ORGANIZATIONS AS NETWORKS OF ACTION

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ABSTRACT

Process-oriented thinking has become increasingly popular among both organizational theorists and practitioners in recent years. We are encouraged to view organizations as collections of processes that transform inputs, create value, and so on. Yet within organization theory, the orthodox model of organization is built on collections of individuals, groups, sub-units, or divisions. This paper describes a method which treats organizations as structured patterns of action and proposes that these patterns can be represented as a network or a directed graphs. Relations between actions in such a graph may be sequential or causal. This network representation makes it possible to apply standard graph theoretic techniques and metrics, such as density and centrality, to analyze patterns of action and to compare them across organizations. Modeling organizations as "networks of action", rather than networks of people, may provide insight into topics such as institutional theory, organizational ecology, and organizational learning.

INTRODUCTION

In our standard theories of organization, structure is in the foreground and action is in the background. We tend to see organizations as collections of individuals or subunits, and to measure the variable properties of those individuals or subunits. But if we reversed figure and ground, and viewed organizations as patterns of action, what could we see? Patterns of action, conceptualized as organizational routines are a central aspect of organization theory (March and Simon, 1958; Nelson and Winter, 1982; Hannan and Freeman, 1983). Some have even argued that organizations are *essentially* repetitive patterns of action (Geser, 1992). Much of the work on agent-based modeling of organizations (e.g., Masuch and Lapotin, 1989) explores the connection between organization level phenomenon and micro-level patterns of action. McKelvey (1997, p. 358) argues that while micro-level processes are stochastic, in the sense that they may vary idiosyncratically from time to time, they embody “patterned regularities” that provide a basis for rigorous theorizing about organizations as a whole.

It is ironic, then, that the major modes of explanation or analysis used in the organizational sciences do not generally focus on actions or their sequence. Most of our research focuses on the variable properties of entities at various levels of analysis, such as individuals, groups, task units, establishments, or organizations. Even network analysis, which emphasizes patterns of relations, generally focuses on the relations among static entities. Thus, our major methodological frameworks leave out an obvious and perhaps essential feature of organization: patterns of action. While there has been increased interest in the analysis of sequences of action (e.g., Abell, 1987; Abbott, 1990), these techniques have just begun to be applied to empirical research in the organizational sciences (e.g., Pentland and Reuter, 1994; Sabherwal and Robey, 1994).

Part of the problem, of course, is that one cannot “see” patterns of action or processes. They typically are distributed in time and space, making it difficult to observe a coherent sequence in its entirety. Many significant processes are distributed between organizational sub-units, as well, making it difficult even for participants to explain what happens. Consequently, if we are to conduct empirical work in the domain of action, we need techniques for summarization and comparison that allow us to capture significant aspects of a process as a whole. While variable properties, such as cycle time, quality, or cost, have practical value in benchmarking, they provide little insight into the underlying phenomena. This potentially rich area of theorizing is limited by our inability to operationalize the central construct -- patterns of action -- in a valid and reliable way.

The purpose of this paper is to introduce a formal approach to organizational analysis that puts patterns of action directly in the foreground. By coding sequences of actions in an organization, one can generate a matrix that summarizes the actions and the relations among them. This matrix represents a “network of actions” that can be analyzed using the same graph-theoretic techniques that have been applied to networks of people and other entities. The contribution here is not to introduce new mathematical tools for the analysis of action, but to apply existing tools to a new kind of data. The advantage of network models is the availability of well-known quantitative measures, such as centrality and density. When applied to networks of action, these measures provide an interesting basis for theorizing about a range of significant organizational phenomena.

Representing routines as networks of action also facilitates the application of Campbell's (1969) concept of blind variation and selective retention. Routines are like ruts in the road; there are commonly followed paths, but there are always variations (Pentland and Reuter, 1994). Over time, some variations may become new ruts. An appropriately constructed network provides a formal representation of this metaphor, to detect variations and map them over time. In the domain of action, "blind variation" is commonplace, as exceptional circumstances force us out of our ruts. So is selective retention: when a course of action succeeds, we try to repeat it. In this volume, several of the papers (e.g., Madsen, Mosakowski, and Zaheer, 1998; Ingram and Roberts, 1998) address VSR concepts in considerable detail. Although I will not concentrate on this particular application in this paper, it provides an implicit backdrop for everything that follows.

After discussing some related literature, I introduce a technique for generating a network of actions and illustrate it with some previously unpublished data on software support hot lines. The body of the paper explores the interpretation of familiar concepts such as density, centrality and cliques when applied to the patterns of action in an organization and then discusses some possibilities for applying these concepts in familiar areas such as institutional theory, organizational ecology, and organizational learning. While a full exposition of any one of these applications would require an entire paper, they are included here to illustrate the potential power of this approach.

WHY NETWORKS OF ACTION?

While representing organizations as networks of action is a significant departure from mainstream organizational theory, it is not without precedent. Czarniawska (1997) uses the concept of "action nets" to describe social institutions and provides a compelling account of the significance of these networks. But stops short of providing a clear way to operationalize the concept in research. There are a variety of points of reference in the organizational literature that provide examples of how networks of action can be modeled. Before examining the details of the method I am proposing here, it seems worthwhile to get an overview of the existing work.

Comparison with Traditional Social Networks

As a starting point, it may be instructive to compare the method described here with the general steps one might use to construct a traditional social network of ties between individuals. To measure a social network, a list of all relevant individuals who may be members of the network is usually prepared. This might be all of the employees in a department, or all the members of a social club. Then, guided by one's theoretical interest, one identifies the kinds of relations (or ties) that one wishes to map. The relations are often operationalized using a survey instrument that is given to each member of the network. To map an advice network, for example, the survey might ask, "Who do you ask for advice about work-related problems?" The data collected in this way can be used to identify the sources and targets of advice-seeking relationships throughout the network. This approach takes a single event category (advice-seeking), and asks members of the organization to identify all instances of it (as primed or instructed by the survey instrument). We have no data about why advice was sought, or what happened as a result. The precursors and antecedents of this event are excluded.

By contrast, the method described here would attempt to locate advice seeking, rather than advice seekers, in a larger network of actions for problem solving. To do so, one would gather data that covered whole sequences of events where advice was sought or problems were being solved. These stories would include a lexicon of other kinds of actions relevant to problem solving, such as problem identification, alternative generation, and so on. One would use this lexicon of actions to code the problem solving episodes among employees of a department, or members of a social club, or whatever. The coding process would generate sequences of events that describe problem solving episodes and can be converted into a network with formal properties analogous to the traditional social network. Since the network explicitly encodes the antecedents and consequences of each action in the lexicon, including advice seeking, it preserves information about the relations between actions that are lost in other methods. The question is how to put this data to use.

The most immediate and obvious area of application would be in institutional theory. I will return to this topic later, but for the time being, consider this definition from Jepperson (1991, p. 145, emphasis in original): "*Institution* represents a social order or pattern that has attained a certain state or property; *institutionalization* denotes the process of such attainment. By *order* or *pattern*, I refer, as is conventional, to standardized interaction sequences." Like Geser (1992), Jepperson (1991) places patterns of action at the center of the phenomenon. Czarniawska (1997) also argues that institutions can be interpreted as "action nets", but warns against mistaking the patterns for the institutions themselves. The interaction sequences that are associated with any particular institution may vary in degree of "taken for grantedness", formalization, and so on. They may also come bundled with an elaborate package of social, technological, and structural arrangements that enable and constrain them. Consequently, it would be an error to completely identify institutions with the patterns of action per se. Still, we recognize and define institutions by the "standardized interaction sequences" that they produce and reproduce.

Process Grammars and Networks of Action

While the explicit analysis of these institutionalized interaction sequences is at an early stage of development in the organizational literature, there have been attempts to create formal, network models. Abell (1987) explores the epistemological foundations of modeling social actions using network representations, such as directed graphs. He provides formal models of social processes where each node represents an action or event. These models can be summarized in matrix form, or displayed as a directed graph. Network models, in the form of Markov transition matrices, have also been used to represent interaction processes (e.g., Gottman and Roy, 1990). These kinds of directed graphs can be interpreted as finite state grammars (Chomsky, 1956). Each node in the graph can be used to represent a symbol in the "language", and the transitions between nodes define the possible "sentences" in that language.

The use of finite state grammars in the representation of natural language is somewhat limited, but they are an excellent tool for modeling a wide variety of computational and organizational processes. The familiar flow chart, for example, is a special kind of directed graph. A flow chart can be seen as a finite state grammar that defines the valid ways in which a process may be performed. In this respect, this framework discussed here represents an extension of previous grammatical models of organizational processes (Pentland & Reuter, 1994). While phrase structure grammars have superior expressive power, directed graphs have the advantage of being easily induced from observational data.

Cause Maps and Dynamic Systems

Two widely used methods for mapping real or perceived relations among activities or events are cause maps and system dynamics. In a sense, these techniques are specialized versions of the idea I am describing here because they focus on particular kinds of relations. For example, “cause maps” (Bougon, Weick and Binkhorst, 1977) represent causality between events as perceived by research subjects. The lexicon of actions is open ended, and the relation being graphed is causality. As Nelson and Mathews (1991) note, cause maps can be seen as matrix (or network) representations of processes. The events or actions in the map are the nodes and the causal relations are the links.

System dynamic models (Forester, 1968) also embody networks of causal relationships between events or activities. While some applications of system dynamics center on the construction of the causal map at a qualitative level (e.g., identifying positive and negative feedback loops), much of the work in this literature depends on identifying specific, quantifiable relations. For example, if production increases but sales do not, inventory increases by a specific amount. This makes it possible to create formal computational representations can be used to simulate the dynamics of the system. Computational accuracy sets a very high standard of rigor for the description of a process. In addition to merely identifying relationships, one must estimate the magnitude of the parameters that govern those relationships. As we shall see, the approach I am describing here could be used to derive causal models such as these, but probably not for purposes of simulation. Also, there is no need to limit oneself to causal relations when constructing a network of actions.

The Process Handbook

An example of action networks that do not rely on causal relations is The Process Handbook (Malone et al., 1993). The Handbook is an electronic database of process descriptions, each of which can be interpreted as a network of action. Each process description consists of a set of activities and, if so desired, the relationships between those activities. The representation emphasizes a coordination theory perspective (Malone and Crowston, 1994), so the relationships among actions include various kinds dependencies, such as flow, fit, and sharing. The database currently contains over 3000 process descriptions, not all of which have information about dependencies. In other words, many of the process descriptions include only decompositions of the process steps without the necessary data to construct a network of relations between those steps. As more process descriptions are collected, it is anticipated that more complete process descriptions -- including dependencies -- will be included. So far, the primary applications of the handbook have been oriented towards process improvement and organizational design (Malone et al, 1993). By making a library of process descriptions accessible in a structured way, with a sophisticated interface, the Handbook provides designers with a novel tool for inventing new processes. At the same time, the database itself may eventually provide organization theorists with a rich set of empirical materials from which to work.

Narrative Analysis

Abbott (1992) has argued that we should treat narrative as the fundamental building block of social analysis (see also Abell, 1987 and Czarniawska, 1997). As we shall see, the general approach described here also has some parallels to the analysis of narrative structure (Bal, 1985; Todorov, 1981;

Propp, 1928). Each entry in the Process Handbook, for example, can be seen as a stylized story about an organizational process. Readers familiar with post-modern (sometimes known as "post-structuralist") analysis will realize that this approach treats narrative as objectively given and analyzable independent of context. That is an important limitation that is worth mentioning because stories and the actions they describe depend on context for meaning. The data are narrative, but the epistemology is positivist, in the sense that the events described in the stories are taken at face value. This results in what Abbott (1988) calls "narrative positivism." The general approach hinges on our ability to code narrative data objectively, thereby rendering it available for more formal methods of analysis. In practice, of course, the significance and interpretation of any action, no matter how objective it may seem, is never completely fixed. In this regard, the method discussed here depends on taking a particular perspective and achieving reliability within that perspective through the use of multiple coders or standard coding techniques. In this respect, it is no more difficult or unusual than any other method for sequential data analysis.

MAPPING A NETWORK OF ACTIONS

To analyze patterns of action, we must collect sequential data. By "sequential", I mean temporally ordered events (Abbott, 1990). This is not the same as time series data, which consist of temporally ordered values for one or more variables (e.g., quarterly reports of productivity or employment). Depending on the phenomenon under investigation, sequential data may include many different kinds of events. For example, Corsaro and Heise (1990) investigate routine interactions among children on a playground, which are comprised of events like chasing, fleeing, displaying fear, and so on. Pentland and Reuter (1994) investigated technical support hot lines, which includes events like opening, transferring, escalating and closing a problem report. As in variance-based research (Mohr, 1981), where the choice of variables is guided by theory, the choice of relevant events is also theoretically driven (Abbott, 1990; Corsaro and Heise, 1990). For organizational decision-making processes, for example, one might include events that represent generation of alternatives, establishing criteria, and so on (Olson, Herbsleb and Reuter, 1994).

Networks of actions are most appropriate as models of routines: organizational processes that are reasonably well defined and repetitive. With the increasing prevalence of electronic communications, databases, and workflow support systems, some kinds of sequential data are becoming more readily available. Still, getting useful accounts of what goes on inside organizations can be difficult and time consuming. The problem is similar to that faced by anyone who engages in process mapping -- how to get a reasonable picture of events and their interrelationships? Broadly speaking, the three main choices are the same as they ever were: interview, observation, and archive. Survey methods are probably inappropriate because of the complexity of the material being collected.

Coding sequential data

Interview, observation and archival methods can all produce textual data that describe sequences of events or actions: what happened first, what came next, and so on. To generate a network, the text needs to be coded, and any approach that will produce coded sequences can be used. There are two essential aspects to consider: (1) a definition of the events to be coded and (2) a definition of the relations between these events (Abbott, 1990; Corsaro and Heise, 1990). This is analogous to the problem of identifying individuals in a traditional social network and the relations among them.

As with any such reduction of narrative to its structural elements, there are a variety of issues to consider. First, one must consider the perspective from which the codes are created. One major distinction is between etic coding, which uses a priori theoretical categories, and emic coding, which uses culturally grounded native categories. Pentland (1992), for example, develops an emic category scheme for software support and hypothesizes that those categories might be more generally applicable. To facilitate comparability across organizations, of course, a common coding scheme needs to be used. There are a variety of different a priori frameworks that have been developed to facilitate comparison of work processes, many of which are used for job analysis (Harvey, 1991). The particular choice of coding scheme has to be driven, ultimately, by the theoretical categories are relevant to the research question. Note that this is quite different than in constructing a traditional social network, where one may choose to include or exclude certain individuals, but the identities of the individuals included are basically given. In constructing a network of actions, the "identities" of the nodes are defined and constructed as part of the research process.

Second, one must consider the granularity (or level of detail) at which coding should take place. Abell (1987) does an excellent job of exploring the roots of this problem and provides some guidance on how to deal with it. Unlike a traditional social network, where individuals are irreducible, one can always subdivide actions into increasingly minute constituents. As Abell (1987) points out, the sociological insights that one might gain from this kind of reductionism are quickly exhausted. The goal is to choose a level of granularity that corresponds to the problem at hand. As in a traditional sociogram, one can aggregate constituents into larger units, if that proves useful.

Relations between actions

Once the core set of events or action that comprise the nodes of the network have been identified, one must identify the relations between them. Identifying relationships between nodes is fundamental to the idea of a network. Network data express relationships between the elements, or nodes, in the network. In traditional social networks, relationships may reflect attitudes, interaction, familial relationships, and so on (Wasserman and Faust, 1994). In the domain of events or actions, however, the kinds of relations are quite different.

The simplest kind of relation between actions is sequential adjacency (action B follows action A). Sequential adjacency seems closest to our intuitive sense of a "pattern" of action because it defines what actions follow others. It is the most easily observed and probably the most reliably measured. Given a coded sequence of action -- A, B, C -- sequential adjacency of the actions is self-evident. These relations can also be quantified by counting the number of times one action follows another. If these frequencies are normalized appropriately, then the matrix represents a Markov process (Wasserman and Faust, 1994). Unfortunately, actions that follow in sequence may do so for a variety of reasons that may or may not reflect any underlying causal process. This is the conceptual equivalent of the familiar distinction between correlation and causation in variance based analysis. For example, coffee and desert are usually served at the end of a meal, but that sequential relationship is imposed, if at all, by cultural norms. This limitation does not invalidate the data, of course, it merely suggests caution while interpreting it.

One can also graph causal relations between events, including whether one event is necessary, sufficient, or both, to cause another event. Causal relations are used to create cause maps (Bougon, Weick and Binkhorst, 1977), as well as process theories of various kinds (Mohr, 1981). They state the necessary and/or sufficient conditions for various events to occur. Corsaro and Heise (1990) describe the use of ethnographic data to create "event structure" models that map the "prerequisite" relation between events; they identify the necessary (but not sufficient) conditions for action to proceed. While identifying such relations is considerably more time consuming and difficult that merely identifying sequential adjacency, they can be summarized in a directed graph and analyzed in the manner described here.

There are other kinds of relations between actions that may be of interest, as well. As I will discuss later, Weick and Roberts (1993) identify "heedfulness" as the central relation in their theory of collective mind. Malone et. al (1993) have identified several other kinds of relations that can exist between activities, such as sharing the same resources or contributing to the same output. In these cases, the relationship between the two activities or events is non-directional and there may be no causal or even sequential relationship. But clearly, sharing resources (such as budget, personnel, space, or raw materials) are critical relationships both in theory and practice.

Extracting Network Data from Coded Sequences

To create a network that represents sequential adjacency, the basic procedure for converting coded narrative into matrix form is purely mechanical and could be automated with a simple computer program. This is because the difficult interpretative work of identifying events and their boundaries has been done in the coding process. Once the data have been reduced to strings of coded symbols, they can be manipulated algorithmically. If the relations of interest are causal, or reflect other kinds of interdependence between the events, then constructing the network is considerably more difficult (Corsaro and Heise, 1990; Pentland et al, 1994). For such relations, one needs to test an hypothesis like "event A causes event B" for each pair of events in the lexicon. Establishing this kind of relationship is obviously a lot of work. To represent sequences of events, however, the task is much simpler. One simply looks for sequentially adjacent events or actions in the coded narrative. In this procedure, one asks, "What happened next?" and records the answers in a single mode matrix of actions. Note that this procedure only works when the coded data are arranged in sequential order.

EXAMPLE: SOFTWARE SUPPORT AT ADVANCED PUBLISHERS.

This example comes from a study of software support hot lines that I have described elsewhere (Pentland, 1992; Pentland and Reuter, 1994). I call the organization "Advanced Publishers", because the product they sell and support is a sophisticated text and graphics package for publishing technical documentation and other complex documents. At the time of the study, the software was available only on high-end Unix workstations from vendors like Sun, Apollo, Digital and HP -- it was not "consumer" software. At the same time, typical users included writers and graphic designers, and the product required a high level of support. The data analyzed here describe the process used to provide technical support to Advanced Publishers' customers. The data are archival records from a database that support specialists use to keep track of information on customer problems as they are being solved.[1] The records are reasonably accurate because the people keeping them depend on them to get their work done. Also, support specialists are evaluated, in part, on how well they keep track of their calls in this database. Nonetheless, to the extent that their needs and objectives are different than mine, one has to exercise some caution in interpreting any findings based on this kind of data.

The raw data consist of printouts of all the steps taken to answer or solve a particular question. In all, 130 sequences were coded using archival records from the software support database. The lexicon of actions used to code these sequences includes basic steps like opening the call, assigning it to a support person, requesting more information (from the customer), running tests, looking up information, and asking for help, as well as the "organizing moves" that delineate the structure of the software support organization, such as transferring, escalating, and referring (Pentland, 1992).

The coded sequences can be used to create a directed graph, as shown in Figure 1. The arrows in this graph represent sequential adjacency in the coded call sequences. In this representation, ties with only a single occurrence in the dataset have been suppressed. Ties that occur ten or more times have been displayed in bold, to indicate their greater frequency. The actual transition frequencies are displayed in the Appendix. Note that a few of the ties are shown as bi-directional to minimize the number of separate lines; these events followed each other. Also, note that "run tests" followed itself in at least some of the sequences. Unlike a network of people, actions can be reflexively related, following themselves in the sequence.

In this figure, there are some definite "ruts in the road" that suggest a very simple process. Calls are opened and assigned to a support specialist. Once assigned, they either begin to diagnose immediately (based on information provided), or they request additional information. In either case, the next step is to make a diagnosis and then close the call. In some cases, it is necessary to run tests to confirm the problem or the solution. After tests are run, there is a diagnosis and call is closed. These patterns represent the most typical scenario, and in a sense, the most routine scenario. At the same time, there are several less frequently traveled paths that add variety to the routine. For example, it is sometimes necessary to request more information (after trying to make a diagnosis), or to look up information (in documentation or on-line). In other cases, when a problem cannot be resolved by the specialist to which it was originally assigned, it is necessary to transfer the call to another specialist or escalate the call to management.

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Some Methodological Issues

As with any method, there are a variety of limitations and considerations on the ways data can be collected and interpreted. Many of these considerations are similar to those one encounters when attempting to collect traditional social network data. A great deal more that could be said, of course, but it is worth at least mentioning these issues here.

One central issue is that the units of observation -- the lexicon of actions -- are constructed through the research process, not objectively given. By varying the level of granularity (or detail) at which data are collected and represented, a very different picture would emerge. Thus, it is important to recognize that there could be many different pictures that equally well represent the same process.

Also, the notion of sequence is not necessarily as well defined as we might like. We know from formal analysis of narrative (Bal, 1985) that many different narratives can be used to convey the same underlying *fabula*, or story structure. Sequence can be manipulated for dramatic effect, for example, without changing the underlying story being told. Mystery buffs will no doubt have noticed that even though the victim may have grown cold by the end of the first chapter, the murderer is usually not revealed until the last. These kinds of structural transformations work wonders for literature, but they introduce noise into the method described here. To solve this problem, narrative data would need to be arranged chronologically before analysis. This issue was resolved automatically in the Advanced Publisher example because the call tracking database time-stamps each record and displays them in chronological order.

The boundary of the network is also an artifact of the research process. Since everything is connected to everything else, where does one draw the line? In the Advanced Publishers example, the boundary seems clear because each call to the software support hot line has a clear beginning and end. But these interactions occur in the context of at least three other processes that one could equally well want to include: (1) the customer's own work process; (2) the software quality control process (i.e., bug fixing and the "maintenance" release cycle); and (3) the overall sales process between the vendor and the customer. In the context of the customer's work process, calls to software support could be aberrations, or a part of the daily routine, and calls could have very different consequences for their work. There is no way to tell from the data reported here. In the context of the overall maintenance and bug fixing process, customer problems and bug reports are one important input. But the actual "release cycle", as it is called, involves many other steps. Individual bugs are fixed; new features, if any, are added; unit testing is conducted, where parts of the software is tested to make sure that problems have been fixed without introducing new ones; and various levels of system testing are also performed (see Crowston, 1996, for a discussion of this process). In the context of that network, responding to individual customer calls is a minor subroutine. Finally, in the context of the overall relationship between the vendor and the customer, answering a particular question may be a relatively minor event or a huge one, depending on the question. As anyone dealing with complex software well knows, the devil is in the details; if there is a particular function or feature that is failing to perform adequately, it could undermine the entire relationship between the two organizations.

One guide to the boundary question may arise from a narrow, structuralist definition of narrative (Bal, 1985), which consists of a temporally ordered sequence of events with a clear beginning, middle and end. The structure of the "story" depends on what White (1981) refers to as the moral or authoritative context. In other words, one recognizes the beginning and end of a story because, at the beginning, there is typically some challenge to the existing order and at the end, some resolution with respect to that order. In fairy tales, when evil descends upon the empire, the hero sets out to put things right. Less dramatically, a customer calls with a problem, and the software support specialist tries to fix it. Within organizations, moral context could be framed more simply in terms of goals or objectives. In other words, one might draw the boundaries of the network around that set of events which relates to a particular goal or set of goals. I think there is no easy answer to this problem;

as in a traditional network, boundaries must be somewhat arbitrary. As long as one is aware of the constructed nature of such boundaries (both by participants and researchers), and the authoritative contexts that inform them, one can make informed decisions about how they should be drawn.

INTERPRETING NETWORKS OF ACTION

Representing the actions occurring in an organization as a network makes it possible to apply conventional tools of network analysis. The difficulty, of course, is that the familiar mathematical formalisms such as centrality, density, clusters, and so on, have very different interpretations when computed in the domain of actions rather than the domain of individuals. In this section, I will explore some ways that the network of actions can be interpreted. As in traditional social networks, the specific relations and the characteristics of the nodes in the network are crucial to the story one tells. For example, if one is examining the pattern of ties between Florentine families in the 15th century (Padgett and Ansell, 1993), it matters that one of those families was the Medici. The significance of the identity of particular nodes may be just as high in the kinds of networks described here. For example, if one of the events in the network is particularly important (for example, closing a sale), then the significance of the network as a whole would likely depend on that particular node. Like any process representation, it seems likely that just having the network map (or going through the exercise of creating it) could have considerable practical value.

The theoretical value, however, remains to be developed. There are a variety of different ways that networks of action could be applied to organization theory. The value hinges on the idea that network measures, such as density, have theoretically relevant and interesting interpretations when applied to networks of action. Abbott (1990) notes that in general, when one is studying patterns of action, one can explore their antecedents, their consequences, or the patterns themselves. Thus, one could ask what leads some networks to be more or less dense than others, or what the consequences of increasing network density may be, and so on. But before advancing specific propositions, let's explore how some familiar network measures can be interpreted in this domain.

Clusters and Cliques

Wasserman and Faust (1994) define many different techniques for computing cohesive sub-graphs of a network. These include cliques, n-cliques, k-plexes, k-cores, and lambda sets. These represent different formal algorithms for extracting sets of nodes that are more tightly interconnected than their neighbors. In a traditional network, these clusters of individuals represent social groups of various kinds; in the domain of action, I would argue that these clusters of actions represent organizational routines -- sequences of action that are tightly connected and yet distinct from other sequences in the organization. Routines are cohesive, integrated chunks of action.

If one imagines a network of actions that includes a wide range of different actions or activities, routines would naturally emerge as the actions that cluster together. Even a purely descriptive study of "membership" is such cliques could be quite interesting, if applied to the right kinds of processes. For example, one might study the comparative structure of strategy formation or new product design. To the extent that important clusters of actions can be viewed as representing "core competencies", this method provides a way of operationalizing this elusive construct very concretely. Gathering the data would be expensive, but with adequate resources, one could begin to study the antecedents and consequences of these clusters, as well.

If one can identify clusters in this way, one can also identify connections between clusters. Exploring linkages between routines creates some interesting possibilities. From a practical point of view, one might want to know how the budgeting process interacts with the hiring process. On a more theoretical level, an action-based perspective presents an alternative view of the concept of "boundary spanning." Rather than looking for individuals that create linkages between formal (or informal) groups, one could look for events that create linkages between routines. Boundary spanning events could be an interesting topic of research in and of themselves.

Reachability and Distance

Measures of "reachability" or distance, are a basic tool in the analysis of networks. In traditional social networks, the famous "small world" experiments provide a vivid reminder of the combinatorial power of network ties. In the domain of actions, distance would have a rather different interpretation: how many steps away is the event of interest? This kind of metric could have practical interest as a benchmarking tool (e.g., how many steps between order and fulfillment?) A simple theoretical application of this concept concerns the existence of isolates -- unreachable nodes -- in a network. Imagine that one has started with a lexicon that covers a wide variety of possible processes in a given domain -- such as decision making or problem solving. If "voting" or "advice seeking" emerge as isolates, it means that these actions never occur in that network. They don't appear in any of the sequences. Alternatively, if certain nodes in a directed graph have only in-bound links or out-bound links, it means that such events begin or terminate the processes in which they occur. In the Advanced Publishers data, "open call" and "close call" are examples of such nodes. One could certainly arrive at these conclusion without all the analytical overhead of creating a network. But it is reassuring to know that concepts like distance have straightforward, meaningful interpretations, because other network measures (such as centrality) depend on them.

Centrality

There are also many different ways to measure centrality in a network (Wasserman and Faust, 1994). These measures generally indicate that a node is on the path between many other nodes in the network. In a network of action, actions that are "on the path" of many different routines are likely to be potential "bottlenecks" -- points of vulnerability or opportunity, depending one's point of view. From a practical standpoint, this is obviously valuable information. More theoretically, one might compare the centrality of certain kinds of actions in different networks. For example, one might measure the centrality of voting as a part of a network that represents organizational decision making. Bougon, Weick and Binkhorst (1977) use the related concepts of in-degree (number of inward links in a directed graph) and out-degree (number of outward links) to analyze cause maps. In a cause map, events or actions that have high out-degree are like "root causes" -- they lead to a large number of other events.

Density

Network density can be measured in many different ways, as well (Wasserman and Faust, 1994). One simple measure of density in a social network is the average number of ties per node, normalized by the total number of possible ties. Intuitively, density provides a measure of the connectedness of the individuals in the network. Figure 2 shows how one might interpret network density for two different kinds of relations.

-------------------- Insert figure 2 about here --------------

A low density graph of sequential adjacency depicts a situation where one event follows another in an order flow. In the limiting case (shown in figure 2), the sequence is perfectly linear. As density increases, it means that many different events were observed to follow any given event. Intuitively, it would be very difficult to discern a pattern in this situation. In the limiting case (all ties, density =1.0), any event could follow any other event.

If the relation being graphed is causality (necessary and sufficient), the same basic intuitions apply, but the implications are much stronger. A low density causal chain is easy to understand, and it would be easy to predict its behavior. But a high density causal chain is like a bomb waiting to go off. If one event is triggered, many others will follow. Unless there is negative feedback in the system to limit the self-reinforcing loops, the action would quickly go out of control. This observation leads to the intuitive expectation that dense networks may be quite rare in real organizations. One thing leads to another -- but probably not to five others, at least not directly. But this intuitive assertion begins to get us into the realm of organization theory, the subject to which we turn next.

USING NETWORKS OF ACTION IN ORGANIZATIONAL THEORY

There are a variety of ways in which one might use networks of action in traditional organizational theory. As mentioned in the introduction, each of these topics would potentially require an entire manuscript. This discussion is sketchy, at best, and is mainly meant to be illustrative and perhaps a little provocative. My purpose is to suggest possible connections between the properties of these networks and more familiar concepts from organization theory. I hope that the reader may think of other, better ways that these analytical tools might be applied. The core argument is simple: routines are a central, if implicit, part of organization theory and networks of action provide a novel way of operationalizing and measuring this central construct. So, assuming we could somehow get the data, how could we put these measures to use?

Institutional Theory

As mentioned in earlier, institutional theory is a natural place to apply networks of action. In this volume, for example, Miner, Ragavan, and Haunschild (1998) discuss various ways in which routines are copied or imitated. Romanelli (1998, this volume) also explores the issue of copying of routines in variation and selective retention. If we conceptualize a routine as a network of actions, it could help clarify what we mean when we say that a routine has been “copied”. For example, the proliferation of a particular technical artifact may or may not entail copying a particular pattern of action. Certain software products, such as Lotus Notes, can be adopted to support a wide range of different internal processes. Other products may only support a particular process. Networks of action would allow us to explore the extent to which the diffusion of technology promotes the diffusion of organizational forms. More generally, one could investigate the extent to which a population of organizations has really copied a routine, rather than just adopting legitimating surface features.

On a deeper level, networks of action may offer a way to operationalize the concept of institutionalization itself. Institutionalized processes are based on “reciprocal expectations of predictability” (Field, 1979, p. 59), so they should be more predictable, with fewer deviations. Without going any further, one might hypothesize a relationship between the perceived legitimacy of a process and the density of the networks of action that represents it. An excessively dense network tends to be unpredictable: too many possibilities exist at each step compared to a relatively sparse network. This line of argument suggests that increased legitimacy could be associated with decreased network density. In other words, as a process becomes more institutionalized, its density may decline.

Whether true or not, these propositions suggest the kinds of relationships one might want to investigate using networks of action. In this case, an empirical test seems justified because one could make the counter argument that increasing legitimacy and institutionalization may be accompanied by a larger repertoire of exceptions and variations. That is, expectations become elaborated, not narrowed, so the range of possible sequences should increase. Alternatively, one could argue that over time, at it becomes more institutionalized, additional constraints and affordances grow up around a process. In effect, the ruts in the road grow deeper and one should observe fewer deviations from the straight and narrow. It is quite possible, of course, that both are true -- that networks become more or less dense over time for a variety of reasons. Either way, networks of action could help identify those reasons and their consequences, if any, for organizations.

Ecological Theory

It is difficult to imagine actually applying the method described here in the domain of organizational ecology: how could one collect time series network data, since founding, for every member of a population? But if we allow ourselves the luxury of temporary omniscience, it is interesting to speculate about the relevance of these ideas for organizational ecology. The point of connection, of course, is the lowly routine -- the “genetic material” for organizations (Nelson and Winter, 1982).

There are two ways in which the concept might be applied. The first was suggested by Salancik and Leblebici (1988) who used grammatical models to generate alternative organizational forms. These “forms” were representations of canonical sequences of events that one might encounter in a food service transaction (i.e., a restaurant). If one takes this view seriously, then the appropriate unit of analysis for vital rates (founding, transformation, and mortality) should be the patterns themselves, not firms or establishments. This is line with the argument that Ingram and Roberts (1998, this volume) and McKelvey (1983) make concerning evolution in organizations, and that characterizes the mainstream view of evolution in biological species: it is the relative frequency of genes in the gene pool that matters, not the fitness of particular individuals or the number of individuals (Kaufman, 1993). Of course, once our temporary omniscience wears off, none of us is likely to attempt measuring these vital rates anytime soon. But from this point of view, organizational ecology is less about environmental selection of *firms* than it is about environmental selection of *processes*. The fact that processes are embedded in firms which have an independent economic and legal existence is an unfortunate source of complication and noise.

The second, more realistic, application would be as a measure of inertia. Recall that inertia is a property of organizations that makes them vulnerable to selection, and that it is most acute in the core of an organization. That is, while an organization may undergo considerable adaptation in many of its functions, its core will usually be highly resistant to change. Caroll and Hannan (1995) suggest that the “core” of a firm can be operationalized using four indicators: the basic mission of the organization, the form of authority, the basic technology, and the marketing strategy. While these indicators are clearly important, it strikes me that their choice was probably influenced to some extent by the practical necessity of getting several decades of time series data on hundreds of establishments. They are not bad indicators, but they are somewhat distant indicators of the underlying construct.

How can networks of action help us do better? If routines really are the genetic material (Nelson and Winter, 1982), and the patterns of action in an organization really do express its productive competence, then a network of actions might be a more valid way to operationalize the “core” of an organization. If so, then one might begin to explore the extent to which these networks (routines, genes) actually demonstrate the kind of inertia ascribed to them. There is good reason to expect that they do, of course. In particular, one might hypothesize a relationship between inertia and the structure of the underlying network of actions. Recall that routines are represented as cliques: tightly clustered bundles of activity. If we take the genetic metaphor seriously for a moment and assume that the routines themselves are largely inertial (because they are so tightly linked to the technology, or the marketing strategy, or the other “core” indicators), then an organization with more “genetic material” should have a harder time changing. It is nailed down in more places, so to speak.

Inertia should also tend to increase if the linkages between these routines (the boundary spanning events) are too few in number. This connects to the previous argument concerning legitimacy, and suggests that increasing legitimacy may go with increased inertia. The intuition is that if there are few paths between routines, there is less flexibility -- less likelihood that the organization can selectively deploy the routines. Rather, they will tend to follow in lock step, as they always have, in spite of changing environmental conditions. Again, the point here isn’t to defend the particular argument, but to demonstrate that networks of action provide a whole new vocabulary in which to cast such debates.

Collective Mind and Organizational Learning

In the domain of organizational learning, networks of action offer a way to operationalize the concept of "organization mind" (Sandelands and Stablien, 1987) or "collective mind" (Weick and Roberts, 1993). To the extent that it is possible to operationalize these concepts more concretely, it would provide additional tools for research in areas such as organizational learning or high reliability organizations. Weick and Roberts (1993, p. 357) define collective mind as "a pattern of heedful interrelations of actions in a social system." Sandelands and Stablien (1987) also suggest that "organization mind" exists in the connections between behaviors, rather than the connections between people. They argue that at the organizational level, knowledge is located in patterns of behavior. Weick and Roberts (1993) also focus on mind as "activity" rather than as "entity", a distinction that mirrors Weick's (1979) emphasis on "organizing" rather than "organization". In their theory of collective mind, the key relation between activities is "heedfulness," which is composed of contributing, representing, and subordinating, as well as a variety of more specific behaviors. In simple terms, it means acting in ways what take into account the actions of others.

Weick and Roberts (1993) offer a detailed and highly nuanced description of this phenomenon, illustrated with examples from aircraft carrier operations. While the result is compelling, the concept of collective mind seems quite difficult to operationalize in a valid or reliable way. It is a hard problem, and they offer an admittedly rough approach, which is worth quoting at some length:

> A crude way to represent the development of a collective mind is by means of a matrix in which the rows are people and the columns are either the larger activities of contributing, representing, and subordinating, or their component behaviors (e.g., converging with, assisting, or supplementing). Initially, the cell entries can be a simple "yes" or "no". "Yes" means a person performs that action heedfully; "no" means the action is done heedlessly. The more "yeses" in the matrix, the more developed the collective mind. (Weick and Roberts, 1993, p. 365)

It is interesting to note that while collective mind is described as emerging from a pattern of interrelations among actions, the matrix they describe is focused on people. This reflects a consistent tension that underlies their exposition -- *people* are interrelating, but *actions* are interrelated. As a result, the proposed matrix would describe the way people are behaving (heedfully or not), but it would not describe what they are actually doing. The matrix they describe would be unable to differentiate a flight crew from a jazz ensemble, because it makes no reference to the content of the work.

If one were to apply the method proposed here to the concept of collective mind as described by Weick and Roberts (1993), it would push the actions squarely into the foreground. Both dimensions of the matrix would be actions; the people would be implicit. The relation between actions could be a summary measure of heedfulness, or one could create separate networks to capture the extent of contribution, representation, subordination and so on. By explicitly representing the relation of heedfulness between actions, such a matrix would be a much better model of the concept of collective mind. Of course, as Weick and Roberts (1993) point out, collective mind is built continuously by people interacting, old-timers coaching newcomers, and so on. Any representation of such a mind would necessarily be a snapshot -- restricted to the moment or moments in time when data were collected.

Nonetheless, such a model would have several interesting features. First, it would retain the ability to express an overall level of heedfulness (as represented by average tie strength, or one of the measures of network density). More heedful networks would be stronger and more dense. Second, it would explicitly represent the kind of work being done. If there were potential weaknesses, they could be located in terms of the specific activities being performed (using measures of centrality, for example). Third, this kind of network would express the structure of information processing in the organization. By mapping the degree of heedfulness in relation to “boundary spanning” events (those that trigger internal activity based on external events), a network of actions could provides a very detailed picture of how an organization reacts (or fails to react) to information. Fourth, and perhaps most important, because the nodes being connected are actions (or behaviors or events), they can be seen as binary: at any point in time, they are either occurring or not. In this representation, the degree of heedfulness is separated from the activity itself, which may be quite heedful of certain considerations and, at the same time, quite heedless of others. That kind of selective interconnection -- the pattern of heedfulness -- is easily captured in a network.

Again, a full exposition of this issue deserves a separate paper, but such models are basically connectionist networks (Davis, 1992). In particular, the kind of network I have outlined here (connections between binary nodes that change state selectively based on the state of the other nodes) embodies Kaufman’s (1993) approach to modeling complex dynamic systems. In this framework, “organization mind” could be simulated and allowed to evolve through a process of blind variation and selective retention, if one chose to do so. But regardless of how one feels about computational modeling and simulation, the possibility of doing so profoundly reinforces Weick and Roberts (1993) basic insight: collective mind is an inherent property of all organizations. Or more specifically, it is an inherent property of all organized patterns of action. Ironically, Weick and Roberts (1993) argue that the application of connectionist models to organizations is problematic for a variety of reasons, but mainly because they view organizations as networks of interacting *people* . If we reversed figure and ground and focused on actions rather than actors, as the concept of collective mind seems to require, we would surely lose much of the social nuance in Weick and Roberts (1993). What we might gain remains to be seen.

CONCLUSION

Whether you can see yourself using these methods in your own research or not, it is interesting to speculate about what we might learn by putting actions into the foreground. Potentially large costs of data collection make it difficult to imagine that this will become the method of choice for organizational research anytime soon. Still, some of the central ideas in organization theory can be recast in these terms. We implicitly rely on concepts like routines, inertia, and information processing all the time; networks of action provide a formal way of operationalizing these constructs. By reflecting on what might be involved in creating valid, reliable measures of these networks, and speculating about their possible application to organization theory, I hope I have provoked some thought.

APPENDIX

Transition Matrix for Software Support Process (N=130 calls)

From. . . **To:**	1	2	3	4	5	6	7	8	9	10	11	12
1) Open Call		130										
2) Assign			30	24	8		9	5	1	6	51	6
3) Request info				7	3	2	5	3	3	3	11	1
4) Try to diagnose			3		1		13			1	12	1
5) Look up info			1	2		2	1	1		1	6	
6) Ask for help				1			1			2		
7) Run tests			2	1	2		2	1		8	13	3
8) Transfer call			1	1							7	1
9) Escalate call			1	1							1	2
10) Refer call			1	2					1		11	10
11) Make diagnosis										4		106
12) Close call												

NOTES

(1) I analyzed data from a similar database in Pentland and Reuter (1994) to create a grammatical, phrase structure model of the work process, but the archival data from Advanced Publishers have never been analyzed for publication.

(2) Visual presentation is important. When I have presented a similar diagram at academic conferences, but laid out so that the sequence of events is more readily observable, people have commented “Oh, that’s just a flowchart. What’s so interesting about that?” Of course, that would be exactly the right question if it weren’t posed in such a dismissive tone. Familiar pictures get taken for granted until we learn to see them from a new perspective.

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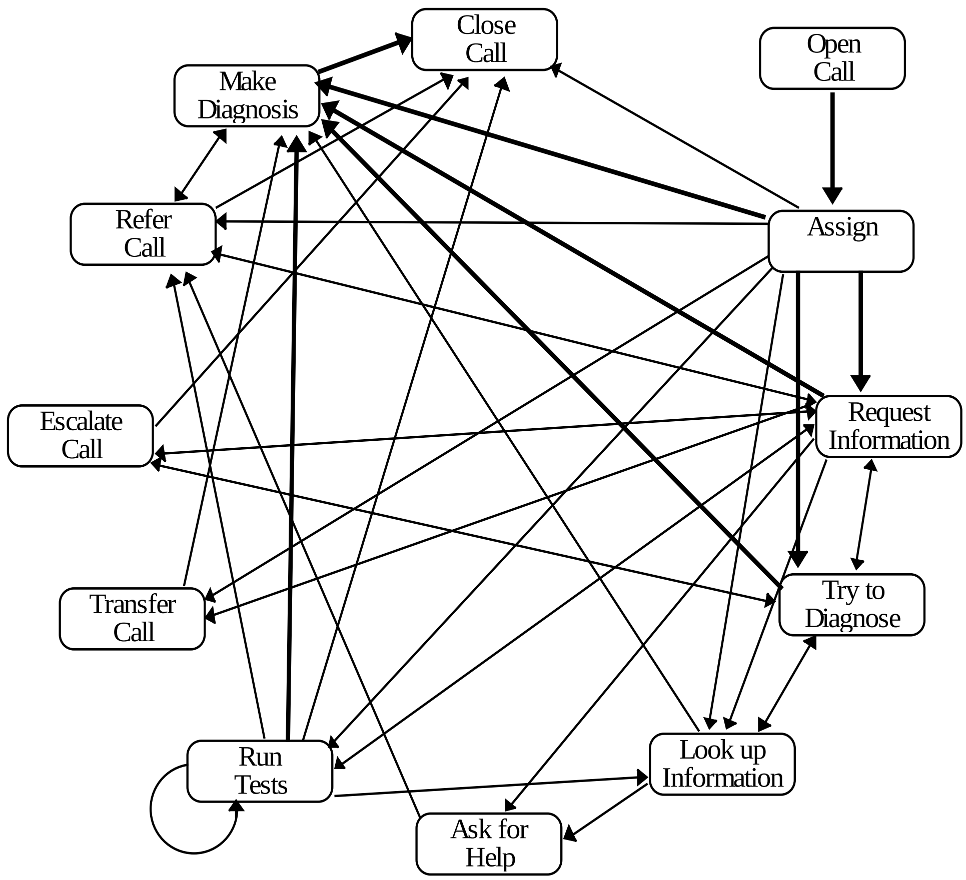
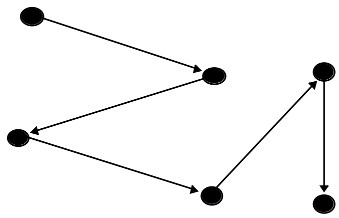
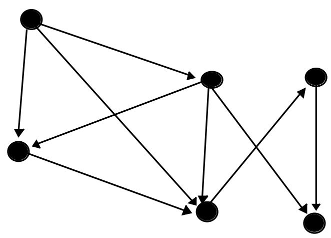


Figure 1: Directed graph of the AP software support process

		Sequential Adjacency	Causality
Low Density		Events tend to proceed in a specific progression	simple causal chain of events
High Density		Nearly any event can follow any other event	Unpredictable; like billiard balls