Multiuser Switched Diversity Transmission

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- A multiuser diversity gain arises from independent fading channels across different users.
- Multiuser diversity can be exploited to maximize the average system throughput by always serving the user with the strongest channel [1,2] and transmitting with the highest possible rate supported by the selected channel.

Traditional approach

- The base station probes all the users and select the user which reports the best channel quality at any given time-slot.
- Deterministic and high feedback load.

Alternative approach

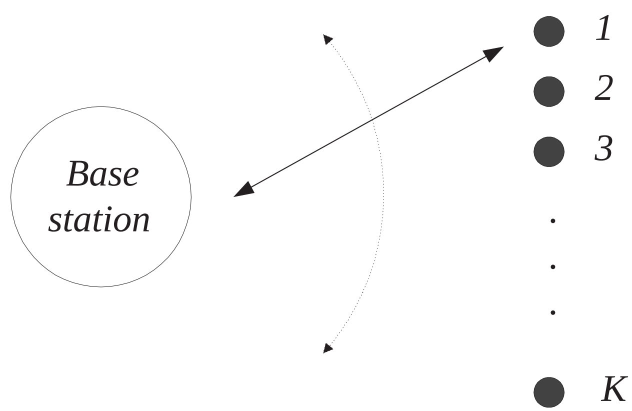
- The base station probes the users in a sequential manner, looking not for the best user but for an acceptable user.
- A user qualifies as an acceptable user and is selected by the base station when the reported channel quality is above a predefined switching threshold.
- Trade-off between performance and feedback load.

Benchmark

- Selection combining transmission (SCT).

Switched access schemes

- Switch-and-examine transmission (SET) [4].
- Switch-and-examine transmission with post-selection (SETps) [5].
- Scan-and-wait transmission (SWT) [6].



- Time-division multiplexed (TDM) system.
- A time-slot is roughly equal to the channel coherence time and is divided into a guard time and an information transmission time.
- During the guard time, the base station selects the user who will access the channel in the subsequent transmission time.
- The data burst is assumed to experience the same fading conditions as the preceding guard period (block fading).

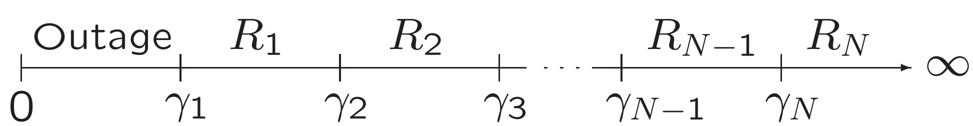
- Only one user has channel access per time-slot (uplink or downlink).
- The base station and all the individual users are equipped with just a single antenna.
- K users are operating on independent and identically distributed (i.i.d.) Rayleigh fading channels.

For i.i.d. fading conditions:

$$\overline{\gamma}_1 = \overline{\gamma}_2 = \cdots = \overline{\gamma}_K = \overline{\gamma}$$

$$\gamma_{T_1} = \gamma_{T_2} = \cdots = \gamma_{T_K} = \gamma_T$$

- A rate-adaptive coding scheme using $N = 8$ multidimensional trellis codes originally designed for AWGN channels is utilized [3].
- The codes are based on QAM signal constellations of growing size $\{M_n\} = \{4, 8, 16, 32, 64, 128, 256, 512\}$.
- Rate adaption is performed by splitting the SNR range into $N + 1$ fading regions (bins).



- The lower limit of each fading region is equal to the smallest SNR which guarantees that a predefined target BER ($\text{BER}_0 = 10^{-4}$) is achieved.

$$\overline{\mathsf{BER}} = \frac{\sum_{n=1}^{N} R_n \cdot \overline{\mathsf{BER}}_n}{\sum_{n=1}^{N} R_n \cdot P_n} = \frac{\sum_{n=1}^{N} R_n \cdot \overline{\mathsf{BER}}_n}{\mathsf{ASE}}. \tag{1}$$

$$P_n = \int_{\gamma_n}^{\gamma_{n+1}} p_{\gamma_{BS}}(\gamma) d\gamma. \tag{2}$$

$$\overline{\mathsf{BER}}_n = \int_{\gamma_n}^{\gamma_{n+1}} a_n \cdot e^{-\frac{b_n \gamma}{M_n}} p_{\gamma_{BS}}(\gamma) d\gamma. \tag{3}$$

- a_n and b_n are code-dependent constants found by least-square fitting to simulated data on AWGN channels.

- γ_T is defined (for fixed K and $\overline{\gamma}$) as the switching threshold that maximizes the ASE subject to a possible average feedback load (AFL) constraint.

$$\text{AFL} = \frac{1-p^K}{1-p}, \tag{4}$$

where $p = 1 - e^{-\gamma_T/\overline{\gamma}}$.

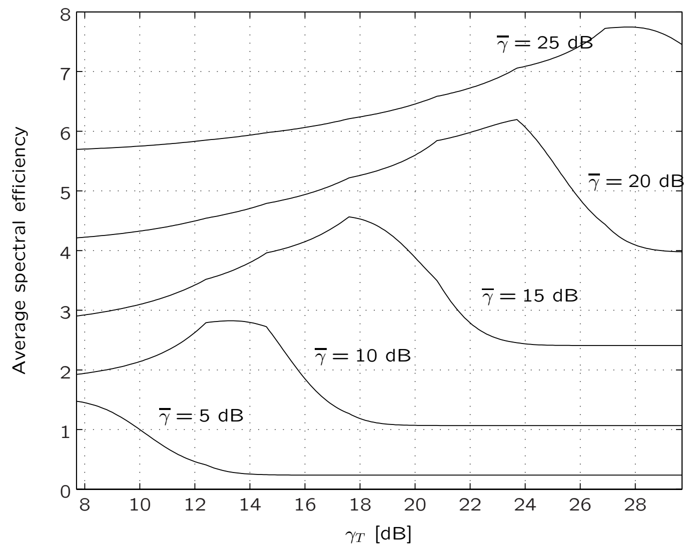
- With no AFL constraint, γ_T is identified within the set [7,8]

$$\mathcal{X} = \{\gamma \in \mathbb{R} : \gamma_1 \leq \gamma \leq \gamma_N\}$$

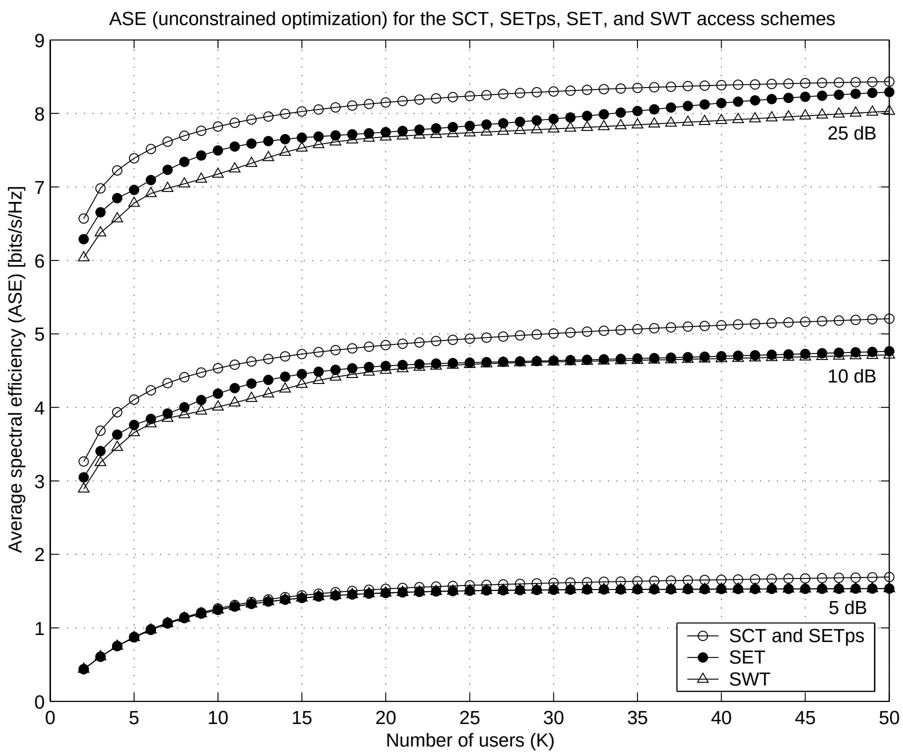
- With an AFL constraint, γ_T is identified within the set

$$\mathcal{X}_{afl} = \{\gamma \in \mathbb{R} : \gamma_1 \leq \gamma \leq \gamma^*\},$$

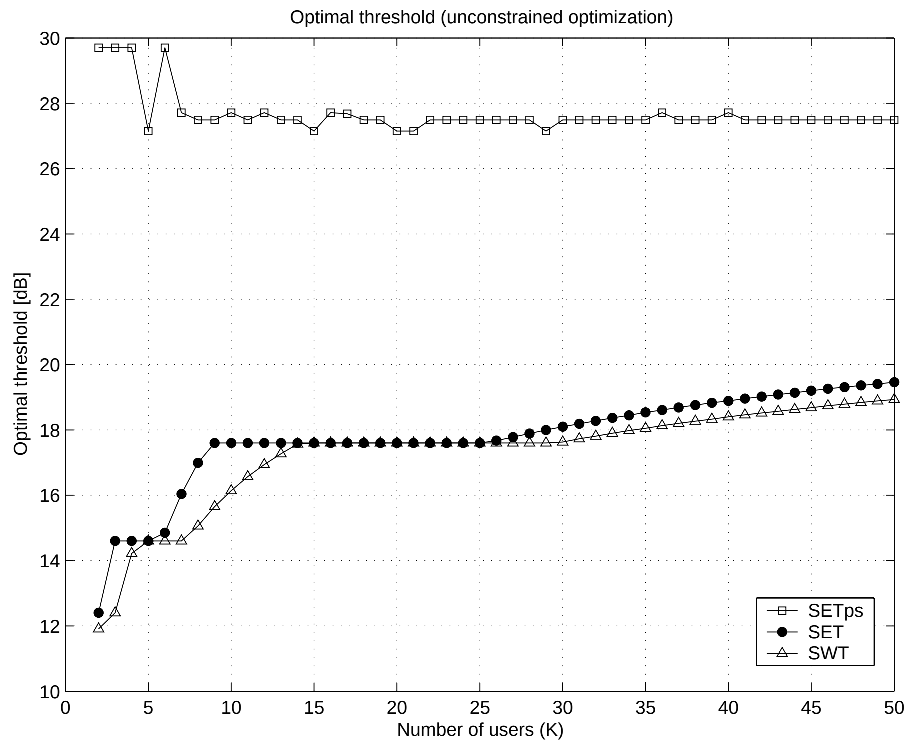
where $\gamma^* \leq \gamma_N$.



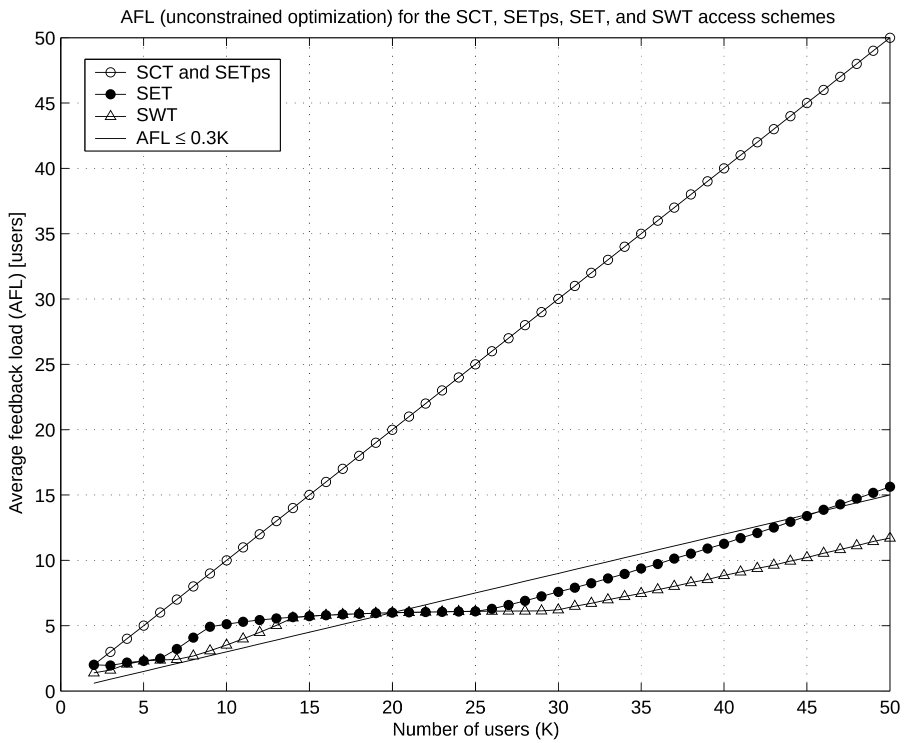
ASE for the SET scheme as a function of γ_T when $K = 20$ and $\overline{\gamma} = [5, 10, 15, 20, 25]$ dB. The multiuser system is operating on i.i.d. Rayleigh fading channels.



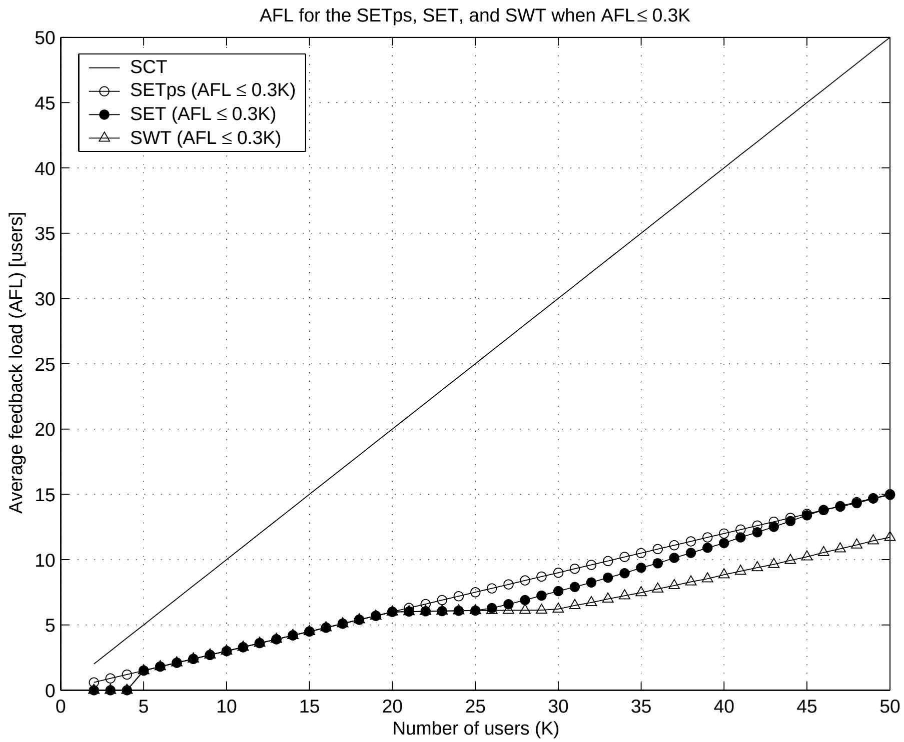
ASE (unconstrained optimization) for the SCT, SETps, SET, and SWT access schemes when the multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = [5, 15, 25]$ dB.



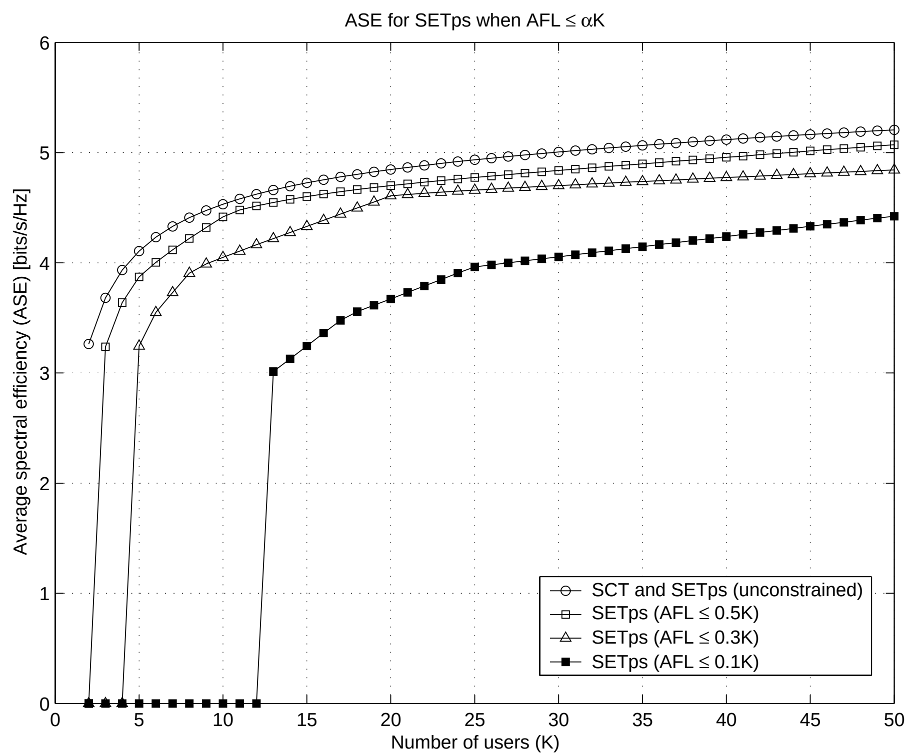
Optimal thresholds γ_T maximizing the ASE subject to no AFL constraints. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



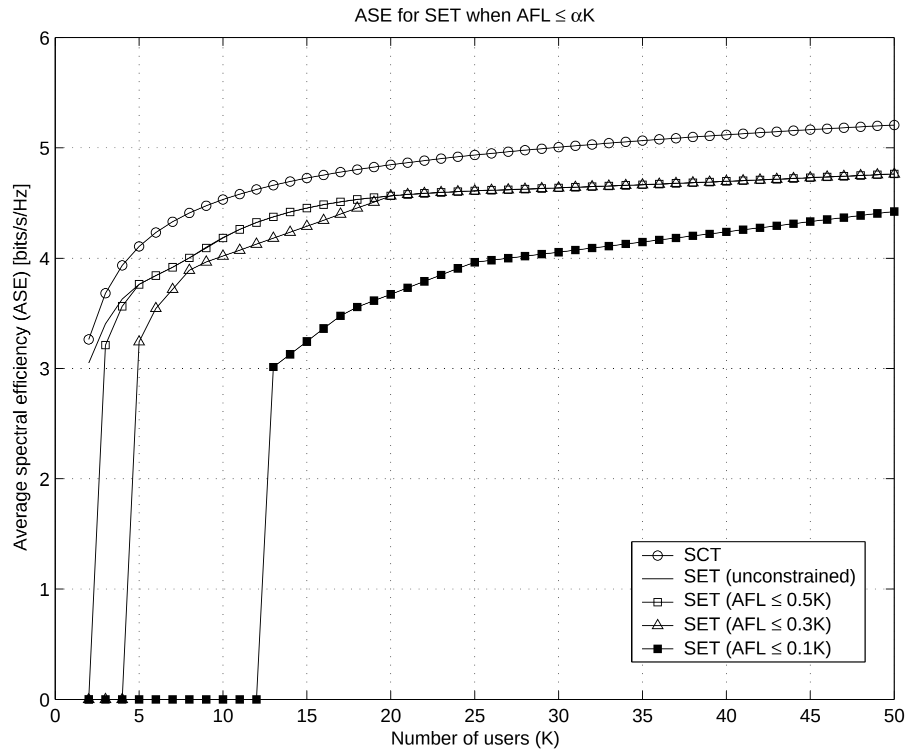
AFL (unconstrained optimization) for the SCT, SETps, SET, and SWT access schemes. For reference purposes, the solid line visualizes the (linear) upper bound for the constraint AFL $\leq 0.3K$. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



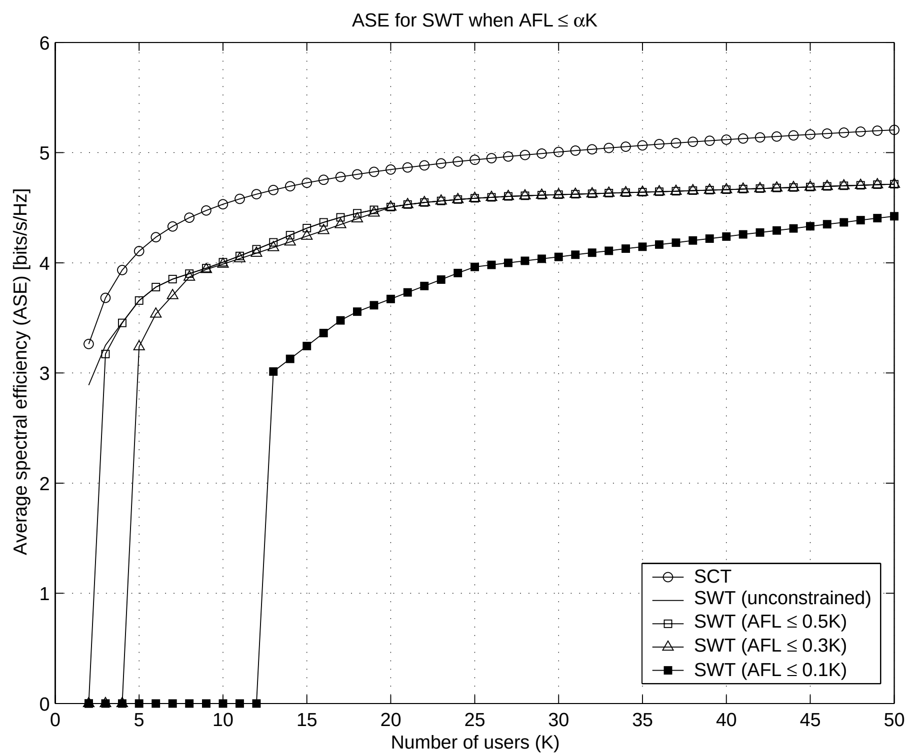
AFL for the SCT, SETps, SET, and SWT access schemes when AFL $\leq 0.3K$. When the constraint cannot be met, AFL $= 0$ for simplicity. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



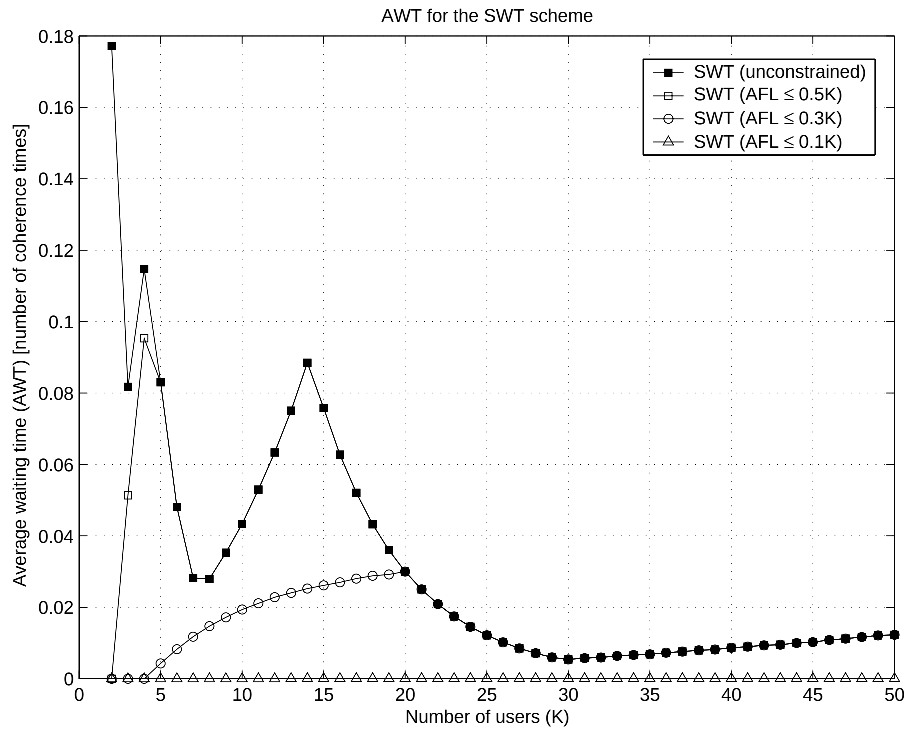
ASE realized by the SETps access scheme when the AFL is upper bounded by AFL $\leq \alpha K$. When the constraint cannot be met, ASE $= 0$ for simplicity. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



ASE realized by the SET access scheme when the AFL is upper bounded by AFL $\leq \alpha K$. When the constraint cannot be met, ASE $= 0$ for simplicity. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



ASE realized by the SWT access scheme when the AFL is upper bounded by AFL $\leq \alpha K$. When the constraint cannot be met, ASE $= 0$ for simplicity. The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.



Average waiting time (AWT) for the SWT access scheme. When the constraint cannot be met, AWT $= 0$ for simplicity (when AFL $\leq 0.1K$, AWT $= 0$ for $K \leq 12$). The multiuser system is operating on i.i.d. Rayleigh fading channels with $\overline{\gamma} = 15$ dB.

- A set of switched multiuser access schemes have been proposed for systems operating in a TDM mode.
- The new access schemes are aimed to reduce the average feedback load in multiuser systems relying on feedback from the users to maximize the ASE.
- Numerical results quantifying the trade-off between ASE and AFL have been presented, showing that the AFL can be reduced significantly compared to the optimal selective diversity scheme without experiencing a big performance loss in ASE.
- The proposed access schemes are quite attractive also from a fairness perspective.

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[4] H. -C. Yang and M. -S. Alouini, ”Performance analysis of multibranch switched diversity systems,” IEEE Transactions on Communications, vol. 51, no. 5, pp.782-794, May 2003.

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[8] B. Holter, M. -S. Alouini, G. E. Øien, and H. -C. Yang, "Multiuser switched diversity transmission," IEEE Transactions on Wireless Communications, to be submitted.