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37 ● Communication Networking in Computer-Conferencing Systems: A Longitudinal Study of Group Roles and System Structure

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ORGANIZATIONAL communication is becoming increasingly facilitated by computers. Computer-mediated communication systems such as electronic mail, computer conferencing, automated offices, and the like (see Keen & Scott-Morton, 1978; Panko, 1980; Rice, Johnson, & Rogers, 1982) are becoming commonplace in businesses and research communities. Associated with these developments are a variety of policy and research issues, including (1) impacts and benefits, (2) fertile sources of communication data for researchers, and (3) the patterns of use and intercommunication among individual and group users. Each of these aspects is considered below.

RESEARCH ISSUES CONSIDERED

Social and Organizational Impacts of Computer-Mediated Communication

A review of the prior research in this area is beyond the scope of this chapter; comprehensive reviews and overviews of impacts can easily be

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found in Bair (1979), Hiltz and Kerr (1981), Hiltz and Turoff (1978), Johansen (1977), Kling (1980), Moss (1981), Rice (1980a, 1980b, 1982), Rice and Case (1981), and Uhlig, Farber, and Bair (1979). The main points of much prior research are that these systems can be very appropriate for some kinds of communication tasks; that their impacts on organizational structure depend to a large extent on the organization's goals, management philosophy, and environment; that users typically increase their satisfaction and comfort with a system with increased use; that reported benefits are not necessarily due to increased use; and that organizational communication networks increase in size and span when facilitated by such systems. Of note here is simply that the potential benefits and impacts of using computer-mediated communications is an important concern for communication researchers, users, organizational managers, vendors, and system designers.

Analytical Opportunities from Computer-Monitored Data

There are several distinct gains for evaluators and researchers in using the kinds of data accessible by a computer that can monitor the usage of the services it provides. Overviews of evaluations using computer-monitored data are available in Penniman and Dominick (1980), Rice and Danowski (1981), Rouse (1975), and Svoboda (1976). Only a few of these issues need be mentioned here.

In computer-messaging systems designed to collect such data, there is typically little or no response bias, and a full census of users is possible. Computer-monitored data are accurate, in that the data can consist of usage measures, who messaged whom, when, for how long, and so on, although content is usually inaccessible to protect the confidentiality of the user. (This is *not* to argue that such data are *complete* descriptions of the events analyzed.) This facility is quite important, considering the wealth of recent research indicating that, in general, respondents' reports of their communication activities diverge widely from their actual communication behavior as observed or monitored (see Berger & Roloff, 1980; Bernard, Killworth, & Sailer, 1980; Nisbett & Wilson, 1977; Shweder, 1980; among others). Although the controversy continues concerning the extent, form, and generalizability of these kinds of divergence, one recent study (Bernard et al., 1981) is very convincing. An experiment administered through the main computer of a computer-conferencing system asked users typical sociometric questions, and compared these data to the communication behavior recorded by the computer. The results not only reaffirmed the typical presence of large discrepancies between reported and actual communication behavior (in both forgetting and inventing recipients of messages), but also showed this discrepancy even in reports collected within minutes of a respondent's sending the message.

Another, related aspect of computer-monitored data is that these accurate census data allow us to investigate the communication networks of groups of users. Rogers and Kincaid (1981, p. 346) define communication networks as consisting of *relations* among "interconnected individuals who are linked by patterned flows of information." These networks embed organizations and user groups in their environments (Farace, Monge, & Russell, 1977; Katz & Kahn, 1966; Rogers & Agarwala-Rogers, 1976; Weick, 1969) and are, in fact, one picture of an organization's or group's structure. Finally, the servicing computer can capture extensive *longitudinal* network data so that researchers avoid the ungrounded assumption of much cross-sectional research that the system under study is at some equilibrium state.

Group Information Exchange and Network Roles in a System

This chapter is concerned primarily with a few specific questions at the analytical level of the multigroup network, concerning groups as they interrelate within the system. Not discussed here are a variety of questions and results at the individual or group-specific level.

In a computer-conferencing system involving formally constituted groups of geographically dispersed members, the nonverbal aspects of human communication are largely missing, so the emphasis in interaction shifts to the exchange of information. Flows of information into groups, out of groups, and within groups become important attributes of system and group structure.

As with Blau's (1977) exchange theory, group members who have low status attempt to provide information to and attract recognition of members of high status, thereby gaining increased status themselves. However, users of computer-mediated communication systems often are freer to search for those information exchanges that provide satisfactory resorces in return than they would be in tyical organizations or communication contexts. Users making initial searches must find rewarding reciprocal exchanges early on, or the time and energy in continual unreciprocated messaging will deplete their physchological and material resources. Indeed, individuals and groups that have early access to information may continue to "occupy" their information-rich or reciprocal positions and thereby function better or have more power than those who have later access to information flows within the system.

At the group level, whether a group is constituted to perform a task or is organized for more undirected reasons also plays a part in cross-group information exchanges. Members of a nontask group are freer to explore their informational environment, because their activities are not necessarily detractions from the group's sense of cohesiveness or interferences with an ongoing task; a group can prosper by "scouting" the environment for useful information. A task group, as a unit, on the other hand, is unlikely to interact with the wider system or environment as long as they are stable, because the task focuses internal group communication exchanges and cohesion.

From this brief overview of the information environment of groups within a computer-mediated communication system, the following analyses based on computer-monitored, accurate, longitudinal communication data will attempt to analyze group communication networks, to assess:

1. the information-based attributes that adequately describe the system-wide communication network;
2. the importance of reciprocity in cross-group networks;
3. the information-based network roles that groups occupy, and whether task orientation is a factor; and
4. longitudinal occupancy of these roles.

THE SYSTEM, USERS, AND DATA ANALYZED

The data represent the "private messaging" behavior of members of eight formal and two other "user groups" during twenty-four months on the Electronic Information Exchange (EIES) computer-conferencing system, sponsored by the National Science Foundation. The EIES system, history, user groups, and research context are described in several sources, including Bamford and Savin (1978), Hiltz (1981), Hiltz and Turoff (1978), and Rice (1980b). Only private messaging data are analyzed here. *Private Messages* (representing 70 percent of all items sent) can be sent to any individual or list of individuals, and confirmation of delivery is provided. There are alternate means of EIES communication, not discussed here.

The user consultants and the system monitor personnel were combined in the analysis to form analysis group zero ($N = 17$). This group consisted of experienced users who earned extra system time by providing help to other users, and of New Jersey Institute of Technology systems personnel who maintained and improved the system. Thus, this group was a "service" entity.

A *task* group is a group that has an explicit task to perform, with or without deadlines, around which the group organizes itself. A *nontask* group is a group that does not have an explicit task to perform, but rather is constituted to enable communication to happen; implicit or informal tasks may arise from this communication activity, but the group as a whole is not designed to perform these informal tasks. For our purposes, we classify groups 1 ($N = 45$), 5 ($N = 56$), 6 ($N = 25$), 7 ($N = 30$), and 8 ($N = 76$) as *task* groups, and groups 2 ($N = 32$), 3 ($N = 46$), and 4 ($N = 67$) as *nontask* groups, in order to explore differences in group communication structure based on the task/nontask distinction.

Group 9 comprised all those accounts of other (very small) groups, and unaffiliated separate individuals. Thus group 9 was not a formal EIES group, but can be taken to represent, loosely, a random collection of individuals that may be used as a control group against which behavior in formal EIES groups may be compared.

RESULTS

We consider two related aspects of system structure: what attributes of information flow best describe the system-level interaction of EIES groups and what information-based roles those groups occupy. We are also interested in changes in each of these aspects over time.

Method and Definitions for Analyzing System Structure

The role of a group can be defined in terms of outward and inward information flow, as well as flow strictly within the boundaries of the group. Group networks, then, are indicators of social structure based simply on information flows. In particular, we here use Marsden's (1981a, 1981b) definitions of network roles, as presented in Table 37.1.

We also utilize Marsden's (1981a, 1981b) GENMRG3D program to analyze the multigroup network. The program fits log-linear models of which information attributes characterize the system to an $I \times I \times 2$ (outflow by inflow by internal group communication flows for a system with I groups) contingency table with varying constraints in the fitting of the three-variable interaction term. Constraints are fitted by entering a "design matrix" that specifies into which "level" (much as in analysis of variance) of the design a given cell of the contingency table is placed. Then the models are tested against the data by means of an iterative proportional scaling algorithm.

This method has several distinct advantages over other network analysis methods for the purposes of the present analyses (see also Marsden, 1981a, 1981b): (1) Unlike network role characterizations as described by Burt (1978), Harary, Norman, and Cartwright (1965), or

Table 37.1
Possible Roles Based Upon Dimension of Information Flow

Sign of Group's Modeled Parameters with Respect to the Average Information Flow Values, Within a System, for Dimensions of a Group's Flows:

In	*Out*	*Roles Based on Two Dimensions**	*Within*	*Roles Based on Three Dimensions**
+	+	Carrier	+	1. Primary
+	+		−	2. Broker
+	−	Receiver	+	3. High-status clique
+	−		−	4. Snob
−	+	Transmitter	+	5. Low-status clique
−	+		−	6. Sycophant
−	−	Isolate	+	7. Isolate clique
−	−		−	8. Isolates

Source. Marsden (1981a).

Richards and Rice (1982), Marsden's method allows for role distinctions based on all three dimensions of information flow. (2) Participation levels are defined probabilistically, relative to average information flow levels, and thus take into account the communication volume and size of both the system and its constituent groups. (3) The program can take into consideration the total amount of links possible. (i.e., two matrices are usually entered as data: one of actual communication links, and one of linkages absent; this last matrix is the difference between potential linkage amount within and across groups, and actual linkage amount). (4) Perhaps the method's most rigorous attribute is that roles defined are subject to statistical testing. That is, roles imposed by the method can be tested against the data for their adequacy rather than accepted arbitrarily. This ability is particularly necessary in light of Burt and Bittner's (1981) article, which emphasizes (1) how few studies have tested the fit of the roles analyzed, and (2) how analyses can be misleading, when, with complex data, several alternative role categorizations are possible but not tested against each other.

Thus this method allows for the detection and testing of group attributes: inflow, outflow, internal relations, and selected cross-group relations. The general model is:

$$\log([m(i, j, 1)] / [m(i, j, 2)]) = t + a(i) + b(j) + g(i, j)$$

where m is the maximum likelihood estimate using the "absent" link matrix (1) and the "actual" link matrix (2), "t is the unweighted conditional log-odds on the presence of a relation (based on the overall network communication volume), a(i) is the (above- or below-average) increment given that the potential sending actor is in category i, b(j) is the (above - or below-average) increment given that the potential receiving actor is in category j, and g(i, j) is an (above- or below-average) interaction effect of the log-odds given that the potential sending actor is in category i and the receiving actor is in category j" (Marsden, 1981a).

Several models will be tested for their utility in describing the information-flow-based role structure of the 10 EIES user groups, considered as a system, over 24 monthly periods. In the Independence model (2), only inputs and outputs are considered, not relations within or across particular groups. This model is used as the baseline explanatory model for tests of the following models. The Reciprocity model (3) tests the tendency of different pairs to communicate reciprocally, while within-group relations may differ across groups. The Constant Inbreeding model (4) tests the tendency for all groups to communicate within themselves equally while not making distinctions among outside groups. The Differential Inbreeding model (5) tests the tendency for all groups to communicate within themselves differentially, while treating out-groups the same. The Strict Reciprocity model (6) tests the tendency of different pairs of groups to communicate reciprocally, while within-group preferences are similar across groups.

A nonsignificant *G* square (i.e., the model "fits" the data) for model 2 or 4 establishes the validity of the fourfold role categorization of Table 37.1, while a nonsignificant *G* square for model 3, 5, and 6 establishes the validity of the eightfold role categorization (because groups under these three models have different in-group preferences). The general test is

$$G \text{ square} = 2(\times[i, j]^{*}\log[\times(i, j)/m(i, j)])$$

distributed as the chi-square distribution. One can test the significance of the *difference* between a more general model and a less general model contained within the first model. Model 2 versus 3, 5, or 6 tests within-group or reciprocal effects over the independence model of no within-group or reciprocal effect. Model 4 versus 5 tests if there are within-group preferences that vary across groups, given equal out-group preferences. Model 4 versus 6 tests if there are reciprocal out-group preferences, given equal within-group preferences. Model 3 versus 5 tests for the tendency of groups to communicate reciprocally, over and above within-group preferences that vary across groups. Model 6 versus 3 tests for within-group preferences, given reciprocal out-group preferences.

The degrees of freedom used in these tests are shown in Table 37.2 (and thus will not be reported later). "I" is the number of EIES groups

Table 37.2
Degrees of Freedom Available for
Simple and Conditional Model Tests

Model	2	3	4	5	6
2	$(I-1)^2$	$\frac{I(I-1)}{2}$	1	1	$\frac{(I-2)(I-1)}{2}$
3		$\frac{(I-2)(I-1)}{2}$			
4			$I(I-2)$	$I-1$	$\frac{I(I-3)}{2}$
5		$\frac{I(I-3)}{2}$		I^2-3I+1	
6		$I-1$			$\frac{I(I-1)}{2}$

Note. Off-diagonals are degrees of freedom for the conditional tests of a column model over a row model; diagonals are degrees of freedom for simple model significance tests, where I is the number of groups in the system.

involved in the monthly analysis. Because some groups became part of the system in different months, or during some months had very little activity, each month's analysis will not necessarily contain all ten groups. Thus, Table 37.4, below, will not show results for every group in every month.

System Structure

The results from the simple and conditional model tests as shown in Table 37.3 are fairly straightforward and concern two issues: (1) How is EIES structure best characterized? That is, which attributes of information exchange are statistically significant aspects of how groups interact internally and externally in a given month? (2) How does this structural description change over time?

In month 2 we see that models 3, 5, and 6 complete as "best fits" to the data, all with nearly perfect fits to the data, each with a $p > .990$. If we had used only one of these models to test against the data, we would have a structural description that does not differ significantly from the data and thus would be valid.

But we can do better. It is clear that in the beginning of the EIES system life, reciprocal relations are important, but so are group differences. We are

Table 37.3
Summary of Simple and Conditional Model Tests

	Simple Tests: Model					Conditional Tests: Models							
Mo.	2	3	4	5	6	2-3	2-4	2-5	2-6	4-5	5-3	6-3	4-6
2	79[a]	2 .993[b]	76	7 .999	3 .999	77	2 .9	72	77	71	5 .89	.2 .999	76
3	241	28 .02	162	64	29 .1	213	79	178	213	98	36	.7 .999	133
4	417	8 .93	87	24 .74	9 .98	408	329	392	408	63	88	1 .983	78
5	949	38	275	126	38 .01	910	673	822	910	149	88	.0 .999	237
6	1265	19 .25	239	128	19 .5	1246	1026	1137	1246	111	109	0 .999	220
7	1382	14 .5	235	88	15 .87	1368	1147	1295	1368	148	73	0 .999	221
8	866	13 .6	165	51	13 .89	853	701	816	853	114	38	0 .999	152
9	1214	7 .96	283	73	7 .999	1207	931	1141	1207	210	67	0 .999	276
10	886	14 .52	238	61	14 .85	872	648	825	872	177	47	0 .999	224
11	1036	32	288	127	32 .07	1005	749	909	1005	161	95	0 .999	256
12	1330	24 .6	636	149	26 .85	1305	694	1181	1304	487	124	2 .975	610
13	1795	15 .6	815	140	15 .8	1780	981	1656	1780	675	125	0 .999	800
15	1549	20 .80	782	138	20 .98	1529	767	1411	1529	644	118	0 .999	762
16	2068	36 .25	815	242	36 .47	2032	1252	1826	2032	574	205	0 .999	779
17	1979	28 .60	685	171	28 .8	1951	1294	1808	1951	514	143	0 .999	657
18	1864	30 .35	671	219	33 .6	1834	1193	1645	1831	452	189	3 .9	731
19	2188	19 .90	792	194	23 .95	2169	1397	1994	2165	596	175	4 .85	769
20	2045	13 .99	747	123	16 .995	2033	1299	1923	2029	634	110	3 .9	731
21	1750	18 .99	719	119	17 .999	1742	1041	1631	1733	600	119	0 .999	702
22	2144	16 .995	878	244	20 .999	2128	1267	1900	2124	634	228	4 .85	858
23	2968	20 .975	1183	201	24 .999	2948	1785	2767	2944	982	181	9 .5	1159
24	3352	15 .995	1049	207	19 .999	3337	2303	3145	3333	842	192	4 .95	1030
25	1007	15 .975	423	105	15 .995	991	584	902	992	318	90	0 .999	408

a. rounded G square
b. p levels (blank if $< .001$)

able to test to see which is a *better* structural description. If we test the model of reciprocity with group differences against the model of no reciprocity but with group differences (model 3 versus model 5), *G* square is 5, with $p > .89$. There is no significant difference between these structural descriptions. Thus, the significant fit of the reciprocity model with group differences is due solely to the group differences aspect of the model, when these two models are compared. But we test model 6 (strict reciprocity) against model 3 (reciprocity) and also find no significant improvement, indicating that the significant fit of model 6 is due solely to the reciprocity aspect of the model. For month 2, there are simply two equally satisfactory structural descriptions: group differences with no reciprocity, and reciprocity with no group differences.

We could turn to the test of model 4, with the baseline model 2, which, for the only month out of the twenty-four, shows no significant difference ($p > .9$), indicating that similar group preferences is *not* a valid attribute of the data. Because similar within-group preferences do not constitute a good descriptor of the data, and because model 6 includes this descriptor along with reciprocity, we can argue that model 5, differential inbreeding with no reciprocity, is actually the best description of the data for month 2. The major point of this ambiguous (or multiple!) result is that system structure is not yet "simple" or uniquely formed; i.e., there are several tendencies in the data for month 2. Our best statement is that reciprocity has not staked a claim as a clear attribute of systemwide interactions in the first month, but that differential group preferences have.

In month three, every model was significantly different from the data (model 6 has a $p < .1$, which is not very convincing). Even though model 6 is not a convincing fit, it is significantly better than model 3, indicating that the apparently significant aspect of group differences is actually an artifact of the strong reciprocity aspect. In any event, we can say that there was no significant system structure based on information flows as proposed by the various models for month 3.

The implication of this result, along with the result for month 2,is that there is unstructured information flow in the early stages of system development, due, hypothetically, to the lack of conclusions across the groups about satisfactoriness of any particular set of information exchanges. Groups are still seeking out relations.

In month 4, as in month 2, models 3, 5, and 6, all fit the data well and thus compete as characterizations of system structure. Here, however, model 3 (reciprocity) is significantly better than model 5 (differential inbreeding; *G* square is 88, $p < .001$), so we know that reciprocity is a valid descriptor of system structure. We can go further and say that only reciprocity, and not group differences, is the best descriptor of cross-group

preferences. So, reciprocity has emerged as a significant aspect of systemwide interaction by month 4, but we are unsure whether group differences persist as a significant aspect.

But system stability has yet to emerge. Month 5 displays the same lack of structural description as did month 3, but here without even a hint of significance from model 6. Taken with the results from the first three months, this result emphasizes that structure is still emerging, as neither reciprocality nor group preferences has yet to become a clear-cut attribute of information exchange.

However, month 6 begins a string of five months of well-defined system structure, which seems to become more stable until month 10. In each of these months, models 3 and 6 are good fits to the data, indicating that reciprocity has emerged as an important factor in exchange relations among the EIES groups. As in every month, the additional descriptive power of model 3 over model 6 is not significant, indicating that group differences are not a strong aspect of system structure but reciprocity is. The decline in the fit of the two models in month 10 prophesizes the result for month 11, as the short stability in system structure ends.

Indeed, we see that the results for month 11 are the same as for month 3: no model is a good fit, although model 6 barely approaches such a fit. The implication here is that although structural stability emerged (in the sense that a model of network structure based on information flows achieved and maintained significant fit with the data) in months 6 through 9, stability declined in month 10 and degenerated into a lack of structure (as defined by the models) in month 11. The early satisfaction of the groups with the information exchanges in month 6 was not permanent. Four months was either not long enough to forge permanent information exchange relations, or four months was long enough for the majority of exchanges to enable the groups to perform their inter- and intragroup tasks, and then move on.

For the rest of the system's analyzed life, the description that held in months 6 through 9 served as a valid characterization of the EIES systemwide information interactions. The early months, then, are characterized by unstable system structure, as reciprocity, group differences, and combinations of the two compete among themselves as valid descriptions of the system while also dropping out altogether in several months as significant aspects of systemwide interaction. After the early instability, reciprocity emerges as a primary aspect of information exchanges, as hypothesized, except for some instabilities in months 10, 11, 16, and 18.

However, because both reciprocity models increase in fit, it is unclear whether groups *increase* their in-group preferences over time or *decrease* those preferences. The miniscule differences in the chi-square values

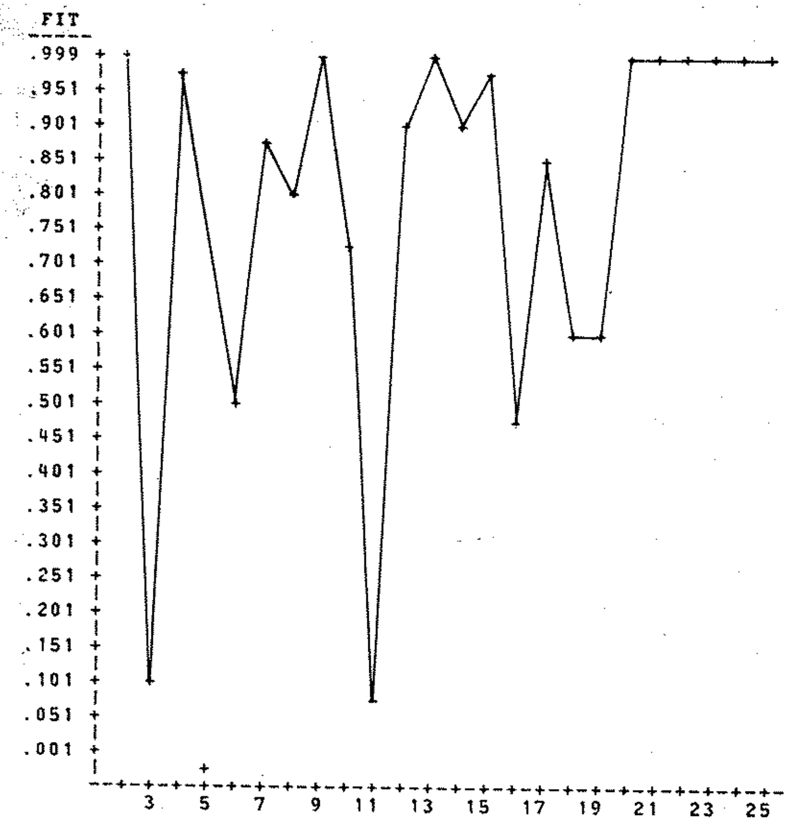

Figure 37.1. Goodness of fit of strict reciprocity model by month. Higher *p* level indicates better fit of model to date.

between the models lead us to conclude that in-group preferences are the same. A visual portrayal of the increase in reciprocity as an attribute of systemwide relations appears in Figure 37.1, which shows the rise in the fit of model 6 to the data, over time.

Inspection of the residuals (a full discussion of this is beyond the scope of this chapter) resulting from the matching of the estimated cell frequencies of the strict reciprocity model to the actual cell frequencies reveals that the reciprocity models do a good job of describing the patterns of communication interaction among groups, and that any particular group relationships over and above those defined by model 6 emanate largely from the two special groups, 0 and 9. This is not too surprising, and no further consideration of residuals is necessary.

Strong cross-group (the third dimension of information flow) parameters reveal which specific groups participated in reciprocal or unreciprocal exchanges. That analysis, beyond the scope of this chapter, showed a tendency of highly reciprocating groups (such as group 4) also to have higher average "success" scores as reported by their members (see Hiltz, 1981, p. 110).

Role Occupancy by Groups Within the EIES System

This section describes how each group is categorized into an information-based role, depending on the sign of the inward, outward, or within-group parameters that Marsden's program estimates.

Using the numbers for the various roles defined in Table 37.1, based on above- or below-average information flows as explained above, Table 37.4 portrays role occupancy of each EIES user group over twenty-four months.

As a brief aid to the reader, here we show how a group is characterized into one of the eight types of roles defined in Table 37.1, based on the three dimensions of information flow. The values for the parameters from the strict reciprocity model's computer output, for each dimension of flow (in-, out-, and within-group) are used to categorize each group (except as noted below). For example, in month 4, the inflow parameter for group 0 is 1.500, the outflow parameter is 2.559, and the within-group-choice parameter is .520. Thus, all three dimensions have positive parameter values, and from Table 37.1 we classify group 0 as a Primary Position, sending, receiving, and internally processing higher-than-average information flows. In addition, the inflow and outflow parameters are greater than 1.00, so we can say that group 0 is strongly defined on the inward and outward information flow parameters. As we see in Table 37.4, group 0 for month 4 is labeled 1I0, taking the 1 from Table 37.1 and capitalizing the I and 0 for the strong parameters.

In the EIES system, roles defined as "snobs" (role 4 in Table 37.1, greater-than-average receivers who do not communicate much internally or externally), "sychophants" (role 6, those who only communicate at above-average levels outwardly) or "isolates" (role 8, those who minimally communicate in any direction) were never occupied. Thus, below-average within-group information flows occurred only for groups that had above-average inward *and* outward flows. It seems as if a group with imbalanced inputs and outputs at least had to maintain a strong group preference; complementarily, only a rich information-based role (the "carrier" of Table 37.1) — occupied by groups 0 and 9 — was able to maintain weak within-group flows. The following paragraphs summarize longitudinal role occupancy for sets of similar groups.

Table 37.4
Role Occupancy of EIES User Groups Over Time

Month	EIES User Group 0	1**	2	3	4	5**	6**	7**	8**	9
* 2	1IO	7I W		3iO	1i W	7				2 o
3	2IO	7IOW	7	7 oW	7	7I W				2
4	1IO	7 OW	7I	3 W	7 o	7IOW				1I
* 5	1IO	7IO	7I	7 W	7I	7 OW				2I
6	1IO	7IOW	5IO	5	5 o	7IOW				1I
7	1IO	7IO	1 O	7I W	7	7IOW				2I W
8	1IO	7IO	7IoW	5	5I	7IOW				1I
9	1 O	7 OW	1i	7	5	7I W				3I
10	2IOw	7io	7	7I W	5 o	7IOW				1I
*11	1IO	7IOW	5	7	7	7I W				1Io
12	2IO		5 o	7IOW	7 o	7IOW	1I W	7IOW	1IO	1 W
13	2IO		1	7	7 o	7IOW	7IOW	7IOW	1	2I
14	2IO		1	7	7IO	7IOW	7IOW	7 W	1IO	2
15	2IO		1 o	7	3	7IOW	7	7IOW	7 W	2IO
16	1IO		1	1	7	7IOW	7 W	7IOW	7	1 W
17	1IOW		3	1 O	7	7IOW	7 W	7IOW	7	1 W
18	1IOW		1	1 O	7	7IOW	7i	7IOW	7 W	1 w
19	1IOW		7	1i	3i	7	7	7IOW	7	1
20	1IOW		1	1	7	7IOW	7i	7IOW	7IO	1
21	2IO	7	1IO	7 W	1	7 OW	7IOW	7IOW	7	1IO
22	2IO	7IOW	1	7 W	1	7 OW	7 W	7IOW	7IO	1
23	2IO	7IOW	1	1	1	1	7 W	7IOW	7	1IO
24	2I	7	1	1io	3	7I W	7IOW	7IOW	7	1
25	2IO		7IOW	7	7I	3	7	7	7	2IO

Note:

I	i	input
O (strongly)	o (weakly) defined	output parameter
W	w	group

*Months when symmetry/reciprocity model did not show a significant fit, although it was significantly better than any other model. The eight-fold role typology is used for these months, even though it does not provide a significant fit to the data, for four reasons: 1) in each month, elements of the eight-fold typology still show conditionally improved fits; 2) in these months, of all groups, only groups 0 and 9 are differentiated when a four-fold typology would not differentiate them; 3) it is a useful heuristic to allow comparisons across months; and 4) roles are collapsed downward again for a pooled analysis (see Table 37.1).
**These groups are considered "task" groups.

User Consultants and the "Random" Group. Group 0 (the user consultants) began as a strong primary group (thirteen of the twenty-four weeks) but shifted over time to its role as a service, or broker, passing information in and out but not primarily within. Group 9 showed variance in role occupancy as it vacillated between primary and broker status, settling into its primary role by month 17. The shift to primary status possibly indicates that many of the "random" group members had been established members of EIES yet were free of group constraints, so they could pass information on to members of other groups of which they had become aware in their existence as "floaters" throughout EIES. Simultaneously, without allegiance to specific groups, they were able to communicate with other "floaters" who also had experience with EIES.

Nontask Groups. The three groups roughly categorized as nontask groups — groups 2, 3, and 4 — all showed a fair amount of variance in role occupancy, generally drifting from isolate or low-status cliques to primary or high-status cliques over time. The progression over time of these groups in and out of roles reveals a shift from groups preoccupied with internal relations only to groups that interact widely with their electronic environment. Group members begin to relate externally and establish reciprocal exchanges. The lack of a strongly motivating groupwide task (relative to task-based groups) not only allows group members to do this, but in fact forces them to do so if they are to continue as viable members of the system.

Task Groups. Task groups — groups 1 and 5 through 8 — on the other hand, continue to occupy the isolate clique role even if there is a slight tendency to enter the system in the primary role. These groups are task-bound, and to survive, their communication structure must be inward-focused. Because of the importance of the group's task orientation to role occupancy, it would be difficult to argue that the inability of these groups to remain in their initial primary position or to exit from their isolate status is indeed a sign of an early role-occupancy advantage by nontask groups. An additional clue as to the importance of a group's task orientation is provided by the fact that all the task groups remained almost totally in the isolate clique role, regardless of whether they entered EIES in month 2 or month 12.

Transitions in Network Role Occupancy

The groups are too few, and their role occupancy too consistent, to perform Markov analysis on their transitions from occupying a particular role in one month to occupying a particular role in the next month. For a brief and nonrigorous insight into general transition patterns, however, roles were collapsed across the third dimension to reduce the many empty transition cells. (Three of the four [+ or −] in-group parameter distinctions never occurred, and the three-dimensional role categorization is not justified in months 2, 5, and 11 anyway, because of the lack of fit of any model to the data in those months.) Under this reduced fourfold role typology (see Table 37.1), groups 0 (service) and 9 (random) are consistently information carriers; task groups generally remain isolate groups after perhaps a few periods as carriers or receivers, while nontask groups shift from isolate roles through transmitters to carriers or receivers. Transitions of groups from one of these four roles from month to month were then pooled over the twenty-four months, as shown in Table 37.5.

Table 37.5
Fourfold Rle Transition Probabilities

From Role	To Role: Carrier	Receiver	Transmitter	Isolate	Totals
C	61 (a)	2	1	8	72
	.85 (b)	.03	.01	.08	
	.87 (c)	.29	.01	.04	
	.32 (d)	.01	.01	.04	
R	1	0	1	4	6
	.17	.00	.17	.66	
	.01	.00	.08	.04	
	.01	.00	.01	.02	
T	2	0	5	8	15
	.13	.00	.33	.53	
	.03	.00	.42	.08	
	.01	.00	.03	.04	
I	6	5	5	79	95
	.06	.05	.05	.83	
	.09	.71	.42	.80	
	.03	.03	.03	.42	
Totals	70	7	12	99	188

Note. Cells are (a) = cell frequency; (b) = proportion of outward transitions; (c) = proportion of inward transitions; (d) = proportion of all matrix transitions.
$\chi^2 = 133.47$; $p < .001$.

Table 37.5 shows that the most frequent transition was to remain an isolate (42 percent of all transitions). The next most frequent transition was to remain a carrier (32 percent). Remaining in either of the other two roles (receiver or transmitter) was infrquent (0.0 percent and 0.03 percent, respectively).

A group was most likely to become a receiver by first being an isolate (.71 transition rate) and most likely to become a transmitter by first being an isolate or a transmitter (.42); once either a receiver or a transmitter, the likely transition was to an isolate (.66, .53) where a group tended to remain (although a transmitter had some chance, .33, of maintaining its role). So there was a general overall trickle into the isolate role (total inward transition to outward rate is 1.04, while the rate for the carrier role is .97), with three (transmitter, receiver, and isolate) roles making transitions primarily into the isolate role but with slight intermediary transitions.

Thus, a group had a reasonable chance overall of occupying the information-rich "carrier" role but for practical purposes faced a struggle against systemwide tendencies, which drew most groups into the isolate role and kept them there. This general flow in role occupancy also represents a hierarchy of roles based on the amount and direction of information passing through a group. That hierarchy begins with the carrier role, moves down through the transmitter and then the receiver, and ends with the isolate.

To illustrate these relationships and critical transitions graphically, the pooled transition matrix of raw frequencies was first iteratively doubly standardized. The resultant matrix (with each row and each column summing to 1.00) was then clustered based on strong components. Links between i and j are added in the same order as the magnititude of transition frequency between the roles. A threshold value is the transition frequency at which two or more components are linked together into a larger component. Figure 37.2 presents the threshold values, critical links, and graphical clustering of the roles into components.

The cluster results repeat, in a different form, the verbal analysis above. The carrier role was the most difficult to which to make a transition from another role, as indicated by the very large gap between any other connecting threshold. The receiver role was clustered quite close to the isolate role but quite far from the transmitter role. Indeed, in this cluster analysis the transmitter role is closer to being joined with the carrier role than with the other two. Again this visual portrayal indicates a hierarchy of roles based on an active-passive scale of a group's information flow.

Considering this hierarchy with respect to reciprocality, it appears that a group does not become primarily a receiver by first transmitting a lot of information, but is motivated to become a transmitter by first receiving above-average levels of messages (when, of course, occupying either role does not lead directly to becoming an isolate, the likely outcome). A strongly transmitting group that escapes immediate isolate status clearly tends to continue transmitting, but this does not seem to generate above-average inward flows. There is a small (.13) tendency for a transmitting group to become a carrier. The upshot of these transitions is that to achieve an information-rich role, a group must (1) continue to exchange information in all directions, and (2) be aware that the other groups in the system must perceive the group as an appropriate receiver of above-average information flows.

SUMMARY

This chapter has reported on research results concerning the development of a communication network involving research groups as they

Component Nodes	Threshold	Critical Link
R, I	.424401	R –>I
R, T, I	.277514	T –>I
C, R, T, I	.222737	R –>C

Hierarchical Clustering Based Upon Critical Link Thresholds

```
Threshold:  41.2        39.3 / /28.3        26.5        24.7        22.8
Role    ..+....+....+....+..//..+....+....+....+....+....+....+.
----
R      -+
        | ----------- // -----+
I      -+                     |----------------+
                              |                |
T    -------------- // ------+                 |
                                               |
C   --------------- // -------------------------+
```

Figure 37.2. Clustering of roles by transitions, with standardized threshold values and critical links. Scale attenuated between threshold values of 39 and 28.

communicate over a two-year period via a nationwide computer-conferencing system.

The major results of this analysis are summarized here. First three information flows — into a group, from a group, and within a group — along with the added constraint of reciprocal relations between pairs of groups, are significant attributes of the systemwide network structure. Second, this description of the network becomes quite stable over the twenty-four months, after some early vacillation. Third, the groups occupy well-defined information-based network roles, with task groups remaining isolates, nontask groups becoming information-rich, and the service/random groups remaining carriers or brokers of information.

There are implications for managers and users of such systems. Reciprocity among groups is an important attribute of communication, as users attempt to achieve stable, equal information exchanges. Nontask groups seem more likely to be able to change their role. While task groups seem less likely to transact with their environment. If the task group requires information from an unstable environment, the manager will need to support specific individuals "scouting" the environment. For a group to remain in an information-rich network role takes constant effort. Becoming a transmitter only or a receiver only is a sign of imminent isolation with respect to systemwide information exchanges. However, a leader of a task

group in a stable environment may well *prefer* receiver or isolate status for the group, in order to focus exchanges within the group. Finally, evaluations of usage behaviors should not be based on early periods of use.

For researchers, one implication is that computer-monitored, accurate, longitudinal network data provide rich insights that are not likely forthcoming from cross-sectional self-report data. In addition, a new network analysis approach has been shown to be useful and rigorous in investigating multigroup networks. This method has revealed some of the principles of computer-mediated human communication networks.

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