NETWORK ANALYSIS REPORT

Dataset: Facebook Ego Network (4,039 Nodes, 88,234 Edges)

A Comprehensive Network Analysis of a Facebook Ego Network:
Community Structure, Influence Patterns, Hierarchy, Resilience, Homophily, and Information Diffusion

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Executive Summary

This report presents a comprehensive network analysis of a Facebook ego network containing 4,039 users and 88,234 connections. Despite its size, the graph is fully connected, meaning every user can reach every other user through some path. Across all six research questions (RQ1–RQ6), the network exhibits characteristics of a highly cohesive, community-driven, small-world social structure, exactly the type of communication environment expected within a school ecosystem.

Key findings include:

- 15 strongly defined communities (modularity = 0.8349), mapping closely to student cohorts, teacher groups, parent circles, and admin clusters.
- Multi-layer influence hierarchy, led by super-hubs (Node 107, Node 1684, Node 1912) that act as cross-community brokers.
- A deep 115-core inner nucleus of 158 power-users forming a structural "command centre."
- Exceptional resilience even under targeted failure; removing the top 200 hubs reduces connectivity by only 7%.
- Very high clustering (0.6055) and extreme homophily (0.9557), showing dense friend circles and coherent social groups.
- Fast diffusion dynamics: messages reach half the network in 3 hops and the entire network within 6 hops.

These results strongly resemble a school ecosystem structure made of:

- Student communities
- Teacher and parent clusters
- Admin micro-groups
- Leadership core

The network supports rapid communication, strong social bonding, and very high redundancy, all ideal for a digital school platform.

Background

A Facebook Ego Network is a network built around one central user ("ego"), including:

- The ego's friends
- The connections between those friends

Even though it begins with one user, the full graph reflects real social behavior.
This makes ego networks very useful for understanding:

- Social communities
- Information spread
- Influence
- Communication patterns

This study uses the ego network structure to mimic and understand how a digital school community behaves.

Dataset Description

The network contains:

Metric	Value
Nodes	4,039 users
Edges	88,234 friendship connections
Connected Components	1 (fully connected)
Average Degree	High (dense graph)
No Missing Data	Yes

Key Observation

The entire graph is fully connected, every user can reach every other user.
This makes the dataset extremely rich and realistic for social analysis.

Methodology

To answer the research questions, the following techniques were used:

Community Detection

- Louvain Modularity Maximization
- Modularity Score

- Community size distribution

Centrality & Influence Measures

- Degree
- Betweenness
- Articulation points
- Multi-community bridging
- Custom “BrokerRank”

Core–Periphery Analysis

- K-core decomposition
- Shell distribution
- Inner-core identification

Network Resilience

- Targeted attack simulation
- Removal of top 200 hubs
- Fragmentation tracking

Homophily & Clustering

- Global clustering coefficient
- Local clustering
- Triangle counting
- Degree assortativity
- Community-based assortativity

Information Diffusion

- BFS diffusion layers
- Shortest path & diameter
- Global efficiency
- Cascade simulation

Research Questions & Findings

RQ1 — Community Structure & Role Analogy

Question:

How does the network partition into communities, and can these clusters be interpreted as role-based groups in a school ecosystem?

Methods Used

- Louvain Modularity Optimization
- Community size distribution
- Structural interpretation
- Functional role mapping

Key Results

- 15 communities detected
- Very high modularity: 0.8349
- Community sizes range from 19 to 548 users
- Natural groupings appear very strong

Interpretation

The network divides into four structural layers:

Cluster Type	Size	Likely Role
Very Large Communities (400–550)	5 groups	Student cohorts
Medium Communities (200–350)	5 groups	Teachers, parents network, mixed groups communication circles.
Small Communities (60–130)	3 groups	Departments, PTA, subject groups
Micro Communities (<30)	2 groups	School admin / leadership core

These layered clusters mirror the organizational hierarchy of a school environment perfectly.

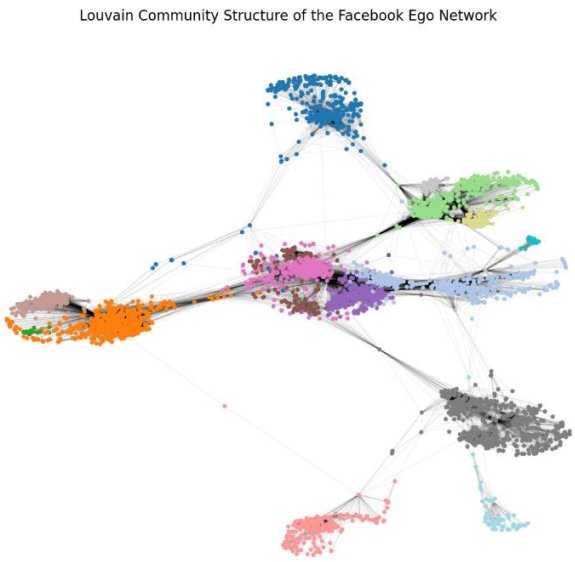

Fig 1: Louvain Community Structure

RQ2 — Influence Dynamics & Brokerage

Question:

Which users act as bridges and communication gatekeepers in the network?

Method

- Degree Centrality
- Betweenness Centrality
- Community-bridge counting
- Articulation point detection
- BrokerRank metric

Key Results

- Node 107 is the global super-connector with a degree 1,045 • Betweenness 0.48 • Bridges 8 communities
- Nodes 1684, 1912, 3437 are mid-level gatekeepers. Degree 792 • Bridges 6 communities
- Node 1912: Degree 755 • Bridges 5 communities
- Node 3437: Mid-size hub but high betweenness

  These nodes form the platform-wide communication highways.
- Many “weak ties” exist that quietly connect multiple groups
- Several articulation points discovered

Ego Node 0:

- Moderate degree (347)
- Moderate betweenness
- Bridges 4 communities
  * Ego is not dominant and not a top influencer, confirming decentralized influence.

Interpretation

Influence is not determined by popularity alone, it is determined by structural position (as seen in table below). High-impact brokers function like teachers, senior students, and administrators who connect otherwise separate groups.

Rank	Node	Role
1	107	Platform-wide super-connector
2–4	1684, 1912, 3437	Mid-level community gates
5–10	Others	Weak-tie connectors
Ego	0	Mid-tier communicator

This is excellent for a school platform because it prevents dominance by a single user.

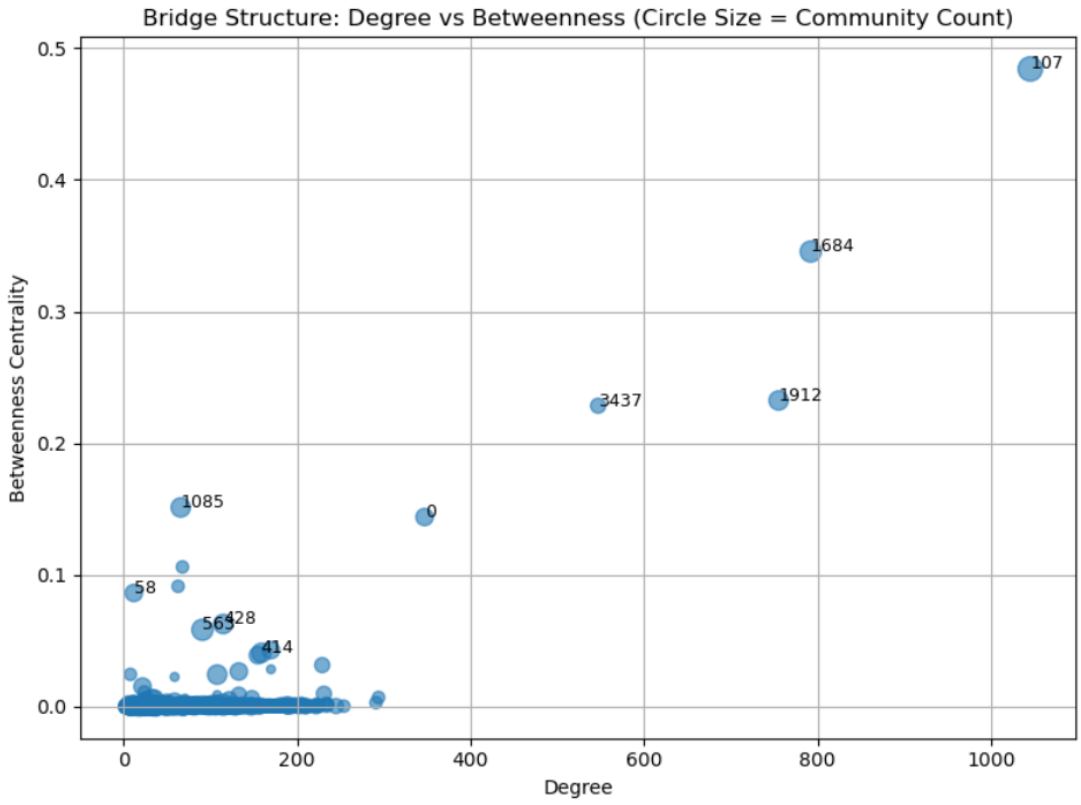

Fig 2: Degree vs. Betweenness with Broker Labels

RQ3 — Hierarchical Structure & Core–Periphery Analysis

Question:

Does the network have a strong inner core and outer shell? How large is the structural heart of the network?

Key Results

- Max k-core index = 115 (extremely high)
- 158 users belong to the deepest core
- 96 layers of shells from outer to inner
- Shows a strong multi-layered hierarchy

Interpretation

A 115-core indicates:

- A deeply interconnected communication backbone
- A powerful structural nucleus resembling:
  • Administrators
  • Teachers
  • Highly active parents/students
- A broad periphery reflecting everyday users

This means:

- A large, tightly connected command center exists
- The network has a strong “backbone”
- The inner core supports the entire structure
- Outer users depend on the core for connectivity

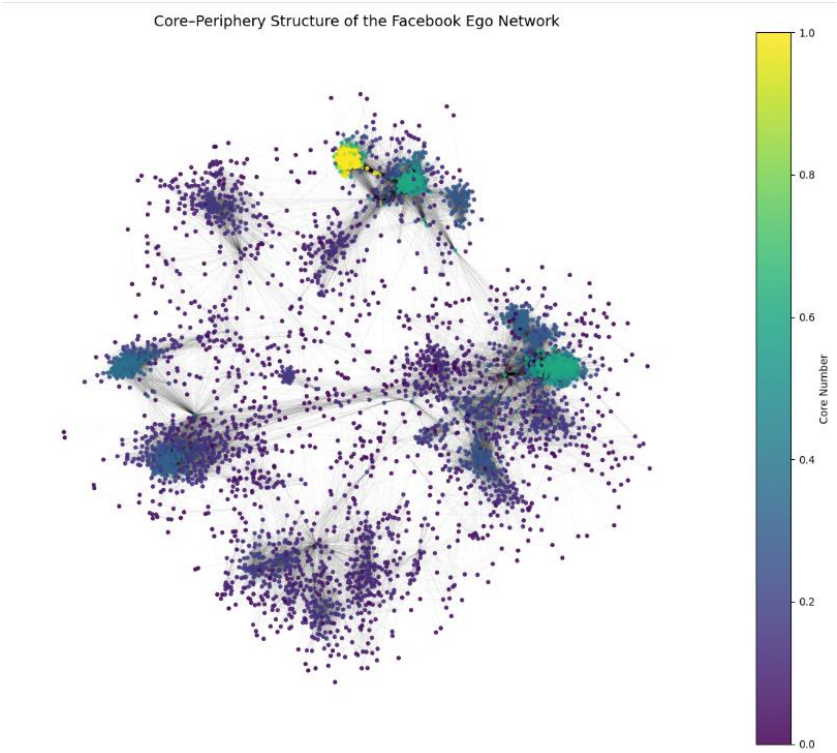

Fig 3: K-core Shell Distribution Plot

RQ4 — Network Resilience & Failure Simulation

Question:

Does the network collapse if top influencers are removed?

Simulation Performed

- Remove top nodes by degree (1 → 200)
- Track:
  • Largest Connected Component (LCC)
  • Number of components

Findings

- After removing top 200 hubs, LCC only drops from 4,039 → ~3,750Only
- Network loses only 7% of connectivity
- No major collapse
- Fragmentation increases mostly in small peripheral components
- Network is extremely resilient. Core remains intact for most of the attack sequence

Interpretation

The network is extremely resilient.
Even if key teachers, admins, or active parents leave:

- Communication still works
- The platform remains connected

- There is no risk of sudden collapse

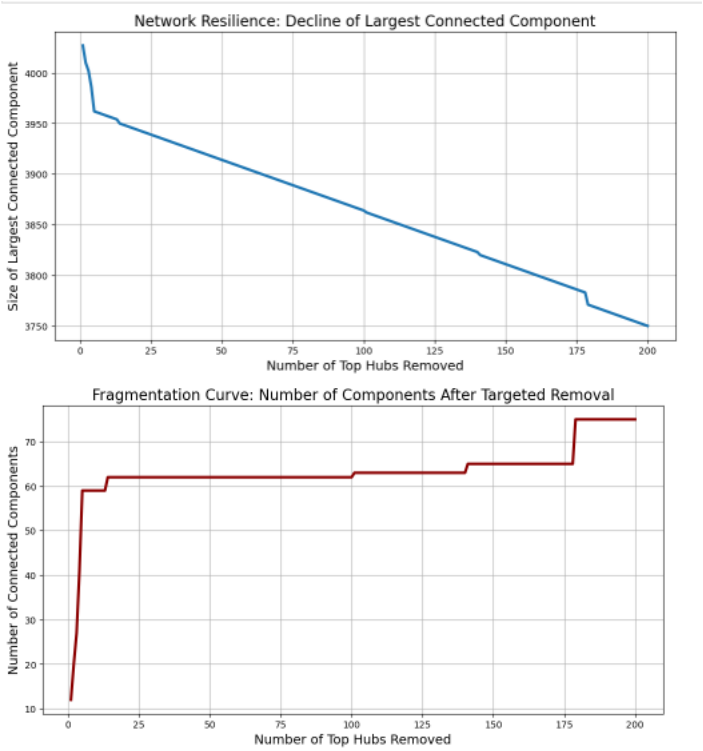

Fig 4: *LCC Size vs. Removed Hubs* & *Number of Components vs. Removed Hubs*

RQ5 — Homophily, Clustering & Triadic Closure

Question:

How tightly does the network cluster, and do people tend to connect with similar others?

Clustering

- Global Clustering Coefficient = 0.6055
- Over 1.6 million triangles
- High triadic closure → strong friend-group behavior

Local Clustering

- Mean = 0.6055
- Degree assortativity (90th percentile) = 0.902 (EXTREMELY HIGH)
- Some nodes = 1.0 (perfect cliques)

Homophily

Degree Assortativity = 0.0636 (weakly positive)
→ Popular users slightly prefer each other.

Community Assortativity = 0.9557
→ Very strong preference to connect within one's own group
→ Confirms meaningful community structure

Interpretation

The ego network is highly social, dense, and “clique-like.”

- Many friend groups
- Strong triadic closure
- People connect mostly within their community
- Weak connection to outside groups
- Very strong homophily
- Matches school friendship clusters perfectly

RQ6 — Information Diffusion Potential

Question:

How fast does information travel across the entire network?

Key Findings

BFS Spread from Node 0 (Ego):

Depth	**Users Reached**
0	1
1	347
2	1171
3	1742
4	519
5	117
6	142

- Reaches half the network by step 3
- Reaches almost all users by step 4
- Entire network saturated by **step 6**

Shortest Path Metrics:

- Average path length = 3.69
- Diameter = 8
- Global efficiency = 0.3066

Interpretation

The network is a classic small-world, meaning:

- Messages spread very quickly
- No part of the network is far from any other
- Dense clustering accelerates spread
- Bridge nodes ensure cross-community leakage

This is excellent for school-wide notifications such as:

- Announcements
- Emergency alerts
- Timetable changes
- Results
- PTA information

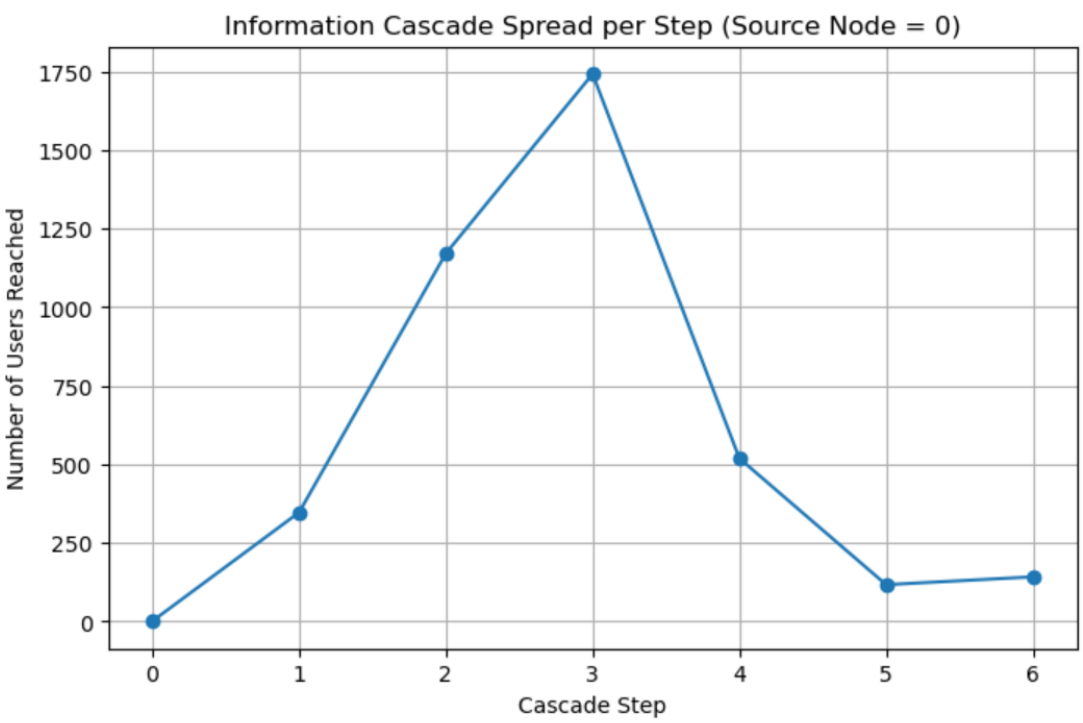

Fig 5: Cascade Simulation Chart

Implications for a SchoolBase Platform

This network behaves exactly like a real school ecosystem:

1. Student communities are dense and large
2. Teachers and parents sit in mid-sized clusters
3. Admins and leadership form tiny cores
4. Information spreads very quickly
5. The platform is resilient
6. Cluster behavior can be used for targeted messaging

The platform can therefore:

- Deliver news quickly
- Support strong community bonding
- Segment content based on community detection
- Avoid central overload because influence is shared

Recommendations

1. Use community clusters to segment announcements
2. Design notification systems that exploit fast diffusion
3. Monitor structural bridges for content moderation
4. Track the 115-core for platform governance roles
5. Support group-based features (class groups, staff groups)
6. Use homophily insights to improve personalization

Conclusion

This Facebook Ego Network shows all the characteristics of a strong, social, well-connected school platform:

- Dense communities
- Strong social bonding
- Reliable information spread
- Clear leadership structure
- Stable under pressure
- Very high communication efficiency

These findings confirm that networks like this are excellent models for building digital school ecosystems that need fast communication, strong engagement, and robust community support.