Efficient and Effective Algorithms for A Family of Influence Maximization Problems with A Matroid Constraint

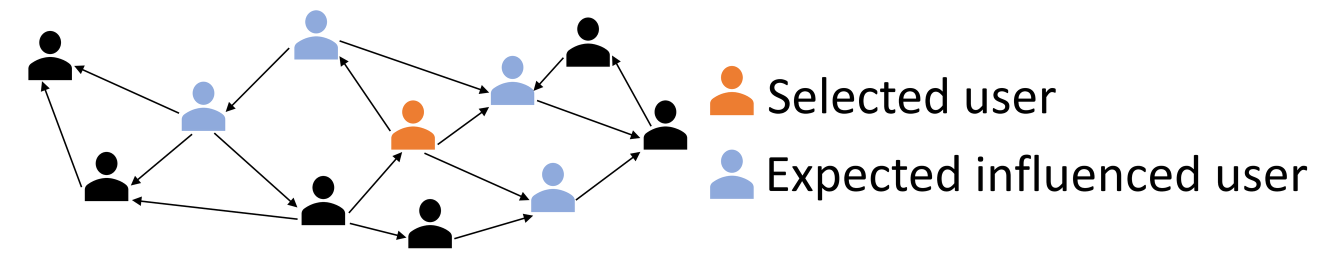
NUS National University of Singapore — Centre for Trusted Internet and Community

Yiqian Huang, Shiqi Zhang, Laks V.S. Lakshmanan, Wenqing Lin, Xiaokui Xiao, Bo Tang

(published in *Proceedings of the VLDB Endowment* (PVLDB) 2024)

Introduction

Influence Maximization (IM): find a set of users S ( ) that maximizes their expected influence (+) in a social network



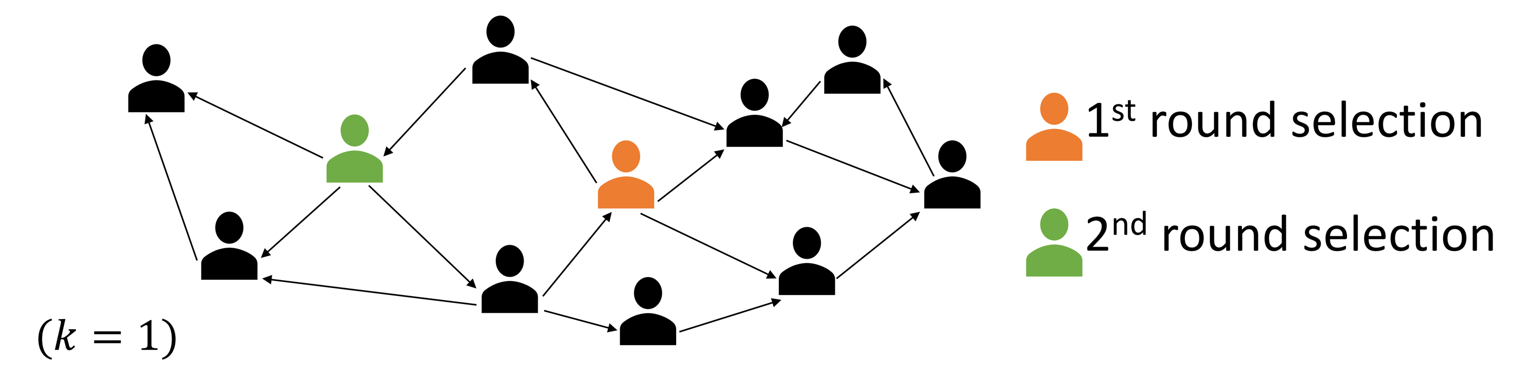
IM with a Matroid Constraint:

S must satisfy a matroid constraint $M = (U, I)$: $S \subseteq U$ and $S \in I$, where I represents certain feasible solutions

A matroid M allows constraints across ***multiple sets of users*** or ***different objects***

Example #1: IM in Multiple Rounds (MRIM)

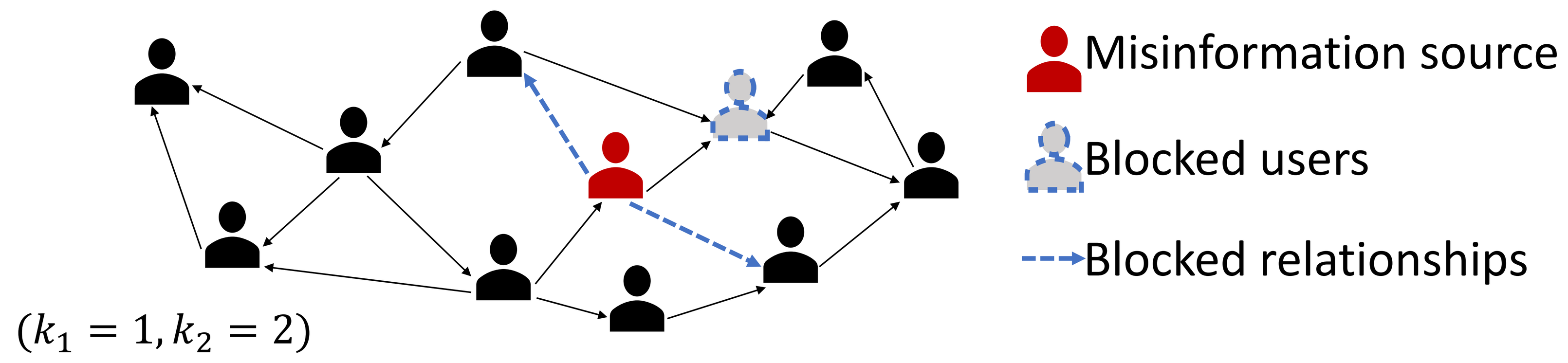
Constraint: select $\leq k$ users each round



Objective: maximize expected influence from selected promoters (and)

Example #2: Adversarial attacks on IM (AdvIM)

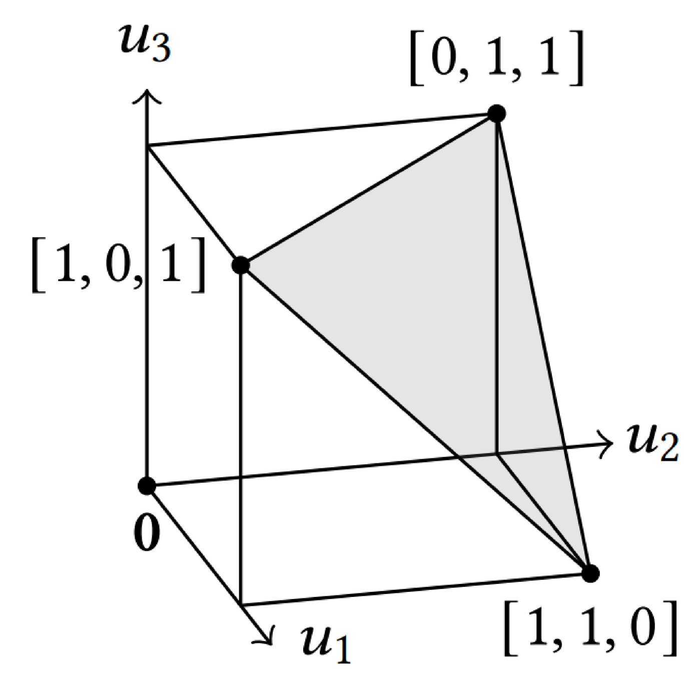
Constraint: *block* $\leq k_1$ users and $\leq k_2$ relationships



Objective: minimize expected influence from misinformation source ( )

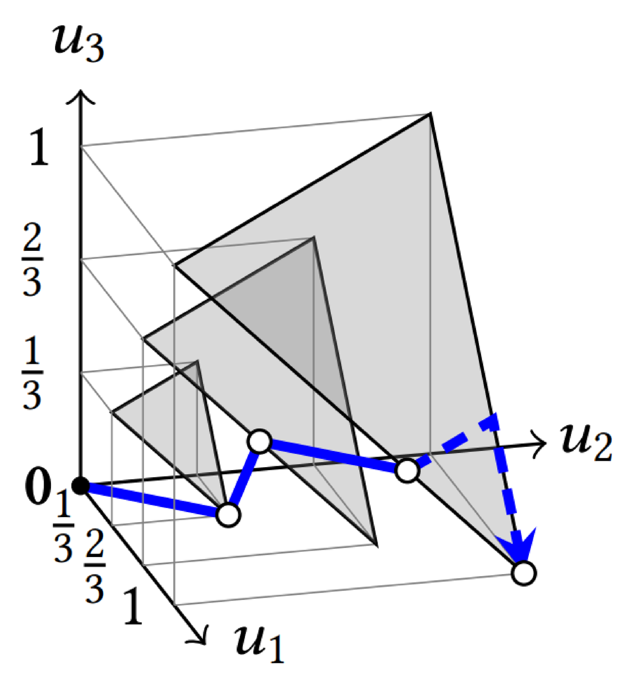
Proposed Solution: Boosting Approximation from 1/2-ϵ to (1-1/e-ϵ)

A hypergeometric view of a matroid with $U = \{u_1, u_2, u_3\}$ and $I = \{S \subseteq U\colon |S| \leq 2\}$



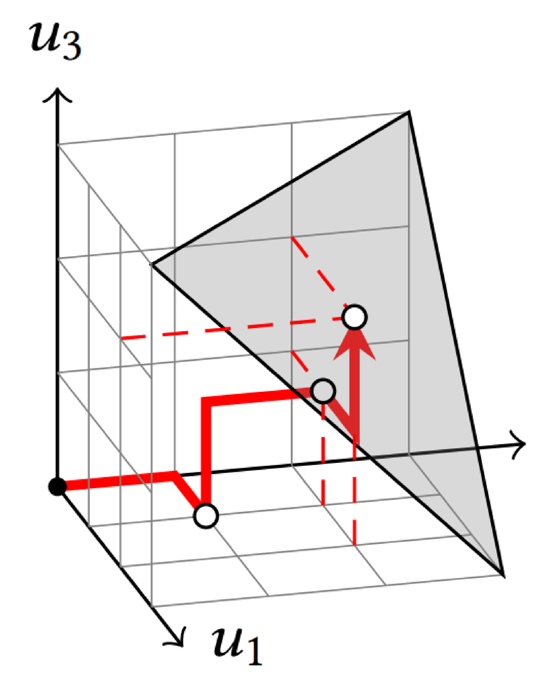
Overview

- polyhedron→solution space
- shaded face→partial solutions
- labeled dots→final solutions



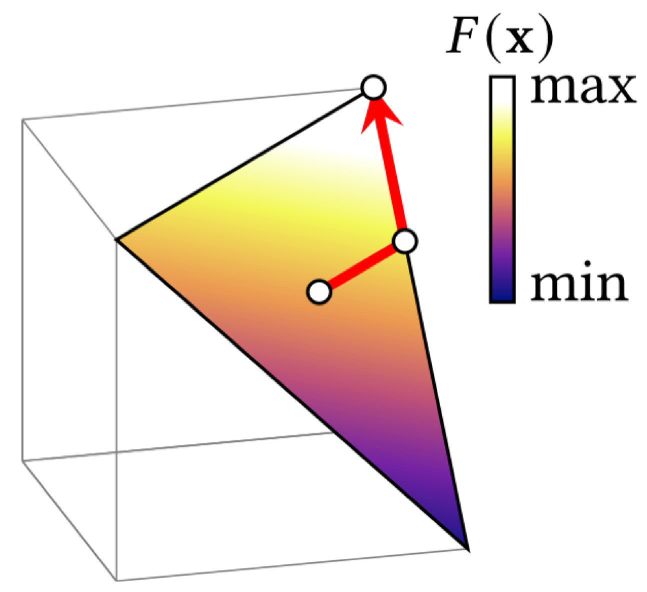
Previous Solver

- coarse-grained hill-climbing
- using sampling to estimate partial solutions
- $\mathbf{O(n^7 \log n)}$ **running time**



Proposed Searching

- fine-grained search
- calculate partial solutions efficiently & **deterministically**
- $\mathbf{O_\epsilon(n \cdot \mathrm{poly}(\log n))}$ **time**



Proposed Rounding

- round partial solutions to final solutions deterministically
- **no loss** in solution quality

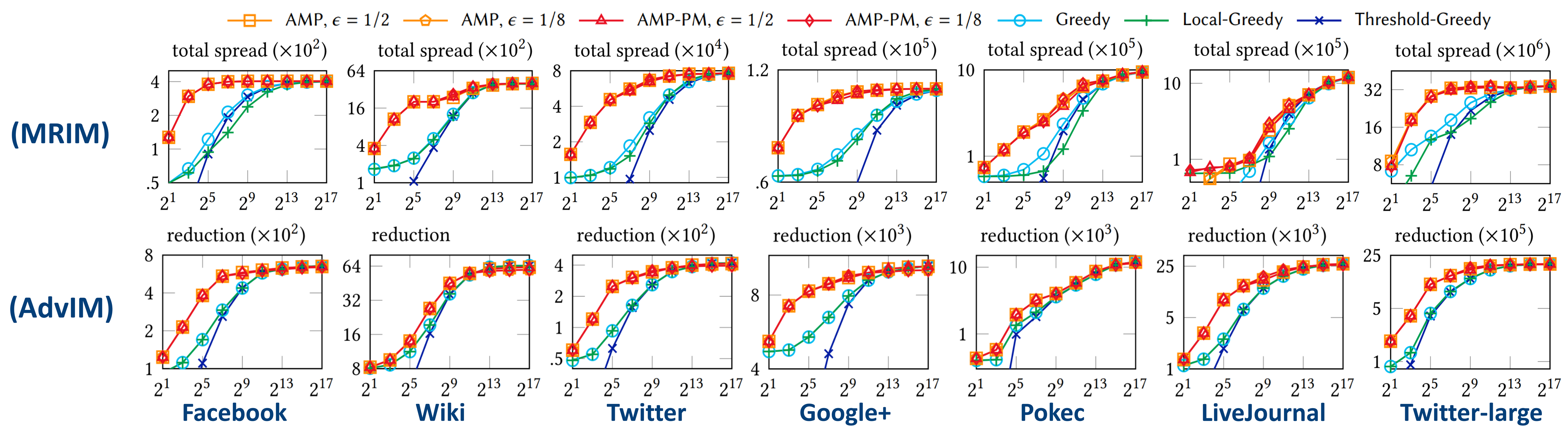
Scalable implementations: follow the framework of OPIM-C and redesign the constants with rigorous analysis

Final Algorithm (AMP and RAMP): $(1 - 1/e - \epsilon)$ − approximation + scalable running time

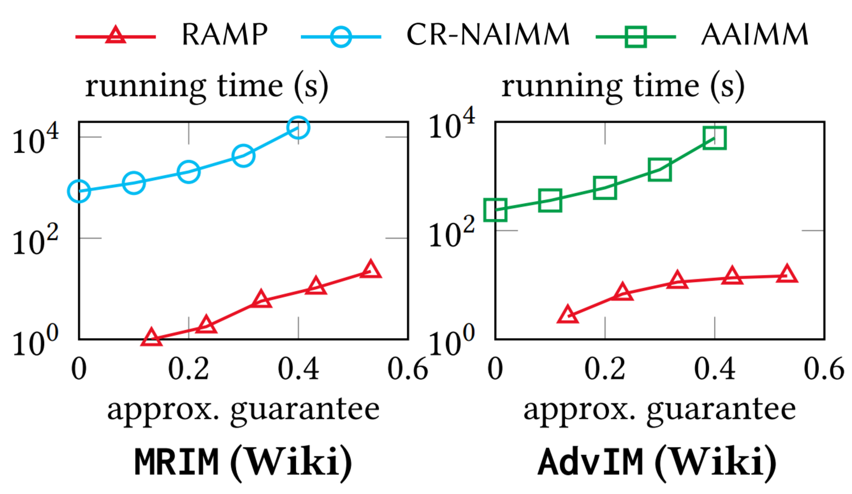
Experiments

- **AMP and its variants outperform all other solvers on 7 public datasets in terms of solution quality**

X-axis: computation resource



- **RAMP outperforms other scalable algorithms in terms of running time**



- **RAMP outperforms other solutions in actual spread of Tencent e-games**

Algorithm	Spread
Most-Click	7.34M
Greedy	7.36M
RAMP	**7.50M**