Time-Critical Social Mobilization

Andrew Han, Rohan Rai, Nikki Xie

Introduction

With the advent of the internet, tasks that were thought to be impossible can now be achieved through crowdsourcing and can be done at unprecedented speed.

Time Critical Social Mobilization

What?

- An incentive strategy to motivate a large amount of people to contribute to a task that must be completed in a short amount of time

Why?

- Challenging crowdsourcing problems usually requires large number of participants and fast execution.

Characteristics:

- Involvement of mass-media
- Search process
- Appropriate incentives
- Implicit social nature of information diffusion

When Do We Need It?

- Hunting down outlaws

- Health threats and emergencies

- Rallying for political causes

DARPA Network Challenge(2009)

- Goal:
  - Explore the roles the internet and social networking play in the timely communication, wide-area team-building, and urgent mobilization required to solve broad-scope, time-critical problems
- Setup:
  - Ten red balloons are to be releases at points located all across the continental United States.
  - Seven hours each day, for up to a week
  - $40,000 challenge award to the first team to submit the locations
  - Contest was announced one month before the start
  - Considered impossible by conventional intelligence gathering strategies

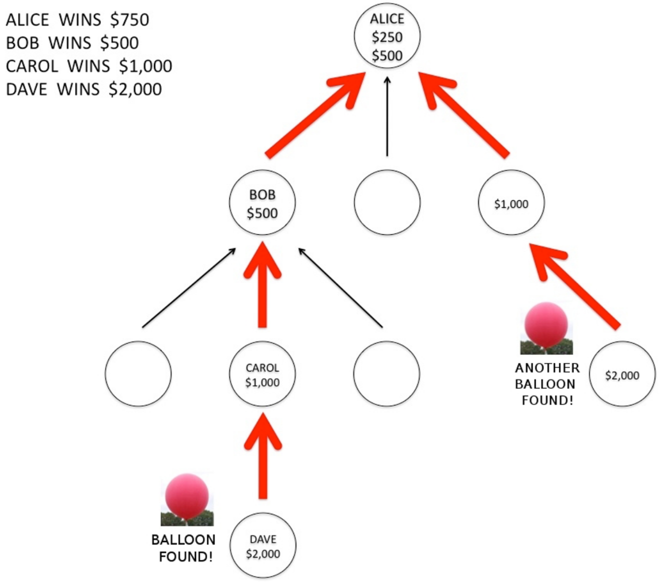
Discussion

- How would you solve the DARPA challenge?

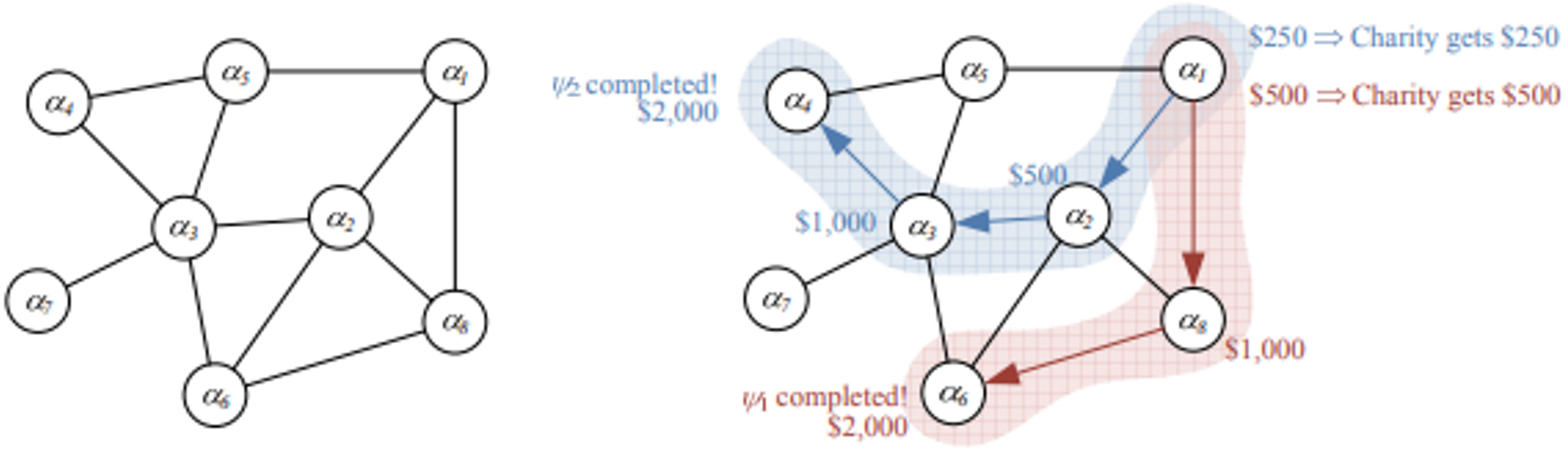
The winning strategy

- MIT won in less than 9 hours by locating every balloon, something no other team managed.
- Done through **recursive incentives**

Using the $40,000 prize, a financial incentive structure was created to reward those who found the balloons and those who connected the finder to MIT. $4000 for 10 balloons. $2000 per balloon to the person who sends in a correct balloon location. $1000 to the person who invited that balloon finder onto the team, $500 to whoever invited the inviter, $250 to whoever invited that person, and so on until you reach the root node (the first recruiter).



Recursive incentives



(a) Example social network. (b) Recruitment tree with two paths (shown in thick lines) initiated by α_1 led to finding balloons.

Measurements

- **size of cascade:**
    - Both in terms of number of nodes and depth
- **attrition rate**: percentage of nodes that terminate the diffusion process
    - E-mail based global search for 18 target persons; AR varying between 60%~68%
    - Diffusion of online recommendation: 91.21%
    - Darpa: 56% ignoring single nodes
- **branching factor**: the number of people recruited by each individual
    - Spread of support for online participations: >90% only one child
    - Newsletter experiment: 2.96 invited, 0.26 subscribed
    - Darpa: 0.93 on average excluding single-node tree (0.80 including single node tree)
        - follows power law distribution (some individuals played important role to diffuse information)
        - A few “Superspreader” individuals do most of the information diffusion and recruiting (high extraversion, charisma)

Other Teams & Strategies

- Georgia Tech (2nd place, 9/10 balloons)
  - appeal to altruism, donate all prize money to charity
  - almost no tweets
  - didn’t amass people as much
  - early start, mass media coverage, and search engine optimization
- George Hotz (4th place, 8/10 balloons)
  - Twitter celebrity with 35,000 followers
  - appeal to an established Internet community of interest
  - short-lived attention
  - most tweets, but less interactivity and motivation(Fig. 4)

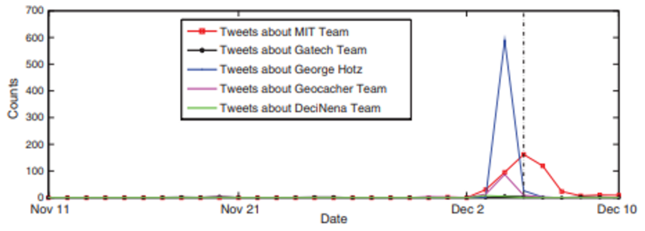


Fig. 4. Raw tweet counts for five teams from the announcement of the challenge to the announcement of the winner. The time series starts at the announcement of the challenge and ends at the announcement of the winner. The dotted line marks the time at which the balloons were launched. The MIT team launched its Web site and mechanism only 2 days before the balloon launch.

Desirable Properties of Recursive Incentives

- Never uses more than its allocated budget

$$\frac{k}{m \cdot 2^i} \qquad \frac{k}{m} \cdot \sum_{i=1}^{x} \left(\frac{1}{2}\right)^i \qquad \sum_{n=1}^{\infty} \left(\frac{1}{2}\right)^n = \frac{\frac{1}{2}}{1-\frac{1}{2}} = 1.$$

- No incentive for a user to start their own root node as payment does not depend on how long the chain is

Vulnerabilities of Recursive Incentives

Examples:

- False name reports
- Duplicate reports and invites
- Inviting yourself
- By doing this, one could theoretically obtain almost the entire reward

$$\rho_j = \sum_{\psi_i | j \in \mathcal{S}(\psi_i)} \frac{v(\psi_i)}{2^{(|\mathcal{S}(\psi_i)| - k + 1)}}$$

$$\sum_{l=0}^{m} \frac{v(\psi_i)}{2^{l+1}}$$

Proposed Solutions:

- Use certified addresses, user rating of reputation, and even criminal prosecution

Discussion

- How can we model Time Critical Social Mobilization that uses recursive incentives in terms of game theory?
- What is the Nash equilibrium of the game?

Modeling the Game

Players: everyone in a network chain that does not include you

Actions: recruit friends or don’t recruit friends

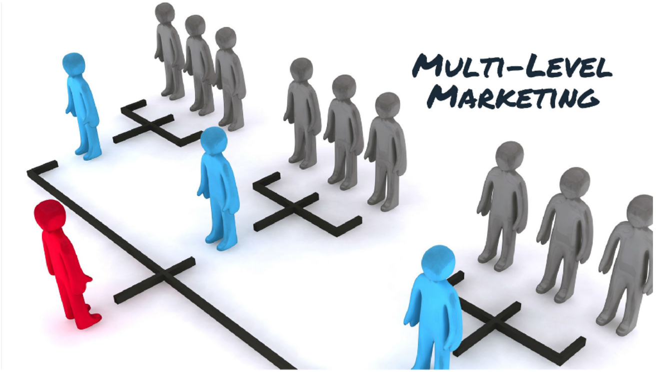
Question: How many friends do you recruit? 1 friend, all your friends, a fraction?

Nash Equilibrium for Recursive Incentives

- Game: recruit 1 to f friends, or do not recruit
- The Nash Equilibrium is to invite all your friends
- Best Case: there are no overlaps in search areas
- Worst Case: adding more people to the search area decreases the probability one member of your chain reports the task: 1/n -> 1/(n+1)
- Assuming you control less than half of the search population, it is always in your best to recruit all your friends!

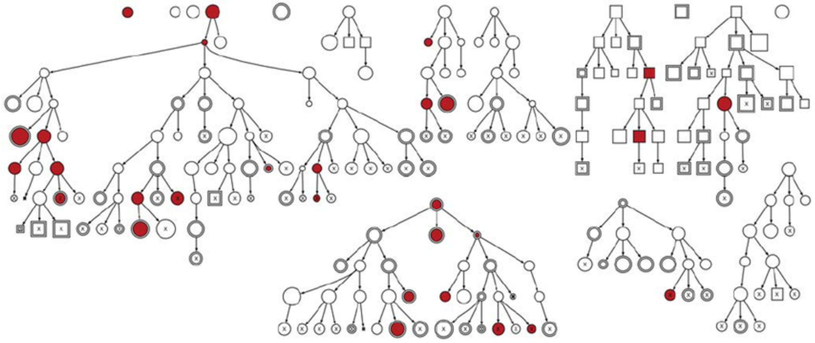
Multi Level Marketing

- A strategy that some direct sales companies use to encourage existing distributors to recruit new distributors
- With the access of information technology this strategy has risen in popularity
- Example: coupons



Referral Tree Model

- Referral forest(T): Collection of directed trees, with nodes that are some buyers who directly purchased products from the seller
- Referral Tree(T_u): rooted subtrees
- Reward of a rooted tree(R_T(u)): the reward of the buyer corresponding to node u under the referral forest T



Constraints

- Subtree Constraint:
  - the reward of the subtree u of T is uniquely determined by the subtree T_u
  - The reward of the subtree u of T depends on the position of u in the forest, so that some users may have undesired behaviors such as delaying buying the product for a better offer(a better position of u in the forest)
- Budget constraint:
  - the seller is willing to spend at most a certain fraction that is less or equal t o1 of her total income on rewarding her buyers for referrals
- Unbounded reward:
  - no limit to the rewards one can potentially receive even if one’s friend circle is limited

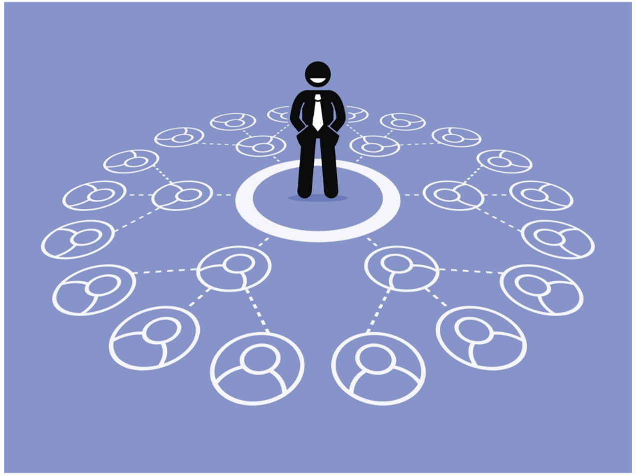
Proposed Reward Mechanism

$$\mathrm{R}(T) = \sum_{u \in T} a^{\mathrm{dep}(u)} \cdot b \, .$$

- Given two constraints 0 < a < 1 and b > 0 such that b + 1 <= 1/a
  - The constraints on a and b ensure that the amount contributed by each node to the reward of its ancestors will not exceed 1.
- Properties:
  - Addictivity
  - Child Dependence
  - Depth Level Dependence

Discussion

- Think of potentially positive examples of multi-level marketing. How would you ensure that it does not become a scam?

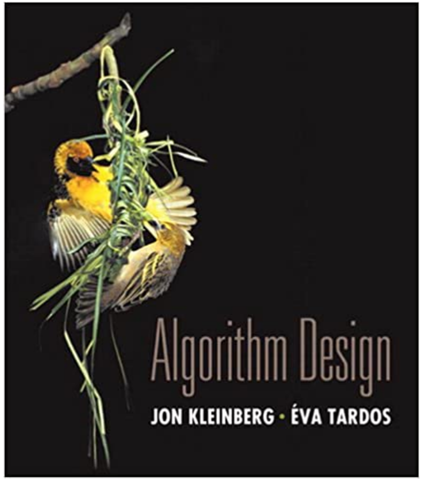


Maximizing the Spread of Influence through a Social Network

- Viral marketing strategies, popularity of “word of mouth” marketing, and game theoretical perspectives, have launched new research in ways to attract consumers
- If we can try to convince a subset of individuals to adopt a new product or innovation, and the goal is to trigger a large cascade of further adoptions, which set of individuals should we target?
- i.e. which individuals have the maximum amount of influence in a social network as represented by a graph?

The answer

- Same authors of this paper as your 347 textbook, lots of analysis of algorithms here
- Selecting the most influential nodes in a social network to maximize spread is NP-Hard (no known polynomial time solution)
- Use an approximation algorithm to find a polynomial time solution



Results

- Empirically proven to obtain 63% of an optimal answer in polynomial time
- A general approach would be useful in handling influence problems
- Some models include the Independent Cascade Model and Linear Threshold model

Models

- Independent Cascade Model: When a node becomes active it has one chance to activate a neighbor. If it succeeds, then the neighbor becomes active but whether or not it succeeds, the node has no other chance for activation.
- Linear Threshold Model: A node is influenced by a neighbor and each node chooses a threshold based on the fraction of neighbors that must be active for the node itself to be active

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