Qubahan Academic Journal
گوڤارا قبهان یا ئەکادیمی
مجلة قبهان الأكاديمية
Doi: 10.58429/Issn.2709-8206

Analysis of Academic Social Networks in Indonesia

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https://doi.org/10.58429/qaj.v3n4a289

***Abstract*—**Social network analysis to detect communities in social networks is a complex problem, this is due to differences in community definitions and the complexity of social networks. One of the social networks for researchers is the academic social network (ASN). We define the relationships between nodes in ASN into two forms, namely interconnection relationships and interaction relationships. Interconnection relationships are researchers' social relationships that are formed from similarities in discipline between researchers, while interaction relationships are researchers' social relationships that are formed through interactions carried out regarding joint article publications. This research aims to measure the social interactions and social interconnections of researchers in Indonesia using the social network analysis method. The ASN data used in this research comes from the academic social network Researchgate. This research produces information on the social networks of scientific groups in Indonesia and a framework for analyzing researchers' social networks using dual identification community mode which has been able to find and understand the structure of the research community based on records of interactions and interconnections with ASN with similarity values in both forms of network connections. 85.9%.

Keywords—Social network analytics, Community detection, Graph Clustering, Academic network.

1. INTRODUCTION

The current Big Data phenomenon produces a dataset that has a structure in which the relationship can be represented by a node and a edge in the network. This data comes partly from user-generated content, mobile sensors, remote sensing, video surveillance. The abundance of datasets available on the internet has an impact on the growing methods of data mining, analytical methods, and algorithms used to study, analyze, observe the structure, and dynamics of social networks. These developments present a new challenge to find solutions to various existing problems with social network analysis approach.

Social Network Analysis (SNA) is an approach that can be used to analyze and investigate social structure of social networking site users with network theory approaches and graph theory. Currently, social network analysis has been used to identify interactions between individuals or groups and determine social patterns and structures in the interaction, and can describe the behavior and dynamics between users of social networks. Social network analysis can also be used for mapping and measuring relationships between individuals, groups, and organizations [11], [2], [9], [8] such as: the strength of a country's researchers, analyzing and studying collaborations between students and counselors in scholarly publications, disseminating publications, communication among researchers, measuring scholarship flow, and measuring the strength of a country's research is to analyze various social cases of society such as terrorist groups, crime organizations, and narcotics groups etc [5], [7], [6], [4].

Currently, to perform social network analysis, both done at the level of element analysis, group analysis, and cores analysis has numerous network analysis methods that can be used to address such issues as network distribution, network segmentation, link prediction, community detection and others. For the purpose of detecting communities in social networks the method that can be used is community detection. Community detection is a method used to analyze complex networks allowing the study of the structure of mesoscopic which is often associated with the organizational and functional characteristics of the underlying network [13]. Community detection aims to find the (cluster) group as subgraph inside the social network. Community detection is a key that can be used to understand complex network structures and properties and can also be used as a tool to extract useful information from the social network [25].

The development and enhancement of algorithmic capabilities and approaches in doing social network analysis especially on community detection on social networks are also continuing. Some approaches and algorithms that have been developed include: Local Seed Selection Algorithm, Seed Set Expansion Algorithm, Speaker-listener Label Propagation Algorithm (SLPA), Multithreaded community detection (MCD), The Kernighan-Lin (KL) algorithm, Agglomerative / Divisive Algorithms, Spectral Algorithms [3], [14], [22], [16], [20], [17], [10]. Of the several approaches and algorithms, each has the ability and accuracy level of detecting communities on social networks. In the group analysis level, the informal community is a group that has a high interconnection and interaction relationship in a network. Detecting communities in social networks is a complex issue, due to a different community and community text decisions community detection to detect them. High resolution is a variable used to improve the relationship between node and edge in non-overlapping and overlapping networks on social networks.

The development of social network analysis involves the development of algorithmic methods and capabilities in various cases used to analyze various network forms such as dynamic network, heterogeneous networks, and directed networks on social networks [15]. In addition, in many cases, community detection on social networks has become problem solver to detect group dynamics with various approaches such as parallel community detection [20], [17].

In Academic Social Network (ASN), community detection is used to detect a research community based on research, science, research collaboration, and authorship relationships in published articles. The researcher's network can be modeled using network relationships through interconnection and interaction relationships that are denoted as:

$$(G = V, E) \qquad (1)$$

Each researcher is denoted as a node (V) on the network, and the relationship between the researchers either interconnects or interactions are denoted as edge (E), so ASN can be studied in structure and properties through several methods and network analysis techniques.

In ASN, communities are formed through two forms of relationships:

- Interconnection. In ASN the interconnection relationship is the relationship of researchers formed through the similarity of the field of science (discipline) between researchers. The interconnect is a self-claim of each researcher posted on a public profile on the ASN website. The phenomenon of community formation based on the similarity of the field of science (discipline) is hereinafter referred to as a stable community.

- Interaction. In ASN the process of interaction is the relationship of researchers formed through scientific interaction in writing articles together (publication) that occurred between researchers published on ASN. The phenomenon of community formation based on this publication interaction is hereinafter referred to the as dynamic community.

The interconnection network is the set of researchers denoted as the (V) node that has a relation of the field of science (discipline) between researchers denoted as (E) edges where this relation is defined as:

$$G_c = (V, E_c) \quad (2)$$

G_c is an interconnect Graph; V is a node researcher; E_c is an interconnect relation in the field of science similarity between researchers (discipline).

The interaction network is the set of researchers denoted as the (V) node which has an interaction relation on co-authoring (publication) denoted as the (E) edge where this relation is defined as:

$$G_i = (V, E_i) \quad (3)$$

G_i is Graph interaction; V is a node researcher; E_i is an interaction relation in the publication relationship.

One of the dynamics that occur in ASN is the joining of a node into a community subgraph caused by dynamical dynamics edge dynamics. This condition is referred to as a joint community. The joint community is a condition where a node previously not a member of the C set, then merges into a member of the C set. This condition is defined as:

$$C = (V', E') \cup v_{i,j} \in (V', E') \quad (4)$$

In addition, the dynamics that occur in ASN leave the community. Where a condition of a previous node is a member of the set C, then exit from the set member C. This condition is defined as:

$$C = (V', E') - v_{i,j} \in (V', E') \quad (5)$$

The formation of a subgraph community on the academic social network can be caused by the interconnection of a node in the network. The node in a social network of academics is determined on the basis of equality of science, expertise, institutions, and organizations. The condition of the formation of community subgraph based on the interconnection will reach a stable position, hereinafter referred to as a stable community. Stable Community is a subgraph formed based on the interconnection relationship defined by C_stable. This interconnection relationship can occur in two ways, namely 1) dynamics internal degree or also called self-clamp, 2) dynamics external degree.

The dynamics that occur based on the interaction of node in the social networking community of academia are called dynamic community. Dynamic Community is a subgraph community formed based on an interaction relationship defined with C_dynamic. The interaction can be a publication with authorship and citation interaction in a published article citation. The higher external degree a subgraph, the more the number of community available on the academic social network.

The high dynamics of a node indicates the number of edges is getting higher as well. The degree of a vertex is the total interconnected edges and interactions connected to node denoted by d(v) on graph theory and in complex network theory with k(v). Furthermore, this research uses the k(v) notation to determine the degree of nodes in community or subgraph. A node that has an elevated degree of vertex will be used as the initial node or also called seed to perform the next analysis of finding a community in a graph (social network of academics).

The interconnection and interaction relations that occur in ASN are shown on researchgate.net site (RG). ASN is used by researchers to communicate, collaborate and share articles related to various research topics and fields of science that have been published either nationally or internationally. Interconnection relationships between researchers can be formed through relationships based on similarities in disciplines, fields of expertise, institutions/universities. While interaction relations can be formed through publication relationships, citation relationships in articles citation, transaction information through article sharing and collaboration relationships.

In ASN, the formation of a research community based on the similarity of discipline and field of expertise derives from the dynamic process that occurs in the interaction relationships in the publication, but still needed empirical proof of this phenomenon. In proving this phenomenon, RG data is representative data for use in proving and detecting communities in ASN. The interaction dynamics

that occur in ASN open up new research space from the heterogeneity point of view that can be utilized to create methods and formalization of community dynamics.

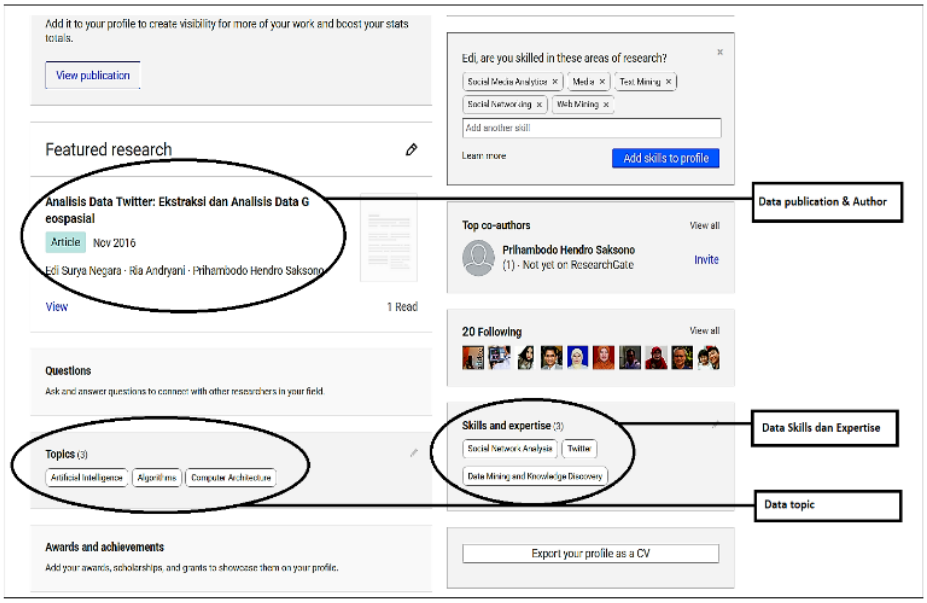

Figure 1. Researchgate data source.

In this article, we propose frameworks and methods that can prove a stable community (interconnection community) in ASN derived from dynamic community dynamics (interactions community). The proof is done by using a network analysis approach and using the community detection method developed with the capabilities of dual-mode identification as an instrument used to uncover the social structure of researchers and recognize the research community based on interaction recordings on social networks. Dual mode identification works in parallel to detect communities in stable communities and dynamic communities.

2. ACADEMIC SOCIAL NETWORKS

Academic Social Network (ASN) is a social relationship of researchers with interconnection and interaction links on academic social network sites for academic and scientific activities. The academic social network is used by researchers to connect, communicate, collaborate and share articles related to various research topics and areas of science that are being worked on or have been published either nationally or internationally. Currently, popular academic social network sites used by researchers are Researchgate (RG) and Academia. These two institutions provide channels and full collaboration facilities for academics and researchers to interconnect and scientific interaction.

RG is an institution formed in 2008 by a physician named Ijad Madisch in Berlin, Germany. Currently, RG has 12+ million members, 100+ million publications from 193 countries with various fields such as Medicine, Biology, Engineering, Chemistry, Computer Science, Physics, Other. Currently, in RG there are 63 winners of Nobel prize and 86% of members have qualified Postgraduate, [16].

Researchers in RG can create and modify profiles, download / upload publications, view, comment, create questions / answers, follow or be followed by other researchers. The main advantages of RG are the features that allow researchers to save the archives of publications, build a scientific reputation text scientific through the stats & matrics feature of published publications, and exchange publication information that will be resulting in good publicity visitability and knowledge sharing.

The same is done by Academia. The institute has also built a collaborative system of researchers with features almost similar to RG. Academia was founded by Richard Price in 2008 in San Francisco, California. In accordance with the mission of this institution is to accelerate world research, user or

member growth is very significant. Currently, the number of researchers incorporated into the academic social network reaches 48,342,924 million people with 17,572,491 articles, [1].

The ASN data used in this study is the RG data of researchers in Indonesia. These data include discipline and publication data. The data is used as input data to answer the formulation of the problem of finding the community on ASN based on the interconnection on the discipline field discipline and the interaction on the publication, see Figure 1. Data discipline is data drawn from the RG site indicating the science field of researchers based on the scientific discipline of the researcher, while the data published in RG shows the published publication data by the researchers either in the form of articles published in national journals, international journals, national seminars and international seminars.

3. METHODOLOGY

This research is divided into 5 stages shown in Figure 2, namely:

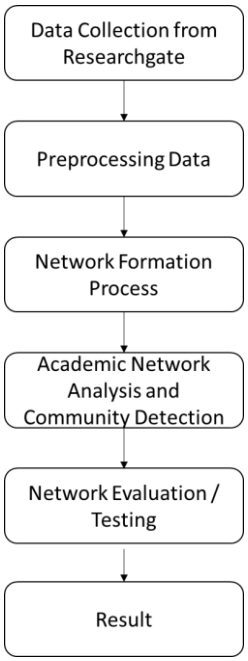

Figure 2. Research stage.

1. Data Collection from Researchgate.

Data collection was carried out using web crawler tools developed using the Python programming language. The data taken is user or profile data, publication data, and scientific discipline data.

2. Data Preprocessing.

Data preprocessing is carried out to clean data from noise obtained during the data collection process.

3. Network Formation Process.

The network formation stage of the researcher aims to construct the network researchers are represented into a graph . The process of forming a research network begins with the process of data withdrawal using a crawler, then the data generated from the process of data withdrawal is processed into a data warehouse. The construction of each node and edge is done to form the graph which is then performed by the measurement of centrality betweenness. After that, the process of community detection is carried out to detect the existing communities in the network of researchers based on the similarity of scientific discipline and publication.

The process of network formation is the stage to perform the network construction based on the interconnection and interaction relationships that occur in the social network of academics and researchers on the site researchagate.net. The process of network formation is done by connecting each node with the edge in accordance with the dataset RG researcher Indonesia that has been generated from the process of data withdrawal. The networking process of academia and researchers using the "user data" denoted as (V) and "disciplines data" denoted by (E_c) resulted in a network of academics and researchers based on the Gc=(V,E_c). The network construction process of academia and researchers using "user data" as the (V) node and using "data publication" denoted as (E_i) generates a network of academics and researchers based on the interaction of Gi=(V,E_i). Figure 3. shows the process of networking academics and researchers who conducted in this study.

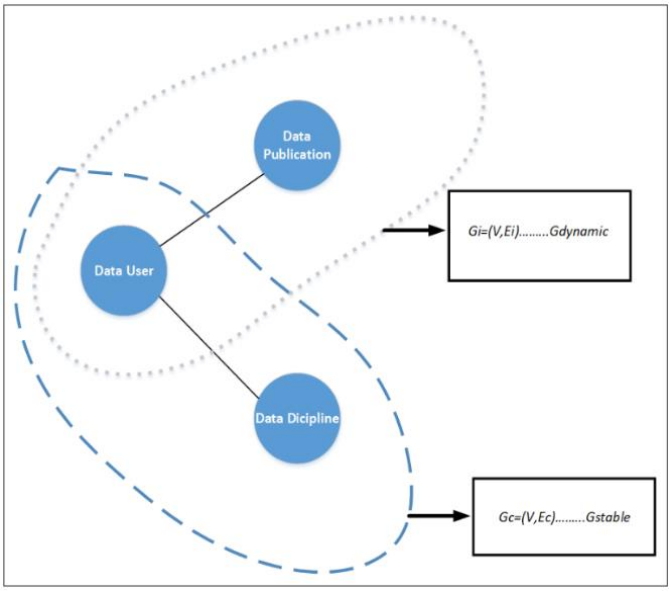

Figure 3. The process of networking researchers.

In general, at this stage two networks are generated: networks based on the field of science (discipline) or called the network stable, (G_c=(V,E_c).....G_stable) and the network based on the research area (publication) or called the network dynamic, (G_i=(V,E_i).....G_dynamic. The process of networking academics and researchers at this stage results in relationships with different types, namely the (G_c=(V,E_c) node represents discipline and the actor, while on the network (G_i=(V,E_i) node represents publication and actor The actor on this network represents an academic or researcher The combination of two different types of nodes on this network is called the network two mode.

Table 1. Indonesia network researchers data based on Researchgate.

Graph	Number of *nodes*	Number of *edges*
Network Interconnection *discipline network*	15.436	53.848
Network Interaction *publication network*	4.579	4.269

4. Academic Network Analysis and Community Detection.

Detects communities on ASN based on interconnection and interaction happens to be done to know the structure of ASN community by field science (discipline) and know the process of formation of community based interactions that occur in publications [23].

In this process, two datasets are generated: interconnection network datasets and interaction network datasets, see Table 1. In the interconnection network dataset G_c=(V,E_c), the network discipline consists of 15,436 nodes and 53,848 edges connected to each other. In the interconnection network, nodes represent discipline and the actor. Meanwhile, this edge of the network represents the interconnection relationship between nodes consisting of the relationship of discipline with the actor, the actor's relationship with the actor via discipline, and the related discipline with discipline through the actor. The result of the visualization of the interconnection network using application Gephi is shown in Figure 3.

In the interaction network dataset G_i=(V,E_i), the network publication consists of 4,579 nodes and 4,269 edges connected to each other. In network interactions, nodes represent publication and actors. The edge of this network represents the interaction relationship between vertices consisting of the relationship of publication to the actor, the actor's relationship with the actor via publication, and the relationship publication with publication through the actor.

5. Network Evaluation.

After the networking process, the next process is the testing process network researchers. Network testing process researchers conducted by determining the data testing that can represent every possible community that exists on the network interconnection and interaction. Data testing consists of interconnection community data and interaction community data which will further be measured similarity of network structure (graph) using graph similarity technique.

4. DISCUSSION

The community detection process has resulted in a (C_c=V',(E')_c) and community interaction.

community (C_i=V',(E')_i) research community in Indonesia. An interconnection community is formed through the detection of every node on the same network of science (discipline). In order to connect any vertex having the same (discipline) field, in the developed method, the addition of a connecting node representing the discipline field of science. After that, the detection process is done by making the connecting node as central in detecting community based on the science field of (discpiline). Similar to the interconnection community, interaction communities are also formed through a process similar to the interconnection community detection process.

In evaluating the results of the study, we used the interconnection community data (C_c=V',(E)_c) and the interaction communities (C_i=V'(E)_i) in Indonesia obtained through the data retrieval process. The interconnected community data and generated interaction communities become input data in analyzing interconnection network structures and network interactions. The analysis of the interconnection network structure aims to answer the research questions and see how the community structure of researchers is based on the field of science (discipline) so that it can provide community science anything in Indonesia and the science community (discipline) is the largest based on the self-claim or declaration itself. While interaction network structure analysis aims to answer research questions and see how the structure of the research community based on publications (publication) conducted by researchers so as to provide information researchers who have interaction and high productivity in generating publication.

To analyze the dual mode community detection, we use test data in the proof process. Test data were obtained from interconnected community data and community interactions that have been previously obtained. The selection of test data is done by considering every phenomenon in the academic social network which can be represented in the test data.

The initial stage in conducting an analysis of the research results is by preparing "interconnection test data" and "interaction test data". Interconnection test data is a community data consisting of 11 vertices and 20 edges, while interaction test data consists of 11 nodes and 10 edges generated from the community detection process in the previous stage. Interconnection test data and interaction test data have shown Figure 4.

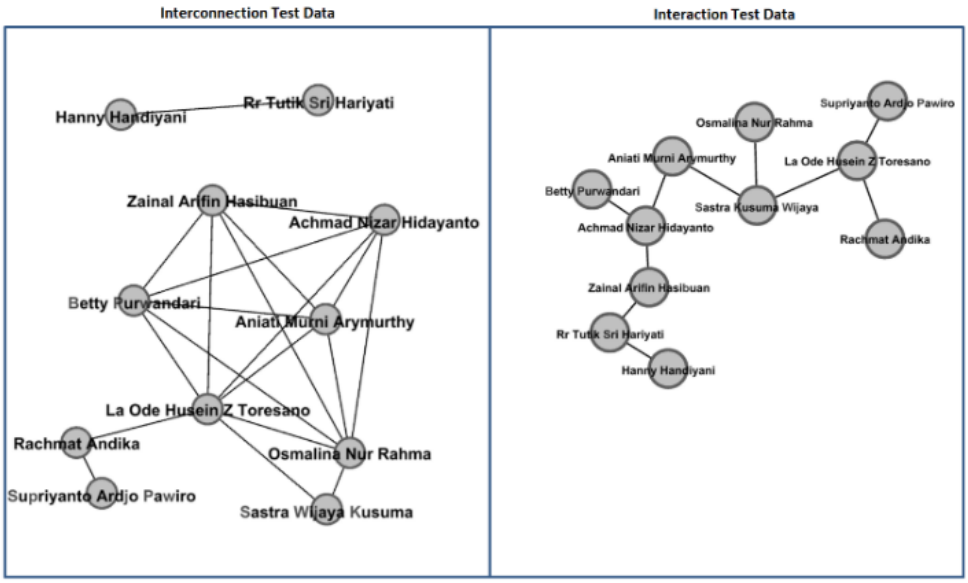

Figure 4. Interconnection and interaction testing data.

After the test data is prepared, the next process is to conduct structural analysis for interconnection community data and interaction community data. The measurement of community structure is done by calculating betweeness centrality, degree, and modularity on each community data.

After the network structure measurement is done, the next step is to do an overlapping analysis to see the differences in the structure of the two community data, ie interconnection community data and community interaction data. To prove the dynamics that occur conducted an analysis of similarity to each community found in the previous process. Overall, evaluation of research results proves the dynamics that occur in each community.

4.1. Network Structure of Researcher

This section describes the results of the researcher network structure based on Researchgate data. The network structure measured includes the degree of a node and average degree, diameter, distance, centrality, and modularity. Measurements were made for both datasets, namely interconnected network data and interaction network data.

- Interconnection Network Structure.

Measurements of the interconnect network (G_c=V,E_c) are performed with several parameters, namely: degree of node and avarage degree, diameter, distance, centrality and modularity. Interconnection network structure consisting of 15,436 nodes and 53,848 edges. The interconnection network structure is shown in Figure 5.

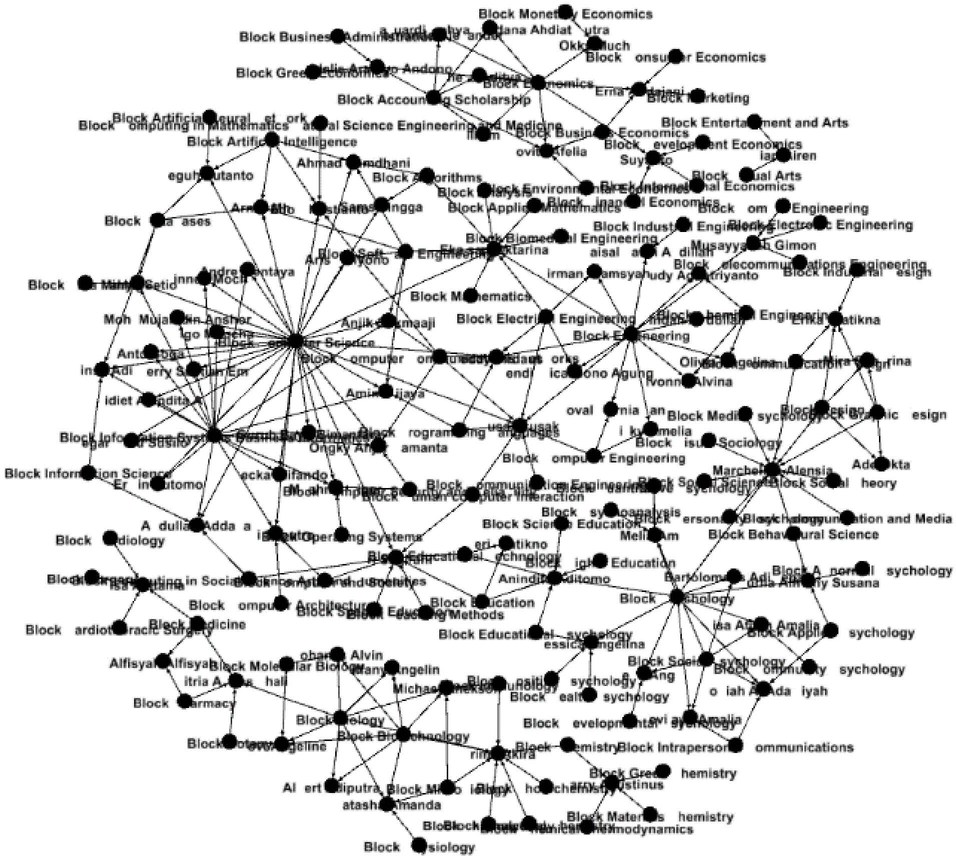

Figure 5. Interconnection network structure.

The degree of the node and the degree of avarage degree are degrees that indicate the number of links connected to a node. This measurement aims to find out that many nodes are connected with other nodes. The measurement results show the average degree of interconnection network ($G_c=V,E_c$) average degree = 3.488. In the directed network there is in-degree k_i^{in} that is the number of links to the node and out-degree k_i^{out} is the number of links going out of the node. Based on the results of the degree calculation conducted on the interconnection network ($G_c=V,E_c$), the research community is based on the largest discipline in Indonesia based on the interconnection records that occur at the Researchgate site [16]:

1. Engineering.
2. Economics.
3. Medicine.
4. Computer Science.
5. Social Science.
6. Psychology.
7. Biology.
8. Chemistry.
9. Education.
10. Mathematics.

Measurement of the centrality of a node is done by using the parameters betweenness centrality, closeness centrality, and eigenvector centrality which produces the most central node in the ($G_c=V,E_c$) network. The result of measurement of betweenness centrality, closeness centrality, is used as a parameter to measure diameter and distance, where the diameter is the maximum shortest distance between two vertices and distance is the average distance between all node pairs in network ($G_c=V,E_c$). The

measurement results show the interconnect network (G_c=V,E_c) diameter = 1, and distance = 1.0. Measurement of modularity is one measure of network structure which is used to measure the power of network division into modules (also called groups or communities). The measurement results on the interconnect network (G_c=V,E_c), modularity = 0.747.

- Interaction Network Structure.

Measurement of the (G_i=V,E_i) network of interactions is done with several parameters, namely: the degree of vertices and mean degrees of the text (average degree), diameter, distance, centrality, and modularity. Interconnection network structure consisting of 4,579 nodes and 4269 edges. The interaction network structure is shown in Figure 6.

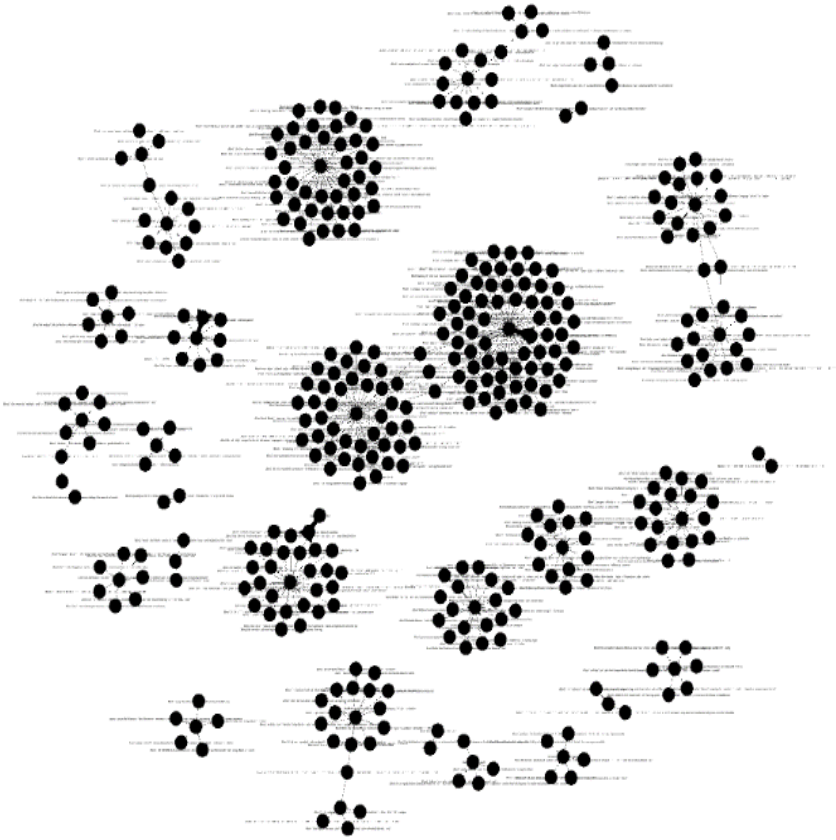

Figure 6. Interaction network structure.

The degree of a node and average degree is a degree that shows the number of links connected to a node. This measurement aims to find out that many nodes are connected with other nodes. The measurement results show the average degree of interconnection network (G_i=V,E_i) average degree = 0.932. The measurement of the centrality of a node is done by using the betweenness centrality, closeness centrality, and eigenvector centrality parameters which produce the most central node in the network (G_i=V,E_i). The measurement result of betweenness centrality, closeness centrality, is used as a parameter to measure the diameter and distance, where the diameter is the shortest maximum distance between two vertices and distance is the average distance between all node pairs in the network (G_i=V,E_i). The measurement results show the interconnect network (G_i=V,E_i) diameter = 1, and distance = 1.0. Measurement of modularity is one measure of network structure which is used to measure the power of network division into modules (also called groups, groups or communities). The measurement results on the interconnect network (G_i=V,E_i), modularity = 0.988.

Table 2 shows the results of the interconnection network analysis (G_c=V,E_c) and the interaction network (G_c=V,E_i) in the avarage degree, diameter, distance, centrality, and modularity.

Table 2. Interconnection and interaction Indonesia researcher network structure.

Graph	Avarage degree	Diameter	Distance	Modularity
Interconnectionnetwork	3.488	1	1.0	0.747
Interaction network	0.932	1	1.0	0.988

4.2. Analysis of Similarity Interconnection and Interaction Indonesia Researcher

The dual mode of community identification is a method developed in this study. The dual mode of community identification works by detecting communities on the interconnection network (G_c=V,E_c) and the interaction network (G_i=V,E_i) researchers in parallel and performs a verification process based on similarity of the network. The community identification process in this study uses prepared test data that is capable of representing each interconnection phenomenon and interaction phenomena that occur in the researcher.

To measure the resemblance of the interconnection community and the interaction community by using a double mode of identification the working community used structural similarity graph method. The structural similarity works by calculating the similarity of two graph structures based on the edit distance graph [12]. Graph edit distance is the number of operations needed to match between graphs with one another. The operation graphs used include the insertion node, deletion node, and substitution node. This graph edit distance can be calculated by the following Equation 6.

$$|sn| + |se| + 2\Sigma_{(n,m)\in M} 1 - (Sim(n,m)) \qquad (6)$$

Where :

- sn = the number of additions or node deletions. sn is obtained from the difference between the number of vertices of the two graphs with the same number of vertices.
- se = the number of edge additions or deletions. se is obtained from the difference between the number of edges that have the same node from graph one to another graph.

To calculate the similarity graph edit distance from both graphs is to use the following Equation 7.

$$Sim = 1 - avg(snv, sev, sbv) \qquad (7)$$

Where:

$$snv = \frac{|sn|}{|N1|+|N2|}$$

$$sev = \frac{|se|}{|E1|+|E2|}$$

$$sbv = \frac{2\Sigma_{(n,m)\in M} 1 - (Sim(n,m))}{|N1| + |N2| - |sn|}$$

The equivalent interconnection community similarity test (C_c=V',(E')_c) with interaction communities (C_i=V',(E')_i) is done using interconnection community test data.

Evaluation of dual mode community identification results focuses on proving structural similarity from the interconnection community (C_c=V',(E')_c) and the interaction community (C_i=V',(E')_i). The proof is done by using 11 community interconnection data and 11 community interaction data that have been through the graph partition process. Partition graph is carried out with the aim to facilitate the verification process. Partition graph process is done by taking into account the interconnections and interactions that occur at each node.

The verification process begins by representing each interconnection and interaction community into a matrix. Then the structural similarity analysis of each community was carried out. The results of the verification of similarity in the test data prove that the average level of interconnection community similarity is (C_c=V',(E')_c) and interaction community (C_i=V',(E')_i) is 85.9% . These results prove that the interconnection community (C_c=V',(E')_c) or the so-called stable community is formed through a dynamic process that occurs in the interaction community (C_i=V',(E')_i) or what is called the community dynamic.

5. CONCLUSIONS

Analysis of academic social networks with modes of interaction and interconnection among Indonesian researchers shows the dynamics of the group formation process with a similarity of 85.9%. The structure of the Indonesian research group based on the interconnection network G_c=(V,E_c) consisting of 15,436 nodes and 53,848 edges shows an average degree of =3.488 and modularity =0.747. The structure of the Indonesian research group based on an interaction network consisting of 4,579 vertices and 4269 edges shows an average degree of =0.932 and modularity =0.988. From the results of structural measurements, researchers in Indonesia show that the average degree of network interaction is higher than the average degree of network interconnection, and modularity measurements in both networks show that the interaction network has a higher modularity value than the interconnection network. From this research it is also concluded that the largest scientific discipline in Indonesia currently is Engineering.

REFERENCES

[1] Academia.edu. About academia. 2017.

[2] Anggraini, D., Madenda, S., Wibowo, E. P., and Boumedjout, L. Network disintegration in criminal network. In 2015 11th International Conference on Signal-Image Technology Internet-Based Systems (SITIS), 2015. pages 192–199.

[3] Clauset, A. Finding local community structure in networks. Physical review E, 2005. 72(2):026132.

[4] Fagan, J. The social organization of drug use and drug dealing among urban gangs. Criminology, 1989. 27(649-652).

[5] Framis, A. Illegal networks or criminal organizations: Power, roles and facilitators in four cocaine tracking structures. 2011. In In Third Annual Illicit Networks Workshop, Montreal.

[6] Kerschbaum, F. and Schaad, A. Privacy-preserving social network analysis for criminal investigations. In in Proceedings of the 7th ACM workshop on Privacy in the electronic society (WPES08), 2008. pages 9–14. Association of Computing Machinery.

[7] Klerks, P. The network paradigm applied to criminal organisations: Theoretical nitpicking or a relevant doctrine for investigators? recent developments in the netherlands. 2001. Connections, 24(53-65).

[8] Kriegler, A. Using social network analysis to profile organised crime, policy brief 57. 2014. Technical report, Institute for Security Studies.

[9] Mastrobuoni, G. and Patacchini, E. Organized crime networks: an application of network analysis techniques to american mafia. 2012. Review of Network Economics, 11(10).

[10] Negara, E. S. and Andryani, R. A review on overlapping and non-overlapping community detection algorithms for social network analytics. 2018. Far East Journal of Electronics and Communications, 18(1):1– 27.

[11] Negara, E. S., Kerami, D., Wiryana, I. M., and Kusuma, T. M. Researchgate data analysis to measure the strength of indonesian research. 2017. Far East Journal of Electronics and Communications, 17(5):1177–1183.

[12] Nindyasari, R. Pengukuran similaritas struktural pada model proses bisnis (studi kasus: Order to cash dan procure to pay dalam sistem erp). 2015. Simetris: Jurnal Teknik Mesin, Elektro dan Ilmu Komputer, 6(1):111–118.

[13] Papadopoulos, S., Kompatsiaris, Y., Vakali, A., and Spyridonos, P. Community detection in social media performance and application considerations. 2011. Data Min Knowl Disc.
[14] Parthasarathy, S., Ruan, Y., and Satuluri, V. Community discovery in social networks: Applications, methods and emerging trends. 2011a. In Social Network Data Analytics, pages 79–113. Springer US.
[15] Parthasarathy, S., Ruan, Y., and Satuluri, V. (2011b). Community discovery in social networks: Applications, methods and emerging trends. 2011b. In Social Network Data Analytics, pages 79–113. Springer US.
[16] Reserachgate Press. About reserachgate. 2017.
[17] Riedy, E. J., Meyerhenke, H., Ediger, D., and Bader, D. A. Parallel community detection for massive graphs. 2011. In International Conference on Parallel Processing and Applied Mathematics, pages 286–296. Springer.
[18] Riedy, J., Bader, D. A., and Meyerhenke, H. Scalable multi-threaded community detection in social networks. 2012. In Parallel and Distributed Processing Symposium Workshops & PhD Forum (IPDPSW), 2012 IEEE 26th International, pages 1619–1628. IEEE.
[19] Tian, B. Parallel community detection on massive graphs. 2016.
[20] Whang, J. J., Gleich, D. F., and Dhillon, I. S. Overlapping community detection using seed set expansion. 2013. In Proceedings of the 22nd ACM international conference on Conference on information & knowledge management, pages 2099–2108. ACM.
[21] Xie, J., Kelley, S., and Szymanski, B. K. Overlapping community detection in networks: The state-of-the-art and comparative study. 2013. ACM computing surveys (csur), 45(4):43.
[22] Xie, J. and Szymanski, B. K. Towards linear time overlapping community detection in social networks. 2012. In Pacific-Asia Conference on Knowledge Discovery and Data Mining, pages 25–36. Springer.
[23] Brianna, D.F., Negara, E.S. and Kunang, Y.N., Network Centralization Analysis Approach in the Spread of Hoax News on Social Media. 2019. In 2019 International Conference on Electrical Engineering and Computer Science (ICECOS), pp. 303-308. IEEE.