
Agenda Item:	11.3
Source:	STMicroelectronics
Title:	Precoding with User Scheduling in MU-MIMO for LTE-A
Document for:	Discussion

1 Introduction

This contribution aims to clarify the achievable gain of various precoding in schemes in a MU-MIMO scenario when a large pool of users is available. If the eNodeB is equipped with M antennas and if there are K single-antenna UEs in the cell then the eNodeB can spatially multiplex up to M UEs. The choice of the user set \mathcal{S} usually depends on several aspects such as fairness among users, cell throughput or higher layer interference coordination. In this evaluation we will analyse how the sum rate of different precoding techniques scales as the multi-user diversity increases. We consider unitary beamforming (UBF), constant modulus UBF, the available Rel-8 codebook based UBF (CB-UBF), zero-forcing beamforming (ZFBF) and regularized ZFBF (R-ZFBF). The performance of this schemes when no multi-user diversity is available has been studied in [1].

2 Methods

All applied precoding schemes are briefly reviewed in the following contributions [2].

3 Simulation And Results

Figure 1 shows the results without user scheduling, when the number of users $K = M$. We first consider a brute-force user selection i.e. we choose the set of users among all possible sets ($|\mathcal{S}| = M$) that maximizes the sum rate. Figure 2 shows the benefits of user selection and scheduling. The performance losses with respect to DPC decrease as K increases. This scheduling algorithm gives the upper bound in terms of achievable sum-rate when user diversity can be exploited.

In the next set of simulations we use the spatial channel model (SCM) to describe the links between eNodeB and the UEs. The simulations assumptions are summarized in Table 1. We use two different user selection schemes, a brute-force user selection and a *greedy* user selection introduced in [3]. Furthermore we consider opportunistic user scheduling (OS) i.e. the scheduling is solely based on the users instantaneous rate $R_k(t)$ and proportional fair user scheduling (PFS) where the scheduling is based on $R_k(t)/T_k(t)$ with

$$T_k(t) = (1 - \alpha)T_k(t - 1) + \alpha R_k(t) \mathcal{I}\{k\} \quad (1)$$

where $\alpha = 1/t_c$, t_c is the time window over which fairness is imposed and $\mathcal{I}\{.\}$ is the indicator function equal to one if the user k is scheduled and zero otherwise.

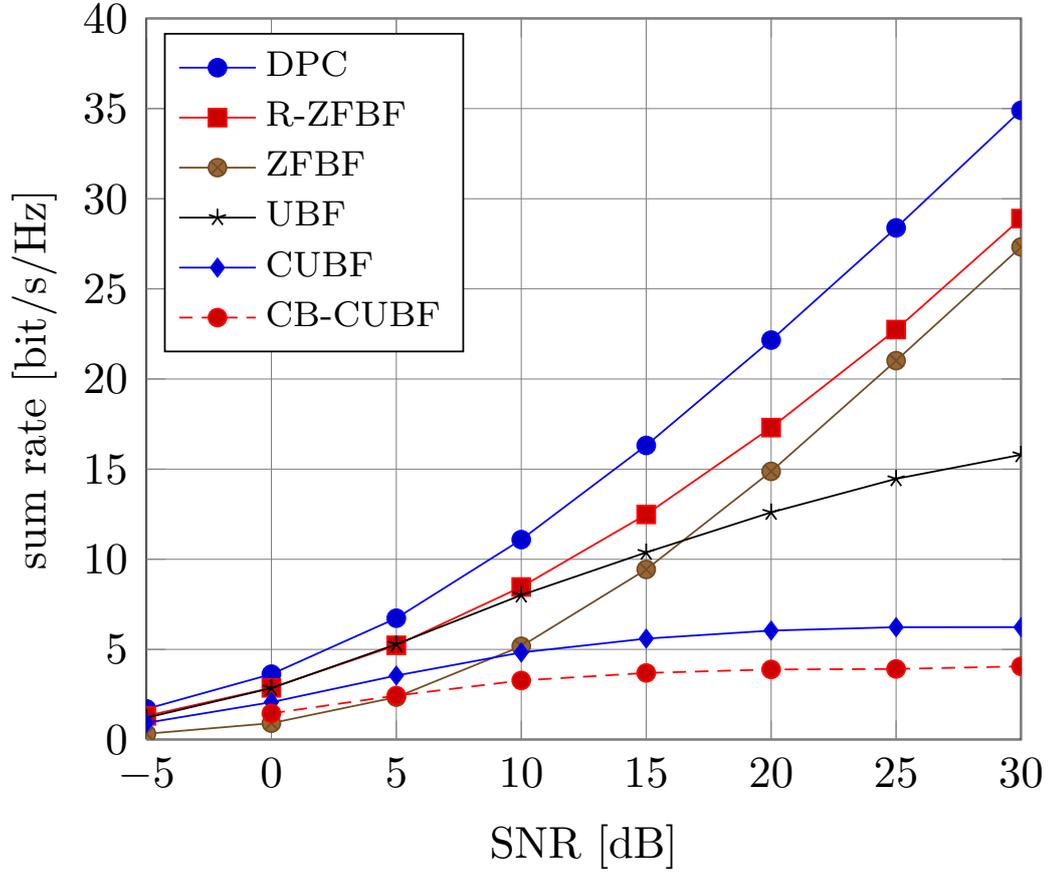


Figure 1: MU-MIMO independent Rayleigh fading channel, $1e3$ channel realizations, $K = 4$, no user scheduling.

From these Figures it can be concluded that

- Rel-8 CB-CUBF performance are poor compared to zero forcing type of algorithms, and optimized (constant modulus) unitary beamforming with and without user selection. By allowing optimization at the eNB the performance can be significantly increased. (For example at SNR of 10dB, CUBF gains $> 20\%$ of sum-rate with and without user scheduling, UBF gains $> 100\%$ with and without user selection).
- ZFBE is highly affected by user diversity, i.e at SNR of 10dB ZFBE shows a gain of 100% with respect to no user selection case. UBF gains 30-40% in terms of sum rate, CUBF gains 40 to 100% and CB-UBF 40 to 50% increase in terms of sum-rate.
- PFS and opportunistic beamforming with greedy user selection provide comparable sum-rate performance.

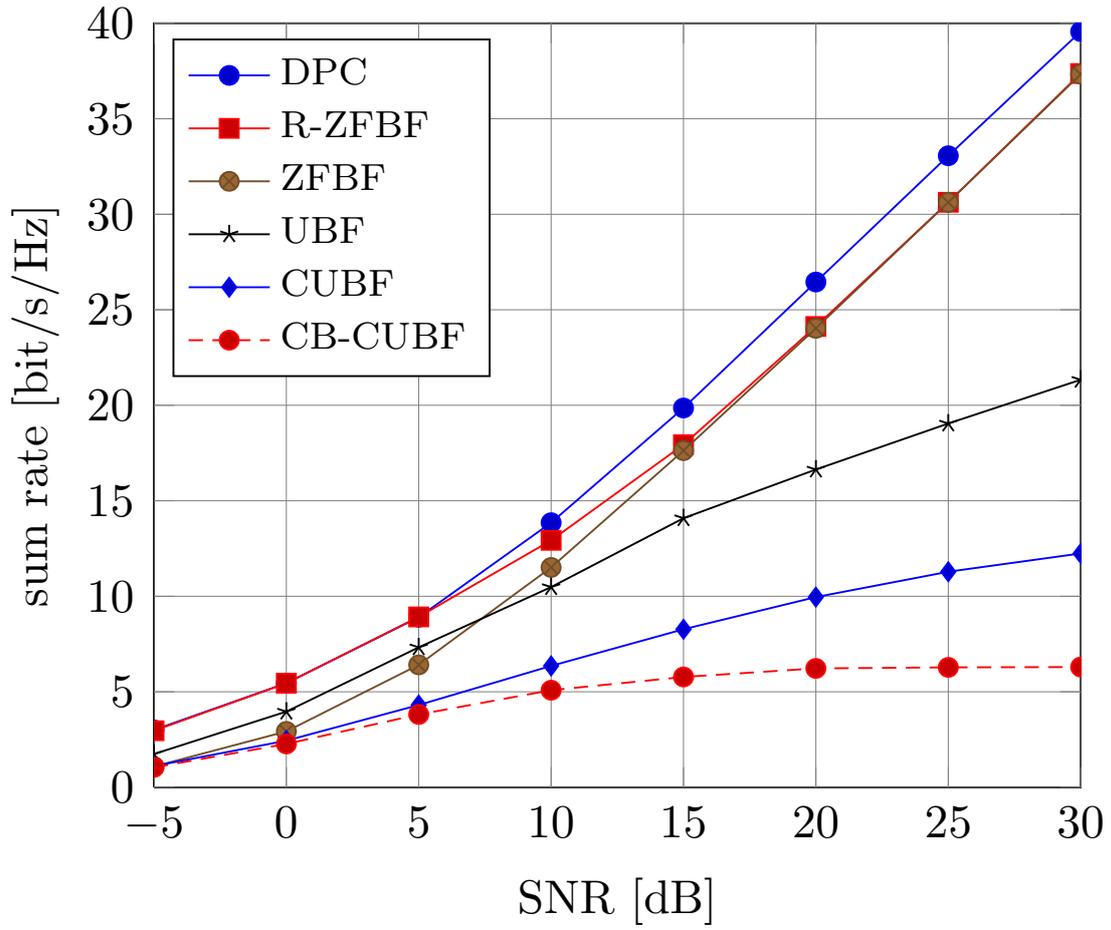


Figure 2: MU-MIMO independent Rayleigh fading channel, $1e3$ channel realizations, $K = 10$, brute-force user selection, opportunistic user scheduling

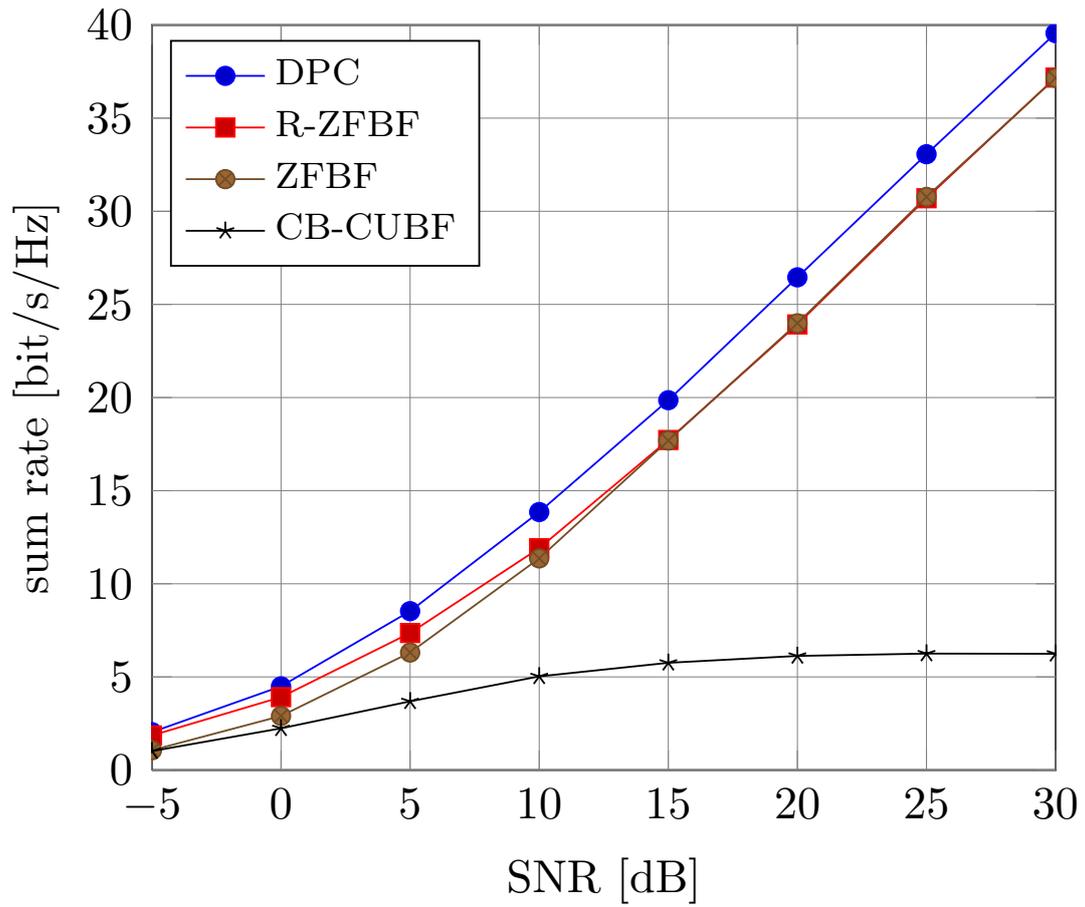


Figure 3: MU-MIMO, $M = 4$, $K = 10$, SCM, brute-force user selection, opportunistic scheduling

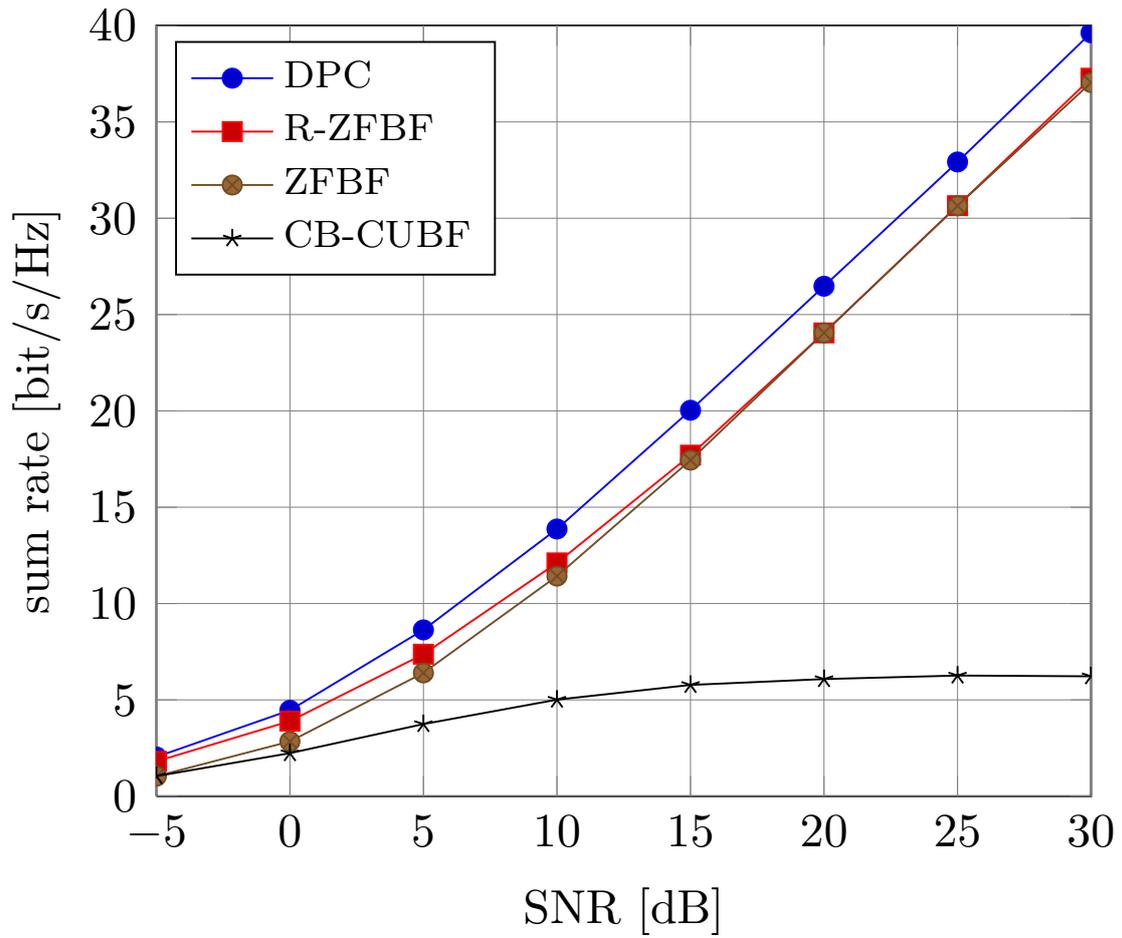


Figure 4: MU-MIMO, $M = 4$, $K = 10$, SCM, brute-force user selection, proportional fair $\alpha = 0.01$

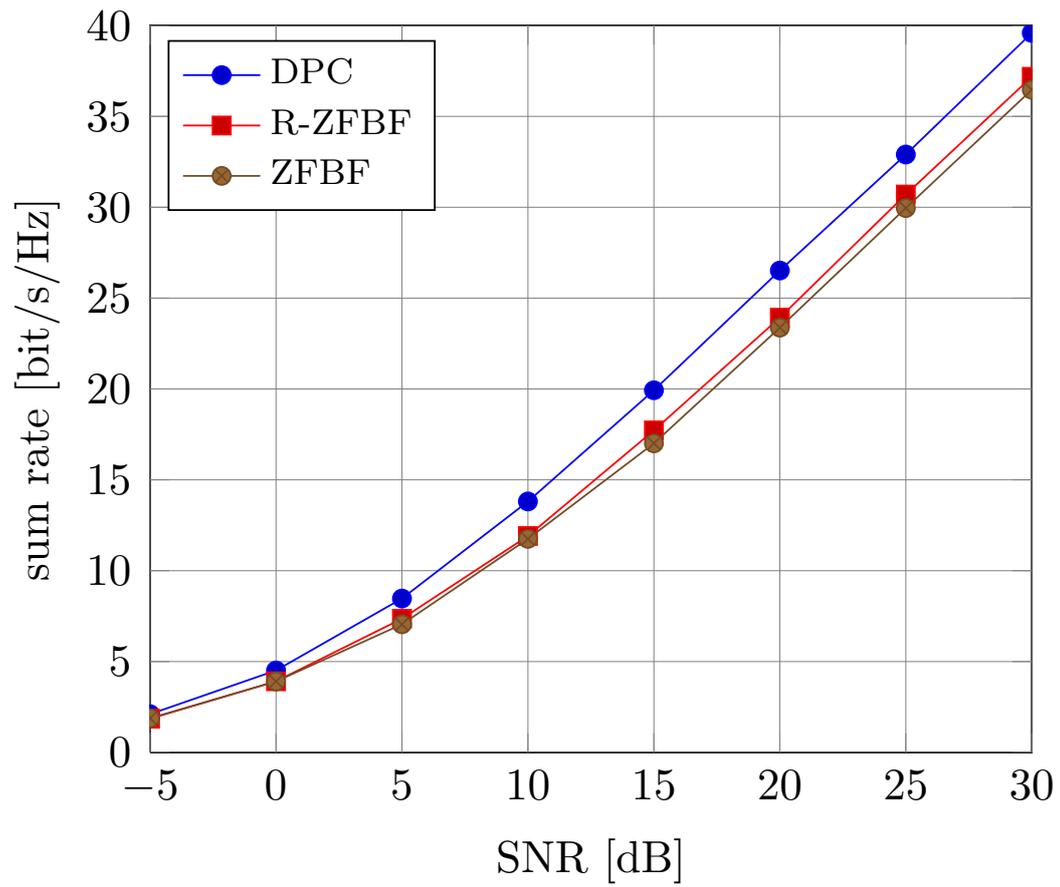


Figure 5: MU-MIMO, $M = 4$, $K = 10$, SCM, Greedy user selection, opportunistic scheduling

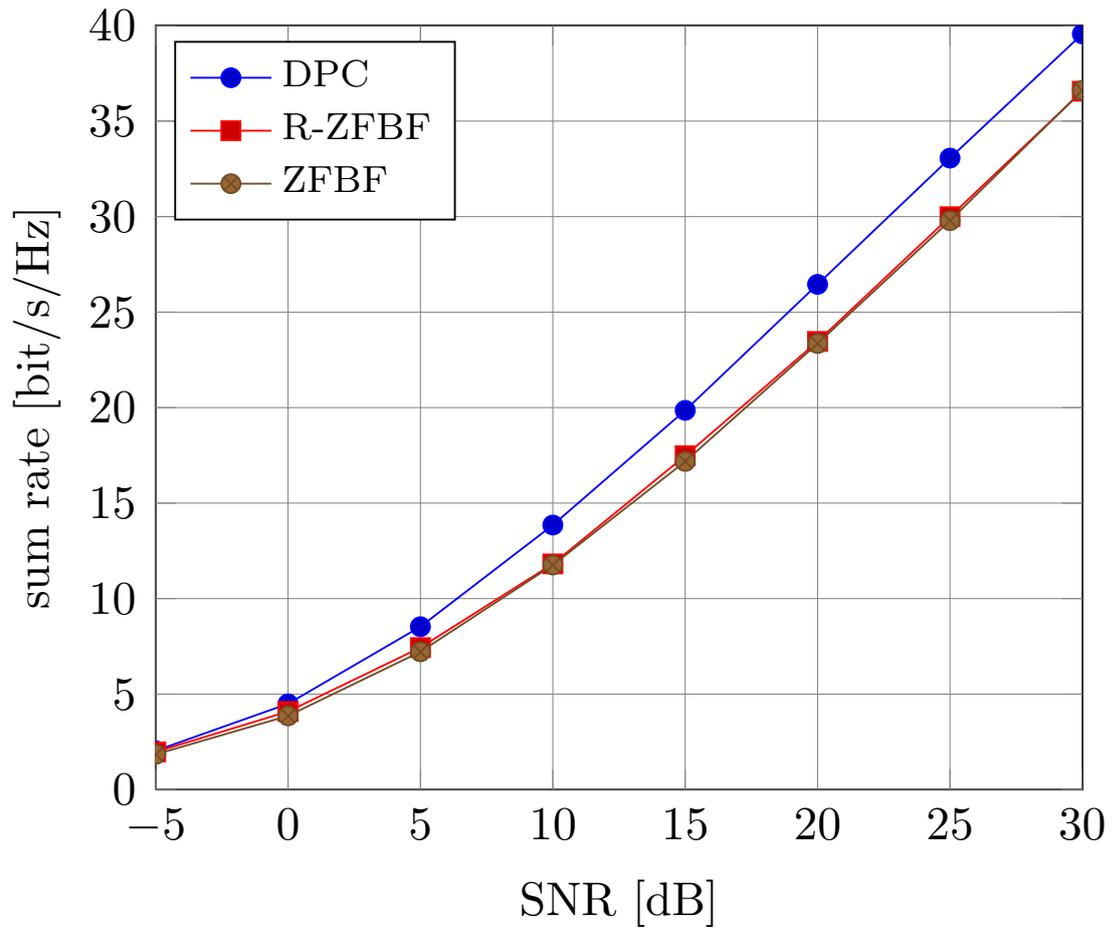


Figure 6: MU-MIMO, $M = 4$, $K = 10$, SCM, Greedy user selection proportional fair $\alpha = 0.01$

Parameter	Value(s)
Number of tx antennas	4
Number of rx antennas	1
Tx antenna spacing	10λ
Number of users	10
Terminal speed	3 km/h
Transmission bandwidth	5 MHz
Center frequency	2 GHz
DFT size	512
Channel model	Urban Micro
Number of paths	10
Subframe time	1 ms
Number of subcarries per RB	12

Table 1: Link-level Simulation Parameters

4 Conclusion

In this paper we show that performance can be highly increased in a MU-MIMO scenario when allowing for an optimized beamforming scheme at the eNodeB w.r.t codebook based precoding scheme, with or without the user selection. The gain in performance range from 20% to 100% depending on the chosen precoding scheme. Moreover, we show that the performance of the studied precoding schemes are highly affected by user diversity. These precoding schemes show gains ranging from 30 to 100% in terms of sum-rate when user diversity is available.

References

- [1] ST Microelectronics, “Unitary Beamforming for MU-MIMO With Per Antenna Power Constraint for LTE-A”, 3GPP TSG RAN WG1 Meeting #55, R1-084492.
- [2] ST Microelectronics, Philips, “Feedback and precoding techniques for MU-MIMO for LTE-A”, 3GPP TSG RAN WG1 Meeting #55, R1-084491.
- [3] Z. Tu and R.S. Blum, “Multiuser diversity for a dirty paper approach”, *IEEE Commun. Lett.*, Vol. 7 No. 8, pp. 370-372, August 2003