Chapter 31
Campaign Optimization through Mobility Network Analysis

Yaniv Altshuler
Endor, Israel

Erez Shmueli
Tel-Aviv University, Israel

Guy Zyskind
Massachusetts Institute of Technology, USA

Oren Lederman
Massachusetts Institute of Technology, USA

Nuria Oliver
Telefonica Research, Spain

Alex "Sandy" Pentland
Massachusetts Institute of Technology, USA

ABSTRACT

Optimizing the use of available resources is one of the key challenges in activities that consist of interactions with a large number of "target individuals", with the ultimate goal of affecting as many of them as possible, such as in marketing, service provision and political campaigns. Typically, the cost of interactions is monotonically increasing such that a method for maximizing the performance of these campaigns is required. This chapter proposes a mathematical model to compute an optimized campaign by automatically determining the number of interacting units and their type, and how they should be allocated to different geographical regions in order to maximize the campaign's performance. The proposed model is validated using real world mobility data.

INTRODUCTION

In a world of limited resources, behavior change campaigns (*e.g.* marketing, service provision, political or homeland security) can rely on creativity and attractiveness up to a certain point. The success of a campaign can generally be defined as the product of *reach* - portion of the population exposed to the campaign messages - and *value* of a single interaction - the capacity of a message to induce a certain behavior in an exposed audience (Danaher & Rust, 1994). Hence, campaign managers typically distribute their budget between content enhancement (to increase the value a single interaction) and wide

DOI: 10.4018/978-1-5225-1793-1.ch031

reach. Yet, to date it seems that the optimal trade-off between these two factors is found as a result of "intuition" rather than based on well-established analysis.

This chapter proposes a novel mathematical method that, given the characteristics of the target audience and its ability to be persuaded, generates an optimized campaign strategy in terms of: (a) the quantity of interacting units, also referred to as *insertions* and (b) the monetary allocation to each unit. The model takes into account the population's mobility in an urban environment as it can be inferred from real data received from a large mobile phone carrier. Even though different populations located in different environments would be tailored with different campaign strategies, the optimality of each strategy would be maintained.

A major contribution in the optimization model is the use of network analysis methods to approximate the reach of a campaign. More specifically, given the network of mobility between the different geographic locations, and a subset of locations, the *Group Betweenness Centrality* (GBC) (Everett & Borgatti, 1999) – a network measure that calculates the percentage of shortest paths among all pairs of network nodes that pass through a pre-defined sub-set of the network's nodes – is used to approximate the reach of this subset of locations. Then, it is demonstrated how this function can be approximated using a smooth and easily analyzed *Gompertz* function. This tackles the main limitation of works on campaign optimization hitherto – efficiently estimating the campaign reach as a function of the number of units and their locations.

Finally, the proposed campaign optimization model is validated using two real-world mobility networks inferred from CDR data and taxi-rides, and it is demonstrated how GBC based deployment of campaign units outperforms several common alternatives.

This chapter is an extension of the work that was published by Altshuler et al. (2014). The main addition to that work is the analysis of an additional and totally different type of mobility dataset, namely the taxi rides dataset. The addition of this new dataset better demonstrates the feasibility and the versatility of our framework.

BACKGROUND

In recent years the social sciences have been undergoing a digital revolution, heralded by the emerging field of "computational social science". Lazer et. al (2009) describe the potential of computational social science to increase our knowledge of individuals, groups, and societies, with an unprecedented breadth, depth, and scale. Computational social science combines the leading techniques from network science (Barabasi & Albert, 1999; Newman, 2003; Watts & Strogatz, 1998) with new machine learning and pattern recognition tools specialized for the understanding of people's behavior and social interactions (Eagle et al., 2009).

Marketing campaigns are essential facility in many areas of our lives, and specifically in the virtual medium. One of the main thrusts that propels the constant expansions and enhancement of social network based services is its immense impact on the "real world" in a variety of fields such as politics, traditional industry, currency and stock trading and more. This field is becoming increasingly popular (Eagle et al., 2010; Leskovec et al, 2007), due to the possibility of increasing the impact of campaigns by using network related information in order to optimize the allocation of resources in the campaign. This relies on the understanding that a substantial impact of a campaign is achieved through the social influence of people on one another, rather than purely through the interaction of campaign managers