NetSciX2026: International School and Conference on Network Science
February 17^{th}-20^{th}, 2026 - Auckland, New Zealand

Beyond Retweets: Contrasting User–User and User–Content in Bow-Tie Decomposition

Keywords: Computational Social Science; X/Twitter; Bow tie decomposition; maximum entropy null models

Extended Abstract

Even though most research on online social media focuses on interactions among users, a substantial branch of the literature addresses interactions between users and content [1–5]. Indeed, ignoring content popularity when studying user interactions may lead to misleading conclusions: viral posts are far less informative than "standard" ones, since their diffusion does not necessarily reflect users' preferences but rather the dynamics of virality itself. A comprehensive analysis of online platforms should therefore account for both types of interactions: user–user and user–content.

In this paper, we compare the insights coming when online debates on X/Twitter are described either considering only user–user interactions or including user–content interactions. Our main focus is the statistical significance of the bow-tie decomposition of the retweet network.

The bow-tie decomposition of directed networks was first introduced by Broder et al. to describe the structure of the early WWW [6]. In Ref. [7], it was shown that in nearly all discursive communities across online debates in different languages, bow-tie structures are both informative (i.e. involving almost all accounts) and statistically significant (i.e. not simply due to random noise). Building on this evidence, several diffusion models that leverage bow-tie structures have been proposed [8].

We analyse three Italian political debates on X/Twitter collected in 2022. Specifically, we adopt two complementary representations of the system. First, the retweet network: a directed network of reposting where nodes represent accounts. Second, the user–content interaction network. Using these two frameworks, we evaluate the statistical significance of quantities involved in the bow-tie decomposition. As a benchmark, we rely on maximum-entropy null models for complex networks, which have proven versatile in many contexts [9]. Our results show that in several relevant cases, significance patterns are reversed: quantities that are significantly larger than expected in one representation are significantly smaller in the other.

This finding has several non-trivial implications. First, the statistical significance of bow-tie components depends on the chosen representation, meaning that interpretation hinges on the interaction type under consideration. Since social platforms inherently involve both user–user and user–content dynamics, neglecting either dimension risks producing a distorted view of the system.

Second, our analysis points to a statistically significant signal of direct information flow from sources to the audience, bypassing intermediaries. Indeed, while the two representations yield partially divergent results, we still find a statistically significant flow of information from official sources to the broader audience. Thus, besides the ambiguities depending on the type of interaction analysed, there remains a clear signal that "ordinary" users often access information directly from sources, bypassing mediators, in line with other results in the literature [1].

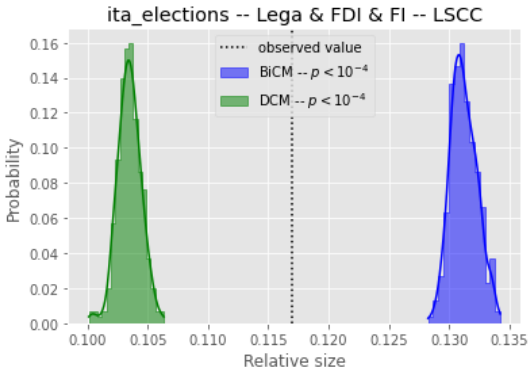

Figure 1: **Statistical significance of the dimension of the Largest Strongly Connected Components (LSCC) of the Right Wing community.** In the present case, the observed value (dashed line) is statistically significant on the right in the user-user representation (green distribution), while statistically significant on the left in a user-content representation (blue distribution).

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