Social Mobilization in Context

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1 Introduction

The Internet and online social media are now credited with the unprecedented ability to coordinate the mobilization of large masses of people to achieve incredible feats that require coverage of large geographical and informational landscapes in very limited time. Endeavors like the DARPA Network Challenge [1] aimed to push the power of the Internet and social media in time-critical social mobilization to its absolute limits. The Network Challenge required competing teams to locate and submit the coordinates of 10 tethered weather balloons dispersed at random locations all over the continental United States. The winning team, based at MIT, won the challenge by locating all balloons in less than 9 hours.

In this work, we build on recent results on social network structure, information diffusion and urban economics, to elucidate the constraints that they pose on social mobilization. In particular, we conduct high-resolution simulations of the DARPA Network Challenge. We obtain statistical characterizations of the population recruited, geography covered, and time to locate the 10 balloons, together with their dependencies on the instrumental variables.

Our results demonstrate, surprisingly, that the DARPA Network Challenge outcome is plausible, and thus it is not simply a fluke that can only be explained by the role of mass media. Having said that, the challenge lies at the limits of time-critical social mobilization. Mobilization requires highly connected, highly active individuals to be motivated to propagate the message to a large number of friends, and to mobilize people in distant locations, overcoming the local trapping of diffusion in highly dense areas. Moreover, even in highly favorable conditions, the risk of mobilization failure remains significant. These findings have implications on the design of better incentive schemes for social mobilization. They also call for caution in estimating the reliability of this capability.

2 Simulation Method

In seeking to understand social mobilization, we must consider the many different dynamics that underpin such a process. In particular the branching dynamics of recruitment, the temporal dynamics of message propagation, the geographical spread of social networks, and the scales and aspects of human mobility.

In accordance with the empirical data from [2], our simulations model a branching recruitment process which begin with an atypical initial burst of recruitment and then continues to propagate according to a power law distribution with a mean reproductive number below the tipping point.

We model the waiting time between receiving and propagating messages in a viral recruitment process after [3]. In a study of a viral email campaign, the time taken to forward a message was found to be log-normally distributed with a mean of 1.5 days. This large heterogeneity has a deep impact in the propagation of information: cascade dynamics is halted by the few individuals with very short response times and thus recruitment events may continue up to the order of years after the seed node starts the cascade.

Liben-Nowell et al analysed a blogging network and noted that friendship correlates more strongly with rank, a measure of the number of closer people, than simply with distance between two people [4].

\[ P_{ij} \propto \frac{1}{\sum_{r_{i\rightarrow j}} p_r} \]  \hspace{1cm} (1)

Where \( P_{ij} \) is the probability of friendship between agents \( i \) and \( j \), \( r_{i\rightarrow j} \) is the vector between the agents and \( p_r \) is the population at \( r \). Thus the spatial distribution of a person’s friends is now strongly dependent on the local population density; with the effect that 2 people separated by a given large distance are more likely to be friends in a rural region than a dense, urban environment. In our simulation, we apply this model of friendship over high-resolution population density data.
In addition to the branching, temporal and friendship mechanisms above, we investigate the role of two other mechanisms: passive recruitment, and mobility. Passive recruitment gives a measure of the number of new recruits each individual successfully invites but not the larger hidden network of individuals who search but do not sign-up or recruit others. While this process is by definition hard to quantify, a good measure of this number is the number of friends a user of a typical social networking service has. The average degree is around 200 with a large range, but it is observed to be up to 400 amongst the most active users [5], it is these users which have been observed to drive such viral recruitment processes [3].

Census data provides a record of where individuals live, but limiting an individual’s effective search area to their home ignores their ability to search their vicinity due to their mobility. We define a fixed mobility radius allowing agents to locate balloons within a neighborhood of size \( r_{\text{mob}} \). A recent study found that on timescales appropriate for time-critical social mobilization (i.e. up to 12 hours) radii of gyration reached 1-2km[6].

3 Results

The main figure of (1) shows the distribution of completion times for successful search using realistic values of mobility radius and passive recruitment. A large variation is seen in completion times, however there is clear correspondence to the observed completion time of 48 hours [2]. The inset gives the ‘natural’ distribution of completion times for unsuccessful searches excluding the additional mechanisms of mobility and passive recruitment.

![Figure 1: Completion Times Averaged over 500 Searches](image)

We consider the ‘searchability’ \( s_i \) of each simulation cell (Figure (2))

\[
s_i = \frac{n_{\text{searched}}}{N} \tag{2}
\]

Where \( n_{\text{searched}} \) is the number of times cell \( i \) is searched in \( N \) searches (\( N=10,000 \) in Figure (2)). Figure (2, black line) demonstrates this trend amongst all cells.

We expect intuitively that adding more people gives increased opportunities to locate a balloon, which the steep linear trend in Figure (2) demonstrates. We also expect that this payoff decreases once sufficiently many people are added that their presence hinders the location of a target. We refer to this quality as the blendability \( b \) of a place. This could be caused by sensory overload in places with many people and so, many stimuli, diminished feelings of individual responsibility to report sightings in large crowds [7] or simply the increased complexity of the physical urban environment. We assume that the scaling behaviour of the blendability follows the result of Bettencourt et al. [8] in which patent activity, wages and crime among others, all scale with population as a power law with exponent \( \beta \approx 1.25 \), the superlinear behaviour describing an economy of scale. We define blendability as the urban complexity per person. Scaling the searchability by the blendability yields the final findability.

The blendability and findability are plotted as the blue and black curves respectively in Figure (2). We isolate a regime of population density defined by a findability greater than 0.8, which corresponds to the grey shaded region, with a population density of \( [1,100 - 13,500\text{km}^{-2}] \). Comparing Midtown Manhattan (population density 36,627km\(^{-2}\)) with nearby Asbury Park, New Jersey (population density 4,975km\(^{-2}\)) we see that, counterintuitively, it is easier to hide in the latter than the former.

Our main finding is that, in contrast to popular reaction to the DARPA Network Challenge, success could actually be expected under realistic parameters, though these parameters lie at the limit. Success strictly depends on the presence of highly-connected individuals, whose temporal reaction lies at the lower end of the distribution, ensures a mobilization that is sufficient for finding all
balloons. Assuming an initial burst of motivated individuals, success takes place despite the branching factor being lower than the critical point.

Having said that, we find two sobering and instructive qualifiers. Firstly, despite the average completion time coinciding with the experience in the actual challenge, the long tail distribution of completion time suggests that the risk of failing to locate the targets within a short time-frame is also significant. The second important qualifier is that the challenge lies at the limits of what social mobilization is able to achieve. Success relies on all parameters being at their practical limits: you need highly connected individuals to be motivated to propagate the message to a large number of friends, and to mobilize people in distant locations, overcoming the local trapping of diffusion in highly dense areas. Furthermore, search is championed by individuals whose waiting time lies at the lower end of the distribution.

Our results have implications on the use of social mobilization to achieve time-critical tasks, like mapping crises in real-time, or conducting search-and-rescue operations over large geographies. Novel mobilization mechanisms need to focus on incentivizing those elements of the network that are most conducive to successful mobilization: highly-connected people, with distant friends, and rapid reaction time. These characteristics can be exploited in a new measure of influence. One can envisage variants of the winning team’s recursive incentive strategy [2, 9] that provide distance- or time-sensitive rewards to recruit such influentials.

Figure 2: Searchability, Finadability and Blendability

References


