

# Feedback-Aware Social Event-Participant Arrangement

Jieying She<sup>1</sup>, Yongxin Tong<sup>2</sup>, Lei Chen<sup>1</sup>, Tianshu Song<sup>2</sup>

<sup>1</sup> The Hong Kong University of Science and Technology

<sup>2</sup> Beihang University

<sup>1</sup>{jshe, leichen}@cse.ust.hk, <sup>2</sup>{yxtong, songts}@buaa.edu.cn

## Introduction

- Event-Based Social Networks
  - Online platforms that facilitate offline event organization and participation, e.g. Meetup
- Motivation
  - The satisfaction scores are hard to learn
    - Different factors, e.g. price and distance, have different weights, which are hard to know
  - Users may not accept the arrangements
    - Alex who likes rock and roll may reject the arrangement of a piano concert
    - Feedbacks of users should be considered to improve quality of services

## The FASEA Problem

- Given
  - A set of events  $V$ 
    - Each  $v \in V$  with capacity  $c_v$ .
  - A set of conflicting event pairs  $CF$
- Each time step  $t$ , a user  $u$  arrives
  - Capacity  $c_u$  and a context  $\mathbf{x}_{t,v}$  for each  $v \in V$  are revealed.
  - Arrange at most  $c_u$  feasible events  $A_t$ .
  - Receive feedbacks of accepting/rejecting the arranged event, i.e. observe rewards  $\{r_{t,v} = 0 \text{ or } 1 | v \in A_t\}$ , where  $E[r_{t,v} | \mathbf{x}_{t,v}] = \mathbf{x}_{t,v}^T \boldsymbol{\theta}$  and  $\boldsymbol{\theta}$  is fixed but unknown.
- Goal
  - Find an arrangement  $A_t$  for each user  $u_t$  such that the total number of accepted events is maximized and the following constraints are satisfied:
    - Invariable constraint.
    - Capacity constraint.
    - Conflict constraint.

## Background: MAB

- Given a set of  $m$  arms
  - Each arm is associated with an unknown distribution of rewards
- Repeatedly play one arm in  $T$  rounds
  - Observe the reward of the arm played
- Maximize the total rewards: exploration and exploitation trade-off
- A variant: contextual combinatorial bandit
  - Combinatorial: play a subset of arms in each round
  - Contextual: before playing, a context (feature vector) of each arm is observed in each round
    - The reward of an arm depends on the context
    - Linear payoff: mean of reward is a linear combination of the features with unknown weights

## Problem Reduction

- Contextual combinatorial bandit  $\rightarrow$  event-participant arrangement
- Each round (for each new-coming user)
  - Values of factors are observed  $\rightarrow$  contexts are observed
  - Arrange a set of events  $\rightarrow$  play a subset of arms
  - User chooses to accept the arranged events or not  $\rightarrow$  observe rewards

## Thompson Sampling Based Solution

- At each time step
  - Sample  $\tilde{\boldsymbol{\theta}} \sim N(Y^{-1} \mathbf{b}, q^2 Y^{-1})$ .
  - Estimated reward of each  $v$ :  $\hat{r}_{t,v} = \mathbf{x}_{t,v}^T \tilde{\boldsymbol{\theta}}$
  - Arrange at most  $c_u$  feasible events  $A_t$  greedily based on  $\{\hat{r}_{t,v} | v \in V\}$

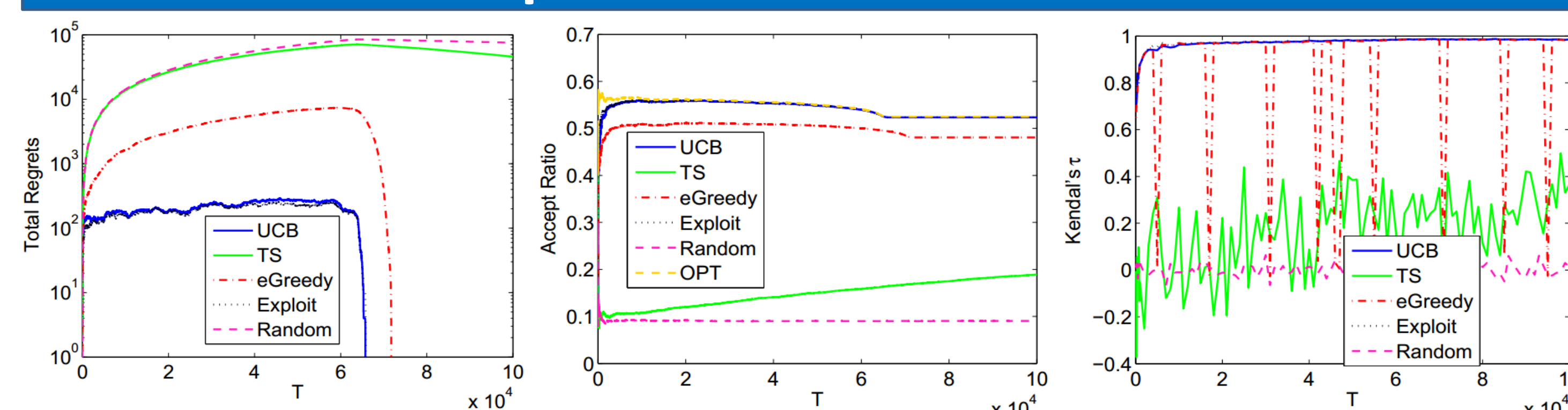
	Round 1 ( $c_u = 2$ )	Round 2 ( $c_u = 1$ )	Conflicts
$v_1$	$\mathbf{x}_{1,v_1} = \langle 0.1, 0, 0.5, 0.2 \rangle$	$\hat{r}_{1,v_1} = -3.94$	$v_2$
$v_2$	$\mathbf{x}_{1,v_2} = \langle 0.2, 0.1, 0, 0.1 \rangle$	$\hat{r}_{1,v_2} = -0.30$	$v_1$
$v_3$	$\mathbf{x}_{1,v_3} = \langle 0.2, 0.3, 0, 0.2 \rangle$	$\hat{r}_{1,v_3} = 1.74$	NA
$v_4$	$\mathbf{x}_{1,v_4} = \langle 0, 0, 1, 0 \rangle$	$\hat{r}_{1,v_4} = -13.07$	NA

## Upper Confidence Bound (UCB) Based Solution

- At each time step
  - Estimate  $\hat{\boldsymbol{\theta}} = Y^{-1} \mathbf{b}$
  - Upper confidence bound of each  $v$ 
    - $\hat{r}_{t,v} = \mathbf{x}_{t,v}^T \hat{\boldsymbol{\theta}} + \alpha \sqrt{\mathbf{x}_{t,v}^T Y^{-1} \mathbf{x}_{t,v}}$
  - Arrange at most  $c_u$  non-conflicting events  $A_t$  greedily based on  $\{\hat{r}_{t,v} | v \in V\}$

	Round 1 ( $c_u = 2$ )	Round 2 ( $c_u = 1$ )	Conflicts
$v_1$	$\mathbf{x}_{1,v_1} = \langle 0.1, 0, 0.5, 0.2 \rangle$	$\hat{r}_{1,v_1} = 1.10$	$v_2$
$v_2$	$\mathbf{x}_{1,v_2} = \langle 0.2, 0.1, 0, 0.1 \rangle$	$\hat{r}_{1,v_2} = 0.49$	$v_1$
$v_3$	$\mathbf{x}_{1,v_3} = \langle 0.2, 0.3, 0, 0.2 \rangle$	$\hat{r}_{1,v_3} = 0.82$	NA
$v_4$	$\mathbf{x}_{1,v_4} = \langle 0, 0, 1, 0 \rangle$	$\hat{r}_{1,v_4} = 2.00$	NA

## Experimental Evaluation



**Experimental finding:** TS that is reported to work well under basic multi-armed bandit does not perform well under FASEA while UCB is the best in overall

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