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Comparison Between Selection and Switching Diversity

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Abstract- *In this paper, the performance of selection diversity and switched diversity is studied .The comparison between selection diversity and switched diversity take place. Instead of relying on feedback from all the users in a multiuser communication system to identify the best user on a time-slot basis, the proposed multiuser access schemes are performed in a sequential manner, looking not for the best user but for an acceptable user. A user qualifies as an acceptable user and is selected by the base station when the reported channel quality is above a predefined switching threshold. In addition, it is argued that the proposed multiuser access schemes can be quite attractive also from a fairness perspective. In case of selection diversity authors consider schedulers with affordable-rate transmission and adaptive transmission based on the absolute signal-to-noise ratio and the normalized SNR. The conventional multiuser switched diversity scheduling scheme uses a single feedback threshold for every user.*

"1.Introduction"

Wireless channels are time varying due to the multipath fading phenomenon. Traditionally, channel fading is viewed as a destructive factor reduces communication reliability. An effective way to combat fading is to obtain multiple independent replicas of the transmitted signal at the receiver by means of diversity. In a wireless network, independent paths between a base station and individual users form a new type of diversity. Recent studies on this multiuser diversity were motivated by [1], which shows that the total uplink capacity can be maximized by picking the user with the best channel to transmit. Essentially, independent variations of channels for many users make it very likely that the communication always occurs over a strong channel. As such, the system throughput can benefit from the randomness due to the fading effect. The study of was extended to the downlink in [2], which showed that the same access scheme is also valid for the downlink case .Unlike the long-established belief that fading effects of wireless channels have a negative Impact on the system of fading and the channels can actually be used to obtain multiuser diversity and thus even help greatly improve the overall system performance in a multiuser environment when used with a proper scheduler [2]. Adding performance gain based on multiuser diversity, however, is not a simple task for schedulers especially when supporting a plethora of users, since the optimal scheduling algorithm is a function of numerous variables, such as available resources, user channel quality, user priorities, and so on.

As the number of users in the system increases, it is often a practical interest to come up with a low complexity scheduling algorithm with a reasonable system performance. In order for schedulers to make a proper user selection, users' channel quality information needs to be collected. Since the resources for a feedback channel from users to the base station are typically very limited, collecting channel quality information from potentially hundreds of users is expensive. To simplify the user selection process and reduce the number of feedbacks, each user can trigger feedback only when the channel quality is greater than the pre-determined threshold, which is termed the feedback threshold [3]. The idea behind the threshold-based feedback scheme is that only the users with good enough channel quality are worth being considered to be scheduled. If feedbacks are triggered in a distributed manner, where each user autonomously decides whether to transmit a feedback or not, then collisions occur when multiple users send feedbacks. Therefore, a collision resolution typically needs to follow and then the whole procedure iterates until a single user is found. On the other hand, a centralized feedback collection method organizes the users to be orthogonal when they send feedbacks, such as time division multiplexing where users are separated over time [4]. In addition, the collision-based feedback schemes may suffer from user fairness problems since the feedback threshold needs to be adjusted in order to find a single user, typically the best user, whereas the time division feedback access can re-arrange the user sequence every scheduling opportunity so that every user can have the same chance of taking the first place in user sequence over an extended period of time.

The major challenges in diversity:

1. 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.

2. 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 probability density functions 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.

3. Capacity-feedback tradeoff: A comparison of muswid schemes with full-feedback opportunistic scheduling schemes is needed to evaluate how much rate we lose due to the feedback savings.

" 2. Related work"

Chiung-Jang Chen and Li-Chun Wang ,[5] presented a paper on Unified Capacity Analysis for Wireless Systems With Joint Multiuser Scheduling and Antenna Diversity in Nakagami Fading Channels that define a cross-layer analytical framework to jointly investigate antenna diversity and multiuser scheduling under the generalized Nakagami fading channels. A narrowband multiple-channel transmission scheme with multiple transmit antennas is proposed and analyzed. The channelization is based on space–time signature matrices, which do not expand bandwidth, unlike conventional schemes such as code-division or time-division multiplexing.

Fumio Ishizaki and Gang Uk Hwang,[6] presented a paper on Queuing Delay Analysis for Packet Schedulers With or Without Multiuser Diversity Over a Fading Channel that compare the delay performance of the individual user under the scheduling algorithm exploiting multiuser diversity with that under the round-robin scheduling algorithm in order to reveal the characteristics of the scheduling algorithm exploiting multiuser diversity.

Yahya S. Al-Harthi,Ahmed H.Tewfik and Mohamed-Slim Alouini,[7] presented a paper on Multiuser Diversity with Quantized Feedback that define optimal discrete rate switch-based multiuser diversity scheduling scheme that reduces the feedback load while preserving most of the performance of opportunistic scheduling. to reduce the feedback rate, quantized values indicating the modulation level are feedback instead of the full values of the SNR.

Guocong Song, Ye Geoffrey Li, and Leonard J. Cimini,[8] presented a paper on Joint Channel and Queue Aware Scheduling for Multiuser Diversity in Wireless OFDMA Networks that define packet scheduling in an orthogonal frequency division multiple access downlink is investigated based on cross-layer design and optimization. The stability property of a scheduling policy is characterized by the stability region, which is the largest region on arrival rates for which the queueing system can be stabilized by the scheduling policy

Reza Moosavi, Jonas Eriksson, Erik G. Larsson,Niclas Wiberg, Pal Frenger, and Fredrik Gunnarsson,[9] presented a paper on Comparison of Strategies for Signaling of Scheduling Assignments in Wireless OFDMA that define the transmission of scheduling information in orthogonal frequency-division multiple access based cellular communication systems such as the Third-Generation Partnership Project long-term evolution . These systems provide efficient usage of radio resources by allowing users to be dynamically scheduled in both frequency and time.

Le-Nam Tran and Een-Kee Hong,[10] presented a paper on Multiuser Diversity for Successive Zero-Forcing Dirty Paper Coding Greedy Scheduling Algorithms and Asymptotic Performance Analysis that define Dirty paper coding scheme is the capacity achieving transmission technique in multiuser MIMO downlink channels. Multiple-input multiple-output systems have great capability of boosting the channel capacity and improving the link reliability over wireless communication channels without any increase of power or bandwidth.

"3.Conventional multiuser switched scheduling scheme"

In order to simplify user selection process, [5] proposed a switched multiuser access scheme, which extends the concept of switched diversity in multiple antennas to a multiuser scenario by analogously linking spatial diversity with multiuser diversity. The basic principle of this scheme is to find any acceptable user a user whose channel quality is higher than the pre-determined threshold instead of the best user. In this scheme, the base station probes the users one after another so only a single user has an opportunity to send a feedback at one time. In order for each user to decide whether to send a feedback or not, a single feedback threshold is used for all the users. Although selection of the feedback threshold is crucial to the performance of such systems, finding the optimal threshold is not well studied in the literature. The switched multiuser access scheme introduced in [5] is an extension of the multibranch switch-and-examine diversity combining scheme to multiuser scenarios. During the guard period of each time-slot, the scheduler performs a sequential search over users. Each user compares its channel quality with the pre-determined feedback threshold, denoted by γs, and sends a feedback containing if its channel quality is higher than the threshold. This process continues until either a user with a higher channel quality than the threshold is found or all the users are examined but no user has a higher channel quality than the feedback. In the latter case, which is called a scheduling outage, the scheduler selects the last examined user for the subsequent data transmission. The optimal feedback threshold, denoted by γ^*, is a function of the total number of users involved in the user selection process and the average channel SNRs of those users. The capacity of the conventional switched multiuser access scheme is written as $\mathcal{C}c = \mathcal{B}\int \infty 0 \log(1 + x) f\gamma(x)dx$, [Bit/sec/Hz] (1) where $\mathcal{B}$ is the system bandwidth, $\log(\cdot)$ is the logarithm function with base 2, and $f\gamma(\cdot)$ is the probability density function of output SNR . Unlike the conventional scheme, the proposed scheme uses a sequence of feedback thresholds, where the kth user compares its channel quality with the kth feedback threshold in the sequence, which is denoted by γsk. Suppose the users are arranged in a certain order. Assuming SEC-based multiuser switched scheduling scheme is used, a brief description for the mode of operation is given as follows. The first user compares its channel quality with γs. If the channel quality is higher than γs, the first user sends a feedback. Otherwise, the first user keeps silent and the second user compares its channel quality against its own feedback threshold γs .Again, if the channel quality of the second user exceeds γs, the second user sends a feedback and otherwise the third user will get a chance. As soon as the scheduler detects a feedback from any user, it immediately selects the user who sent the feedback for the subsequent data transmission or reception and the whole user selection process ends. This process continues until either a user with a higher channel quality than its corresponding feedback threshold is found or all the users are examined. The kth user always compares its channel quality with its corresponding threshold γsk, which is potentially different from the thresholds for other users. If all the users fail to exceed their feedback thresholds, then the last examined user is selected for simplicity. Therefore, the threshold for the last user is not required. If the feedback threshold stays constant for all the users $\gamma s = \cdots = \gamma sM{-}1 = \gamma s$, then the proposed scheme becomes identical to the conventional scheme described in the previous section. The proposed scheme, therefore, is a generalized form of switched multiuser access schemes.

“4.Conventional multiuser selection scheduling scheme”

This type of multiuser selection diversity was studied from a different perspective, namely, the Tradeoff between the system throughput and the fairness among different users. It was argued that although the selection diversity based on the “best channel” criterion maximizes the system. Throughput, it can result in an unfair scheduling of the system resources across users. Indeed, with this system, users with the strongest channels on average will end up monopolizing the resources most of the time. For this reason, proportional fair scheduling that uses a modified selection criterion based on the “relative channel strength” was then proposed to exploit multiuser diversity while maintaining fairness among users. The basic idea is to pick the user with the best channel compared to its own average. A variant of this scheduling algorithm was also proposed in [4] by taking into consideration the tradeoff between the multiuser diversity gain and the mobility of users. The viability of such scheduling schemes largely depends in practice on the number of active users and how fast the channel changes. While more users increase the multiuser diversity gain, the average amount of time each individual user is picked to communicate decreases. On the other hand, if the channel varies too fast, an accurate estimate of the channel strength would be difficult. However, the channel fading must be fast enough so that the average time any user accesses the channel is not too long to ensure certain fairness among all users. Clearly, a key measure to evaluate the viability of the multiuser scheduling algorithms is to determine the average channel access time based on the fading rate and the number of users [1], and this is the main motivation of this paper. The average access time and the average access rate of individual users in a multiuser environment subject to Rayleigh fading. Extension to Nakagami fading environment is straightforward. The AAT can be used for the time slot length consideration, since if the time slot is long compare to the AAT, the scheduler basically cannot track the channel variation fast enough, and the scheduling gain will be seriously reduced. On the other hand, if the time slot is too short compare to AAT, there is too much unnecessary feedback. We also introduce another quantity which is the average waiting time to indicate how long in average a user has to wait for the next access. The AWT is important for the time-out timer consideration in the upper layer protocols. The relative channel strength in [3] is defined as the ratio of the data rate each individual's channel can afford to its average throughput which is assumed to be tracked by the base station over a certain time window. In this paper, we take an alternative point of view and assume that the scheduling is based on the relative signal-to noise ratio [5], that is, each mobile user can measure its received SNR and feeds it back to the base station. The base station tracks the average SNR of each user over a time window. In each time slot, the base station chooses the user with the largest ratio of SNR to its own average SNR. Further, as argued in [4], the power constraint at the base station is usually based on the maximum power rather than the long-term average power which is typical in battery-limited applications. Therefore, we assume that the transmitting power is constant over all time slots. In order to achieve the rate adaptation to wireless fading channels while maintaining a target error performance and utilizing the channel capacity more efficiently, adaptive modulation and coding through a variation of the constellation size and coding mode has been widely adopted to improve the link spectral efficiency (*R/W* [bits/sec/Hz]). This efficiency is defined as the average transmitted data rate per unit bandwidth for a specified power constraint and target error performance [6]. Another important issue raised by multiuser diversity systems is the degree of fairness of the employed scheduling scheme. There are different ways to quantify the DOF. For example, one can take the variance of each user's throughput as a fairness indicator.. In this paper, we adopt the fairness measures developed in [7] to compare the fairness of the different scheduling algorithms for multiuser Diversity systems.

"5.Conclusion"

In this paper, we studied the performance of the multiuser selection diversity under an absolute SNR-based scheduling scheme and a normalized SNR-based scheduling scheme. Affordable-rate-transmission and adaptive-transmission schemes were considered. In order to maximize the sum capacity (bits/sec) of the network, we should always schedule the user with the best instantaneous channel quality. It was argued that although the selection diversity based on the "best channel" criterion maximizes the system throughput, it can result in an unfair scheduling of the system resources across users.

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