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• Supplementary File •

Queue-aware Energy-efficient Scheduling and Power Allocation with Feedback Reduction in Small-cell Networks

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Appendix A Performance Evaluation

Simulations are executed in an area of 1000×1000m with 4 BSs and 4 MSs, as shown in Figure A1. The initial positions of MSs are stochastic. Assume MSs move randomly as Brown motion [1]. Assume the process of data arrival is independent and identically distributed (i.i.d), and a_j follows a λ poisson distribution. Table A1 lists our simulation parameters. According to [2], energy efficiency of the system in the simulations is defined as the ratio of sum rate of all the MSs and total energy consumption. In the simulations, Rayleigh fading is considered and the path loss model in Equation (A1) is used [3].

$$L(d) = 35 + 35\log_{10}(d) \quad (dB). \tag{A1}$$

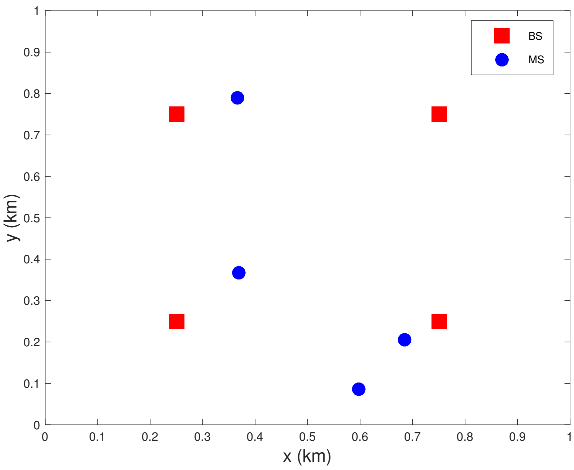

Figure A1 Scenario of Simulations ($N = 4$, $K = 4$).

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Table A1 Simulation parameters

Parameter	Explanation	Default value
p_i^m	Maximum transmitting power of BS	6dB
n_0	Spectral density of noise power	-174dBm/Hz
B	System Bandwidth	20MHz
τ	Duration of slot	2ms
σ_x	Variance of Brown motion in x-coordinate	0.004m/s
σ_y	Variance of Brown motion in y-coordinate	0.004m/s
N	Number of BSs	4
K	Number of MSs	4
λ	Mean of a_j	80Mbps
V_0	Default value of penalty factor V	0.05bit/s/watt/Hz

Appendix A.1 Simulation Results HA

In this part, the performance of HA is compared with two other algorithms:

- MaxWeight joint GAP Algorithm (MW-GAPA): In each slot, MSs transmit with full power and user scheduling can be got by solving the problem in (A2) with $V_{ij} = -Q_j r_{ij}$.

$$\begin{aligned}
\min_{s_{ij}} \quad & \sum_{i=1}^{N}\sum_{j=1}^{K} V_{ij}s_{ij} \\
\text{subject to} \quad & \sum_{i=1}^{N} s_{ij} \leqslant 1, \quad j=1,\ldots,K, \\
& \sum_{j=1}^{K} s_{ij} \leqslant 1, \quad i=1,\ldots,N, \\
& s_{ij} \in \{0,1\}, \quad i=1,\ldots,N, j=1,\ldots,K.
\end{aligned} \tag{A2}$$

- Exhaustive Search Algorithm (ESA): brute-force search is applied for the problem to find the best strategy of user assignment and power allocation.

Figure A2 compares the energy efficiency of MW-GAPA, HA and ESA. It can be seen that with different V the performance of HA is close to that of ESA, which verifies the performance of the proposed algorithm. Because inter-cell interference is considered in HA, its energy efficiency is higher than MW-GAPA. Besides, this figure also illustrates the influence of the parameter V. When $V = 5V0$, the energy efficiency is better than $V = V0$. When the traffic load rises, the energy efficiency of HA draws near to that of MW-GAPA. At this moment, both HA and MW-GAPA make the best effort to transmit with full power.

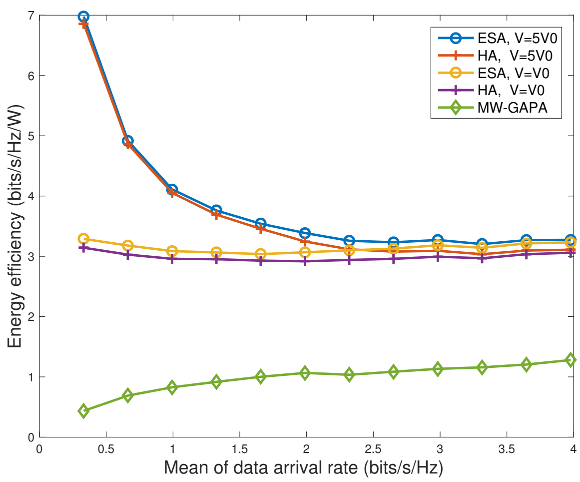

Figure A2 Energy efficiency under different traffic load.

Appendix A.2 Simulation Results for CSI Feedback Algorithm

In this part, the performance of three feedback algorithms are compared:

- LQ: A QSI-based feedback algorithm, where L_j is define as:

$$L_j = L(Q_j, Q_j^{mean}, L_{max}) = \min\left(L_{max}, \left\lfloor \frac{L_{max}Q_j}{2Q_j^{mean}} \right\rfloor\right). \tag{A3}$$

- LH: A CSI-based feedback algorithm, where CSI is used to determine the number of channel gains to be reported. In LH algorithm, L_j is defined as in (A4).

$$L_j = \min\left(L_{max}, \sum_{i}^{N} \min\left(1, \left\lfloor \frac{|h_{ij}|}{|h_{mean}|} \right\rfloor\right)\right). \tag{A4}$$

- LQH: A feedback algorithm based on QSI and CSI, which is defined in this letter.

The performance of LQH is simulated by 1000 independent trials, and each trial contains 500 slots. Figure A3 illustrates the performance of LQH when HA scheduling algorithm is applied. When the data arrival rate is small, LQ and LQH algorithms cause less feedback overhead compared to LH algorithm. Meanwhile, the sum rate, which is achieved with partial CSI by LQ and LQH feedback algorithm, is similar to that with full CSI as shown in Figure A4. When the traffic is high, MSs with LQ and LQH feedback strategy report more CSI in order to guarantee the system throughput.

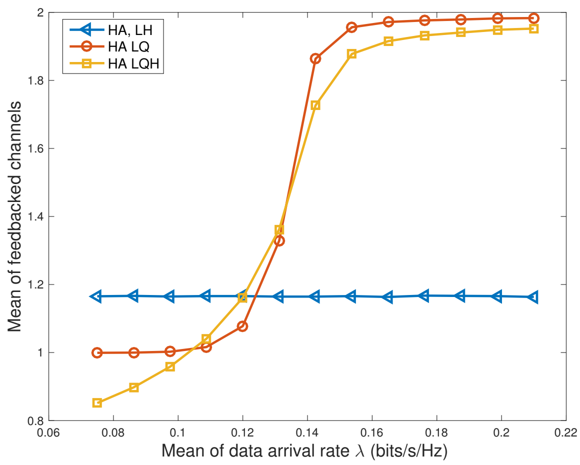

Figure A3 Performance of feedback reduction for LQ and LQH algorithm under different traffic load.

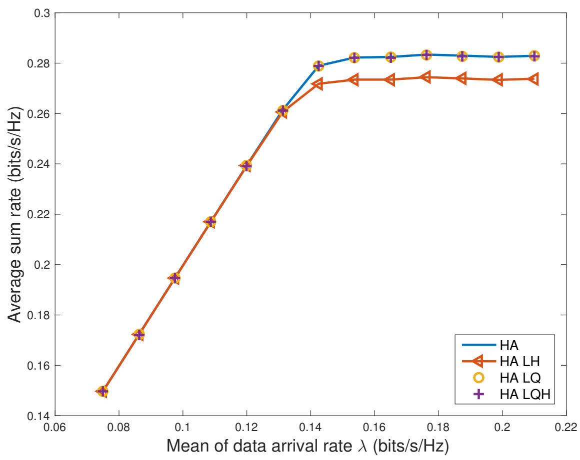

Figure A4 Performance of sum rate with partial CSI for LQ and LQH algorithm under different traffic load.

References

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