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Threshold Based Multiuser Switched Diversity Scheduling Schemes

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Abstract—

Multiuser switched-diversity scheduling schemes were recently proposed in order to overcome the heavy feedback requirements of conventional opportunistic scheduling schemes by applying a threshold-based, distributed, and ordered scheduling mechanism. The main idea behind these schemes is that slight reduction in the prospected multiuser diversity gains is an acceptable trade-off for great savings in terms of required channel-state-information feedback messages. In this project work, we characterize the achievable rate region of multiuser switched diversity systems and compare it with the rate region of full feedback multiuser diversity systems. We propose also a novel proportional fair multiuser switched-based scheduling scheme and we demonstrate that it can be optimized using a practical and distributed method to obtain the feedback thresholds. We finally demonstrate by numerical examples that switched-diversity scheduling schemes operate within 0.3 bits/sec/Hz from the ultimate network capacity of full feedback systems in Rayleigh fading conditions.

Keywords— Opportunistic scheduling reduced feedback, multiuser-switched diversity, achievable rate region, proportional fairness.

I. INTRODUCTION

We can classify the solutions for the multiuser case into two main approaches:

- Compression of the CSI messages by using quantization methods or source coding techniques to exploit the channel correlation across the air-link resource units, and
- Reduction of the feedback load by selectively choosing when to acquire a CSI feedback message based on its likelihood to be useful in obtaining MUD gains. The latter approach is generally more effective in reducing the feedback load significantly and it is less complex to implement.

Under the theme of reduced-feedback opportunistic scheduling, Holter et al proposed the multiuser "switched diversity" (MUSwiD) scheduling scheme. The basic principle in MUSwiD scheduling schemes is to find any acceptable user (i.e. having good channel condition) instead of finding the best user among all. The term "multiuser switched diversity" was suggested in certain research works because the proposed scheduling scheme has a similar principle of operation to the "switch-based" antenna selection scheme used long-time ago in multiple-antenna receivers. It was suggested to use a scheduling strategy based on examining the CSI of the users sequentially instead of jointly. Once a "good-channel" user is found, the process of examining the channel conditions terminates, and that user is scheduled. The decision whether the channel condition of a specific user is acceptable or not is assessed by a predefined threshold. The state-of the- art in this field are the recent works in which fundamental concepts were suggested to enhance the performance of the MUSwiD schemes; namely the per-user thresholds and the post-user selection strategy. In this project or research work, we basically build upon the per-user threshold approach.

The operation mode (i.e. protocol) of the MUSwiD scheduling schemes is based on using a tiny- slotted feedback channel that is shared by all active users in the network. Each mini time-slot of the shared feedback channel can be used to send a 1-bit flag signal. Furthermore, each mini slot can be firmly accessed by a single user. The users are ordered into a sequence and assigned access to the mini-slots of the shared feedback channel accordingly. Per-user channel state thresholds are used. After a pilot signal is detected and a channel measurement is done, each user compares its current channel condition with respect to its associated channel threshold. A user sends a flag signal in its associated mini time-slot if it has above threshold channel condition, and all users before it in the feedback sequence have not sent flag signals. The first user to send a flag signal is the scheduled user to access the next resource unit. If the system adopts adaptive modulation and coding transmission, the selected user sends a full CSI message after the 1-bit flag signal in order for the base station to adapt the transmission rate accordingly.

The feedback in MUSwiD systems is reduced significantly into only one feedback channel per resource unit instead of per-user feedback channels due to the distributed scheduling mechanism that makes the mobile terminals participate in the scheduling process by comparing their channel condition locally against a pre-defined threshold, and sending feedback flag signals using an ordered strategy which resolves contention. Another advantage of the system is that a user sends CSI feedback only ahead of the resource units that it will be allocated instead of sending feedback for all resource units and this provides considerable savings in terms of battery life of mobile terminals. Despite the evident feedback-reduction advantage of the state-of-the-art MUSwiD schemes, there are some fundamental technical challenges that should be addressed adequately before MUSwiD schemes can lend themselves for practical implementation. In our opinion, there are mainly three technical challenges:

Fairness: Maximizing the sum capacity is not always an appropriate optimization criterion for realistic network scenarios since users usually have asymmetric channel statistics. Furthermore, in MUSwiD schemes, the users' ordering strategy gives an advantage to the users who are placed in the first positions in the feedback sequence. It becomes likely that users placed in the latter positions of the sequence may not get channel access despite having very strong channel. So, is it possible to achieve fairness in MUSwiD schemes? The current The time duration of the feedback channel is not long, and hence the MUSwiD scheduling scheme does not cause additional delay to the scheduling process. We demonstrate in this paper that we can maintain fairness without this requirement.

Centralized optimization: The optimization of the feedback thresholds in MUSwiD systems is done at the central scheduler and it requires the knowledge of the statistics (i.e. probability density functions (PDF)) of all users' channels. However, due to the CSI feedback reduction, the central scheduler will not be able to have accurate estimates of the PDFs of the users' channels. This will affect the optimality of the assigned per-user thresholds and will consequently degrade the system performance.

Capacity-feedback tradeoff: A comparison of MUSwiD schemes with full-feedback (MUSelD) opportunistic scheduling schemes is needed to evaluate how much rate do we lose due to the feedback savings. Such analysis is not provided in the available literature. In this report we provide a comprehensive study to answer the aforementioned technical challenges. Furthermore, we aim in this work to persuade that MUSwiD scheduling systems are actually attractive options for practical implementation in emerging mobile broadband communication systems. Toward this end, we take the following steps; We provide detailed discussions to enhance our understanding about the attributes of the system and how to optimize its performance. In particular, we characterize the achievable rate region of MUSwiD systems. Also, we show that the achievable rates in MUSwiD systems are comparable with selection-based systems although they are significantly more economic in terms of CSI feedback load. Furthermore, we propose a novel MUSwiD scheduling scheme that achieves the proportional fairness criterion, which is preferable for practical implementation. We show that this can be achieved by proper per-user threshold optimization based on the objective function of maximizing the sum of the logarithms of the achievable rates. We demonstrate that our proposed scheme has a special interesting feature that the solution of the corresponding optimization problem yields independent equations for each user, and hence the threshold optimization can be decentralized, which overcomes the centralized optimization challenge.

Multiuser diversity is a diversity technique using user scheduling in multiuser wireless channels where user scheduling allows the base station to select high quality channel users so as to transmit information through a relatively high quality channel in time, frequency and space domains based on the channel quality information fed back from all candidate UEs. Multiuser diversity is obtained by opportunistic user scheduling at either the transmitter or the receiver. Opportunistic user scheduling is as follows: at any given time, the transmitter selects the best user among candidate receivers according to the qualities of each channel between the transmitter and each receiver. A receiver must feedback the channel quality information to the transmitter using limited levels of resolution, in order for the transmitter to implement Multiuser diversity the notion of capacity is directly related to the QoS perceived by the users. In general, a certain bit error rate (BER) target is required, which is application specific (e.g. lop3 for voice users, and or better for data applications). The achieved BER is directly related to the level of interference in the system, which thus dictates the system capacity. It immediately follows that any improvement in the management and suppression of interference, greatly impacts the system capacity.

Numerous suboptimal approaches to multiuser detection have been proposed, to trade off performance and complexity. The most widely studied solutions can be classified into two categories: linear and nonlinear multiuser detectors. For linear multiuser receivers, a linear transformation is applied to the vector of matched filter outputs, and a new, better decoupled. Set of decision variables is produced, which can then be quantized to produce symbol decisions. The two most important linear receivers are the decorrelating detector and the linear minimum mean-square error (LMMSE) detector . Non-linear detection, also called subtractive detection, is based on estimating the interference and removing it from the signal before detection. Examples of non-linear receivers are the successive interference cancellation (SIC) and the parallel interference cancellation (PIC) receivers . This multiuser receiver classification is summarized in Fig. 7.

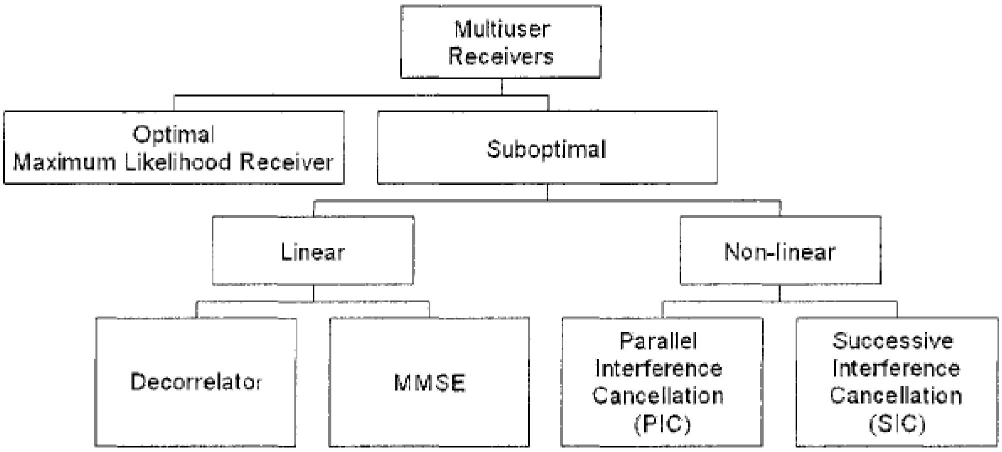


Fig 7: Classification of multiuser receiver

In the linear receiver category, the decorrelator completely eliminates the multiple access interference by orthogonalizing the users. A common characteristic of multiple access wireless communication systems is that their capacity is limited by interference. As a result, admission of a new user into such a system results in more interference to the existing users and a consequent degradation in their signal quality.

II. STATEMENT AND FORMULATION OF THE PROBLEM (PROPOSED METHOD)

- **Existing System**

This concept of Multiuser diversity scheduling or "opportunity scheduling" was originally initiated in a proposal where it was shown that in order to maximize the sum capacity (bits/sec) of the network, we should always schedule the user with the best instantaneous channel quality. In many of the research work the design of opportunistic schedulers has been further studied taking into consideration of the dominant key factors like fairness among users and maintaining the quality-of-service (QoS) constraints etc. Considering the quality of service as well as network efficiency, it can be said that a number of parameters are there which are to be optimized so as to achieve a better QoS and system performance. Majority of communication techniques employ individual air link or air resources (channel) to send the feedback signals or CSI. This causes the unnecessary use of air link and thus the system throughput is reduced. But At present there is no general theory of single or multiuser wireless feedback communication networks that can effectively minimize the number of feedback messages and thus preserving a significant amount of air link resource as well as power.

- **Drawbacks of Existing system**

Till date whatever scheduling schemes have been proposed are manly employing the "opportunistic scheduling, where the scheduling is being made in random as well as in unfair manner. On the other hand every participating node is having its own feedback channel for CSI transmission, that causes a lot of resource losses and even data loss occurs. In opportunistic scheduling scheme [88] in many cases a needy node doesn't get access to send its data or feedback when it is urgent, therefore it diminish the quality of network. When each node is transmitting it CSI regularly, it losses certain amount of energy or battery power, that causes the degradation of node's life.

- **Proposed system**

In the proposed system we provide a comprehensive study to answer the aforementioned technical challenges. Furthermore, we aim in this work to persuade that MUSwiD scheduling systems are actually attractive options for practical implementation in emerging mobile broadband communication systems. Toward this end, we take the following steps; we provide detailed discussions to enhance our understanding about the attributes of the system and how to optimize its performance. In particular, we characterize the achievable rate region of MUSwiD systems. Also, we show that the achievable rates in MUSwiD systems are comparable with selection-based systems although they are significantly more economic in terms of CSI feedback load. Furthermore, we propose a novel MUSwiD scheduling scheme that achieves the proportional fairness criterion, which is preferable for practical implementation.
We show that this can be achieved by proper per-user threshold optimization based on the objective function of maximizing the sum of the logarithms of the achievable rates. We demonstrate that our proposed scheme has a special interesting feature that the solution of the corresponding optimization problem yields independent equations for each user, and hence the threshold optimization can be decentralized, which overcomes the centralized optimization challenge.

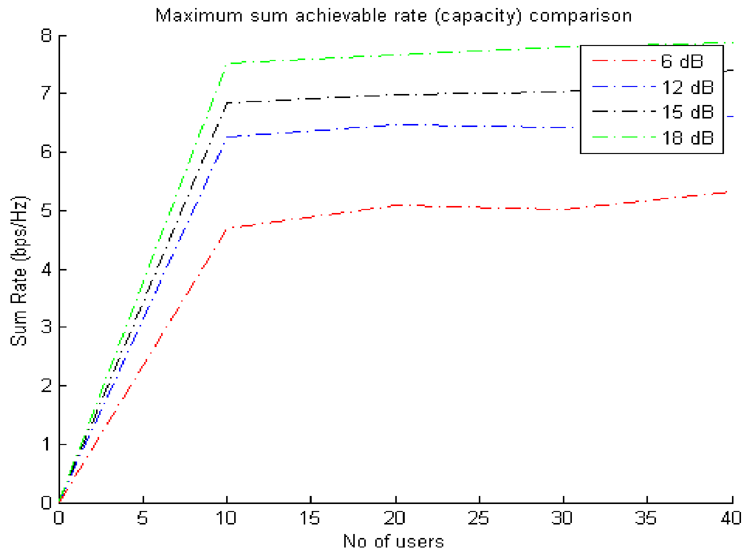
The proposed system will be efficient to

1. Saving a lot of air link resources or spectrum which can be used for further data communication
2. The proposed system is made much fast and efficient
3. The proposed system will be capable of using a single feedback channel, in spite of using individual channel for feedback
4. The proposed system will be designed for getting various outputs like graphs of fairness (fairness index) and comparison of our proposed switching based approach with selection based approach.
5. We will be obtaining comparative results for Sum capacity (channel Capacity) for both selection based scheduling approach and switching based approach, where we will be finding that our proposed system will be having better performance.
6. The graph will be generated for average sum rate and will be compared with existing system
7. Likewise we will be obtaining a graph for maximum achievable rate for our proposed system.

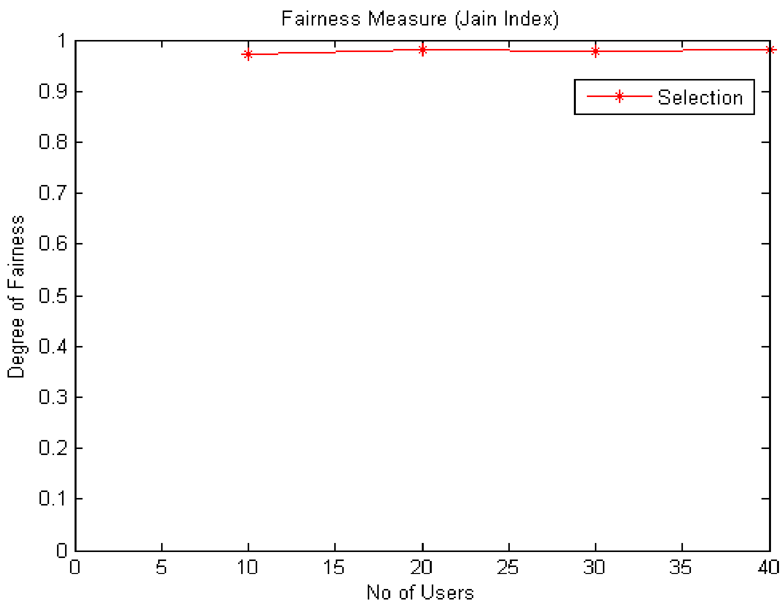
III. RESULTS

The graph will be generated for average sum rate and will be compared with existing system. The graph will be generated for maximum sum rate and will be compared with existing system. The proposed system outputs like graph of fairness (fairness index) and comparison of our proposed switching based approach with selection based approach

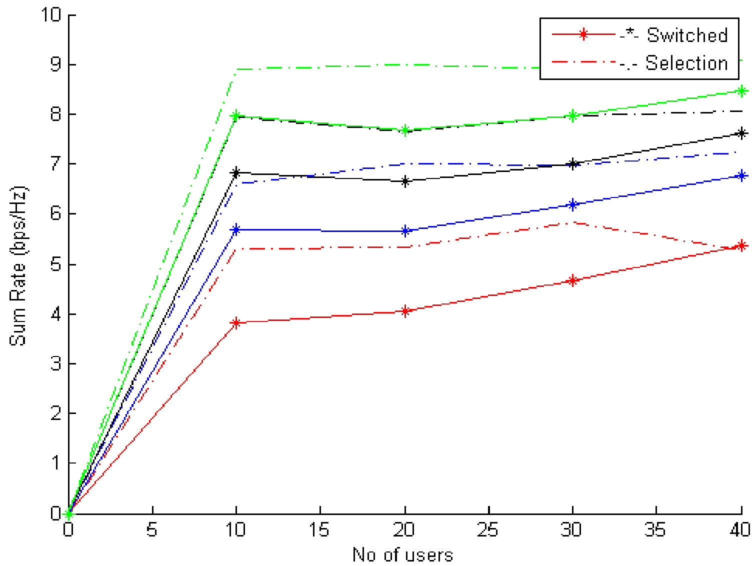
Setting 1 : (Selection Diversity system)



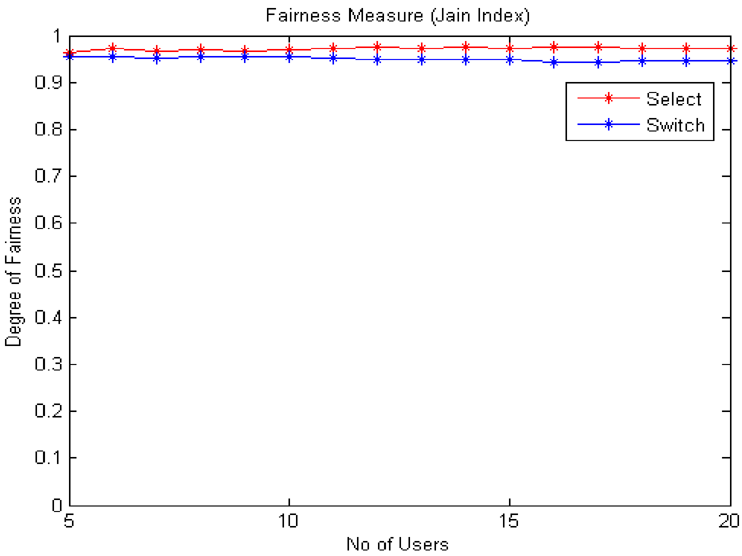
Fairness:



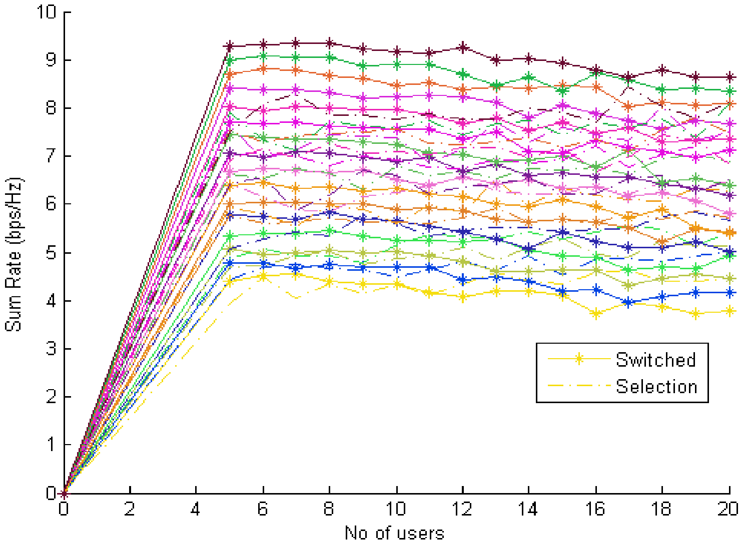
Setting 2: (Selection and Switched)



Fairness:

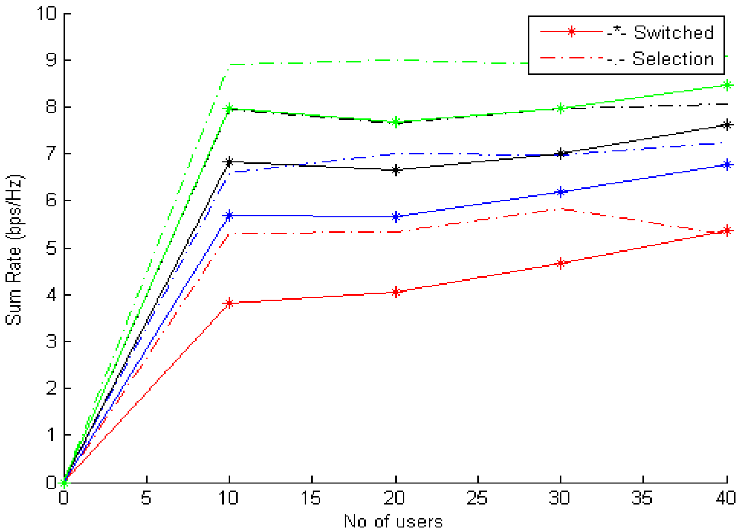


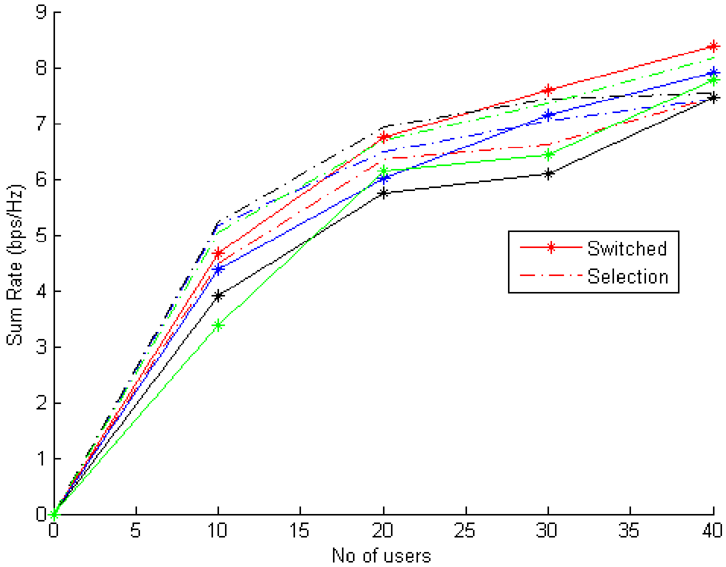
The complete results for the simulation is (for 5 to 20 users)



Comparison:

The Fairness measure as Jain index is nearly 1, in all cases of selection, switched and new switched (proposed) method indicates all the above methods are quite





From the first figure, it is clear that the Switched diversity is quite comparable to Selection diversity in terms of maximum sum achievable rate but having less value in all the cases of signal to noise ratio. But the proposed method i.e. new switched diversity outperforms selection diversity even at low value of signal to noise ratio.

IV. CONCLUSIONS

We show that the achievable rates in switched diversity systems are comparable with selection-based systems although they are significantly more economic in terms of CSI feedback load. Furthermore, we proposed a novel switched diversity-scheduling scheme that achieves the proportional fairness criterion, which is preferable for practical implementation. We show that this can be achieved by proper per-user threshold optimization based on the objective function of maximizing the sum of the logarithms of the achievable rates. We demonstrate that our proposed scheme has a special interesting feature that the solution of the corresponding optimization problem yields independent equations for each user, and hence the threshold optimization can be decentralized, which overcomes the centralized optimization challenge. The future scope of the proposed implementation lies in the fact that it needs improvement in much lower values of signal to noise ratios.

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