Network Analysis of Public Sector Coordination and Collaboration: Conceptual and Methodological Applications

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Abstract

Over the last 15 years research into the functioning and effectiveness of government has paid increasing attention to coordination, cooperation, and collaboration within and across organizations and agencies. This reflects the fundamental observation that as the complexity of the public policy-making and –implementation process in and around government has grown the need to coordinate the efforts of multiple actors and organizations has also grown. In general, this huge literature has been based heavily on qualitative and case study-based research and analytical methods. There have been a number of quantitative applications as well, but these are dwarfed by the former. This paper argues that research on public sector coordination, cooperation, and collaboration, both in its qualitative and quantitative realizations, could benefit greatly by employing social and organizational network analytical methods and concepts. Employing network analysis can assist greatly with specifying measures, generating hypotheses, and operationalizing theories underlying research on coordination structures and processes.

This paper 1) discuss es the use to date of social and organizational network analysis in the public administration and policy field; 2) identifies several key assumptions and premises underlying network analysis and the implications of those assumptions for studying and understanding public sector coordination; 3) identifies important methodological considerations underlying the collection of network data and relates these to methodological considerations for studying coordination more generally; 4) presents an array of specific concepts and findings the broader network analysis research field and shows how these can be used to operationalize or inform our understanding of coordination concepts, structures, and processes.

Introduction

Over the last 15 years research into the functioning and effectiveness of government has paid increasing attention to coordination, cooperation, and collaboration within and across organizations and agencies. This reflects the fundamental observation that as the complexity of the public policy-making and –implementation process in and around government has grown the need to coordinate the efforts of multiple actors and organizations has also grown. We see this across a wide array of phenomena: local government service provision, intergovernmental/interstate relations, social service delivery, emergency management, subcontracting/outsourcing federal government services, etc. (for recent compilations, see, e.g. the collection of studies in Kamensky and Burlin, eds. 2004 and the December 2006 volume of Public Administration Review [for overview see O'Leary et al, 2006]).

In general, this huge literature has been based heavily on qualitative and case study-based research and analytical methods. There have been a number of quantitative applications as well, but these are dwarfed by the former. This paper argues that research on public sector coordination, cooperation, and collaboration, both in its qualitative and quantitative realizations, could benefit greatly by employing social and organizational network analytical methods and concepts. There has been very limited use of network analysis methods and concepts in the public administration coordination literature.[1] Employing network analysis can assist greatly with specifying measures, generating hypotheses, and operationalizing theories underlying research on coordination structures and processes.

This paper proceeds as follows.[2] First, we discuss the use to date of social and organizational network analysis in the public administration and policy field, and place this work in the context of the broader network analysis re-

[1] In the remainder of this paper, we use the phrase "public sector coordination" as a shorthand term covering the related phenomena of coordination, cooperation, and collaboration, all of which have been problematized in the public sector adminstration and policy-making context. Likewise, we use "network analysis" as an umbrella term covering the wide array of methodological and substantive network research lines in sociology, political science, international relations, economics, anthropology, and other disciplines.

[2] Throughout this paper I make extensive use of concepts drawn from Wasserman and Faust (1994) and Carrington, Scott, and Wasserman (2005).

search field. Second, we identify several key assumptions and premises underlying network analysis and the implications of those assumptions for studying and understanding public sector coordination. Third, we identify important methodological considerations underlying the collection of network data and relate these to methodological considerations for studying coordination more generally. Fourth, we present an array of specific concepts and findings from the broader network analysis research field and show how these can be used to operationalize or inform our understanding of coordination concepts, structures, and processes. The basic point underlying this section is that there is a wide array of studies that would seem to have direct application to the measurement and analysis of coordination structures and processes.

A. Network Analysis Research Antecedents

There has been very limited limited use of network analysis methods and concepts in the public administration and policy fields writ large. Perhaps the earliest most significant work was that of David Knoke and Edward Laumann on National Policy domains (see e.g. Laumann and Knoke, 1987; Knoke and Pappi, 1991). Their work focused on how coalitions and alliances of interest groups, in the U.S. and other places such as Germany and Canada, form up and shift over time in pursuit of public policy influence goals. Their approach was sophisticated methodologically and analytically, and they employed an array of hypotheses and methods for detecting, tracking, and comparing national-level interest alliances.

The Knoke and Laumann work originated in a sociological context and generated relatively limited sustained subsequent interest in research in the public sector coordination field understood more narrowly. More recently, in this narrower domain, we see some more direct applications of network analysis to coordination and effectiveness of public sector policy and management initiatives. Authors of chapters in an edited volume (Durland and Fredericks (2005)) of studies collect network-type data (about which more later) on an array of programs and initiatives; however, the network analysis here is used largely descriptively, with analytical implications being drawn out only to a limited extent. Kapucu's presentation of network analytic metrics and graphics for the 9/11 New York City interorganizational emergency management network and Barsky's analysis of (intraorganizational) core-periphery structures in an agency budgeting process both provide useful insight into coordination in their particular contexts.

Perhaps the most sophisticated use of network analysis in the public sector collaboration field is the series of articles published by (1998, 2005), Milward, and their colleagues on network integration and the effectiveness of health service provision in Tucson, Albuquerque, and Providence. They developed a network survey for identifying the informational linkages between collections of service providers in their three sites and then used these data to link measures of network centrality and cohesion to performance concerns.

Aside from these few examples, however, there has been little additional application of network analysis to public sector coordination. Nevertheless, there is a wide array of research in other social science areas that can be mined for useful applications to the coordination problematic. The field is extremely broad and evokes an array of interesting analytical possibilities for understanding coordination.

A first, and most evident example of this, is the large sociological literature that looks at intraorganizational work and communication networks in and around private sector businesses and other types of organizations. A prevalent question in this research is how do informal networks of communications, information-sharing, trust, etc. inform our understanding of formal organizational structures as reflected in bureaucratic procedure, law, or organizational strategy and policy. This has evident application to the issue of managing and coordinating work processes and communication at various levels of public sector organizations.

A second example is the equally voluminous literature on interorganizational networks in business examining how varying degree and quality of interconnectedness among firms (and other organizations) as reflected in their purchasing practices, share ownership relationships, conditions their performance and innovation potential. While the application to public sector coordination is somewhat more tenuous than with the first application, the basic issue of identifying agency-level embeddings and relationships, and how those affect performance is front and center in the public sector coordination literature.

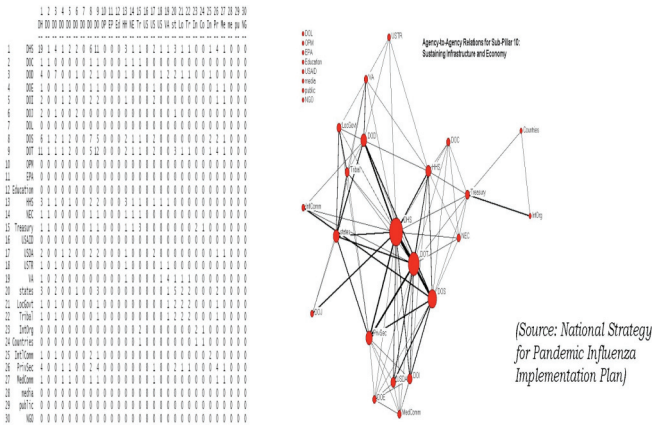
B. Conceptual Premises For Applying Network Analysis To Coordination

The aim of this paper is to identify ways that methodological and analytical concepts can be applied usefully to the public sector coordination problem. Before entering into a detailed analysis of that, however, in this section we introduce a number of key premises driving network analysis and draw forth their implications for what they mean for understanding coordination.

The working definition that we use for network analysis in this paper is as follows: "Quantitative techniques for analyzing, summarizing, and graphically representing complex patterns of relationships among actors or entities." This definition is useful because it delimits three key elements: quantitative perspective, relationships, and actors.

i. Quantitative Perspective.

Network analysis provides a toolkit of quantitative techniques drawn from matrix algebra and graph theory for measuring, diagramming, typifying, and understanding social and organizational structures (and, increasingly, processes). It is useful to present the basic data and graphic representation underlying network analysis. Network data at their root are simple, though different than the data arrays that we typically encounter in quantitative analysis. The most typical network data structure is a symmetric matrix with the same entities or actors arrayed both from top to bottom and across from left to right. In its most basic form any particular cell will contain either a '0' or '1,' with the latter representing the presence of a relationship between the two intersecting entities, and the former representing its absence. Other network data can be valued (as opposed to dichotomous), where the quantity in any given cell represents a measure of the intensity or frequency of the relationship between the relevant pair of entities.



(Source: National Strategy for Pandemic Influenza Implementation Plan)

Graphic representations derive directly from such data structures. Most basically, we can reproduce the data matrix graphically by drawing a line between entities that possess the relationship of relevance. While approaches to the spacing and location of the entities vary depending on analytical priority (about which more later), a general simple principle typically used is to place entities that are tied to each other close to each other.

Starting from this basic data and graphical structure, a wide array of less and more complex measures and techniques have been developed to detect underlying structures in data (see section D). Obviously, both the graphic and, even moreso, data representations provided above beg the question of underlying principles and structures.

ii. Relationships.

We turn attention now to the second term from our working definition – relationships. Network methods and techniques contrast with most other quantitative methods used in social science in that they focus on analysis of relationships rather than attributes. Data for a typical multivariate statistical analysis is asymmetric, arraying the observations (entities, actors, organizations in our terms) from top to bottom and then across the top the specific attributes of interest are arrayed, with values for each observation specified for each attribute. Such data generally speaking is at the individual level and tells us nothing about the relationships among the observations. By contrast, basic network data provide information only about the relationships rather than attributes of individual cases.

Network analysis is thus centrally focused on relationships, and in its social science applications is centrally concerned with the phenomena that connect social actors or entities – communication, information, transactions and exchanges,

affect, etc. A core concept in social and organizational network analysis thus focuses on the content of, the material making up, these exchanges – the "type of tie" concept (White, 1992). In network research, a wide array of types of ties have been employed. These can be grouped on a continuum from the tangible/concrete to the intangible/affective and include:

Tangible
- Gifts, donations
- Monetary payments
- Physical asset transfers
- Share ownership
- "Hard" information: email, documents
- Co-membership in organizations or events
- Kinship relations
- Advice

Intangible
- "Soft" information: word of mouth, phone calls
- Friendship, liking
- Conflict, disliking

A number of comments on this focus on relationships and types of tie are in order. First, these relationships may be "directed," meaning that the interaction at issue may be observed to be flowing or moving in one particular direction, from one entity to another.

Second, networks may be "multiplex" with pairs of actors characterized by the presence (or not) of several types of ties between them. More sophisticated network analyses make use of the typically multiplex character of networks to draw out distinctions between, for example a set of financial relationships among network members and information flows among them. The following is drawsn from Padgett and Ansell's (1993) analysis of brokerage processes in the elite family power network of Renaissance Florence.

Third, the distinction between attributional and relational approaches to social science analysis was somewhat overstated previuosly. In particular, most network analyses in one way or another incorporate attributional data. Most typically, network diagrams color-code nodes (or relations) attributionally, for example, differentiating male and female networks of a workplace environment to visually draw out distinctions in their placements within the network. Conversely, a common approach in more traditional statistical modeling exercises is to "attributize" network members' relational characteristics, such as their centrality in the network; network measures thus became covariates in regression models, for example. Taking such an approach enables the identification of associations and dependencies between relational and other kinds of characteristics.

The prominence of relationships and the content of connections between actors would seem to have direct relevance to the study of public sector coordination. Perhaps the central issue in achieving well-functiong coordination or collaboration is to establish the right kinds of relationships among the right sets of actors. To the extent that we can develop metrics and methods for specifying and evaluating these relationships the more able we may be to improve on existing coordination efforts or to plan more viable ones.

iii. Actors/entities/agents

Who are the actors and agents among whom these relationships obtain? Network analysis allows for treatment of a wide array of social and organizational agents, arrayed from micro to macro. Correspondingly, network analysis moves easily between varying levels of analysis, with both micro-level studies of individuals and their detailed interactions in workplace, leisure, or other settings, on the one hand, and macro-level studies of states and international organizations in areas such as trade, world systems, international politics both common. Following are types of agents that have been analyzed (or could be) in network analysis, in order from micro to macro:

- Individuals/Persons
- Social Groups (Families, Clubs, Tribes)
- Organizational Sub-Units (Departments, Teams)
- Organizations (Firms, Agencies, Associations)
- Towns/Counties/Cities/Regions
- Nations/States/Governments

Network analysis also enables aggregations and disaggregations of actors, thus making it a very flexible framework for multi-level analysis. First, network analysis provides tools and methods for grouping actors into higher-order entities. For example, a common practice is to employ blockmodeling to simplify a complex network of dozens or even hundreds of members by identifying relationally equivalent actors, that is, actors who have the same or similar patterns of ties, and then combining them into a series of macro-actors, or "blocks," whose relations can then be diagrammed and presented in simplified form. There are other, simpler ways that network analysts combine actors as well, for example, by treating the members of a fully linked up sub-network, or clique, as one actor.

Second, this process can be performed in reverse, as well – assuming the data are at a sufficient level of disaggregation. For example, blocking or other aggregation techniques may produce a bottom representation of underlying structure of a complex coordination network. On the other hand, however, there may be particular pieces or

places in the network that our attention is drawn to, for a variety of reasons. A common practice, for example, is to disaggregate and analyze particular blocks or cliques of actors.

The ability to move between levels has evident application to analysis of public sector coordination. As with network analysis, research on coordination has occurred across a wide array of levels, ranging from the micro-individual level to the macro-department or -agency levels.

C. Network Data Collection

Research on public sector coordination has potentially a wide array of choices for collecting network data. Recall that the core data requirement of network analysis is that the data should specify the presence or absence (or other quantity or quality) of the relationship(s) of interest for all pairs of actors in the network. Network research has two primary means for collecting such data: i) mining documentary sources and ii) surveys of network participants.

Mining Documentary Sources. Network research has used a wide array of documentary sources for detailing pairwise relationships among collections of actors. These have included the following:

- Newspapers, Periodicals
- Budgets/Accounts/Financial Reports
- Report co-authorship listings
- Meeting Minutes or Rolls
- Telephone or email records
- Historical Documents
- Published Social or Economic Data, e.g. input-output data

As with the types of relations and agents that network analysis can accommodate, these data sources suggest also that network analysis can accommodate a wide array of temporal perspectives, ranging from very short-term timeframes focused on instantaneous, recent interactions to long-term timeframes occurring over years or even decades. Analysis of coordination thus has a wide array of options for detailing systematically relationships among relevant actors or organizations. Important to recognize here, however, is that it is always necessary to perform some level of coding or content analysis of documentary evidence, particularly when the data are qualitative in nature, e.g. in the form of narratives of other kinds of reports. One immediate example from this is Kapucu, who used FEMA after-action reports to identify the network of relationships among local, state, and national-level public-and private-sector organizatations that emerged to deal with the aftermath of the 9/11 bombings. Based on a personal communication, Kapucu developed a coding scheme to a) identify relevant relationships and to b) systematize an understanding of the presence or absence of those relationships among pairs of actors.[3]

Network Surveys. Network surveys are well-established in the field, and are supported by numerous successful applications. Important examples are Burt (1992), Krackhardt, and Rob Cross. Rob Cross, for example, has developed a scheme for surveying the relational activity of workers and managers in business organizations. He identifies a number of commonly used questions to get at the relational underpinnings of activities common in such organizations, such as the following:

Decision making	Please indicate whom you turn to for input prior to making an important decision.
Problem solving	Whom do you typically turn to for help in thinking through a new or challenging problem at work? How effective is each person in helping you to think through new or challenging problems at work?
Information	Please indicate the extent to which each person provides you with information you use to accomplish your work. From whom do you typically seek work-related information?/To whom do you typically give work-related information?
Communication	How much do you typically communicate with each person relative to others in the group? I would be more effective in my work if I were able to communicate more with this person.
Innovation	Whom are you likely to turn to in order to discuss a new or innovative idea?
Task flow	Please indicate the extent to which people listed below provide you with inputs necessary to do your job.

Source: https://webapp.comm.virginia.edu/NetworkRoundtable/Default.aspx?tabid=58

Useful to recognize in the above is that each of the six categories of question can be understood as separate "types of ties." In other words, each of the different sets of ques-

[3] Important strides have been made in recent years in terms of automating search for relational information in narrative data (see, e.g. Krebs, 2002). However, the prevailing approach is to identify potential nodes (by searching for capitalized proper names) and use a relatively crude criterion for determining relationship presence of semantic distance between the potential nodes measured in number of words. The conclusion that emerges here is that coding and content analysis at successive analytical iterations remains necessary to ensure data reliability.

tions could, at least in some contexts, be understood as indexing very different patterns of ties among actors. Maxim Tsvetov (personal communication, George Mason University) suggests that for studies of intraorganizational coordination and communication three broad types of questions should be asked, with wordings depending on the particular context: 1) routine communication contacts: gets at institutional structures; 2) adviceinformal information sharing contacts: gets at informal information sharing patterns; 3) "saving one's butt in an emergency" contact: gets at power and authority relationships.

Data Collection and Network Boundaries. For both forms of data collection, a key concern in network analysis is dealing with network boundary issues. Just who or what should be considered in the network or out? This is obviously relevant in an interagency coordination context where the array of actors and levels that could be considered for inclusion quickly becomes prohibitively large. Take the homeland security area, for example. The organizations involved in homeland security potentially span the entire geographical space of the United States as well as organizations at all levels of government, and the non-profit and private sectors.

The approaches taken to scoping network boundaries vary, depending on context and capabilities. Defining the problem in narrower terms is one obvious solution. Kapucu, in the aforementioned work, limited his network to organizations appearing in FEMA after-action reports. In a surveying context, one approach oftentimes is to obtain a list of the potential network participants and then survey each of those on the list about their relations with each of the others on the list only; this works well oftentimes in an intraorganizational context where the population of participants sometimes is fairly well known. Another approach under a survey approach is to ask "name generator" questions to generate the network. Question 1.a. above reads like such a question. Here the respondent is being asked to self-identify relevant contacts rather than being asked about a pre-determined set of contacts. Such an approach is typically combined with a snowballing approach, where the contacts named by a small core set of people are also interviewed for their contacts. This process can be repeated iteratively. In some cases, it becames relatively clear what the boundaries of the network are; in others, snowballing must be arbitrarily cut off. A third approach focuses less on data collection and more on using analytical techniques to identify the most relevant members of the network. For example, Powell et al (2005) analyze only the "main component" of organizations in a biotechnology sector communication network; a component in network analytic terms is the set of entities in an organization who are all reachable to each other without any breaks in connectivity (this and related concepts are discussed in greater detail in the next section).

D. Applying Network Analytic Concepts to Public Sector Coordination

As alluded to previously there is a huge research and technical literature elaborating and applying a wide array of network analytical procedures and techniques. Many of these procedures and techniques would seem to have a direct overlay to the area of public sector coordination. Indeed even the names of many of the concepts evoke an array of coordination concerns, such as centrality/centralization, fragmentation, prestige, cohesion, cliques, autonomy, control, coherence, clustering, equivalence, proximity, position, brokerage/mediation, power, diffusion. All of these terms (and more) have a basis in specific mathematical formulae drawn directly from matrix algebra and graph theory and thus have specific methodological and analytical underpinnings.

In this section, I selectively elaborate a number of the most promising network analytic concepts and techniques and describe how they have been used in existing research and might be applicable to the specific problem of analyzing public sector coordination.[4] We begin by discussing some prominent quantitative network metrics and measures and some of their analytical uses. We move from there to consideration of concepts and techniques for understanding the network substructures and of ways they have been used and could be used analytically in a coordination context. Finally, we elaborate a number of techniques for understanding overall network structure and their potential coordination applications.

i. Network Metrics and Measures: Centrality and Centralization

Centrality. Perhaps the core measurement concept in network analysis is that of centrality and its related concept of centralization. Most network analyses start out by asking

[4] Throughout this section I make extensive use of concepts drawn from Wasserman and Faust (1994) and Carrington, Scott, and Wasserman (2005).

the individual-level question of who the most important or best-connected members of a network (centrality) are and, relatedly, at the overall network level, of how concentrated network connections are around specific network members.

From the point of view of coordination, and from a metaphorical point of view, centrality and centralization are obviously important considerations for the coordination problematic. In general, treatments of public sector coordination start from a basic premise that governmental activities are much less centralized and hierarchical now than they have been in the past. So, in general, understanding the degree to which a public sector coordination effort is centralized around particular actors may help greatly in understanding the challenges to effective coordination. Similarly, knowing the degree of individual actors' relationships with the rest of the network may help inform an understanding of bottlenecks in a system or coordination effort (see Smith-Doerr et al, 2004, for nuanced analysis).

Centrality/centralization is actually a family of measures from which an analyst can choose, depending on the anaytical context. In terms of individual-level centrality measures, the most basic measure of centrality is degree centrality. Degree centrality measures the number of direct ties that a network member has with all other members. There is, in addition to degree centrality, a number of other measures of centrality that incorporate indirect ties into the picture as well. The most common of them is betweenness centrality, which measures the degree to which an entity lies on the shortest paths (geodesics) between all other pairs of entities. Closeness centrality determines the average geodesic distance between a given member and all other network members.[5]

ii. Network Substructures: Brokerage and Cliques

Network measures like centrality and centralization are useful as indices for key network traits. But they provide at best limited information on network structure and specific connectivity patterns. Knowing the level of centrality of a particular network member or the degree to which a network is centralized only limitedly informs us about the structure of the network. It doesn't tell us who is connected to who, or what the connections of the central actors to each other are. It doesn't tell us whether the network is disconnected with a number of highly connected pockets, whether there are long chains of connectedness, or whether there is a more even distribution of connections through the network. These are all issues that could be of potential interest to examinations of public sector coordination issues. We examine a number of ways network analysts have delved into these more specific network questions.

Structural Holes and Brokerage. We saw in the previous section that networks often have some number of actors who are centrally positioned in terms of the degree of connectedness that they have with the rest of the members of the network. Since Granovetter's statement on weak ties (1973) it has been recognized, however, that high levels of simple centrality may not be reflective of an actor's prominence or power in a network. If, for example, all of the contacts of a highly central actor are also all interconnected with each other, the power and influence of the central actor are likely to be more limited than in the case where the central actor's contacts are disconnected. In the latter case, for example, the central actor is in a position to mediate between or broker a potential connection between the disconnected contacts.

This concept of brokerage roles has in recent years gained prominence as a key indicator of network power and influence. Perhaps the best-known operationalization of the brokerage role concept is Ron Burt's (1992, 2004) structural holes approach. Burt's approach revolves around the paired ideas of autonomy and constraint. A network actor is relatively constrained in his opportunities for action to the extent that his contacts are interconnected, and relatively autonomous to the extent that they are not.[6] Burt and others have shown in numerous business firm contexts in the U.S. and internationally (France, Canada, etc.; Burt et al, 2000) that models predicting a variety of individual-level outcomes such as whether a person's ideas are valued by peers, promotions, pay or strongly associated with an actor's possessing an autonomous brokerage role in a network.

In a public sector coordination context this question of brokerage is potentially as relevant as in a private sector context. Identifying, for example, the information brokers in an intraorganizational agency-specific setting and their role in the effective functioning of the organization would seem an obviously important question. In an interorganiza-

[5] Each of these individual level centrality measures have corresponding centralization measures.

[6] Burt emphasizes the strategic importance of actors identifying and filling the structural holes between various diverse pockets of connectedness that are not, themselves, interconnected.

tional setting brokerage could be even more important. In situations where, for example, voluntary interagency initiatives to share information, develop plans, or prepare for contingencies, identifying actors who are playing or potentially could play brokerage roles could be useful analytically and managerially; setting people up in such roles might make excellent sense from the point of view of motivating the development of the coordination network.

Cliques and Other Cohesion Sub-Structures. The concepts of centrality and structural holes/brokerage are keyed to individual network actors – with the structural hole idea extending our perspective on individual roles to a consideration of the individual's network "neighborhood" and the consequences of that for network effectiveness and power. While such perspectives are important both in understanding network structure and for evaluating network coordination, a logical extension from the neighborhood idea is to give more systematic consideration to the "groupness" of networks and coordination processes. In particular, how does a complex "largeish" network break out into specific substructures, groups, components, segments, etc.? The umbrella termed used to refer to techniques for identifying and analyzing such substructures is "cohesion." As with the centrality concept, research on cohesive subgroups provides a wide array of techniques that constitute options to be used depending on context, data, and theoretical perspective.

The most basic concept of a cohesive subgroup is the clique, defined as a "maximally connected" set of network members or nodes – each member of the substructure is connected directly to all others in the group. In many situations, particularly where the linkage structure is relatively sparse, the requirement that all subgroup members be connected can be overly restrictive, resulting in the identification of very few or analytically trivial subgroups. As a result, an array of techniques that weaken these requirements in a variety of ways have been developed. Common examples of these include the following:

- n-cliques: A subgroup where all members are connected to each other by paths of n or less;
- n-clan: A subgroup where all members are connected to each other by paths of n or less and where the "diameter" of the subgraph constituting the subgraph is equal to n. This makes for more compact subgroups than n-cliques with oftentimes fewer members;
- k-plex: A subgroup where each member is directly connected to a specified, required number[7] of other subgroup members. Thus, while not all members need to be directly connected to each other, the requirement is that each member be connected to some meaningful number of the others in the subgroup.

There are numerous other cohesive subgroup concepts constituting both minor and major variations on these concepts. One of the most interesting recent such examples is that of k-connectivity (see Moody and White, 2003) which identifies subgroups based on the minimum number of actors who, if removed from the group, would disconnect it. Moody and White show that this conception of cohesiveness has a wide array of applications in organizational and social contexts.

Analyzing the subgroup structure using these and related concepts has great potential as a tool for understanding coordination efforts. At its heart, a cohesiveness perspective could enable identifying the parts of the network where coordination is functioning most effectively or where communication is most intensive. Evaluations could be made of whether such high connectivity in these particular pockets is appropriate or could be copied elsewhere in the network. High subgroup cohesiveness could, in some situations, be an indication of a problem if that subgroup is disconnected in general terms with the rest of the network. An example of the potential usefulness of clique analysis to studying coordination is the work of Provan et al (1998, 2005).

iv. Overall Network Structure: Positional Analysis, Blockmodels, and Equivalence.

Analysis of network substructures as reflected in structural holes or cohesive subgroups moves us in the direction of asking about the overall structure of a coordination effort. How do all the pieces of the network fit together? Analysis of cohesive subgroups provides one type of answer to this, in that typically, once subgroups are identified the natural next step is to examine the extent to which those subgroups are connected to or overlap with one another. A variety of measures have in fact been developed to measure subgroup connectedness and overlap.

Beyond this, however, the network perspective has developed an array of techniques for identifying and sys-

[7] The required number is defined as the total number of nodes in the subgraph minus k. The larger k is in relation to the total number of nodes, the more restrictive the requirement for membership in the subgroup.

tematizing our understanding of positions and roles across the network and their relationships to each other. Such perspectives allow for a "bird's eye" view of overall network structure that could be fruitful for examining public sector coordination. Here, as with other network analysis techniques, position and role are defined structurally, in terms of the patterns of relations characterizing the actors occupying particular positions/roles.

The core concept underlying positional analysis is that of "equivalence." The basic task in identifying and systematizing an understanding of network position(ing) is to determine the degree of similarity of between different actors in the network defined in terms of their pattern of ties to all other members of the network.. Network members whose patterns of ties with all others in the network resemble each other are viewed as "similar" or "equivalent" (depending on the definitions being applied). To complete the identification of positions similar/equivalent members are then grouped together, based on varying algorithmic specifications of acceptable degrees of similarity. The typical result is a "blockmodel," specifying an overarching finite set of main positions and their relationships to each other. {Provide example and further elaboration.}

Analysis of equivalence and blockmodeling has a variety of potential applications to public sector coordination settings. Equivalence and blockmodeling methods have been used extensively in both intra- (McKenney et al, 1992) and inter-organizational settings (Beckfield, 2003), and to answer a variety of analytical questions. A key insight provided by these methods that has direct overlay onto the analysis of coordination is that networks are typically not uniform constructs where members' involvements simply vary quantitatively as measured by the extent of their involvement (e.g. reflected in the number of connections they have) but rather there are qualitative differences (arrived at primarily quantitatively) in the ways that different actors fit into the network or coordination effort. The ability to specify these differences will increase our understanding of why a particular coordination may or may not be effective, where and in what ways it may be lacking or need improvement, and who is fulfilling which kinds of roles.

Conclusion

The purpose of this paper has been to identify specific applications of formal quantitative network analysis to the public sector coordination field and to demonstrate that the latter could make use of network analysis to inform a more systematic understanding of the relational aspects of coordination. As shown, there is a wide variety of potentially fruitful avenues for exploration ranging from the less to more sophisticated. Any applications would certainly constitute a useful addition to our understanding of public sector coordination.

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