Efficient dynamic centrality metrics for election advertising - a case study

Soheil Eshghi
Yale Institute for Network Science, soheil.eshghi@yale.edu

Leandros Tassiulas
Yale Institute for Network Science, leandros.tassiulas@yale.edu

Efficient Dynamic Centrality Metrics for Election Advertising – A Case Study

Soheil Eshghi, Leandros Tassiulas
Yale Institute for Network Science
{soheil.eshghi, leandros.tassiulas}@yale.edu

YALE INSTITUTE FOR NETWORK SCIENCE

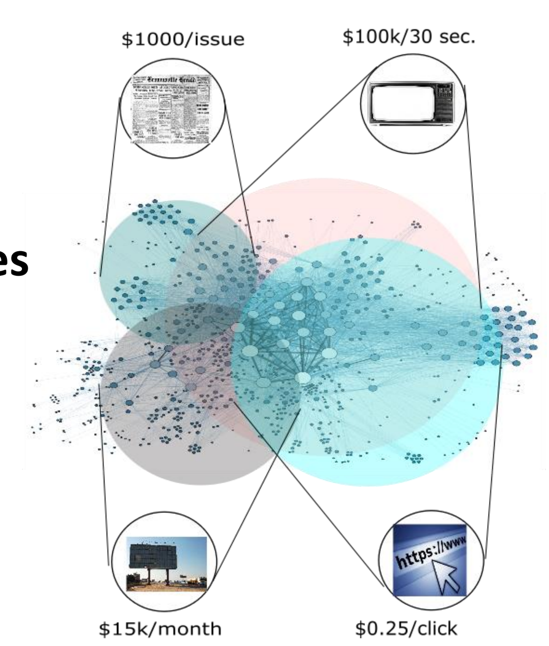
Based on joint work with:
Victor M. Preciado, Saswati Sarkar, Santosh S. Venkatesh (Penn)
Qing Zhao (Cornell), Raissa D'Souza (UC Davis), Ananthram Swami (ARL)

Abstract:

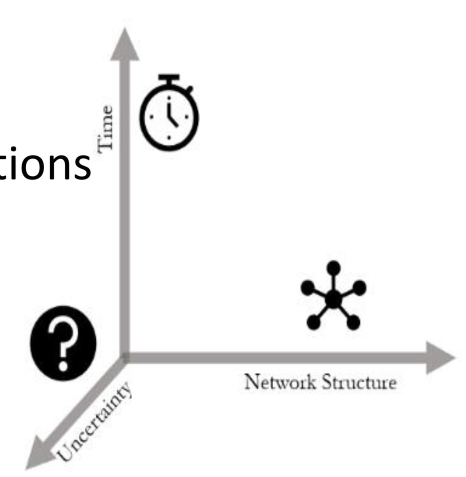
In prior work [1], we have shown how advertising channels should be chosen by a budget-constrained electoral campaign. In this poster, we apply the resulting proposed algorithm to the MIT Social Evolution [2] data-set (N=84), which captured political discussions, inclinations, and voting behaviors around the 2008 US Presidential Election within a student dorm. We compare the resulting centrality metrics developed from our algorithm (which have a direct mapping to optimal channel choice decisions) against more traditional static centralities, and show how employing them leads to more votes.

Problem: How can a political campaign maximize **votes** for their candidate given a **limited budget?**

Advertising channels have:
- Differing **audiences**
- Differing **effects on audiences**
- Differing **costs**



Decision is complicated by:
- **Timing** of ads
- **Discussions** among population
- **Uncertainty** about adversarial actions



This resource allocation decision is important: $9.8 billion was spent on advertising in the 2016 US elections across all channels [3].

YALE DAY OF DATA

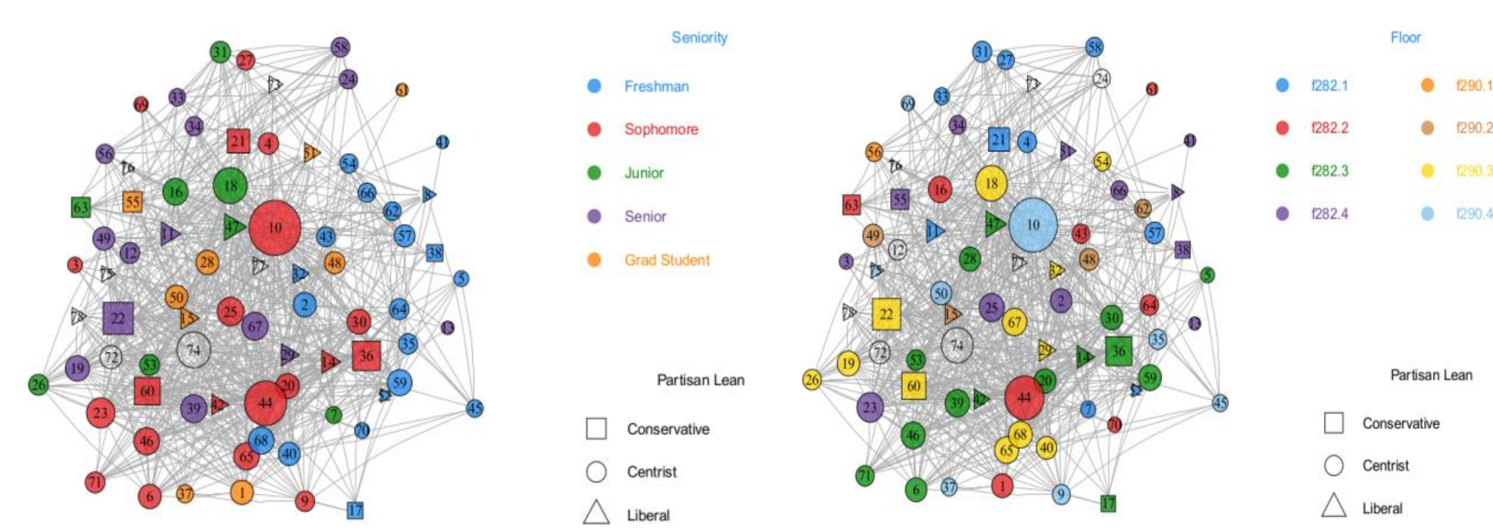
Dataset:

MIT Social Evolution dataset [2]:
"track[ing] the everyday life of a whole undergraduate dormitory with mobile phones"
- Overall: N~100, T= 9 months (5 data-points)

We created the network of political discussions among dorm-members before the 2008 US Presidential election:
- N=84 (N=78 without isolates)
- T= 2 data-points (2008-09, 2008-10)

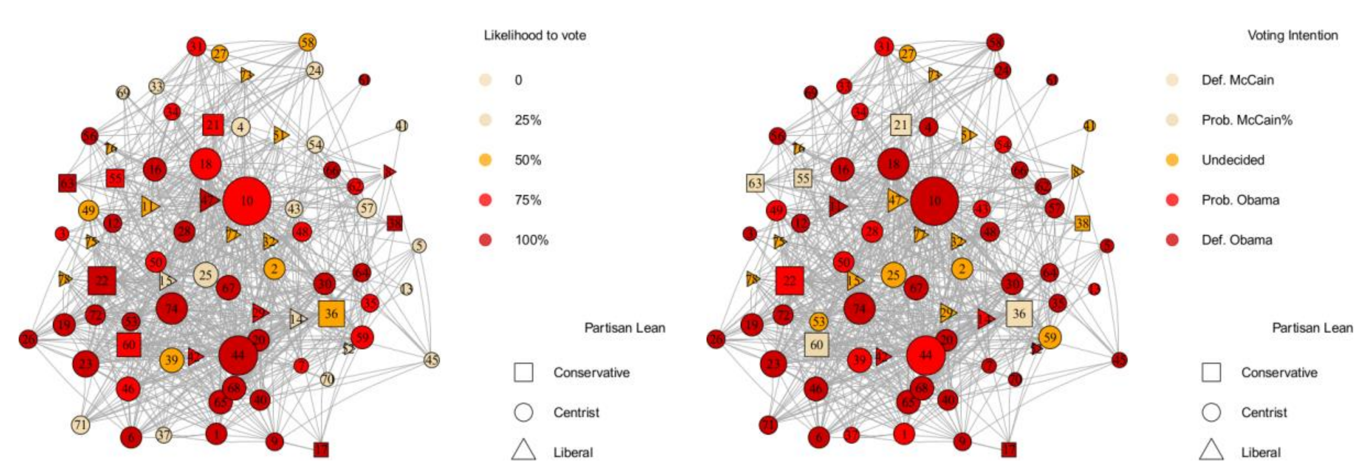
Political discussion network created from self-reported conversations in two-week period prior to surveys:
(Nodes: Individuals, Edges: Discussions, Edge-weights: frequency of discussions).

Possible advertising channels were taken to be based on dorm-room locations (e.g., for flyers) and 5 seniority levels (e.g., for mailing lists). The effect of each channel is modified by the partisan lean of the target (liberal_or_conservative).



It is interesting to see that discussions seem to happen across partisan lines, and there is no observable partisan clustering.

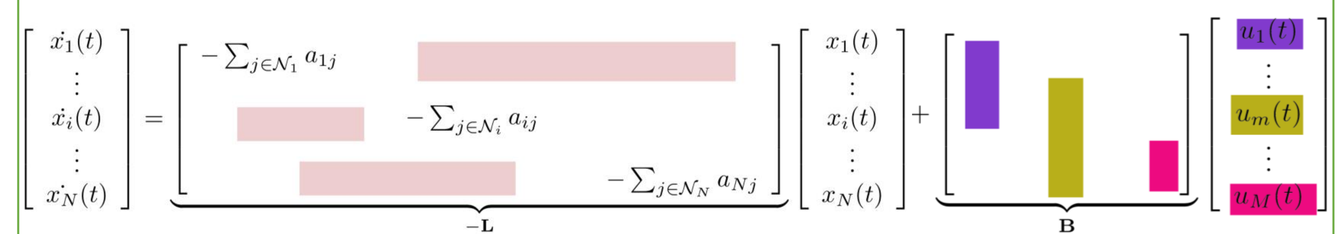
The probability of voting for each individual is derived from their self-reports in 2008-09 (likelihood_of_voting), as is their provisional vote on 2008-09 (voting_for_today).



We can see that likelihood of voting and partisan lean are also mostly unrelated. However, partisan lean is strongly correlated with voting intention.

Theory:

Opinion update models based on Abelson (1964), Taylor (1968), and DeGroot (1974):



Basis:
- Individuals update their opinions in interactions to decrease disagreement
- Their opinions are affected by the advertising channels that target them

Decision-making constraints:

$$0 \leq u_m(t) \leq u_m^{\max}, \quad \forall_{1 \leq m \leq M} \text{ (influence constraint)}$$

$$\int_0^T \sum_{m=1}^{M} c_m(u_m(t))\, dt \leq r \qquad \text{(budget constraint)}$$

Objective: (Simplest case) — Probability of voting

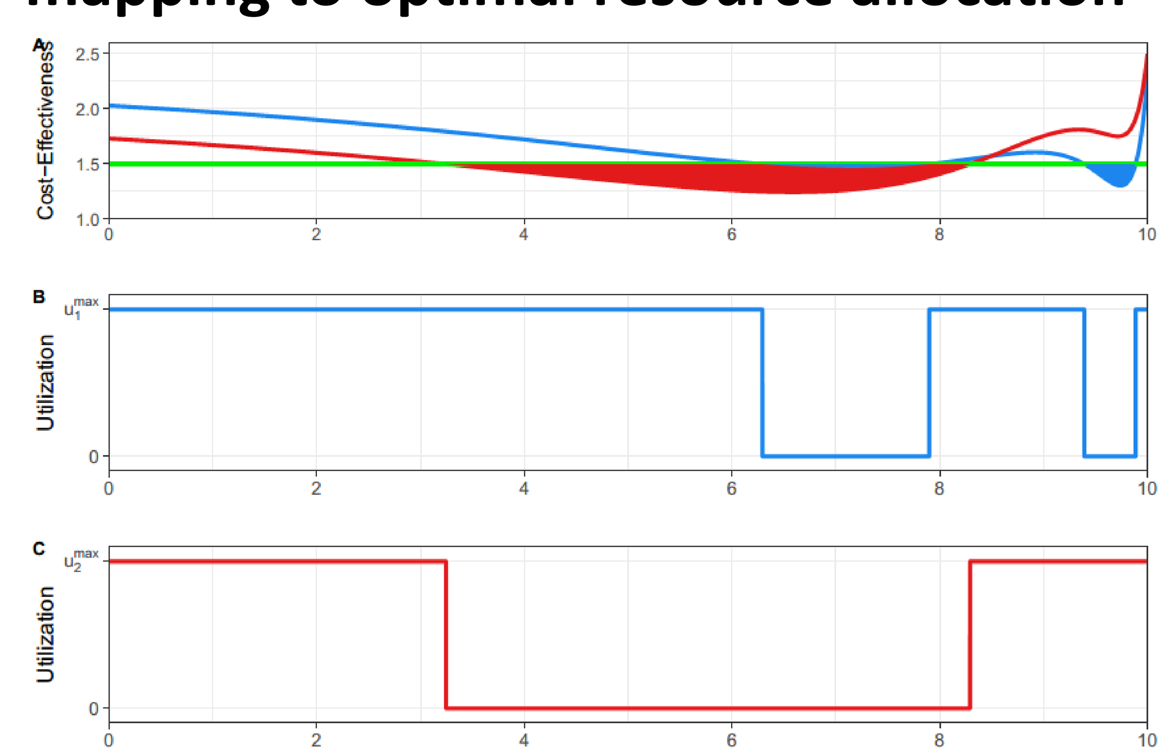
$$J(\mathbf{x}(T)) = \sum_{i=1}^{n} J_i(x_i(T)) = \sum_{i=1}^{n} p_i x_i(T)$$

In [1], we fully characterize the structure of the optimal resource allocation among channels, and show that it is directly mapped to a water-filling problem based on the following novel dynamic cost-effectiveness centralities.

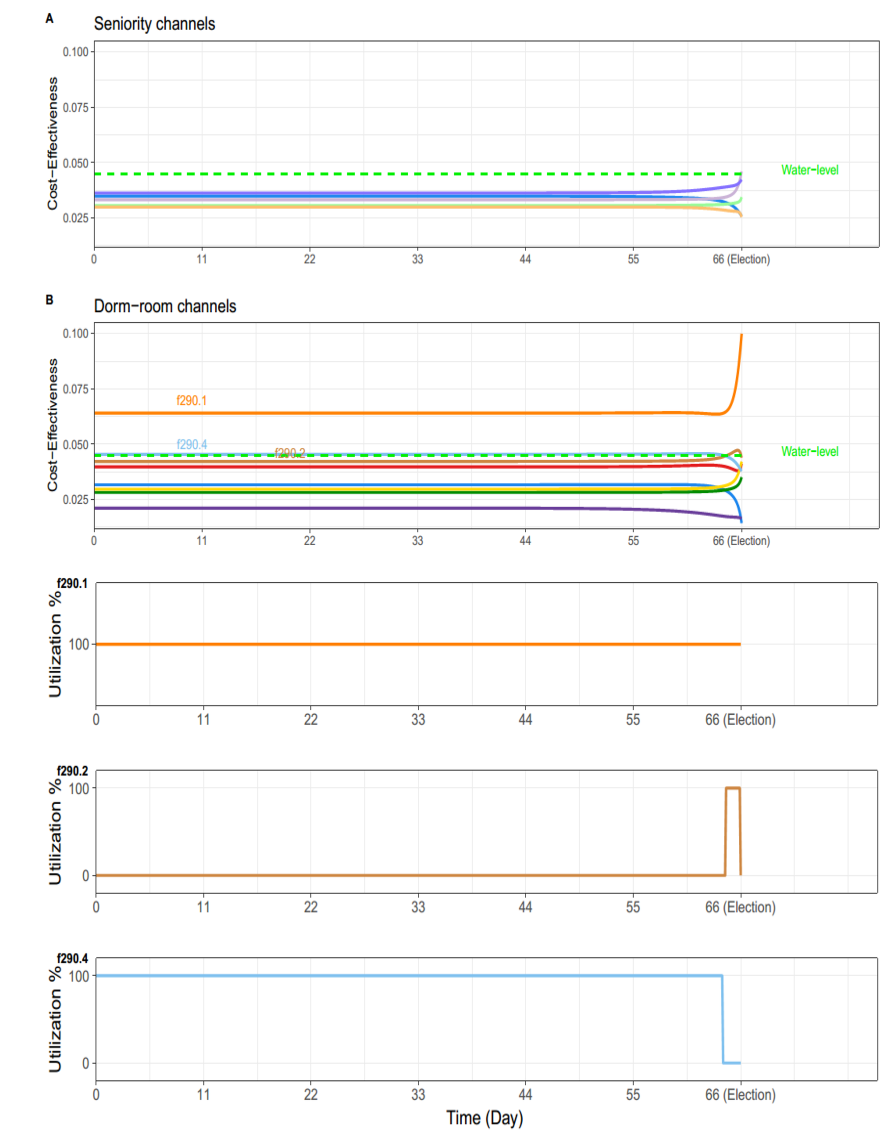
$$h_i(t) := \sum_{j=1}^{n} (\mathbf{Q_j}^T \mathbf{p})(\mathbf{Q_j}^T \mathbf{B}_i) e^{-\xi_j (t-T)}$$

Here, $\mathbf{Q_j}$ and ξ_j are the j-th eigenvector and eigenvalue of the Laplacian (discussion) matrix.

Water-filling solution method and mapping to optimal resource allocation



Results:



Basis of decisions	Expected Votes
Optimal Allocation*	39.03
Between-ness centrality	30.82
Eigen-centrality	29.16
Page-rank	29.89
Degree centrality	30.03

Summary:

We applied our dynamic decision-making algorithm for maximizing votes obtained in an election to the MIT Social Evolution data-set. We showed that using dynamic centralities improves outcomes (vote totals) **by over 26% as compared to heuristics.**

References:

[1] Eshghi, S., Preciado, V.M., Sarkar, S., Venkatesh, S.S., Zhao, Q., D'Souza, R. and Swami, A., 2017. Spread, then Target, and Advertise in Waves: Optimal Capital Allocation Across Advertising Channels. arXiv preprint arXiv:1702.03432.
[2] A. Madan, M. Cebrian, S. Moturu, K. Farrahi, A. Pentland, Sensing the 'Health State' of a Community, Pervasive Computing, Vol. 11, No. 4, pp. 36-45 Oct 2012
[3] K. Kaye, "Data-driven targeting creates huge 2016 political ad shift: broadcast tv down 20%, cable and digital way up," Ad Age, January 3, 2017