Volume 11, 2025, 163-178 https://doi.org/10.5281/zenodo.17849952

THE UTILITY OF SOCIAL NETWORK ANALYSIS RESEARCH METHDOLOGY APPLIED TO CRIMINAL ORGANIZATIONS: A CASE STUDY IN THE PENITENTIARY ENVIRONMENT

Laurenţiu-Octavian MUTULEANU
Bogdan-Ion CÎRSTEA

* National Academy of Intelligence Mihai Viteazul, Romania

Abstract

This article highlights the relevance and necessity of applying the principles of Social Network Analysis (SNA) research methodology for the study of individuals and connections that occupy positions of power within a criminal network, one of the main analytical features applied to the organizational structure of criminal networks. In fact, this approach aims to identify individuals (as nodes) and connections situated in positions of power (also considered forms of social capital manifestation), characterized dually by both their low visibility within the network and their increased influence over the processes and phenomena occurring throughout the entire network (e.g. the organizational structure, the communication structure, and resource circulation flow).

In this context, in a case study applied within the penitentiary environment on a network comprising 14 inmates who have committed violent acts together (as a group) and their 15 mutual caregivers, centrality measures are applied to identify those individuals and direct relationships (formed by pairs of two network members) that:

a) occupy positions of power, indicated by popularity/visibility (reflected through the determination of the ”Social hub” and ”Social hub's connections” statuses values of the network members);

b) exhibit another type of influence, namely the ability of individuals and relationships to influence the indirect connection of other network members (reflected through the determination of the ”Betweenness” and ”Link betweenness” statuses values of the network's connections).

This subject is rarely adopted in the specialized literature that can be found in Romania and the motivation for using analysis technique of Social Network Analysis (SNA) lies in the increased utility and relevance of its analytical tools for studying the characteristic features structures of the organizational structure of criminal networks, including those formed by inmates.

Thus, decision-makers can be advised to make decisions that lead to the disruption or even which will result in the dismantling of criminal networks within penitentiaries and, consequently, to the prevention and combating of the undesirable effects they may generate at a social level.

Keywords: criminal groups, social network analysis, social capital, centrality measures, social influence, information flow, communication flow

Introduction

Social network science is a theory that can be applied in various fields, from cellular biology to social environment, within which the technique of Social Network Analysis (SNA) has developed.

SNA has found utility even in the field of national security, for studying and analysing criminal networks, including those formed by inmates and their mutual caregivers (visitors and persons that stay in touch with). In this regard, an illustrative example in the specialized literature is the analysis of the Al Qaeda terrorist network in the context of the September 11, 2001 attacks.

The wide applicability of SNA has drawn the attention of authors such as Burt R.S. (2018), Barabasi A.L. (2017), Christakis N.A. Fowler J.H. (2015), Borgatti S.P. (2005), who propose fundamental analytical landmarks for the study of social networks, such as measuring centrality within the network, as well as centrality of its nodes (members), which reveal forms of social capital manifestation, such as (Hâncean G., 2014; Ciupercă E. M., Vlăduțescu Ș., 2014): identification of nodes that play the most important role in influencing social processes and phenomena within the network (hub dominance), identification of nodes and connections that play the most important role in facilitating the flow of information within the network and even the importance of identifying structural holes within the network.

Moreover, with the help of SNA can be made a relevant analysis of criminal groups, offering the advantage of analysing their characteristic features (representative traits or particularities), considering the intensification of social dynamics in the context of globalization. Thus, it offers the possibility of measuring social dynamics, mapping interdependencies and monitoring multiple connections across various social environments on a transnational level, within the prison environment and in free society.

This study integrates and applies the analytical landmarks of SNA with the aim of studying the characteristic features of the organizational structure of a criminal network formed by inmates (which jointly participated in criminal activities, resulting in arrest and imprisonment) and their mutual caregivers.

With certain exceptions, compared to the specialized literature in Romania or abroad, is noted a scarcity of specialized works regarding the application of social network analysis research methodology for studying criminal groups, especially those operating in the prison environment.

ANALYTICAL LANDMARKS IN APPLYING SOCIAL NETWORK SCIENCE IN THE FIELD OF NATIONAL SECURITY

Today, network science, that include subfield social network science, is used to explain engagement, promotion, illness, innovation adoption, success and failure of promoting a new product, the effects of a pathogen spreading and the dynamics of relationships within a criminal organization (Christakis N.A., Fowler J.H., 2015; Hâncean G., 2014).

Social network science represents the study of interactions (connections) between entities (nodes) with applicability in the field of social phenomena (in this case targeting the connections between people), in the field of telecommunications (links between websites forming the internet), national security (connections within criminal groups) or even at a biological level (neuronal connections or connections of infected individuals in epidemics), leading to predictive models of node behaviour in networks (Committee on Network Science for Future Army Applications, 2006; Hâncean G., 2014).

Summarizing, social network science is strictly applying to phenomena that can be represented by structural modelling in the form of a network.

Social network science was a continuously developing field over the last two decades5 and focuses on the study of complex networks, primarily, focusing on the analysis of the connection patterns of the network's nodes (Hansen D.L., Shneiderman B., Smith M.A., 2011; Karyotis V., Khouzani M.H.R., 2016).

In simpler terms, network theory often finds practical utility in an intelligible descriptive-visual manner by schematically mapping out the consecutive one-way/bi-directional connections between various entities (generically called nodes) projected in the network with the aim of applying measurements regarding the identified connections, considered forms of social capital manifestation (Hâncean G., 2014; Ciupercă E. M., Vlăduțescu Ș., 2014). The concept of "social capital" is defined by more than the number of people a person knows. In many cases, the value of a connected person is not given by the resources they hold (e.g., the information they know), but by the resources you (as a connected person) can access through their network (Ciupercă E. M. & Vlăduțescu Ș., 2014).

Social Network Analysis (SNA) technique, with its particular aspect of organizational network analysis (ONA), is a subfield of network science that particularly targets the study of interactions among people or social units (groups, organizations, etc.), in order to understand and predict the dynamics of connected entities (Christakis N.A., Fowler J.H., 2015). In other words, it seeks to understand how connections are made in a network and how its members are organized.

Social connections have always existed, most of them manifesting subtly at the societal level (without being highlighted through charts). But with the evolution of communication and information technology, a form of representing social interdependencies is found in the virtual environment.

A social network6 can also be considered a map of relationships between individuals, indicating how individuals are connected through various degrees of social familiarity, from weak ties like casual acquaintances to strong ties like close family ties.

---

[5] At the beginning of the 21st century, Albert-Laszlo Barabasi predicted in his book "Linked - The New Science of Networks" that the next scientific revolution would take place in the field of social networks. Historically, social network analysis was applied even in the medieval period, with specialized writings indicating the zero moment in the 18th century, when the Swiss mathematician Leonhard Euler applied principles from graph theory (later applied in SNA) to solve the "problem of the seven bridges of Königsberg." (Barabasi A.L., 2017).

[6] To avoid terminological confusion, it is necessary to distinguish the academic meaning of the term "social network" from the common meaning attributed to social networks (referring to social media platforms like Facebook, X, etc.). Thus, social media platforms can be considered merely resources that can be taken into account in the application of SNA's scientific technique.

Therefore, social networks can be considered a human superorganism that grows and evolves, having its own structure and functions (Christakis N.A., Fowler J.H., 2015).

Considering this, the emergence of social network theory or analysis as a technique was necessary, to be used primarily in sociology and anthropology, but also having a prominent role in the analysis of the criminal environment abundant in connections, thus proving its relevance to studying social networks operating within the penitentiaries.

THE NECESSITY OF USING SOCIAL NETWORK ANALYSIS IN INSTITUTIONS RELEVANT TO NATIONAL SECURITY

Applying social network analysis research methodology leads to obtaining essential data regarding how the networks are organized and how they function, allowing to: observe the dynamics of connections between network members, identify patterns (regularities) of structure and organizational structure of the network, as well as identify and evaluate models of diffusion of various resources or, as the case may be, social/relational phenomena occurring within the network (e.g. spreading of norms, behaviours or communication flow pattern7 etc.).

All these aspects prove their practical value in decision-making process, aimed at disrupting and dismantling criminal groups that affect the balance and stability of the entire society or certain social entities.

Social network analysis applied in the field of national security was necessary as a response to the challenge represented by asymmetric threats such as the robust and versatile nature of organized crime groups adapted to globalization and knowledge society (European Union Serious and Organised Crime Threat Assessment, 2021).

It should be noted that the robustness of criminal networks arises from reasons of the entity's survival, the same reason why members and connections in positions of power prefer to remain invisible (Cavallaro, Ficara, De Meo, Fiumara, Catanese, Bagdasar, Song & Liotta, 2020).

Thus, in recent times, with the help of modern communication means, these entities operate even in the virtual environment (e.g., online social networks), where they evolve and organize more easily and gain social capital8 (new followers) by exploiting vulnerable persons and vulnerable social environments (Morselli C. & Décary-Hétu D., 2013; Maryland Coordination and Analysis Center, 2024).

In this context, it is necessary to improve methods and techniques of analysis for gathering intelligence about criminal networks and establishing databases that are adequately evaluated, especially those consisting of hyperconnected environments, abundant in data and information of interest, such as the virtual or the prison environment (which can at any time become sources for identifying victims or recruiting new adherents for criminal networks).

DEFINITION OF MAIN POWER CONCEPTS MANIFESTING AS FORMS OF SOCIAL CAPITAL

According to the General Report on Europol Activities, published in 2011, ”with the support of SNA, analysts apply mathematical algorithms to identify and measure complex data sets (on a large-scale), as well as to quickly observe less visible key actors, relevant suspect groups and their partners. All of which would be hard to observe if other methods of investigating social groups were applied”9 (European Union Agency for Law Enforcement Cooperation, 2011).

Therefore, to simplify the task of applying SNA technique, including the centrality measures, specialized advanced software was created with the help of information technology (e.g., i2Notebook, UCINET, Pajek). These programs are important because they reveal the individuals, relation between them and the positions of power occupied by each of those, as well as other structural aspects of the network.

Thus, using this computer software, measures (considered forms of social capital manifestation) can be applied to networks, including criminal groups, with the aim of determining structural characteristic features such as:

1. Measures that can be applied at the network level: network size, network density, the degree distribution of network, the degree of subgroup cohesion, the degree of reciprocity and transitivity of connections between nodes.

[7] The application of social network analysis can also lead to the identification of the communication and coordination model of activities within the network (based on the information flow model circulated in the network).

[8] The ancestral tendency of humans to connect for evolutionary reasons, also manifested in today's hyperconnected virtual society, is explained by Nicholas A. Christakis and James H. Fowler (2015).

[9] "SNA represents a valuable approach that complements conventional connection analysis techniques, enhances the quality of information reporting, and contributes to the prioritization of investigative activities" (Europol, 2011).

2. Measures that can be applied at the node level of the network through could be identified the individuals in key positions, which confer power, depicted by the types and degree of influence they have within the network, as follows:

2.1. The Social hub position occupied by the most popular/visible members of the network, meaning those who have the most direct connections with other people. This position is determined by applying centrality measures specific to the ”Degree” indicator/metric.

According to ONA methodology, ”a Social hub is a person who has social ties to many other people compared to most people. In organizations, there are popular employees who are, in fact, a ”Social hub”, which have influence on other employees” (Demir&Ozkan, 2015).

According to i2 Analysis Notebook, ”Degree centrality measures how connected an entity is by counting the number of direct links each entity has to others in the network” (i2 Group by Harris Computer Corporation).

2.2. The influencer position for Social hubs is occupied by individuals who influence the Social hubs the most, meaning those who are directly connected to network members who themselves have the most connections with other people. This position is determined by applying centrality measures specific to the ”Eigenvector” indicator/metric.

According to ONA methodology, ”mathematically, eigenvector centrality is closely related to the measures proposed by Katz (1953), Hubbell (1965), Taylor (1969), Hoede (1978), Coleman et al. (1966), and Friedkin (1991), almost all of which are known as influence measures. The idea is that even if a node influences just one other node, who subsequently influences many other nodes (who themselves influence still more others), then the first node in that chain is highly influential” (Borgatti S.P., 2005).

Also, according to i2 Analysts Notebook, ”Eigenvector measures how connected an entity is and how much direct influence it might have over other connected entities in the network” (i2 Group by Harris Computer Corporation).

2.3. The position of social broker or gatekeeper is occupied by individuals who are positioned at the confluence of connections of other network members in order to indirectly connect them through the shortest paths. This position is determined by applying centrality measures specific to the ”Betweenness” indicator/metric.

According to i2 Analysts Notebook, ”This measure might identify entities with the ability to control information flow between different parts of the network. Gatekeepers might have many paths that run through them that allows them to channel information to most of the others in the network. So, existing between different network clusters, they play a powerful communication role” (i2 Group by Harris Computer Corporation).

Also, according to ONA methodology, ”Betweenness centrality is a measure of how important a given vertex is in connecting other pairs of vertices in the graph. In people networks, individuals with higher betweenness centrality can be regarded as playing important roles in ensuring overall connectivity of the network, and if they are removed from the network the risks of overall disconnection are higher” (McNulty, 2022).

”Hence, individuals with high betweenness centrality in people networks could be regarded as ”superconnectors”. The superconnectors can play very valuable roles in the social integration of new entrants to the network, and they can also present greater risk of connective disruption if they leave the network” (McNulty, 2022).

For example, in article ”Disrupting resilient criminal networks through data analysis: The case of Sicilian Mafia (Cavallaro, Ficara, De Meo, Fiumara, Catanese, Bagdasar, Song & Liotta, 2020)”, a significant practical application for disrupt (through dismantling) Sicilian Mafia criminal networks activities is the Betweenness centrality, which it is concluded to be the most effective strategy in prioritizing the nodes to be removed.

2.4. The position of rapid accessibility is occupied by individuals who are closest to the rest of the network members. It can be determined by applying centrality measures specific to the ”Closeness” indicator/metric.

According to Freeman (1979) ”a node’s closeness centrality is the sum of graph-theoretic distances from all other nodes, where the distance from a node to another is defined as the length (in links) of the shortest path from one to the other”. Meanwhile, in a flow context, Borgatti S.P. (1995) interpret closeness as an index of the expected time until arrival of something flowing through the network (Borgatti S.P., 2005).

According to i2 Notebook Analysis ”Closeness centrality measures the proximity of an entity to the other entities in the social network”.

3. By monitoring the emergence of connections between nodes, scenarios can be developed regarding the dynamics of network members' connections and, at the same time, can be identified those relationships between individuals (connections) that confer power, indicated by the types and degree of influence they have within the network, as follows:

3.1 Popular connections discovered by identifying links between the most popular network members to find connections that might be the most popular in the network. These measures can be marked by ”Degree C” (Social

hub`s connections - concept derived from the definition of the ”Social hub” term), which sums the number of direct links of the two directly related people linked by the popular connection, according to definition of Social hubs.

3.2 Influential connections discovered by measuring ONA`s ”Link betweenness” methodology, which measures the number of paths that pass through each link in order to identify the connections that indirectly connect the other members of the network by the shortest paths. ”This measure can help identify key influence connections within the network” (i2 Group by Harris Computer Corporation).

Last but not least, the analytical principles of SNA technique (highlights above, such as measures that can be applied to networks and also considered forms of social capital manifestation) are also applicable to criminal groups operating within the prison environment, because they can be used to deepen and understand their particularities, such as: robust organizational structure combined with increased density and hyperconnectivity; pronounced emergence combined with frequent mutations in connectivity; the way control is exercised over the flow of information within the network (information flow model); the manner of distributing influence within the network, as well as identifying members and connections situated in positions of power within the network who have hidden visibility (power rendered by their popularity and the possibility of indirectly influencing the connection of other individuals); and the accelerated dynamics of activities of inmate networks and their mutual caregivers (among the types of activities we highlight: illegal activities, activities aimed at domination and control of the prison environment, organizational activities).

METHODS, TESTING HYPHOTESES AND RESULTS

In order to apply the analytical principles of SNA technique within the prison environment, a case study was conducted on a network formed by inmates (who committed violent acts together, as a group; this being the reason for which they were imprisoned) and their mutual caregivers.

The general objective of the case study was to conduct a network analysis of the relational structure of a network composed by inmates who committed violent acts together (as a group) and their mutual caregivers.

Consecutive, the aim of the case study is to identify the individuals and connections occupying key (central) positions within the network. By occupying these positions, individuals and the connections they form grants power reflected by the types and levels of influence they have within the network, due to their important role in shaping processes and phenomena within the network, such as organizational structure, communication structure or flow resource.

In this regard, the research aims to achieve two main objectives, as follows:

The first objective involves investigating the association between the values of the ”Degree” indicator (also referred to as the ”Social hub” status index), which reflects the importance of individuals based on their level of popularity/visibility (independent variable) and the ”Betweenness” indicator, which reflects the importance of individuals based on their level of influence (control) in indirectly connecting other network members (dependent variable), within the aim of identifying those individuals who might hold the greatest power within the network.

The second objective involves investigating the association between the values of the ”Degree C” indicator (also referred to as the ”Social hub’s Connections” status index, by definition a concept derived from the definition of the ”Social hub” term), which reflects the importance of individuals' relationships (pairs of two people) based on the popularity/visibility of their direct connections (independent variable) and ”Link betweenness” indicator, which reflects the importance of individuals' relationships (pairs of two people) based on their level of influence in indirectly connecting other network members (dependent variable), within the aim of identifying those connections that might hold the greatest power within the network.

Therefore, to meet the objectives, the criteria for the network selection (suitable for achieving the goals of this study) were defined as follows:

a) The number of inmates, meaningly individuals arrested or convicted for committing crimes in a group, must be at least nine people;

b) The inmates must have participated together (as a group) in committing violent crimes;

c) The inmates' caregivers must be shared by at least two convicted individuals (referred to in this study as ”mutual caregivers”);

d) The inmates must be at least eighteen years old;

e) The inmates must be Romanian citizens;

f) The period of entry into the penitentiary system must be between June 1, 2018, and June 1, 2023.

Subsequently, the necessary approvals were obtained to access the non-classified database of the National Administration of Penitentiaries, where a network of individuals was identified and selected. This network consists of 14 inmates who committed crimes together and 15 mutual caregivers, meeting the selection criteria. It is worth

mentioning that within this network, connections are not drawn between the inmates themselves, but only between the incarcerated individuals and their caregivers, due to the fact that the structure of the network is based on phone calls initiated by the inmates with their caregivers who are not in prison.

To identify the relational structure of the network, the identification data of each inmate (first and last name) as well as the phone calls made by each one (which show the connections between inmates and their caregivers) were collected for the purpose of exporting them in ”xls” format.

Finally, the data was imported into the I2 Analyst's Notebook application for several purposes:

a) creating a graphical representation of the network connections (reflected by the phone calls made by inmates to contact their caregivers);

b) identifying mutual caregivers called by the inmates (reflected by the phone numbers dialed by the inmates);

c) identifying connections with associates who were not called by at least two inmates and discarding them;

d) applying centrality measures specific to network analysis to determine the values of power indicators (also considered forms of social capital manifestation), namely: ”Degree” or ”Social hub” – highlights popular/visible individuals; ”Betweenness” – highlights influential individuals; ”Degree C” or ”Social hub’s connections” (by definition a concept derived from the definition of the ”Social hub” term) – highlights popular/visible connections in connecting others; ”Link betweenness” – highlights influential connections in linking others.

Additionally, it is important to emphasize that the final network, on which centrality measures were applied, consists solely of inmates who committed violent acts together and their shared connections with their caregivers (referred to in this study as ”mutual caregivers”).

In fact, the mutual associates of the inmates are represented by the phone numbers dialed by the inmates, while the inmates' shared connections with their caregivers are reflected by those phone calls made to numbers dialed by at least two inmates in the network.

Based on the previously mentioned scientific principles used to define the power indicators of members and their connections (direct relationships between two individuals) within the network, in this study were formulated research objectives and hypotheses.

To test these hypotheses, centrality measures specific to SNA-ONA were applied to the social phone calling network consisting of 14 inmates who committed crimes together and their 15 mutual caregivers.

DEVELOPMENT AND TESTING OF WORKING HYPOTHESES

The working hypotheses were developed taking into account the previously formulated objectives, as well as the way individuals and relationships situated in positions of power who influence10 the processes and phenomena occurring at the level of the social network (also the ones who accumulate social capital) are defined in the specialized literature (Demir & Ozkan, 2015; McNulty, 2022).

Testing these hypotheses leads to the identification of individuals and relationships that may hold the greatest power (reflected by the degree of popularity and the level of influence they have in indirectly connecting other network members) within the network consisting of 14 inmates who committed crimes together and their 15 mutual caregivers.

The individuals and connections that occupy positions of power within the network identified in this way are described in the specialized literature as:

a) ”Social hubs” (Demir&Ozkan, 2015), representing popular or visible individuals;

b) ”Social hubs’ connections” (by definition a concept derived from the definition of ”Social hub”), referring to popular or visible connections;

c) ”brokers” (McNulty, 2022), highlighting influential individuals in connecting others;

d) ”Link betweenness” (i2 Notebook Analysis), emphasizing influential connections in linking others.

Hypothesis No. 1 (definition) – The top of the ranking of individuals` importance determined by their level of influence in indirectly connecting other network members is different from the top of the ranking of individuals` importance based on degree of popularity/visibility.

Hypothesis No. 1

• Independent variable: the importance of individuals based on their degree of popularity.

The value of this independent variable, which reflects the importance of individuals based on their degree of popularity, is calculated by measuring the values of the ”Social hub” status index as indicated by the Degree indicator/metric values. In turn, the values of the ”Social hub” status index and the Degree metric are determined by applying ONA-specific centrality measures, which are based on summing the number of direct connections each network member has.

[10] Such as the way other members of the network connect or the way resource flows circulate within the network.

Even though popular individuals (”Social hubs”) possess the ability to influence other network members (Demir&Ozkan, 2015), it is important to consider that the popularity indicator, calculated using the Degree/Social hub metric, has a measurement limitation. This limitation arises from the fact that it only accounts for the direct connections of network nodes, which enhances the visibility of the network representatives.

Furthermore, unlike other types of networks, some of the particularities of criminal networks are especially the positions of power occupied by less visible individuals. In fact, influential people within criminal networks prefer to be less visible in order to be less vulnerable to the interests of the authorities (Cavallaro, Ficara, De Meo, Fiumara, Catanese, Bagdasar, Song & Liotta, 2020).

Therefore, considering that in criminal networks, individuals with the highest visibility, known as ”Social hubs”, are not necessarily those with the greatest influence within the network, it becomes necessary to enhance the accuracy of the measurements used to identify such individuals (referred to as ”hidden persons”). This requires determining the influence level of group members using the Betweenness metric, which accounts for the structure and connections of the entire network, unlike the Degree/Social hub metric, which focuses solely on direct connections.

• Dependent variable: the importance of individuals based on their level of influence in indirectly connecting other network members.

The value of this dependent variable, which reflects the importance of individuals based on the degree of control they have in indirectly connecting other network members, is calculated by measuring the values of the Betweenness metric. The values of the Betweenness metric are determined by applying ONA-specific centrality measures, which are based on identifying the number of instances where nodes act as intermediaries on the geodesic paths between pairs of two nodes across the entire network.

Generally speaking, the ”Social hub” status index (which`s values derived from the Degree metric) measures the level of individuals` popularity (these individuals often stand out due to having higher visibility compared to other members). In contrast, the Betweenness metric identifies the level of influence individuals have in indirectly connecting other network members (some of these individuals may have lower visibility).

Using the i2 Notebook Analysis application, the network comprising 14 inmates who committed crimes together and their 15 mutual caregivers was identified and graphically represented (Appendix no. 1.1). Consequently, after applying centrality measures, the following maximum values for the two variables (highlighted by the values of the two indicators/metrics derived through the ONA methodology) were obtained:

• Referring to the Degree indicator/metric, which highlights the ”Social hub” status index (a position that grants increased visibility to network representatives) and, in descriptive terms, reflects the importance of individuals based on their level of popularity (the independent variable in this study):

First place is occupied by the individual with the pseudonym ”Lambda”, who has the highest score of 25.

Second place is occupied by the individuals with the pseudonyms ”Kappa” and ”Fi”, both having a score of 17.857.

Third place is occupied by the individual with the pseudonym ”Omicron”, who has a score of 14.286.

Fourth place is occupied by the individuals with the pseudonyms ”Fipsilon”, ”Kambda”, ”Omega”, and ”Sigma”, each having a score of 10.714.

• Referring to the Betweenness indicator/metric, which reflects the importance of individuals based on their level of influence (control) in indirectly connecting other members of the network (the dependent variable in this study):

The first place is occupied by the individual with the pseudonym “Lambda” with the highest score of 49.603.

The person with the pseudonym ”Alpha” ranks second, with a score of 26.984.

The person with the pseudonym ”Kappa” ranks third, with a score of 24.603.

The person with the pseudonym ”Fi” ranks fourth, with a score of 20.723.

Regarding the statement of hypothesis No. 1, for the members occupying the top 4 positions in the power hierarchy within the network11 based on the values of the two power indicators/metrics, Degree/Social hub and Betweenness (determined above), the ranking of network members primarily differs between the two power measurement scales12, with one exception, according to the following data (the most relevant values of network

[11] In other words, the most important individuals occupying positions of power within the network are presented, ranked in the highest positions on both power measurement scales.

[12] determined both by the popularity of the network members and by the level of influence they have in the indirect connection of other network members. These represent the two methods of measuring the importance of members within the network, thereby identifying those individuals who possess the greatest potential to influence the processes and phenomena which occur within the network. This ability is determined by the central (key) position which members occupy in the network, a

members are presented below, while the full data are available in Table from Appendix No. 1 and Appendix No. 1.1):

On the same positions of the two power measurement scales, both in terms of the degree of popularity/visibility of the network members and the level of influence individuals have in indirectly connecting other members of the network, the individual with the pseudonym ”Lambda” occupies the 1st position.

On different positions of the two power measurement scales, both in terms of the degree of popularity (a status that provides higher visibility to network representatives) and the level of influence individuals have in indirectly connecting other members of the network, the individuals rank as it follows: ”Kappa” - ranked 2nd and 3rd, ”Fi” - ranked 2nd and 4th, ”Omicron” - ranked 3rd and 13th, ”Fipsilon” - ranked 4th and 5th, ”Kambda” - ranked 4th and 6th, ”Omega” - ranked 4th and 7th, and ”Sigma” - ranked 4th and 15th.

Therefore, Hypothesis No. 1 is partially confirmed, as, in addition to the individuals who occupy different positions on the two power measurement scales of the network members, the highest-ranked member of the network holds the same position (rank 1) on both scales.

In this case, what is relevant is the fact that the retention of the number 1 power position by the same person on both power measurement scales represents not only a confirmation of the increased visibility held by the individual (”Lambda”) within the network, but also the importance of the power he holds in their relationships with other members of the targeted network.

Another relevant observation can be made regarding the person who occupies different positions on both power measurement scales, such as the one with the pseudonym ”Alfa”. This individual has lower visibility compared to the other network members (as demonstrated by occupying a lower position on the Degree/Social hub scale, the 5th place), but at the same time, he has an increased influence in indirectly connecting other network members (as evidenced by their top position on the Betweenness scale, the 2nd place).

Appendix No. 1

Degree (Social hub) score/rank and Betweenness score/rank correlation

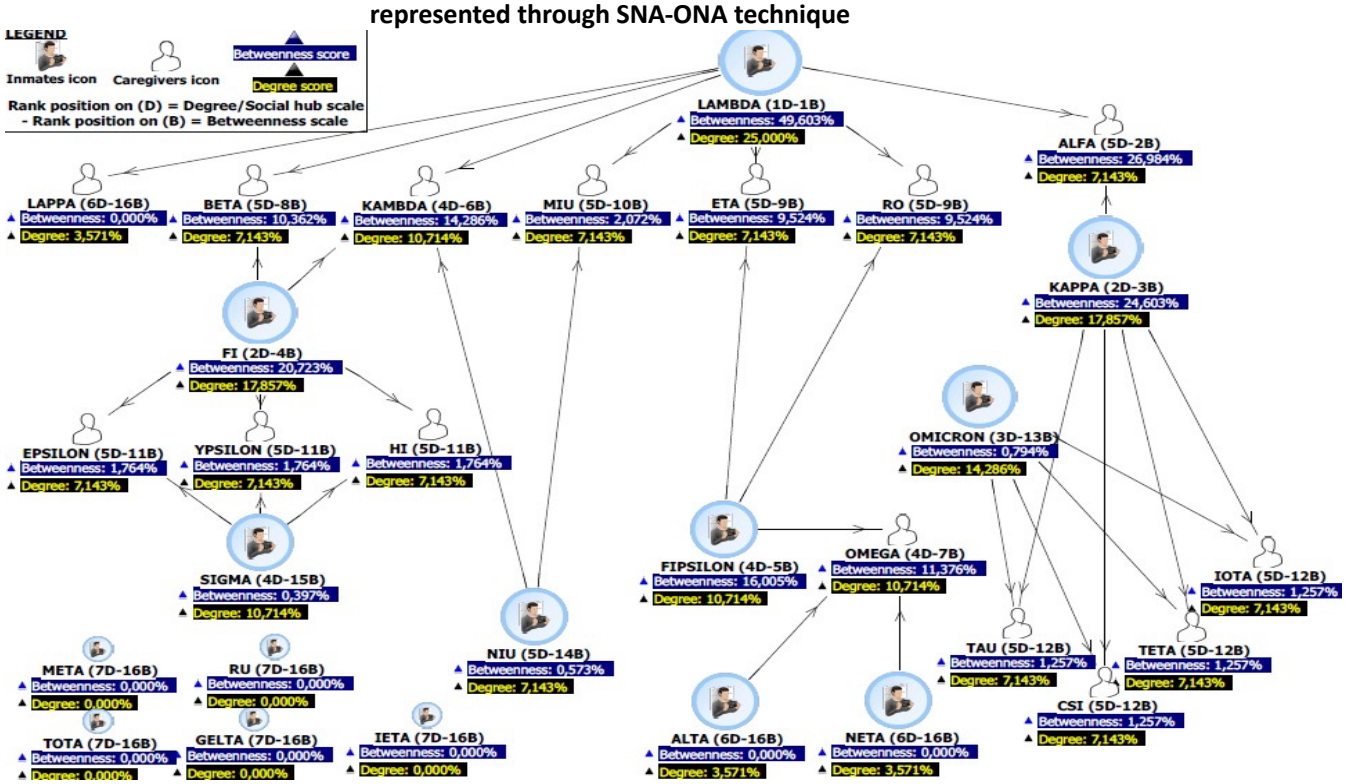
Entity anonymizer	Degree% score/Social hub score (independent variable)	Betweenness% score (dependent variable)	Betweenness% rank reported to Degree% rank/Social hub rank	Degree% rank/Social hub rank	Betweenness% rank
Lambda*	**25**	**49,603**	**=0 (same rank position)**	**1**	**1**
Kappa*	17,857	24,603	**↓-1 (lower 1 rank positions)**	**2**	**3**
Fi*	17,857	20,723	**↓-2**	**2**	**4**
Omicron*	14,286	0,794	**↓-10**	**3**	13
Fipsilon*	10,714	16,005	**↓-1**	**4**	5
Kambda	10,714	14,286	**↓-2**	**4**	6
Omega	10,714	11,376	**↓-3**	**4**	7
Sigma*	10,714	0,397	**↓-11**	**4**	15
Alfa	7,143	26,984	**↑+3 (uppers 3 rank positions)**	**5**	**2**
Beta	7,143	10,362	↓-3	5	8
Eta	7,143	9,524	↓-4	5	9
Ro	7,143	9,524	↓-4	5	9
Miu	7,143	2,072	↓-5	5	10
Epsilon	7,143	1,764	↓-6	5	11
Ypsilon	7,143	1,764	↓-6	5	11
Hi	7,143	1,764	↓-6	5	11
Csi	7,143	1,257	↓-7	5	12
Tau	7,143	1,257	↓-7	5	12
Iota	7,143	1,257	↓-7	5	12

position determined by the following indicators: a) degree of popularity/visibility, measured through the Degree/Social hub scale; and b) level of influence in the indirect connection of other network members, measured through the Betweenness scale.

Teta	7,143	1,257	↓-7	5	12
Niu*	7,143	0,573	↓-9	5	14
Neta*	3,571	0	↓-10	6	16
Lappa	3,571	0	↓-10	6	16
Alta*	3,571	0	↓-10	6	16
Ieta*	0	0	↓-9	7	16
Tota*	0	0	↓-9	7	16
Meta*	0	0	↓-9	7	16
Ru*	0	0	↓-9	7	16
Gelta*	0	0	↓-9	7	16
The entities with* means they are inmates					
The entities without* means they are not inmates, but they are the inmates`s caregivers					

Appendix No. 1.1

The network[13] of 14 inmates who committed crimes together and their 15 mutual caregivers graphically represented through SNA-ONA technique



- Hypothesis No. 2 Definition – The top of the ranking of the importance of relationships based on the level of influence they have in indirectly connecting other network members is different from the ranking of the importance of relationships based on the degree of popularity/visibility of these connections.

Hypothesis No. 2

• Independent variable: the importance of relationships between individuals (pairs of two people) based on the popularity/visibility level of those each two members directly connected who form each connection within the network.

The value of this independent variable, which indicates the importance level of direct connections between pairs of two individuals (formed by sets of two individuals), based on their degree of popularity, is calculated by determining the values of the ”Social hub's connections” status index (concept derived from the definition of the ”Social hub” term), as indicated by the Degree C indicator/metric values. In turn, the values of the ”Social hub's connections” status index and the Degree C metric are determined by applying ONA-specific centrality measures,

[13] By using the SNA-ONA technique the values of the power indicators *Degree/Social hub* and *Betweenness* were calculated (shown in the image below every node). Below to every node are shown Betweenness and Degree values (scores) on the two power scales. Also, next to every node is shown every rank position of these on the two power scales (the first is rank position on Degree/Social hub scale and the second is rank position on Betweenness scale).

which are based on summing up the number of direct connections of the nodes that form each pair of two individuals in a direct connection.

Although the relationships between popular individuals (in other words, pairs of individuals with a high ”Social hub” status) also have the ability to project their influence across the network, it is important to note that the Degree C/Social hub’s connections indicator measures the popularity of relationships based on the values of the Degree/Social hub indicator. Consequently, the Degree C/Social hub’s connections indicator inherits the same limitation as the Degree/Social hub indicator, specifically as it takes into account only the direct connections of the network's nodes.

Therefore, considering this limitation, as well as the particularity of criminal networks regarding the increased influence of less visible individuals (known as “the power of hidden persons”) and, implicitly, of their connections, it becomes necessary to be determined the level of influence of relationships between group members to enhance the accuracy of measurements used to identify the most important power relationships (pairs of two individuals) within the network. This level of influence is measured using the Betweenness indicator, which accounts for the structure and connections of the entire network, rather than only the direct connections, as is the case with the Degree/Social hub indicator.

• Dependent variable: the importance of relationships between individuals (pairs of two individuals) based on the level of influence these connections have in the indirect linkage of other network members.

The value of this dependent variable, which highlights the importance of direct connections between two individuals (formed as pairs of two individuals) based on the level of control these connections have in the indirect linkage of other network members, is calculated by determining the values of the Link betweenness metric. In turn, the values of the Link betweenness metric are determined through the application of ONA-specific centrality measures, which identify the instances where the relationships between individuals (pairs of two) intersect the geodesic paths between pairs of two nodes across the entire network.

Broadly speaking, the ”Social hub's connections” status index (by definition a concept derived from the definition of the ”Social hub” term), which`s values resulting from the Degree C metric, measures the popularity level of relationships between individuals (pairs of two), while the Link betweenness metric identifies the level of influence these relationships (pairs of two) have in the indirect connection of other network members.

Using the i2 Notebook Analysis application, a network was identified and graphically represented, consisting of 14 inmates who committed crimes together and their 15 mutual caregivers (Appendix no. 2.1). Consequently, after applying centrality measures, the following maximum values of the two variables (as indicated by the values of the two indicators/metrics derived through the ONA methodology) were obtained:

• Regarding to the Degree C indicator/metric, which reflects the status index of ”Social hub's connections” (a position that provides increased visibility to connections within the network), and, in descriptive terms, highlights the importance of direct connections between pairs of individuals (formed by pairs of two people) based on the level of popularity of these connections (relationships) and, implicitly, of the two individuals who form them (the independent variable in the study):

Ranked first, with the highest visibility within the network, is the connection between individuals with the pseudonyms ”Lambda” and ”Kambda”, this relationship scoring the highest value of 35.714.

Ranked second are the following individual connections of the person with the pseudonym ”Lambda” with those bearing the pseudonyms ”Alpha”, ”Beta”, ”Eta”, ”Ro” and ”Miu”. All five connections share the same score of 32.143.

Ranked third are the connections between the individuals with the pseudonyms ”Lambda” and ”Lappa” as well as those with the pseudonyms ”Fi” and ”Kambda”. Both connections share the same score of 28.571.

• Regarding to the Link betweenness indicator/metric, which reflects the importance of direct connections between pairs of two individuals based on the level of influence (control) these connections have in indirectly linking other members of the network (a dependent variable in the study).

Ranked first is the relationship between individuals with the pseudonyms ”Lambda” and ”Alpha”, which has the highest score of 14.655.

Ranked second is the relationship between individuals with the pseudonyms ”Kappa” and ”Alpha”, with a score of 13.3.

The third place is occupied by the relationships between individuals with the pseudonyms ”Lambda” and ”Kambda”, as well as ”Fipsilon” and ”Omega”, both relationships having a score of 7.759.

Regarding the statement of Hypothesis No. 2, in the case of direct relationships formed by pairs of two individuals occupying the most important positions in the hierarchy of power within the network based on the

values of the two power indicators14, Degree C/Social hub's Connections and Link betweenness (determined above), the ranking of these relationships differs across the two scales used to measure the power15 of relationships. This is demonstrated by the following data (the most relevant relationships values are presented below, while the full data are available in Table from Appendix No. 2 and Appendix No. 2.1):

- The relationship between the individuals with the cryptonyms ”Lambda” and ”Kambda” ranks 1st (on the Social hub’s connections scale) and 3rd (on the Link betweenness scale);
- The relationship between the individuals with the cryptonyms ”Lambda” and ”Alfa” ranks 2nd (on the Social hub’s connections scale) and 1st (on the Link betweenness scale).
- The relationship between the individuals with the cryptonyms ”Lambda” and ”Miu” ranks 2nd (on the Social hub’s connections scale) and 9th (on the Link betweenness scale).
- The relationship between the individuals with the cryptonyms ”Lambda” and ”Lappa” ranks 3rd (on the Social hub’s connections scale) and 11th (on the Link betweenness scale).
- The relationship between the individuals with the cryptonyms ”Kappa” and ”Alfa” ranks 4th (on the Social hub’s connections scale) and 2nd (on the Link betweenness scale).
- The relationship between the individuals with the cryptonyms ”Fipsilon” and ”Omega” ranks 6th (on the Social hub’s connections scale) and 3rd (on the Link betweenness scale).

As a result, Hypothesis No. 2 is validated, because of the relationships presented above are ranked differently (occupy distinct positions) on the two power measurement scales.

The most relevant aspect is that the most visible connection within the network, namely the one between individuals with the cryptonyms ”Lambda” and ”Kambda”, ranked 1st on the Social hub's connections measurement scale, does not hold the highest potential to influence the indirect connection of other network members. This is reflected in 3th place ranking on the Link betweenness scale.

The strongest influence in indirectly connecting other network members is the relationship between ”Lambda” and ”Alfa”, ranked 2nd in terms of popularity and visibility on the Social hub`s connections scale, but 1st on the Link betweenness scale. This fact highlights the importance of knowing the relationships revealed by applying measurements to test the level of influence (control) that these pairs of two individuals have in indirectly connecting other network members.

It is also important to highlight the following significant differences in positioning across the two measurement scales, which hold increased relevance for the hypothesis established in the study:

- The relationship between ”Lambda” and ”Miu”, which ranks 2nd on the Social hub’s connections scale for detecting popularity and visibility, simultaneously occupies only the 9th position on the Link betweenness scale, which measures influence in the indirect connection of other network members. A similar situation is also found in the relationship between ”Lambda” and ”Lappa”, ranked 3rd on the Social hub’s connections scale and 11th on the Link betweenness scale.
- On the other hand, in the case of the relationship between ”Kappa” and ”Alfa”, ranked 4th on the Social hub’s connections scale and 2nd on the Link betweenness scale. So, although the degree of popularity and visibility for this connection is relatively low compared to other relationships, the level of influence in the indirect connection of other network members is high. A similar situation is also found in the relationship between ”Fipsilon” and ”Omega”, ranked 6th on the Social hub’s connections scale and 3rd on the Link betweenness scale.

Appendix No. 2

Social hub`s connections (Sum A+B Degree%) score/rank and Link betweenness% score/rank correlation

1	2	3	4	5	6	7	8
Entity A anonymizer	**Direction**	**Entity B anonymizer**	**Social hub`s connection score (Sum A+B Degree% score) - independent variable**	**Link betweenness% score - dependent variable**	**Link betweenness% rank reported to Social hub`s connect**	**Social hub`s connections rank (Sum A+B Degre**	**Link betweenness% rank**

14 in other words, the most important connections (formed by pairs of two individuals) that occupy positions of power within the network are presented (ranked in the highest positions on the two measurement scales.

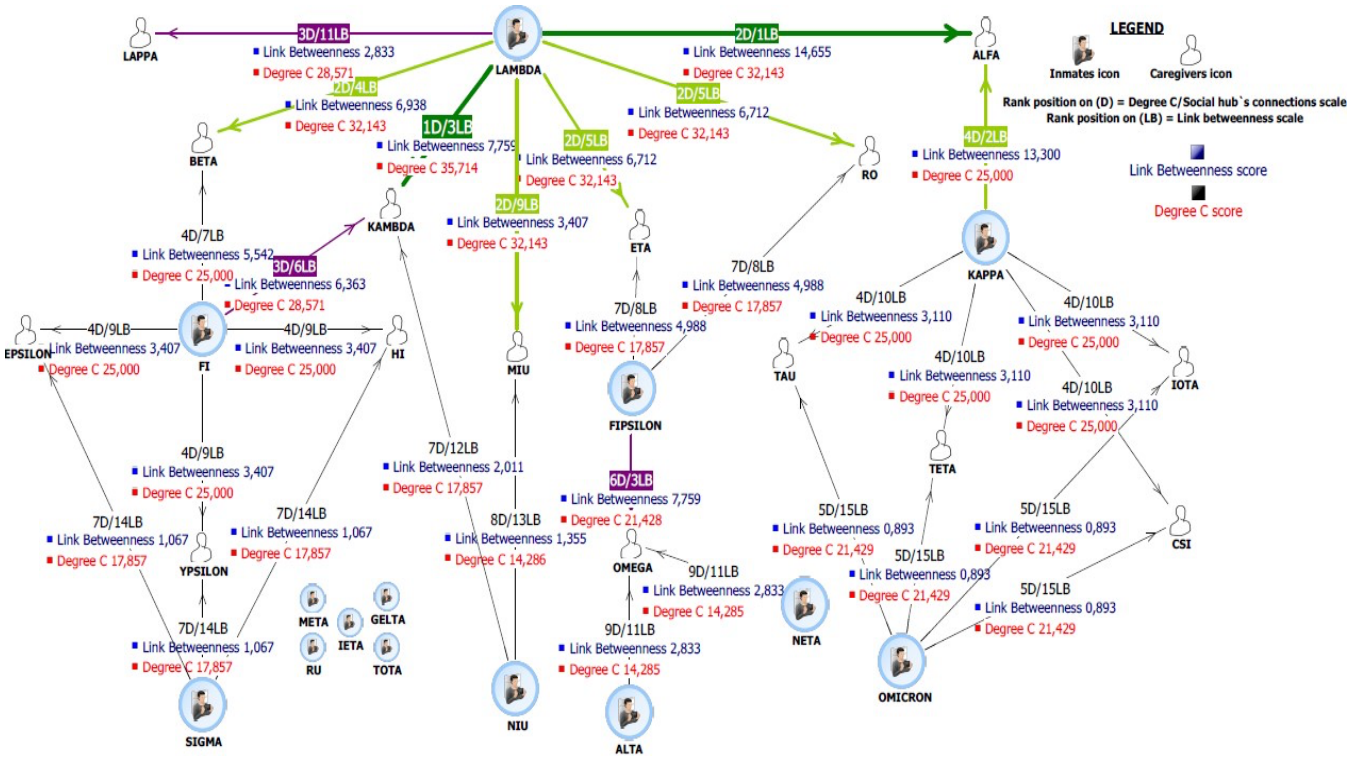
15 determined both by the degree of popularity of direct relationships (formed by pairs of two individuals) and by the level of influence these relationships have in indirectly connecting other network members.

					ions rank (Sum A+B Degree % rank)	e% rank)	
LAMBDA*	A -> B	KAMBDA	**35,714**	**7,759**	**↓-2 (lowers 2 rank positions)**	**1**	**3**
LAMBDA*	A -> B	ALFA	**32,143**	**14,655**	**↑+1 (upper 1 rank positions)**	**2**	**1**
LAMBDA*	A -> B	BETA	**32,143**	6,938	↓-2	**2**	4
LAMBDA*	A -> B	ETA	**32,143**	6,712	↓-3	**2**	5
LAMBDA*	A -> B	RO	**32,143**	6,712	↓-3	**2**	5
LAMBDA*	A -> B	MIU	**32,143**	3,407	**↓-7 (lowers 7 rank positions)**	**2**	9
LAMBDA*	A -> B	LAPPA	**28,571**	2,833	**↓-8 (lowers 8 rank positions)**	**3**	11
FI*	A -> B	KAMBDA	**28,571**	6,363	↓-3	**3**	6
KAPPA*	A -> B	ALFA	25	**13,3**	**↑+2 (uppers 2 rank positions)**	**4**	**2**
FI*	A -> B	BETA	25	5,542	↓-3	4	7
FI*	A -> B	EPSILON	25	3,407	↓-5	4	9
FI*	A -> B	YPSILON	25	3,407	↓-5	4	9
FI*	A -> B	HI	25	3,407	↓-5	4	9
KAPPA*	A -> B	IOTA	25	3,11	↓-6	4	10
KAPPA*	A -> B	TETA	25	3,11	↓-6	4	10
KAPPA*	A -> B	CSI	25	3,11	↓-6	4	10
KAPPA*	A -> B	TAU	25	3,11	↓-6	4	10

OMICRON*	A -> B	IOTA	21,429	0,893	↓-10	5	15
OMICRON*	A -> B	TETA	21,429	0,893	↓-10	5	15
OMICRON*	A -> B	CSI	21,429	0,893	↓-10	5	15
OMICRON*	A -> B	TAU	21,429	0,893	↓-10	5	15
FIPSILON*	A -> B	OMEGA	21,428	7,759	**↑+3 (uppers 3 rank positions)**	**6**	**3**
FIPSILON*	A -> B	RO	17,857	4,988	↓-1	7	8
FIPSILON*	A -> B	ETA	17,857	4,988	↓-1	7	8
NIU*	A -> B	KAMBDA	17,857	2,011	↓-5	7	12
SIGMA*	A -> B	HI	17,857	1,067	↓-7	7	14
SIGMA*	A -> B	EPSILON	17,857	1,067	↓-7	7	14
SIGMA*	A -> B	YPSILON	17,857	1,067	↓-7	7	14
NIU*	A -> B	MIU	14,286	1,355	↓-5	8	13
ALTA*	A -> B	OMEGA	14,285	2,833	↓-2	9	11
NETA	A -> B	OMEGA	14,285	2,833	↓-2	9	11
The entities with* means they are inmates							
The entities without* means they are not inmates, but they are the inmates`s caregivers							

Appendix No. 2.1
The network[16] of 14 inmates who committed crimes together and their 15 mutual caregivers graphically represented through SNA-ONA technique

[16] By using the SNA-ONA technique the values of the power indicators *Degree C/Social hub`s connections* and *Link betweenness* were calculated (shown in the image attached to every link). Attached to every link are shown Link betweenness and Degree C/Social hub`s connections values (scores) on the two power scales. Also, next to every link is shown every rank position of these on the two power scales (the first is rank position on Degree C/Social hub`s connections scale and the second is rank position on Link betweenness scale).



Conclusions

In this case study, it is shown that the analytical principles of SNA, revealed through the application of centrality measures (”Degree/Social hub”, ”Betweenness”, ”Degree C/Social hub's connections” and ”Link betweenness”) are suitable for analysing the robust nature specific to the organizational structure of criminal networks.

The robust configuration of the organizational structure of criminal networks emerged from their need for survival.

In fact, these criminal groups have a constant need to reorganize quickly to protect themselves from frequent disruptions to their organizational structure caused by various reasons, such as: interventions by authorities, betrayals by members or collateral losses of members.

In this context of exposure, the members and connections in positions of power within criminal networks benefit from reduced visibility in order to avoid interventions by authorities and rivals being directed against them. Thus, leaders of criminal organizations aim to maintain key (central) positions within the network and gain the advantage of coordinating the criminal activities of the organization discreetly.

This is the reason for it is important to analyze the robustness of the organizational structure and to discover the members and connections situated in powerful positions within the network, whose occupation grants them a dual advantage within the organization. They benefit from both low visibility within the network and also from increased influence over the processes and phenomena occurring within the organization, such as organizational structure, communication, and resource circulation.

Therefore, given the alignment between the SNA research methodology and the objectives of this study, centrality measures were applied in the case study to a network consisting of 14 inmates who committed violent acts together (as a group) and their 15 mutual caregivers. Thus, the aim of the study was to identify those individuals and direct relationships (formed by pairs of two network members) that hold positions of power, even though their placement in these key (central) positions is not immediately intuitive or visible when observing the network’s configuration without applying SNA technique.

In this case study, the power of members and connections is represented by popularity/visibility (indicated by determining the values of the network members ”Social hub” and ”Social hub's Connections” statuses) and another type of influence, namely, the ability of individuals and relationships to influence the indirect connection of other network members (reflected by determining the values of the network connections ”Betweenness” and ”Link betweenness” statuses).

In the case of testing Hypothesis No. 1, which reflects the hierarchy of power among network members, the most significant finding is the retention of the No. 1 position of power (on both measurement scales) by the same person, namely ”Lambda” (which is shown graphically in Appendix no. 1.1). This fact shows a concordance between the two measurement scales, with the same person having the highest level of visibility and popularity

within the network also having the most important influence on the indirect connection of other network members.

Besides it, at least as relevant is observation (that partially validated Hypothesis No. 1) about the individuals who occupy different positions on the two power measurement scales, such as those with the codenames ”Kappa”, ”Fi”, ”Omicron”, ”Fipsilon”, ”Kambda”, ”Omega”, ”Sigma” and ”Alfa”. This fact shows that these members have different importance in the power hierarchy of the two scales. Also, the same two power measurement scales measured different levels of influence that the same members have within the network, depicted according to their level of visibility/popularity and by importance these individuals have in the indirect connection of other network members.

These differences are important in the process of analysing criminal networks with the aim of identifying individuals who accumulate social capital and can influence in different ways the processes and phenomena occurring at the level of the social network. In this way, not only the visible nodes can be identified, but also the hidden ones.

In this context, another relevant observation can be made regarding individuals who occupy different positions, not just leading ones on both power measurement scales of network members, such as the individual with the codename ”Alfa”.

”Alfa” although enjoying lower popularity and visibility compared to other network members (as demonstrated by occupying a lower position relative to others on the Degree/Social hub scale, specifically ranked 5th), simultaneously he holds an increased influence in the indirect connection of other network members (as evidenced by ranking 2nd on the Betweenness scale).

In the case of testing Hypothesis No. 2 (fully validated), which addresses the hierarchy of power among network connections, the most significant observation is that the most visible connection within the network, namely the one between the individuals with the cryptonyms ”Lambda” and ”Kambda”, ranked 1st on the Social hub's connections measurement scale, does not have the highest potential influence in the indirect connection of other network members. In fact, this connection is ranked 3rd on the Link betweenness scale (which is shown graphically in Appendix no. 2.1).

Additionally, the relationship between ”Lambda” and ”Alfa”, ranked only 2nd on the Social hub’s connections scale of popularity and visibility is ranked 1st on the Link betweenness scale, that highlights the importance of interpersonal relationships based on the level of influence (control) that connections (pairs of two individuals) have in indirectly linking other members of the network.

One other highly relevant cases stand out, demonstrating that although the relationships rank lower on the visibility and popularity scale, they exhibit a high level of influence in the indirect connection of other network members, as seen in the case of the relationship between “Fipsilon” and “Omega”.

Therefore, these are the data that confirm Hypothesis No. 2 and show the importance of applying network analysis to criminal groups, as it reveals relationships that accumulate social capital and can influence in different ways the processes and phenomena occurring at the level of the social network. In this way, not only the visible relationships can be identified, but also the hidden ones.

Although it is not a frequently addressed topic in Romanian specialized literature, as highlighted in this article, the use of analytical technique of SNA proves useful and relevant for studying the characteristic features of the organizational structure of criminal networks, including networks formed by inmates. Examples of such specific features of these types of networks include their robust nature and the power positions occupied by individuals and connections with low visibility.

Finally, this study shows that decision-makers can be supported through the application of SNA's analytical principles in making decisions that lead to disrupting or dismantling criminal networks within detention, and, implicitly, in preventing and managing the undesirable effects they may generate at the social level.

References:

Andrei, A. (2013). Beneficiile golurilor structurale în rețelele sociale, evidențiate în teoria lui Ronald Burt. Revista Intelligence published on 07 mar 2013; site:

https://intelligence.sri.ro/beneficiile-golurilor-structurale-retelele-sociale-evidentiate-teoria-lui-ronald-burt/

Andrei, E.A. (2017). Secrete interconectate. Analiza Rețelelor Sociale. Revista Intelligence published on 29 mar 2017; site: https://intelligence.sri.ro/secrete-interconectate-analiza-retelelor-sociale/

Barabasi, A.L. (2017). Linked - Noua Ştiinţă a Reţelelelor Sociale, Timișoara, Romania.

Borgatti, S. P. (2005). Centrality and network flow. Social networks, 27(1), 55-71.

Burt, R. S. (2018). Structural holes. In Social stratification (pp. 659-663). Routledge.

Cavallaro, L., Ficara, A., De Meo, P., Fiumara, G., Catanese, S., Bagdasar, O., Song. W, & Liotta, A. (2020). Disrupting resilient criminal networks through data analysis: The case of Sicilian Mafia. Plos one, 15(8), e0236476.

Choudhary, P., & Singh, U. (2016). Ranking Terrorist Nodes Of 9/11 Network Using Analytical Hierarchy Process With Social Network Analysis, ISAHP Article: A Style Guide for Paper Proposals To Be Submitted to the International Symposium of the Analytic Hierarchy Process, London, U.K.; site: http://www.isahp.org/uploads/isahp16_proceeding_1155428.pdf

Ciupercă, E. M., & Vlăduțescu, Ș. (2014). Social capital in social networks. Neutrosophy, Paradoxism and Communication, 44-60.

Christakis, N.A., Fowler, J.H. (2015). Connected, Curtea Veche Publishing.

Committee on Network Science for Future Army Applications (2006), Study Report Network Science, National Research Council, Washington DC.

European Police Office (2011), Europol Review Gnereal Report on EUROPOL Activities; site: https://www.europol.europa.eu/cms/sites/default/files/documents/en_europolreview.pdf

Hansen, D.L., Shneiderman, B., Smith, M.A. (2011). Analyzing Social Media Networks With Nodexl, Burlington, USA; site: https://www.sciencedirect.com/book/9780123822291/analyzing-social-media-networks-with-nodexl

Hâncean, M. G. (2014). Rețelele sociale. MintRight Inc.

Karyotis, V., Khouzani, M.H.R. (2016). Malware Diffusion Models for Wireless Complex Networks, Cambridge, SUA; site: https://www.sciencedirect.com/book/9780128027141/malware-diffusion-models-for-modern-complex-networks

Luca, D. (2016). Connected – Puterea surprinzătoare a rețelei sociale și felul în care ne modelează viața; site: https://intelligence.sri.ro/connected-puterea-surprinzatoare-retelelor-sociale-si-felul-care-ne-modeleaza-viata/

Maryland Coordination and Analysis Center (2024). Using gang activity on social media to drive intelligence-led policing; site: https://mcac.maryland.gov/2024/01/using-gang-activity-on-social-media-to-drive-intelligence-led-policing/

McNulty, K. (2022). Handbook of graphs and networks in people analytics: with examples in R and python. Chapman and Hall/CRC.

Mircea Mitruțiu (2005), Curs analiza reţelelor sociale, Academia de Ştiinţe Ecomomic din Bucureşti; site: http://www.asecib.ase.ro/mps/Analiza_retelelor_sociale.pdf

Morselli, C., & Décary-Hétu, D. (2013). Crime facilitation purposes of social networking sites: A review and analysis of the 'cyberbanging' phenomenon. Small Wars & Insurgencies.

N. Harris Computer Corporation. i2 Analyst's Notebook v9.4.0; sites: https://docs.i2group.com/anb/9.4.0/about_degree.html;
https://docs.i2group.com/anb/9.4.0/about_eigenvector.html;
https://docs.i2group.com/anb/9.4.0/about_betweenness.html
https://docs.i2group.com/anb/9.4.0/about_link_betweenness.html

Smarandache, F., & Vladutescu, S. (2013). Neutrosophic emergencies and incidences.

Shakarian, P., Shakarian, J., Ruef, A. (2013). Introduction to Cyber – Warfare, 225 Wyman Street, Waltham, SUA; site: https://www.sciencedirect.com/book/9780124078147/introduction-to-cyber-warfare

Sukthankar, G., Goldman, R.P., Geib, C., Pynadath, D.V., Bui, H.H. (2014). Plan, Activity, and Intent Recognition, Waltham, SUA site: https://www.sciencedirect.com/book/9780123985323/plan-activity-and-intent-recognition

United Nations Office on Drugs and Crime (2019). Criminal groups engaging in cyber organized crime. Regional Perspective: Eastern and Southern Africa - added in April 2020; site: https://www.unodc.org/e4j/zh/cybercrime/module-13/key-issues/criminal-groups-engaging-in-cyber-organized-crime.html

Voicu, B., Rusu, H.M., Popa, A.E. (2015). Este România altfel? Societatea și sociologia… încotro?, Sibiu, România.

https://cambridge-intelligence.com

https://www.history.com

www.sciencedirect.com

www.researchgate.com