Optimizing network infrastructure for streamlined information technology execution in a Federal Higher Education Institution

Otimizando a infraestrutura da rede de execução de tecnologia da informação em uma Instituição Federal de Ensino Superior

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Claudio Zancan
PhD in Administration
Institution: Universidade Federal do Paraná (UFPR) – Litoral
Address: Rua Jaguariaíva, 512, Caiobá, Matinhos – PR, CEP: 83260-000
E-mail: claudiozancan@ufpr.br

João Luiz Passador
PhD in Administration
Institution: Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto da Universidade de São Paulo (FEA - RP - USP)
Address: Av. Bandeirantes, 3900, Vila Monte Alegre, Ribeirão Preto - SP, CEP: 14040-905
E-mail: jlpassador@usp.br

Cláudia Souza Passador
PhD in Administration
Institution: Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto da Universidade de São Paulo (FEA - RP - USP)
Address: Av. Bandeirantes, 3900, Vila Monte Alegre, Ribeirão Preto - SP, CEP: 14040-905
E-mail: cspassador@usp.br

ABSTRACT
This research aimed to analyze the structure of both formal and informal networks involved in Information Technology (IT) activities at the Federal University of Alagoas (UFAL). A survey was conducted to find the actors and assess the structural, relational, and centrality indicators within the formal and informal networks linked to IT activities at the university. The research employed document analysis, direct observation, and interviews with network members to set up the relationships among the actors in these networks and draw the main conclusions. The results revealed a significant disparity between the actors and indicators of the formal and informal networks. The informal network showed a larger number of actors and sectors involved, while the network density was low. This suggests the presence of untapped potential for exploring information, resources, and alternatives in the execution of IT activities. Additionally, it is recommended...
that future studies compare the networks and indicators based on their determinants to evaluate their impact on execution.

**Keywords**: social network analysis, SNA, information technology, Federal University.

**RESUMO**
Esta pesquisa teve como objetivo analisar a estrutura das redes formais e informais envolvidas nas atividades de Tecnologia da Informação (TI) da Universidade Federal de Alagoas (UFAL). Foi realizada uma pesquisa para encontrar os atores e avaliar os indicadores estruturais, relacionais e de centralidade dentro das redes formais e informais ligadas às atividades de TI na universidade. A pesquisa empregou análise de documentos, observação direta e entrevistas com membros da rede para estabelecer as relações entre os atores nessas redes e tirar as principais conclusões. Os resultados revelaram uma disparidade significativa entre os atores e os indicadores das redes formais e informais. A rede informal apresentou um número maior de atores e setores envolvidos, enquanto a densidade da rede foi baixa. Isso sugere a presença de um potencial inexplorado para a exploração de informações, recursos e alternativas na execução das atividades de TI. Além disso, recomenda-se que estudos futuros comparem as redes e os indicadores com base em seus determinantes para avaliar seu impacto na execução.

**Palavras-chave**: análise de redes sociais, SNA, tecnologia da informação, Universidade Federal.

**1 INTRODUCTION**

Social Network Analysis (SNA) can be understood as a research technique that allows us to understand the interaction among any class of individuals, organizations, and societies through the roles and positions assumed by actors, as well as the attributes, structures, and dimensions of the relationship network between them (ALEJANDRO; NORMA, 2005).

The strategic management of information technology resources has played a crucial role in the federal public agencies of the Brazilian Executive Branch in recent years, due to the significant investments needed and its cross-cutting nature within institutions. The primary focus of IT is the effective use of information to support organizational management practices. People, structure, processes, and knowledge must be articulated to ensure that computer resources meet the requirements of public administration and society, whether in terms of administrative process efficiency,
improvement of public service delivery, conditions for social control, or popular participation (CEPIK; CANABARRO, 2014).

Therefore, there is a need for investigation to clarify whether this articulation is being adequately conducted, with planning, monitoring, and evaluation of what is being executed. To that end, the study of social network analysis can be part of this process, measuring the relationships among the actors involved in IT activities. Given the relationship between the need for resource articulation for the execution of strategic IT activities in public service and the identification of social network analysis as a possible tool to influence the determinants of activity execution, the objective of this study is to analyze the network structure for the execution of information technology activities at the Federal University of Alagoas.

The research aims to bring together the two categories—social network analysis and determinants of strategic IT activity execution—within the reality of a federal university. Therefore, it opens the possibility for the diffusion of management practices in institutions like these, examining the networks formed and the type of relationship between actors in the execution of these IT activities.

The Federal Institution of Higher Education was chosen for the research as it stands for an agency of the Executive Branch of the Federal Public Administration. To analyze the variables that govern the execution of IT activities, the formal network identified in the institution's documents will be measured, as well as the informal networks that will be constructed based on determinants from Esteves and Carneiro (2015), such as: establishment of responsibilities, coordination of activities, information dissemination, change management, people management, leadership roles, control, and feedback. To analyze the existing relationships in the execution network, indicators of structural properties of the networks, roles and positions of the actors, and relational ties will be studied.

The discussion presented highlights the theoretical contribution of a research study focused on the implementation of technology and information strategies in federal public administration agencies within the Executive Branch, specifically in universities. The research aims to improve the management and governance of IT resources and provide a strategic direction for information technology within the studied institution,
which in this case is the Federal University of Alagoas (Ufal). The research question that emerges from this context is: "How are the relationships structured between the formal and informal actors in the execution network of information technology activities at Ufal?" This question seeks to understand the dynamics and interactions among different actors involved in the execution of IT activities, both formally recognized roles and informal participants, within the university.

By investigating these relationships, the study aims to shed light on the mechanisms and attributes of Social Network Analysis (SNA) and how they can be applied to the field of information technology. SNA is a theory and method used to analyze social structures and relationships. In this case, it is proposed as a valuable tool to analyze and understand the execution of technology strategies within the university setting. The practical analysis of applying SNA to information technology can have several potential benefits. It can provide insights into the existing social networks and collaborations among individuals involved in IT activities at Ufal. This knowledge can help find key actors, influencers, and knowledge brokers within the network, which can be crucial for effective decision-making and resource allocation. Furthermore, the study can reveal any existing gaps or barriers in the network that may hinder the implementation of technology strategies. By understanding the relationships between formal and informal actors, the research can find potential bottlenecks, communication breakdowns, or power dynamics that may impede the flow of information and collaboration within the university's IT ecosystem.

Overall, this research holds significant theoretical and practical implications. The theoretical contribution lies in the exploration of the relationships and dynamics within the execution network of IT activities at Ufal. By applying SNA, the study aims to enhance our understanding of how technology strategies can be effectively implemented in federal public administration agencies, particularly in the context of universities. From a practical perspective, the research findings can inform decision-makers and IT managers at Ufal about the strengths and weaknesses of their existing IT network. It can provide guidance for improving governance, collaboration, and resource management in the university's IT department. By showing opportunities for enhancing relationships
between formal and informal actors, the study can contribute to more efficient and effective IT practices within Ufal.

In summary, this research study addresses the need for understanding the relationships structured within the execution network of information technology activities at Ufal. It aims to contribute to the field of information technology management by applying Social Network Analysis as a theory and method. Ultimately, the study's outcomes have the potential to drive positive changes in the management and governance of IT resources in federal public administration agencies, specifically in federal universities.

2 THEORETICAL BACKGROUND

The concept of Social Network Analysis (SNA) can be applied in various areas of study as a tool for analyzing the interaction between elements in a network. According to Alejandro and Norman (2005), a network is understood as a group of individuals who, either collectively or individually, relate to each other with a specific purpose, characterized by the existence of information flows. SNA is a tool that allows us to understand the interactions among any class of individuals.

According to Burt (1992), the structure of networks does not directly predict attitudes or behaviors, but rather predicts similarity among the attitudes and behaviors of its elements. Cooperation networks ease joint actions and the exchange of resources to achieve common goals (BURT, 1992; WASSERMAN & FAUST, 1994; PECI, 1999; BALESTRIN, VERSCHOORE & REYES JUNIOR, 2014). Further research has highlighted the importance of social networks in influencing behavior. For instance, Granovetter (1973) proved that weak ties between individuals in a network play a crucial role in the dissemination of information and the pursuit of opportunities. Additionally, Watts (1999) argued that the structure of networks affects the spread of contagious behaviors, such as the adoption of innovations or the spread of epidemics.

These findings underscore the relevance of network interactions in understanding collective attitudes and behaviors. Nohria and Eccles (1992) propose an interesting conceptual development of Social Networks for the organizational field. They assume that the goals of network concepts include interaction, relationship, mutual aid, sharing,
integration, or complementarity among social actors. Hitt and his colleagues (1997) conceptualize social networks as a set of multiple partnerships set up by organizations with the purpose of achieving shared goals. The authors argue that cooperative relationships among organizations in a network create more value than mere competition among them.

The concepts mentioned above are quantified through mathematical calculations to map the networks under analysis. The group structure characteristics serve as indicators of the network. According to Alejandro (2005), centrality indicators allow for the analysis of the network as a whole and individually, yielding various results: network connectivity degree, individuals with the highest and lowest number of interactions, intermediation of certain actors in the relationships between individuals, and proximity between individuals based on their interactions.

Quantifying complex networks plays a crucial role in understanding and studying interconnected systems such as social networks, computer networks, neural networks, and others. To understand the structure and behavior of these networks, it is necessary to quantify and measure their characteristics. It is within this context that mathematical calculations come into play, allowing for the mapping of the networks under analysis. One way to quantify a network is through centrality indicators. These indicators supply insights into how nodes or actors in a network are interconnected and what their prominent or influential positions are. Alejandro (2005) argues that centrality indicators allow for the analysis of the network as a whole and individually, producing various relevant results.

The first centrality indicator is the network's degree of connectivity. The degree of a node refers to the number of connections it has with other nodes in the network. The average degree of the network supplies a measure of the overall density and connectivity of the system. In this regard, a high average degree writes down a densely connected network, while a low average degree suggests a fragmented or dispersed network. Another important result that can be obtained through centrality indicators is the identification of actors with the highest and lowest number of interactions in the network. These actors are known as hubs and peripherals, respectively. Hubs are the most central and influential nodes, interacting with a large number of other nodes. On the other hand,
peripherals are nodes with few connections and, therefore, have less influence on the flow of information or resources within the network.

Additionally, centrality indicators also allow for the identification of intermediaries in a network. These actors play a crucial role in communication and the flow of information between other nodes in the network. By showing these intermediaries, we can gain a better understanding of how information spreads and flows within the system. Furthermore, centrality indicators also enable the identification of proximity between individuals based on their interactions. Proximity is a measure of how easily a node can reach other nodes in the network. This allows us to identify groups or communities within the network, where nodes within a group have more frequent interactions among themselves compared to nodes from other groups. In summary, quantifying complex networks through centrality indicators supplies a deeper understanding of the structure and dynamics of these networks. Mathematical calculations enable the identification of central and peripheral nodes, analysis of network connectivity, identification of intermediaries, and mapping of proximity between actors. These measures are essential for advancing knowledge in various fields, such as sociology, computer science, biology, among others.

Therefore, Social Network Analysis (SNA) is not a formal or unitary theory; it is a broad strategy for analyzing social structures (EMIRBAYER & GOODWIN, 1994). Social networks are sets of contacts of distinct types, with distinct contents and diverse structures. To understand how these structures manifest in practice, it is necessary to understand some concepts of morphological and structural elements of the network. Then, four morphological elements (ROSSONI, HOCAYEN DA SILVA, & FERREIRA JÚNIOR, 2008; SACOMONE NETO, 2004) are presented in the following table.
Table 1. Morphological and structural elements of the network

<table>
<thead>
<tr>
<th>Elements</th>
<th>Concepts</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actors</td>
<td>Entities (individuals, organizations, or countries) subject to study in social network analysis</td>
<td>Rossoni, Hocayen da Silva and Ferreira Júnior (2008); Sacomone Neto (2004); Alejandro and Norman (2005)</td>
</tr>
<tr>
<td>Relational tie</td>
<td>Link proved between the pair of actors</td>
<td></td>
</tr>
<tr>
<td>Social network</td>
<td>Finite set of actors and the relations between them</td>
<td></td>
</tr>
<tr>
<td>Positions</td>
<td>Position is directly associated with the division of labor among different agents. It defines the locations of actors within the structure.</td>
<td></td>
</tr>
</tbody>
</table>

Source: elaborate by authors

Wasserman and Faust (1994) define that methods related to Social Network Analysis can be grouped into structural properties, such as centrality measures, density, transitivity, and cohesion; roles and positions, such as structural equivalence analysis, regular and local analysis, cluster and block model analysis, and statistical analysis of relationships, used to test theoretical propositions about relational properties.

An actor is locally central when they have many connections to other nodes; they will be globally central if they hold a significantly strategic position in the network (SCOTT, 2000). Sacomone (2004) defines centrality as when the actor centralizes relationships with other actors in the network, getting a strategic position. Wasserman and Faust (1994) inform that there are three most common measures for calculating centrality: degree centrality, closeness centrality, and betweenness centrality.

Degree centrality is measured by the number of ties an actor has with other actors in a network (WASSERMAN; FAUST, 1994). Alejandro and Norman (2005) point out that, in the calculation for degree centrality, both in-degree - the number of interactions other actors have with a given actor - and out-degree - the number of interactions an actor has with other actors - will be considered. Closeness centrality is measured by the distance from an actor to other actors in the network (ROSSONI; HOCAYEN DA SILVA; FERREIRA JÚNIOR, 2008). According to Alejandro and Norman (2005), closeness centrality is calculated by accounting for the geodesic distances from an actor to all others. Betweenness centrality occurs when an intermediary actor connects with other actors who cannot directly connect. It is calculated by summing the number of times a particular node appears in geodesic paths, i.e., paths that connect all pairs of network members (ALEJANDRO; NORMAN, 2005).
According to Sacomone Neto (2004), density is the extent of interconnection among the actors in a network. Greater interconnection means higher density. Cohesion, on the other hand, uses at the level of actor pairs; cohesive relationships are related to the gain of refined information, tacit knowledge, social control, and reciprocity, according to Sacomone Neto (2004). Confirming this concept, Wasserman and Faust (1994) state that actors with strong, direct, cohesive, intense, and frequent relational ties.

Structural properties, such as form, size, geodesic distance, and network diameter, help understand and map how unusual positions in the network structure can influence the intensity of organizational relationships. According to Alejandro and Norman (2005), size can be defined as the total number of effective connections (actual relationships) proved among actors in a social network. Geodesic distance is the shortest path between two actors in a social network. Finally, among the structural properties, network diameter corresponds to the greatest geodesic distance between any pair of network features measured.

In conclusion, Social Network Analysis (SNA) serves as a valuable method for examining the dynamics of interaction within networks across various fields of study. By quantifying the concepts of centrality, density, and cohesion through mathematical calculations, SNA enables researchers to map and understand the structural properties of networks. Centrality measures such as degree, closeness, and betweenness supply insights into the prominence and strategic positions of actors within the network. Additionally, density writes down the level of interconnection among actors, while cohesion pertains to the strength of relationships between actor pairs. Structural properties like size, geodesic distance, and network diameter shed light on the overall form and influence of network positions. Through its multifaceted approach, SNA allows for a comprehensive analysis of social structures, aiding in the identification of key actors, the examination of information flow, and the exploration of collaborative potential within networks.

3 METHODOLOGY PROCEDURES

The present study analyzed the network structure for the execution of information technology activities at the Federal University of Alagoas. For this analysis, a documentary research was conducted, with emphasis on the Information Technology
Master Plan (PDTI) for the development of formal networks. In the same document, the actors including the formal network for IT activities were found. The structuring of informal networks was based on the determinants proposed by Carneiro and Esteves (2015).

From the perspective of the goal, this study can be classified as descriptive research. According to Collis and Hussey (2005), this type of research evaluates and describes the behavior of phenomena and is used to obtain characteristics of the problem or research question. In terms of method, a Case Study was employed, as the intention was to apply the study focusing on the specific case of the execution of IT strategies at the Federal University of Alagoas. Case studies are the primary technique when the research question is of the "how" or "why" type (YIN, 2023).

Two main categories of analysis were found for the study, namely the indicators shown in ARS studies and the determinants of execution for strategic activities proposed by Esteves and Carneiro (2015). The first category encompasses ARS indicators such as size, density, geodesic distance, diameter, cohesion, and centrality of the network. The variables within this category will help in gathering information to measure the relationships between network actors, directing information flows, and naming central actors. The second category involves determinants that will aid in mapping the informal network to analyze the execution of IT strategies. These determinants include responsibility establishment, activity coordination, information dissemination, change management, people management, leadership roles, control, and feedback. This model is based on eight dimensions for strategy execution.

The level of analysis is individual, and the unit of analysis is the IT activities extracted from the Goals and Actions Plan of the Information Technology Master Plan of Ufal. The following IT activities are included: Implementation of Management Information System for academic, administrative, strategic, personnel management, and electronic document management purposes; Maintenance and training of users in Virtual Learning Environments; Restructuring and expansion of logical networks on campuses; Implementation of Information Security policy; Implementation of a technological solution for recording and monitoring the attendance and punctuality of University public agents; Universalization of high-speed internet access on all campuses; Internet access at
official events organized by Ufal; Acquisition and maintenance of computer equipment to enhance academic and administrative activities.

The research process was divided into three phases: (a) a survey was conducted by analyzing the Information Technology Master Plan (PDTI) and the Ufal Management Report (2015) to name the main strategic IT activities of the university. The formal network actors, i.e., those solely responsible for executing each IT activity, were also shown in these documents; (b) in a second phase, members of the formal execution network named in the earlier step were interviewed. These interviews aimed to address two indirect research questions: first, the identification of determinants for the execution of strategic IT activities in the context of Ufal, using Carneiro and Esteves (2015) as a starting point.

Another question addressed in this phase was whether there were added actors involved in and personally responsible for the execution of IT activities at the university, who may not be documented formally by the institution. The findings of this research phase resulted in the identification of determinants for the execution of strategic activities at Ufal and the exploration of actors forming the informal network involved in the execution of IT activities at the university. In the final stage of the study, the data was processed using Ucinet 6.0, enabling the identification of informal networks based on each previously found determinant, to quantify the attributes of the execution network. Furthermore, this phase involved data analysis that compared the execution determinants and the indicators shown in the discovered networks with the content analysis of the interviews. Finally, the study compared the indicators of the determinants within the informal network as well as between the formal and informal networks.

These research phases supplied valuable insights into the prominent information technology activities at the university under investigation, as well as helping the understanding of the key determinants influencing their execution. Moreover, the identification of actors responsible for the implementation of both formal and informal IT strategies (according to each determinant) was a crucial outcome. These findings later informed suggestions for actions to use the influence of the identified networks on the execution of IT activities at Ufal. The first actors within the comprehensive (formal)
network were found by considering the formalized strategic IT activities outlined in the Information Technology Master Plan (PDTI) of the university in question.

The data collection process employed three techniques: the documentary analysis, which involved naming the IT activities to be executed and the actors involved in the execution network derived from the Information Technology Master Plan. Interviews, where the sample consisted of the execution network shown in the institution's strategic plans. Through the interviews, other actors were identified as potential interviewees, employing the snowball technique to include individuals recommended by earlier interviewees. The research participants were assigned the following codes: E1: Director of the Distance Education Coordination Office, E2: Director of the Distance Education Coordination Office, E3: Systems Coordinator, E4: Pro-rector of People Management, E5: Advisor to the Rector, E6: Asset and Supplies Manager, E7: Networks and Infrastructure Coordinator, E8: Pro-rector of Institutional Management.

The data collection instruments consisted of open-ended questionnaires aimed at gathering information on the determinants influencing the execution of IT activities at the university, as well as finding the actors involved and assessing the degree of their interrelationships. The analysis of documentary research data was conducted using publicly available documents. This approach helped a comprehensive contextualization of the case study and enhanced the reliability of the information obtained through the interviews. The interviews were transcribed, organized, coded, and categorized using qualitative variable analysis techniques to supplement the examination of execution determinants and the mapped networks.

The content analysis method, based on Bardin (2010), was employed to systematically describe and interpret the message contents, enabling the observation of relevant aspects and inferred variable information. The analysis encompassed various stages, including pre-analysis (first reading, document selection, material preparation, and indicator development). The categorization of data collected during the interviews was guided by the determinants of strategy execution in the model developed by Esteves and Carneiro (2015).

The analysis of the researched network structures involved the mapping and measurement of relationships among university departments and staff using the Ucinet
and Netdraw software. Actor relationships were input into Excel, generating a matrix that was after imported into Ucinet for visualization. The resulting graphs, created using Netdraw, served as visual representations of these relationships.

4 RESULTS AND DISCUSSION

The main findings are presented through the following categories, which encompass the formal network, informal network, and a comparative analysis between the two. These categories serve to supply a comprehensive understanding of the networks under study and their respective characteristics, allowing for a more nuanced analysis of the data. By examining the formal network, we can explore the established structures, roles, and relationships as defined by official documents and regulations. On the other hand, the informal network sheds light on the dynamic interactions, connections, and collaborations that appear organically within the university community. By comparing these two networks, we can find similarities, differences, and potential areas for improvement. This comprehensive approach enables a deeper exploration of the network dynamics, highlighting the significance of both formal and informal networks in the execution of strategic activities.

4.1 FORMAL NETWORK FOR THE EXECUTION OF STRATEGIC IT ACTIVITIES

To meet one of the specific research goals, this section shows, through documentary research with a focus on the Information Technology Master Plan (PDTI) produced by the Federal University of Alagoas, valid from 2015 to 2017, the actors and structure of the overall network for the execution of IT activities at the university. In the overall network for the execution of IT activities at the university, fourteen actors were named, divided into six different sectors. The sectors with a greater number of actors in the network are the Technology Center (4) and the Infrastructure Superintendence (3), as shown below.
Table 2. Morphological and structural elements of the network

<table>
<thead>
<tr>
<th>Actors</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Director of the Information Technology Core</td>
</tr>
<tr>
<td>2</td>
<td>Systems Coordinator of the Information Technology Core</td>
</tr>
<tr>
<td>3</td>
<td>Data Management Coordinator of the Information Technology Core</td>
</tr>
<tr>
<td>4</td>
<td>Network and Infrastructure Coordinator of the Information Technology Core</td>
</tr>
<tr>
<td>5</td>
<td>Director of the Institutional Distance Education Department</td>
</tr>
<tr>
<td>6</td>
<td>Vice Chancellor for People Management</td>
</tr>
<tr>
<td>7</td>
<td>Training Manager</td>
</tr>
<tr>
<td>8</td>
<td>Vice Chancellor for Institutional Management</td>
</tr>
<tr>
<td>9</td>
<td>Coordinators of Academic Events at the University</td>
</tr>
<tr>
<td>10</td>
<td>Infrastructure Superintendent</td>
</tr>
<tr>
<td>11</td>
<td>Asset and Supply Manager</td>
</tr>
<tr>
<td>12</td>
<td>General Services Manager</td>
</tr>
<tr>
<td>13</td>
<td>Director of the Personnel Department</td>
</tr>
<tr>
<td>14</td>
<td>Representative of the Campus Network and Infrastructure Coordinator at the University</td>
</tr>
</tbody>
</table>

Source: elaborate by authors

The network consists of a size of fourteen actors, with 182 potential relationships. This data can be calculated by multiplying the number "X" of actors in the network by "X-1". In this case, "14x13=182". Out of this total number of possibilities, sixty are effective, resulting in a density of 0.330. This number, when analyzed in absolute terms, reflects a low connectivity, as only 33% of the potential relationships are being used. Therefore, 67% of the potential relationships in the network and the possibility of current information related to IT activities are being wasted. Another piece of information gathered is that the average geodesic distance reached a value of 1.7. This means that any actor in the network needs, on average, less than two contacts to prove a relationship with any other actor in the same network. The diameter of the network reached three, which is the greatest distance between the actors.

The figure one below illustrates the actors identified with a higher degree of centrality. The actor "Director of the IT Core" is the most dominant actor in this formal network, meaning that they have the most influence over the network. According to Lemioux and Ouimet (2012), an actor is in a dominant position when they are the sender of a connection to each of the other actors in each set of actors. This can be explained by the nature of their positions. The Director of the IT Core is the manager of the key stakeholder in executing IT activities. Also, the Vice Chancellor for People Management is also a central actor due to their responsibility for hiring and supplying training courses.
for professionals involved in the execution of IT activities. The positions of Superintendent and Manager of Assets and Supplies in the Infrastructure Superintendent are identified as important actors due to their responsibility for overseeing processes such as: logical network design, acquisition of IT assets, checking contracts related to IT services, and others.

Figure 1. Formal Execution Network of Activities

Table 3 shows the centrality degrees of all nodes in the overall network. The normalized degree in the second column stands for the percentage representation of those degrees. Since it is a bidirectional network, the actors have the same degree of input and output. Therefore, it is identified that the central actors in the network, in terms of received and outgoing interactions, are the Director of the Information Technology Core (92.3%), the Vice Chancellor for People Management (46.2%), and two members of the Infrastructure Superintendence, the Infrastructure Superintendent (46.2%), and the Asset and Supply Manager (46.2%).
Table 3. Overall Network Centrality

<table>
<thead>
<tr>
<th>Function</th>
<th>Centrality Degree</th>
<th>%</th>
<th>Intermediate Degree</th>
<th>%</th>
<th>Proximation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director of the Information Technology Core</td>
<td>12</td>
<td>92.3%</td>
<td>43.667</td>
<td>56</td>
<td>92.9%</td>
</tr>
<tr>
<td>Vice Chancellor for People Management</td>
<td>6</td>
<td>46.2%</td>
<td>13.5</td>
<td>17.3%</td>
<td>65%</td>
</tr>
<tr>
<td>Infrastructure Superintendent</td>
<td>6</td>
<td>46.2%</td>
<td>3.833</td>
<td>4.9%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Asset and Supply Manager</td>
<td>6</td>
<td>46.2%</td>
<td>3.333</td>
<td>4.3%</td>
<td>65%</td>
</tr>
<tr>
<td>General Services Manager</td>
<td>5</td>
<td>38.5%</td>
<td>1</td>
<td>1.3%</td>
<td>61.9%</td>
</tr>
<tr>
<td>Network and Infrastructure Coordinator of the Information Technology Core</td>
<td>4</td>
<td>30.8%</td>
<td>0.833</td>
<td>1.1%</td>
<td>56.5%</td>
</tr>
<tr>
<td>Director of the Personnel Department</td>
<td>4</td>
<td>30.8%</td>
<td>0</td>
<td>0</td>
<td>59.1%</td>
</tr>
<tr>
<td>Systems Coordinator of the Information Technology Core</td>
<td>3</td>
<td>23.1%</td>
<td>0.5</td>
<td>0.6%</td>
<td>54.2%</td>
</tr>
<tr>
<td>Director of the Institutional Distance Education Department</td>
<td>3</td>
<td>23.1%</td>
<td>1</td>
<td>1.3%</td>
<td>56.5%</td>
</tr>
<tr>
<td>Vice Chancellor for Institutional Management</td>
<td>3</td>
<td>23.1%</td>
<td>0.333</td>
<td>0.4%</td>
<td>54.2%</td>
</tr>
<tr>
<td>Representative of the Campus Network and Infrastructure Coordinator at the University</td>
<td>3</td>
<td>23.1%</td>
<td>0</td>
<td>0</td>
<td>54.2%</td>
</tr>
<tr>
<td>Data Management Coordinator of the Information Technology Core</td>
<td>2</td>
<td>15.4%</td>
<td>0</td>
<td>0</td>
<td>52%</td>
</tr>
<tr>
<td>Coordinators of Academic Events at the University</td>
<td>2</td>
<td>15.4%</td>
<td>0</td>
<td>0</td>
<td>52%</td>
</tr>
<tr>
<td>Training Manager</td>
<td>1</td>
<td>7.7%</td>
<td>0</td>
<td>0</td>
<td>40.6%</td>
</tr>
</tbody>
</table>

Source: elaborate by authors

According to Alejandro and Norman (2005), one reason to consider the importance of an actor lies in their degree of intermediation. This expresses the possibility of a node mediating communication between pairs of nodes, thus enjoying a position that can be helpful in the network. The measure of intermediation can be obtained by summing the number of times a node appears on geodesic paths that connect all pairs of nodes in the network.

Once again, the same three actors with the highest centrality scores also have the highest degrees of intermediation. They are the Director of the Information Technology Core (56%), the Vice Chancellor for People Management (17.3%), and the Infrastructure Superintendent (4.9%). The closeness degree writes down the proximity of a node to the rest of the network. It stands for the ability of a node to reach other nodes. This ability can be highlighted in the following actors: the Director of the Information Technology Core (92.9%), the Vice Chancellor for People Management (65%), and the Asset and Supply Manager.

The analysis of the overall network for the execution of IT activities at the Federal University of Alagoas revealed valuable insights. With fourteen identified actors
distributed across six sectors, the network displayed a low connectivity, using only 33% of the potential relationships. Consequently, 67% of the network's potential relationships and the associated opportunities for latest information remain untapped. The centrality analysis highlighted the Director of the IT Core as the most dominant actor, owing to their extensive influence over the network.

Additionally, the Vice Chancellor for People Management appeared as a central figure, responsible for hiring and training IT professionals. Notably, the Infrastructure Superintendent and the Asset and Supply Manager held crucial roles in overseeing essential processes within the network. The centrality degrees, normalized degrees, intermediation scores, and closeness degrees highlighted the significance of these key actors in helping communication and proximity within the network. These findings underscore the importance of using the network's potential and perfecting collaborations among actors to enhance the execution of IT activities at the university.

### 4.2 INFORMAL NETWORK FOR THE EXECUTION OF STRATEGIC IT ACTIVITIES

The complete relational network of IT activity execution at the Federal University of Alagoas has been identified with 31 actors. The majority of those present in the network hold strategic and tactical positions within the university. These actors include six vice chancellors, ten department directors, infrastructure superintendent, attorney general, and student representative, among others. The full list of actors is shown in the table below.

<table>
<thead>
<tr>
<th>Actors</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ascom (Communication and Marketing) Management</td>
</tr>
<tr>
<td>2</td>
<td>Attorney General</td>
</tr>
<tr>
<td>3</td>
<td>Chancellor's Office</td>
</tr>
<tr>
<td>4</td>
<td>Chancellor's Office Assistant</td>
</tr>
<tr>
<td>5</td>
<td>Chief of Staff</td>
</tr>
<tr>
<td>6</td>
<td>Contracts Division</td>
</tr>
<tr>
<td>7</td>
<td>Controller's Office Management</td>
</tr>
<tr>
<td>8</td>
<td>Coordinator of Information Technology (IT) Service Center</td>
</tr>
<tr>
<td>9</td>
<td>Copeve (Entrance Examination Committee) Management</td>
</tr>
<tr>
<td>10</td>
<td>Data Management Coordinator of the Information Technology Core</td>
</tr>
<tr>
<td>11</td>
<td>DCF (Financial Department) Director</td>
</tr>
</tbody>
</table>
It is important to highlight that the position of Information Technology Advisor in the Office of the Chancellor is not formalized, and the Institutional Coordination of Distance Education does not appear in the organizational chart or the university's bylaws. The 31 actors or nodes in the relational network generate a possibility of 930 direct relationships among themselves. Out of these relationships, 108 are realized, being a density of 11.60% for the network. The high number of actors and a low-density index show that there is a lot of information, resources, and innovative solutions that have not yet been implemented due to a lack of contact between the actors.

Table 5. Measures of cohesion in the informal network

<table>
<thead>
<tr>
<th>Density</th>
<th>Average distance</th>
<th>Diameter</th>
<th>Transitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.6</td>
<td>1.7</td>
<td>4</td>
<td>0.56</td>
</tr>
</tbody>
</table>

The average distance between actors was found to be 1.7, showing a dwindling number of barriers for direct contact among them. On average, an actor was able to set up connections with the network within just two nodes. Furthermore, the maximum number of intermediary steps required for one actor to reach another was limited to four
nodes. These findings prove the network's efficient connectivity. Additionally, the network showed a significant level of transitivity, with a transitivity index of 0.56, writing down a tendency for interconnectedness and cohesive relationships among actors.

Figure 2 supplies a visual representation of the entire network, displaying the intricate web of relationships within it. Upon careful examination, it becomes clear that certain actors hold more central positions in terms of their connectivity and influence. Specifically, the Vice Chancellor for Institutional Management and the Director of the Information Technology Core appear as the most central actors, both accounting for a considerable proportion of the network's relationships at 23.3% each. Their prominent roles within the network imply their crucial involvement in information flow, decision-making processes, and collaboration dynamics.

Figure 2. Informal Execution Network of Activities

![Informal Execution Network of Activities](image-url)

Source: elaborate by authors

In addition, the Office of Information Technology Advisor deserves special attention due to its noteworthy outdegree, reflecting its pivotal role as an intermediary actor. With a substantial presence in 4.01% of the relationships, the Office of Information Technology Advisor acts as a crucial conduit for information exchange, bridging different segments of the network and helping communication among various actors. This finding
highlights the office’s strategic position and emphasizes its significance in fostering coordination and collaboration across the network.

Furthermore, alongside the Office of Information Technology Advisor, the Vice Chancellor for Institutional Management shows a comparable degree of intermediation, with an outdegree representation of 5.81% in the network. This suggests their active involvement in helping connections between actors and serving as influential brokers of information and resources. The collective influence of these central actors contributes to the overall cohesion and effectiveness of the network, promoting efficient communication and collaboration among its members.

By analyzing the network’s structure and finding these central actors, we gain valuable insights into the underlying dynamics and functional aspects of the network. Understanding the pivotal roles played by these actors is crucial for enhancing network effectiveness, showing potential bottlenecks, and devising targeted strategies to strengthen collaboration and information flow within the network.

Table 6 below supplies compelling evidence that underscores the significant control exerted by the Vice Chancellor for Institutional Management and the Director of the Information Technology Core over the network. Their positions as critical actors within the network landscape highlight their pivotal roles in driving and shaping the execution of strategic IT activities within the university. By having control over the network, these actors have a considerable degree of influence and decision-making power that enables them to steer the direction of technological initiatives and shape the overall IT landscape. Their involvement ensures that key decisions align with the broader institutional goals and effectively contribute to the advancement of the university’s IT infrastructure and services.

Table 6. Measures of centrality in the informal network

<table>
<thead>
<tr>
<th>Actors</th>
<th>Type of centrality</th>
<th>Index %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director of the Information Technology Core</td>
<td>Degree centrality</td>
<td>23.3</td>
</tr>
<tr>
<td>Vice Chancellor for Institutional Management</td>
<td>Degree centrality</td>
<td>23.3</td>
</tr>
<tr>
<td>Infrastructure Superintendent</td>
<td>Betweenness centrality</td>
<td>5.81</td>
</tr>
<tr>
<td>Vice Chancellor for Undergraduate Affairs</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Vice Chancellor for People Management</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Vice Chancellor for Institutional Management</td>
<td></td>
<td>4.04</td>
</tr>
<tr>
<td>Office of Information Technology Advisor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The data show that the Vice Chancellor for Institutional Management, with their comprehensive oversight and authority, holds the ability to set strategic directions, distribute resources, and prove policies that govern the integration and use of IT across various departments and units within the university. Their control over the network underscores their instrumental role in ensuring seamless coordination, collaboration, and alignment of IT initiatives with the university's strategic aims. Similarly, the Director of the Information Technology Core assumes a critical position, wielding substantial influence over the network. With their ability and domain knowledge, they play a pivotal role in guiding the development and implementation of IT strategies, policies, and standards. As a central figure in the network, they could foster collaboration, leverage resources, and drive innovation in the realm of information technology.

Recognizing the control exerted by these key actors within the network highlights their indispensability for the effective execution of strategic IT activities. Their ability, decision-making capabilities, and network control position them as vital catalysts for enhancing the university's technological capabilities, streamlining processes, and achieving organizational goals. Given their critical roles, it becomes clear that using the insights, recommendations, and active involvement of the Vice Chancellor for Institutional Management and the Director of the Information Technology Core is imperative for driving meaningful improvements in the execution of strategic IT initiatives across the university. Their leadership, influence, and control over the network position them as key drivers of transformative change, ensuring the university stays at the forefront of technological advancements and innovation in the realm of higher education.

4.3 COMPARING BOTH ANALYZED IT NETWORKS

The earlier section was dedicated to an analysis of the comparison of network indicators based on determinants. From this point forward, a comparative analysis will be conducted between the structural indicators (shape, size, geodesic distance, and network
diameter), relational indicators (network cohesion), and centrality indicators (indegree and outdegree, betweenness, and closeness) of the formal network, along with the same indicators of the informal network.

The table below illustrates a comparative synthesis of the formal network indicators and the informal network indicators for conducting the strategic IT activities of the Federal University of Alagoas.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Overall Network (Formal)</th>
<th>Relational Network (Informal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determinants</td>
<td>Undefined</td>
<td>Defined</td>
</tr>
<tr>
<td>Symmetric</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Network Size</td>
<td>14</td>
<td>31</td>
</tr>
<tr>
<td>Potential of Relationships</td>
<td>182</td>
<td>930</td>
</tr>
<tr>
<td>Effective Relationships</td>
<td>60</td>
<td>108</td>
</tr>
<tr>
<td>Network Density</td>
<td>33.3%</td>
<td>11.6%</td>
</tr>
<tr>
<td>Geodesic Distance</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Network Diameter</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Transitivity</td>
<td>0.46</td>
<td>0.56</td>
</tr>
</tbody>
</table>

| Network Centrality | Director of the Information Technology Core, the Vice Chancellor for People Management | Rectorate, Vice-rector, Chief of Staff of the Rectorate, Director of the Information Technology Core, Infrastructure Superintendent, and Vice Chancellor for Institutional Management |

Source: elaborate by authors

Comparing the two networks, it becomes clear that the formal network, being proved through a document, in this case, the Information Technology Master Plan (PDTI) of the university, becomes a more static network with bidirectional relationships, theoretically increasing the network density. For the analysis of informal networks, the execution determinants were clearly defined through the studies of Esteves and Carneiro (2015).

There were found seventeen added actors in the informal network, which creates a potential for 80.43% more relationships among actors in the network. These new relationships can generate added information, exchange of novel resources, and innovative solutions for conducting IT activities. The need for a formal update of these networks is so significant that a sector working within the informal network was named, which is not formalized in the university's regulations, as wrote down by the interviewee.
Interviewee 2: "Perhaps Cied doesn't have a greater protagonist in the network because it doesn't exist in Ufal's regulations. It was created during a Consuni session but was never formalized in the regulations on its activities, structure, relationships, and positioning with other sectors. Informally, I would say that Cied would be an administrative or academic advisory body."

The density of the overall network tends to be higher due to its reliance on written connections, which may not always accurately reflect the true relationships and interactions among actors in practice. However, by examining the density within the relational network, we aim to approximate the current reality within the university context, considering the insights from classic studies in social network analysis. For instance, Granovetter's seminal work on "The Strength of Weak Ties" (1973) proved that weak ties play a crucial role in information dissemination and the pursuit of opportunities. By considering the insights from such classic studies, we can better understand the intricate dynamics and relational patterns that shape the network's density within the university context.

The analysis of Figures 1 and 2 have written down visual differences in centrality between the two networks, which can be seen in the illustration. In the formal network, there is one actor who centralizes, dominates, and influences the other actors. This actor is the IT director. On the other hand, the informal network is more decentralized, with a better distribution of information control. By considering the indegree (as well as outdegree) centrality indices, the prominence of at least five actors can be noticed: the director of the Information Technology Core, the vice Chancellor for Institutional Management, the vice Chancellor for People Management (considering indegree centrality), the Asset and Supply Manager, and the Systems Coordinator of the Information Technology Core (considering outdegree centrality). This centrality is further affirmed through the accounts provided by the interviewees.

Interviewee 2: "I understand that at the first level, the central actor would be the NTI."
Interviewee 3: "In the case of the NTI specifically, I believe that all or most of the sectors [involved in the execution of IT activities at the university] interact with the NTI. The NTI is a facilitator of activities, so it ends up interacting with many people."
Interviewee 4: "I advocate the following: the sphere of IT planning should be under the authority of the Rectorate and Pro-rectorates because it involves strategic decision-making. Execution falls under Sinfra and NTI. However, control
and evaluation are the responsibility of Proginst. They won't carry out the exec-
uction, but they will be responsible for providing feedback to the Rectorate on
what is being implemented."

The testimonies above confirm what was already showed by the numbers. Indeed,
the NTI director and the Vice Chancellor for Institutional Management are the key actors
for the execution of IT activities at the University. Therefore, with the data gathered from
the informal network and the comparison with the indicators of the formal network, the
existing differences between the two networks can be illustrated. These pieces of
information supplied valuable insights for a concrete action plan, including suggestions
for improvements in conducting strategic IT activities at the university.

This analysis highlights the importance of understanding the roles and influence
of specific actors within the network. By showing the central actors and their interactions,
it becomes clear which individuals or departments play crucial roles in helping IT
activities. The formal network, set up through documented structures, may have its
limitations and may not fully capture the dynamics and relationships among actors in
practice.

The insights gained from comparing the formal and informal networks supply
valuable inputs for developing an actionable plan to enhance IT activities. The
suggestions for improvements can address issues such as decentralization, better
distribution of information control, and strategic decision-making. By using the strengths
of both networks and aligning them effectively, the university can perfect its IT
operations, foster collaboration, and drive innovation in the execution of strategic IT
initiatives.

5 FINAL CONSIDERATIONS

This research looked to conduct a comprehensive analysis of the network structure
involved in the execution of information technology activities at the Federal University
of Alagoas (UFAL), aiming to gain deeper insights into this dynamic ecosystem.
Specifically, the study aimed to diagnose the current state of strategic IT activities at
UFAL by thoroughly mapping both the formal and informal networks of the actors
responsible for their execution. To achieve this objective, Social Network Analysis
(SNA) indicators were employed, and specific determinants of execution were carefully selected for examination.

To supply a robust foundation for the study, a case study approach was employed, focusing on the university as the research setting. Documentary research was conducted, extensively reviewing key documents such as the Information Technology Master Plan, Institutional Development Plan, and Internal Regulations of UFAL. These documents were instrumental in finding the actors who were formally appointed as responsible for IT activities within the university.

The formal relationships among these actors were captured and analyzed using SNA indicators, shedding light on the structural aspects of the formal network. However, recognizing that formal networks often only stand for a fraction of the actual collaboration and communication dynamics, the research also delved into the realm of informal networks. To capture the full breadth of actor interactions and uncover potential influential actors not captured in formal documents, interviews were conducted with the formally named actors. Through these interviews, insights were gained into the presence and significance of informal actors within the IT ecosystem at UFAL.

By encompassing both formal and informal networks, this study aimed to provide a comprehensive understanding of the network structure supporting the execution of IT activities at UFAL. By using SNA indicators and examining execution determinants, it sought to uncover the underlying dynamics, interdependencies, and potential bottlenecks within the network, ultimately contributing to the identification of strategies for optimizing the execution of IT activities and enhancing overall efficiency and effectiveness at UFAL.

The formal network for IT activity execution at UFAL was identified with fourteen actors, characterized by bidirectional relationships. It is important to note that most actors (9) hold intermediate management positions at the university. The network showed a static configuration with strong connections between actors, with a density of 33% of all relationships. Cohesion indicators revealed a small network with a low diameter of only three nodes. Actors identified as central, based on centrality degree, included the NTI director (92.3%), the Vice Provost for Personnel Management, the Infrastructure Superintendent, and the Property and Supplies Manager (46.2%).
The informal network for IT activity execution was mapped with 31 actors, and the interactions were unidirectional. All high-level management positions, including the rector, vice-rector, Chief of Staff, and six vice provosts, were identified as members of the network. The informal network appeared disconnected, with a density of 11.60%. The main actors found were the Vice Chancellor for Institutional Management and the NTI director.

When comparing the structural indicators of the formal and informal networks, several significant differences were seen, highlighting the unique characteristics and potential advantages of each network type. The formal network, characterized by its documented nature, showed a more static and smaller structure, suggesting a higher level of manageability. However, the informal network, with a larger number of actors (31), presented a compelling potential for accessing more information, resources, and alternative channels for IT activity execution.

Despite the lower density saw in the informal network (11.60%) compared to the formal network (33.33%), it is noteworthy that the informal network boasted a significantly higher number of effective relationships (108) when compared to the formal network (60). This finding underscores the importance and effectiveness of informal connections in helping communication and collaboration within the network. Moreover, the informal network showed a higher level of inclusivity, involving a greater number of sectors (23), while the formal network appeared to have a narrower range of sectors involved (7). Interestingly, it was discovered that one sector (CIED) and one actor from the informal network (IT Advisor of the Office) were not officially named in the formal documents. This discrepancy highlights a significant divergence between the formalized structure and the actual day-to-day practices within the university context.

Overall, these findings shed light on the contrasting characteristics and potential benefits of both formal and informal networks. While the formal network may offer better manageability due to its documented nature and smaller size, the informal network holds advantages in terms of its larger actor base, greater number of effective relationships, inclusivity across multiple sectors, and access to valuable information and resources. Recognizing and understanding these differences can greatly inform decision-making
processes and enable more effective network management strategies within the university environment.

The study makes a valuable contribution to the field of organizational networks, particularly within the context of public administration. One innovative aspect of the research is the use of networks to analyze the factors influencing the implementation of strategic information technology activities. However, it is important to acknowledge the limitations of the study, specifically the incomplete coverage of actors within the identified informal network due to time constraints and the availability of interviewees. Future research in the realm of Social Network Analysis (SNA) and public administration should aim to replicate these findings in other public administration agencies to enhance the generalizability of the results.

To further enrich the research, it is recommended to incorporate a time series analysis that would allow for the examination and comparison of indicators associated with each determinant. Such an analysis would supply valuable insights into the execution process and serve as an effective means of evaluating implementation progress. The data obtained from this study is expected to supply significant support to the university in finding alternative pathways for executing technology and information strategies. By improving the management and governance of IT resources, the institution can enhance its overall strategic direction in the field of information technology.

In conclusion, this research stands for a significant and valuable contribution to the comprehension of organizational networks and their impact on public administration. By acknowledging the identified limitations and supplying insightful recommendations for future research, this study sets the stage for further advancements in this field, ultimately enriching the collective knowledge of the discipline.
REFERENCES


