





consider the conventional user scheduling algorithms as references: maximum signal-to-noise ratio (*maxSNR*) and minimum interference-to-noise ratio (*minINR*) algorithms. The *maxSNR* scheduling algorithm selects the user having the maximum SNR without considering inter-cell interference, which is known to yield the optimal performance in a single cell network. The scheduling algorithm of the *maxSNR* in the  $k$ -th cell is given by

$$s_k^{\text{MaxSNR}} = \arg \max_j |h_k^{[k,j]}|^2, \quad j = 1, 2, \dots, N \quad (12)$$

The *minINR* scheduling algorithm has been known to yield a better performance than the *maxSNR* scheduling algorithm in an interference-limited cellular network. The scheduling algorithm of the *minINR* in the  $k$ -th cell is given by

$$s_k^{\text{minINR}} = \arg \min_j \left[ \sum_{i=1, i \neq k}^K |h_k^{[i,j]}|^2 \right], \quad j = 1, 2, \dots, N \quad (13)$$

Fig. 2 illustrates the SE and EE trade-off when  $K = 3$ ,  $\alpha = 0.5$ ,  $P_c = 20$  dBm, and  $N = 30, 50, 100$ , respectively. We observe that the IAPC scheduling algorithm yields a significantly improved trade-off relationship compared with the conventional algorithms. In this simulation, we assume that the optimum threshold is used for the IAPC scheduling algorithm. For given parameters, the optimal threshold is numerically determined. The trade-off becomes improved as the number of users in a cell increases for all scheduling algorithm. Fig. 3 shows the power consumption of the scheduling algorithms for achieving the spectral efficiency when  $K = 3$ ,  $\alpha = 0.5$ ,  $P_c = 20$  dBm, and  $N = 30, 50, 100$ , respectively. For each scheduling algorithm, there exists a limit of the spectral efficiency which cannot be achieved. The IAPC algorithm significantly reduces the power consumption for a given spectral efficiency. In addition, the power consumption becomes decreased as the number of users in a cell increases due to the multiuser diversity.

## V. CONCLUSION

We investigate the effect of the user scheduling and the transmit power control on the trade-off between spectral efficiency (SE) and energy efficiency (EE) in multi-cell multi-user uplink networks. Simulation results show that the user scheduling algorithm with IAPC significantly outperforms the conventional scheduling algorithms in terms of the trade-off SE and EE and the power consumption.

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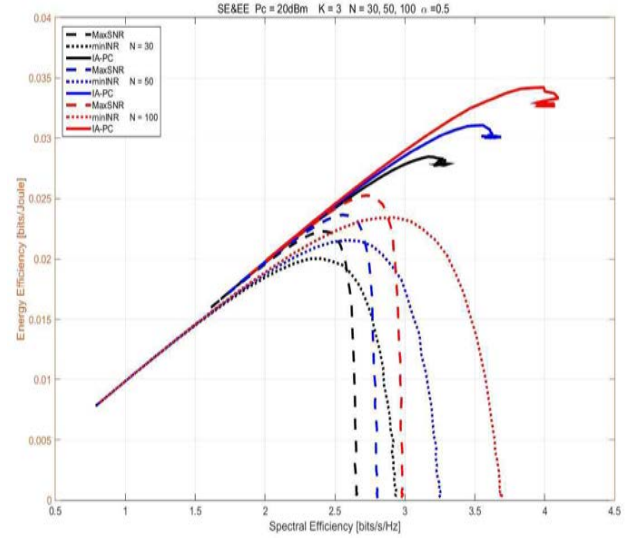


Fig. 2. Trade-off between SE and EE for varying the number of users in a cell when  $P_c=20$ dBm,  $K = 3$ , and  $\alpha = 0.5$ .

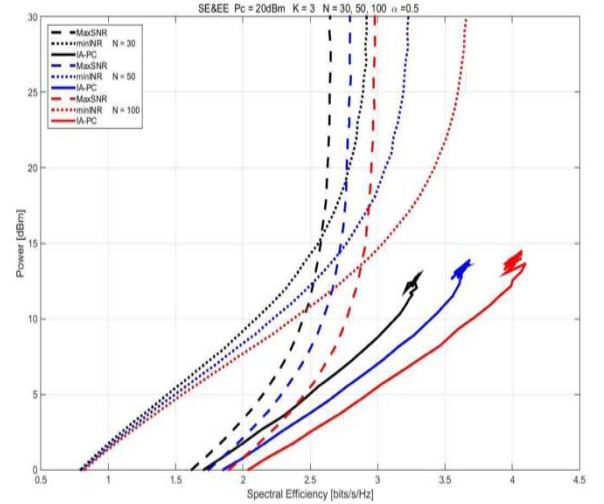
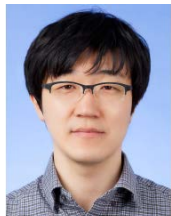


Fig. 3. Power consumption for varying the spectral efficiency with different the number of users in a cell when  $P_c=20$ dBm,  $K = 3$ , and  $\alpha = 0.5$ .

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