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Application of Graphs in Social Network Analysis on The Organizational Structure of Immigration Office Class I TPI Jambi

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Abstract: In the digital era and modern bureaucracy, understanding the dynamics of internal communication is very impor improve the effectiveness of public organizations. This study aims to analyze the structure of social networks in the organization of the Class I Immigration Office of TPI Jambi through a graph approach. The data was obtained through interviews with employees and then modeled as a graph, where each node represents the unti or position of the position and each side shows the communication relationship between the units. The weight on the sides indicates the intensity of the communication: weight 1 for strong bond and weight 2 for weak bond. Three main centrality metrics are used in this analysis, namely centrality of degree, proximity, and inequality. The results of the analysis show that the positions of the Head of Office and Head of the Administration Subdivision are nodes with the highest centrality, indicating that they play a role as the main communication center in the organization. In contrast, units such as Kasi TIKKIM have a low centrality value, which signifies relative isolation in the information network. This finding indicates a gap in the communication flow between units, which has the potential to affect operational efficiency. By understanding the strategic position of each unit in the flow of information, institutions can design more effective communication strategies to support the improvement of the quality of public services. This research proves that social network graphs and analysis can be a powerful tool for evaluating and optimizing organizational structures, particularly in government agencies such as the Immigration Office.

Keyword: Graph, Social Network Analysis, Organizational Structure, Centrality, Immigration Office

INTRODUCTION

Internships are an important component of higher education, especially for students of mathematics study programs. Through this activity, students are given the opportunity to implement the knowledge gained in college in real work situations. At the University of Jambi, internship activities are an academic requirement that aims to improve students' professional skills and work readiness. In this context, the author carried out an internship at

the Class I Immigration Office of TPI Jambi, an institution that has a vital role in the management of immigration documents and public services.

The Immigration Office as the front line of cross-border population mobility services, has a complex organizational structure and requires effective cross-unit coordination. However, formal structures that are hierarchical in nature often do not fully reflect the actual communication patterns between units. In some cases, the flow of information becomes inefficient due to the limitations of mapping informal relationships that are naturally formed in the work environment.

Social Network Analysis (SNA) offers an approach that is able to uncover the communication structures hidden behind formal organizational structures. By representing organizational units as nodes and communication relationships as edges, graphs allow visualization and quantification of information flows within institutions. Metrics such as centrality, degree, proximity, and interconnectedness are used to identify key actors as well as their strategic roles in the organization's network.

In this study, the author uses a weighted graph approach to map and analyze the communication relationship between work units at the Class I Immigration Office of TPI Jambi. The weight of the relationship is determined based on the intensity of communication between the units which are classified as strong bonds and weak bonds. This approach narrows the reality of how information flows and who is an important liaison in the internal coordination process.

The main objective of this study is to identify strategic positions in organizational structures that play an important role in information exchange and work coordination. By understanding the actual communication network patterns, the results of this analysis are expected to contribute to improving operational efficiency and quality of public services within the Immigration Office as well as becoming a methodological reference in the structural study of other government organizations.

METHOD

This study uses a quantitative approach with a graph modeling method to analyze the internal communication structure at the Class I Immigration Office of TPI Jambi. Organizational units are represented as nodes and communication relationships as *edges*. Data was obtained through semi-structural interviews with employees and observation of communication flows between departments.

The graph model used is a weighted directionless graph. Weight 1 indicates an intense (daily) communication relationship, while weight 2 is for incidental or weekly communication relationships. From the graph, three main centrality metrics were calculated:

1. Degree Centrality – measures the number of direct connections of each node,
2. Centrality of Proximity – measures the speed of access to information from a single node to the entire network,
3. Centrality of Intermediary – identifies the nodes that most often mediate communication.

Visualization of the graph is done manually with the help of a sketch of the modified organizational structure. The calculation of metrics is done using spreadsheets and manual methods, adapted to the organization's original structure.

RESULTS AND DISCUSSION

Communication Network Modeling

The analysis of social networks (SNA) in this report begins with the process of modeling the communication network at the Class I Immigration Office of TPI Jambi. This process converts qualitative data from interview results into quantitative representations that can be analyzed mathematically.

a. Graph Identification and Representation

Each position or position in the organizational structure (for example: Head of Office, Head of Administration Subdivision, Head of Information Technology and Immigration Communication) is represented as **nodes**. The communication relationships that exist between these positions, both in the form of formal and informal interactions, are represented as **edges**. The graph model used is a weighted graph, where the weights on each side indicate the strength of communication interactions.

b. Network Visualization

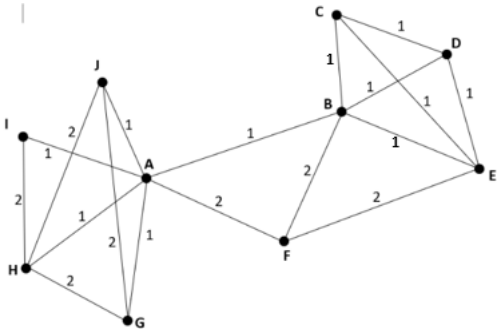

Figure 1. Internal communication network graph of the Class I Immigration Office of TPI Jambi based on intensity

Once the data is collected, the communication network is visualized in the form of a graph as shown in Figure 1. This visualization provides a visual representation of the actual interaction pattern. In the graph:

a) Each circle (node) represents one position in the Immigration Office, labeled with letters (A, B, C, etc.) according to the job list.
b) The edges that connect the nodes indicate the existence of a communication line between positions. The direction of the arrows on the side indicates the direction of the flow of information, reflecting who is giving information to whom.
c) It is important to note that positions that have many connections and are at the center of the network, such as node A (Head of Office) and node B (Head of Administration Subdivision), visually already show their central role in the communication structure. This position is seen as the main link for many other parts.

c. Adjacency Matrix Formation

The data from the visualization of the graph is then converted into the form of a proximity matrix. This matrix is a numerical representation of a graph, where its rows and columns represent each node (position). This matrix forms the computational basis for calculating all centrality metrics, such as degree, proximity, and intermediateness, the results of which will be discussed further in the next section.

Degree Centrality

The *degree* of a node in graph theory is the simplest measure of centrality. In the context of social network analysis, degrees measure the number of direct connections that a node (individual or position) has. The higher the degree of a node, the more direct communication relationships it has, which can be interpreted as the level of popularity or activeness of the individual in socializing and interacting in the organization.

Table 1. Results of Degree Calculation of Each Node

Knot	Position	Degree
A	Head of Office	6
B	Head of Administration Subdivision (KTU)	5
C	Personnel Matters	3
D	Finance Cabinet	3
E	Kaur General	4
F	Functional Position Group	3
G	Kasi Intaldakim	3
H	Kasi Lantaskim	4
I	Kasi Tikkim	2
J	Kasi Intaltuskim	4

The calculation results show that the Head of Office (A) has the highest degree (6), followed by the Head of the Administration Subdivision (5), and the Head of Lantaskim and the Head of Intaltuskim (4 each). This indicates that these positions have a direct relationship with many units, playing an active role in the exchange of information and daily decision-making.

Closeness Centrality

The *Closenness value* measures how close a node (individual/position) is to all other nodes in the network. In a weighted graph, "proximity" is calculated based on the shortest total distance (with minimum weight) from one node to all other nodes. The lower the total distance, the higher the proximity value.

$$Cc(v) = \frac{(n-1)}{\sum_{t \neq v \in V} d_G(v,t)}$$

Calculation of the Shortest Distance

Example calculation for node A (Head of Office)

A – B = 1
A – C: A – B – C = 1 + 1 = 2
A – D : A – B – D = 1 + 1 = 2
A – E: A – B – E = 1 + 1 = 2
A – F: 2
A – G: 1
A – H: 1
A – I: A – I = 1 + 1 = 1
A – J : 1
Total distance from A = 13, so Cc (A) = 9/13 = 0.692

Table 2. Closeness Centrality Value for Each Node

Position	Closeness Centrality
Head of Office (A)	0,692
Head of Administration Subdivision (B)	0,642
Personnel Rank (C)	0,45
Finance (D)	0,45
General Address (E)	0,473
Functional Position Group (F)	0,409
Kasi Intaldakim (G)	0,428
Kasi Lantaskim (H)	0,428
Kasi Tikkim (I)	0,409
Kasi Intaltuskim (J)	0,428

The Closeness Centrality value shows that the Head of Office and the Head of the Administration Subdivision not only have many direct connections, but can also reach all other nodes in the shortest time. These positions are strategic to efficiently disseminate information throughout the organization.

Centrality

Betweenness centrality is a measure of the centrality of a node. The intermediate value measures how often another node is in the network. Nodes with high intermediate values mean that they are often passed by the shortest path, so they have a great influence on the flow of information in the network.

$$C_B(v) = \sum_{(s \neq t \neq v \in V)} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

The calculation of this value is based on the shortest path between the nodes. In a weighted graph, the edge weights are inverted with the formula:

$$w' = \frac{1}{w}$$

Where is the new weight and is the original weight. Large weights indicate ease of communication, so by flipping weights, we can apply the shortest path search algorithm precisely.w' w

Table 3. Shortest Path Between Nodes (Based On Reverse Weight)

From the Knot	To the Node	Shortest Path
A	B	A – B
A	C	A – B – C
A	D	A – B – D
A	E	A – F – E
A	F	A – F
A	G	A – G
A	H	A – H
A	I	A – H – I
A	J	A – J
B	C	B – C
B	D	B – D
B	E	B – E
B	F	B – F
B	G	B – A – G
B	H	B – A – H
B	I	B – A – H – I
B	J	B – A – J
C	D	C – D
C	E	C – E
C	F	C – B – F
C	G	C – B – A – G
C	H	C – B – A – H
C	U	C – B – A – H – I
C	J	C – B – A – J
D	E	D – E
D	F	D – B – F
D	G	D – B – A – G
D	I	D – B – A – H – I
D	J	D – B – A – J
E	F	E – F
E	G	E – F – A – G
E	H	E – F – A – H
E	I	E – F – A – H – I

E	J	E – F – A – J
F	G	F – A – G
F	H	F – A – H
F	I	F – A – H – I
F	J	F – A – J
G	H	G – H
G	I	G – H – I
G	J	G – H – J
H	I	H – I
H	J	H – J
I	J	I – J

Betweenness *centrality* identifies the nodes that most often mediate in the shortest path between the nodes of two other nodes. The Head of the Office and the Head of the Business Administration Subdivision have re-emerged as the nodes with *the highest betweenness*, showing that they have great control over the distribution of information between units.

Interpretation

The combined analysis of the three metrics confirms that the Head of Office and the Head of the Administration Subdivision are central actors in the organization's social network. The other positions have different roles: some as cross-sectional connecting nodes, and others as peripheral nodes. This condition suggests that although formal structures are important, actual communication mapping provides deeper insights into the effectiveness of internal coordination.

CONCLUSION

This study successfully applied a graph to analyze the internal communication network at the Class I Immigration Office of TPI Jambi. Through the three metrics of centrality, degree, proximity, and interconnectedness, nodes that have a strategic role in organizational coordination can be identified. The results show that formal structures do not necessarily reflect the actual communication roles between work units.

The application of the graph approach provides a more objective understanding of positions that have the potential to become information centers and bridges between other parts of organizations within government and private agencies, as well as as a basis for designing more inclusive and adaptive communication strategies.

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