# Analyzing Social Structures: Blogger Ego Networks on Google+

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## Abstract

**Online social networks like Facebook, YouTube, and Instagram have revolutionized communication, connecting billions of active users worldwide. Among these platforms, Google Plus (Google+), despite its discontinuation in 2019, presents a unique opportunity to study early social media dynamics. Google Plus introduced features such as "circles," allowing users to organize their personal networks and manage information streams. Although the platform faced adoption challenges, analyzing the behavior and connectivity of bloggers on Google Plus provides valuable insights into community formation, content dissemination, and core-periphery dynamics within the social media ecosystem of the early 2010s. This study aims to uncover the influence, connectivity, and roles of bloggers through an in-depth analysis of the ego networks of eight bloggers from the ego-Gplus dataset, part of the Stanford Large Network Dataset Collection, which includes 132 ego networks. The analysis applies Social Network Analysis (SNA) techniques learned in the Complex Data Analysis course at the Faculty of Science of the University of Lisbon. The findings reveal a dynamic interplay of strong and weak ties, centralized and decentralized structures, and influential nodes that shape the Google Plus blogger ego networks. The research highlights the resilience and adaptability of online communities, suggesting that some groups may have migrated to other platforms following the shutdown of Google Plus.**

## Keywords

**EgoNetwork, EgoNode, Deep Analysis, Network Science, Social Media, Directed Graph, Blogger, Gplus, Google Plus, SNA, Social Network Analysis**

## 1 Introduction

Online social networks such as Facebook, YouTube, or Instagram have introduced new forms of communication into our society and have become increasingly popular. Currently, the three main platforms mentioned account for approximately 7.569 million active users [6]. Online social networks allow us to follow streams of posts generated by hundreds of friends and acquaintances. However, these individuals produce overwhelming volumes of information, and to manage this information overload, we need to organize our personal social networks [1].

One of the primary mechanisms social network users employ to organize their networks and the content generated within them is grouping friends and acquaintances into social circles. Almost all major social networks offer this functionality, for example, Facebook provides this feature in the form of "lists," and Google Plus offers it as "circles." Once created, these circles enable users to filter content, set privacy settings, and share user groups that others may wish to follow.

In the case of the social network Google Plus, it is worth mentioning that this platform, developed by Google, was launched in June 2011 and discontinued for consumers in April 2019. Despite the initial enthusiasm and heavy promotion by Google, the platform struggled to gain widespread adoption and faced challenges in competing with established social networks such as Facebook, Twitter (now X), and LinkedIn. However, a version for enterprise (Google Currents) persisted as part of Google Workspace until it was replaced by Google Chat in 2023.

Although Google Plus (Google+) was discontinued in 2019, investigating the presence of bloggers on this platform remains interesting. Studying bloggers on Google+ is still relevant as it offers insights into the social media ecosystem of the early 2010s. Additionally, analyzing how bloggers connected within and across their circles provides valuable understanding of community formation, content dissemination, and the dynamics of core-periphery structures. Therefore, the purpose of this study is to uncover what the networks reveal about bloggers' influence, connectivity, and roles within the Google Plus ecosystem.

This investigation analyzes the ego networks of eight bloggers on the Google Plus platform using Social Network Analysis (SNA) techniques to evaluate differences and similarities among the networks and understand the potential effects of varying network dimensions. By employing SNA techniques, this research contributes to the growing field of network science and provides insights into the unique characteristics of individual bloggers' roles within the ecosystem.

## 2 Literature Review

Ego networks models describe the social relationships of an individual (ego) with its social peers (alters). A series of Analysis conducted on different OSNs have shown that online ego networks have the same structural properties found in offline social environments. Specifically, the work by *Gonçalves et al.* found the first evidence of Dunbar's number in Twitter [2]. The Dunbar Number is a theoretical cognitive limit to the number of meaningful social

relationships a person can maintain. Proposed by British anthropologist *Robin Dunbar*, the number is often cited as around 150 relationships, though it can vary slightly depending on context and individual differences. Dunbar's theory suggests relationships are organized into concentric circles of intimacy: 5 close friends, 15 good friends, 50 friends (regular social connections), and 150 casual friends (stable relationships), where larger circles represent weaker or more peripheral relationships (500 acquaintances, 1,500 people you can recognize).

Regarding bloggers, some of the studies related to bloggers characteristics are the effect of gender on content and writing style of blogs (Herring et al., 2005; Armstrong & McAdams, 2009), role of gender in switching behavior of bloggers (Zhang et al., 2009), perception of credibility of blogs (Armstrong & McAdams, 2009). Herring et al. (2005) found that the writing of female bloggers is primarily interpersonal whereas that of male bloggers tends to be informative. The perceived credibility of blogs is influenced by gender, writing style and the information seeking nature of the reader of the blog (Armstrong & McAdams, 2009). Majority of women's blogs are usually journals or diary entries. Men more often discuss politics, technology, and money, and their blogs are deemed to be more credible (Armstrong & McAdams, 2009). Switching behavior has been found to vary based on gender. Whereas women tend to care most about satisfaction and are likely to switch only if they are not satisfied, men tend to switch blogs if they find some other attractive alternative (Zhang et al., 2009). Bloggers are highly interconnected, reading each other's blogs, linking to the blogs of others, and referring to other blogs in their own writing (Du & Wagner, 2006). Thus, online communities are increasing rapidly due to the ubiquitous nature of the Web (Taricani, 2007).

# 3 Methodology

## 3.1 Dataset Description

The dataset was provided by Stanford Network Analysis Platform (SNAP)[5] which is a general purpose, high performance system for analysis and manipulation of large networks. It includes a collection of large network datasets and from which it was selected ego-Gplus [5] social network to conduct this analysis.

This dataset is a directed network with 107.614 nodes and 13.673.473 edges and it consists of 'circles' from Google+. Google+ data was collected from users who had manually shared their circles (e.g., "Friends," "Colleagues") using the 'share circle' feature. The dataset includes node features (profiles), circles, and ego networks.

The data set is composed of the following files:

- **gplus.tar.gz** - contains individual ego networks for 132 users;
- **gplus_combined.txt.gz** - combines the edges (connections) from all 132 ego networks into a single, large graph;
- **readme-Ego.txt** - provides a detailed description of the dataset, including: File formats and structures, with the definition of the terms of this network (e.g., circles, ego networks);

For the creation of the subset, it was decided that the best way to analyze different networks was by choosing some similarity between them, so, since some entities of the dataset had a job title attribute, it was chosen the job blogger. For the selection of the files, a function (*isBloggerNetwork* [3]) was made that obtained all the Ego Networks that had this job, giving in total 8 Ego Networks.

## 3.2 Network Construction

As it was mentioned before, obtaining the ego networks involved using a function that analyzed the dataset files and their features, specifically focusing on entries with a job title of "blogger." After obtaining the relevant ego networks, they were transformed into networks, allowing for the extraction of corresponding files containing detailed information such as feature names, edges, followers, and circles.

To efficiently store this extracted information, individual functions were created for each data type. During the process, a discrepancy was found between the numbers of nodes and edges in the full dataset and the files. After investigation, it was decided to use the values from the full dataset due to higher accuracy and consistency. Additionally, for the nodes in the networks, duplication in the circles and possibly in the followers category was calculated and stored.

The edges between nodes in the network represent different types of connections, edges closer to the Ego Node (the central node) suggest a possible "friendship" or a stronger relationship, indicating a closer social or professional connection. In contrast, edges connecting nodes farther from the Ego Node may represent a simpler form of interaction, such as following someone with shared interests or being part of the same community.

## 3.3 Analytical Methods

In order to further deepen the understanding of the chosen ego networks, they were submitted to a deep analysis through Social Network Analysis (SNA) techniques. These can be Centrality Measures such as Degree Centrality, which represents the number of direct connections a node has; Closeness Centrality, calculates how quickly a node can interact with all other nodes in the network and it measures the average length of the shortest paths to all other nodes, identifying efficient information spreaders; Betweenness Centrality, identifies nodes that frequently act as bridges between other nodes and it measures how often a node appears on the shortest paths between pairs of other nodes, highlighting important gatekeepers of information; Eigenvector Centrality, measures a node's influence based on the centrality of its connections and assigns higher scores to nodes connected to other high-scoring nodes, revealing nodes with connections to influential parts of the network.

Besides Centrality Measures, Network Level Measures were also conducted such as Average Degree, which is the mean number of connections per node in the network; Density, which measures the proportion of actual connections in the network compared to the total possible connections; Average Clustering Coefficient, which measures the degree to which nodes tend to cluster together and it quantifies how tightly-knit the network is and can indicate the presence of local communities. Community Detection, measures such as the Louvain Algorithm which is a method for detecting communities within networks, optimizes modularity to find groups of nodes that are more densely connected to each other than to the rest of the network.

To perform such analysis it was used Visual Studio Code, Google Colab and used the *Network X*[4] library on Python 3.10, together with the default libraries such as *numpy* and *matplotlib*.

# 4 Results and Discussion

## 4.1 Descriptive Analysis

For a better comprehension of the Ego Network, it was decided to replace the original 22 character values of the ID, for a easier 4 character ID, where it represent the first and last 2 digits of the network, being display as such:

- EgoNet ID: 104987932455782713675 –> EgoNet ID: 1075;
- EgoNet ID: 106724181552911298818 –> EgoNet ID: 1018;
- EgoNet ID: 108541235642523883716 –> EgoNet ID: 1016;
- EgoNet ID: 118107045405823607895 –> EgoNet ID: 1195;
- EgoNet ID: 116825083494890429556 –> EgoNet ID: 1156;
- EgoNet ID: 110809308822849680310 –> EgoNet ID: 1110;
- EgoNet ID: 101626577406833098387 –> EgoNet ID: 1087;
- EgoNet ID: 107489144252174167638 –> EgoNet ID: 1038;

Here are the graphs generated for each of the eight ego networks identified in the Google Plus dataset. These visualizations provide a graphical representation of the network structures, highlighting the connections, clustering, and community formations within each ego network.

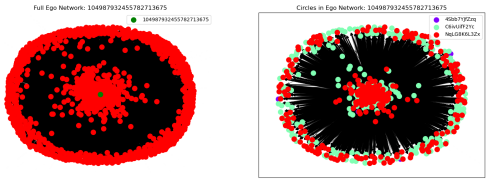

**Figure 1: EgoNet ID: 1075**

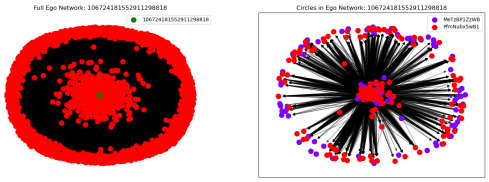

**Figure 2: EgoNet ID: 1018**

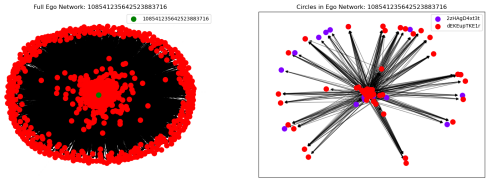

**Figure 3: EgoNet ID: 1016**

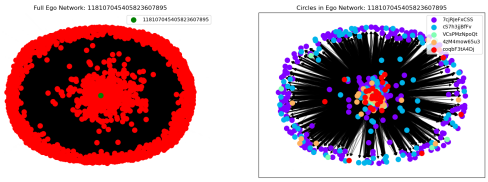

**Figure 4: EgoNet ID: 1195**

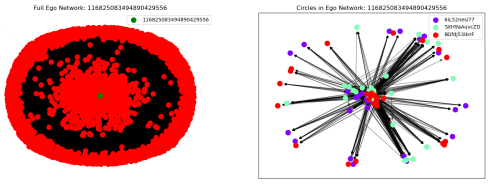

**Figure 5: EgoNet ID: 1156**

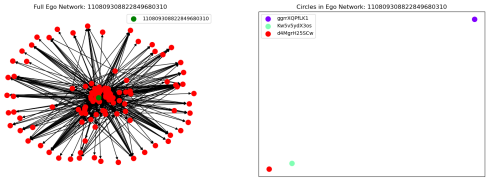

**Figure 6: EgoNet ID: 1110**

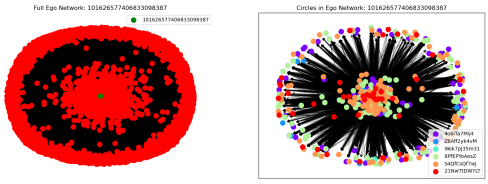

**Figure 7: EgoNet ID: 1087**

Unfortunately, due to computational resource limitations, it was not feasible to generate a graph for EgoNet ID: 1038. This constraint underscores the challenges inherent in visualizing exceptionally large and densely connected networks, which require significant processing power and memory to render effectively. Despite this limitation, the analysis of this highly influential ego network remains robust, as key metrics and patterns have been comprehensively examined to provide meaningful insights into its structure and dynamics.

The Table 1 provides a demographic and professional overview of eight bloggers' ego networks within the Google Plus ecosystem.

The majority of the bloggers (7 out of 8) are identified as male, while only one is identified as female. All bloggers exhibit diverse professional roles, indicating a multidimensional presence in the digital space. This variety suggests that bloggers often integrate multiple skills to enhance their digital presence and maintain their influence.

Egonet ID: 1018 (Michael) stands out with the most extensive range of professional titles, including Entrepreneur and Partner. This suggests a potentially high level of connectivity and influence within the ecosystem. Egonet ID: 1016 lists multiple cities, indicating a dynamic presence across regions. This could point to broader audience reach or a nomadic lifestyle that enhances their networking ability.

The next table 2 provides quantitative metrics for the ego networks of eight bloggers, focusing on their gender, node counts, and edge counts. These metrics are critical for understanding the size, connectivity, and overall structure of each ego network.

Bloggers with large networks and high edge counts (e.g., Egonet ID: 1038) are likely key i*influencers* in the ecosystem, capable of disseminating information widely and rapidly. Smaller or moderate-sized networks (e.g., EgoNet ID: 1016) may indicate niche influence or focused community-building efforts. The severe difference in the size and connectivity of the female blogger's network highlights a potential gender-based disparity in influence or engagement on the platform.

The Table 3 is a summary of circles and node distribution in bloggers ego networks. This table reveals important patterns in audience segmentation and network dynamics among bloggers.

The number of circles per blogger ranges from 2 to 6, indicating varying levels of audience segmentation. Bloggers with many circles (e.g., EgoNet ID: 1087) demonstrate greater audience segmentation, which could reflect efforts to target distinct groups with tailored content. Bloggers with fewer circles (e.g., EgoNet ID: 1016 and EgoNet ID: 1018 with 2 circles each) might have more homogeneous or concentrated networks.

Bloggers with a dominant Circle1 (e.g., EgoNet ID: 1195) rely heavily on a central audience group, which may concentrate their influence within that cluster. These findings underscore the diversity in bloggers connectivity strategies and offer a basis for further analysis of their roles in the Google Plus ecosystem.

## 4.2 Comparative Analysis

In this segment of the study, we analyze the circles and node distribution, graph-level metrics, node-level metrics, and community detection using an algorithm.

*4.2.1 Circles and Node Distribution.* For a detailed analysis of patterns and trends in the distribution of circles and nodes, we created a comparative table that provides an overview of bloggers' ego networks. Table 4 presents a comparative analysis of these networks, focusing on the number of circles, total nodes, sizes of the largest and smallest circles, and commentary on activity levels.

Analyzing the distribution of nodes across different circles and drawing on *Granovetter's theory*, we can suggest that smaller circles (1–50 nodes) likely represent strong ties, such as family and close friends, while larger circles (100+ nodes) are indicative of weak ties, such as acquaintances, professional connections, or followers. In this case, it is observed that EgoNet ID: 1195 and EgoNet ID: 1087, with both small and large circles, likely manage both personal (strong ties) and professional (weak ties) relationships effectively.

Users like EgoNet ID: 1075 and EgoNet ID: 1195 have circles with hundreds of nodes, indicating a focus on broader or professional networks (weak ties). EgoNet ID: 1038 follows a similar pattern with large and evenly sized circles. EgoNet ID: 1016 has very small circles, possibly representing personal or family connections (strong ties). Similarly, EgoNet ID: 1156 presents three circles with relatively small sizes (40, 68, 28 nodes), suggesting close-knit relationships or niche networks, and this might also indicate limited platform involvement.

Finally, EgoNet ID: 1110 presents three circles, each with a single node. This reflects low engagement, potentially indicative of inactive usage or placeholder connections. The user may use the platform sporadically or for specific, narrow purposes.

*4.2.2 Graph-Level Metrics Analysis: Total Nodes, Total Edges, Average Degree and Density.* In order to study fundamental metrics of bloggers' ego networks we have selected two basic metrics: average degree and density. Table 5 presents the fundamental metrics of bloggers' ego networks, offering insights into their overall structure and connectivity.

By examining these metrics, we can assess the extent of each blogger's influence, the cohesion of their networks, and their potential reach within the Google Plus ecosystem. The most connected network by total edges is EgoNet ID: 1038, with 1,460,413 edges, indicating an exceptionally high level of interaction. It has the highest average degree, suggesting a hub-like structure where nodes have numerous connections. Additionally, it is the most dense, reflecting strong cohesion and clustering. This EgoNet is ideal for studying dense clustering and community structures.EgoNet ID: 1156 is the least dense network, representing a sparse structure with weaker connectivity. On the other hand, EgoNet ID: 1087 is the largest network, with the highest number of nodes but relatively sparse connectivity.

Finally, EgoNet ID: 1110 shows the lowest degree and is the smallest network, indicating sparse and less interconnected nodes, likely forming a highly localized or specialized network.

*4.2.3 Graph-Level Metrics Analysis: Degree Assortativity Coefficient and Attribute Assortativity Coefficient.* Next, we present a Table 14 that provides insights into the degree assortativity coefficient and attribute assortativity coefficient of various ego networks.

By analyzing the data, it is evident that the degree assortativity coefficient, which reflects whether nodes with similar degrees tend to connect, shows negative values across all networks. This suggests an efficient structure for information dissemination, as influential nodes tend to connect broadly across the network. Additionally, the attribute assortativity coefficient, which measures the similarity of connected nodes based on specific attributes (e.g., demographics, profession), presents neutral values. This indicates that these networks are not strongly influenced by homophily in attributes, potentially highlighting diversity in their connections.

*4.2.4 Graph-Level Metrics Analysis: Reciprocity.* The provided data presents an overview of several EgoNets, emphasizing their structural characteristics through key metrics such as total nodes, total

edges, and reciprocity. Table 15 summarizes the analysis of this data.

Reciprocity measures the likelihood that connections between nodes are mutual. Networks with high reciprocity (e.g., EgoNet ID: 1110) likely feature strong ties, representing close, personal connections. Networks with low reciprocity and high node counts (e.g., EgoNet ID: 1016) are indicative of weak ties, more suitable for information dissemination rather than cohesion. Also, we can see that EgoNet ID: 1038 acts as a central hub, suggesting its owner has significant influence, likely drawing diverse interactions while fostering community cohesion.

*4.2.5 Node-Level Metrics Analysis: Degree Centrality.* Degree centrality measures the importance or influence of a node based on the number of direct connections it has within a network. It is a fundamental metric in Social Network Analysis (SNA) and provides insights into a node's immediate connectivity. To investigate this, we calculated various degree centrality metrics across blogger ego networks on Google Plus. Table 6 summarizes these metrics for eight ego networks, emphasizing variations in centrality distributions and maximum connectivity levels within each network.

By observing these results, we can confirm that all ego networks exhibit high maximum degree centrality values (ranging from 1.027 to 1.468), which is expected since the ego node in a network often has direct connections to many alters. The highest maximum degree centrality is observed in EgoNet ID: 1075 (1.468), indicating it is densely connected relative to its size.

Networks with larger sizes, such as EgoNet ID: 1087 and EgoNet ID: 1156, tend to have lower mean degree centrality, likely due to their sparser connectivity. Median values are consistently lower than mean values, highlighting a skewed degree distribution where a few nodes are highly connected while most nodes have fewer connections. Networks like EgoNet ID: 1075 and EgoNet ID: 1038 exhibit a broader range of centrality values, suggesting a more pronounced hierarchy or stratification in node connectivity.

*4.2.6 Node-Level Metrics Analysis: Closeness Centrality.* Closeness centrality is a metric in Social Network Analysis (SNA) that measures how "close" a node is to all other nodes in the network. It is based on the concept of shortest paths and reflects the efficiency or speed with which a node can access other nodes. To explore this, we calculated various closeness centrality metrics across blogger ego networks on Google Plus. Table 7 presents the closeness centrality metrics for eight ego networks, highlighting differences in the accessibility of nodes within their network structures.

From this data, we can observe the following: High Closeness Centrality Networks: Networks such as EgoNet ID: 1075 and EgoNet ID: 1038 exhibit strong centrality values for both the ego node and overall nodes. These networks are more compact and well-connected, enabling efficient communication and information flow. Low Closeness Centrality Networks: Networks such as EgoNet ID: 1087 and EgoNet ID: 1156 show lower efficiency in terms of node accessibility, likely due to their larger sizes and sparser connections.

*4.2.7 Node-Level Metrics Analysis: Betweenness Centrality.* Betweenness centrality is a key metric in Social Network Analysis (SNA) that quantifies the extent to which a node acts as a bridge or intermediary within a network. It measures how frequently a node lies on the shortest path between other nodes, reflecting its role in controlling the flow of information or resources. To explore this, we calculated various betweenness centrality metrics across blogger ego networks on Google Plus. Table 8 presents the betweenness centrality metrics for these networks, highlighting differences in intermediary roles and influence across nodes.

Ego nodes with high betweenness centrality values, such as in EgoNet ID: 1110, indicate centralized roles in controlling network flow. This is more common in smaller networks where individual nodes hold disproportionate importance. Conversely, networks where the ego node's betweenness centrality is lower, such as EgoNet ID: 1038, likely have a more distributed flow structure, reducing dependency on the ego node.

Smaller networks, like EgoNet ID: 1110 (114 nodes), exhibit higher betweenness centrality metrics for both the ego node and key intermediaries, indicating a more centralized structure. In contrast, larger networks, such as EgoNet ID: 1018 (3,877 nodes), demonstrate lower betweenness values across the board, suggesting decentralized communication pathways.

The predominance of zero median betweenness values highlights that most nodes in these networks are peripheral and do not act as significant connectors, emphasizing the role of a few key nodes. Maximum betweenness centrality values point to the presence of highly influential nodes in terms of bridging roles, for example, EgoNet ID: 1110 includes a node with substantial influence (0.338), while EgoNet ID: 1038 shows less centralized flow with a maximum betweenness value of 0.054.

*4.2.8 Node-Level Metrics Analysis: Eigenvector Centrality.* Eigenvector centrality is a metric in Social Network Analysis (SNA) that measures the influence of a node in a network based on the connectivity of its neighbors. Unlike degree centrality, which simply counts the number of direct connections, eigenvector centrality assigns greater weight to connections with more influential or highly connected nodes. To explore this, we calculated various eigenvector centrality metrics across blogger ego networks on Google Plus. Table 9 presents the eigenvector centrality metrics for these networks, highlighting differences in influence across nodes.

EgoNet ID: 1110 stands out as the most hierarchical and influential network. The ego node has strong connections to other high-centrality nodes, as reflected in its maximum, mean, and median eigenvector centrality values. Networks like EgoNet ID: 1087 and EgoNet ID: 1156 have low eigenvector centrality values across the board. This suggests they are more decentralized, with few or no dominant nodes exerting influence. The disparity between mean and median eigenvector centrality in most networks highlights heterogeneity. A few nodes dominate in terms of influence, while most remain peripheral. Larger networks, such as EgoNet ID: 1156 (4622 nodes), tend to have lower eigenvector centrality values for the ego node and mean values, indicating the challenge of maintaining influence in expansive networks. Smaller networks, such as EgoNet ID: 1110 (114 nodes), are more cohesive and exhibit higher centrality measures.

*4.2.9 Node-Level Metrics Analysis: Multi-Centrality Metrics Comparison.* For a comparative analysis of multiple centrality metrics across blogger ego networks on Google Plus, we have created Table

10. This table consolidates key centrality measures—degree, closeness, betweenness, and eigenvector centrality—enabling a comprehensive assessment of each blogger's position and influence within their network.

By examining these metrics collectively, we can gain insights into how nodes are interconnected, how information flows through the network, and the roles that individual bloggers play in shaping the dynamics of their Google Plus communities. So EgoNet ID: 1075 stands out for its high degree and closeness centrality, signifying a well-connected and efficiently reachable ego node. EgoNet ID: 1110 excels in eigenvector and betweenness centrality, marking the ego node as a critical influencer and bridge within the network. EgoNet ID: 1087 exhibits the lowest scores across most centrality metrics, representing a more dispersed and decentralized network with a less prominent ego node. Networks like EgoNet ID: 1016 and EgoNet ID: 1195 display a balance, with moderate-to-high values across multiple metrics, indicating both direct connectivity and indirect influence.

*4.2.10 Node-Level Metrics Analysis: Ranking of Blogger Ego Networks Based on Centrality Metrics.* The ranking in Table 11 allows for a comparative assessment of the influence and structural importance of ego nodes within their respective networks. We observe that EgoNet ID: 1075 and EgoNet ID: 1110 are tied for the top position based on their cumulative rank scores (7), being the most influential across most centrality metrics. In the middle tier, EgoNet ID: 1016 (Rank 14) and EgoNet ID: 1195 (Rank 16) demonstrate a balanced performance, performing moderately well across all metrics. As the bottom performer, EgoNet ID: 1087 ranks last (29), with consistently low values in all centrality measures. Interestingly, EgoNet ID: 1038 performs well in closeness centrality (Rank 2) but falls behind in betweenness centrality (Rank 7).

*4.2.11 Community Detection: Louvain Algorithm.* Community Detection is a fundamental task in network analysis, aiming to identify groups or clusters of nodes that are more densely connected internally than with the rest of the network. These communities often reveal hidden structures, functional groups, or roles within networks, such as social circles in social networks or tightly linked groups in collaboration networks.

The Louvain algorithm is a widely used method for detecting communities in large networks due to its efficiency and effectiveness. It is a hierarchical, modularity-based approach that iteratively optimizes the modularity of the network—a measure of the density of connections within communities compared to connections between communities. Table 12 presents the results of community structures in blogger ego networks on Google Plus using the Louvain algorithm.

After applying the Louvain algorithm, we observe that the number of communities ranges from 3 to 6, highlighting the structural diversity across the ego networks. The "best community" (largest community) in each ego network accounts for a significant portion of the total nodes, indicating its dominance. These dominant communities often contain the majority of nodes and may serve as the network's core. They could represent central hubs of activity, such as *influencers* or primary groups, or reflect shared interests or common affiliations among the nodes.

Notably, EgoNet ID: 1195 features a "best" community with 856 nodes, closely rivaled by another community with 855 nodes, suggesting potential competition or a dual-core structure. Smaller networks, such as EgoNet ID: 1110, display tightly-knit communities with fewer, similarly sized groups, indicative of a close-knit group of bloggers with limited external interactions. In contrast, larger networks, such as EgoNet ID: 1156, feature larger and more heterogeneous communities, reflecting diverse interests or roles within the network. In highly skewed networks, such as EgoNet ID: 1038, the best community comprises 50.1% of the nodes, suggesting a central group that dominates the network's interactions.

Finally, the last Table 13 provides an analysis of community structures and the average clustering coefficient across blogger ego networks on Google Plus. By combining these metrics, the table enables a deeper understanding of how bloggers' networks are organized and the extent to which communities exhibit localized clustering.

This table highlights the relationship between the detected communities and the clustering tendencies of nodes within each network. The average clustering coefficient measures the tendency of nodes to form tightly-knit groups, offering insights into the cohesiveness of the communities. The key observations from the data are that we have centralized networks, EgoNet ID: 1038 and EgoNet ID: 1075 are a showcase centralization with dominant largest communities and relatively high clustering coefficients. We also have decentralized networks, for example, EgoNet ID: 1156 and EgoNet ID: 1087 have more distributed community sizes and lower clustering coefficients, indicating fragmentation. In terms of average clustering coefficient (ACC), networks like EgoNet ID: 1075 (ACC: 0.4344) and EgoNet ID: 1110 (ACC: 0.4207) exhibit high clustering, indicating a propensity for forming tightly-knit groups. Conversely, networks such as EgoNet ID: 1087 (ACC: 0.2889) and EgoNet ID: 1156 (ACC: 0.3098) display lower clustering, hinting at looser structural cohesion. This analysis highlights the diversity in community structures across blogger ego networks. Networks with high clustering coefficients and dominant largest communities suggest cohesive interaction hubs, while those with balanced or fragmented community sizes reflect more decentralized or heterogeneous networks. Further investigation could explore the characteristics of the largest and smallest communities, their roles within the network, and the factors driving cohesion or fragmentation.

## 5 Conclusion

The study highlights EgoNet ID: 1038 as a key *influencer* within the ecosystem, demonstrating exceptional connectivity and interaction. This network stands out with 1,460,413 edges, the highest average degree, and strong cohesion and clustering, forming a hub-like structure ideal for analyzing dense clustering and community dynamics. Other key observation includes detection of centralized networks: EgoNet ID: 1038 and EgoNet ID: 1075 exhibit dominant largest communities and high clustering coefficients, emphasizing their centralized nature. There were also dominant communities. In highly skewed networks like EgoNet ID: 1038, the largest community contains 50.1% of the nodes, underscoring its role as a central group driving interactions.

It was also observed in the distribution of nodes across different circles and drawing on *Granovetter's theory*, that smaller circles (1–50 nodes) likely represent strong ties, such as family and close friends, while larger circles (100+ nodes) are indicative of weak ties, such as acquaintances, professional connections, or followers. These findings underline the diversity and structural characteristics of blogger ego networks, highlighting the influence of central nodes and community dynamics. The analysis reveals a dynamic interplay of strong and weak ties, centralized and decentralized structures, and influential nodes shaping the Google Plus blogger ego networks. Centralized networks drive cohesion and interaction, while decentralized ones reflect diverse interests and fragmentation.

These findings provide a robust foundation for understanding how bloggers leverage their networks for influence and connectivity. Despite the shutdown of the Google Plus platform, it is likely that some communities migrated to other social networks. Studying these communities could provide insights into digital migration patterns and the resilience of online groups. Furthermore, subsequent studies could also involve conducting a comparative analysis of bloggers' behaviors on Google Plus with those on current platforms such as Twitter, Instagram, or LinkedIn, which would help identify how social media preferences and strategies have evolved.

However, analyzing such complex and dense networks presents significant computational challenges. The intricate nature of blogger ego networks, characterized by millions of edges, high clustering coefficients, and a dynamic interplay of strong and weak ties, demands substantial computational resources. The need for flexibility and scalability in real-time analysis posed a significant hurdle, restricting the research group's ability to perform deeper and more dynamic analysis and the only solution to overcome these limitations is by requiring advanced computing infrastructures.

## References

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| EgoNet ID | Gender* | Job Titles | Last Name | Places | Institution |
|---|---|---|---|---|---|
| 1075 | 1 | Blogger, Photographer | Thomas | Los | - |
| 1018 | 1 | Blogger, Columnist, Editor, Entrepreneur, Partner | Michael | Izmir | - |
| 1016 | 1 | Blogger, Podcaster, Creator, Youtuber | - | Atlanta, Knoxville, Memphis, Pittsburgh, Washington | University |
| 1195 | 1 | Blogger, Developer, Designer, Consultant | James | - | - |
| 1156 | 1 | Blogger, Chef, Photographer, Food Lover | Jake | - | - |
| 1110 | 2 | Blogger, Poet, Political Writer | - | Florence | - |
| 1038 | 1 | Blogger, Photographer | Steve | - | - |
| 1087 | 1 | Blogger, Youtuber, Web Designer | - | - | - |

**Table 1: Blogger Ego Network Profile Summary**

*Gender: 1 indicates Male; 2 indicates Female.

| EgoNet ID | Gender* | Total Nodes | Total Edges |
|---|---|---|---|
| 1075 | 1 | 1755 | 231095 |
| 1018 | 1 | 3877 | 526486 |
| 1016 | 1 | 1052 | 55894 |
| 1195 | 1 | 2438 | 269049 |
| 1156 | 1 | 4622 | 484935 |
| 1110 | 2 | 114 | 733 |
| 1038 | 1 | 4338 | 1460413 |
| 1087 | 1 | 4737 | 438061 |

**Table 2: Summary of Bloggers Ego Networks: Gender, Node, and Edge Counts**

*Gender: 1 indicates Male; 2 indicates Female.

| EgoNet ID | No. of Circles | Total Nodes | Circle1 (Nodes) | Circle2 (Nodes) | Circle3 (Nodes) | Circle4 (Nodes) | Circle5 (Nodes) | Circle6 (Nodes) |
|---|---|---|---|---|---|---|---|---|
| 1075 | 3 | 996 | 18 | 491 | 487 | 0 | 0 | 0 |
| 1018 | 2 | 371 | 151 | 220 | 0 | 0 | 0 | 0 |
| 1016 | 2 | 81 | 27 | 54 | 0 | 0 | 0 | 0 |
| 1195 | 5 | 790 | 494 | 209 | 23 | 33 | 31 | 0 |
| 1156 | 3 | 136 | 40 | 68 | 28 | 0 | 0 | 0 |
| 1110 | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1038 | 3 | 848 | 320 | 314 | 214 | 0 | 0 | 0 |
| 1087 | 6 | 817 | 193 | 210 | 1 | 184 | 184 | 45 |

**Table 3: Summary of Circles and Node Distribution in Bloggers Ego Networks.**

| EgoNet ID | No. of Circles | Total Nodes | Largest Circle | Smallest Circle | Commentary |
|---|---|---|---|---|---|
| 1075 | 3 | 996 | 491 | 18 | Highly active; large network with two dominant circles. |
| 1018 | 2 | 371 | 220 | 151 | Moderate activity; balanced circle sizes. |
| 1016 | 2 | 81 | 54 | 27 | Small, focused network; likely personal connections |
| 1195 | 5 | 790 | 494 | 23 | High activity; mix of large and small circles, varied roles. |
| 1156 | 3 | 136 | 68 | 28 | Low engagement; small, tightly knit circles |
| 1110 | 3 | 3 | 1 | 1 | Minimal activity; all circles have single nodes. |
| 1038 | 3 | 848 | 320 | 214 | Highly active; evenly distributed large circles. |
| 1087 | 6 | 817 | 210 | 1 | High activity; diverse segmentation, mix of small and large. |

**Table 4: Comparative Analysis of Circles and Node Distribution in Blogger Ego Networks.**

| EgoNet ID | Total Nodes | Total Edges | Average Degree | Density |
|---|---|---|---|---|
| 1075 | 1755 | 231095 | 263.356 | 0.075 |
| 1018 | 3877 | 526486 | 271.595 | 0.035 |
| 1016 | 1052 | 55894 | 106.262 | 0.050 |
| 1195 | 2438 | 269049 | 220.713 | 0.045 |
| 1156 | 4622 | 484935 | 209.838 | 0.023 |
| 1110 | 114 | 733 | 12.860 | 0.057 |
| 1038 | 4388 | 1460413 | 665.639 | 0.076 |
| 1087 | 4737 | 438061 | 184.953 | 0.020 |

**Table 5: Ego Network Basic Metrics: Total Nodes, Total Edges, Average Degree and Density.**

| EgoNet ID | Degree Centrality | Mean Degree Centrality | Median Degree Centrality | Maximum Degree Centrality |
|---|---|---|---|---|
| 1075 | 1.468 | 0.150 | 0.0958 | 1.468 |
| 1018 | 1.101 | 0.070 | 0.045 | 1.101 |
| 1016 | 1.206 | 0.101 | 0.065 | 1.206 |
| 1195 | 1.240 | 0.091 | 0.057 | 1.240 |
| 1156 | 1.115 | 0.045 | 0.025 | 1.115 |
| 1110 | 1.354 | 0.114 | 0.062 | 1.354 |
| 1038 | 1.330 | 0.152 | 0.105 | 1.330 |
| 1087 | 1.027 | 0.039 | 0.025 | 1.027 |

**Table 6: Degree Centrality Metrics Across Blogger Ego Networks in Google Plus.**

| EgoNet ID | Closeness Centrality | Mean Closeness Centrality | Median Closeness Centrality | Maximum Closeness Centrality |
|---|---|---|---|---|
| 1075 | 0.498 | 0.315 | 0.311 | 0.498 |
| 1018 | 0.339 | 0.290 | 0.295 | 0.469 |
| 1016 | 0.350 | 0.273 | 0.270 | 0.428 |
| 1195 | 0.384 | 0.293 | 0.292 | 0.415 |
| 1156 | 0.325 | 0.257 | 0.252 | 0.386 |
| 1110 | 0.385 | 0.250 | 0.240 | 0.385 |
| 1038 | 0.423 | 0.318 | 0.316 | 0.486 |
| 1087 | 0.276 | 0.248 | 0.244 | 0.377 |

**Table 7: Closeness Centrality Metrics Across Blogger Ego Networks in Google Plus.**

| EgoNet ID | Betweenness Centrality | Mean Betweenness Centrality | Median Betweenness Centrality | Maximum Betweenness Centrality |
|---|---|---|---|---|
| 1075 | 0.160 | 0.000 | 0.000 | 0.160 |
| 1018 | 0.075 | 0.000 | 0.000 | 0.075 |
| 1016 | 0.178 | 0.000 | 0.000 | 0.178 |
| 1195 | 0.107 | 0.000 | 0.000 | 0.107 |
| 1156 | 0.139 | 0.000 | 0.000 | 0.139 |
| 1110 | 0.338 | 0.005 | 0.000 | 0.338 |
| 1038 | 0.054 | 0.000 | 0.000 | 0.054 |
| 1087 | 0.088 | 0.000 | 0.000 | 0.088 |

**Table 8: Betweenness Centrality Metrics Across Blogger Ego Networks in Google Plus**

| EgoNet ID | Eigenvector Centrality | Mean Eigenvector Centrality | Median Eigenvector Centrality | Maximum Eigenvector Centrality |
|---|---|---|---|---|
| 1075 | 0.093 | 0.018 | 0.015 | 0.093 |
| 1018 | 0.014 | 0.010 | 0.005 | 0.103 |
| 1016 | 0.050 | 0.019 | 0.009 | 0.150 |
| 1195 | 0.063 | 0.014 | 0.008 | 0.091 |
| 1156 | 0.016 | 0.008 | 0.002 | 0.092 |
| 1110 | 0.301 | 0.074 | 0.048 | 0.301 |
| 1038 | 0.041 | 0.011 | 0.007 | 0.054 |
| 1087 | 0.003 | 0.006 | 0.001 | 0.097 |

**Table 9: Eigenvector Centrality Metrics Across Blogger Ego Networks in Google Plus**

| EgoNet ID | Degree Centrality | Closeness Centrality | Betweenness Centrality | Eigenvector Centrality |
|---|---|---|---|---|
| 1075 | 1.468 | 0.498 | 0.160 | 0.093 |
| 1018 | 1.101 | 0.339 | 0.075 | 0.014 |
| 1016 | 1.206 | 0.350 | 0.178 | 0.050 |
| 1195 | 1.240 | 0.384 | 0.107 | 0.063 |
| 1156 | 1.115 | 0.325 | 0.139 | 0.016 |
| 1110 | 1.354 | 0.385 | 0.338 | 0.301 |
| 1038 | 1.330 | 0.423 | 0.054 | 0.041 |
| 1087 | 1.027 | 0.276 | 0.088 | 0.003 |

**Table 10: Multi-Centrality Metrics Comparison Across Blogger Ego Networks in Google Plus.**

| EgoNet ID | Degree Centrality Rank | Closeness Centrality Rank | Betweenness Centrality Rank | Eigenvector Centrality Rank | Overall Rank (Sum of Ranks) |
|---|---|---|---|---|---|
| 1075 | 1 | 1 | 2 | 3 | 7 |
| 1018 | 6 | 7 | 6 | 7 | 26 |
| 1016 | 4 | 5 | 1 | 4 | 14 |
| 1195 | 3 | 4 | 4 | 5 | 16 |
| 1156 | 5 | 6 | 3 | 6 | 20 |
| 1110 | 2 | 3 | 1 | 1 | 7 |
| 1038 | 3 | 2 | 7 | 5 | 17 |
| 1110 | 8 | 8 | 5 | 8 | 29 |

**Table 11: Ranking of Blogger Ego Networks Based on Centrality Metrics.**

| EgoNet ID | No. of Communities | Total Nodes | Comm. 1 (Nodes) | Comm. 2 (Nodes) | Comm. 3 (Nodes) | Comm. 4 (Nodes) | Comm. 5 (Nodes) | Comm. 6 (Nodes) |
|---|---|---|---|---|---|---|---|---|
| 1075 | 4 | 1755 | 537 | 4 | 572 | 642 | - | - |
| 1018 | 5 | 3877 | 970 | 897 | 217 | 573 | 1220 | - |
| 1016 | 5 | 1052 | 34 | 137 | 152 | 274 | 455 | - |
| 1195 | 4 | 2438 | 856 | 519 | 855 | 208 | - | - |
| 1156 | 6 | 4622 | 840 | 1145 | 14 | 865 | 1409 | 349 |
| 1110 | 4 | 114 | 32 | 41 | 21 | 20 | - | - |
| 1038 | 3 | 4388 | 1183 | 2200 | 1005 | - | - | - |
| 1087 | 6 | 4737 | 830 | 737 | 854 | 1276 | 734 | 306 |

**Table 12: Summary of Community Structures in Blogger Ego Networks on Google Plus Using the Louvain Algorithm**

| EgoNet ID | Total Nodes | No. of communities | Largest community | Smallest community | Average Clustering Coefficient |
|---|---|---|---|---|---|
| 1075 | 1755 | 4 | 642 | 4 | 0.434 |
| 1018 | 3877 | 5 | 1220 | 217 | 0.306 |
| 1016 | 1052 | 5 | 455 | 34 | 0.348 |
| 1195 | 2438 | 4 | 856 | 208 | 0.304 |
| 1156 | 4622 | 6 | 1409 | 14 | 0.310 |
| 1110 | 114 | 4 | 41 | 20 | 0.421 |
| 1038 | 4388 | 3 | 2200 | 1005 | 0.370 |
| 1087 | 4737 | 6 | 1276 | 306 | 0.289 |

**Table 13: Community Structures and Average Clustering Coefficient in Blogger Ego Networks on Google Plus.**

| EgoNet ID | Total Nodes | Degree Assortativity Coefficient | Attribute Assortativity Coefficient |
|---|---|---|---|
| 1075 | 1755 | -0.231 | 0.000 |
| 1018 | 3877 | -0.137 | 0.002 |
| 1016 | 1052 | -0.207 | -0.001 |
| 1195 | 2438 | -0.137 | 0.000 |
| 1156 | 4622 | -0.111 | 0.007 |
| 1110 | 114 | -0.380 | -0.018 |
| 1038 | 4388 | -0.151 | 0.000 |
| 1087 | 4737 | -0.092 | 0.005 |

**Table 14: Ego Network Metrics: Total Nodes, Degree Assortativity Coefficient and Attribute Assortativity Coefficient**

| EgoNet ID | Total Nodes | Total Edges | Reciprocity |
|---|---|---|---|
| 1075 | 1755 | 231095 | 0.0223 |
| 1018 | 3877 | 526486 | 0.198 |
| 1016 | 1052 | 55894 | 0.189 |
| 1195 | 2438 | 269049 | 0.264 |
| 1156 | 4622 | 484935 | 0.203 |
| 1110 | 114 | 733 | 0.426 |
| 1038 | 4388 | 1460413 | 0.279 |
| 1087 | 4737 | 438061 | 0.252 |

**Table 15: Ego Network Metrics: Total Nodes, Total Edges and Reciprocity**