A Sybil-proof and Time-sensitive Incentive Tree Mechanism for Crowdsourcing

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Outline

Introduction & Motivation

Crowdsourcing Model

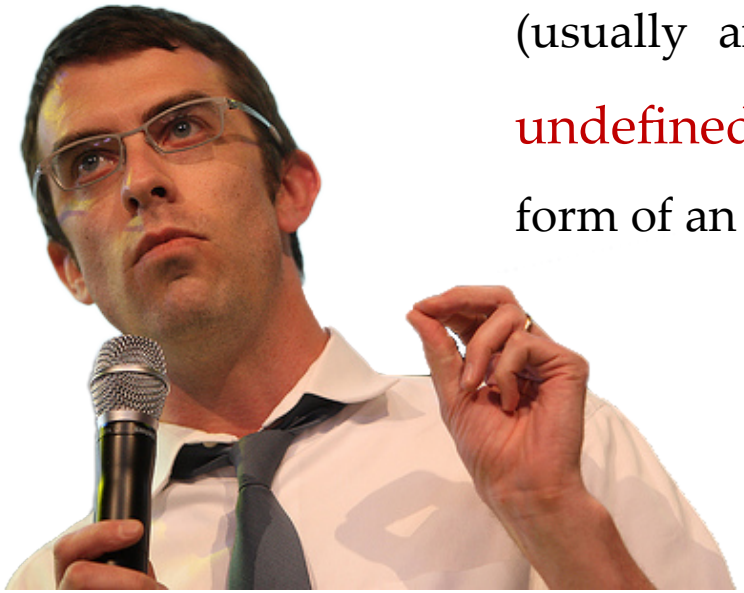
Incentive Tree Mechanism

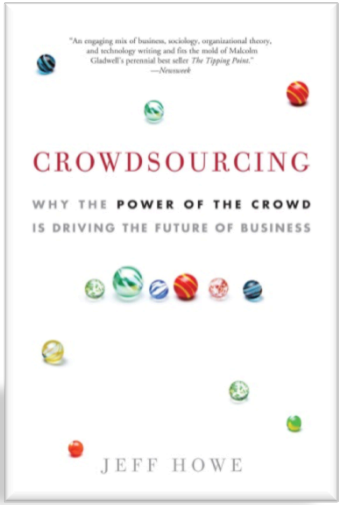
Performance Evaluation

Conclusion

Crowdsourcing

"Crowdsourcing is the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call. [1] "



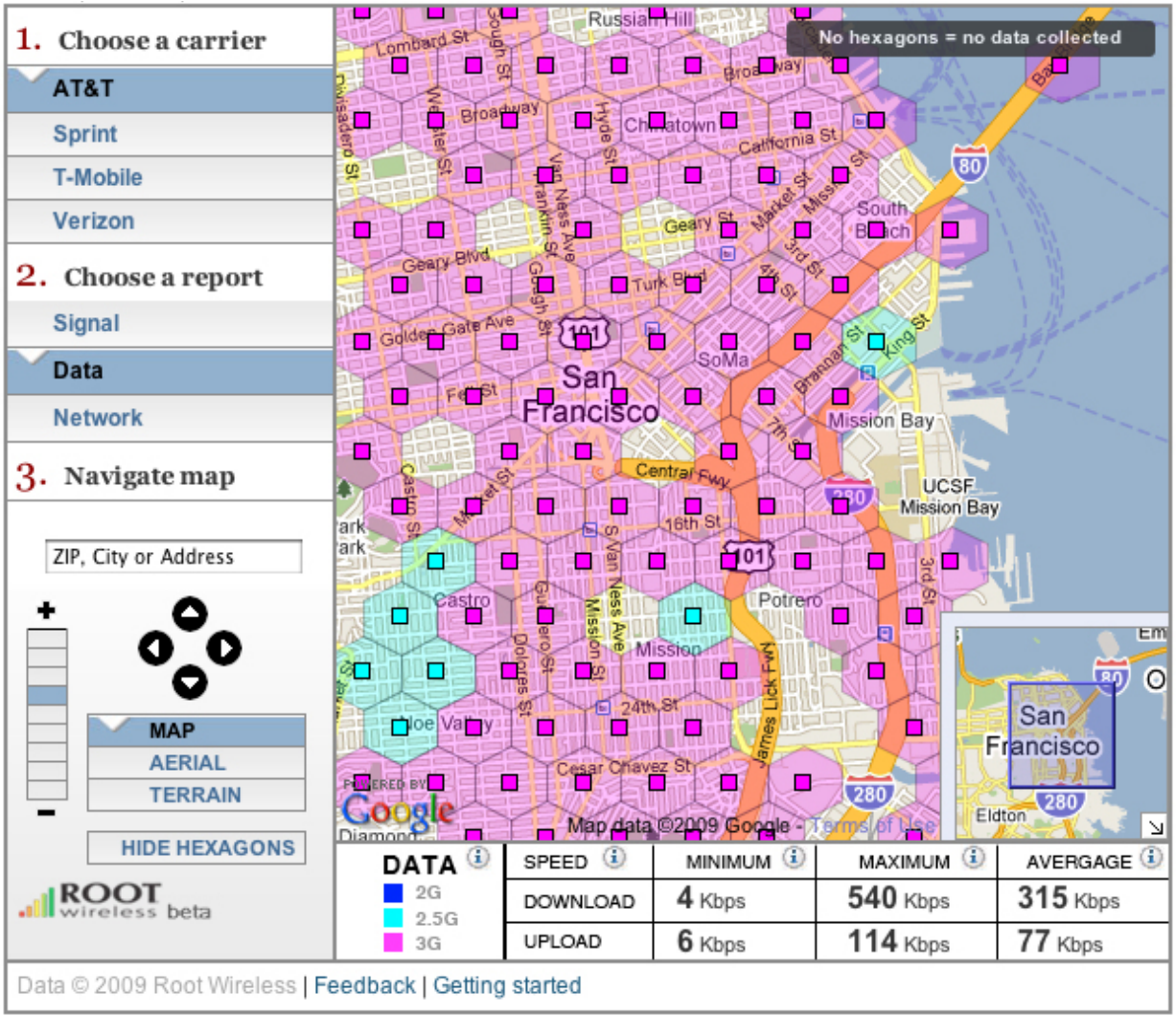


[1] Jeff Howe, "*Crowdsourcing: Why the Power of the Crowd Is Driving the future of Business*," Crown Publishing Group, 2008.

Crowdsourcing Applications

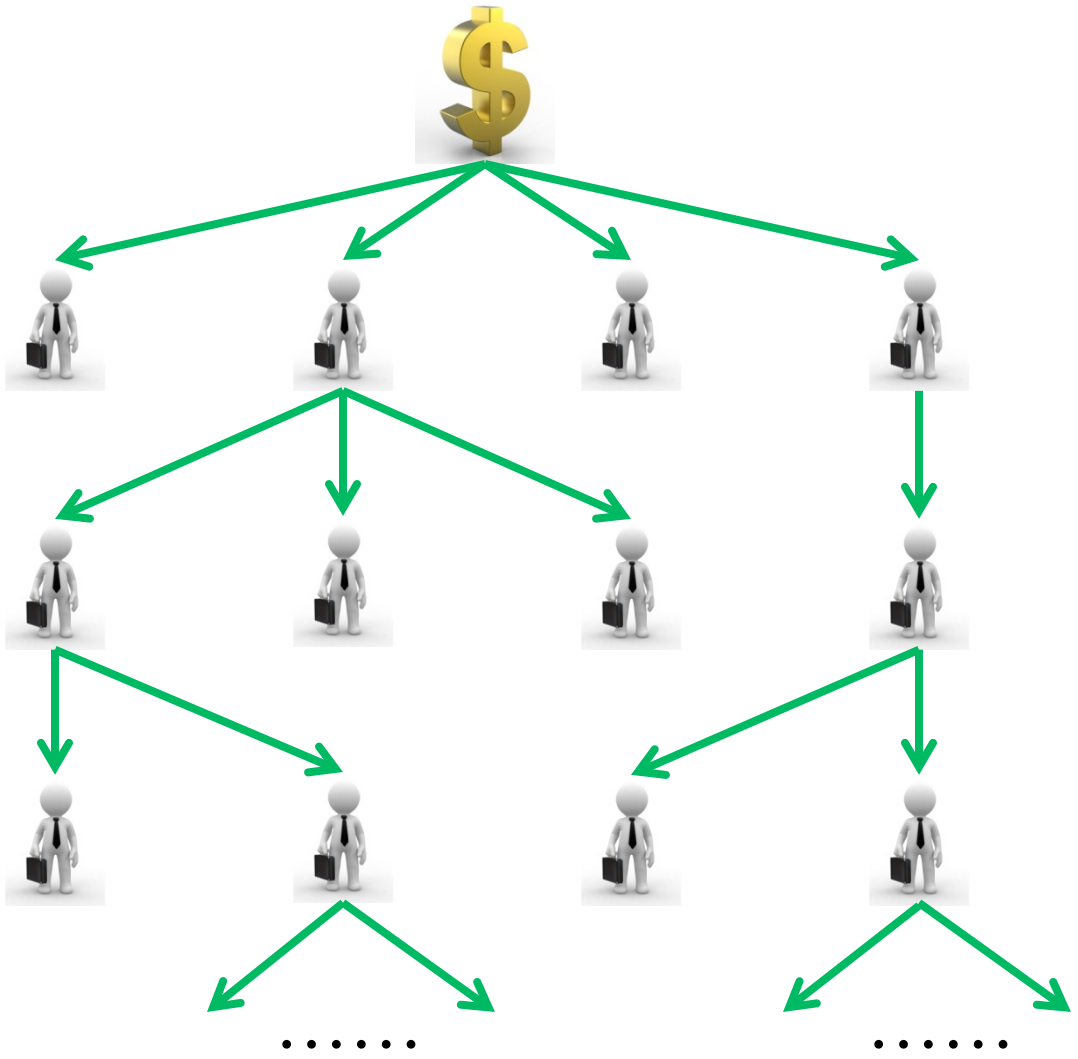
The power of a single provider is limited

- A large nu



Graph source: https://gigaom.com/2010/01/15/crowdsourcing-offers-the-best-cellular-coverage-maps-yet/

Incentive Tree Mechanism



DARPA Network Challenge

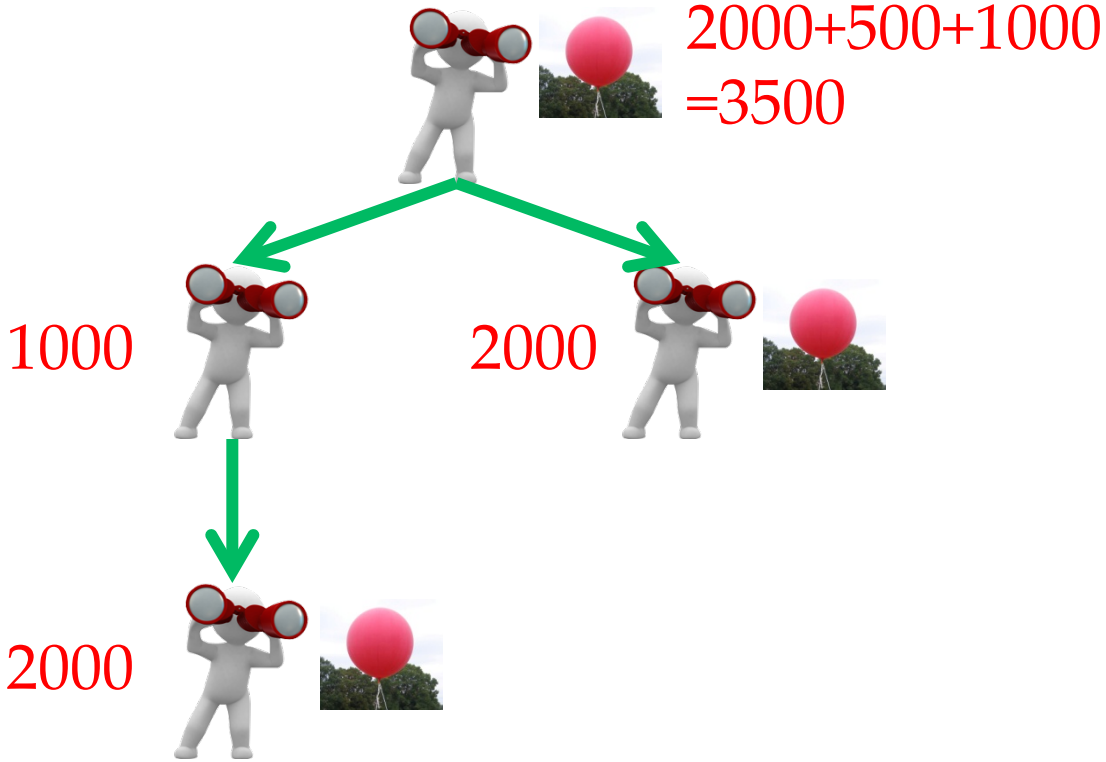
- In 2009, DARPA launched the ***DARPA Network Challenge*** [2], which offered $40,000 for the team to find ***10 red balloons*** randomly deployed in the U.S. in the shortest time.

- An MIT team wan the challenge by applying an ***incentive tree*** mechanism [3] to recruit balloon finders and found all balloons in the shortest time.

- [2] http://archive.darpa.mil/networkchallenge
- [3] G.Pickard, W. Pan, I. Rahwan, M. Cebrian, R. Crane, A. Madan, and A. Pentland, "Time-critical Social Mobilization," Science, vol. 334, pp. 509-512, 2011.

MIT Strategy

- MIT Strategy rewards each balloon finder $2000, the inviter of the finder $1000, the inviter of the inviter $500, and so on…

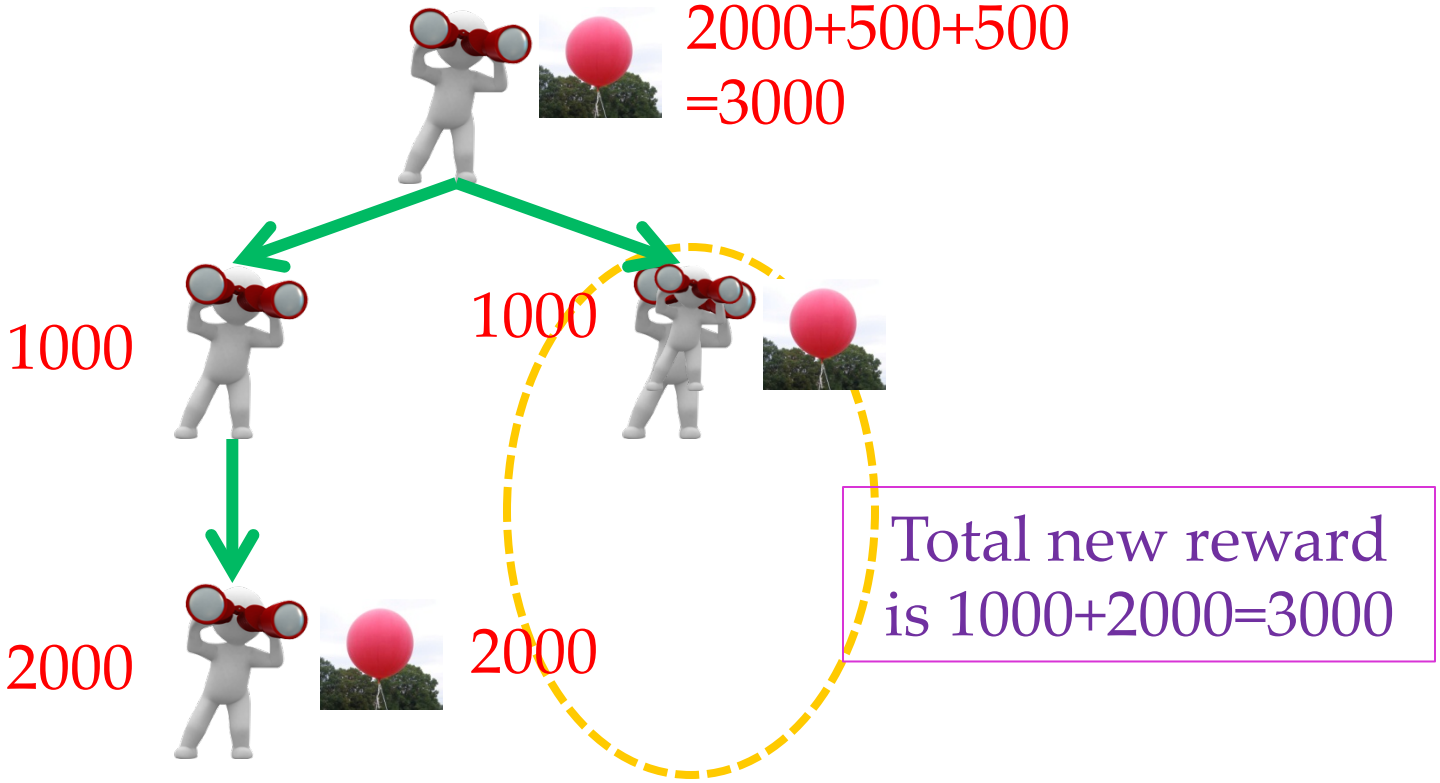


Sybil Attacks

- A *Sybil attack* is that a dishonest individual who creates *multiple fake identities* for extra rewards with no extra contribution devoted.

- Many incentive tree mechanisms are vulnerable to sybil attacks, and it blocks the purpose of solicitation, and encourages providers to generate fake identities instead of make contribution.

Vulnerability of MIT Strategy



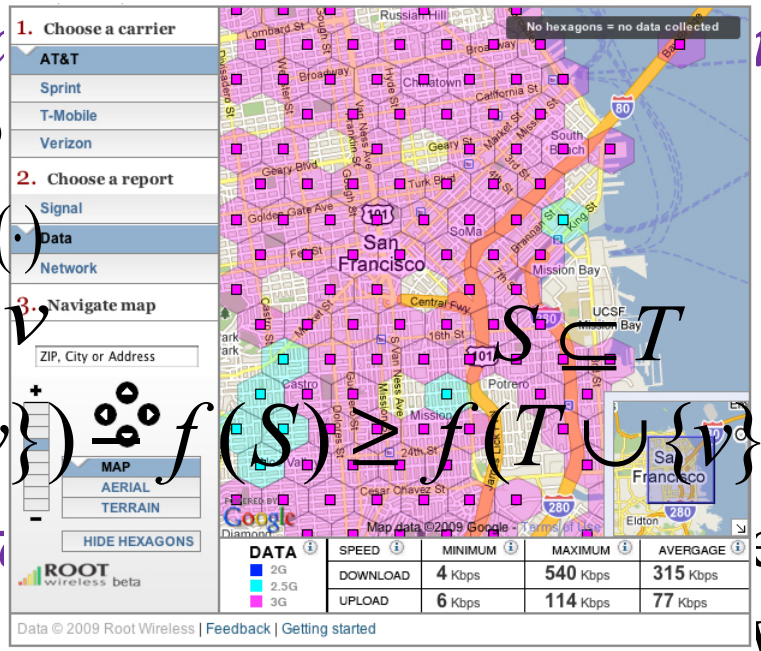
- After the sybil attack, the attacker has a reward of $3000, which is more than what he deserves ($2000)

Submodular & Time-sensitive Contribution

- Most of the research uses a *linear summation* contribution model when calculating the contribution from a set of providers
- However, this is not always true.
- A *submodula* *e sensitive model* is app
- A function $f(\cdot)$ only if, for any element v, $S \subseteq T$

$$f(S \cup \{v\}) - f(S) \geq f(T \cup \{v\}) - f(T)$$

- *Time-sensiti* efforts, the contribution with time



Contribution

- The main contributions of this paper:
  - To the best of our knowledge, we are the first to consider the ***sybil-proof incentive tree*** under the ***submodular and time-sensitive*** contribution model
  - We propose a reward function for the incentive tree, and prove that it satisfies the desired economic properties

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System Model

- A ***task owner*** requires one task to be finished
- potential ***provider*** set $P = \{p_1, p_2, \ldots, p_n\}$
- p_i joins at time t_i
- $C(S)$ is the ***submodular contribution function*** over a subset of providers $S \subseteq P$
- S_{t_i} is the set of providers joining before t_i
- $c(p_i, t_i)$ is the ***time-sensitive marginal contribution*** of provider p_i joining at time t_i :

$$c(p_i, t_i) = C(S_{t_i} \cup \{p_i\}) - C(S_{t_i})$$

- T is the incentive tree; T_i' is the set of providers who are descendants of p_i

Desired Properties of Incentive Tree

- Continuing Contribution Incentive (CCI)

  A provider always has the incentive to make more contribution

- Continuing Solicitation Incentive (CSI)

  A provider always has the incentive to make more solicitation

- θ-Reward Proportional to Contribution (θ-RPC)

  A provider's reward is at least θ times its contribution

- Early Contribution Incentive (ECI)

  A provider always has the incentive to join earlier

- Sybil-proofness

  A provider always no incentive to launch any sybil attack

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Reward Function

- We propose the reward function as $R(p_i, t_i)$

- The mechanism works as follows:
  - The platform announces the task;
  - Each providers makes contribution and solicitation
  - The platform decides the reward for each provider according to this reward function

Theoretic Result

Theorem: The reward function guarantees CCI, CSI, θ-RPC, ECI, and sybil-proofness.

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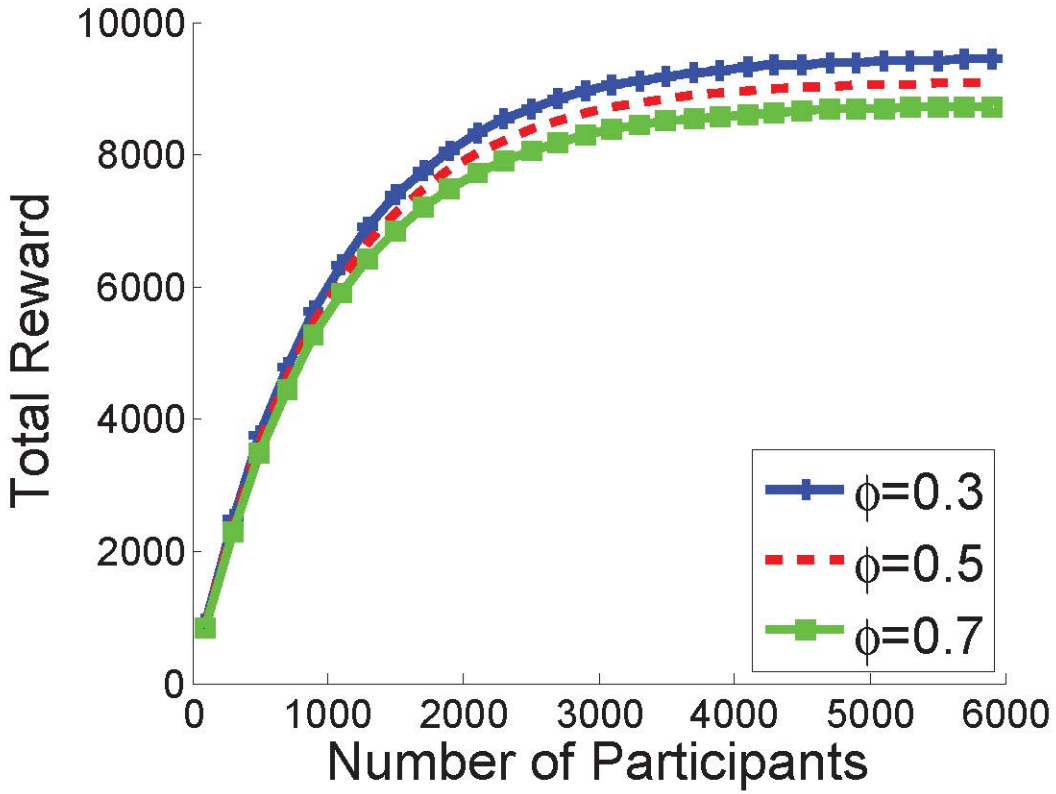
Simulation Setup

- Task size 1000, each provider covers (0,20]
  - The marginal contribution of each provider is the ***marginal coverage size***, i.e., the size that is first covered by the provider
- The number of children for each non-leaf provider is uniformly and randomly distributed over (0,5]
- Averaged over 10,000 instances

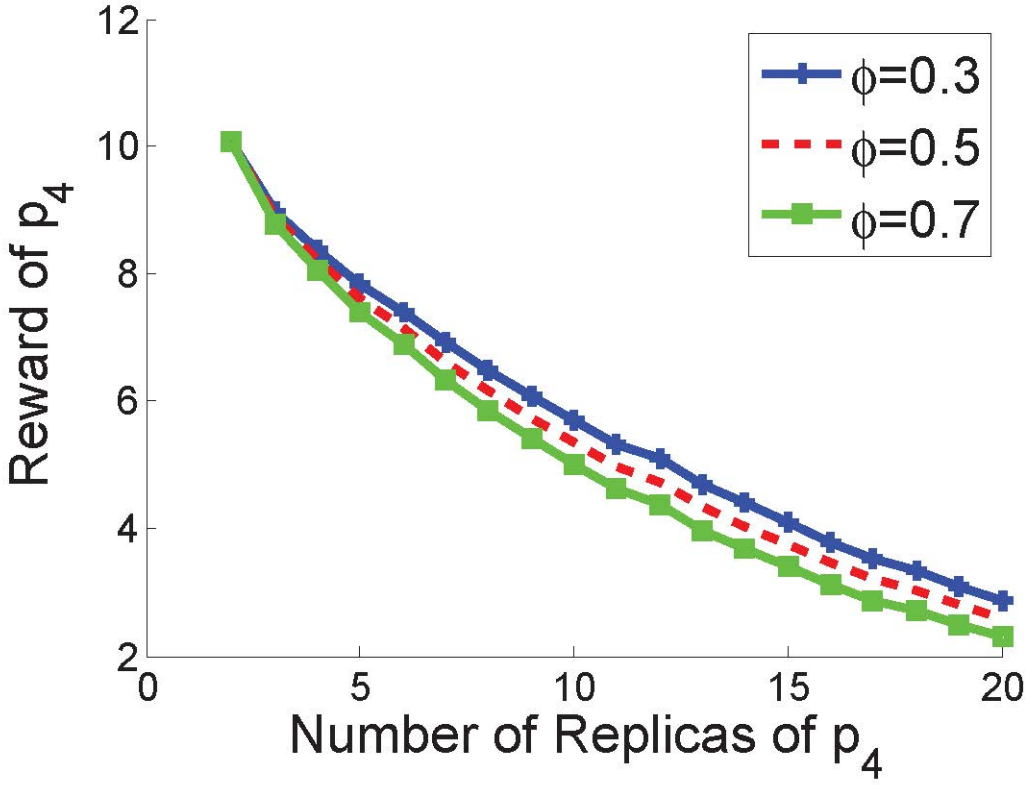
Simulation Result

- Total rewards



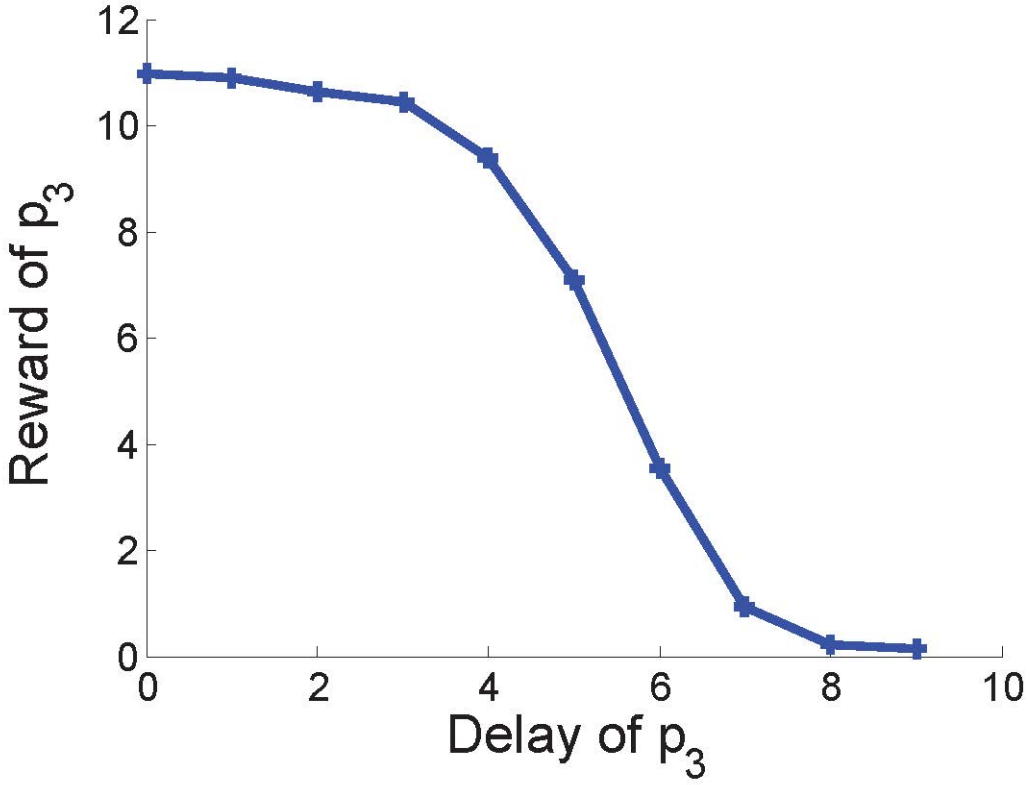
Simulation Result

- Sybil-proofness



Simulation Result

- Time-sensitivity



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- We propose a ***sybil-proof, submodular, and time sensitive*** incentive tree mechanism for crowdsourcing;
- We proved that the mechanism satisfies ***CCI, CSI, θ-RPC, ECI, and sybil-proofness***;
- Extensive evaluation results further confirm our analysis.

Thank you!