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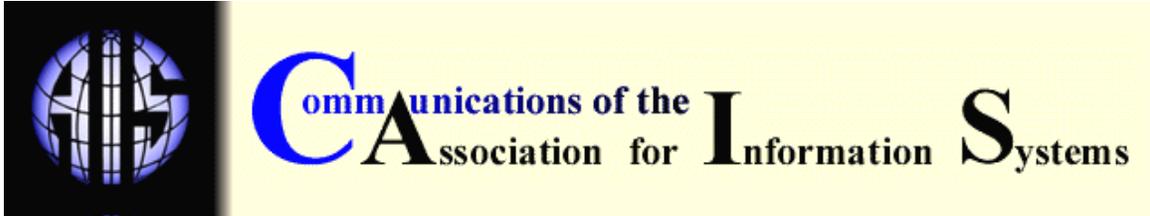*University of Reunion*

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LIFTING THE VEIL ON ORGANIZATIONAL STRUCTURE: A SOCIAL NETWORK ANALYSIS OF PROFESSIONAL E-MAIL USE

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ABSTRACT

This study is about the structure embedded in e-mail relationships. Based on data describing organizational e-mail exchanges, this research deals with organizational structure, personal power, and the centrality of people in a network. Social network analysis is used to study the centralization dimension of the structure embedded in the data. The data concerns 385 employees of 36 firms within a group. Our empirical study first explores several possible assessments of power and centrality concepts; then, it tests a causal relationship between personal and organizational attributes of power and centrality indexes. Results show the relationships between personal characteristics, aspects of organizational power, and e-mail network centrality. A discussion of the way managers may use electronic communication data to better interpret the nature and the dynamic of the organizational structure concludes the article.

Keywords: Structure, Power, Centrality, Social Network Analysis, IT use, Electronic Mail, Structural Equation Modeling.

I. INTRODUCTION

In a context of competitive pressure, the importance of designing organizational capacity for handling information processing requirements has been recognized [Wang, 2003]. While Information Systems (IS) and Technologies (IT) investments are growing rapidly to fill the need for this capacity, an important management question is their effect on the organizational structure and performance [Barua, et al., 1995]. Information technologies are thought to enable decentralization of control and decision-taking by facilitating the dissemination and sharing of information throughout the firm. Complex structures imply more elaborate coordination, control, and communication mechanisms that in turn require more information technology [Bergeron, et al., 2001]] E-mail is one of these technologies and is used to improve organizational coordination and communication. Telecommunication use is closely linked to organizational structure and culture [Rowe and Struck, 1995; Rowe, 1998]. However, unlike workflow technology, it is a versatile technology that does not limit the communication flow between 'actors' (where 'actor' designates a participating member of the organization). Thus, the study of such communication tools may reveal a different structure to the one embedded in the organizational chart. The study of this structure embedded in e-mail relationships is the object of this work. Based on the data

describing organizational e-mail exchanges, this research deals with organizational structure, personal power, and actors' centrality in a network. Social Network Analysis (SNA) is used to study the social relationships embedded in these data. The aim is to discover the way an individual's characteristics and aspects of organizational power may influence actors' centrality in the e-mail network. More precisely, the aim of this paper is:

- to compute centrality indexes related to Social Network Analysis

- to test the relationships between the individual and aspects of organizational power and the network centrality indexes

To do so, the first part of this work describes some conceptual aspects. A section is dedicated to the structure and the information processing view of the organization. Another section deals with power and centrality in Social Network Analysis. The second part describes an empirical test of this hypothesis. Data comes from 385 employees, the email users within a group, and from its staff file. A Structural Equations Modeling (SEM) method is used to test the influence of personal and organizational attributes on indexes of network centrality. Results are discussed and guidelines for future research are described in the conclusion.

II. STRUCTURE, POWER AND CENTRALITY

STRUCTURE AND INFORMATION

"The beginning of administrative wisdom is the awareness that there is no one optimum type of management system," [Burns and Stalker, 1961]. One of the most influential theories in organizational structure literature is the contingency approach. Originally developed by Woodward, Burns and Stalker, this approach considers that many different organizational structures may be adopted to reach a high level of performance. There is no "one best way", one best organizational structure, but different structures which may be used to better fit organizational needs. Thus, the structure is dependent on the organization. In the field of strategy, researchers have looked at the contingency effects of the relationships between the firm's environment, strategy, structure, and information systems [Bergeron, et al., 2001].

The structure of a firm is a complex set of goals, functions, and relationships among units that allow an organization to react effectively to market demands. Factors such as technology, environmental uncertainty, and strategy may affect the organizational structure [Woodward, 1958; Lawrence and Lorsch, 1973; Galbraith, 1973]. The information processing (IP) view of the organization [Galbraith, 1973, 1977] combines the decision-making process view of it [Simon, 1983] with the contingency approach. It considers that organizational information needs vary according to technological, environmental, strategic, and structural contexts. These areas differ in their dynamism, complexity or uncertainty, and the related decisions need differing amounts of information. However, according to the bounded rationality approach, information processing capacity is bounded [Simon, 1983]. Thus, according to the IP view, a high level of organizational performance can be reached when information processing capacity fits information processing requirements. Although organizational performance measures and concepts of fit are somewhat problematic, several models and methodologies may be used in the measurement assessment [Bergeron, et al., 2001; Raymond L., 2002; Seddon, 1997].

From a global point of view, organizational structure is dependent upon the level of coordination, formalization and specialization of organizational tasks [Bergeron, et al., 2001]. Two prominent structural dimensions of organizations are centralization and formalization [Rapert and Wren, 1998]. Formalization indicates "the extent to which an organization uses rules and procedures to prescribe behavior". This definition is close to that of the standardization concept [Mintzberg, 1982; Kalika, 1995]. Centralization represents "the degree to which the right to make decisions and evaluate activities is concentrated" [Fredrickson, 1986].

The purpose of this paper is to better interpret the centralization dimension by applying SNA to e-mail use. In the IP view of the organization, centralization is related to the information flow and the way it is concentrated. In human interactions, SNA measures the way human relationships are concentrated. These relationships build a network where actors' positions condition their power. The assumption of this paper is that e-mail supports human interactions. The idea is to use the centrality measures of the SNA in the e-mail context to better interpret the relationships embedded in this network. To do so, two main concepts need to be described: Power and Centrality.

POWER CONCEPTS AND ASSESSMENTS

IS researchers have had difficulty defining and measuring the theoretical concept of power [Jasperson, et al., 2002]. Several academic disciplines have studied this concept using a variety of approaches. These interdisciplinary aspects provide a useful perspective, but also bring more difficulties. "The concept of power is as ancient and ubiquitous as any that social theory can boast" [Dahl, 1957].

What is power and how can it be assessed? Several definitions of power have been proposed, focusing either on the characteristics of a "powerful actor" or on the relationship between "powerful actors" and others. Most studies of power have focused on hierarchical power, the power of supervisors over subordinates. Dahl for example defined power as the relations between actors [1957]. The power of an actor A is his capacity to get another actor B to do something that B would not otherwise have done. Similar definitions have been given by authors such as Emerson [1962] or Salancik and Pfeffer [cited by Pfeffer, 1981], for whom power is "the ability of those who possess power to bring about the outcomes they desire" [Salancik and Pfeffer, 1977]. However, power is not only hierarchical. According to Crozier and Friedberg [1977], power is multiform and one can define the common denominator as the possibility for a person or a group to have an effect on other people or groups. The definition is deliberately simple in order to focus on the main aspect: the relational characteristic of power. More precisely, power can only spread through exchange between actors engaged in a relationship, which is to say through negotiation.

In a complex organization, the subunits are not equally powerful [Pfeffer, 1981]. Therefore, power is also "a structural phenomenon, created by the division of labor and departmentalization that characterize the specific organization or set of organizations being investigated." However, from an organizational point of view, power can be used in the coordination of organizational activities. According to Mintzberg [1982], coordination is the main feature of organizational structure. Coordination is based on organizational rules and processes that are neither fixed nor imposed by executives. Behind the organizational charts and official rules, a set of tacit and social interactions regulates employee activities. This underground structure embedded in social interactions may affect individual power and organizational efficiency.

Although many definitions of power can be used, it is largely agreed that power characterizes relationships among social actors. As Pfeffer said, "a person is not "powerful" or "powerless" in general, but only with respect to other social actors in a specific social relationship" [1981]. Different power approaches are summarized in Table 1.

The assessment of power requires "the ability to know what would have happened without the intrusion of the power holder" [Pfeffer, 1981]. Power assessment is therefore difficult because it requires the measurement of to what extent an actor manages to influence the behavior of others.

However, several authors have proposed some possible power assessments. Pfeffer's proposition can guide our reflection. He argued that power can be assessed by its determinants, by its consequences, by its symbols, or by reputation indicators [Pfeffer, 1981]. Let us examine these four possibilities.

Assessing power by its determinants implies knowing the causes of power. An actor's power is therefore measured by the number of causes possessed [Pfeffer, 1981].

Table 1: Power Conceptualizations
[adapted from [Jasperson et al., 2002, p.400]].

Power as Authority	Hierarchical power, institutional power, organizational power, rational power.
Power as Centralization, Decision rights, participation in decision making	Disciplinary power, rational power, resource control, sovereign power, systems/structural power, zero sum power.
Power as Influence	Behavioral power, interpretive power, network centrality.

Assessing power by its consequences implies knowing, in contested decisions within organizations, which actor benefits and to what extent. The example given by Pfeffer to illustrate this idea is the budget distribution among subunits [1981]. In our case, we must be able to identify which resources or decisions are likely to be determined on the basis of power in an organization. A relevant one is salary, which one can consider as individual budget distribution. Salary is a scarce resource and is usually a source of conflict; we can consider it as a consequence of power. Moreover, the status position of the employee (from the higher status of Director to the lower status of employee) is an indicator of hierarchical power. In this context, the powerful actor will be the one with the higher salary and higher status.

Concerning the assessment of power by its symbols, the idea here is to assess power through the use of symbols of power. Examples given by Pfeffer are titles, special parking places, automobiles, and so on [1981]. In our case, the status position of the employee mentioned above, communication tools such as a cellular telephone or an individual phone number can all be considered as symbols of power.

Concerning the reputation indicators of organizational power, the idea is to ask people who the powerful actor is. However, this method may have several biases [See Pfeffer, 1981, p.55 for details.]

Pfeffer's power assessments describe relevant items to measure the actors' level of organizational power. Organizational status, salary level, telephone number, and cellular phone are registered in the management files. They have been chosen to assess the organizational power of an actor in this study.

Jasperson et al. have described an interesting study of power in the area of information technology research [Jasperson et al., 2002]. They studied 82 articles which concerned power. Their study shows that more than a quarter of the 82 articles defined power as the ability to influence. This observation is in accordance with the idea of power as a relationship. In this study, the relationships between actors will be assessed through e-mail exchanges. In SNA literature, the structure of the relationship conditions actors' power, and those placed centrally in a network should be more powerful than others. Is it true in the e-mail context? To test this hypothesis, SNA centrality measures need to be described.

CENTRALITY FROM A SOCIAL NETWORK PERSPECTIVE

In his description of managerial work, Mintzberg [1975] considered that "managers are vested with formal authority over an organizational unit. From formal authority comes status, which leads to various interpersonal relations, and from these comes access to information. Information, in turn, enables the manager to make decisions and strategies for the unit" [Mintzberg, 1975]. Managerial work integrates different roles, resulting from formal authority and organizational

power. He identified ten roles: three which are interpersonal, three informational, and four decisional. Among these roles, four focus on information processing. In their liaison role, managers link people from the vertical chain of command to people outside their units. In their monitoring role, they perpetually scan the environment for information, questioning liaison contacts and subordinates, and receiving unsolicited information, much of it as a result of the network of personal contacts. In the disseminator role, the manager passes some privileged information directly to subordinates, who would otherwise have no access to it. In the spokesperson role, the manager sends some information to people outside the unit, to the influential people who control the organizational unit. As a result, processing information is a key part of the manager's job and, in large part, communication *is* their work [Mintzberg, 1975]. These roles describe managers as informational brokers and reveal their centrality in the organizational information processing. SNA can be used to assess this centrality.

The social network perspective

SNA is an unusual way to interpret organizational phenomenon and management issues, particularly in the Information Systems domain [Cucchi, C., 2004]. Although it has existed for a long time [Tichy, et al., 1979], three main reasons have usually been cited to explain why it is so rarely used in the organizational area:[1] an incomplete conceptual framework, [2] specialization of academic disciplines and [3] methodological constraints in considering a large data set [Tichy, 1981].

SNA describes a society as a system of participants – individuals, groups, organizations – linked by a variety of relations. Several kinds of link may [or may not] link each pair of participants [Tichy, 1981]. A social network is a collection of nodes [people, organizations] linked by a collection of social relations [friendships, payments, etc.] [Laumann, et al., 1978]. Network analysis describes the structure and the configuration of these relations. It attempts to identify their causes and consequences [Tichy, 1981; Laumann and Pappi, 1976; Nohria, 1992]. From a social network perspective, actors interact socially with each other. This perspective focuses on these interactions (between individuals in groups, among groups within an organization, among groups and individuals performing roles in different organizations, and so on) and allows a better description and understanding of organizational activities [Lamb and Kling, 2003]. Thus, it allows one to take into account both kinds of characteristics: the social actor ones [relative to other actors] and the relational ones which tie each actor to the whole network. Of these, the one that is of interest is an actor's centrality.

Centrality Concepts and assessments

The usual concept of centrality implies the study of the involvement of each actor in a network. A system is said to be centralized when all the relations involve the same actor [Burt, 1980; Burt, 1982]. This feature greatly contributes to the description of inequality in actors' relations [Burt, 1980]. Although some authors argue the importance of peripheral positions [Granovetter, 1973], centrality in the network is generally supposed to produce power [Bonacich, 1987]. The difficulty remains how to assess this concept of centrality.

How can one identify the 'most important' actors in a social network? How can we manage to highlight the differences between important and unimportant actors? Many authors agree that the most important or most prominent actors are usually located in strategic locations within the network. In a graphical representation of a network, if we consider the term centrality to refer to its center, i.e. its centroid, one can ask whether this center really contains the most important person. An actor is prominent if "the ties of the actor make the actor particularly visible to the other actors in the network" [Wasserman and Faust, 1994]. The ties concerned here are not only direct ties but also indirect paths involving intermediaries.

Authors such as Knoke and Burt have distinguished two classes of prominence: centrality and prestige [Wasserman and Faust, 1994]. The most intuitive definition of centrality is to consider that a central actor is the one involved in many ties [Bavelas, 1948, 1950; Wasserman and Faust,

1994]. Many experiments and extensions concerning this concept have been proposed [Wasserman and Faust, 1994]. Several measurements have been proposed in the past to assess an actor's "importance". Differences in indexes are based on the level of analysis. It may be the actor (activity (degree and related measures) and position (between-ness, closeness)), the dyad (dyadic measures), or the network (eigenvector, flow-between-ness). Another difference depends on the data. The relationships may be symmetric or not. When symmetric, relationships from A to B and B to A are equal. When asymmetric, the information flow from A to B may differ from B to A. When the communication flow is symmetric, related indexes are labeled "centrality", whereas for asymmetric communication flow, related indexes are labeled "influence" [See Wasserman and Faust, 1994 for a detailed description]. Several assessments can be used to measure the centrality concept. They are summarized in Table 2.

These measures allow us to better interpret the centralization dimension of the structure embedded in the e-mail communication flow. They are used in an empirical study of the e-mail communication exchanges of a firm.

Table 2: Summary of centrality assessments

Degree	A measure of activity. Central actors have the most ties to other actors in the network.
Between-ness	Strategic location on paths linking pairs of actors. Position which implies controlling, or increasing the dependence of others.
Closeness	A measure of independence from others. Measure which also represents efficiency.
Flow-between-ness	When between-ness is applied to a whole social network.
Eigenvector	A measure of an actor's connections to others, weighted by their centralities.
Dyadic Influence	A measure of the relative influence between pairs of actors.
Information	A measure of the quantity of information which is contained in the paths that originate [and end] at an actor.

III. METHOD

PARTICIPANTS

The study of electronic mail exchanges took place in a group with 1452 employees. It is composed of 36 firms. This group carries out trade activities related to automobile and goods distribution. Transversal services manage common activities (staff services, accounts department, management). They correspond to the strategic apex and to the techno-structure in the Mintzberg configuration [1982]. All 385 employees with an electronic mail address are considered.

DATA COLLECTION

We favoured in this study a collecting method based on quantitative observation of the communicational exchanges, from technical sensors in the firms; in this case, the electronic mail servers. By doing so, we made it easier to reproduce the process, and we also avoided some bias and disadvantages [Thiétart, 1999; Mourgues et al, 2002; Mintzberg, 1973]. The data in this study were not collected by questionnaires; we analyzed data coming from individual actions rather than perceptions.

Independent variables

Several variables were available to describe the organizational context. The aim was to test the relationships between personal and organizational attributes and centrality indexes. Both organizational and individual attributes came from a human resources management system. These data are used to identify employees and to manage resources (wages, promotion, training, and so on). Information has been selected from these data according to two criteria.

Table 3: Independent variables

Gender	Sex gender [0=male, 1=female]	Igbaria and Baroudi, 1995; Boukef, Kalika, 2002
Seniority	Age Seniority in the firm Seniority in the job	Limayem, Bergeron, Richard, 1997; Boukef, Kalika, 2002; Venkatesh et al., 2003
Personal telephone number	Does the firm allocate a personal telephone number? [0=no, 1=yes]	Pfeffer, 1981
Cellular	Does the firm allocate a cellular telephone number? [0=no, 1=yes]	
Salary Position	Salary position within the firm	Mintzberg, 1975; Daft, Lengel, 1986; Boukef, Kalika, 2002; Baile,Lefievre, 2003
Status	From worker [1] to manager [5]	

The first criterion is personal. Age, gender, seniority, and diploma were initially selected to better identify personal features. However, due to unreliable information, 'diploma' was removed from the list. Experience and age influence the way people use technologies [Limayem, Bergeron, Richard, 1997]. This influence is explicitly mentioned in the Unified Theory of Acceptance and Use of Technology (UTAUT) [Venkatesh et al., 2003]. These indexes are used to identify the effect of experience on e-mail centrality. Age may be relevant considering that young people are better trained and more aware of internet related technologies [Boukef, Kalika, 2002]. People that have worked for a long time in the firm are well-known and integrated into the professional social network, which explains why seniority in the firm may influence centrality indexes. Gender differences in the IS workplace exist [see, for example, Igbaria and Baroudi, 1995]. However, its effect on e-mail use is not always significant [Boukef, Kalika, 2002]. Gender is selected to measure its effect on centrality.

The other criterion is organizational. Data are selected to better describe organizational power attributes. Based on tacit and explicit relationships among workers, a quantitative measure of an individual's power in an organization is difficult to achieve. However, one can consider that power is not homogeneously distributed within organizations. The aim is to select relevant attributes of organizational power. Three variables have been selected:

- Salary level: the more your work is important and provides added value, the more your salary level should increase. This rationale supposes that the organization is rational and can identify individual performance. If a person's skills and abilities are not properly recognized, he or she will probably look for other jobs with better wages. Conversely, the more people are remunerated, the more their skills and abilities are recognized, but individual remuneration is a cost for the firm. The level of remuneration is the result of negotiation and it depends on an individual's power in the firm. People keep on working in a firm when a balance is realized between individual power

and organizational needs. The more the organizational performance is dependent on these skills and abilities, the more people are remunerated.

- Organizational Status: According to Mintzberg [1975], organizational status is related to formal authority and power. Managers' informational requirements increase as a function of the levels of uncertainty and ambiguity [Daft, Lengel, 1986; Baile, Lefievre, 2003]. However, results from different studies are not homogeneous. Some of them find a significant relationship between the use of e-mail and the hierarchical level, while some others do not find such a relationship [Boukef, Kalika, 2002]. In this study, people are associated with an organizational status varying from Chief Executive Officer, Senior Manager, etc. to Employee and Worker. Thus, individuals are ranked according to the internal hierarchy described in the organizational chart. Organizational status ranks people and displays organizational power in the firm.

- Symbolic attributes of organizational power: These symbolic attributes are generally related to scarce resources: a personal car parking space, a company car, high class travel. The attributes used in this study are having a cellular telephone, and having a personal telephone number.

Dependent variables

The dependent variables are the centrality indexes described above. The data used to process these indexes were based on quantitative observation of the electronic mail exchanges in a firm. Every user had an electronic mail box available on the electronic mail server. Every message sent or received by each user was stored in a log file (the server's record). Each week, data from this file were extracted. Weekly extractions were justified because of technical constraints (loading time, volume). A database covering electronic mail exchanges was constituted and completed little by little. This database contained:

- the identification number of the message,

- the electronic mail address of the receiver,

- the electronic mail address of the sender,

- the date and time of the exchange,

- the volume of the message (the volume of the message (kilobytes) has not been taken into consideration in this work).

Most of the automatic messages, like virus alarms, were identified and removed. However, automatic but involuntary messages (such as some viruses which send messages to address books) were not detected. However, these messages should not deeply bias the results. Antivirus and firewall systems limit the consequences of this problem, and in any case we did not encounter it during the data collection. The other automatic messages (such as acknowledgements) were considered as normal messages. The contents of the electronic message were not read. Thus, the employees' privacy rights were respected.

Using the Ucinet software (V6.00), several centrality indexes were computed for these data. All exchanges between the 385 e-mail users were taken into account. As a result, the analysis treats all kinds of ties within the firm's social network. This global approach, including low density links, is important because of "the strengths of weak ties" [Granovetter, 1973].

There were 291,869 messages collected over five months. Of these, only internal messages were studied, so that in all, 188,198 messages were processed. From these data, a flow matrix was constructed. This matrix is the raw material for the centrality indexes described above and 36 indexes were treated with Ucinet using the centrality option. However, these indexes were often highly correlated. A measurement assessment had to be carried out in order to reveal the main factors embedded in the data.

MEASURE AND MODEL ASSESSMENTS

Methodology and Criteria

The measure of centrality is built upon SNA using Ucinet 6 software. A measure assessment process was used to select the relevant indexes and calculate the factors. This was achieved using the correlation coefficient, by removing indexes which were too close together. The Kaiser, Meyer, Olkin (KMO), the Measure of Sampling Adequacy (MSA) and Bartlett's Sphericity Test criteria were used to measure the data adequacy and to select relevant variables. To calculate the factors, the maximum likelihood method was used. Factors were selected according to the Kaiser criterion (eigenvalues greater than 1), and the rotated factor matrix (varimax) method was used to identify initial measures.

LISREL software was used to test the Structural Equation Modeling (SEM) that links individual and organizational characteristics to centrality factors. The model was tested with the Maximum Likelihood method. To evaluate its fit, one can use several criteria. The main fit indexes described in the literature [see Jöreskog and Sörbom, 1993, 2001 for detailed information] are summarized in Table 5.

The initial SEM was set up in order to identify and evaluate the relationships between individual and organizational characteristics on the one hand, and the centrality indexes on the other. However, according to the fit indexes, this theoretical SEM model poorly fits the one embedded in the data. It has been changed according to LISREL results (Modification indexes, Chi-square expected change, observation of the covariance/correlation matrix, residuals, and so on) in order to enhance the fit. The results of the final model are described below.

The final model was composed of measurement models and a structural model. Measure models for the centrality indexes are composed of five factors.

Table 4: Centrality Factors (dependent variables)

Centrality Factors	Centrality Indexes
F1	Degree
	Fragmentation
F2	Katz Relative Dyadic Influence
	Katz Relative Score Influence
F3	Eigenvector
F4	Information
F5	Hubbel Dyadic Influence

F1 is an activity-based factor. According to the Freeman definition, this factor is viewed as an index of communication activity. F2 and F5 measure the dyadic influence of each actor within the network. F5 is an absolute measure according to the Hubbel definition, whereas the F2 ones are relative according to the Katz definition. F3 is a measure where the centrality is a function of the centrality of the other actors. F4 is an extended measure of between-ness that takes into account all paths from an actor to another weighted by their length. It is an information measure related to the position in the network.

These factors are used to describe actors' centrality in the e-mail network. They are used as dependent variables in a structural equations model. In this model, organizational and individual attributes are the independent variables (see the table of independent variables). As the results show, the indexes indicate a very good overall model fit.

Table 5: Model Adjustment

Index	Criterion	Value
Chi Square [χ2]	As small as possible	48.79
χ2/ df	< 2	1.11 [df=44]
GFI [Goodness of Fit Index]	≥ 0.9	0.98
AGFI [Adjusted GFI]	≥ 0.9	0.96
RMSEA	< 0.05	0.017
RMR [Root Mean Square Residual]	< 0.05	0.018
NFI	> 0.9	0.98
CFI	> 0.9	1.00
NNFI	> 0.9	1.00

Thus, the model is unlikely to be poorly specified and the estimates of the structural parameters can be used for analysis. The equations below describe the final structural model.

Results description

One can see that the centrality factors are fairly well explained with the R2 index which is the percentage of explained variance, ranging between 0.61% and 63%. It means that the centrality factors are fairly sensitive to the dependent variables. The eigenvector (F3, R^2=1.9%) and Hubbel dyadic influence (F5, R^2=0.61%) are not explained at all. Communication activity (F1, R^2=29%) and Katz relative influence (F2, R^2=26%) are more sensitive to the effects of the dependent variables. The information index (F4, R^2=63%) is the most sensitive. This index

Table 6: The Structural Model Equations

```
R² = 0.29
F1= 1.27*Gender + 0.16*Senior - 0.34*TelNb + 0.56*Cell + 0.43*Salary - 0.016*Status
   [0.46]        [0.13]        [0.48]        [0.31]       [0.094]       [0.028]
    2.73          1.21         -0.70          1.81         4.54         -0.58
```

```
R² = 0.26
F2=0.0*Gender - 0.19*Senior + 0.90*TelNb - 0.19*Cell + 0.47*Salary - 0.039*Status
             [0.060]        [0.26]       [0.12]       [0.11]        [0.067]
             -3.17           3.47        -1.54         4.31         -0.58
```

```
R² = 0.019
F3=-0.35*Gender -0.12*Senior + 0.16*TelNb -0.18*Cell + 0.0036*Salary - 0.031*Status
   [0.25]        [0.085]       [0.32]      [0.19]       [0.090]        [0.054]
   -1.38         -1.42          0.50       -0.98         0.040         -0.57
```

```
R² = 0.63
F4=1.20*Gender - 0.039*Senior + 0.18*TelNb + 0.52*Cell + 0.51*Salary + 0.086*Status
   [0.18]        [0.015]        [0.050]      [0.078]     [0.080]       [0.059]
    6.72         -2.55           3.66         6.63        6.37          1.46
```

```
R² = 0.0061
F5=0.0*Gender + 0.0*Senior + 0.0*TelNb - 0.052*Cell - 0.046*Salary + 0.0*Status
                                         [0.053]      [0.053]
                                         -0.99        -0.88
```

measures "how much information is contained in the paths that originate [and end] at a specific actor" [Wasserman and Faust, 1994]. In other words, one can consider the information index as a

control level over the information flow within the network. This control level is not the one described in the organizational chart but the one emerging from collective action, embedded in the human relationships. This control level over information flow is significantly related to Gender (1.20, t=6.72), the use of a professional cellular phone (0.52, t=6.63), the salary position (0.51, t=6.37), and the attribution of a specific professional telephone number (0.18, t=3.66). One can notice that seniority in the firm (-0.039, t=-2.55) inhibits the information index. In other words, in this firm, seniority does not increase control over e-mail information flow. People who have worked for a long time within the firm may not see the use of e-mail, and keep on using traditional media such as the telephone, fax or meetings. Conversely, young people are more aware of and trained in this internet technology, and they probably better understand the advantages of using this asynchronous communication system. Moreover, one can notice that organizational status does not have a significant effect on the control over e-mail information flow. It means that a difference exists between organizational hierarchy, the official structure, and the one embedded in the e-mail communication flow. It lends weight to the hypothesis that the structure of human relationships, studied by SNA, is hardly influenced by the official structure.

Another reading is to consider the dependent variables. One can see that, whatever the centrality factor, the dependent variable effects are homogeneous. When significant, the coefficients influence the centrality indexes in the same way [positive or negative]. With coefficients greater than 1.20, the gender effect is significantly positive for communication activity (F1) and control over information flow (F4). It is not significant for the other centrality indexes. It means that, when significant, women are more related to a high level of centrality. The use of a professional cellular telephone is positively correlated to F1 and F4. It means that when people have a professional cellular phone they are probably more central in the network. This correlation is less important for the traditional telephone. A direct professional telephone number is positively correlated to centrality for Katz relative influence (F2) and control over information flow (F1). Both of these attributes, the use of a professional cellular telephone and of a traditional one, describe the use of communication tools. One can see that the use of these tools is positively correlated to e-mail centrality indexes. In other words, traditional telephone and cellular phones are not competing with e-mail. The increase of communication needs, such as mobile communication, has generated the use of a new tool, the cellular telephone. Thus, people are continuously linked to the network and the communication flow increases. To deal with this phenomenon, people are using more and more communication tools to process the information flow, such as asynchronous communication tools (e-mail, Short Message Service (SMS), and so on). Kalika [2002] considers that the uses of these tools are complementary, in stratum, in which the use of traditional communication technologies keeps on growing alongside the new ones. These uses are stacked, closely linking the tools and communication contexts [Cucchi A., 2004].

Salary coefficients are significant in the communication activity (F1), Katz relative influence (F2) and control over information flow (F4]) Therefore, it follows that, the higher the salary, the more central the actor. If one assumes that salary is proportional to the individual's value in the organization, salary is not directly linked to the organizational chart. Thus, specific skills, technical knowledge, personal involvement, and so on may enhance wages. According to the equations above, salary is more closely related to the centrality indexes than the organizational status, which is not significantly correlated with any centrality indexes. As a result, status is not a relevant item to explain an actor's centrality of in the e-mail network.

Seniority coefficients are negatively correlated to centrality indexes. Young people are more aware of new technologies, such as e-mail, and can adopt them quickly, whereas older people do not want to disturb their habits; senior staff members probably use more traditional media such as the telephone.

Table 7 summarizes the results. Women are more central. The organizational power "in action", measured by the symbolic attributes of power (telephone number, cellular) and salary level, increases actors' centrality. "Official" organizational power measured by organizational status has

no significant effect on centrality. On the other hand, seniority inhibits actors' centrality. These results lead to some interpretations that are developed in the discussion section below.

Table 7 : Effects on centrality

	Gender [1=Women]	Seniority	Telephone	Cellular	Salary Level	Status
Centrality	+	-	+	+	+	

IV. DISCUSSION

The results above show significant correlation between the centrality indexes (Information, degree, dyadic measures) on the one hand, and individual and organizational attributes on the other. However, they reveal the difference between the structure described in the organizational chart and the one embedded in the communication flow. E-mail communication activity reveals a structure and results show that it is not correlated to the actors' status. The question is about the nature of this emergent structure.

If one assumes that the level of communication centrality is correlated to the level and the nature of decision activity, central actors process a lot of information in reaching decisions. According to the IP view of the organization, communication flow converges to information-processing requirements. Thus, central actors are the ones for whom information-processing requirements are highest. As centrality indexes are not significantly correlated to status, decision activity is not correlated to organizational status. A high quantity of information is required in contexts of ambiguity and uncertainty. Strategic decisions are typically made in such contexts. Thus, senior managers taking strategic decisions need a huge amount of information for a small number of decisions. Conversely, operational decisions need little information, but the frequency of these decisions is high. Employees and junior managers need a lot of information to make these operational decisions. As a result, communication flow related to decision activity is shared along the organizational chart, whatever the status of the actor.

However, information and decision processes are not always closely linked. Dennis [1996] showed that if informational technology (GSS) "enabled groups to exchange more information […], it did not help – perhaps even hindered – participants' ability to process it. In short, GSS use can lead participants to more information, but it can't make them think about it". A more realistic assumption is that e-mail communication flow is embedded in the human interactions of the organization. It means that it results from different activities: decision-making roles, communication and coordination activities, social interactions, and so on. In this case, the structure that emerges from e-mail communication activity, that we can call "communicational structure", depends on multiple factors. It is the result of dynamic exchanges that are at odds with the traditional static view of the organizational chart. Dynamic and grounded in actors' interactions, one can assume that this structure results from a structuring process as described in Giddens' research [Giddens, 1988; Cucchi and Houze, 2002]. Although it is not the purpose of this paper, a qualitative and long-term study of e-mail use could help us better understand the role of electronic media in the structuring of three systems: the meaning system with semantic rules, the domination system with resource allocation rules, and the legitimization system with moral rules. In such a study, one could link the centrality indexes to the semantic system [communication activity] and to the domination system [organizational power]. But message content analysis may provide more explanations of this phenomenon, allowing us to describe recurrent communication processes such as the genres described in Yates and Orlikowsky's research [Yates and Orlikowski, 1992; Orlikowski et al., 1995; Ducheneaut, 2002]. It should provide fruitful information about the characteristics of this underground communicational structure and about its coexistence with the formal one. As mentioned by Ducheneaut [2002], the relationships between the use of ICT (communicational structure) and the relational power games which take place in organizations (structure of organizational power) are complex. According to

his study, large organizations can maintain their older corporate structure after the introduction of ICT. Networked e-mail capabilities can coexist with an established hierarchy. In our study, the organizational status following from the formal authority described in the organizational chart is not significantly correlated to actors' centrality in the communicational structure. It means that, in this firm, the communicational structure is loosely linked to formal authority. As a result, further studies must be carried out to better interpret this phenomenon.

From a methodological point of view, the data used came from the e-mail management system log. Other communication technologies handle logs, such as Private Automatic Branch Exchanges (PABX) which use logs in managing telephone invoicing and in avoiding undesirable behavior, servers, network devices such as firewall, gateways, and so on. These communication devices store informational traces of social relationships. This work shows that one can compute indexes with these data. Graphical representations can be used to improve the understanding of this structure [Cucchi C, 2004]. Many approaches study the organizational structure using questionnaires, senior manager interviews, etc. These methods have provided relevant insights but they cannot consider the structure in action. Informational technologies provide operational data to puzzle out the structure in action. Up until now, these communicational traces have been scattered in specialized devices. With technological convergence, one can expect that the collection of these data will be easier and centralized, using homogeneous formats. Based on these data, indexes and graphical representations will provide relevant reports about the organizational structure and its evolution. SNA indexes, such as centrality indexes, provide relevant metrics to better interpret these data. As a result, the electronic communicational traces will allow managers to lift the veil on the nature and the dynamic of the organizational structure.

V. CONCLUSION

This work aimed to test the hypothesis that individual and organizational power attributes affect an individual's centrality within the social network of a firm. To do so, individual and organizational power attributes and centrality concepts have been discussed. Related indicators have been chosen. Using data from 385 employees' mail exchanges in a group, a structural equation model has been derived. The model tests the influence of individual and organizational power attributes on actors' centrality in the e-mail network. The structural equation model converges. Results show that women are more central. The organizational power "in action", measured by the symbolic attributes of power (telephone number, cellular phone) and salary level, are related to actors' centrality. "Official" organizational power measured by the organizational status has no significant effect on centrality. On the other hand, seniority inhibits actors' centrality.

However, certain constraints limit the results described above. The data collected came from a single group. Research in other contexts must be carried out in order to compare the strengths of the relationships and one of the measures used. Moreover, the data came from an email server and a staff file. Email use may cause interference in the social relationships. Technical aspects of email use may filter and transform professional and social relationships. Email, as a communication tool, may have affected the way people interact. Thus, these results are relevant in a mediated social network context. They must be compared to ordinary social network analysis.

From a methodological point of view, it should be noted that the data collection method was original. This research used data from an email server and an organizational staff file. By doing so, perceptual data constraints were avoided. Perceptual and measurement biases were minimized in as far as questionnaires were not used to identify email use. Information Systems (IS) tools provide relevant information to observe the communicational structure of the organizational relationships. Individual observations may be used to describe local interactions in a team, with a limited number of actors. IS tools provide information about the overall organization. They allow researchers to go one step further and to reach the organizational and inter-organizational levels. Now, organizational area can be observed directly, simultaneously, as a whole.

However, this study is quantitative in nature. It focuses solely on the flow of communication without looking at the content. Its purpose is to study the communicational structure and to show that it can reveal information improving our understanding of organizations. It is complementary to the content analysis that may reveal crucial, even contradictory findings. For instance, the content of the messages may show in what proportion the use of these internet technologies provides the actors with new ways to use 'political tactics' and to gain more power.

From a managerial point of view, these results show that individual and organizational attributes are correlated to actors' centrality. These results can be interpreted from a human resources' point of view. Centrality measures reflect the level of individual involvement in the network. They may provide useful information for promoting involved employees. Moreover, such an approach should provide insight into managerial decision consequences. Training, team-building, pay raises, etc. should influence employees' involvement and interactions. Social network analysis associated with IS tools should help managers to diagnose organizational issues and to evaluate decision consequences. In other words, the e-mail system provides fruitful information to analyze the communicational structure and its evolutions.

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