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AUTHOR Monge, Peter R.; Lindsey, Georg N.
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ABSTRACT

This report describes a set of procedures for analyzing communication networks in large organizations. The procedures include the identification and evaluation of various kinds of networks, assessment of the organizational hierarchy, appraisal of various departments within the organization, and evaluation of individual communication behavior. The report begins by describing and illustrating the essential concepts of network analysis, thereby providing a vocabulary for talking about the process. In the second chapter several comparative techniques are described for evaluating the network, including overlaying the actual network on the organizational chart and comparing different networks. Several important network metrics, called communication structure variables, are identified, and their relationships to important aspects of organizational processes are suggested in the third chapter. Finally, information is provided to enable a reader to gain access to and utilize existing software for conducting a large-scale network analysis by computer. (Author/RB)

# THE STUDY OF COMMUNICATION NETWORKS AND COMMUNICATION STRUCTURE IN LARGE ORGANIZATIONS*

Peter R. Monge
Department of Speech Communication
San Jose State University

and

Georg N. Lindsey
Institute for Communication Research
Stanford University

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## A B S T R A C T

Communication networks consist of the regular patterns of interpersonal communication contacts which develop among people within an organization as they use various forms of communication (face-to-face meetings, memos, telephone calls, etc.) to accomplish the daily activities of an organization. Information regarding the functioning of the various types of human networks is important since it can be used to understand the organizational process and to assess its effectiveness and efficiency.

The report describes a set of procedures for analyzing these networks in large organizations. These include: (1) identification and evaluation of various kinds of networks, (2) assessment of the organizational hierarchy, (3) appraisal of various departments within the organization, and (4) evaluation of individual communication behavior.

The report begins by describing and illustrating the essential concepts of network analysis, thereby providing a vocabulary for talking about the process. In the second chapter several comparative techniques are described for evaluating the network: overlaying the actual network on the organizational chart, comparing different networks, etc. In the third chapter several important network metrics, called communication structure variables, are identified and their relationships to important aspects of organizational processes are suggested. Finally, information is provided to enable a reader to access and utilize existing software for conducting a large-scale network analysis by computer.

The report has been written primarily for practitioners, i.e., for people who have had little previous experience with network analysis but who wish to utilize the method for managing and appraising large organizations. The presentation is, therefore, as non-technical and non-theoretical as possible.

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# THE STUDY OF COMMUNICATION NETWORKS AND COMMUNICATION STRUCTURE IN LARGE ORGANIZATIONS

The essential functions of every organization are accomplished through processes of communication. Though these processes have many dimensions, one of the most important is the communication network. Communication networks consist of the regular patterns of person-to-person contacts which develop as people meet with one another, phone one another, send memos and letters to one another, etc., in the daily process of getting the job done. Communication networks are crucial since they provide the basic structure through which information flows throughout the organization.

Typically, executives and managers are already somewhat acquainted with the notion of communication networks. The basic organization of any firm is often represented in an organizational chart, i.e., a formal communication network indicating the appropriate "pathways" for instructions, reports, etc. Reorganization of the firm generally means reorganization of the formal communication networks.

Managers are also aware of the fact that members of almost every organization often form their own networks which do not conform to those specified in the organizational chart, but which may fulfill other purposes or needs of the organization's members. It is not surprising to find discrepancies between the "designated network" and the "actual networks," e.g., the grapevine. Some of these additional networks are beneficial to the organization and some are detrimental. Good managers frequently develop intuitive feelings for the various kinds of networks that exist in their areas, but if the number of persons is large--say, 50 or more--many managers recognize that their intuitive insights regarding contact patterns are often limited and possibly biased.

Because of the size and complexity of networks in large organizations and because of the problems and inadequacies inherent in intuitive approaches, it is important to utilize objective, scientific network analysis techniques to provide complete and accurate information on the "health" of an organization's networks. Optimally, network analysis techniques provide (1) a general evaluation of the organizational hierarchy (the formal network), (2) a clear delineation of non-formal

networks, (3) an appraisal of the various departments or units within the organization, and (4) an evaluation of individuals within the various departments. This report describes a scientific network analysis technique which provides information at these four levels.

In our presentation of this methodology we have attempted to provide practical, easy-to-use information for persons not familiar with network analysis techniques. To accomplish this, we begin an actual application of the network technique very quickly by conducting a network analysis of a hypothetical company. After an explanation and an application of each aspect of the network procedure, the reader should then be quite "at home" with the various methods. While it is quite probable that the reader could then conduct a network analysis, the complexity of the analysis makes the use of available computer software a much more viable method than conducting the analysis "by hand."

This report has been organized into four chapters. Chapter 1 describes how to locate and identify the major parts of a communication network within an organization. Chapter 2 presents the basic methods by which the communication network may be assessed. Several procedures for quantifying networks and producing measures of communication structure are described in Chapter 3. Finally, Chapter 4 provides a consideration of some of the pragmatics of network analysis, such as available computer programs, preparation of data for computer analysis, etc.

CHAPTER 1

IDENTIFYING A COMMUNICATION NETWORK

One of the easiest ways to explain the terms and concepts of network analysis is through an example which can be maintained in subsequent chapters. This will enable the reader to follow step by step the methods used in identifying, assessing, and quantifying the network. Although most analyses involve organizations of 100 or more persons, our hypothetical organization will

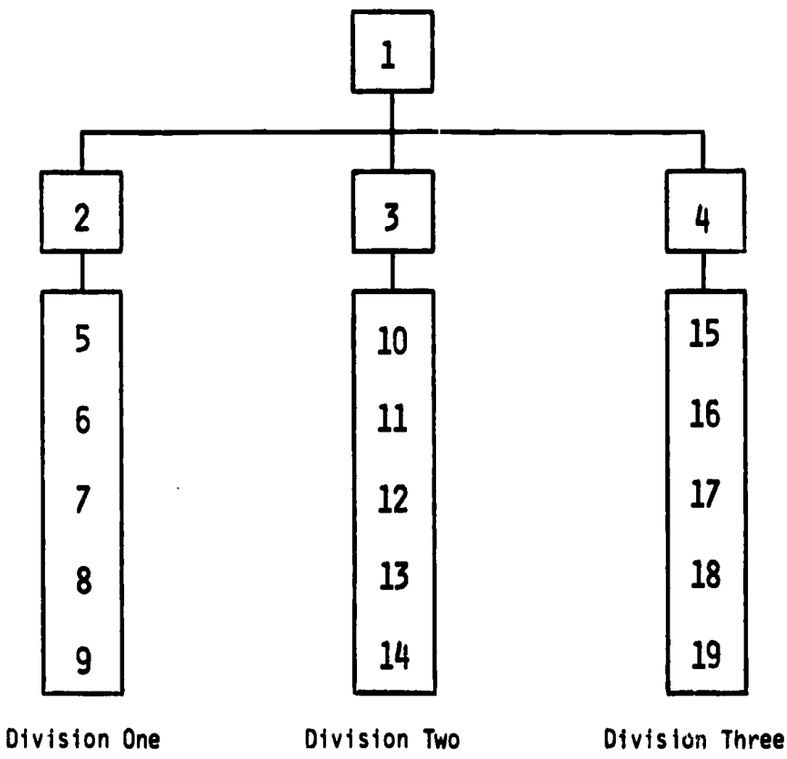


Figure 1. The organizational hierarchy of Company X

have only 19 employees.

The organizational hierarchy of Company X is shown in Figure 1. From this chart we can see that there are three major divisions within this organization. The numbers within the blocks represent individual persons in the company. Thus, Person 1 is in charge of the entire organization. Persons 2, 3, and 4 are supervisors or managers of Divisions One, Two, and Three, respectively. The remaining numbers (5-19) represent the various employees of the three divisions.

To begin the analysis we ask each person to indicate his communication relationships with other people in the organization. To obtain this information a questionnaire is provided to each individual with a list of all persons (in our example, 19) within the company. Typically, an individual is asked to indicate his frequency of "communication with" each person using a numbered continuum. For instance, a frequency of "almost never" could be represented by a "1" while "several times a day" could be represented by a "5." Thus, each person would place a number ranging from 1 to 5 by every other person's name. In Figure 2 we present a hypothetical questionnaire (minus the instructions) with data filled in for Person 1.

YOUR NAME John Jones

Frequencies

1 = almost never
2 = once or twice a month
3 = once or twice a week
4 = almost every day
5 = several times a day

Please indicate your frequency of communication with the following persons:

| | | |
|---|---|---|
| (1) | John Jones | - |
| (2) | Jenny Doe | 4 |
| (3) | - | 5 |
| (4) | - | 5 |
| (5) | - | 3 |
| (6) | - | 1 |
| (7) | - | 2 |
| (8) | - | 3 |
| (9) | - | 2 |
| (10) | - | 2 |
| (11) | - | 3 |
| (12) | - | 1 |
| (13) | - | 2 |
| (14) | - | 2 |
| (15) | - | 1 |
| (16) | - | 3 |
| (17) | - | 1 |
| (18) | - | 3 |
| (19) | Sarah Smith | 1 |

Figure 2. Communication network questionnaire with data for Person 1 in Company X

In Figure 2 we can see that John Jones (Person 1) indicates that he communicates with Jenny Doe (Person 2) almost every day. On the other hand, Person 1 almost never communicates with Person 6. In analyzing these data it is possible to examine the entire range of frequencies in the scale (in our example, 1 through 5) or to restrict the analysis to some part of the scale. For the purposes of this example, let us restrict our analysis to communication at a frequency of daily or more often (i.e., almost every day and/or several times a day).* Thus, only those persons mentioned at a frequency of four or five would be considered connected with Person 1. From Figure 2 we see that Person 1 communicates at this frequency with only three persons; they are Persons 2, 3, and 4 whom he directly supervises. Obviously, if we selected a different frequency of communication (say, weekly or more often, i.e., frequencies 3, 4, and 5), then Person 1 would "communicate with" a different (probably larger) number of people.

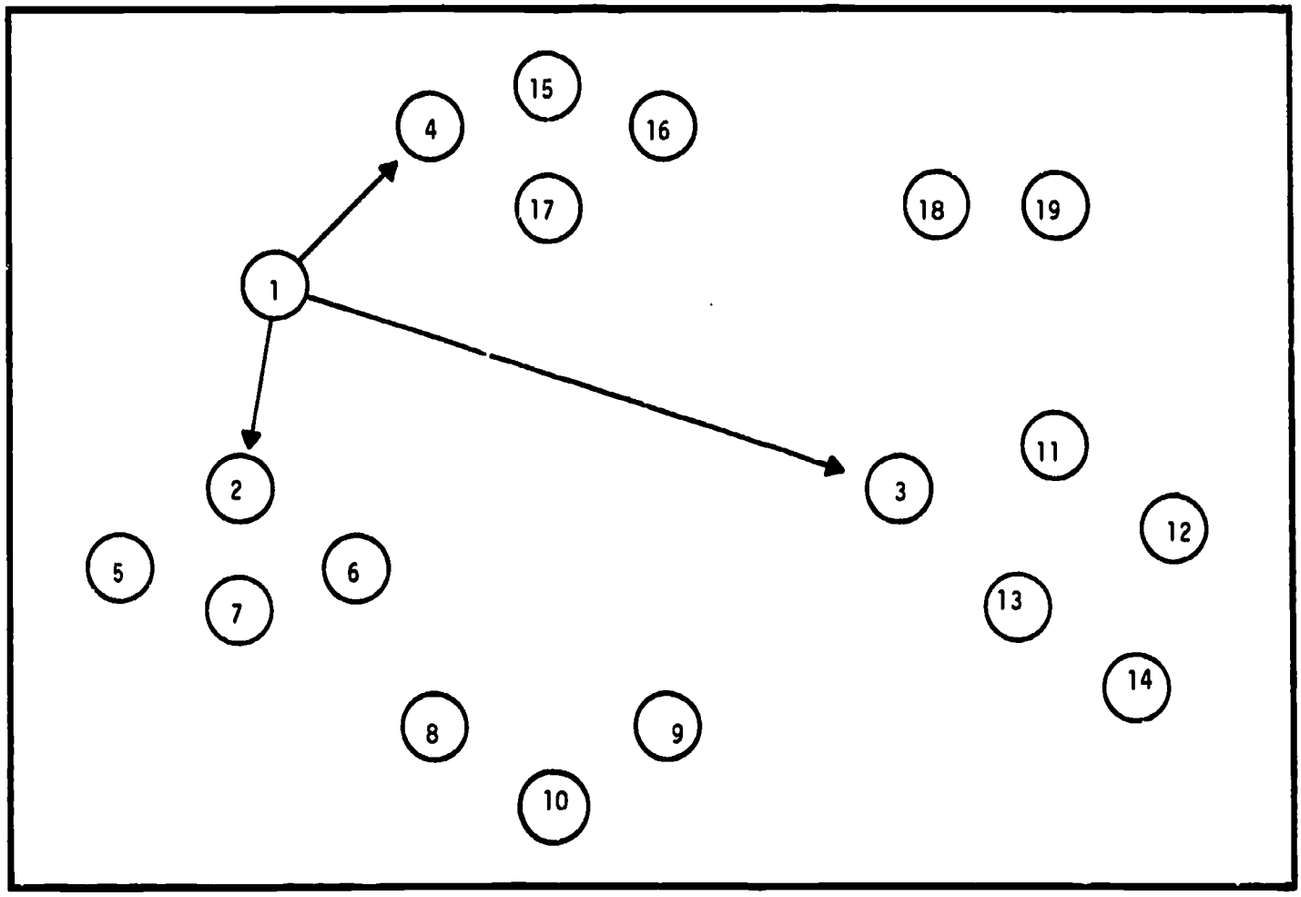


Figure 3. The communication contacts possessed by Person 1 to the other employees of Company X

*In practice, all frequencies are utilized but are weighted differentially to account for differences in strength of communication.

Person 1's communication with other people has been represented graphically in Figure 3. Individuals in Company X are indicated by placing their person numbers within a circle; they are called communication contacts. The relationship between any two people is represented by a line called a link. The arrowhead on the link simply indicates which person of the pair is reporting the relationship; the convention is that the person from whom the arrow is emanating is the one reporting the relationship. In Figure 3 the relationship "communicates with daily or more often" is shown by a link between Person 1 and each of the three people that he reports on his questionnaire (Persons 2, 3, and 4).

By itself Figure 3 tells us nothing that was not already immediately apparent from Person 1's questionnaire. Figure 4, however, combines the data from the questionnaires for all 19 persons in Company X. Links have been drawn to indicate each contact mentioned by each person at a frequency of daily or more often (i.e., a frequency of 4 or 5). This combined format for presenting the data makes it possible to discern several network characteristics which cannot be seen by examining questionnaires individually.*

Before examining Figure 4 in greater detail, several comments are in order about the nature of network data. Communication relationships which exist between pairs of people in the real world may be characterized by a number of properties; one of the most important of these is symmetry. For example, the relationship "communicates with" is symmetrical because "Person A communicates with Person B" implies that "Person B communicates with Person A." On the other hand, the relationship "supervises" is asymmetrical since if "A supervises B," then it is not possible to have the relationship "B supervises A" (at least in most organizations). Sometimes the symmetry property is ambiguous as in the relationship "gets information from," for example, "A gets information from B" may or may not imply that "B gets information from A." The symmetrical property of the relationship is established by the selection and wording of the questions that people are asked to respond to.

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*Many readers will recognize the form of Figures 3, 4, and 5 as a "sociogram." It should be noted, however, that for explanatory purposes this "simplified" example was constructed so that the network parts could be demonstrated. In actual practice constructing a sociogram for large numbers of people (say, 30 or more) is extremely difficult, as is the task of interpreting it. This is due in part to the visual complexity of such networks and the lack of criteria available for interpreting them.

A communication link indicates or represents a communication relationship among people in the real world. Links are created from the data collected in a set of network questionnaires. Like any other data, these data are subject to measurement error, i.e., a link may not accurately represent the true relationship. One way in which this problem can be detected is in the correspondence between properties of a link and properties of a relationship for which the link stands. If a relationship between two people is symmetrical, then both parties should indicate the relationship on their respective questionnaires. For example, if there is a symmetrical relationship between Persons A and B called "communicates with," then A should indicate B on his questionnaire and B should list A on his. If this occurs, then the link representing the relationship between the two is said to be reciprocated and it is assumed that there is no measurement error. On the other hand, if either person omits mention of the other, then measurement error has occurred, the link is called unreciprocated, and a decision must be made as to what to do about the measurement

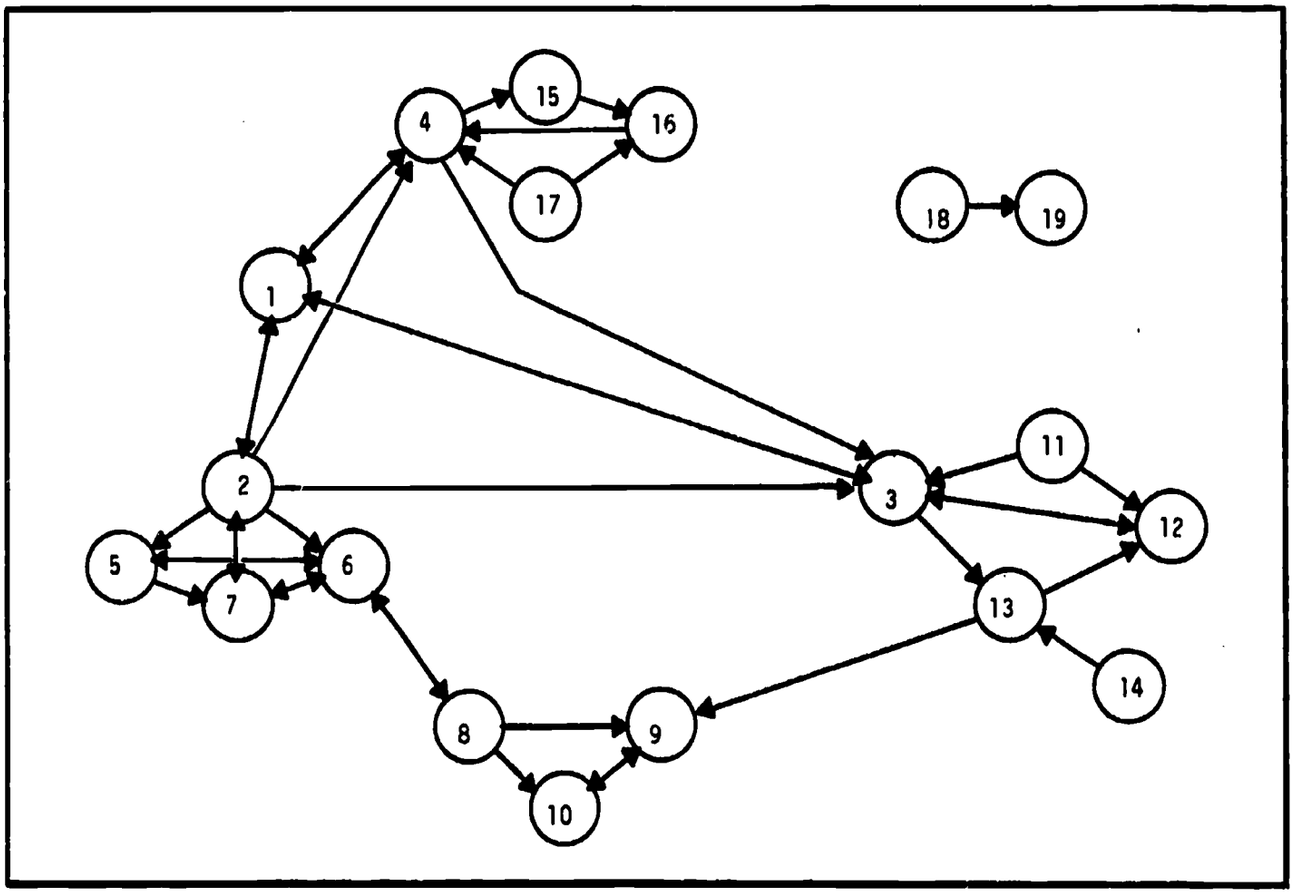


Figure 4. Communication contacts among the employees of Company X

error. It should also be apparent that if the real world relationship is asymmetrical then the links representing that relationship should all be unreciprocated and any occurrence of reciprocated links is attributable to measurement error; again a decision must be made as to how to handle the error.*

Figure 4 clearly presents the distinction between reciprocated and unreciprocated links. A reciprocated link is represented by two arrowheads between persons. For example, the double arrows between persons 1 and 4, 1 and 2, 3 and 12, etc., mean that persons 1 and 4 indicated a relationship with each other, persons 1 and 2 list each other on their questionnaires, etc. An unreciprocated link, on the other hand, is indicated by a single arrow between any pair. Thus, the single arrow between 2 and 4, 4 and 15, 15 and 16, etc. means that 2 indicated a relationship with 4 but 4 did not indicate that relationship with 2; 4 listed 15 but 15 did not list 4, etc.

It is obvious from even a cursory review of Figure 4 that there are both reciprocated and unreciprocated links in the data. Since the relationship "communicates with" is symmetrical, all links should be reciprocated; unreciprocated links represent measurement error. Consequently, a decision must be made as to how to treat the unreciprocated links. Two alternatives are available: (1) unreciprocated links may be dropped from the analysis indicating the analyst's belief that the relationships these links represent don't really exist among the people in the real world, i.e., some people reported a relationship that doesn't really exist, and (2) unreciprocated links may be converted to reciprocated links indicating that one person in the pair merely forgot to indicate the relationship, i.e., some people neglected to indicate a relationship that really does exist.

In Figure 5 we have adopted the latter option, converting all unreciprocated links to reciprocated ones. Since all links are now reciprocated, single lines without arrowheads are sufficient to represent them. This simplification makes the patterns of relationships among the links much easier to visually discern.

Examining Figure 5 permits the development of a classification scheme for categorizing the communication network roles filled by people. First, note the several clusters of

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*For a more extensive discussion of relationship and link properties as well as the problem of measurement error, see Richards, William D., Network Analysis in Large Complex Systems: Theoretical Basis (Stanford, Calif.: Institute for Communication Research, 1974).

individuals, e.g., 4, 15, 16, 17 or 3, 11, 12, 13. These are called communication groups. The "simplest" definition of a communication group is that three or more people have at least 50 percent of their contacts with each other.* Let us examine the cluster of Persons 4, 15, 16, and 17 to see if they qualify as a communication group. Person 4 has six total links, and three of these six (or 50 percent) are with persons 15, 16, and 17. Person 15 has two links and both are to members of this tentative cluster (or 100 percent). Person 16 has three links all to members of this group and Person 17 likewise has two contacts, both members of this group. Both 16 and 17 then have 100 percent of their links with other persons in this group. All of the persons in this cluster, then, have more than 50 percent of their links with each other. They do in fact meet our rule requirements and constitute a communication group. If we examine the clusters of Persons 3, 11, 12, 13, Persons 8, 9, 10 and Persons 2, 5, 6, 7, we find that each set of people also forms a communication group. The groups are labeled A, B, C, and D, respectively.

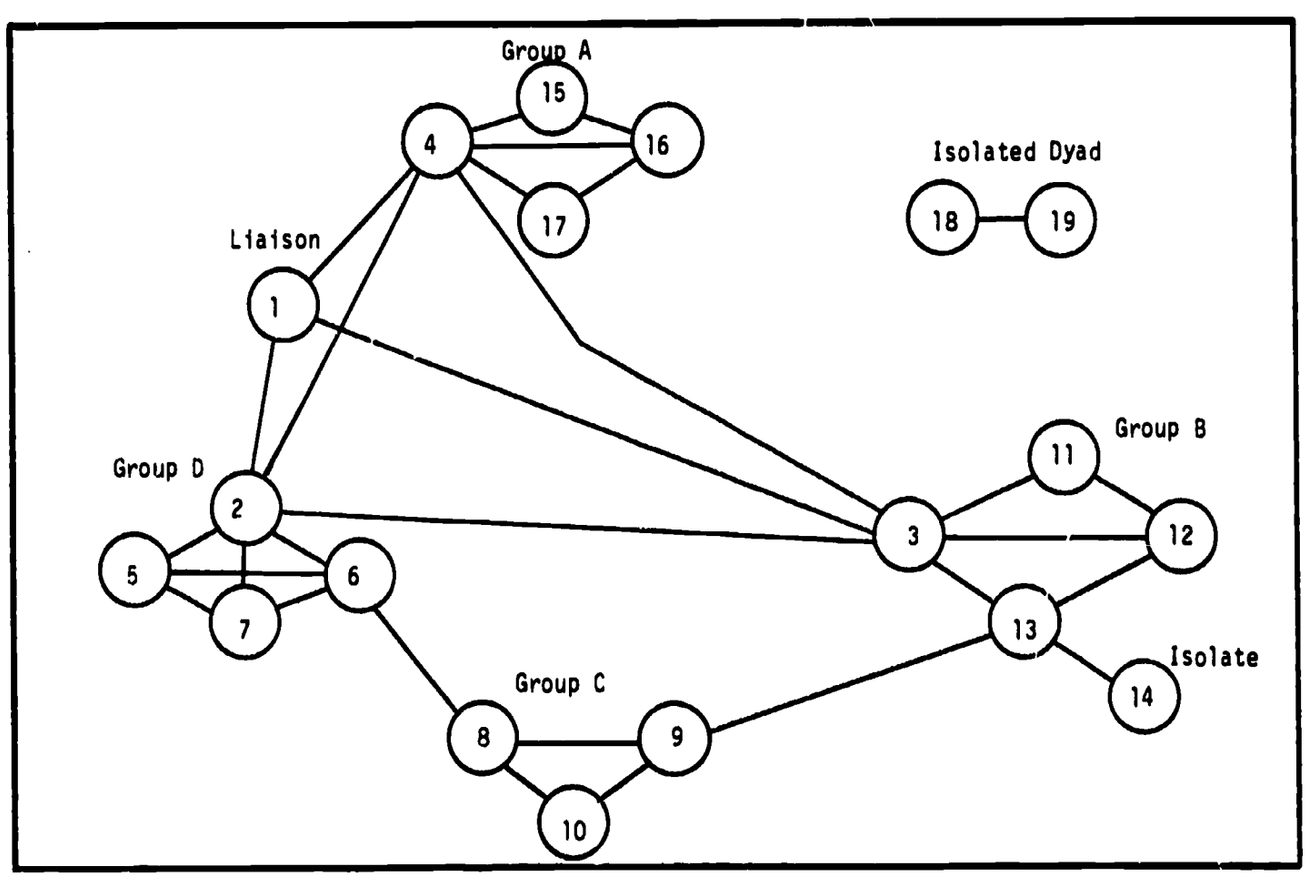


Figure 5. Communication link network among the employees of Company X.

*Theoretically, any criterion percentage, e.g., 40 percent, 49 percent, 50 percent, 57 percent, 60 percent may be imposed in constructing groups. Furthermore, the network computer routine described later uses more than mere shared percentage of links. For our purposes, however, the method developed in the text is quite adequate.

Thus far we have only discussed links among members of each communication group. These links are called internal or within-group links. Now that the communication groups have been isolated, we can identify a second type of link: the external links. One important type of external link is the bridge link which connects the various communication groups.*

As an example of bridge links in Figure 5, consider the group composed of persons 4, 15, 16, and 17; its members have three links other than their within-group links. Two of these are to Groups D and B, and are bridge links.

Another important intergroup linkage function which a person may perform is the liaison. A liaison is defined as a person who has at least three communication links but less than 50 percent of his or her contacts are members of any one group. For example, Person 1 has three links but they are to people in three different groups; Person 1 is a liaison.

Two other categories will complete our classification scheme. A person with fewer than two links does not substantially participate in the network and is called an isolate. Three persons in Figure 5 fall into this category: Persons 14, 18, and 19. If a person fails to meet the criteria for inclusion in any of the above categories, he is placed in a residual category called others; usually there are relatively few "others" in a communication network.

It is now possible to summarize the application of this category scheme to all 19 persons in Company X:

| | | |
|---|---|---|
| Communication Group A | = | Persons 4, 15, 16, 17 |
| Communication Group B | = | Persons 3, 11, 12, 13 |
| Communication Group C | = | Persons 8, 9, 10 |
| Communication Group D | = | Persons 2, 5, 6, 7 |
| Liaison | = | Person 1 |
| Isolates | = | Persons 14, 18, 19 |

*It is important to note that both bridge and within-group links are defined with respect to the observed communication groups (in this case, Figure 5). If a change in the criterion for analysis were made, such as accepting a lower frequency as a contact, we might change the communication groups and this would change the within-group and the bridge links. In other words, the distinction of within-group or bridge link is not found directly from the questionnaire. Unreciprocated and reciprocated links, on the other hand, can be determined without considering the communication groups.

When considering bridge and liaison linkages, Figure 5 may be simplified even further. Since these links are associated with between-group connections only, communication groups may be used as the primary units of analysis. Then the connections which are drawn will be only those links between groups. Chapter 2 provides several examples of graphic representations of bridge and liaison connections which have been simplified in this manner.

A number of concepts and definitions have been developed in this chapter which may be summarized as follows:

1. Bridge: a person who is a member of a communication group and who has a link to a person who is a member of a different communication group.

2. Bridge link: a one-step, direct communication link between two persons who are members of different communication groups.

3. Communication group: three or more persons within a network who have at least 50 percent (or some criterion measure) of their links with each other.

4. Contact: A person who is listed on a network questionnaire as someone with whom the lister has a communication relationship.

5. External link: A link between a group member and another person who is not a member of his group. External links may be bridge links, liaison links, or other links.

6. Group member: a person who belongs to a communication group. A group member has at least 50 percent (or some criterion measure) of his links with people who share their links with each other.

7. Internal link: A link between two persons who are both members of the same communication group. Internal links are also called within-group links.

8. Isolate: an individual within a network who has fewer than two communication links.

9. Liaison: a person within a network who has links with two or more communication groups, but does not have a majority of links with any one group.

10. Liaison link: a link which another person in the network has with a liaison.

11. Link: a representation or indicator of a communication relationship in the real world.

12. Measurement error: the failure of network data to adequately represent the nature of a communication relationship in the real world.

13. Others: a category for classifying people who do not meet the criteria for classification into the standard role categories.

14. Reciprocation: a property of a communication link which indicates whether both people in a pair reported a communication relationship. A link is unreciprocated if only one person reports the relationship.

15. Relationship: the fundamental phenomenon in the real world between pairs of people which network analysis attempts to study.

16. Role: the categories into which persons are classified in a network analysis. They include group member, liaison, bridge, isolate, and other.

17. Symmetry: A property of relationships which indicates whether the relationship is implied for one or both of the persons who enter into it.

18. Within group link: A link between two persons who are both members of the same communication group, i.e., an internal link.

In this chapter we have shown how a communication network may be identified within an organization, and have presented the basic terms and definitions of network analysis. In Chapter 2 we will indicate several methods for organizing the data in order to evaluate the network.

## CHAPTER 2

## ASSESSING THE COMMUNICATION NETWORK

This chapter reviews the material which we have discovered about the hypothetical company (Company X) and describes methods which will allow organization of this information into a coherent, logical framework. Chapter 1, however, provided coverage of only one network within the company; let us call this the Work Communication Network, which is the network through which information related to "getting the jobs done" flows. In Chapter 2 another network is considered within Company X: the Innovation Network through which new ideas and suggestions flow. This will give us some additional perspectives and also provide a comparison between the two networks.

One of the most useful methods of organizing network data is to superimpose the communication network groupings upon the organizational hierarchy of the company. Coded charts are often very useful for this purpose. In Figure 6 we have drawn the organizational hierarchy (identical to Figure 1) but have coded the numbers of the members of the four communication groups of the Work Network. We may examine Person 10, for instance, and see from the legend that this code represents Group C. We can, conversely, easily see Group C's hierarchical location in Company X. With this simple graphic representation our network analysis begins to provide some useful information. To consider this information more carefully we may consider how each individual group fits into the hierarchy.

Group A of the Work Network was found to be comprised of four persons (4, 15, 16, 17) and has been distinctly coded in Figure 6. We see that all of these members are found in Division Three of Company X. But what of Division Three's other two members, Persons 18 and 19? It can be seen from Figure 6 that 18 and 19 are both isolates (blank code). Thus, Division Three has two individuals who appear to be isolated from (i.e., not communicating with) others in their division. Obviously, this finding could be used by management to institute changes for improving the performance of Division Three.

Communication Group B was comprised of 3, 11, 12, and 13. All of these individuals are found in Division Two, and, therefore, seem to constitute an essentially logical grouping.

However, there remain two other members of Division Two, i.e., Persons 10 and 14. Person 14 is seen to be an Isolate; Person 10 on the other hand is a member of an entirely different communication group, i.e., Group C!

Group C indeed is found to contain members from Division One (8, 9) and from Division Two (10). This communication group does not fit "neatly" into the corporate hierarchy. A finding such as this often indicates that a re-evaluation of the corporate hierarchy may be in order. Is it the case that since these three persons function together as a group, an appropriate corporate structure would place them below the same supervisor? Is it the case that a breakdown in communication within this division is dysfunctional to the organizational hierarchy? Or does a high need

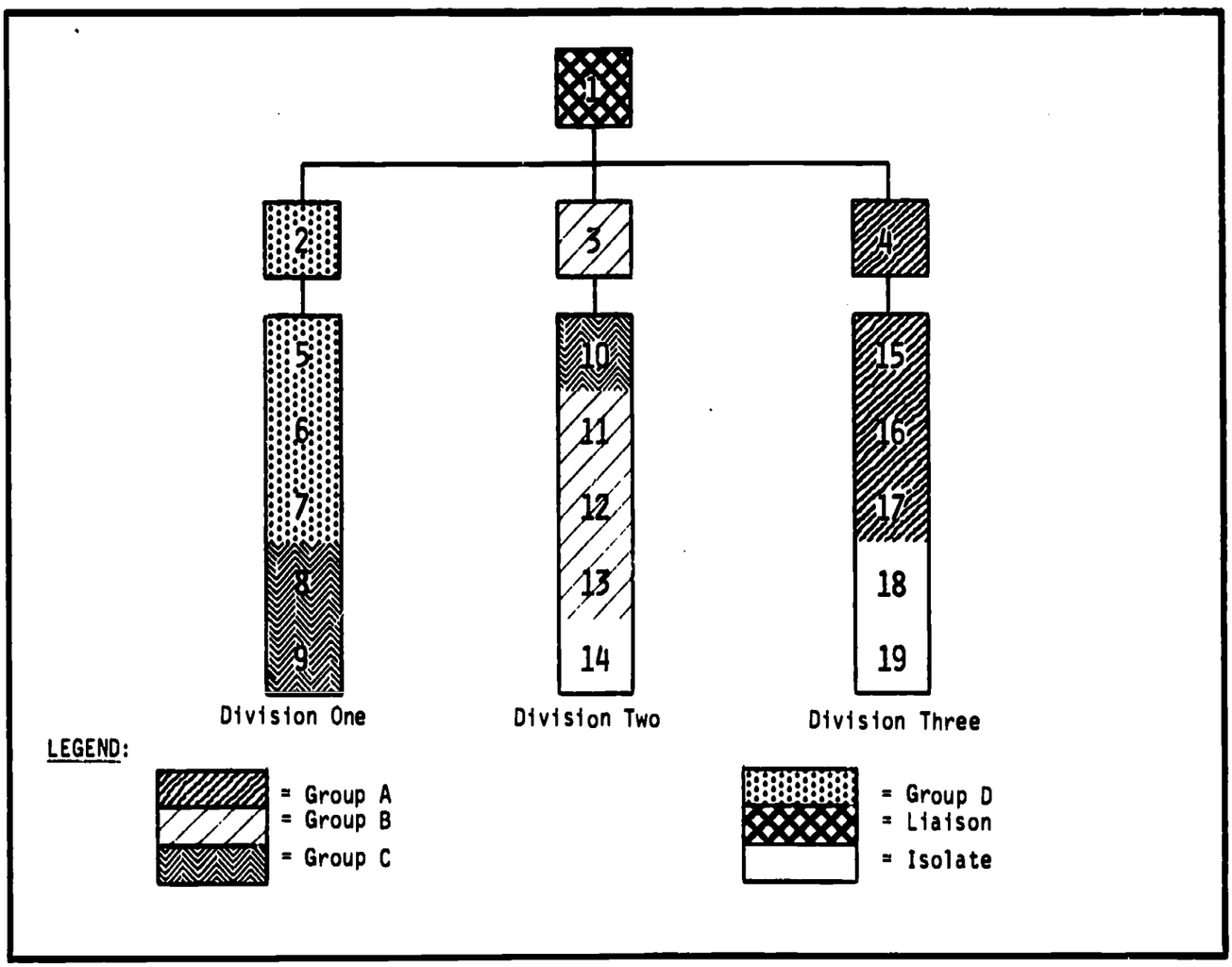


Figure 6. The four Communication Groups of the Work Network within the organizational hierarchy

for coordination cause members of one division to interact more with members of another division than they do with members of their own division? The network analysis cannot answer questions of this type; rather it functions as a diagnostic device to locate problems such as these and provides initial suggestions for solutions that are logical from a communication flow viewpoint. These problems become even clearer a little later in the chapter when we examine the bridge and liaison patterns of these groups.

Communication Group D (persons 2, 5, 6, 7) appears quite consistent with the organizational hierarchy, since all members are found in Division One.

Thus far, merely by "fitting" the communication groups into the corporate structure of Company X, some interesting patterns have begun to emerge, e.g., isolated persons, unexpected groupings. We may make additional important observations by developing Figures 7 and 8 which show the bridge and liaison links between the groups.

Figure 7 shows the bridge links between the four groups. We note that Group A possesses two links to the other three groups, while Group B, on the other hand, has bridge links to all three of the other communication groups. We also note that Group C (our "problem" group) appears to be reasonably interconnected to the other groups since it has two bridge links.

In Figure 8 we see that Person 1 has emerged as the only liaison. This would seem logical since he is hierarchically above all of these groups. Also, not surprising is the fact that each of his links are to the division supervisors, persons 2, 3, and 4. This is worthy of note since Group C, which is not a recognized grouping, is then cut off from direct communication with Person 1. Not all liaisons, however, are "higher level" people; liaisons may--and frequently do--emerge from any level in the organizational hierarchy. This is an important point which management should closely review.

As a result of this analysis, Company X might want to consider a re-evaluation of its hierarchy to create a more functional environment for Group C. Also, the fact that three of the nineteen individuals within the organization are isolated would certainly indicate a need to improve communication channels to these persons. Obviously, other interpretative comments could be made, however, our purpose is more to explain techniques rather than improve the communication of Company X.

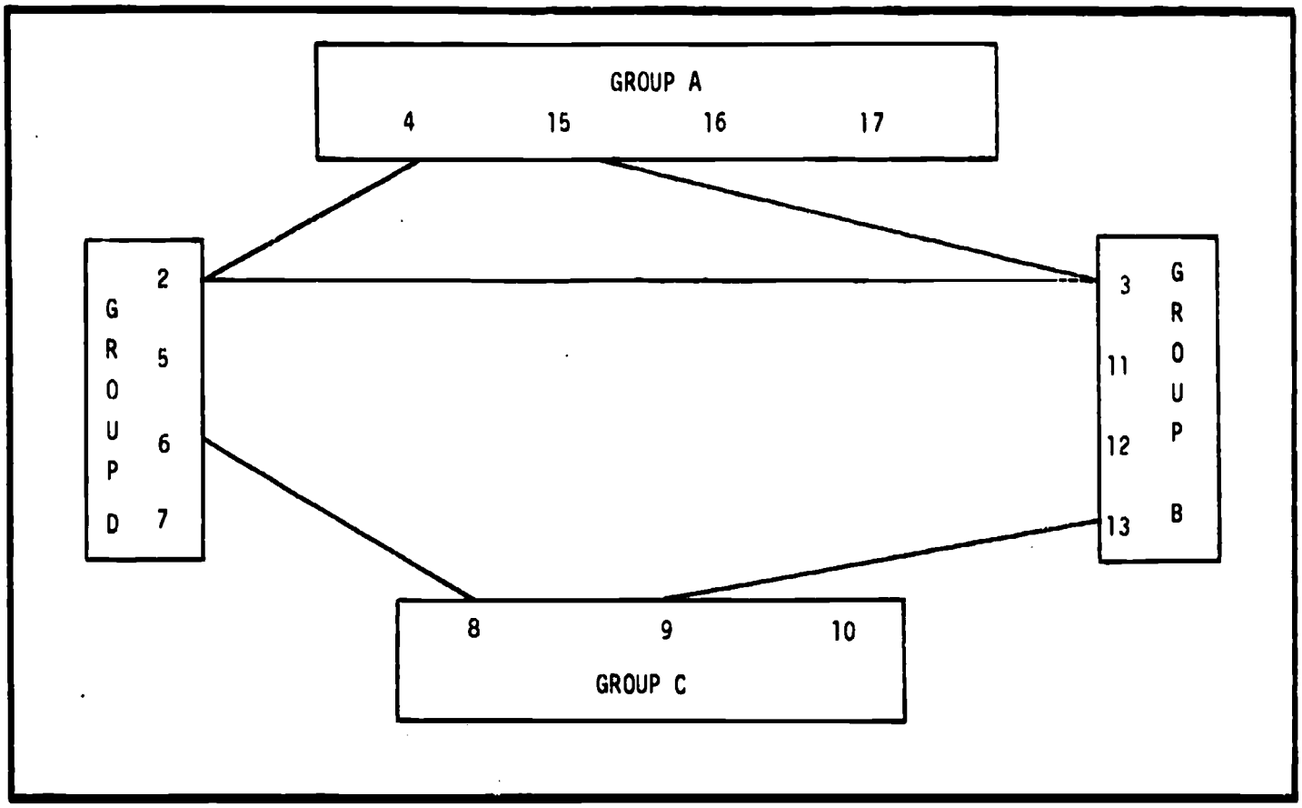


Figure 7. Bridge communications between the four Communication Groups of the Work Network

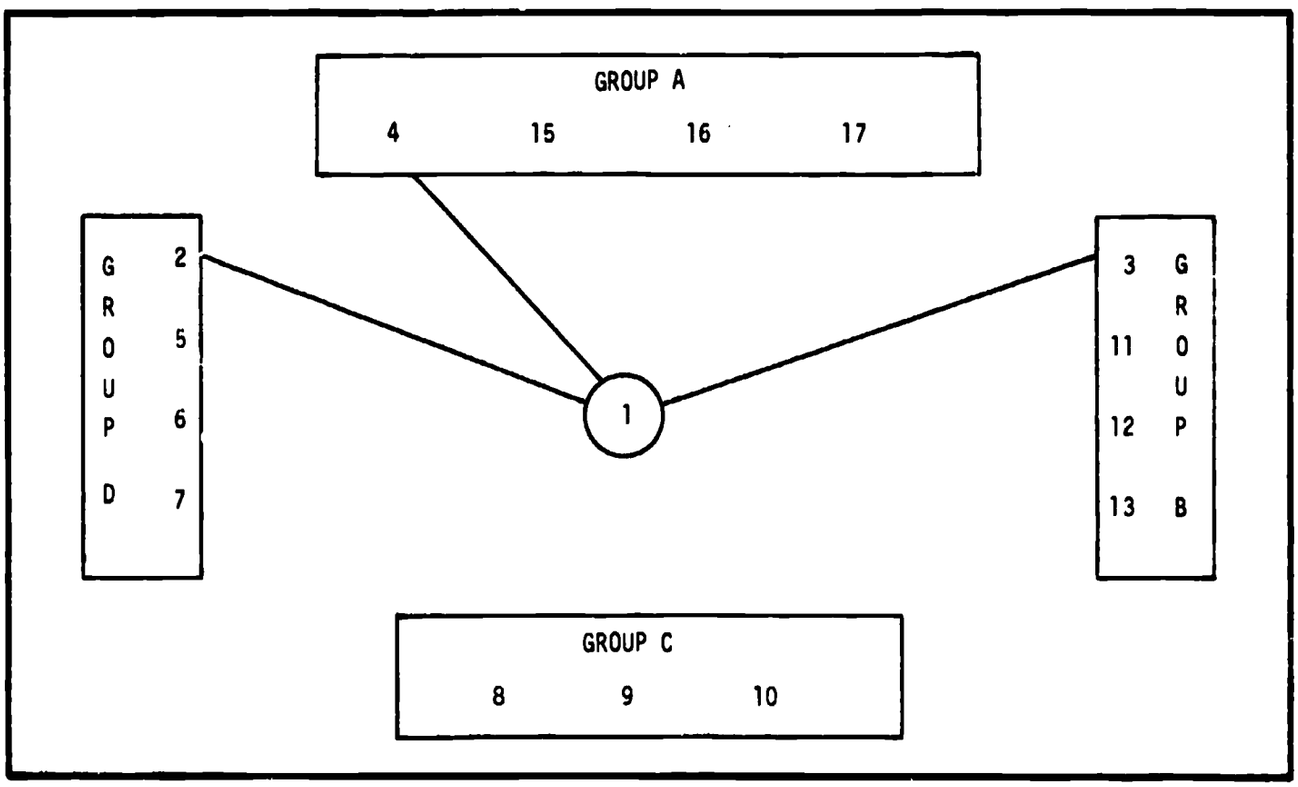


Figure 8. Liaison connections between the four Communication Groups of the Work Network

Analysis of A Second Network Within Company X

The preceding discussion has shown some information concerning the Work Network. It is often useful, however, to consider more than one kind of network within an organization; we may, in fact, consider as many networks as we desire. In this section we will consider the diffusion of new ideas through the communication channels of Company X, which we call the Innovation Network.

Figure 9 shows that three communication groups were isolated in this Innovation Network; these groups are quite different from those isolated for the Work Network (c.f., Figure 6). As with the Work Network, it is interesting to note how these groups fit into the formal organizational structure. Group P has nine persons and is found in Divisions One and Two of Company X. This innovation communication group does not extend to higher managerial levels.

Group Q has membership in all three divisions of Company X. As is obvious from Figure 9, however, this group is not exactly a random set of persons from each division of Company X. Indeed, the group is composed of only higher managerial personnel. Communication about new ideas, then, seems to be shared only with other supervisors at this level.

Communication Group R contains only three persons and is found in Division Three of Company X. We may also note from Figure 9 that there are two isolates in this network (15 and 16) and one liaison (14).

Before we undertake additional evaluation of the network we should consider the relationships among the communication groups. To do this we examine the intergroup connections, i.e., the bridge and liaison linkages. Figure 10 shows the bridge connections in the same manner as was done in Figure 7 for the Work Network. We immediately see that this network is much more connected than the Work Network. None of the groups are isolated; in fact, all of the groups have a good number of links. Group P has the most links (7), which is due in part to the fact that it has the most members. Group R has only three members, yet four bridge links; Group Q, with only four members, has five links.

The other type of intergroup connections is liaison links which have been depicted in Figure 11. We note that there are also a large number of liaison links with one liaison (14) connecting all three groups.

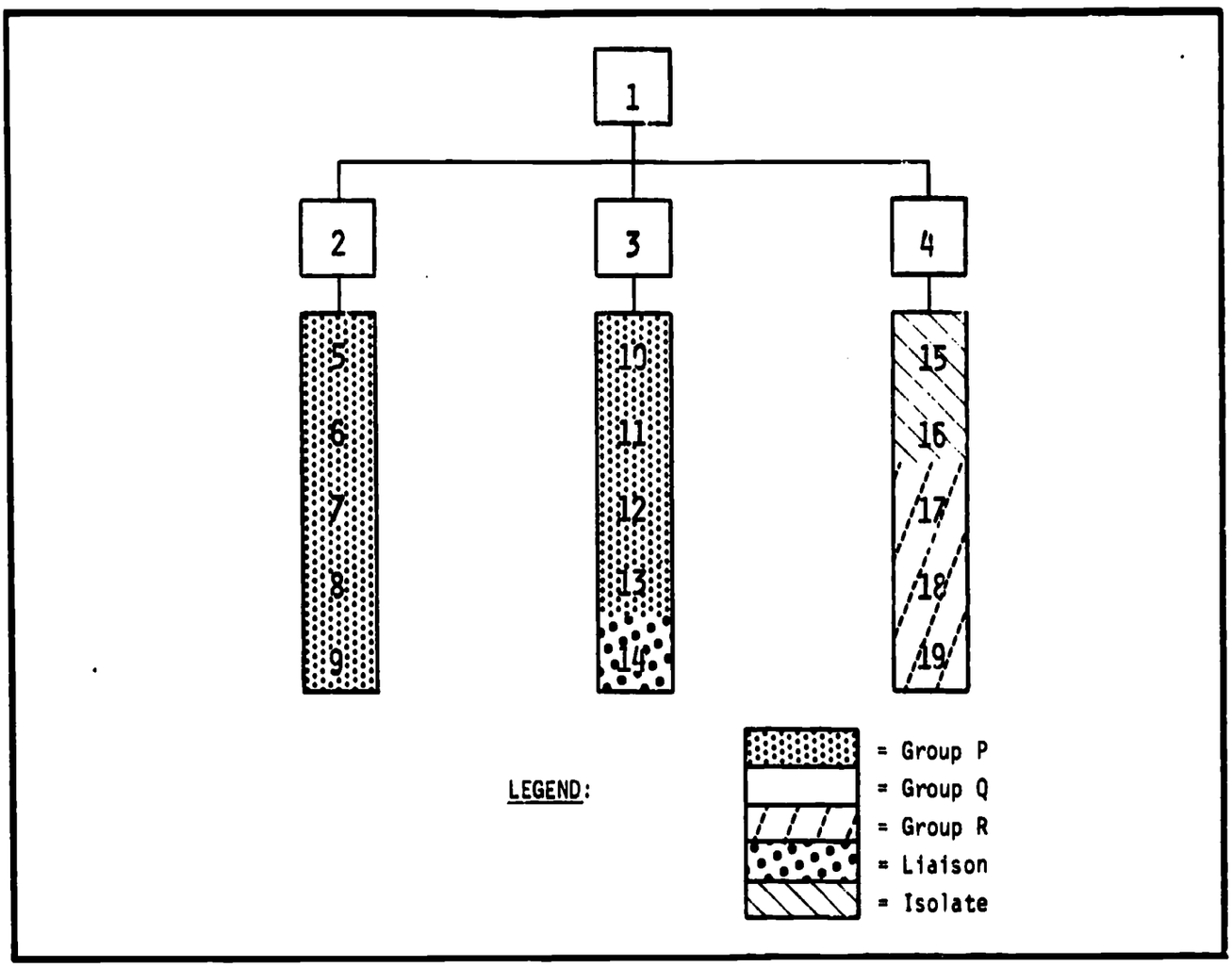


Figure 9. The three Communication Groups
of the Innovation Network within the organizational hierarchy

Comparison Between the Networks

Additional insight into the functioning of the organization is often provided when we compare various networks. Often, findings in one network may help to explain those in another, e.g., a trouble spot in one network may also appear as a problem area in another. For instance, from Figure 6, we noted that persons 14, 18, and 19 were all isolates. When we examine the Innovation Network we arrive at a possible explanation for their behavior in the Work Network. That is, they seem to be persons who are very active innovators and perhaps less important (communicationally) as workers.

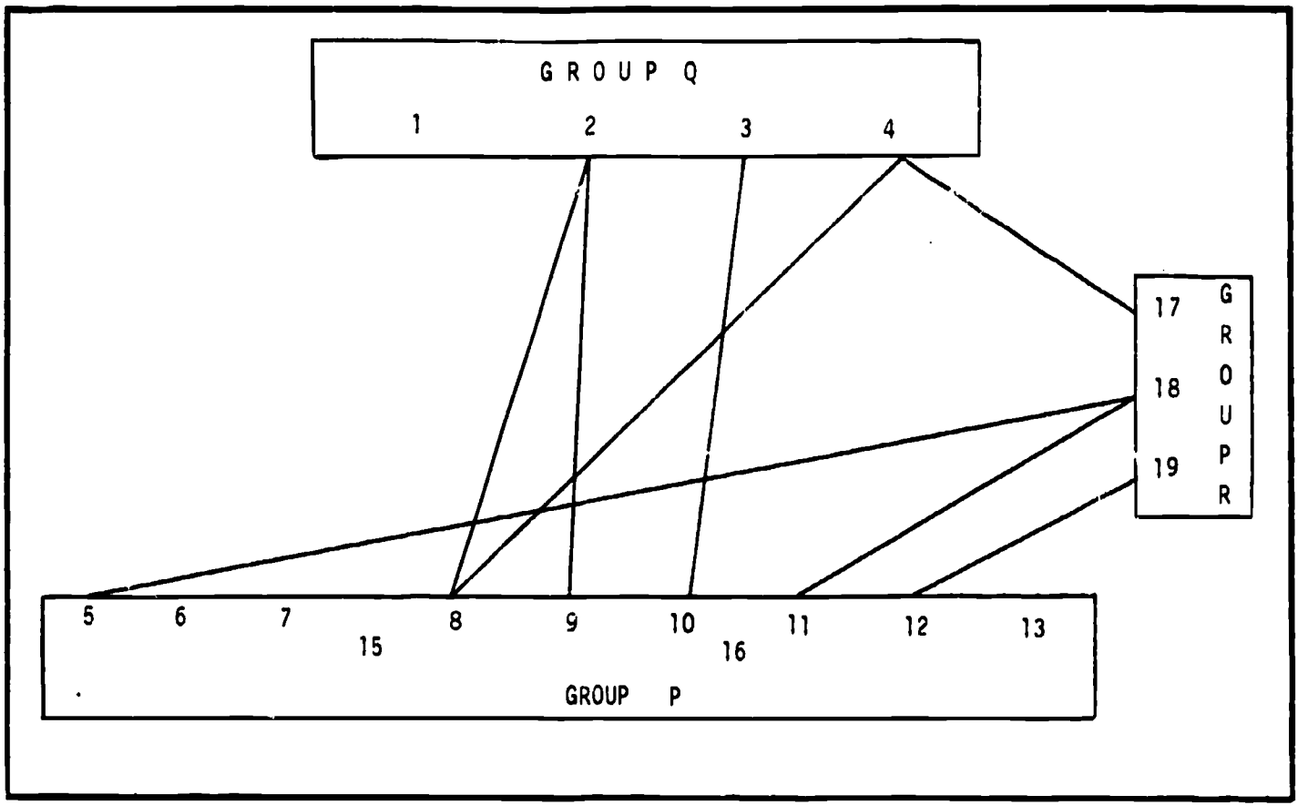


Figure 10. Bridge Connections among
the three Communication Groups of the Innovation Network

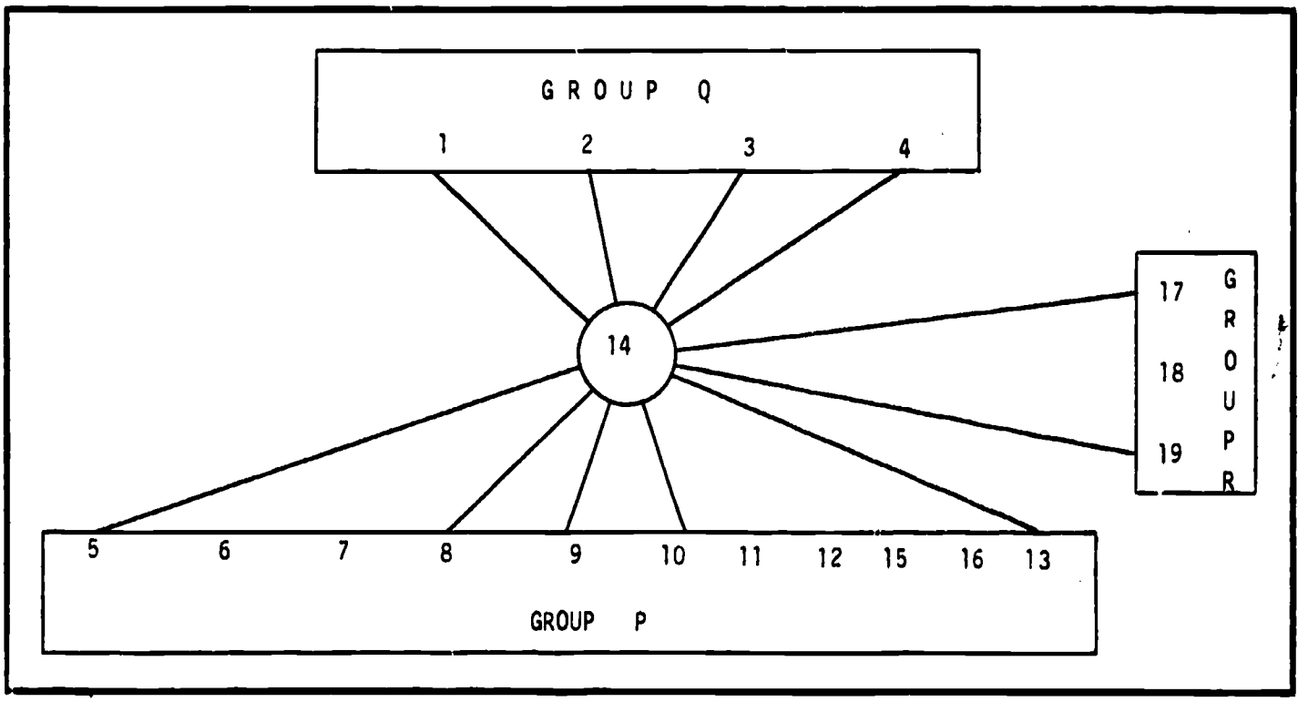


Figure 11. Liaison Connections Among the Three Communication Groups of the Innovation Network

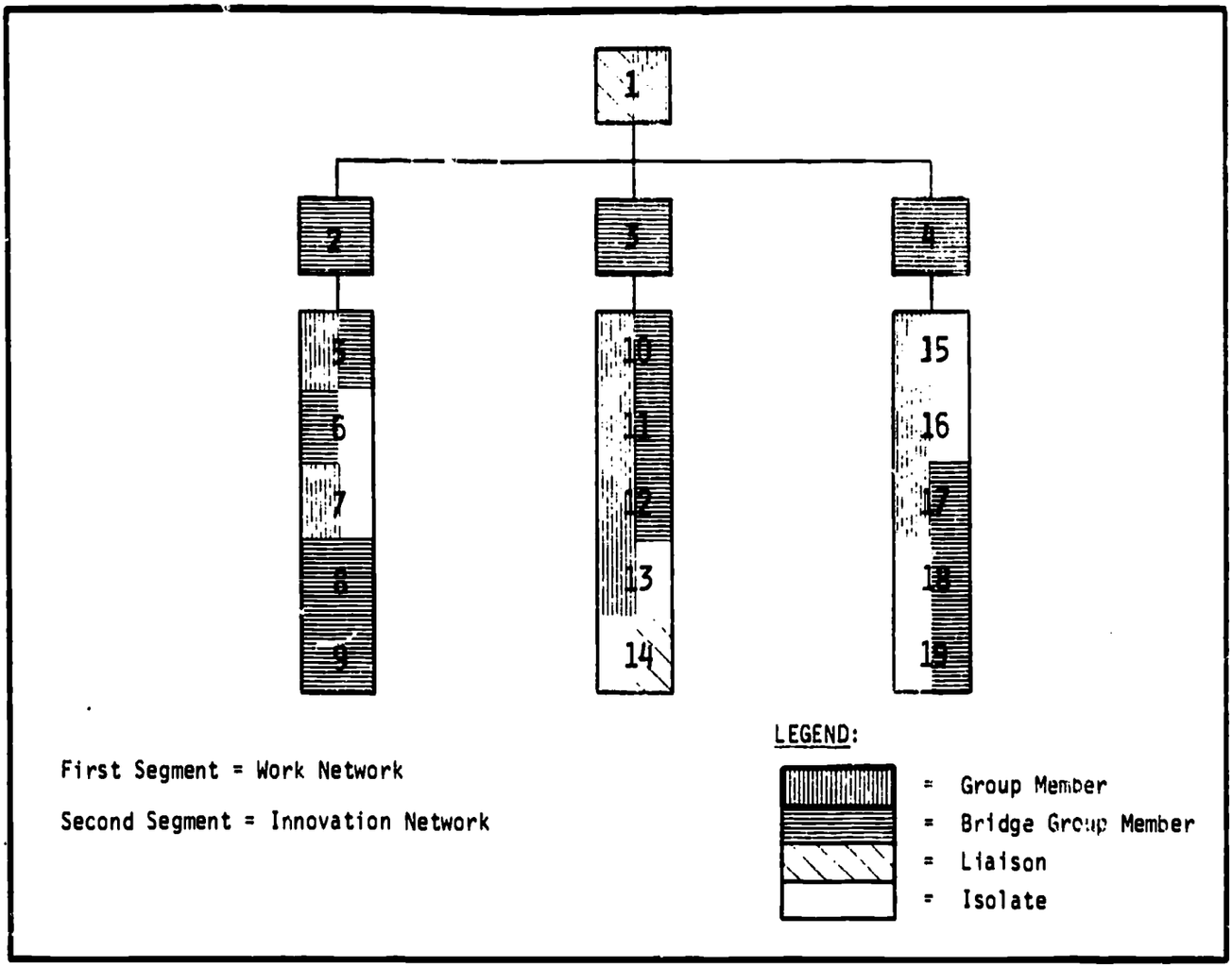


Figure 12. Relationships among individual memberships in the Work and Innovation Networks

Person 14 was seen as an isolate in the Work Network but we see from Figure 11 that Person 14 is an important liaison in the Innovation Network. Similarly, Persons 18 and 19 can be seen to be in a well-functioning communication group in the Innovation Network (Figure 10).

Also interesting is Person 1, who was the liaison of the Work Network. In the Innovation Network, however, we find that Person 1 is not a liaison, nor does he have any bridge contacts. His only inter-group link is a liaison contact. This might be interpreted to mean that "the boss" is more concerned with getting the job done than with dealing with new ideas.

A useful technique for comparing various network roles is illustrated in Figure 12. Each

person's hierarchical position has been divided into two segments (since there are two networks) and each segment has been coded according to the person's role in that network. The accompanying legend explains the coding scheme.

Examining Person 1's position shows that Person 1 is a liaison in the Work Network and a group member in the Innovation Network. Person 14, on the other hand, is an isolate in the Work Network and a liaison in the Innovation Network.

Comparing networks in this manner calls attention to individuals who fulfill broad-based communication roles or who are more limited in their network participation. A person who is an isolate in <u>all</u> networks, for instance, may have significant communication problems. Similarly, Persons 2, 3, 4, 8, and 9 "stand out" since they are bridges in both networks.

The network analysis techniques described so far provide data on two levels: first, the general adequacy of the overall organizational hierarchy; and secondly, an evaluation of specific groups within the hierarchy. A third level of information, to be discussed in the following chapter, deals with individuals.

CHAPTER 3

COMMUNICATION STRUCTURE:

THE METRICS OF NETWORK ANALYSIS

Much of the material presented in Chapter 3 is directly parallel to the graphic descriptions of the networks presented in Chapter 2. However, in this chapter we quantify various aspects of the networks as ratios or percentages. This allows greater precision in describing communication groups and individuals within the networks. It also permits communication networks to be studied in relation to other important organizational dimensions, e.g., productivity, climate, error rate, employee satisfaction, etc.

We use the term "metric" to refer to different quantifiable measures of communication network properties. We present two types of metrics. First, there are metrics which may be used to assess the communication groups; second, there are metrics which provide evaluations of individuals. Since the Work Network of Company X contained few bridge and liaison links, we will use the Innovation Network as an example of group metrics. In developing individual metrics we will utilize data and examples from both the Work and the Innovation Networks.

## Group Metrics

One of the first evaluations we may make of a communication group is a determination of its connectedness. This measure indicates the number of connections that exist among the members of a group. If a group has only a few "within-group" links it is said to be "loosely" connected, whereas a group with a large number of within-group links is said to be "tightly" connected. If everyone in a group had a link with everyone else, its group connectedness would be 100 percent. This measure is influenced by group size, since members of larger groups may find that it is more difficult to communicate with everyone else. Thus, we can see from Table 1 that the largest group also has the lowest group connectedness, i.e., Group P has a value of 63 percent. Similarly, we find a 100 percent connectedness for Group R; however, with only three members this is not surprising.

Group bridge linkage and group liaison linkage are both straightforward quantifications of Figures 10 and 11, respectively. These measures indicate the percentage of total bridge or liaison contacts that exist in a group. From Figure 11 we see that there are a total of sixteen bridge links. Group P possesses seven of these sixteen which accounts for 7/16 (44 percent) of the total. Group Q is involved with five (31 percent), and Group R is connected with four (25 percent).

Table 1

Summary Values for the Three Communication Groups of the Innovation Network

| Group | Number in Group | Connectedness | Group Bridge Linkage | Group Liaison Linkage |
|---|---|---|---|---|
| P | 9 | 63% | 44% | 45% |
| Q | 4 | 75 | 31 | 36 |
| R | 3 | 100 | 25 | 18 |
| | | | 100% | 100% |

Calculations for group liaison linkage proceed in exactly the same manner. There are 11 liaison links; Group P is involved with five links (46 percent), Group R with 18 percent of the links, and Group Q, 36 percent. Tables such as Table 1 are very useful for "ranking" different groups, especially when a large number of groups are present.

There are, of course, many ways by which a communication group may be described; consequently, the development of many types of network metrics is possible. We have presented several quantifications which are both straightforward and useful; however, at this point we would like to briefly mention two slightly more technical concepts. These are indirect links and dominance (sometimes called centrality).

The concept of indirect link provides a measure of communication "distance." For instance, an individual (let's call him Person 1) may not have a link to another person (say, Person 2), however, he may have a communication link to someone else (say, Person 3) who is linked to

Person 2. Thus for communication to flow from Person 1 to Person 2, it would likely pass through Person 3. The link from Person 1 to Person 2 is then an indirect link or more, precisely a two-step link. Obviously, a direct link is a one-step link. Similarly, indirect links may be three-step, four-step, or n-step. For a communication group, a matrix which presents the number of links necessary to connect any pair of individuals in the group could be given. We could then examine the maximum "distance" between any pair of group members or we could develop methods of quantifying "average distance."

With the concept of indirect links established, it is possible to make additional observations about the nature of the communication group (and for that matter about individuals). "Dominance" describes the degree to which communication in a group is centered around only one (or a few) of the persons in the group. A group with low dominance would be one in which a large ratio of people communicate directly with each other; therefore the ratio of direct to indirect links is quite high. In a group with high dominance communication is centered around one (or a few) person(s), yielding a low ratio of direct to indirect links, i.e., information in the group flows to others only through these dominant individuals.

Normally, the choice of how many and what types of metrics to use when undertaking the analysis of a large organization remains up to the particular investigator. The options available are enormous, thus the primary criterion for choosing a particular technique must involve a careful consideration of the purpose of the investigation.

## Individual Metrics

As has been pointed out earlier, if a network is large and/or richly connected, developing by hand a graphic display of every single connection for every person in the network is both cumbersome and impractical. However, it is possible to present data in tabular form for each individual, thus providing a basis for evaluation of individual communicators. In Table 2 we have provided a typical tabular summary for the Work Network of Company X. The information for the calculations can be taken from Figure 4.

Data in this table are arranged by communication group and then by person identification number, in ascending order. This number is entered in the first column. In the "Role" column the designation M is used for group member, B is used for bridge group member, L indicates liaison,

Table 2

Summary of Individua nunicators in the Work Network of Company X

| Person Number | Role | Group | LINKS Total | Within | Bridge | Liaison | Reciprocated | Unreciprocated | Unacknowledged | % Reciprocity | % Individual Connectedness | % Individual Bridge Linkage | % Individual Liaison Linkage | % Contribution to Group-Bridge Linkage | % Contribution to Group Liaison Linkage | % Contribution to Between Group Linkage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | B | A | 6 | 3 | 2 | 1 | 1 | 2 | 3 | 33 | 100 | 67 | 33 | 100 | 100 | 100 |
| 15 | M | A | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 67 | 0 | 0 | 0 | 0 | 0 |
| 16 | M | A | 3 | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| 17 | M | A | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 67 | 0 | 0 | 0 | 0 | 0 |
| 3 | B | B | 6 | 3 | 2 | 1 | 2 | 1 | 3 | 67 | 100 | 67 | 33 | 67 | 100 | 75 |
| 11 | M | B | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 67 | 0 | 0 | 0 | 0 | 0 |
| 12 | M | B | 3 | 3 | 0 | 0 | 1 | 0 | 2 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| 13 | M | B | 3 | 2 | 1 | 0 | 0 | 2 | 1 | 0 | 67 | 67 | 0 | 33 | 0 | 25 |
| 8 | B | C | 3 | 2 | 1 | 0 | 1 | 2 | 0 | 33 | 100 | 67 | 0 | 50 | 0 | 50 |
| 9 | B | C | 3 | 2 | 1 | 0 | 1 | 0 | 2 | 100 | 100 | 67 | 0 | 50 | 0 | 50 |
| 10 | M | C | 2 | 2 | 0 | 0 | 1 | 0 | 1 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| 2 | B | D | 6 | 3 | 2 | 1 | 2 | 4 | 0 | 33 | 100 | 67 | 33 | 67 | 100 | 75 |
| 5 | M | D | 3 | 3 | 0 | 0 | 1 | 1 | 1 | 50 | 100 | 0 | 0 | 0 | 0 | 0 |
| 6 | B | D | 4 | 3 | 1 | 0 | 3 | 0 | 1 | 100 | 100 | 50 | 0 | 33 | 0 | 25 |
| 7 | M | D | 3 | 3 | 0 | 0 | 2 | 0 | 1 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| LIAISON(S) | | | | | | | | | | | | | | | | |
| 1 | L | - | 3 | - | - | - | 3 | 0 | 0 | 100 | - | - | - | - | - | - |
| ISOLATES | | | | | | | | | | | | | | | | |
| 14 | I | - | 1 | - | - | - | 1 | 0 | 0 | 100 | - | - | - | - | - | - |
| 18 | I | - | 1 | - | - | - | 1 | 0 | 0 | 100 | - | - | - | - | - | - |
| 19 | I | - | 1 | - | - | - | 0 | 1 | 0 | 0 | - | - | - | - | - | - |

and I represents an isolate. The column entitled "Group" designates a person's group affiliation. Naturally, liaison's and isolates are not group members and will thus have no entry for "Group."

The next seven columns give two breakdowns for the type of communication links possessed by an individual. The first column indicates a person's total links. The next three, "Within," "Bridge," and "Liaison," describe the individual's internal and external links. The "Within" column indicates the number of contacts to members of an individual's own group and the "Bridge" column presents the number to members of other communication groups. The "Liaison" column shows the number of links a person has with liaisons. Person 4, for instance, has one liaison contact. If one wanted to know with which liaison this contact was, it is possible to refer to Figure 8 (or the appropriate computer print-out described later) where it could immediately be seen that it involves Liaison 1 (often, though not in this example, there are several liaisons in an organization). Similarly, if one wanted to know who Person 4's two bridge contacts were, he could consult Figure 7 and see that Persons 2 and 3 were involved. It can be seen that the number of within-group (internal) links, plus the number of bridge and liaison (external) links, add to equal the total number of links.

The last three columns under the "Links" section of Table 2 present the number of reciprocated, unreciprocated and "unacknowledged" links for a person. These should also add to equal the total number of links. A word is in order regarding the "unacknowledged" category. It is sometimes useful to know which person in an unreciprocated link reported the relationship (assuming symmetry). To do so, we subdivide the unreciprocated category: (1) those people who indicate a relationship are said to have an unreciprocated link, i.e., they list a relationship that the other person does not also list, and (2) those people who are indicated by another in a communication relationship are said to have an "unacknowledged" link, i.e., they are listed in a relationship which they do not list.

Reciprocity. A measure has been developed which enables identification of a person's perception of his communication contacts. Reciprocity is calculated by determining the percentage of the contacts a person mentions who also mention him. That is, reciprocity represents the percent of the links a person indicates which are reciprocated by those he mentions. For Person 4 it can be seen that 33 percent of the people he mentions also mention him. His reciprocity index is therefore 33 percent.

Individual Connectedness. This measure signifies how many links a person has within his own group. If there were 15 members in a group and a person had links with all of them, his connectedness would be 100 percent. This becomes obvious when we see that Person 4 has three within-group links. Since there are only three people in this group (besides Person 4), his connectedness must be 100 percent since he talks to all three.

Taking into account indirect links, we can develop a variation of the basic "connectedness" concept which provides a slightly different sort of information. This concept is called integration. Integration represents the number of persons with whom an individual is linked who are also connected to each other.

Individual Bridge Linkage. This measure must not be confused with Group Bridge Linkage. Individual Bridge Linkage indicates the percentage of a person's total contacts which are bridge contacts. There is qualification, however: the Individual Bridge Linkage measure represents the percentage of bridge contacts a person possesses of the total he could possess and still qualify as a group member. In the previous example, Person 4 had a total of six contacts. If all six were bridge links to other groups, he would certainly not qualify as a member of Group 1, since a person must have at least half of his contacts with people in a group in order to be a member of that group. Thus, a person with Bridge Linkage measure of 100 percent would have half of his contacts within a group and the remaining contacts would be with persons in other groups. In other words, he would have the highest percentage possible of his contacts to other groups and still remain a group member. On the other hand, a person with zero percent Bridge Linkage would have all of his contacts within his own group (and to liaisons and isolates).

Individual Liaison Linkage. Another measure of an individual's linkage to other groups is Individual Liaison Linkage and is obtained in a manner identical to Individual Bridge Linkage. The Individual Liaison Linkage measure indicates the proportion of a person's links that are to liaisons. Again, since a person could not have all of his links to liaisons and still be a group member, this quantity has been expressed as a percentage of the possible number of liaison links a person could have and still belong to a group. Thus, Individual Liaison Linkage, like Individual Bridge Linkage, can range from zero percent to 100 percent.

Contribution to Group Bridge Linkage. This measure signifies the percentage of bridge links which an individual provides to his communication group. If a person's communication group

has ten bridge links and one of them involved him, his contribution to Group Bridge Linkage would be one-tenth or 10 percent.

Contribution to Group Liaison Linkage. This calculation provides a measure of the proportion of the group's liaison contacts which are provided by each person. Thus, if a person's Contribution to Group Liaison Linkage were 50 percent, then one-half of all the liaison contacts to his group would involve him.

Contribution to Between Group Linkage. For this measure, bridge and liaison links have been combined for a group and a determination is made of the proportion of the total Between Group Linkage which is contributed by each individual. For example, if a group had five liaison links and five bridge links, then the total number of links for that group would be 10. If a person within this group provided three of the bridge links and two liaison links, his total contribution would amount to five of the group's ten contacts or 50 percent. This measure, then, combines Contribution to Group Bridge Linkage and Contribution to Group Liaison Linkage.

So far, Table 2 has been discussed as a means of analyzing and evaluating the total network characteristics of individuals. To do so, we read across a row for any given individual. A second useful approach to the table is to examine the columns for distinctively high or low values. For instance, considering the "Contribution to Between Group Linkage" column we see that in Group 1, Person 4 provides 100 percent (we may also note that Person 4 is the supervisor of this group). Interesting observations may be made when this value is highest for a person other than the designated supervisor.

Our discussion so far has centered on the Work Network. To complete our set of metrics for Company X, we would need to provide a Summary of Individual Communicators table for the Innovation Network. Thus, we would need a separate table for each network unless we chose to present the data in a combined format such as Table 3.

In Table 3, data are arranged by person, not by communication group. From this table we can see how a person performs in a number of communication networks. For instance, Person 1 is a liaison in the Work Network with a reciprocity of 100 percent. In the Innovation Network, however, he is a group member with a reciprocity of 50 percent. Person 18, on the other hand, can be seen to be an isolate in the Work Network. In the Innovation Network, however, he is a group member with fairly high individual metric values.

Table 3

Combined Individual Profiles for Both Networks of Company X

| Network | Role | Group | LINKS Total | Within | Bridge | Liaison | Reciprocated | Unreciprocated | Unacknowledged | % Reciprocity | % Individual Connectedness | % Individual Bridge Linkage | % Individual Liaison Linkage | % Contribution to Group Bridge Linkage | % Contribution to Group Liaison Linkage | % Contribution to Between Group Linkage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PERSON 1 | | | | | | | | | | | | | | | |
| W | L | - | 3 | - | - | - | 3 | 0 | 0 | 100 | - | - | - | - | - | - |
| IN | M | Q | 4 | 3 | 0 | 1 | 2 | 2 | 0 | 50 | 100 | 0 | 50 | 0 | 25 | 10 |
| | PERSON 2 | | | | | | | | | | | | | | | |
| W | B | D | 6 | 3 | 2 | 1 | 2 | 4 | 0 | 33 | 100 | 67 | 33 | 67 | 100 | 75 |
| IN | M | Q | 6 | 3 | 2 | 1 | 3 | 0 | 3 | 100 | 100 | 67 | 33 | 33 | 25 | 30 |
| . | | | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | | | |
| | PERSON 14 | | | | | | | | | | | | | | | |
| W | I | - | 1 | - | - | - | 0 | 1 | 0 | 0 | - | - | - | - | - | - |
| IN | L | - | 10 | - | - | - | 7 | 1 | 2 | 88 | - | - | - | - | - | - |
| . | | | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | | | | |
| | PERSON 18 | | | | | | | | | | | | | | | |
| W | I | - | 1 | - | - | - | 1 | 0 | 0 | 100 | - | - | - | - | - | - |
| IN | B | R | 4 | 2 | 2 | 0 | 3 | 1 | 0 | 75 | 100 | 100 | 0 | 50 | 0 | 33 |
| | PERSON 19 | | | | | | | | | | | | | | | |
| W | I | - | 1 | - | - | - | 0 | 1 | 0 | 0 | - | - | - | - | - | - |
| IN | B | R | 4 | 2 | 1 | 1 | 1 | 2 | 1 | 25 | 100 | 50 | 50 | 25 | 50 | 33 |

The advantages of comparing several networks were discussed in Chapter 2 (increased perspective, confirming trouble areas, etc.). One drawback, however, is that we lose the ability to easily locate high values within groups since the order by groups has been removed. The decision to use one form of information display or the other would depend upon whether group information or individual information was most important. The format of Table 3 is more useful for individual information, while Table 2 is more helpful in finding relationships within groups.

In certain instances, highly specific information concerning particular individuals within an organizational hierarchy may be desirable, e.g., the organization may wish to consider the communication performance of its high-level supervisors. Additionally desirable would be to compare the performance of these individuals within different communication networks. To make such specific evaluations we may examine explicitly who communicates with whom; this information is readily available. To merely examine, however, with whom each person communicates would be to examine a tremendous amount of raw data. We have developed, therefore, a method which summarizes this information and provides the desired "between-network" comparison.

To present this information we make one drawing for each person being considered; these drawings are merely the organizational hierarchy with certain codings provided. We compile these drawings to create an "individual communicator's portfolio."

To begin, the person whose communication contacts are under consideration is coded; for our example we use diagonal lines. Next, all other individuals' positions within the hierarchy are divided into segments corresponding to the number of networks being considered. For the example under consideration we considered two networks and thus every number in the organizational hierarchy is divided into two segments (see Figure 13). We then code each segment corresponding to whether the person under consideration has a communication link or not.

Figure 13 has been prepared to show the communication links of Person 1. From this figure we see that Person 1 (diagonal lines) has links to Persons 2, 3, and 4 in the Work Network, but he has links with only Persons 2 and 3 in the Innovation Network. We see that Person 1 has no contacts in either network with persons below the level of supervisor. Drawings similar to this could be drawn for Persons 2, 3, and 4 if Company X were evaluating its supervisory staff.

This chapter has shown a number of methods which allow quantification of network structure, whereas Chapters 1 and 2 discussed the identification and assessment of communication

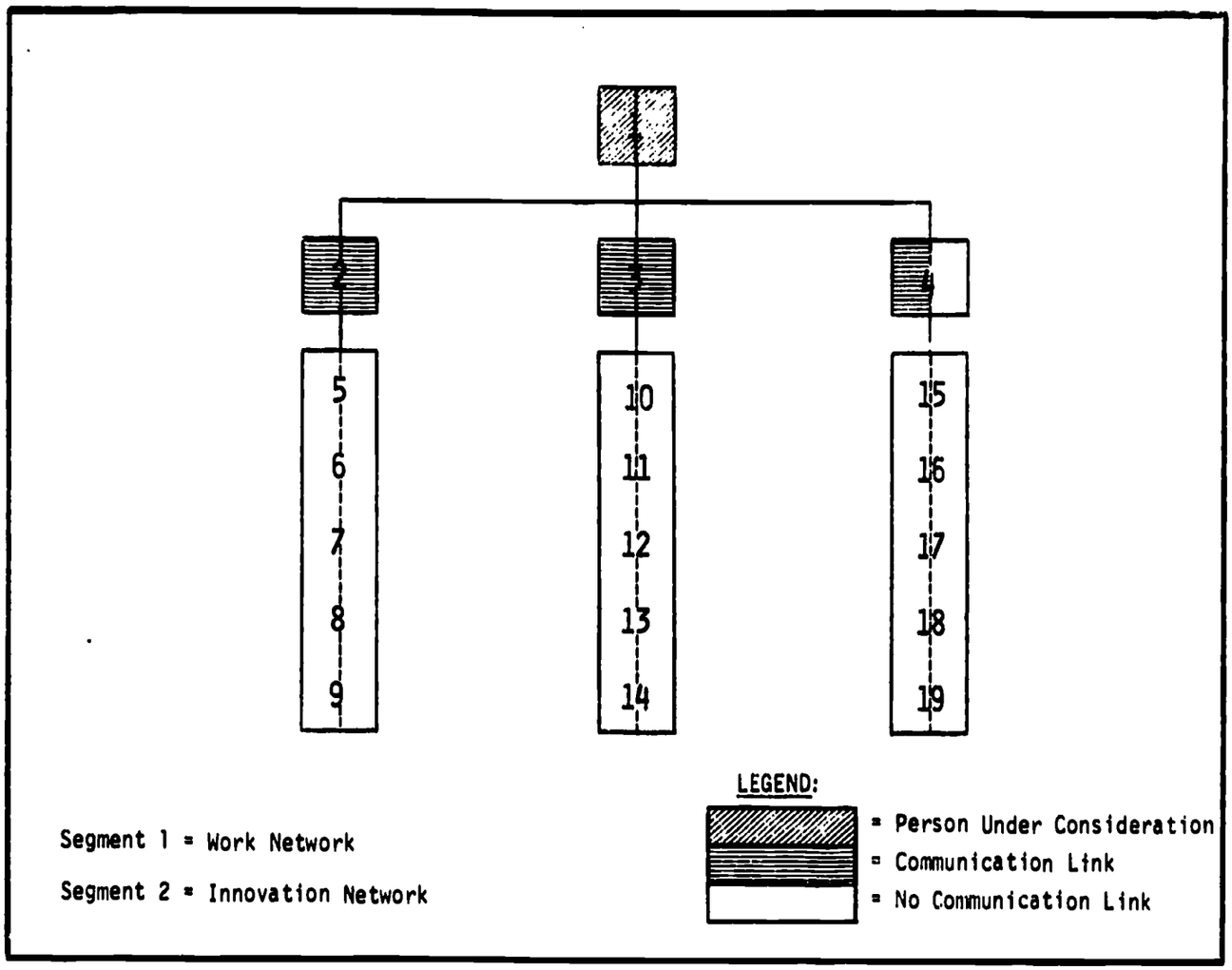


Figure 13. Individual profile for Person 1 showing communication links in the Work and the Innovation Networks

networks. The remaining chapter will present practical information useful in accessing and utilizing current computer software for analyzing large scale networks.

## CHAPTER 4

## PRAGMATICS OF A LARGE-SCALE NETWORK ANALYSIS

We have seen that the analysis of communication networks within an organization may provide managers and officers with extremely useful information. Why, then, is network analysis not in wider use as a standard management tool? The answer resides, we believe, in the fact that when the size of the group to be analyzed gets very large (say, above 25-50 people) the analytic technique becomes difficult for the expert and nearly impossible for the novice. This is true because as the number of persons to be analyzed increases, visual intuitive techniques become prohibitively complex and the number of mathematical calculations required, though relatively simple, becomes exceedingly large.

The calculation difficulties imposed by group size has led several social scientists to attempt to computerize the procedure. Previous attempts to do so, however, have all suffered from one or another of several difficulties. Some have been limited in their capacity to groups no larger than 100 people. Several have identified communication groups but provided no additional information on important aspects of communication structure or metrics. Few, if any, used rigorously defined criteria for performing the analysis: Almost none provided for flexibility in analysis by providing the user with power to select among alternative criteria to be used in the analysis.

During the past several years a research program conducted at Michigan State University under the direction of Dr. Richard V. Farace has taken as part of its goal the development of computer software that would overcome each of these problems. The result of those efforts is a highly sophisticated and efficient computer program entitled "Negopy," written by William D. Richards. It is the purpose of this chapter to briefly describe in non-technical terms the three aspects necessary for utilizing the program: input, parameters, and output. More formal program documentation is available in Richards.*

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*Richards, William D. Network analysis in large complex organizations: The network analysis program--Version 3.2. (Stanford, Calif.: Institute for Communication Research, 1973.)

Input to the program is extremely simple. Data are gathered from a network questionnaire in which a person indicates every other person with whom he communicates; they are then punched on computer cards. This requires identification numbers for the respondent and for each person he talks with. It also requires a code to indicate frequency of contact. Additionally, it is possible to add a second code to represent another dimension of the contact such as "importance" provided, of course, that these data were obtained in the questionnaire. Computer cards are prepared in similar manner for all persons in the network.

The program has many options and is designed for a sophisticated user. Those with less sophistication, however, can still use it effectively because many of the program control values (parameters) are pre-set unless the investigator chooses alternative values. The parameters discussed here are particularly critical and should be carefully thought through by the investigator prior to using the analysis technique.

Frequency of Contact. If the network questionnaire provided a respondent with a scale indicating a wide frequency of contacts (say, several times a day to once a month), the data will obviously reflect a network of wide variation in contact. It may be desirable, however, to restrict the analysis to a more limited frequency (say, daily or more often). This parameter permits the user to choose any subset of frequency(ies) that he wishes to analyze. This, of course, implies that any given network may be re-examined at any or all of the frequencies originally provided in the questionnaire.

Strength of Contact. If the user has gathered data from respondents about a dimension of their contacts such as importance, it is possible to use these data as a weighting factor in determining the networks' strength of links among participants in the study. This enables the analyzer to provide a degree of parity between different contacts that would otherwise be impossible, as for example in the difference between infrequent, though important contacts and frequent but unimportant ones.

Reciprocity. In Chapter 1 we described the difference between reciprocated and unreciprocated links. This option permits the user to determine whether unreciprocated links are to be deleted or converted to reciprocated links.

Group Criterion Percentage. This parameter determines the value to be used in determining whether a person qualifies for membership in a communication group, i.e., whether a person has some

criterion percentage of his links (typically 50 to 51 percent) with people who also share at least that percentage of their links with each other. Though the standard value of this parameter is preset at 50 percent, there are circumstances under which the user may wish to adjust this value, say to 49 percent or 51 percent or to even much more extreme values.

Maximum Step Length. One of the structural measures produced by the program is "connectiveness" which indicates the overall amount of direct and indirect contacts among people in the network. The program requires that the maximum indirect path length to be analyzed among people in the network be set--the standard value is 10, meaning that indirect path lengths of two through ten steps will be used in calculating group connectiveness. The user may lower this value to meet his needs. A lower setting of this parameter will allow only more tightly-knit groups to be located.

The program produces an extensive output, any part of which may be suppressed by the user if it is undesired. Initially, the program provides a listing of each person in the network, all contacts reported, the frequency of contact with each, and, if included in the questionnaire, any contact weighting data such as "importance." Each contact is identified as reciprocated, unreciprocated, or unacknowledged by the other person. As a summary measure, a table is provided which indicates the percentage of reciprocated and unreciprocated contacts for the entire network.

The printout clearly identifies the communication network. First, each group and its group members are listed. Next, for each group, the number of 2-step, 3-step, and up to n-step paths is identified and the maximum level of connectedness for the group is specified. The number of steps between each person in the group and any other member is summarized in a distance matrix.

The next section of the printout is a link analysis. For each individual, a within-group summary indicates the number and strength of reciprocated, unreciprocated, and unacknowledged links within his group, of links to other groups, to liaisons, and to others. A measure of integrativeness is provided. After each person in a group is described, the analysis is repeated for the group as a whole. For the group, connectedness values to other groups are provided.

The final section of the printout provides lists of all non-group members: isolates, others, and liaisons as well as a summary table of each of these categories. The final information contains a listing of each person in the network, identifying their final classification as group member, liaison, isolate, etc., and providing the measure of integrativeness.

## SUMMARY

In this report we have attempted to provide a non-technical overview of network analysis for people who might find the technique very useful in managing large organizations. We began by describing and illustrating the basic concepts of network analysis, essentially providing a vocabulary for talking about the process. We then described some comparative techniques for evaluating network data: overlaying the actual network on the organization chart, superimposing different networks on the same hierarchy, etc. In the third chapter we identified several important network metrics, what we called communication structure variables, and showed how they could be used to describe important aspects of communication in an organization. Finally, we provided information to enable a reader to access and utilize existing computer software for undertaking large-scale analyses.

## POSTSCRIPT: FOR FURTHER INFORMATION

For readers interested in additional information the following suggestions are provided. Those interested in accessing and using these techniques are advised to contact:

Dr. Richard V. Farace
Department of Communication
Michigan State University
E. Lansing, Michigan 48823

Those wishing additional information regarding the logic, technical details, and programming should contact:

Mr. William D. Richards
Institute for Communication Research
Stanford University
Stanford, California 94305

Regarding the procedures involved in network and structural analysis described in this report and for general information regarding Negopy, readers should contact the authors.

APPENDIX A

COMMUNICATION CONTACT QUESTIONNAIRE

One of the problems that people often experience is getting information quickly and efficiently from one place to another. Sometimes serious work problems occur because the right information doesn't get to the right place when it is needed. This questionnaire is designed to help diagnose such communication problems; it will enable us to make a "roadmap" of the paths which information can take when traveling from one place to another. With the data we will be able to locate bottlenecks and isolation points where communication problems might occur.

The questionnaire is quite simple and shouldn't take you any more than ten minutes to complete. All we want you to do is to think about <u>every</u> person in this organization and decide how frequently you communicate with them about two different general topics of communication. To make this easy for you, we have listed the names of all 98 members of the department in alphabetical order. Next to each name there are two blank lines, one for each of the two topics of communication. On <u>each</u> line you should place <u>one</u> number that indicates how frequently you communicate about that topic with that person. The numbers that you should use are as follows:

1 - We almost never communicate

2 - We communicate once or twice a month

3 - We communicate once or twice a week

4 - We communicate almost every day

5 - We communicate several times a day

Now that you know what numbers to use, let us explain what we mean by the word "communicate." You are communicating whenever you are exchanging ideas, discussing a topic, sending information, receiving information showing how to do something, etc., with another person. All of this may be done by:

1 - talking to a person face to face (either alone or in a group),

2 - writing a memo or communication to someone

3 - conversing with a person on a phone, and

4 - reading a memo or communication written for you to read.

People on the job talk about an endless variety of communication topics. We have chosen to organize these various topics into general categories. The first is ESSENTIAL COMMUNICATION and the other is INCIDENTAL COMMUNICATION.

(1) ESSENTIAL COMMUNICATION is everything that you say and write to another person or hear and read from that person which is necessary for you to complete your job. This would include such things as the processing of routine work matters, dealing with special problems in getting work out, discussing new ideas and new ways of doing things, settling personnel problems such as arguments and disagreements, etc.

(2) INCIDENTAL COMMUNICATION refers to all other communication with this person while you are at this organization. Topics might be discussed during lunch, breaks, or any other time on the job. Conversation might include such things as news events, politics, sports, vacation plans, things happening at home, etc.

Here is an example of how to proceed: Imagine that the first two people on the list are Susan Appleton and Jim Ashby. Suppose that you talk to Susan almost every day about work but almost never discuss other matters with her. You and Jim, on the other hand, don't really work together so you talk only once or twice a month about work topics essential to your job, but you do talk several times a day about sports and politics. You would mark the sheet this way:

| | ESSENTIAL COMMUNICATION | INCIDENTAL COMMUNICATION |
|---|---|---|
| Susan Appleton | 4 | 1 |
| Jim Ashby | 2 | 5 |

In addition to the examples above, it is possible for you to have either a high or low volume of both types of communication with another person. Remember, each person's name needs <u>one</u> mark in each space. To help you remember the scale, we have placed it on top of each page. If the frequency that you spend talking to a person varies a lot from day to day, just think back over the past couple of months and try to decide how much you communicate on a "typical" or "average" day. As you proceed through the questionnaire, try to take as much care and effort with the names at the end of the alphabet as you give to those at the beginning. Be sure that you put your name on the top of <u>each</u> page.

# COMMUNICATION CONTACT QUESTIONNAIRE

Your Name _____

Frequency of contact:

1 - We almost never communicate
2 - We communicate once or twice a month
3 - We communicate once or twice a week
4 - We communicate almost daily
5 - We communicate several times a day

| | ESSENTIAL COMMUNICATION | INCIDENTAL COMMUNICATION |
|---|---|---|
| Person 1 | ____ | ____ |
| Person 2 | ____ | ____ |
| Person 3 | ____ | ____ |
| Person 4 | ____ | ____ |
| Person 5 | ____ | ____ |
| Person 6 | ____ | ____ |
| Person 7 | ____ | ____ |
| Person 8 | ____ | ____ |
| Person 9 | ____ | ____ |
| Person 10 | ____ | ____ |
| Person 11 | ____ | ____ |
| Person 12 | ____ | ____ |
| Person 13 | ____ | ____ |
| Person 14 | ____ | ____ |