. This corresponds to the implementation of a Selective Repeat Automatic Repeat reQuest (SR–ARQ) protocol, where PDUs are individually acknowledged and, if necessary, retransmitted.

Before going more deeply into CTS policy definition, it should be noted that a random back off is needed for nodes that do not receive a CTS, as otherwise persistent attempts may lead the system into deadlock. Here, a standard exponential back off is used. Accordingly, before transmitting, nodes wait for a random number of frames, uniformly distributed in the interval $[1, BW(i)]$, where i tracks the current attempt, and $BW(i) = 2i-1W$, with W a fixed back off window parameter. An accurate study of the effects of different back off strategies can be found in [12].

IV. CLASS AND MAC LAYER POLICIES

Class is a new concept that limits the maximum number of antennas that a transmitter can use while transmitting to a particular receiver. There exists a tight relationship between the number of used antennas (thus, bit rate) and the average received power, thus the maximum coverage distance affordable.

4.1 Class

The maximum number of antennas as related to the distance of a node is called the “class” of the node. For any transmitter, the total power allocated for a single instance of transmission is a constant quantity, say for example 100 W. As the number of transmit antennas increase, this power is divided equally among the same i.e. 2 transmit antennas implies 50 W through each, 4 transmit antennas implies 25 W through each and 10 transmit antennas implies 10 W through each.

Now based on the location of the receiver, it is an obvious conclusion that as the distance between the transmitter and the receiver increases, the power necessary to ensure successful reception with good signal quality, increases and hence the CLASS of the receiver with respect to that particular transmitter decreases. In order to calculate the class of different nodes with respect to each other, assuming free space propagation losses only, the free space path loss model is used to account for the power loss. By setting a minimum threshold of necessary received power for satisfactory signal quality, the maximum number of transmit antennas permissible is calculated.

In simple terms, the maximum number of antennas permissible (I) is inversely proportional to the distance between the transmitter and the receiver. Looking at a multiple receiver context as in MIMO, where the transmitter could send data to many neighbours at once, the concept of class can be a very useful tool to ensure a satisfactory amount of quality along with the maximum data rate. Together with this concept of class and a modified set of RTS and CTS policies, an increase in performance levels may be made, by making best use of the available spatial diversity due to MIMO.

4.2 MAC Layer Policies

The traditional collision avoidance approach makes use of control signals (RTS/CTS) in order to avoid collisions by ensuring only one transmission at every time slot. But when MIMO is used at the physical layer, multiple transmissions can be supported simultaneously with the use of a modified RTS and CTS policy.

4.2.1 RTS – In this RTS policy, parallelism and allow simultaneous transmissions have been encouraged. Here, RTS/CTS messages are used for traffic load estimation rather than blocking simultaneous transmissions. Since signalling packets are shorter and transmitted with a single antenna at full power, they are expected to be detectable in large quantities without significant errors.

In the modified policy, the concept of class has been integrated along with RTS messages of the traditional 802.11 to create a new RTS policy. The algorithm recursively checks the sender end queue, which holds the receiver ID, the number of PDU’s to be transmitted and the class of the receiver with respect to the particular transmitter, for each intended transmission. Based on the class of the receiver, the algorithm successively includes requests to various receivers in the same RTS packet. Each RTS packet includes as many requests for PDU’s as the minimum class of those receivers included in that packet.

Two modifications in the RTS packaging that would result in performance improvements are as follows.

1. The queue is scheduled (reordered) with all the requests with higher class at the front end, so the number of simultaneous requests is large. This ensures best utilization of the available antenna resources. This also implies that the number of RTS packets itself reduce thereby providing further power saving.
2. The FIFO queue that was assumed in the original policy could result in starvation to a particular node, if its distance from the transmitter is particularly large and hence, its class is minimum. Hence priorities may be assigned to all the neighbours of a node and in case of a node being by passed once, its priority comes into picture and has to be included in the next round of RTS packaging.

4.2.2 CTS – In collision avoidance schemes like 802.11, concurrency is avoided by blocking the nodes other than one sender and transmitter pair. In contrast to this, in the following CTS policy, simultaneous transmissions are encouraged. At the same time, the receivers should also be warned of potential interferers and should be capable of exploiting the spatial de multiplexing capabilities of the MIMO system. A receiver node can receive multiple RTS packets, each of which can contain multiple requests. Each request in turn comprises of the receiver id and the number of PDUs requested to be sent. Against this background, the receiver node first sorts all the requests contained in every correctly decoded RTS packet in the order of decreasing received power, and divides them into two subsets depending on the receiver ID mentioned in the request, namely Destination oriented ‘D’ (containing the requests meant for itself) and non Destination oriented ‘ND’ (containing all remaining requests). If a request by node x implies the transmission of, say, y PDUs, the receiver has to account for channel estimation resources that will be needed for all the y PDU transmissions. Since the maximum number of simultaneous PDUs that can be tracked by a receive antenna is limited to, say, $N_s$max, each time a transmission is granted, the number of available tracking resources is decreased by y. This is done until there are no more resources left. This process of granting resources involves a tradeoff between the number of simultaneous transmissions that it allows to itself and the amount of interference from transmission by other nodes that it cancels. There are four different CTS policies here:

- ***Priority Scheduling Without Interference Cancellation* (PS-WIC):**

Do the following steps till end of D.

- Read source S_i and number of PDUs P_i for the packet with index i
- Insert grant (S_i,P_i) in the CTS.
- $N_s=N_s-P_i$
- If for any i, $N_s<P_i$, allot N_s-P_i PDUs for the particular request.
- If $N_s=0$, STOP

- ***Partially Fairness Scheduling*(PFS):**

Do the following steps till $N_s=0$

- i=D(1). (Insert the first request in the destination oriented list in the CTS)
- Read source S_i and number of PDUs P_i for the packet with index i
- Insert grant (S_i,P_i) in the CTS.
- $N_s=N_s-P_i$
- queue=queue-i
- Let k be the request with highest power in the queue € D ND ND
- If k€D then
  - Insert grant (S_i,P_i) in the CTS.
  - Else store in interference cancellation list
    Endif
- Stop
- Using resources allotted accept incoming packets and cancel interference from other exchanges.
-

- ***Priority Scheduling* (PS):**

Do the following steps till $N_s=0$

- Start with request in D
- Read source S_i and number of PDUs P_i for the packet with index i.
- Insert grant (S_i,P_i) in the CTS.
- $N_s=N_s-P_i$
- If for any i, $N_s<P_i$, allot N_s-P_i PDUs for the particular request.
- After all the requests in D are exhausted, if $N_s>0$, Do the following steps for ND
- Read S_i of the non destination oriented request and the number of PDUs P_i.
- If $P_i<N_s$, add (S_i,P_i) to interference cancellation list
- $N_s=N_s-P_i$
- Stop
- Using resources allotted accept incoming packets and cancel interference from other exchanges

- ***Partially Fairness Scheduling Without Interference Cancellation* (PFS-WIC):**

Do the following steps till $N_s=0$

- i=D(1). (Insert the first request in the destination oriented list in the CTS)
- Read source S_i and number of PDUs P_i for the packet with index i
- Insert grant (S_i,P_i) in the CTS.
- $N_s=N_s-P_i$
- queue=queue-i
- Let k be the request with highest power in the queue € D Ủ ND
- If k€D then
  - Insert grant (S_i,P_i) in the CTS.
  - Else store in interference cancellation list
  - Endif
- Stop
- Using resources allotted accept incoming packets.

In real time networks, only Partially Fairness Scheduling (PFS) and Priority Scheduling (PS) are practical for use, since the other two do not provide any interference cancellation. Between PFS and PS, choice is made depending on which of the two performance parameters, SNR and throughput, is critical to the network under consideration.

V. SIMULATION RESULTS AND DISCUSSIONS

In order to evaluate the performance of these RTS/CTS policies specifically designed for MIMO-VBLAST physical layer, 4 nodes, each with 10 antennas, are deployed. The 4 nodes are assigned varying coordinates, thereby simulating a mobile topology. The assumption made is that condition of frame synchronization holds throughout the simulation. Traffic is generated according to a Poisson process at the rate of Λ packets per second per node. Each generated packet has ‘k’ 1000-bit long PDUs, where ‘k’ is a whole number. This specific configuration is tested because; all nodes are within coverage range of each other. This is a demanding scenario in terms of interference, required resources and efficient protocol design. All the simulations have been made using MATLAB codes. Transmissions follow the MAC protocol, as described in the previous section.

5.1 MIMO Performance

A comparison is made between the capacity of a Single Input Single Output and Multiple Input Multiple Output systems for specific Eb/No values. Capacity is measured in bits per second per hertz (bps/Hz) of the given frequency and Eb/No is measured in Decibels (dB). From figure 3, it is observed that the capacity of the MIMO system is higher than the SISO system for every value of Eb/No. Shannon’s capacity theorem is used for the capacity calculation. Thus, performance of MIMO is found to be much better than the performance of SISO for every value of Eb/No. In fact, the capacity increases ‘N’ fold for MIMO, where ‘N’ is related to the number of transmitting and receiving antenna.

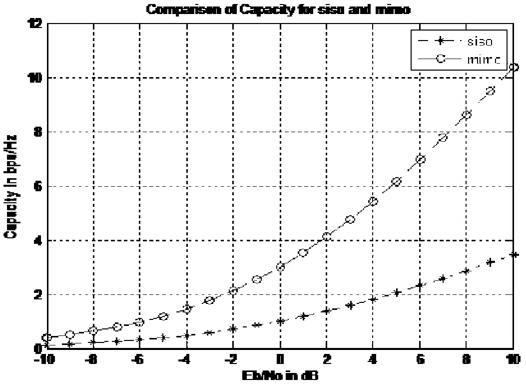

Figure 3: MIMO performance

5.2 V-Blast Performance

To simulate the performance of the BLAST physical layer, V-BLAST algorithm with optimal ordering has been used for a codebook of a specified length. Optimal ordering of received signals in the descending order of power ensures that signal decoding is of better quality. In this paper, the spatial multiplexing technique has been implemented using V-BLAST in the physical layer.

5.2.1 Transmitter Diversity -- Figure 4 shows an insight into the performance of the system. Here, the Bit Error Rate (BER) vs. SNR values has been plotted for a system having 12 receivers and varying number of transmitters. It can be seen that for the same value of SNR, in every case, the system with fewer antennas is found to have a better BER performance i.e. have a lesser Bit Error Rate than systems with more number of transmitters. This is because as the number of transmitters increase, there is more interference caused at the receiver side due to other unwanted transmissions (transmissions not addressed for the receiver).This causes degradation in the performance, as shown in the graph.

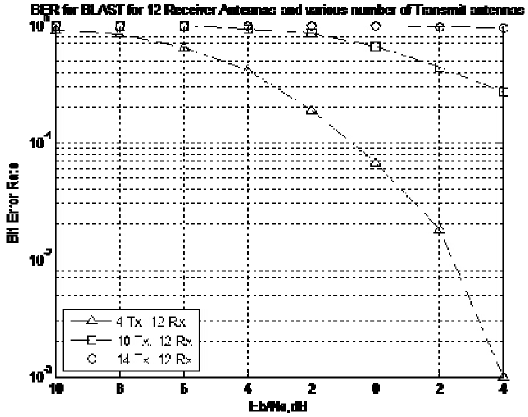

Figure 4: Transmitter diversity

To combat this degradation in performance the concept of CLASS has already been mentioned in this paper. This specifies the optimal number of transmitter antennas to be used for a specific distance between the transmitter and receiver. In mobile wireless networks, where the distances of the nodes keep varying with respect to each other, it is not advisable to use a fixed number of transmitter antennas for all distances. A brief discussion of CLASS follows next.

5.2.2 Class -- To do the classification, a topology consisting of a number of transmitters at varying distances from the receiver has been considered. The graph of figure 5 specifies the maximum number of antennas a transmitter can use when it is at a particular distance from the receiver. This number (number of transmit antennas to be used) classifies the transmitter into its respective CLASS. This classification is based on the power levels of the received packets. When transmit diversity is employed, the total power level at the node is divided equally among all the transmit antennas to be used for the transmission. Thus power of every PDU (each antenna transmits one PDU per transmission) decreases in accordance to this division. The channel employed here is a multipath Rayleigh fading channel. Power allotted to each transmit antenna should be sufficient to withstand the fading caused by the channel. Each receiver has a threshold power level for decoding. If a packet arrives with a power level below the threshold it cannot be detected.

In the figure 5, below, it can be seen that, when the distance is very high the number of transmitter antennas used is very less. This is because the packet has to travel a long distance and thus requires a lot of power to withstand the fading and attenuation losses. For the maximum distance, literally, only one antenna is used. For distances above this maximum distance, multi-hop transmission is employed. The number increases exponentially with decrease in distance and it is observed that the maximum number of antennas is used for shorter distances.

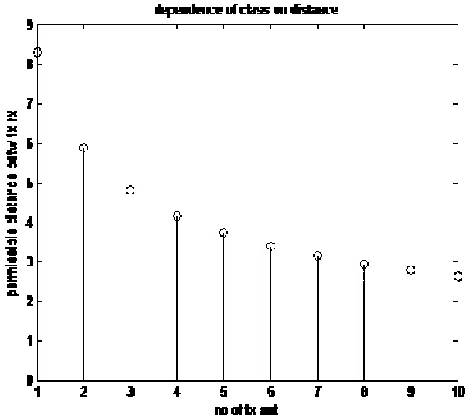

Figure 5: Class vs. Distance

5.2.3 Receiver Diversity – Contrary to the previous case of transmitter diversity, performance increases in the case of receiver diversity. Figure 6 is a clear proof of this statement. Here the cases of 8 transmit antennas for varying number of receiver antennas is compared.

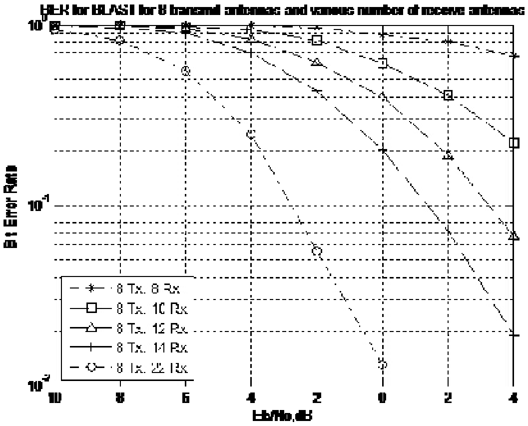

Figure 6: Receiver diversity

It is seen that the best Bit Error Rate performance is for the receiver having 22 antennas. This is because with increase in the number of receivers more paths exist from each transmitter antenna and each path exhibits varied levels of fading. This indicates possibilities of channels with lesser levels of fading. In every case it can be seen BER decreases with increasing values of SNR. However, for each value of SNR the node with 22 antennas has the least value of BER. Thus, robustness increases with receiver diversity.

5.3 Performance Comparisons

The primary comparison among the policies is based on data rates, which in turn is dependent on the number of grants allotted for the wanted PDUs. The packet arrival rate is varied each time, and the corresponding data rate is noted. As seen in figure 7, in every case, i.e. for any packet arrival rate, the data rate of Priority Scheduling (PS) is greater than Partially Fairness Scheduling (PFS). This is because PS prioritizes allotting resources (for the destination oriented packets) to interference cancellation. Thus, data rate is higher in PFS scheme.

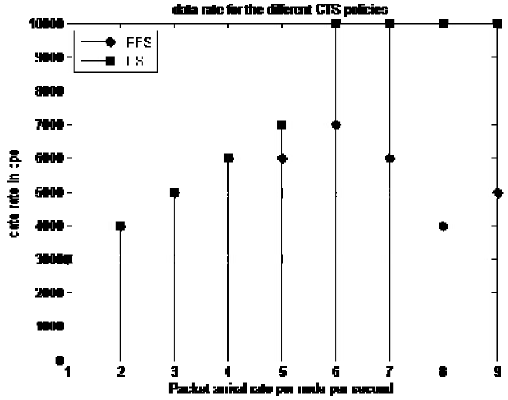

Figure 7: Comparison of Data Rates between PFS and PS

The plot for Priority Scheduling without Interference Cancellation (PS-WIC) and Partially Fairness Scheduling without Interference Cancellation (PFS-WIC): are not shown here, because their grants are similar to PS and PFS, respectively. Thus, it is sufficient to compare the latter two schemes. The next parameter for comparison is the amount of interference cancelled by the two schemes. From figure 8, it can be seen that PFS outperforms PS for almost every Λ value. This is just the inverse of the previous graph, as the total resources are divided between these two activities of accepting data and cancelling interference from other parallel transmissions. For the initial values, both PFS and PS seem to show the same performance in case of interference cancellation because the number of arriving packets themselves is very less.

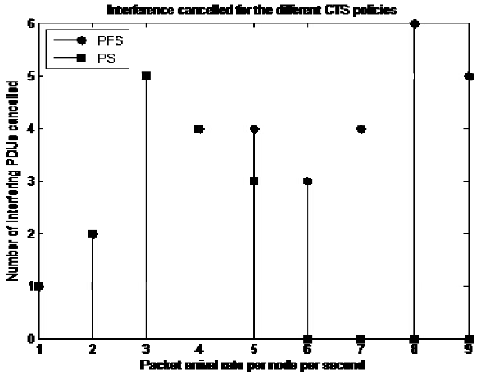

Figure 8: Comparison of interference cancellation for PFS and PS

As the number of packets arriving increases PS has only enough resources to grant for the wanted packets. Thus it can be seen for higher values of Λ interference cancellation for PS is zero.

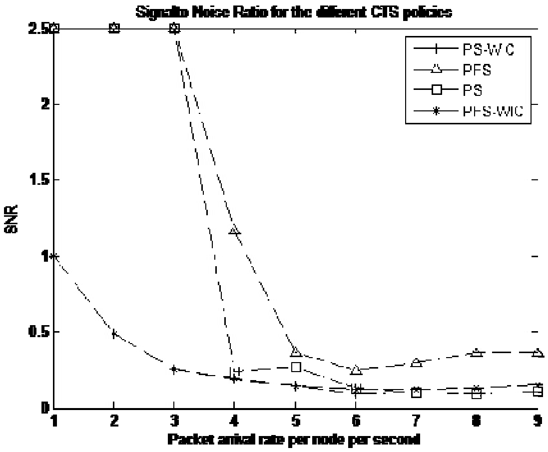

Figure9: SNR for various CTS policies

Another very important way of interpreting the above two graphs is by comparing the SNR performance of the schemes. The interference cancelled and the grants given actually have a direct implication on the SNR at the receiver.

From figure 9, it can be seen that the SNR performance of PFS is the best followed by PS. In PFS, major portion of the resources are allotted for interference cancellation. Hence, noise caused due to other interfering packets is less, and SNR is higher. In PS, the resources are given preferably to the wanted packets. Interference cancellation plays second fiddle here, a direct consequence of which is seen in the graph above. However, as the number of packets arriving increases, there is a decrease in the SNR in both the schemes due to limited availability of resources. In every case, PS-WIC is found to have the least performance. As the arrival rate becomes higher, it can be seen that PFS-WIC performs slightly better than PS. This can be explained as follows: At high arrival rates, PS exhausts all its resources towards allocation to the wanted set and hence may not be left with any resources for interference cancellation. PFS-WIC, too, by itself does not perform any interference cancellation. However, the above mentioned performance degradation in PS can be attributed to the fact that PS could allocate resources to requests of very low power levels which have low immunity to noise. However PFS-WIC, following PFS, allocates resources only for packets with sufficient power. Thus, SNR performance of PFS-WIC is better than PS at high arrival rates.

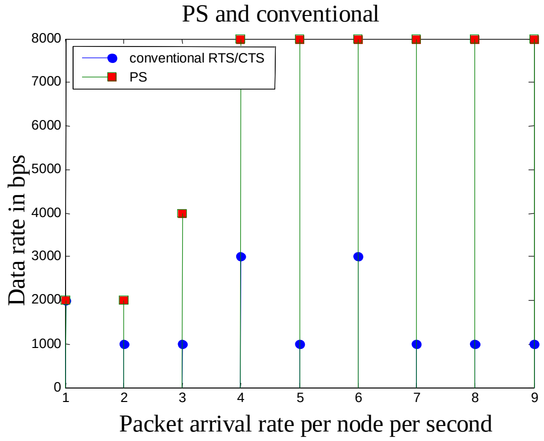

Figure 10: Data rate comparison of conventional and PS

Next, the importance of the RTS/CTS schemes, so far explained, is highlighted. This is done by making a comparison of data rates between our scheme and the conventional 802.11 collision avoidance scheme.

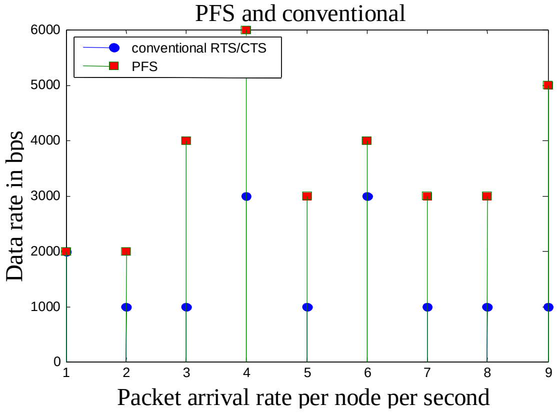

Figure 11: Data rate comparison of conventional and PFS

In the conventional collision avoidance system, simultaneous transmissions are not allowed, and the MIMO wireless channel is reserved for one request at a time. This limits the data rate. However, in the improved RTS/CTS policy, simultaneous transmissions from different senders are encouraged by providing for interference cancellation, thereby improving the data rate per receiver. In both figures 10 and 11, (comparison of PFS and the conventional policy, and comparison of PS and conventional policy), the improved RTS/CTS policy is found to give a better data rate than conventional policies. However the performance improvement in PS is found to be more than in PFS.

VI. CONCLUSIONS AND FUTURE WORK

In this work, the advantages of Multiple Input Multiple Output (MIMO) over Single Input Single Output (SISO) have first been addressed. The performance of the V BLAST physical layer (with optimal power ordering) has also been studied. The cross layer policies to drive traffic requests and grants have been considered, with the aim of designing an efficient way to let multiple point-to-point links coexist while keeping interference under control. Simulations of MAC policies in a demanding mobile network scenario with all nodes within the coverage of each other have been carried out. These results have been used to highlight the key features that yield the best performance in terms of throughput and signal to noise ratio.

Future work on this topic includes a study on the impact of channel estimation at the transmitter on the overall performance, and the extension to multihop topologies and routing issues.

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