Performance of Low-Feedback-Rate, Gradient-Based OFDMA Subcarrier Allocation with Partial Channel Information

Somsak Kittipiyakul, Amnart Boonkajay, and Therdkiat Aphichartsuphapkhajorn
somsak@siit.tu.ac.th Sirindhorn International Institute of Technology, Thammasat University, Thailand

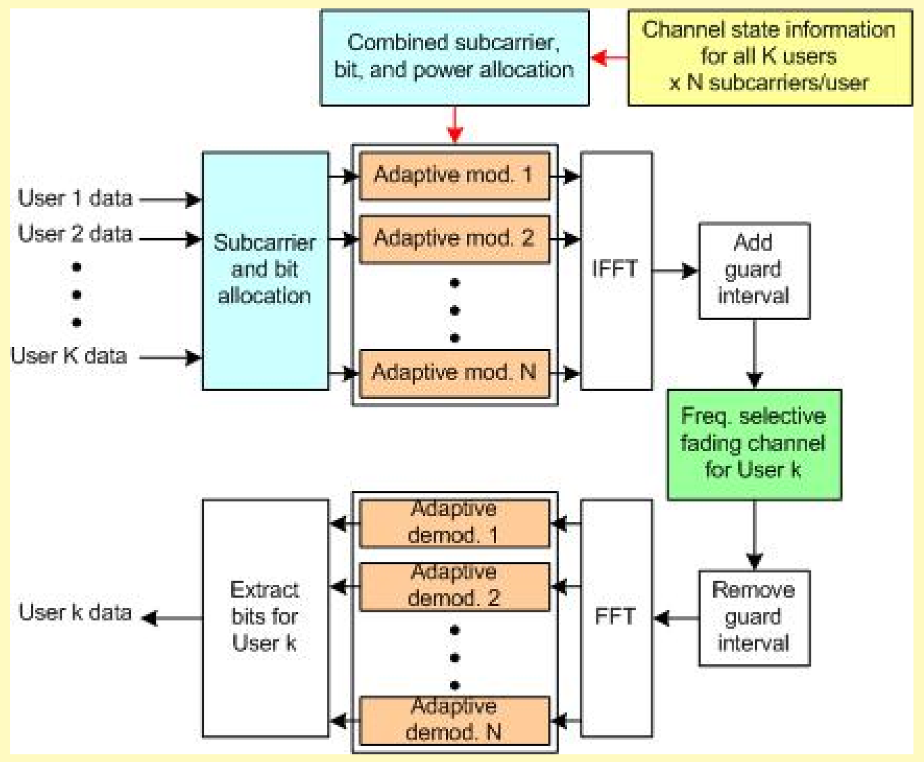
Contribution

We consider a downlink OFDMA subcarrier allocation problem where the allocation algorithms are gradient-based but only CSI for some subset of subcarriers from each user is available at the transmitter (partial channel information). We propose:

1. An iterative version of gradient-based OFDMA subcarrier allocation schedulers which performs better than the standard non-iterative gradient-based schedulers.
2. An adaptive, weighted M-Best feedback mechanism (called wM-Best) suitable for gradient-based schedulers than the standard M-Best feedback.

Simulation results show improvement of system performance, in term of average throughput and queue length (or equivalently average delay), of the iterative scheduler and also the wM-Best feedback. This confirms the intuition that feedbacks are needed for users who are likely to be allocated the resources.

OFDMA Subcarrier Allocation

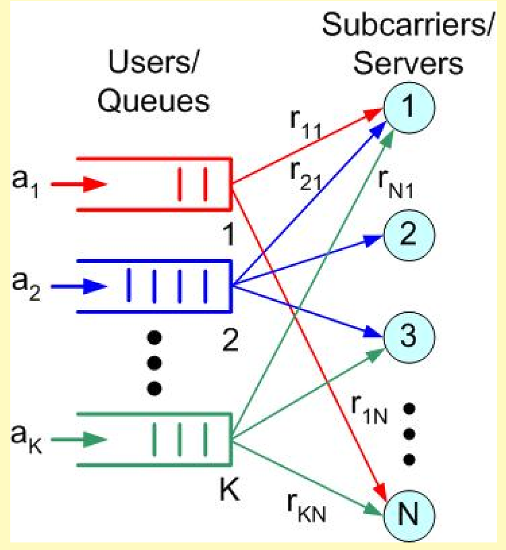


Downlink OFDMA Subcarrier Allocation Problem

N OFDM subcarriers, K homogeneous users. Block fading channels. Time-varying iid (over time and user) non-responsive arrivals. Infinite buffers. The scheduler has perfect knowledge of queue lengths but perfect knowledge of subcarriers for some users and some subcarriers. Equal power load across subcarriers.

Multi-Queue Multi-Server Scheduling

With equal-power distribution, the subcarrier allocation problem is modeled as a multi-queue multi-server scheduling problem:



Multi-queue multi-server server scheduling problem

Gradient-Based Schedulers

Let $r_i(t)$ be the total rate for user i at timeslot t, summed over all subcarriers assigned to user i. At each timeslot t, gradient-based schedulers allocate subcarriers such that the rate vector $[r_1(t), \dots, r_K(t)]$ solves

$$\max_{[r_1(t),\dots,r_K(t)]\in R_t} \sum_{i=1}^{K} \mu_i(t) r_i(t), \quad (1)$$

where the time-varying weight $\mu_i(t)$ is

$$\mu_i(t) = \begin{cases} (W_i(t))^{\alpha-1}, & \alpha \in [0,1], \\ (Q_i(t))^{\alpha-1}, & \alpha > 1, \end{cases} \quad (2)$$

$W_i(t)$ = running-average throughput of user i,
$Q_i(t)$ = queue length of user i,
α gives throughput-fairness tradeoff, e.g., $\alpha = 0$ is "Proportionally Fair" rule, $\alpha = 1$ "Max-SNR", and $\alpha = 2$ "MaxWeight".
Two types of schedulers:

1. Non-iterative: $Q_i(t)$ are not updated as carriers are being assigned. Sequential allocation: for each subcarrier j, assign to user with largest $\mu_i r_{ij}$.
2. Iterative: $Q_i(t)$ are updated as subcarriers are assigned. ← Avoid over assignments but allocation ordering becomes important.

CSI feedbacks

1. Full CSI feedback: benchmark performance
2. M-Best feedback (M-Best): Each user feeds back only its M highest channel gains.
3. Weighted M-Best feedback (wM-Best): User i report $M_i(t)$ highest channel gains where

$$M_i(t) = \left\lceil \frac{\mu_i(t)}{\sum_{k=1}^{K} \mu_k(t)} KM \right\rceil. \quad (3)$$

References

[1] J. Huang, V. Subramanian, R. Agrawal, and R. Berry, "Downlink scheduling and resource allocation for OFDM systems," *IEEE Trans. Wireless Commun.*, vol. 8, no. 1, pp. 288–296, 2009.

[2] Y. Kim and J. Kim, "An efficient subcarrier allocation scheme for capacity enhancement in multiuser OFDM systems," in *VTC Spring 2008*, 2008, pp. 1915–1919.

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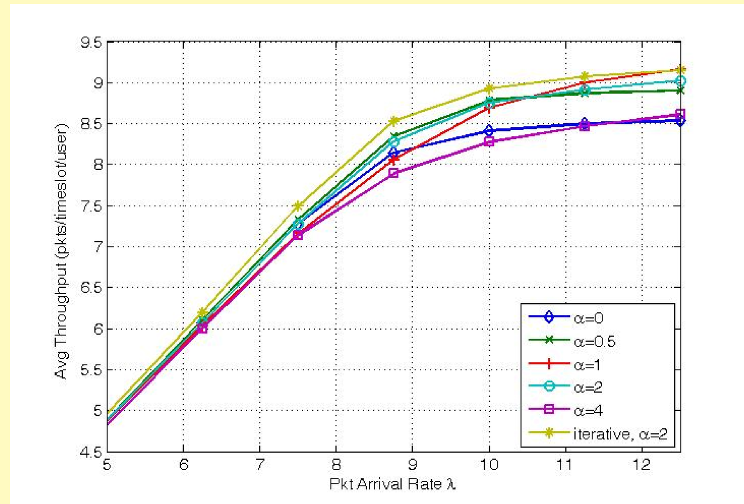
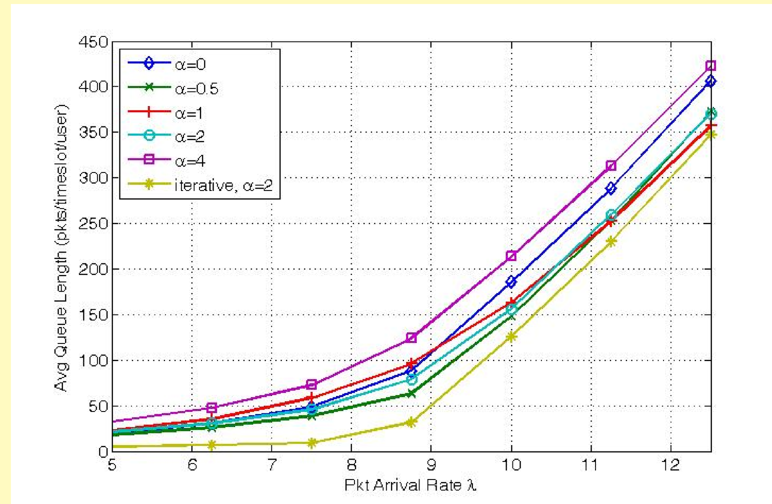
Simulation Results

Simulations are performed with $N = 64$ subcarriers and $K = 64$ users under 200 timeslots. $L = 10$-tap delay line channels. Average SNR of 10 dB. Parameters are chosen such that the system capacity is about 9 packets/user/timeslot. Performances are compared for schedulers with $\alpha = 0, 0.5, 1, 2, 4$.

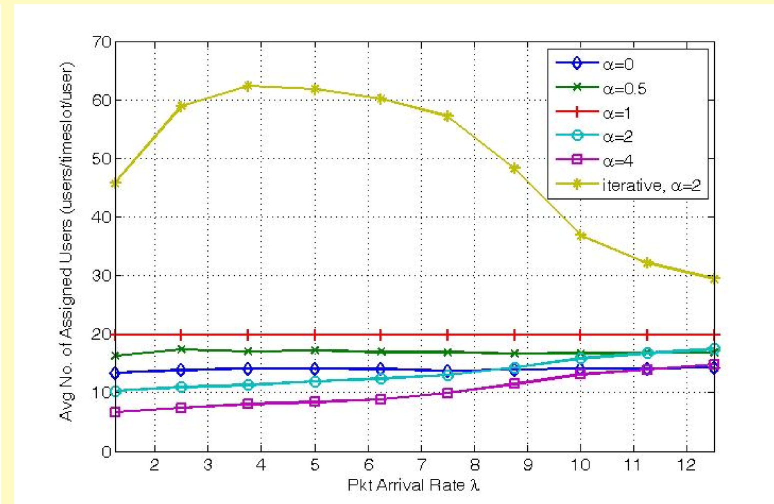
Figures a.1) to a.4) compare non-iterative schedulers with $\alpha = 0, 0.5, 1, 2, 4$ and iterative scheduler with $\alpha = 2$). Figure b) compares M-Best and wM-Best CSI feedbacks. Figure c) shows the average number of assigned users for different schedulers with wM-Best feedback.



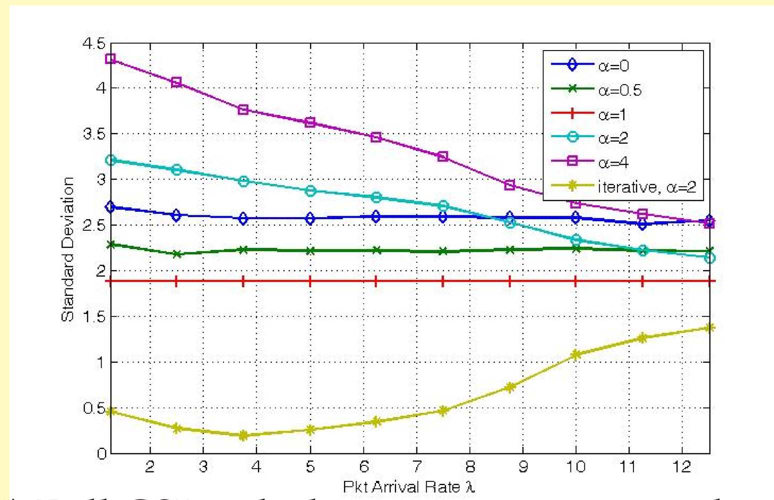
a.1) Full CSI: avg. throughputs



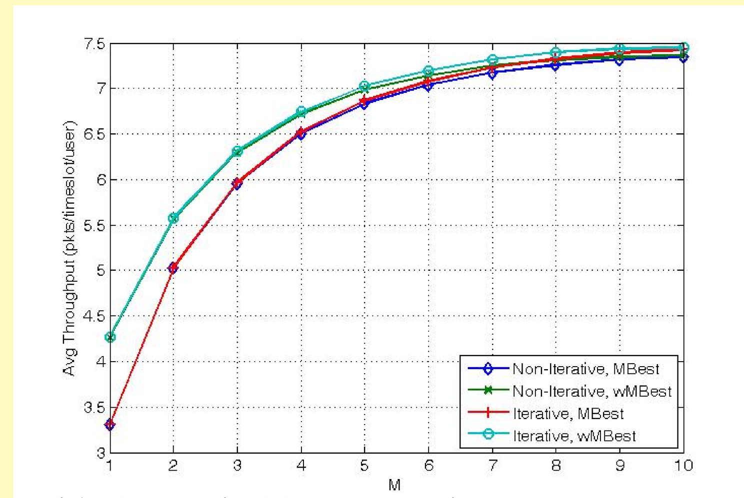
a.2) Full CSI: avg. queue lengths



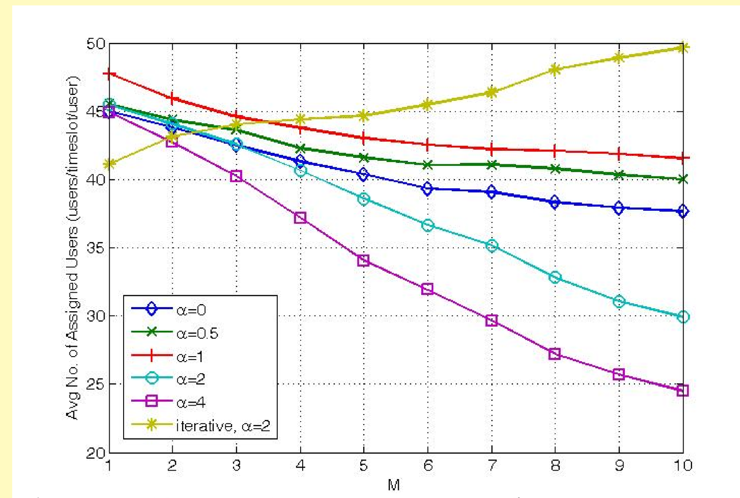
a.3) Full CSI: avg. no. assigned users



a.4) Full CSI: std. deviation no. assigned users



b) Partial CSI: Avg. thruputs vs M



c) wM-Best: Avg. assigned users vs M

Summary/Future Works

The proposed iterative scheduler performs better than non-iterative scheduler in term of average queue length or equivalently average delay. In addition, the MaxWeight scheduler works better with wM-Best CSI feedback than with M-Best feedback. Extension: optimal CSI feedback mechanisms for queue-aware gradient-based schedulers (non-iterative and iterative).