Scheduling for moving users to guarantee proportional fairness

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SARA Meeting, 30 January 2020

Proportional Fair scheduling for moving users

Objective: guarantee all users have minimal level of service + getting high total throughput

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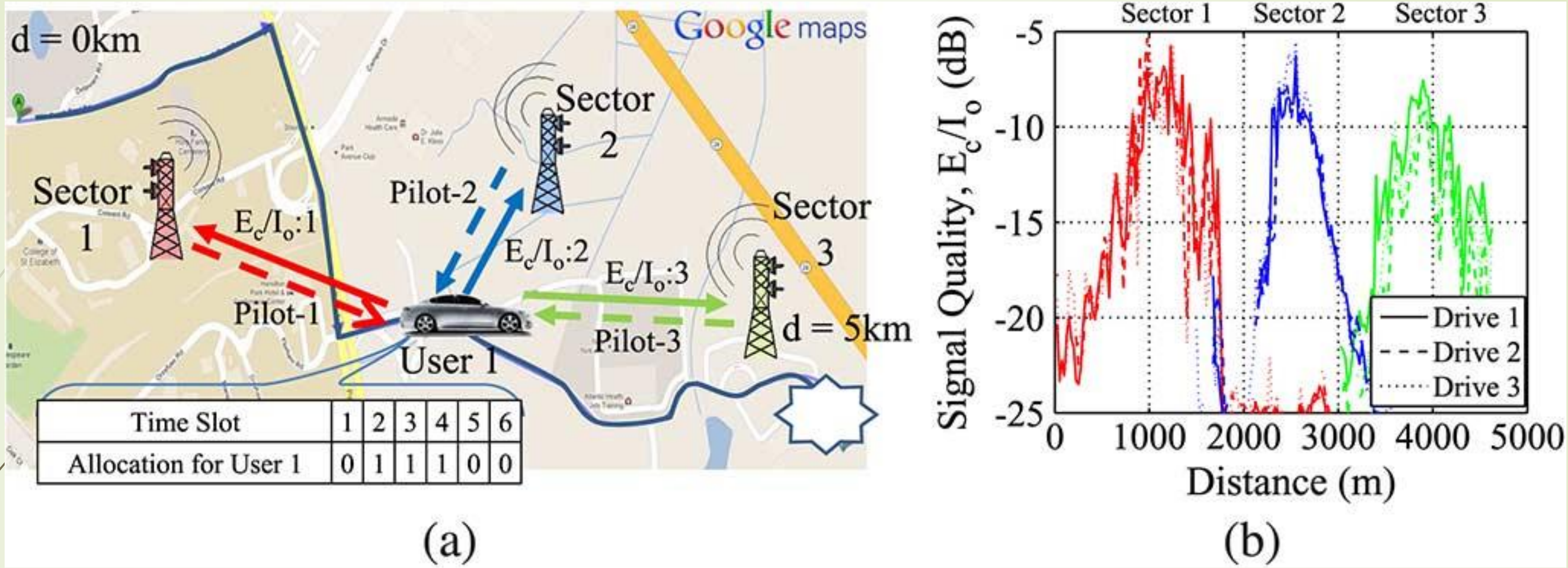
Introduction



- Current scheduling algorithms use current/past information

- Connected vehicles technology will gives access to future information (most probable path; SNR maps for future rate)

Introduction

1,Improved scheduling algorithms based on predicted future path.

2, Run on real time.

Important numbers

1. Every small slot = 2ms, each BS makes decision: serves which user.

2. Every big slot = 1 second, arrivals come to the system.

3. Objective:

Guarantee Proportional Fairness while maintain High Total Throughput.

Optimization Problems

$$\max O(\alpha) = \sum_{i=1}^{K} \log \Big(\sum_{m=1}^{M} \sum_{j=1}^{T} \alpha_{ij}^{m} r_{ij}^{m} \Big),$$

subject to

$$\begin{cases} \sum_{i=1}^{K} \alpha_{ij}^{m} = 1, \quad \text{for any } j, m \\ \sum_{m=1}^{M} \alpha_{ij}^{m} \leq 1, j = 1, \ldots, T, \; i = 1, 2, \ldots, K. \\ \alpha_{ij}^{m} \in \{0, 1\}. \end{cases}$$

Utility function: U(x) = log(x), log stands for proportional fairness between users.

Computationally hard

Some Existing Algorithms

- **Greedy**. Current info only: BS m is choose the vehicle with best current rate: $i^{m*} \in \text{argmax}_i(r^m_{i,j})$.
- **PF-EXP**[1]. Current + past info: choose user with best

$$\frac{\text{current rate}}{\text{total allocated rate in the past}} = \frac{r^m_{ij}}{\sum_{t=1}^{j} \sum_{m=1}^{M} r^m_{i,j} \alpha^m_{i,j}}$$

$\longrightarrow$ Used in 3G network; optimal in some cases (not necessarily true for road traffic)

- **(PF)^{2}S** [2]. Use current + past + future info: choose user with the best

$$\frac{\text{current rate}}{\text{total in past} + \text{current} + \text{estimated future allocated rate}}$$

Our Heuristic: Short-term Objective (STO) projeted dradient

- Assumption: can predict future path of the users in the system.

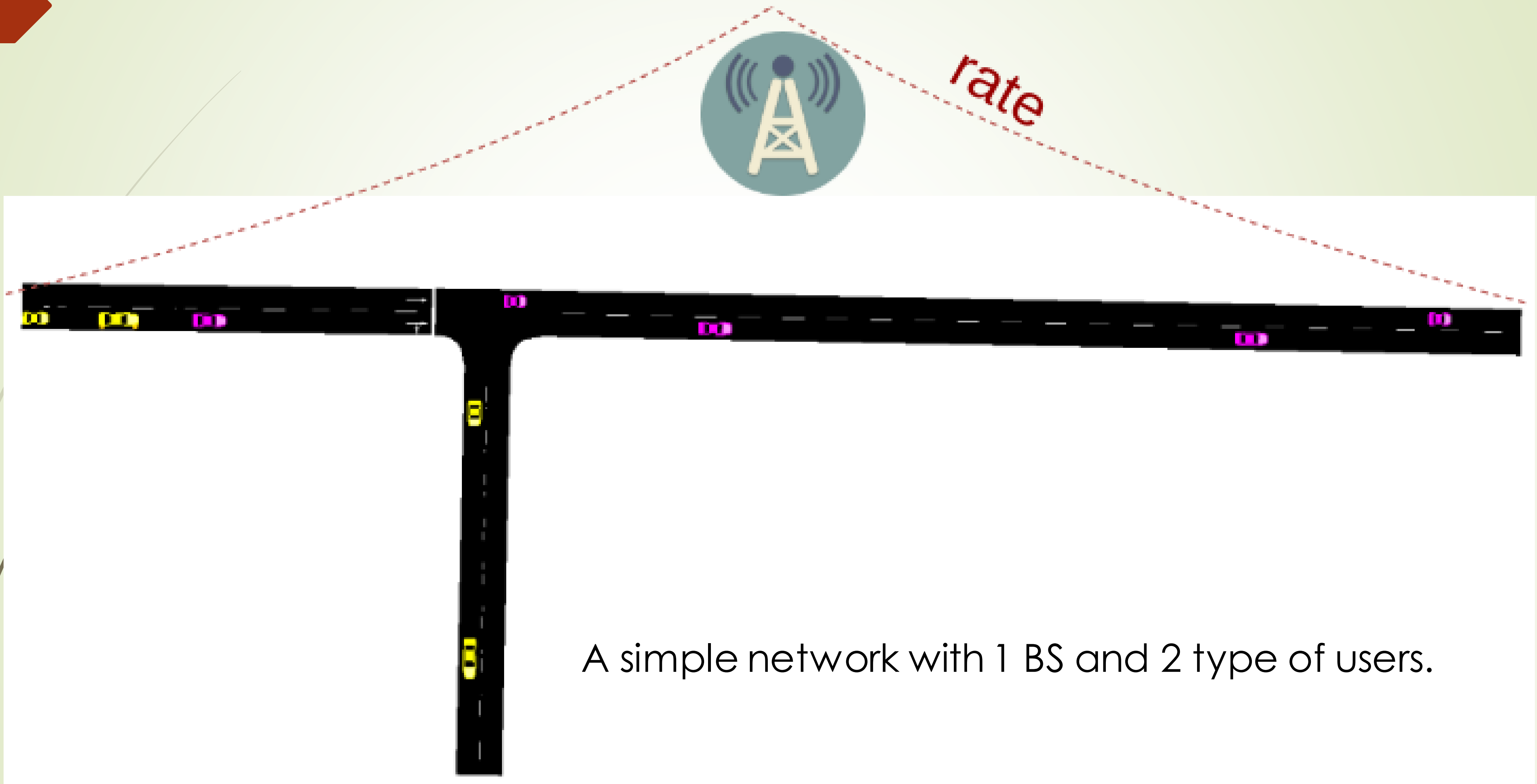
- At beginning of every 1 second, observe the state of the system.

-Solving the relax problem associated to the original problem in short term objective (instead of whole time horizon) based on projected gradient to get future allocation in every second.

- Apply that estimated future allocation in the formula in every small slot:

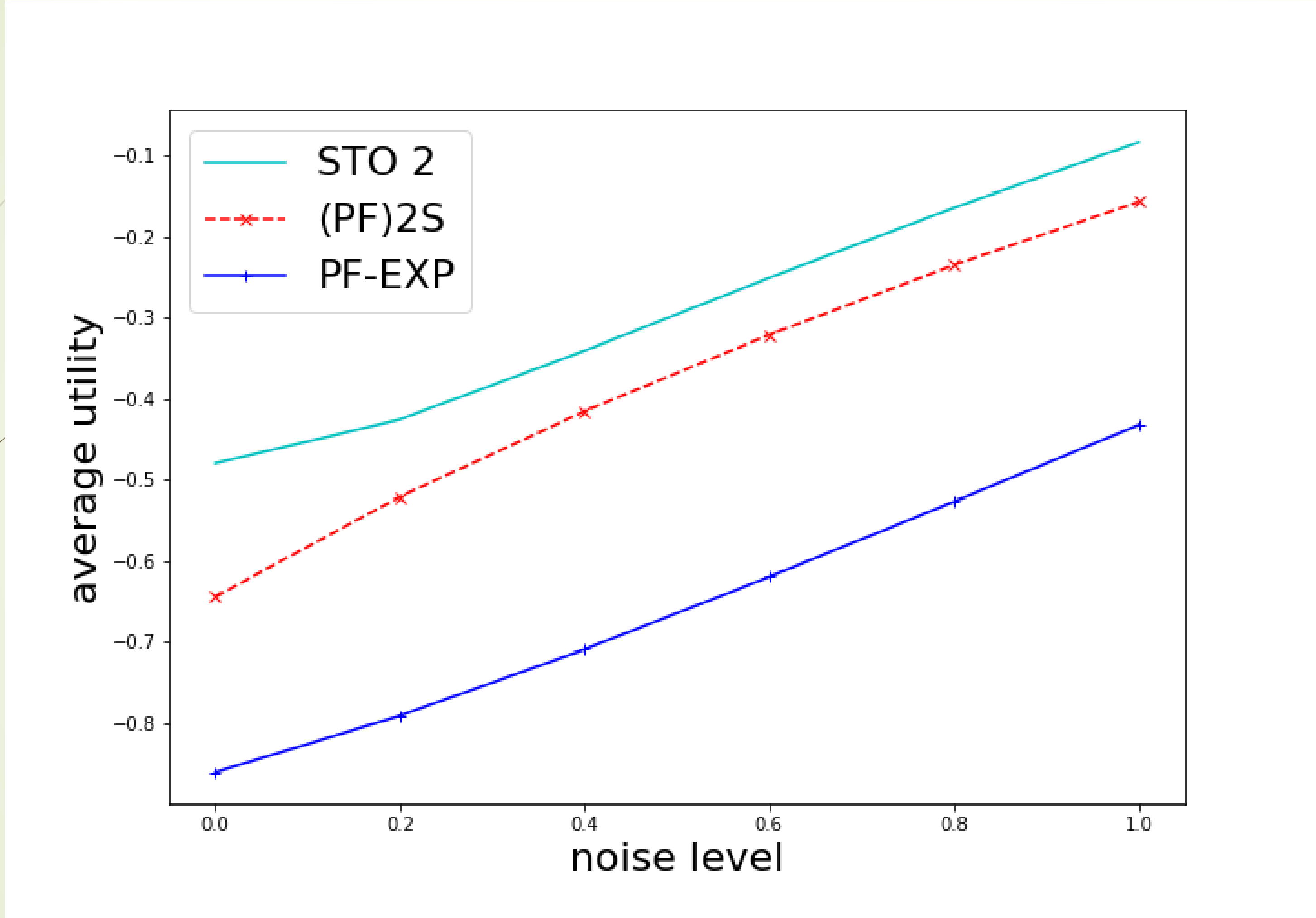
$$\frac{\text{current rate}}{\text{total in past} + \text{current} + \text{estimated future allocated rate}}$$

A simple network



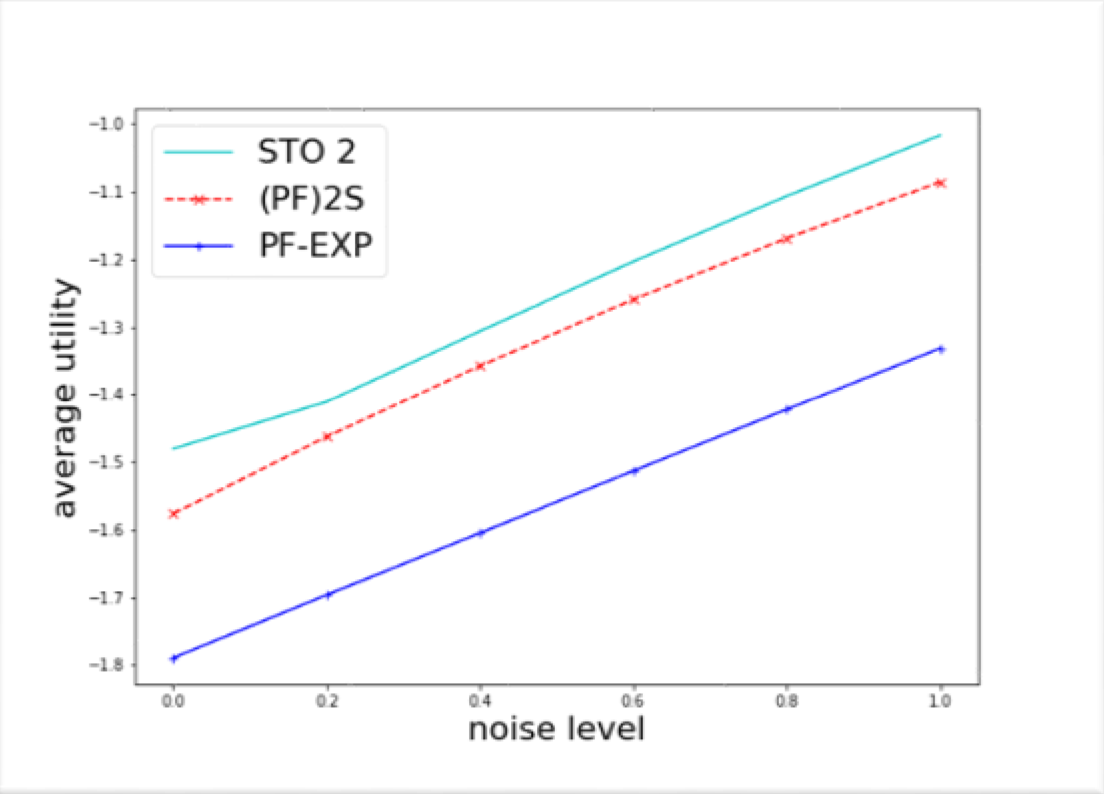
A simple network with 1 BS and 2 type of users.

A simple network



Utility Comparison. Greedy is not in the plot since there are starve users, that makes –inf objective.

Numerical results



Grand Rond area with 4 BSs with many type of users: car, motorbike, bike, pedestrian.

Utility comparison. It take 0.94 hour to run STO for 1.05 hour of simulation.

Future work

1. Test for more diversity system: static users, non predictable (path) users, etc.
2. Study analytical guarantee.
3. Adding quality of service constraints (delay).

References

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Thank you for your attention!