

Chapter 8

Information Diffusion in Social Networks

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ABSTRACT

The issue of information diffusion in small-world social networks was first systematically brought to light by Mark Granovetter in his seminal paper “The Strength of Weak Ties” in 1973 and has been an area of active academic studies in the past three decades. This chapter discusses information proliferation mechanisms in massive online social networks (MOSN). In particular, the following aspects of information diffusion processes are addressed: the role and the strategic position of influential spreaders of information; the pathways in the social networks that serve as conduits for communication and information flow; mathematical models describing proliferation processes; short-term and long-term dynamics of information diffusion, and secrecy of information diffusion.

BACKGROUND

Social networks as abstract means of representing relations and communications within and between social groups of arbitrary size, and information dissemination in them, have been an object of active studies for the greater part of the XXth century—see, e.g. Davis (1969) and especially Rogers (1995) who reviewed 506 diffusion studies,

though without proper sociometric information. In what follows I present a brief overview of key ideas and key authors. Readers interested in the subject are advised to consult additional literature listed at the end of the chapter.

The issue of information diffusion in small-world social networks was first seriously studied by Mark Granovetter in his seminal paper “The Strength of Weak Ties” (1973) and the follow-up paper “The strength of weak ties: a network theory revisited” (1983). Granovetter suggested that the

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main information exchange takes place along the so-called weak ties—loose, “acquaintance-style” connections between social network members, while strong (“friendship-style”) ties are responsible for decision-making and knowledge generation and preservation. The theory of weak and strong ties serves as a basis for contemporary information diffusion theories.

Information in social networks spreads in the form of messages, wall posts, and even so-called one-bit pokes researched by Kaye *et al.* (2005) and Xiao *et al.* (2007). Golder *et al.* (2007) published the first massive study of message dynamics in Facebook and discovered that the messages follow regular temporal patterns based on time of day, day of week, and season. The origins and the destinations of the messages are not random, suggesting that the dissemination processes are homophily driven. The findings of Golder *et al.* (2007) were corroborated by Singla & Richardson (2008) and Leskovec & Horwitz (2008) who explored homophily and planetary-scale message traffic in Microsoft™ Instant Messenger, respectively. Gruhl *et al.* (2004) observed similar temporal message patterns. In addition, Leskovec & Horwitz have shown that there is a dependency of communication patterns on geographical proximity of the correspondents at the session-level (rather than message-level): longer distances yield fewer and shorter conversations.

Navigability in complex networks—i.e., efficient mechanisms for finding intended communication targets—was modeled by Boguñá *et al.* (2008). The authors proposed a concept of a hidden metric space underlying a complex network, with its own coordinates and distances that serve as guidelines for making routing decisions. At the observable level, navigability translates into scale-free node degree distributions and strong clustering, both properties being common in social networks—which are, thus, navigable.

Kossinets *et al.* (2008), based on the work of Gibson (2005), noticed that the members of a social network do not continuously participate in

communications with their neighbors. Information only spreads as a result of discrete communication events and the frequencies of these events make strong influence on the preferred communication pathways. These pathways form a communication backbone that dynamically changes to reflect the momentary fluctuations of the event frequencies.

Wilson *et al.* (2009) further elaborated the concept of the communication backbone by correlating social and interaction degrees of network members and discovering that they do not scale uniformly.

Viswanath *et al.* (2009) traced the mechanisms that trigger communications in online social networks and discovered that 54% of the interactions are attributed to site mechanisms (such as birthday reminders) and that most links in a communication backbone rapidly die out.

Chwe (2000), Pastor-Satorras & Vespignani (2001), and Kitsak *et al.* (2010) studied dissemination protocols and information origins. Chwe (2000) and Kitsak *et al.* (2010) applied gossiping protocols described by Kermack & McKendrick (1927) and Bailey (1975) and widely used by mathematicians and computer system theoreticians, to social network systems. They emphasized the role of cliques as the “containers” of community knowledge and singled out the role of “insurgent network members” as influential spreaders.

For some special cases of social networks—e.g., one-shot networks commonly found in online commerce,—it is possible to apply mathematical game theory to decide whether or not the next round of communications between any two network members takes place. Emanuelson & Willer (2009) argue that the interactions in one-shot networks differ from “continuous” networks, where the connections between members are relatively stable. Zinoviev & Duong (2010) and Zinoviev *et al.* (2010) also used mathematical game theory to study information flow along a communication link, based on the psychological traits of the participants.

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