Project collective mind: Unlocking project discussion networks

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\textbf{A B S T R A C T}

A project discussion network is a space where project stakeholders form relationships among each other and share information about the project. Virtual discussion networks may refer to networks of e-mails, document exchange and social media (such as Twitter, Facebook, YouTube, etc.). As such, both social linkages and semantics of the exchanged content must be considered in analysis of such networks. The proposed framework in this study aims to analyze both the social and semantic aspects of these networks. We developed the framework through analysis of the social networks formed around Twitter accounts of infrastructure megaprojects. To assure relevance to construction research and practices, three objectives guided our analysis: relaying on a large and diversified data corpus from construction projects; testing the applicability and usage of a set of relevant algorithms to the context of construction project management; and linking the results of data analysis and algorithm evaluation to the conditions of construction projects at hand. In examining algorithms for detecting sub-communities, the Louvain fast unfolding modularity maximization was more suitable in detecting project relevant sub-groups. For assessing the relative influence of actors, PageRank algorithm performed better than centrality measures. For extracting key terms, we found that modifying the term frequency-inverse document frequency (TF-IDF) measure to incorporate the relative importance of the source nodes enhances the relevance of extracted terms. Obliquely, Twitter networks are only one type of project networks that can cover a limited/biased sample of participants. Their analysis should be one component of the overall project network analysis. We believe that the proposed framework has the same level of applicability to internal networks of project teams as well as non-Twitter networks.

\textbf{1. Introduction}

Projects are essentially networked phenomena. People interact and build complex relationships with others who have interests in a project throughout the project life cycle. In the early stages of applying social network analysis (SNA) in construction, researchers focused on analyzing case studies to explore actual social ties between project players (see for example: [28]). With the transformation of computers from automated calculators to communication amplifiers [24], interest started to grow in the use of SNA to study communication patterns and their relationships to project organization [11]. Project “networked” stakeholders exchange a large volume of information—in the form of documents, e-mails, and even contribution to the project social media outlets. In other words, a project embodies (or can be perceived as) a social network of knower agents (people), overlaid by (semantic) networks of exchanged content encapsulating not only their views but also their knowledge and experience. If we analyze both networks, we can extract insightful measures in relation to the relative influence of project players, flow of information and its impact on the opinion dynamics, etc. We can also detect major problem areas and distill ideas for possible solutions. Repeated analysis can reveal patterns of concept association, which can be used to enrich our knowledge models.

Until now, limited work has been directed towards integrated socio-semantic analysis of project networks. Further, the use of SNA in construction has been limited by the size of project networks due to the difficulty of tracking communication between project professional staff. In most cases, researchers had to construct the social network through interviews and observation (see for example: [2,38]). The emergence of social media usage in construction projects can be a helpful in automatically capturing large sets of data over a long period of time. Moreover, analysis of social media outlets related to construction projects can be helpful in better managing project relationships with its community [36]. However, current work on analysis of project social media accounts is lagging [19].

In this paper, we advocate that socio-semantic analysis of project discussion [social] networks (PDN) should be a major task for decision
makers; similar to the analysis of project data for cost, schedule, and productivity. To support that, we developed an analysis framework based on benchmarking similar practices in other domains and monitoring a sample of Twitter accounts for major infrastructure construction projects in North America. These accounts are meant to engage local communities in project planning, approval, and execution phases. We argue that while using Twitter networks dedicated to public engagement, the approach is valid and beneficial to the analysis of other types of PDN as well. Research studies show that communicating in short messages via Twitter has made it one of the most favorite communication channels among practitioners in the domain of Architecture/Engineering/Construction (AEC) [4]. Twitter networks were targeted, however, for two reasons: firstly, the extensive size of networks and open access to them provided adequate data-sets to test the suitability of different analysis algorithms. Secondly, the discussions in public engagement networks helped to encapsulate diversified debates with richer semantics, ranging from engineering and economic to environmental, social, and even political issues.

We tracked 23 projects with 34 Twitter networks (accounts associated with them) and analyzed in detail 6 networks associated with 4 major projects; among which, in-depth analysis of one project was carried-out over a span of 18 months. To enhance the relevance to construction practices, we selected projects at different cities and at different stages of execution: from conceptual planning to post construction/operations. This provided us with a better opportunity to link network attributes/trends to project phases/conditions of work. Our work included extensive testing of different algorithms to assess four major issues: stakeholders’ typology, stakeholders’ influence level, stakeholders’ vested interests, and stakeholders’ position. In our analysis, we conducted comparison of network dynamics (over 12 to 18 months) and project features/state of execution. Effectively, this means that there is a better chance that the proposed framework and the selected algorithms are sensitive and relative to the construction domain. Of course, future research on networks from twitter and other social media outlets can further enhance the applicability and relevance of the framework.

The paper, first reviews the relevant work in using social network analysis (SNA) in project management. Then we discuss the scope of PDNs as networks that embody knowledge; manifest a socio-semantic continuum; and are indifferent to whether the members are internal or external stakeholders. In other words, in the PDN, project external players may become as important and influential as the internal project team members and decision makers. The data-set used in our analysis is then presented and we discuss the algorithms tested, followed by our findings. Based on the selected algorithms, a modeling and analysis process was designed and a web portal was developed to support the semi-automated application of our proposed framework. These are presented in the paper along with a sample application.

2. Related work: Project social networks

Our conceptualization about the role of social networks in project management has lately evolved tremendously especially with the prevalence of social media and the advancement of social network analysis. Two broad approaches can be observed in this regard:

2.1. Social networks of professionals (project team)

In this regard, the interest is in networks formed based on contractual relationships among all entities involved in a project, including but not limited to the owner, financier, design team, contractor and sub-contractors, operation and facility management, etc. We can observe here three phases to this approach:

2.1.1. Mapping/Modeling

Initially, this perspective used social networks as descriptive tools to map actors’ relationships. Loosemore [25,26], a pioneer in the field, studied interpersonal communication networks in conditions of crisis. However, Loosemore did not use socio-grams to visualize communication networks. At that stage, the relevance of social networks to project management was in line with the stream of thinking that perceived management as a practically-oriented branch of social science. The focus of management research was to understand and explain managerial practices, events and actions as well as to identify the underlying social processes at work. Sociological, psychological, and even economic constructs/parameters are used to explain managerial actions, structures and beliefs (see [44]). Albeit the contrasting (and more dominant) theory is that management is more related to natural sciences, and is concerned with objectively applying scientific methodology, or principles, to the management decisions [13]. The aim, in this view, is to use scientific approach to quantify problem solving for executive management [41]. In the same line, Pryke [38] proposed using social networks as means for comparative analysis of construction project governance and enabled the exploitation of visualization techniques involving SNA socio-grams. The objective was still limited to exploring, mapping, visualizing, and understanding the nature and behavior of project teams.

2.1.2. Theory of Project management and governance

The next phase of studying the nexus between social networks and project management in construction, investigated the fundamentals of project management theory through the lens of social networks. Pryke [39] used SNA (particularly density and actor centrality) as measures to compare governance schemes. Ch invisowsky et al. [10] proposed to balance the traditional emphasis on efficiency of communications with insights from social factors that move the project team from efficient to effective. Since introducing social network model of construction by Ch invisowsky, et al. [9], many researchers have focused on social network analysis of project networks ([14,42] among others). They used analytical and graphical tools to illustrate a multi-perspective analysis of the project team configuration and dynamics.

2.1.3. Decision analysis and support

As the availability and depth of project data increased—mainly due to the extensive use of databases for tracking performance, the dominance of e-mail as a communication mode, and the use of e-business transactions—more quantified uses of SNA became possible. Researchers started using SNA to study issues such as efficiency of supply chains ([6,21]; risk assessment [45]; modeling complex mechanisms of defect generation and propagation [1], etc.

2.2. Social networks of public stakeholders

Researchers in the domain of planning and community engagement have lately started to pay attention to community debates on social media regarding proposed urban projects. This included, mainly, measuring levels of approval of projects as illustrated by online discussions on social media such as Twitter [31,43]. In this aspect, and compared to other domains, construction project management is just starting to scratch the surface of SNA potentials [19].

3. Gap, scope, and objectives

The main gap that this research attempted to bridge is to provide construction managers (and researchers in this domain) with a framework for algorithmic analysis of the social and semantic aspects in large PDNs. Through using the framework, we aim to offer project managers a mechanism to monitor the formation and evolution of the project-related social network, track and profile its participants, analyze and interpret the contents communicated over this network, and link these measures to the project performance.

Our approach tried to overcome several limitations that SNA in
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