This dissertation addresses the problem of influence maximization in social networks. Influence maximization is applicable to many types of real-world problems, including modeling contagion, technology adoption, and viral marketing. Here we examine an advertisement domain in which the overarching goal is to find the influential nodes in a social network, based on the network structure and the interactions, as targets of advertisement. The assumption is that advertisement budget limits prevent us from sending the advertisement to everybody in the network. Therefore, a wise selection of the people can be beneficial in increasing the product adoption. To model these social systems, agent-based modeling, a powerful tool for the study of phenomena that are difficult to observe within the confines of the laboratory, is used.

To analyze marketing scenarios, this dissertation proposes a new method for propagating information through a social system and demonstrates how it can be used to develop a product advertisement strategy in a simulated market. We consider the desire of agents toward purchasing an item as a random variable and solve the influence maximization problem in steady state using an optimization method to assign the advertisement of available products to appropriate messenger agents. Our market simulation accounts for the 1) effects of group membership on agent attitudes 2) has a network structure that is similar to realistic human systems 3) models inter-product preference correlations that can be learned from market data. The results on synthetic data show that this method is significantly better than network analysis methods based on centrality measures.

The optimized influence maximization (OIM) described above, has some limitations. For instance, it relies on a global estimation of the interaction among agents in the network, rendering it incapable of handling large networks. Although OIM is capable of finding the influential nodes in the social network in an optimized way and targeting them for advertising, in large networks, performing the matrix operations required to find the optimized solution is intractable. To overcome this limitation, we then propose a hierarchical influence maximization (HIM) algorithm for scaling influence maximization to larger networks. In the hierarchical method the network is partitioned into multiple smaller networks that can be solved exactly with optimization techniques, assuming a generalized IC model, to identify a candidate set of seed nodes. The candidate nodes are used to create a distance-preserving abstract version of the network that maintains an aggregate influence model between partitions. The budget limitation for the advertising dictates the algorithm’s stopping point. We show on synthetic dataset that our method comes close to the optimal node selection, at substantially lower runtime costs.

We present results from applying the HIM algorithm to real-world datasets collected from social media sites with large numbers of users (Epinions, SlashDot, and WikiVote) and compared it with two benchmarks, PMIA and DegreeDiscount, to examine the scalability and performance. Our experimental results reveal that HIM scales to larger networks but is outperformed by degree-based algorithms in highly-connected networks. However, HIM performs well in modular networks where the communities are clearly separable with small number of cross-community edges. This finding suggests that for practical applications it is useful to account for network properties when selecting an influence maximization method.

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