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Information communities: The network structure of communication

Peter Pal Zubcsek[a,*], Imran Chowdhury[b], Zsolt Katona[c]

[a] Warrington College of Business Administration, University of Florida, Gainesville, FL 32611, United States
[b] Lubin School of Business, Pace University, New York, NY 10038, United States
[c] Haas School of Business, University of California at Berkeley, Berkeley, CA 94720-1900, United States

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ABSTRACT

This study puts forward a variable clique overlap model for identifying information communities, or potentially overlapping subgroups of network actors among whom reinforced independent links ensure efficient communication. We posit that the average intensity of communication between related individuals in information communities is greater than in other areas of the network. Empirical tests show that the variable clique overlap model is indeed more effective in identifying groups of individuals that have strong internal relationships in communication networks relative to prior cohesive subgroup models; the pathways generated by such an arrangement of connections are particularly robust against disruptions of information transmission. Our findings extend the scope of network closure effects proposed by other researchers working with communication networks using social network methods and approaches, a tradition which emphasizes ties between organizations, groups, individuals, and the external environment.

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1. Introduction

Recent research in organizational theory has attempted to understand how individuals and groups are linked via the network structure, and how this relates to important behavioral outcomes such as collaboration and information transmission. Some scholars have attempted to explore this structure more deeply, focusing on the pattern of connections within and between groups in social networks (Everett and Borgatti, 1998; Moody and White, 2003), the nature of resources which inhere in these connections (Burt, 1992; Coleman, 1988), average path lengths between individuals and their relationship to information transmission (Killworth and Bernard, 1978), and by examining the high local clustering of individuals which seems to be a recurring characteristic of linked global communities (Uzzi and Spiro, 2005; Watts and Strogatz, 1998).

Nevertheless, our understanding of networks of individuals remains incomplete. Much remains unexplored in our structural understanding of social networks, and there is a paucity of research on how clusters of individuals actually link to each other and to the broader organizations and institutions within which they are embedded to make information transmission happen. While we know a good deal about the role of intermediaries in spreading information between disjoint groups (Burt, 1992), we know much less about the mechanisms which underlie the broader structure of information transmission within social networks (Stinchcombe, 1990). Accordingly, our paper moves to explore these mechanisms further. We do so by building on the extensive literature on the detection of cohesive subsets in social networks, which uses formal mathematical methods to define structural concepts within social networks (Borgatti et al., 1990; Forsyth and Katz, 1946; Moreno, 1934; Wasserman and Faust, 1994).

Taking up this approach, we first define a family of cohesive subgroup models called *information communities*, which consist of potentially overlapping subgroups of network actors among whom reinforced independent links facilitate efficient communication (defined, in general, as lossless information transmission). Subsequently, we demonstrate how information communities include the models of Luce and Perry (1949) and Palla et al. (2005), and introduce a new *variable clique overlap model* within this family of cohesive subgroup models. This model is distinct from prior models in that it allows researchers to more loosely (that is, they exhibit higher global connectivity) or tightly (they exhibit lower global connectivity) define cohesive subgroups as required by the question and the independent and dependent variables under study.

The form of organization we study is one that utilizes multiple independent paths throughout the network to mutually reinforce

* Corresponding author. Tel.: +1 3522733283.
E-mail addresses: pzubcsek@ufl.edu (P.P. Zubcsek), ichowdhury@pace.edu (I. Chowdhury), zskatona@haas.berkeley.edu (Z. Katona).

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both the strength of relationships as well as the integrity of the information traveling within a particular group. In this instance, having reinforced independent communication paths for information transmission takes on heightened importance. Imagine, for instance, the remarkable resilience of the regime of Bashar al-Assad in Syria. As of this writing, Assad and most of his government have survived an uprising that began peacefully in March 2011 and, following a harsh and repressive response by Assad's forces, quickly transformed itself into an armed uprising supported financially and militarily by numerous international opponents. While the support of important allies, such as the Russian and Iranian governments and the Lebanese political party Hezbollah, has been important in keeping Assad's regime intact, more important may be the fact that the regime's core actors have tightly coalesced as an array of domestic and international forces has aligned against it (Bellin, 2004; Robinson, 2012). This core group, which is generally thought to include Assad, family members such as Assad's brother Maher, key senior military officials, and senior business and government executives (many of whom are drawn from Assad's Allawite religious community and Christian and Sunni elites aligned with the regime), has seen relatively few defections since the start of the conflict. Working in close coordination, this group serves as the regime's "brain," driving its survival, in particular in Syria's major urban centers, and gains against rebel forces. A similar phenomenon has been noted by observers of the North Korean regime, where information access is tightly controlled and key decision-makers cluster around the supreme leader (since late 2011 Kim Jong-un and before him his father and grandfather, respectively, Kim Jong-il and Kim Il-sung) within important elite institutions such as the National Defense Commission, the Cabinet and the Korean Workers' Party (Bermudez, 2004).

While a number of communications configurations might be possible for a top leadership group, in the instances noted above a tightly-linked group with little scope for brokerage and multiple reinforced paths for information transmission ensures that outside information and influence impacts the whole group, which in this manner remains secure against attempts to dislodge it. In addition, due to its cohesive nature, the group itself can broker between the various important constituencies in the country, including the military, business interests and the civil service. Importantly, however, it is the group which serves a brokering function across the whole network, not individual actors within the group.

Tightly-controlled authoritarian governments are one area where the network structure we describe is particularly evident, but these structures can be identified in any settings where cohesive groups play a role in regulating information flow (e.g., certain departments of corporations, government security agencies, religious orders such as the Catholic Church). Indeed, while in recent years the rise and increasing complexity of information communication technologies has seemingly complicated information exchange in fundamental ways and thereby increased the likelihood of strategic information manipulation by organizational actors (Burt, 1992; Daft and Weick, 1984; Yates, 1993; Zmud, 1990), these technologies have also concomitantly strengthened the ability of organizations to build in fault tolerance mechanisms that greatly increase both the efficiency of information transmission and the likelihood that individual-level brokering behaviors will be detected and sanctioned. Thus, notwithstanding the diversity of relationships present in contemporary organizational settings, by focusing on one key characteristic of social networks, information conductivity, we may be able to increase our understanding of how the structure of connections within a particular social network is related to the survival of the organization or group within which this network is constituted.

In the next section, we briefly describe prior work in the organization studies literature which looks at communication, in particular work which examines the structure of cohesive subgroups within social networks. Section 3 introduces the generic concept of information communities and provides the mathematical details of a variable clique overlap model for identifying communities building on the research described in Section 2. In Section 4, we test the efficacy of the variable clique overlap model against earlier cohesive subgroup models on two sets of communication data – a telephone network and an organizational email network – and present our empirical methods and results. We conclude with a summary of our findings, suggestions for future research, and potential applications in Section 5.

2. Theoretical background

Starting at least as far back as Forsyth and Katz (1946), who developed the concept of a "sociomatrix," organizational scholars have noted the impact of subsets of the network which are characterized by greater cohesiveness relative to the rest of the network. Cohesive subgroups provide a crucial link between individuals and organizations – between the micro and macro levels of analysis – and are characterized by a high number of ties between individuals within the group. They are also relatively closed to outsiders, as most of the interactions of the subgroup as a whole happen between members (Borgatti et al., 1990; Freeman, 1992; Moody and White, 2003).

Early research on cohesive subgroups attempted to elucidate the mechanisms by which group behavior within social networks affected different outcomes. Subsequent research in this area has explored network structure using graph-theoretic criteria to examine group behavior (Alba, 1973; Luce, 1950; Mokken, 1979; Seidman and Foster, 1978). A working assumption of this school of thought is that an optimally cohesive subgroup is a clique, in which all subgroup members interact with one another. Cliques are important to understanding the concept of network closure. As noted by Burt (2005), networks in which people are very highly connected to each other, that is, where two actors are both connected to the same third-parties, are better at transmitting information. As the strength of third-party ties connecting two people increases, the network around them becomes more closed (Burt, 2005). Thus, closure in an organizational setting is measured by the strength of the indirect connections between individuals with colleagues acting as third parties. In this schema, some individuals are more strongly connected through third parties than others in the study population. The relationships of such individuals are said to be strongly embedded in the closed network. One of the important outcomes of strongly embedded close relationships is an increase in trust between individuals, which can lead to increased information transfer as well (Coleman, 1990).

While structural definitions of groups based on cliques have proven fairly effective at identifying various organizational variables such as relationship intensity, group centrality, and even performance (Balkundi and Harrison, 2006; Borgatti et al., 2009; Evans, 2010), further refinements are necessary to link these set definitions with particular behavioral outcomes such as interpersonal communication. A first step towards accomplishing this was introduced by Borgatti et al. (1990), who proposed using independent paths as a way to identify cohesive subsets. Specifically, they defined subgroups based on high connectivity between any pair of within-group actors. While this method results in groups – termed "Lambda sets" – that are likely to persist despite the loss of a few relationships within them, it produces non-overlapping groups which remain relatively independent from the rest of the network. One recent approach, put forward by Moody and White (2003), addresses this issue by proxying vertex connectivity (the minimum number of actors that one has to remove from a group to disconnect

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