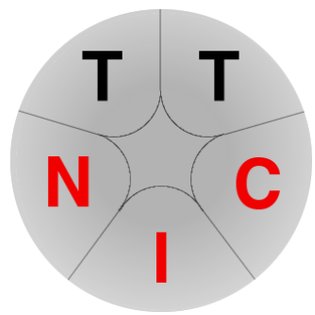
On the Performance of

Heuristics For OSN Revenue Optimization

Inzamam Kaleem Rahaman
inzamam.rahaman@outlook.com

Updated: 2016/02/15



Agenda

Agenda

1. The Problem of Advertising on OSNs
2. A Model for Distributing Ads to Maximize Clicks
3. Heuristics to Improve the Efficiency of the Model

The Problem

Advertising on the Internet

There has been a rapid increase in the use of the Internet in advertising campaigns. Internet campaigns are becoming preferred to traditional mediums due to:

- Ease of deployment
- Ability to target consumers based on additional information
- Wide reach

Using OSNs

OSNs are becoming increasingly popular as a means of advertising. User actions on an OSN and OSN structure, i.e. who is friends with whom, can be mined for information to refine campaigns.

Good vs Bad Campaigns

$$\#\text{ of Purchases generated} \propto \#\text{ of Clicks generated}$$

Hence, the efficacy of an advertising campaign can be determined by the number of clicks that it would generate.

Related Works

Several papers have described methods of assessing influence in OSNs, and using influence in OSNs to affect buying behavior. Abbassi et al.'s model in particular, focuses on allocating impressions on a user-by-user basis, then evaluating the two outcomes (clicked and did not click) before evaluating other users.

Model

Hosein and Lawrence's Model vs Abbassi et al.'s Model

Unlike many other solutions, Hosein and Lawrence's model allocates impressions across several stages. Abbassi et al.'s model can be considered a special case of Hosein and Lawrence's model wherein a single impression is allocated per stage.

Formulation of Hosein and Lawrence's Model

Let the network be a graph, G, with vertex set, V, and edge set E

Let K be the number of stages.

Let k be the number of stages left. Hence, $k = K - 1$ in the first stage, and $k = 0$ in the last stage.

Let vectors, x, u, c, and p for a particular k be indexed by 1 to $|V|$, where x, u, c, and p are defined as follows:

Formulation of Hosein and Lawrence's Model

$$x_k[i] = \begin{cases} 1 & \text{if } i \text{ was previously given an impression} \\ 0 & \text{otherwise} \end{cases}$$

$$c_k[i] = \begin{cases} 1 & \text{if } i \text{ clicked a given past impression} \\ 0 & \text{otherwise} \end{cases}$$

$$u_k[i] = \begin{cases} 1 & \text{if } i \text{ is given an impression in this stage} \\ 0 & \text{otherwise} \end{cases}$$

$$p_k[i] = \begin{cases} \text{prob}(c_{k-1}[i] = 1 | u_k[i] = 1, \vec{x}_k, \vec{c}_k) & \text{if } x_k[i] = 0 \\ 0 & \text{otherwise} \end{cases}$$

Hosein and Lawrence's Model

Consider, a particular u_k. To compute the associated probability, we need to sum across all possible outcomes. Each possible outcome is a vector $v \in \{0,1\}^{|V|}$. For a particular outcome, its probability is

$$Pr(\vec{v}) = \prod_{i=1}^{N} u_k[i]\{p_k[i]v[i] + (1 - p_k[i])(1 - v[i])\} + 1 - u_k[i]$$

Stochastic Dynamic Programming Formulation

Drawing from the above, if we $J^*_{k-1}(\vec{x}_{k-1}, \vec{c}_{k-1}, \vec{p}_{k-1})$ be the optimal expected number of clicks in the subsequent stages, then for any k, the optimal expected number of clicks is

$$J^*_k = \max_{\vec{u} \in \{0,1\}^N} \sum_{\vec{v} \in \mathcal{V}|\vec{u}} Pr(\vec{v}) J^*_{k-1}(\vec{x}^k + \vec{u}, \vec{c}_k + \vec{v}, \vec{p}_{k-1})$$

Stochastic Dynamic Programming Formulation

In the final stage, the optimal expected number of clicks is simply the m_0 users with the greatest probability of clicking, thereby giving us the following formulation for the oth case:

$$J_0^* = |\vec{c}_0| + \sum_{i=1}^{N} p_0[i]u^*[i]$$

Heuristics

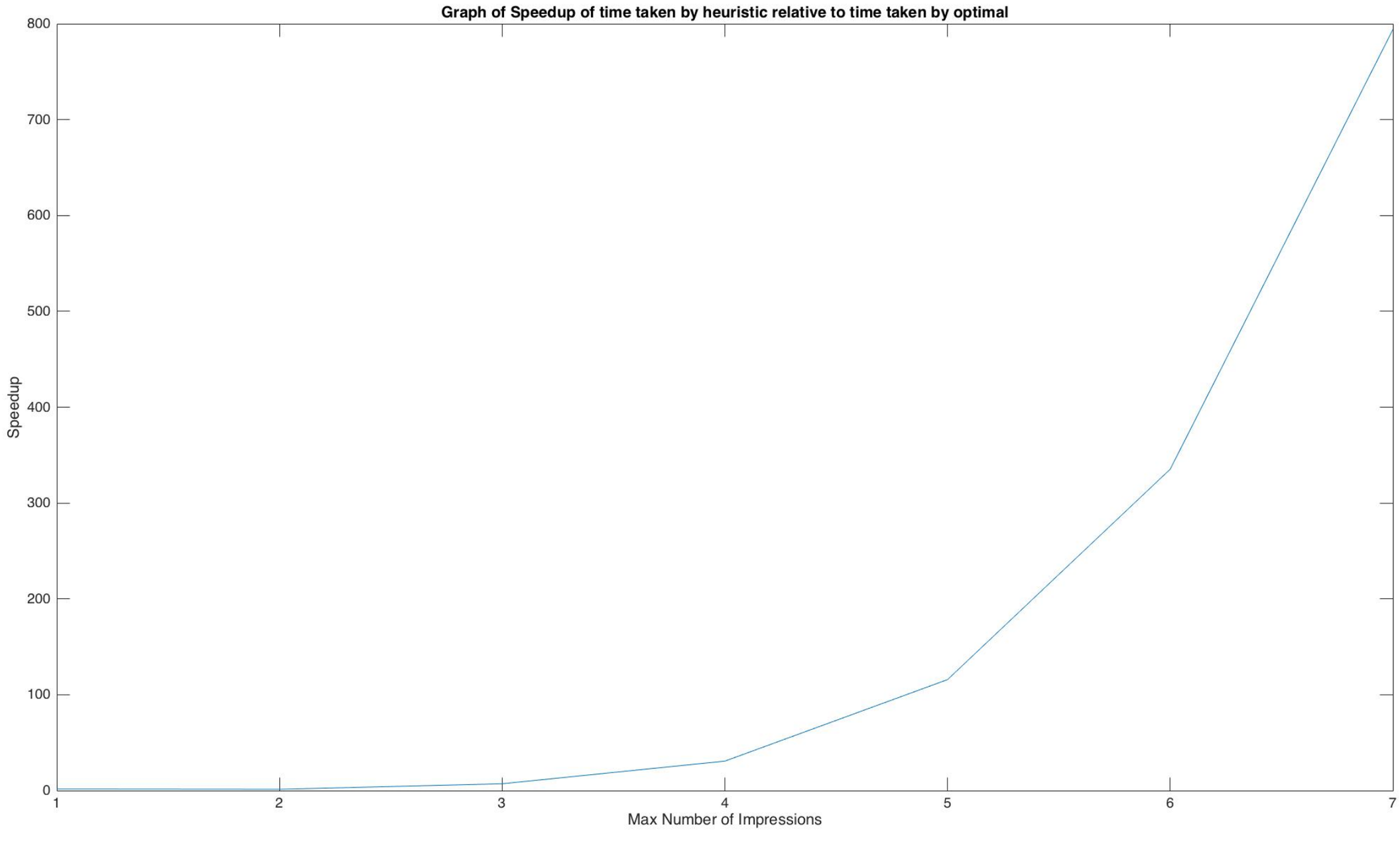
The Need for Heuristics

The above solution, however, is computationally complex. Every single stage problem requires us to solve $\binom{n}{m}2^m$. subproblems. Since OSNs can comprise millions of users, heuristics need to be developed to make the problem more tractable.

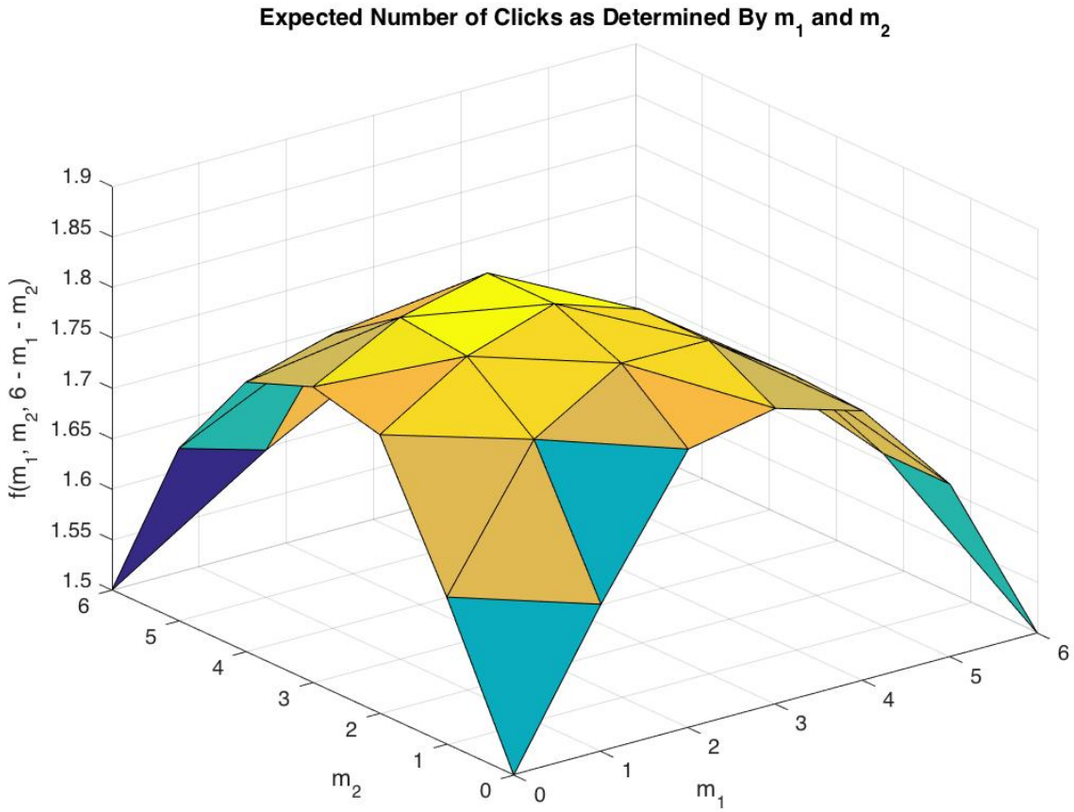
Heuristic #1

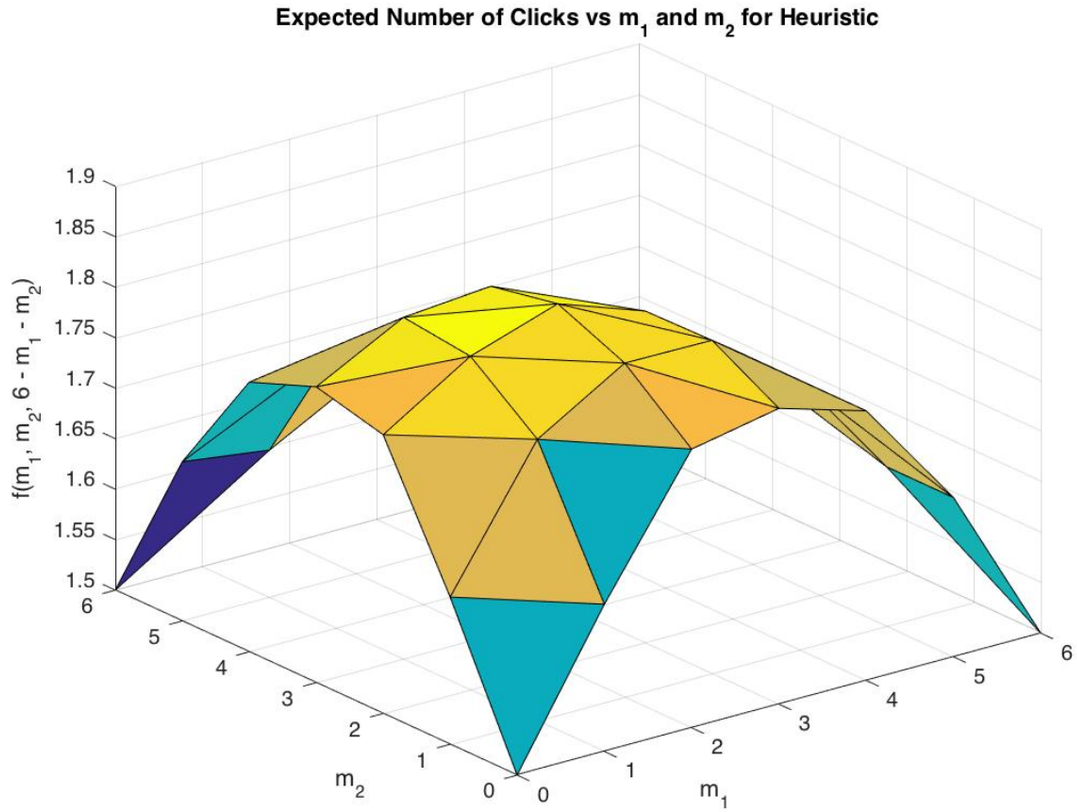
Suppose that we have n users left and m impressions to allocate in some stage k. Iterate through all n users until the user that would provide the largest expected optimal number of clicks, u_1. Then, using u_1, find the next user that when used together with u_1 would yield the highest expected value. Continue this process until we have u_m for stage k.

Heurisic #1 Performance



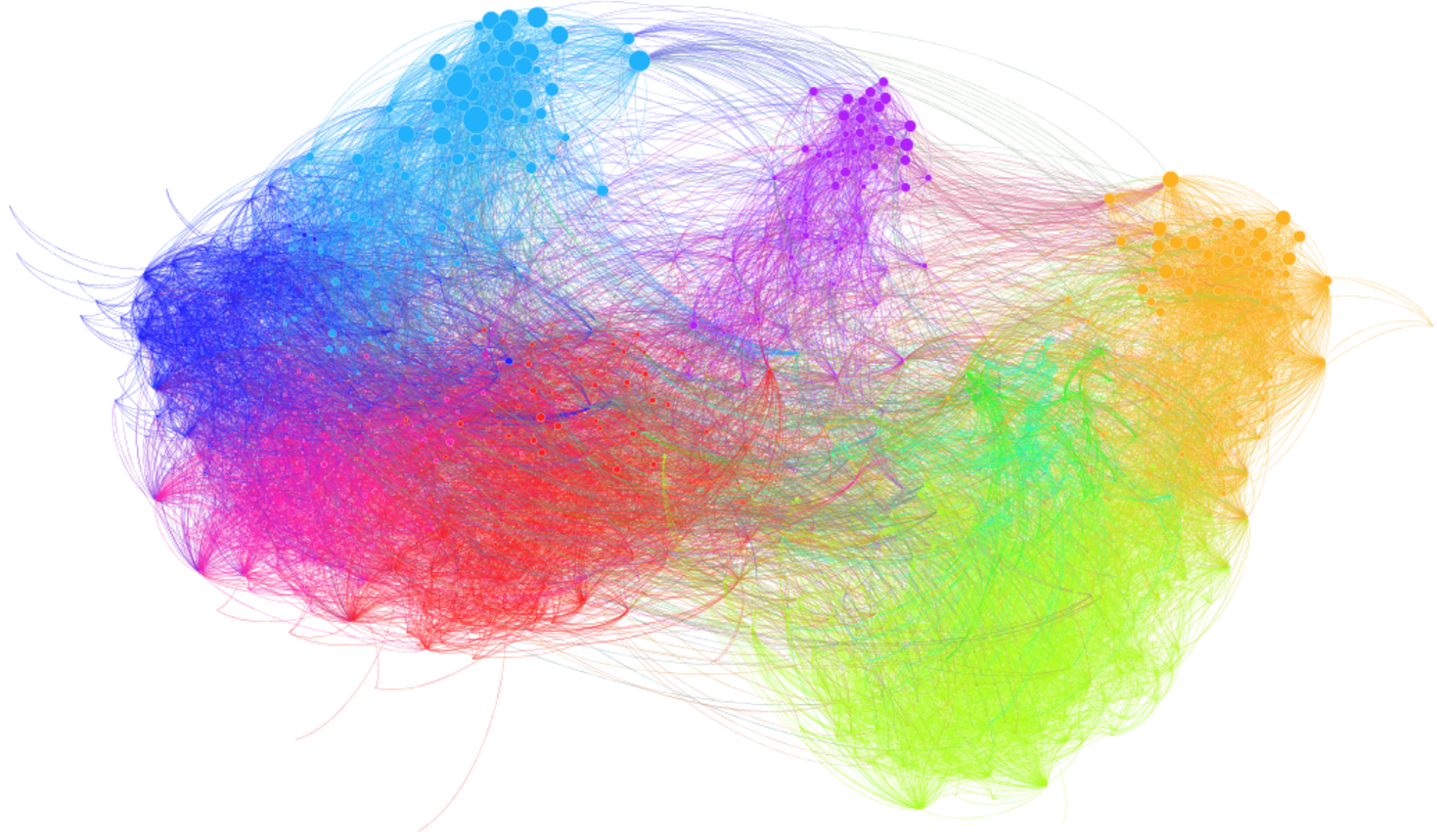
Heuristic #1 Performance





Heuristic #2

Social networks can be partitioned into tight-knight communities.



Heuristic #2

We sort the communities by average internal degree in descending order. Select communities until we have enough nodes to distribute all of the impressions to, and then use these communities to construct a subgraph of the initial social network, thereby reducing the dimensional of the problem.

Future Work

Future Work

- Finding a way to allocate impressions to different clusters
- Determining ways of computing probabilities

Questions?