DOCUMENT RESUME

ED 098 630 CS 500 865

AUTHOR Farace, Richard V.; Johnson, Jerome David
TITLE Comparative Analysis of Human Communication Networks in Selected Formal Organizations.
PUB DATE Apr 74
NOTE 27p.; Paper presented at the Annual Meeting of the International Communication Association (New Orleans, April 17-20, 1974)

EDRS PRICE MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS *Comparative Analysis; Computer Storage Devices; *Educational Research; Higher Education; Human Relations; Information Dissemination; *Information Networks; Information Systems; *Interpersonal Relationship; *Organizational Communication

ABSTRACT

This paper briefly describes the organization of a "data bank" containing research on communication networks, specifies the kinds of information compiled about various network properties, discusses some specific results of the work done to date, and presents some general conclusions about the overall project and its potential advantages to researchers in organizational communication. (RB)

Comparative Analysis of Human Communication Networks
In Selected Formal Organizations

Richard V. Farace
Jerome David Johnson
Department of Communication
Michigan State University

April, 1974

(Paper presented at International Communication Association, New Orleans)

The analysis of human communication networks in large complex organizations has been approached from several distinctly different starting points in the papers presented at this convention. Richards[1] described the concepts and principles that provide a theoretic perspective for the emergence of communication network theory. He also described a computational algorithmn that explicitly defines communication networks from data on the communication behaviors of a system's members.

One output of network analysis is a representation of its group composition and the linkages among these groups. Danowski and Farace[2] used the group structure (N=56) from one organization to test the relationship between the internal communication structure of each group and its uniformity or cohesiveness along several other dimensions. Monge[3] is using network analysis to develop a causal model of the evolution of group structure, based on data gathered recently in a different organization. Wigand[4] and Brophy[5] are using network analysis to propose and/or test specific hypotheses about both intra-organizational and inter-organizational network properties.

The paper by Pacanowsky[6] presents an important contribution to network analysis in two rather unique ways. First, it portrays a working simulation of organizational processes that sensitizes participants to important communication problems found in many organizations. It also provides a realistic setting for manipulating and testing organizational communication hypotheses that would seldom be available to a researcher in the field.

The present paper has a purpose which is distinct from that of the other papers noted above. This purpose is perhaps best illustrated by the research on job satisfaction, employee attitudes, morale, motivation, etc. In both the academic and commercial research in these areas, there are summaries of results from many studies against which to compare the results of a given study. There are numerous conceptual analyses indicating the theoretic components within these topic areas. There are even more empirical analyses that provide descriptive, normative statistical summaries of the findings from these studies.

These conceptual and empirical baselines make it possible to supplement the results of one isolated study with a normative context that gives added meaning to the results and provides a potential bonus to the insights the study reveals. Thus a research finding might be that "of the 45 surveys done in the mid-West in your type of industry, your employees rank in the top 20th percentile in the commitment to the organization, but are at the bottom 40th percentile on their overall satisfaction with the kinds of supervision they receive." Without those "other 45 studies," the authors would probably be reduced to reporting that "63% of the employees say they are committed to the organization, but only 27% are satisfied with the level of their supervision." In this latter case, other criteria must be applied to evaluate the results; typically, these criteria are based on management's perception of how things "ought to be."

We have similar conceptual and empirical interests in our research on communication n tworks. We want to explicate a range of communication network properties and also gather sufficient data so that we can provide normative statements about these properties. For example, the concept of the liaison has long been a central role in communication network research. A legitimate question to raise is "How many liaisons are typically found in a bureaucratic organization?" Until recently, the best answer to that question is "15-20%," based on three studies done some 20 years apart, in two adjunct military organizations and one mid-Western college of education. Most of us would agree that this is a limited basis from which to generalize.

Consequently, as our research on communication networks has proceeded, we have begun to accumulate sets of data from a variety of organizations. We have developed an initial set of promising communication network properties. We have been able to analyze the data sets using the same algorithm. And we have begun to accumulate the results of these efforts into summary format. We have, then, a fledgling "data bank," with codebooks, copies of analyses, associated reports, and procedures for compiling data on different aspects of networks.

The purpose of the present paper, is to, (1) briefly describe the organization of the "data bank," (2) specify the kinds of information we are compiling about various network properties, (3) present some specific results of our work to date, and (4) present some general conclusions about the overall project and its potential "payoff."

Organization of the Data Bank

In its present form, the data bank[7] contains some or all of the following items for each network analysis with which we have been associated: (a) a "hard" copy of the data, in card form, stored in standard IBM card-storage cabinets; (b) copies of the data on permanent tape or disk files associated with Michigan State's CDC 6500 computer (these files can be accessed either through direct input of control cards or through the department's CRT terminal); (c) a complete copy of the codebook(s) for each data set, indicating all non-network variables as well as the network data itself; (d) library copies of the analysis runs on the data, indicating time and date of analysis, the variables used in the analysis, the version of the computer programs used, and the particular parameter settings used for the analysis; (e) copies of work sheets, memos, research reports, papers, or other documents associated with the data set; and (f) an overall appraisal of the strengths and weaknesses of the data, plus an indication of the types of analysis remaining to be done as time and energy become available.

It would be nice to report to you that all six of these goals are fully met for each data set. This is not the case; there is considerable variability in meeting these goals for several reasons, ranging from the fact that this effort is not directly funded to the fact that some data sets simply do not appear to be worth further analysis (a clear case is one data set in which all members--literally--appear to spend most of their waking hours talking to all other members; hence the network is nearly fully connected and consists of one large group). However, our goal in this work remains clear--to collect, analyse and synthesize the results of a wide range of network studies in order to generate the norms and basic distribution of various network variables so that we can provide meaningful context to the interpretation of any subsequent analysis.

What Information is Contained in the Data Bank?

The data sets we have in hand were gathered over the past five years, although the rate of accumulation of the data has increased markedly in the past two years. A brief description of the settings in which the data have been collected will give an indication of the diversity of applications of network analysis. The "N" of the data sets ranges from about 50 persons to about 1,000 persons, with a median of about 300 per study.

Three data sets were gathered at different time periods in different units of a large, eastern commercial banking firm, and two sets were gathered a year apart in a federal agency in the Pentagon. Two sets have been acquired from mid-Michigan manufacturing firms. One was collected in the State of Michigan Youth Correctional Agency and another in a regional office of the Veterans Administration in Wisconsin. One data set has been gathered outside the United States--in the State of Victoria Department of Agriculture in Australia.

Two data sets have come from different units in the armed forces, and three were collected in separate communities of a women's religious order. We have also obtained a set of the data used in the Katz, Coleman and Menzel study of the diffusion of new drugs among physicians. Finally, varying numbers of artificial data sets designed to test some aspect of the analysis routines have been drawn up, and a number of sets of data from various MSU courses have been collected. One of the more intriguing uses of network analysis by a graduate student in history at MSU has been to trace the changing networks of interaction and kinship in a 17th century New England town.

In its simplest format, the network analysis portion of each of these data sets requires each respondent to indicate <u>who</u> he or she talks with, and the <u>frequency</u> of contact. The naming of communication contacts has been done either by having the respondent write in the person's name (or sufficient identifying information), or noting the name in a list of names. Frequency of contact has been operationalized in several ways, ranging from a binary "yes/no" answer to ordinal estimates of frequencies (i.e., "x" times per month, per week, or per day) to ratio estimates of number of minutes per day. In some studies, the type of <u>content</u> of the conversation is indicated, i.e., "work-related" conversations vs. "socio-emotional" conversations, or other categories. Sometimes, <u>channel</u> questions are asked.

Hence the basic ingredients in network analysis--the designation of contactees by respondents and the description of their communication link--has been operationalized in many different ways. This means that the studies were "tailored" to the particular research setting, and while this is of considerable advantage to the conduct of a given study, it introduces significant problems in any attempt to compare and contrast findings across a series of studies. The goal of making each study design optimal for the specific research site is in conflict with the goal of generating data that can be readily compared across many studies. It seems likely that this problem will continue as further research occurs, although it is possible that a multi-purpose common instrument design may eventually be developed.

Given the array of data sets described above, and this description of the basic network data included in each set, how can this information be arranged in such a way that it will facilitate the development of meaningful generalizations about communication networks? We have decided to approach this problem by developing an organizing framework that is logically related to our basic conception of the components or "ingredients" in network analysis.

The main organizing principle we use is system level--i.e., network variables at the level of the individual, the dyad, the group, and the overall network. However, there is a second guiding principle in this category system--that as many as possible of the variables that we use be applicable across system levels. So we start out by recognizing that many variables are relevant at only certain system levels...but that the interests of parsimonious theory-building are best served by dealing with variables that apply across system levels, thus simplifying our conceptual space. So our goal here is to derive a limited set of system-wide variables that are powerful in their ability to explain other network properties and/or non-network variables.

Individual-level Network Variables. The most important variables at the individual level of analysis are the communication roles filled by the system's members. Roles can be initially divided into two groups: participants in the network, and non-participants, or isolates. Participants are further broken down into group members, bridges, liaisons, and others. Each study yields a different percentage distribution of these roles; we can compare the distributions within a study if more than one communication content question is asked (e.g., work-related vs. socio-emotional content), or across studies.

This information, like almost all of the types of information we will be describing, can be presented under several statistical headings: the range of the results, the average (mean, median, mode) of the results, and the variability of results (standard deviation). As information accumulates, we will begin to take advantage of various statistical distributions that allow us to make inferences to larger populations (with due regard to the problems of randomness of initial sampling, etc.).

Given the role distribution in a network, we can next focus on the links for different types of role members. We can generate statistics on the links for each role type, to answer such questions as "Which roles have the highest average number of links...and are their cases where the typical results do not obtain?"

We move a step farther toward integrating the role members and their links by examining the patterns of link distributions between roles. Here our interest focuses on the ways, for example, bridges distribute their links to other bridges, or to liaisons, or to other groups. We can get an indication of how critical a given link or role member is by assessing the effect on the network of cutting the link or removing the member: are sizeable parts of the network no longer connected?

What we've done for communication roles, and communication links, can also be done for the strengths of the links. Only in the case of binary (1-0) links is strength minimally variable; in many studies our link measures are continuous and may cover a wide range of values. Thus we can calculate descriptions of link strength by network role, and, separately, link strength between network roles. The first calculation asks the question "Which roles have the greatest link strengths?" while the second question asks "Which roles share the greatest link strengths?"

Finally, we can determine the correlation between links and link strengths, e.g., "What is the relationship between number of links and the average strength of links?" "Does the relationship change by communication role?"

Dyadic Network Variables. Since networks are, in effect, built on a series of overlapping dyads, the question as to what constitutes a dyad is non-trivial. Some would argue that if either person testifies that communication takes place between him or her and the designated other, then a dyad exists. Others take a more cautious position; they are more stringent in their definition of a dyadic relationship. The most stringent definition is one that requires both persons to testify that they communicate with one another, at the same frequency and on the same topic areas. Intermediate definitions are often used. However, the result of this process yields the first and perhaps the most important measure of the network at the dyadic level: the percentage of reciprocated contacts. It should be easy to see that the level of reciprocation in a data set can vary considerably, depending on the criteria used to establish reciprocity.

Once reciprocity has been established, we can then report the strength discrepancy for each dyad. This will range from "0" when both report the same link strength, to a maximum value that depends on the particular scale used. Furthermore, the discrepancies can be computed on a simple summative basis (adding or subtracting the strengths involved) or on an absolute difference basis (ignoring the signs). The first procedures allows the discrepancies to "balance out," while the second insures that all differences will be reflected in the final score.

These two types of strength discrepancies can also be expressed in terms of the basic statistics noted earlier, and we can correlate these values with the number of links or link strengths of the members involved.

In effect, then, the discrepancy measures provide one way of assessing the accuracy with which members of the network perceive their communication relations within it. We can break down our analysis to particular pairs of roles and investigate questions such as, "Are bridge:bridge dyads within groups more or less accurate than group member:group member dyads?" This type of information has important bearing on the accuracy of information flow within the group, or to the group if you use bridge: bridge dyads that fall outside the group for one member.

We can also return to the question of reciprocity and examine it as more than a definitional problem alone. We can study reciprocity as a function of different roles, or in terms of its relationship to the number of links or link strengths of the reciprocated pairs, etc. We can also extend this to a comparison of different role pairs, to find answers to such questions as, "Are liaisons more or less likely to report reciprocal relations with other liaisons than bridges are to other bridges?"

Group Network Variables. Many new and intriguing variables appear at the group level. Initially, there is a very simple one: group size. This is limited at one end to three or more members, and limited at the upper bound according to other group-defining parameters that are used in the analysis. For example, requiring that more than two-thirds of the contacts of a group be within the group will generate fewer groups than lowering this criterion to "more than half".

Perhaps the most exciting analytic device at the group level is the ability to use the basic information-theoretic measure to determine a wide array of group communication properties. This index assumes that all instances of a property are equally distributed among the members and to the extent deviation from this occurs a clear, comparable and size-free measure is produced. The index is not bound to a particular network property and hence can be used in several different ways. For example, it can be used to generate a measure of communication dominance in the group, an index which shows how much of the communication content is directed to one or a few individuals, as opposed to being uniformly spread throughout the group. Dominance is a variable which becomes important in setting up group structure to accomplish various tasks, such as a military operation (high dominance) or a creative, innovative group (low dominance).

Connectivity is another group property, one that expresses the degree to which members are linked together. This can be computed solely on the basis of one-step (direct links) and expressed as a ratio of the total number of possible one-step links. Or, the measure can take indirect links into account as well, thus drawing in pathways whereby one group member reaches another by virtue of links with various intermediaries. Openness is a property which reflects the degree to which a group is linked into the larger system of which it is a part.

It is also possible to use the group as the focus of analysis, yet perform the analysis at a lower level--dyadic or individual. For example, within a given group, it is possible to analyse the link patterns within it; your interest is in the number (and strength) of links within the group, between the group and others, with liaisons, etc.

Network Level Variables. In addition to the lower-level variables described in the section above, it is possible to sample such whole-network properties as system differentiation, i.e., the degree to which the entire set of system members divides itself into subgroups within the whole. One straightforward measure of this is to compute the number of groups found in the system as a proportion of the total number of possible groups (using perhaps N=3 as the minimum size for groups and making some allowance for liaisons, isolates, or others). Another variable at this level is network connectivity.

Preliminary Results of Network Analyses

Next we turn to some of the preliminary results of our on-going summary and analysis of communication network properties. The intent of this section is primarily to illustrate the kinds of information that can be accumulated from network analysis studies, although this is by no means an exhaustive set of potentially useful information.

For this paper, we have taken three networks drawn from a study in a large eastern commercial bank. The networks deal with communication contacts on topics related to production (getting the work done), innovation (the development of new ideas and practices), and maintenance (building self-concept, interpersonal relationships and commitment to the organization). The label for this data set is "Chase." A second set of data, labelled "MacDonald," was gathered from a regional office of the Veteran's Administration; three networks (production, innovation, and maintenance) are separately reported for this set of data. The final set of data, labelled "Johnson" was gathered in an introductory Communication 100 course at Michigan State University.

A major initial decision in the analysis is to define the conditions under which a link between two individuals can be said to exist. For the "Chase" and "MacDonald" analyses, we required that the links be mentioned by both participants before inclusion in the analysis--i.e., we were interested then in reciprocated links alone. For comparison purposes, we also present results from the "MacDonald" maintenance network when unreciprocated links were used--i.e., the testimony by either person alone was sufficient to establish the presence of a link. This comparison reveals the different results one can obtain depending on the analysis option the researcher selects.

In Table 1, we present the distribution of network roles for each of the analyses. One point to observe in the Table (and in the several succeeding ones), is that a more elaborate category scheme is employed than was initially described. In the actual analyses, we make several additional distinctions: "isolates" become Isolate Type 1's (completely isolated individuals) and Isolate Type 2's (persons with only one link to anyone else in the network). Dyad members are pairs of individuals whose only links are with each other. Tree nodes are individuals with links to individuals with other network roles, and which in turn have Type 2 isolates attached to them. These additional categories have become important as we have inspected the networks produced by the analysis procedures.

Some points from Table 1 are that isolates are much more common in innovation and maintenance networks than in production networks. This is a somewhat comforting finding; however, for the most part, the number of group members is not very high, with the exception of the "MacDonald" production network. Liaisons are much less frequent than in the three studies noted earlier in the paper. At most 2.9% of the individuals in the network are liaisons. This seems to be due to the greater stringency of criteria we impose before an individual is considered a liaison, plus the uniformity of application of the criteria that the computerized routine gives over the prior "by hand" analysis.

Also in Table 1, we find that when unreciprocated links are used on the MacDonald run, 82% are "others," a generally unsatisfying solution. However, the purpose of the "other" category is clearly revealed here, since one of its functions is to point out instances of network role classifications that do not meet the other, rather extensive, set of role categories.

In Table 2 we turn to the mean number of links for each role type. The linking roles (bridge and liaison) have the highest mean number of links (which may suggest that their linking function is in addition to, rather than a replacement of, their total linkages). The highest number of mean links is in production networks, while innovation links are much lower. This reflects a pattern of findings in several organizations, in which both the maintenance and innovation networks tend to be far less elaborate and integrated than the production networks. In part, this may be reasonable, yet it does give emphasis for the need for management communication policies regarding precisely the extent and nature of innovation networks and/or maintenance networks that they desire. Notice also in Table 2 that the mean number of links for all roles in the unreciprocated "MacDonald" network is much higher than in those where reciprocation was required.

Table 3 provides the data on the mean strength of the links for each role across the various networks. The strength indices, although computed by somewhat different formulas, show that links in production networks are not only more common (from Table 2) but are considerably stronger (Table 3). Furthermore, the various linking roles have higher strengths than other roles.

In Table 4 we move to some of the dyadic level indices by examining the degree of discrepancies in link strengths as reported by each member of a dyad pair. Both a "sum of discrepancies" and a "sum of the absolute value" (independent of plus or minus signs) is presented. Bridges and liaisons have a tendency to over-report or over-estimate the strength of their links with other individuals in the network, while group members have a tendency to under-report the strength of their links with the other individual in their dyad pairs. Dyad members, whose only link is with each other, mis-estimate their link strengths less frequently than any other network role. The mean absolute discrepancy for all reciprocated links ranges from 20.67 to 24.01 for networks with comparable strength formulas.

There are three main indices reported at the group level of analysis, the first of which is group size, shown in Table 5. The number of groups located varies from three to forty-six, and their size varies from three persons to eighteen persons. The standard deviations reported in Table 5 demonstrate there is some variability in group size within networks. Group size can be correlated with a number of other network variables. For example, the correlation between mean group size and mean group connectedness for the "Chase" and "MacDonald" networks is -.34. In Table 6 the mean connectedness of the groups is presented (a ratio of the existing links to the total possible links). This measure shows considerable variability within networks, with standard deviations always greater than 0.22.

At the network level three indices are reported. One useful result from these figures is that considerable variation is found in index to index, and hence the variance in these measures makes it possible for important associations with other variables to be uncovered. In Table 7, network connectedness values are reported. Network connectedness clusters by organizations: the "Chase" networks having a range of 0.014 to 0.041; "MacDonald" networks with a range of 0.111 to 0.134, and the "Johnson" network and "MacDonald" unreciprocated network, with three and four groups respectively, having a network connectedness of 0.667. This index can be correlated with a number of other network variables, network size, mean group size, etc. In Table 8 we shift our attention to the mean intergroup linkages in the various networks, using both bridges, liaisons, and a combination of both to show how interconnected the groups are within each network. The percentages for linking roles between groups are shown in Table 9; bridges generally account for a higher percentage of individuals in groups than do liaisons. A subset of others may also be important for intergroup linkages in networks. Groups can be connected through two to five others. These liaison chains of others account for 22 intergroup linkages in the "Chase" maintenance network. Thirty-three, or 47.8%, of the others in this network are in a liaison chain.

Table 10 is perhaps the most complex of the lot. In it we take the three "MacDonald" networks and indicate the mean number of links and mean link strengths between the various network roles. Basically, these figures reveal the patterns of communication linkages between the various roles and offer a starting point for analysis of the strong and weak points of the networks under analysis. In general, Table 10 shows that intrarole communication is the most frequent; group members communicate primarily with group members, tree nodes communicate most frequently with other tree nodes; and others communicate most frequently with other others.

Finally, in Table 11, we present the analysis of the interrelationships among the group linkages for the three "MacDonald" networks. For mean number of links, maintenance links are more likely to be within-group than are production links. Innovation links are higher between-groups than for maintenance or production links. Group communication is greatest within the group, with at least 80.7% of the links and at least 86.3% of the strengths within this category. The percentage of strengths in every message content network is higher for within group and lower for the other categories, than the percentage of links. This indicates that group communication is more frequent in the within group category than it is in the other categories.

Conclusions

This paper has sought to give an outline of the procedures and goals we are pursuing as we assemble data on communication networks and attempt to draw inferences and conclusions from the assembled sets. We are obviously only new participants in this activity and non-funded ones as well. We suffer the consequences of "tailoring" instruments to specific studies while at the same time hoping for comparable data to fill in the elements in a larger data matrix about communication network properties. We expect this activity to continue over the next several years and to be speeded up in both the rate and standardization of data input and the rate and quality of findings that emerge from these efforts. The amount of work involved in managing and maturing a data base is definitely non-trivial, but its potential seems self-evident.

TABLE 1

DISTRIBUTION OF ROLES BY PERCENTAGE ACROSS ALL NETWORKS

Role	Production Networks		Innovation Networks		Maintenance Networks		Unreciprocated Maintenance	Johnson
	Chase	MacDonald	Chase	MacDonald	Chase	MacDonald	MacDonald	Communication 100
Isolate T1's	28.1	5.0	38.9	37.2	40.4	38.9	0.0	30.0
Isolate T2's	15.4	8.8	17.8	15.1	15.5	18.8	5.0	20.0
Dyad Members	4.5	0.8	4.1	3.3	4.3	6.6	0.0	0.0
Tree Nodes	3.6	0.4	5.8	5.4	6.0	6.6	0.7	2.0
Others	15.8	18.8	11.4	10.0	7.1	1.6	81.5	0.0
Liaisons	1.2	2.9	0.4	0.4	1.2	0.4	0.7	0.0
Group Members	23.4	53.1	18.9	20.9	21.0	23.4	10.5	26.0
Bridges	7.7	10.0	2.4	7.5	4.2	3.3	0.7	22.0

TABLE 2

MEAN NUMBER OF LINKS FOR ROLES ACROSS NETWORKS*

Role	Production Networks Chase	Production Networks MacDonald	Innovation Networks Chase	Innovation Networks MacDonald	Maintenance Networks Chase	Maintenance Networks MacDonald	Unreciprocated Maintenance MacDonald	Johnson Communication 100
All Individuals	2.26	4.23	1.52	1.70	1.52	1.41	8.64	2.00
Bridges	5.36	6.12	4.87	4.44	4.17	4.00	6.00	4.82
Group Members	3.86	4.62	3.28	3.18	3.52	3.35	7.55	2.85
Liaisons	5.33	6.28	4.25	5.00	3.92	2.00	6.00	0.00
Tree Nodes	2.34	2.00	2.32	2.30	2.24	2.37	3.00	3.00
Others	3.69	4.71	3.54	3.71	3.06	4.25	9.40	0.00

*By definition the mean number of links for Isolate T2's and Dyad members is equal to one, and the mean number of links for Isolate T1's is equal to zero.

TABLE 3

MEAN STRENGTH* FOR ROLES ACROSS NETWORKS**

Role	Production Networks Chase	Production Networks MacDonald	Innovation Networks Chase	Innovation Networks MacDonald	Maintenance Networks Chase	Maintenance Networks MacDonald	Unreciprocated Maintenance MacDonald	Johnson Communication 100***
All Individuals	100.07	180.43	50.08	60.97	59.19	55.72	266.91	7.72
Bridges	229.48	277.25	172.25	152.00	170.98	93.25	254.00	15.09
Group Members	176.36	197.46	112.46	128.72	135.91	134.60	286.11	15.30
Others	156.16	181.88	96.72	121.58	113.72	114.00	283.74	0.00
Liaisons	201.08	290.86	122.75	152.00	164.33	16.00	142.00	0.00
Dyad Members	55.95	64.00	43.97	45.50	51.12	55.88	0.00	0.00
Tree Nodes	117.37	72.00	86.19	67.15	89.58	104.38	43.00	5.00
Isolate T2's	44.77	46.19	34.15	30.42	36.44	32.13	33.92	2.40

*By definition Isolate T1's strengths are equal to zero.

**The network analysis program assumes a ratio scale. To convert the ordinal scales used to gather data for Chase and MacDonald into a ratio scale, a link-weighting formula is used. The following results are obtained from the formula for these data sets: communicating once or more a day = a strength of 64; once a day = a strength of 27; and once or twice a week = a strength of 8.

***The strengths for this network were computed by a different formula.

TABLE 4

MEAN OF STRENGTH DISCREPANCIES (SD) AND MEAN OF ABSOLUTE DISCREPANCIES (AD) FOR NETWORK ROLES ACROSS NETWORKS

Roles	Production Networks MacDonald		Production Networks Chase		Innovation Networks MacDonald		Innovation Networks Chase		Maintenance Networks MacDonald		Maintenance Networks Chase		Johnson* Communication 100	
	SD**	AD***	SD	AD	SD	AD	SD	AD	SD	AD	SD	AD	SD	AD
All Individuals	-0.04	21.40	0.31	20.68	-0.16	23.13	0.15	22.36	0.68	24.01	0.00	22.78	0.01	1.45
Bridges	5.07	21.03	-0.94	22.04	3.51	22.16	2.53	25.49	-1.75	22.75	4.25	20.19	0.03	1.58
Group Members	-2.26	17.62	0.43	20.43	-0.71	23.45	-0.28	22.80	2.42	24.74	-1.22	22.86	-0.21	1.29
Dyad Members	0.00	0.00	0.00	11.00	0.00	18.50	0.00	21.45	0.00	7.00	0.00	16.90	----	----
Liaisons	13.54	22.04	4.06	21.56	14.80	14.80	-2.23	28.23	-28.00	28.00	7.15	23.83	----	----
Tree Nodes	0.00	56.00	-0.70	19.77	3.73	19.93	3.78	25.21	4.92	24.50	-0.42	24.01	-0.33	.33
Others	-0.86	15.92	1.67	20.73	0.70	24.73	-0.65	18.20	-3.29	16.47	2.47	23.49	----	----
Isolate T2's	6.19	20.38	-3.11	21.23	-13.41	24.83	0.66	25.56	-5.40	23.64	-4.32	24.58	0.60	1.20

*The strengths for this network are based on a different formula than the others networks in this table.

**Represents the sum of link discrepancies, divided by their number.

***Represents the absolute value (independent of sign) of the links, also divided by their number.

TABLE 5

GROUP SIZE

Network	Number of Groups	Number of Individuals in Groups	Mean Size	Range	Median	Standard Deviation
Production						
Chase	46	303	6.58	3/18	6	3.31
MacDonald	17	151	8.88	3/18	8	5.47
Innovation						
Chase	39	208	5.33	3/11	4	2.62
MacDonald	13	68	5.23	3/9	5	2.04
Maintenance						
Chase	44	245	5.57	3/18	5	2.90
MacDonald	9	64	7.11	3/11	7	2.76
Unreciprocated Maintenance						
MacDonald	3	29	9.66	4/17	8	5.44
Johnson Communication 100	4	24	6.00	3/9	6	2.12

TABLE 6

MEAN GROUP CONNECTEDNESS AND MEAN OF GROUPS FOR STEPLINKS

	Production Networks		Innovation Networks		Maintenance Networks		Unreciprocated Maintenance	Johnson
	Chase	MacDonald	Chase	MacDonald	Chase	MacDonald	MacDonald	Communication 100
Mean Group Connectedness	0.644	0.620	0.691	0.702	0.683	0.534	0.605	0.500
Mean of Groups for Step Links	1.472	1.471	1.377	1.385	1.393	1.735	1.400	2.555

TABLE 7

NETWORK CONNECTEDNESS

	Production Networks		Innovation Networks		Maintenance Networks		Unreciprocated Maintenance	Johnson
	Chase	MacDonald	Chase	MacDonald	Chase	MacDonald	MacDonald	Communication 100
Network Connectedness	0.041	0.129	0.014	0.134	0.032	0.111	0.667	0.667

TABLE 8

MEAN INTERGROUP LINKAGES FOR GROUPS BY TYPE

Type	Production Networks		Innovation Networks		Maintenance Networks		Unreciprocated Maintenance	Johnson Communication 100
	Chase	MacDonald	Chase	MacDonald	Chase	MacDonald	MacDonald	
Bridges	1.17	0.94	0.43	0.92	0.84	0.67	0.67	2.00
Liaisons	1.00	1.17	0.17	0.69	0.77	0.22	0.67	----
Both*	1.85	1.75	0.56	1.61	...39	0.89	1.33	2.00

TABLE 9

MEAN PERCENTAGE FOR LINKING ROLES BY GROUPS

Linking Roles	Production Networks		Innovation Networks		Maintenance Networks		Unreciprocated Maintenance	Johnson Communication 100
	Chase	MacDonald	Chase	MacDonald	Chase	MacDonald	MacDonald	
Bridges	23.7	21.0	12.4	24.7	19.4	11.9	10.1	65.2
Liaisons	10.7	17.8	3.9	4.9	15.6	2.8	12.5	----
Both*	31.2	35.8	14.9	29.6	31.8	14.8	22.8	65.2

*Both represents the total for Liaisons and Bridges excluding duplicates of links between two groups and counting group members who are bridges and talk to Liaisons as one.

TABLE 10

INTERROLE COMMUNICATION ACROSS PIM NETWORKS FOR MACDONALD DATA SET

ROLES	MEAN NUMBER OF LINKS			MEAN STRENGTHS		
	Production	Innovation	Maintenance	Production	Innovation	Maintenance
Group members with:						
Same group members	3.92	2.28	2.92	177.86	100.72	118.01
Liaisons	0.21	0.08	0.03	6.56	1.02	1.28
Others	0.33	0.22	0.10	8.64	5.88	3.19
Bridges with:						
Same group members	4.20	2.78	1.87	207.70	119.50	45.50
Other group members	1.33	1.22	1.00	34.08	29.61	12.75
Others	0.62	0.38	----	16.70	7.38	----
Liaisons	0.20	----	----	8.66	----	----
Others with:						
Liaisons	0.17	0.03	----	7.24	1.12	----
Others	3.11	2.50	2.00	133.77	88.16	67.75
Isolate 2's with:						
Group members	0.52	0.25	0.40	26.00	9.80	14.00
Bridges	0.09	0.02	0.15	3.42	0.22	4.57
Others	0.19	0.22	0.06	6.85	5.97	1.37
Tree Nodes	0.09	0.47	0.37	3.42	13.97	13.00
Liaisons	0.04	----	----	3.05	----	----
Tree Nodes with:						
Group members	----	0.07	0.25	----	2.07	16.00
Bridges	----	0.07	0.18	----	0.61	8.50
Tree Nodes	----	0.61	----	----	9.30	31.75
Others	----	----	0.75	----	----	----
Liaisons with:						
Liaisons	0.28	----	----	18.28	----	----

TABLE 11

GROUP LINK ANALYSIS FOR MACDONALD PIM NETWORKS

Type	Mean Number of Links For Groups						Mean Strength For Groups					
	Production %	mean	Innovation %	mean	Maintenance %	mean	Production %	mean	Innovation %	mean	Maintenance %	mean
Within Group	82.8	35.41	80.7	14.15	91.9	20.22	89.0	1647.18	88.3	594.69	95.1	764.77
Between Group	4.4	1.88	9.6	1.69	4.0	0.88	2.4	44.82	6.1	41.61	1.4	11.33
Liaison	4.5	1.94	1.7	.30	1.0	0.22	3.3	61.76	0.5	3.92	0.9	8.00
Other	8.2	3.53	7.8	1.38	3.0	0.66	5.1	95.59	4.8	32.76	2.4	19.88
Total		42.76		17.53		22.00		1849.35		673.00		804.00

FOOTNOTES

(1) Richards, William D. "Network Analysis: Rationale, Techniques, and Methods." Paper presented to the International Communication Association, New Orleans, April, 1974.

(2) Danowski, James A., and Richard V. Farace. "Communication Network Integration and Group Uniformity in a Complex Organization." Paper presented to the International Communication Association, New Orleans, April, 1974.

(3) Monge, Peter R., Kenneth K. Kirste, and Jane A. Edwards. "A Causal Model of the Formation of Communication Structure in Large Organizations." Paper presented to the International Communication Association, New Orleans, April, 1974.

(4) Wigand, Rolf T. "Communication, Integration and Perceived Satisfaction in Large Social Systems." Paper presented to the International Communication Association, New Orleans, April, 1974.

(5) Brophy, Margaret. "Communication Frequency- An Analysis Based on Network Data." Paper contributed to the International Communication Association, New Orleans, April, 1974.

(6) Pacanowsky, Michael, and Richard V. Farace. "An Instructional Simulation for Organizational Communication." Paper presented to the International Communication Association, New Orleans, April, 1974.

(7) Separately, we are also maintaining a central library of documents related to network analysis and are planning a project that will abstract these documents and make them retrievable on demand.