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Multi-network multi-message social media message dissemination problem for emergency communication

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ABSTRACT

Social media has been widely adopted by emergency management organizations and agencies to disseminate emergency messages to the public. However, the traditional one-to-all post-and-wait practice does not serve this purpose well in the complex and dynamic environments in disasters and extreme events. In this paper, we examine an engaged social media node targeting strategy to facilitate message propagation, and propose an optimization scheme incorporating this strategy to determine the optimal sets of nodes to target with planning horizon length, source messaging capacity, social network characteristics and user behaviors considered. Experiments, computational results and managerial insights are discussed.

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1. Introduction and background

In recent years, social media has been receiving significant attentions from various governmental and non-governmental emergency management organizations and agencies as a viable and accessible communication platform in disasters and extreme events. In particular, there has been increasing use of social media in disseminating emergency messages to the public. These messages carry important event-related information that contributes to individuals' situational awareness and decision making in an event. Hundreds of emergency management organizations and agencies, including FEMA, NWS, and NOAA, have their own accounts or pages on social media sites like Twitter and Facebook (Sutton et al., 2012). As of May 2017, FEMA has 593 K and 286 K followers on Twitter and Facebook respectively. While the use of social media in emergency situations is increasing among emergency management (Sutton et al., 2015), much contemporary message dissemination still resembles traditional 'broadcasting' (Lachlan, Spence, & Lin, 2017 with great gaps existing in the theoretical underpinnings of social media use in emergency events (Wukich & Steinberg, 2016). A new generation of research, (Lachlan et al., 2017) argue, is necessary in order to investigate and determine "best practices for planning and implementing new media campaigns concerning developing crisis."

The message dissemination process starts from an official source posting a message on several social media sites. This message will automatically show on the wall of its followers, and these followers may choose to redistribute it by sharing (retweeting) to their friends (followers) on the same network. They can also "transfer" this message to another social media site they use. This happens when there is a link in the original message, which directs them to an article and they will have multiple redistribution options there. This process is illustrated in Fig. 1.1. When they do the transfer, they are redistributing this message on another social media site, which creates a larger message exposure to the public (we note that such network crossing is nearly seamless, as is the case with Facebook and Instagram where a single push of an icon allows Facebook followers to see a post originating on a user's Instagram account). Such a "word of mouth" message propagation mechanism is shown to be effective in emergency communication contexts, in that people tend to react more actively when information is provided by family members and close friends than government officials (Crowe, 2010).

As one of the major stakeholders in an event, the official source would likely hope for the best dissemination outcome from any message distribution, which one might interpret as delivering the message to as many people as possible within a short period of time (i.e., within the planning horizon for a specific event). However, the simple one-to-all, post-and-wait message dissemination strategy (referred to as traditional broadcasting) may not satisfy such expectations and in practice quite often tends to fail in

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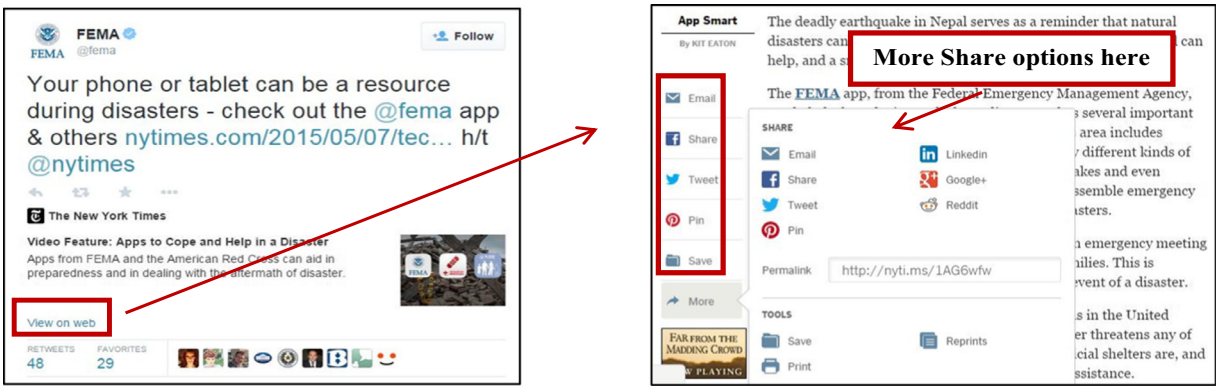

Fig. 1.1. An illustration of message transfer between sites (FEMA, 2015).

delivering key messages to specific audiences in need (CDC, 2012; Lachlan et al., 2017). On one hand, by only posting the message to existing followers, the official source has a good chance of missing the opportunity to reach to the non-follower social media users who are more relevant or more proactive in sharing such information (Kempe, Kleinberg, & Tardos, 2003). On the other hand, many factors, including planning horizon length and structure and condition of the underlying social media networks, impact the outcome of message dissemination significantly. A social media messaging strategy without considering these factors and limitations could barely be effective in the complex and dynamic environments in disasters and extreme events.

Given the aforementioned observations and challenges in distributing time-sensitive messages through social media, it is necessary to identify ways that emergency management organizations and agencies could play a more engaged role in the message dissemination process, exploiting those well-known and exhibited social media behaviors to increase message penetration and message retention to influence or induce derivative action of a population (Lachlan et al., 2017). As an alternative to the current message 'blasting', a social media messaging strategy that integrates decision environments with an emphasis on node targeting could be a viable solution for emergency management organizations and agencies to achieve wide and timely message dissemination in disasters and extreme events. An illustration of node targeting is given in Fig. 1.2. In reality, the decision environments are becoming more complex, in the sense that multiple official sources (FEMA, NWS, local agency, etc.) send messages through multiple social media sites at the same time, and social media users try to gather as much information as possible from multiple official sources for better preparedness and potential evacuation. In light of these facts and to help emergency managers achieve an informed and systematical decision making, we present an optimization scheme to determine optimal sets of target users, considering planning horizon length, source messaging capacity, social media network structure and conditions as well as user behaviors, such that the overall message dissemination outcome in terms of faster message propagation and wider message reception on the social media sites is optimized.

This paper contributes to the theory and application of social media use in emergency communication mainly three aspects. First, it summarizes the mainstream literature on this topic and points out the research need for social media messaging strategies for emergency management organizations and agencies. Second, it conceptualizes the social media message dissemination problem, generalizes message dissemination scenario and develops a discrete optimization model to solve the problem. Third, it conducts extensive computational experiments on small-scale random and Twitter networks to verify the model and study its performance. The implications derived from the results may provide valuable insights for emergency manages in developing social media messaging strategies in the real-world applications.

The remainder of this paper is organized as follows. Section 2 summarizes recent research on social media use in emergency communication. Section 3 provides the conceptualization and description of the proposed Multi-network Multi-message Social Media Message Dissemination Problem (MM-SMMDP), and introduces the optimization model to solve the problem. Section 4

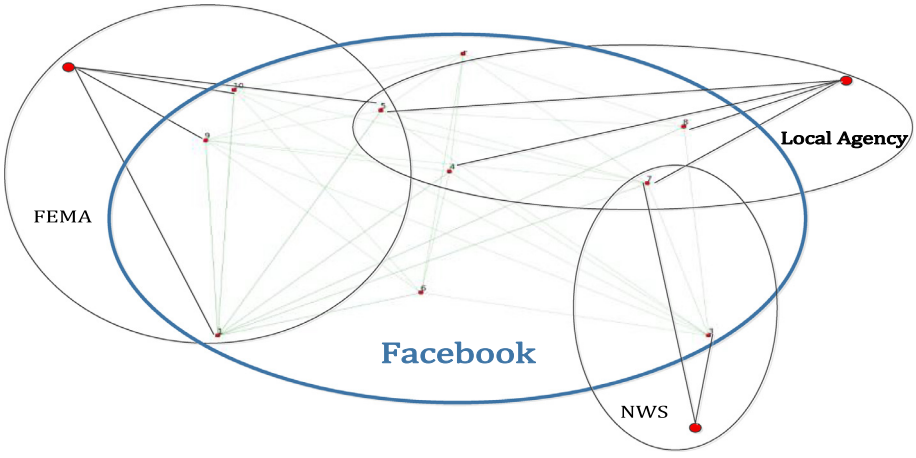

Fig. 1.2. An illustration of node targeting by official sources on Facebook.

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