

Taxonomy of Network Analysis Indicators

Macro, Meso, and Node-Level Measures

SMM638 Network Analytics

Three Levels of Analysis

Network indicators operate at different scales:

Level	Focus	Questions
Macro	Entire network	How big? How centralized? How connected?
Meso	Groups/Communities	Are there clusters of nodes? How modular?
Micro/Node	Individual positions	Who is central? Who bridges groups?

 Caution

Key Principle: Different levels reveal different insights

- ▶ Macro: Overall structure and properties
- ▶ Meso: Subgroup organization
- ▶ Micro: Individual advantages and constraints

Macro-Level Indicators

Whole Network Properties

Characterize the overall structure and global patterns

Key Measures:

1. **Network Size:** Number of nodes and edges
2. **Density:** Proportion of possible connections realized
3. **Centralization:** Concentration of connections
4. **Diameter:** Maximum distance between any two nodes
5. **Average Path Length:** Mean distance across all pairs
6. **Fragmentation:** Presence of disconnected components

Purpose: Understand network-wide characteristics and compare across networks

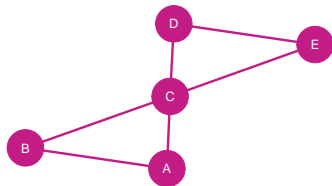
Example: Network Size and Density

Definition: Basic structural properties

- ▶ **Node count:** Total number of vertices (n)
- ▶ **Edge count:** Total number of connections (m)
- ▶ **Possible edges:** $\frac{n(n-1)}{2}$ for undirected networks

Business Example: LinkedIn Network

- ▶ **Small startup network** (50 employees)
 - ▶ Possible connections: 1,225
 - ▶ Observed connections: 245
 - ▶ Density: 20%
- ▶ **Large corporation network** (5,000 employees)
 - ▶ Possible connections: 12,497,500
 - ▶ Observed connections: 187,500
 - ▶ Density: 1.5%



Network Metrics:

Nodes (n)

5

Edges (m)

6

Possible Edges

10

Density

60.0%

Example: Centralization

Definition: Extent to which connections concentrate around few nodes

- ▶ **High centralization:** Star-like, hierarchical structure
- ▶ **Low centralization:** Distributed, egalitarian structure

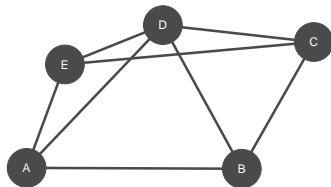
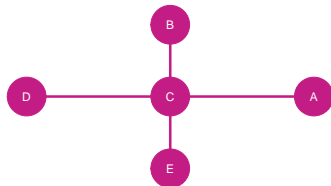
Business Example: Communication Patterns

Startup (Low Centralization = 0.25)

- ▶ Flat structure with distributed communication
- ▶ Multiple people coordinate projects
- ▶ Information flows through many channels

Traditional Corporation (High Centralization = 0.78)

- ▶ Hub-and-spoke: most communication through managers



Network Metrics:

Network

Size

Density

Higher centralization (top)

5 nodes, 4 edges

40.0%

Meso-Level Indicators

Community and Subgroup Structure

Identify cohesive groups and organizational patterns

Key Measures:

1. **Modularity:** Quality of network partitioning into groups
2. **Community Detection:** Algorithmic identification of clusters
3. **Core-Periphery:** Distinction between dense core and sparse periphery
4. **Structural Holes:** Gaps between groups creating brokerage opportunities
5. **k-cores:** Subgraphs where all nodes have minimum degree k

Purpose: Reveal hidden organizational structure and group boundaries

Example: Network Modularity

Definition: Strength of division into communities

- ▶ Measures how well network separates into distinct groups
- ▶ Higher values indicate stronger community structure

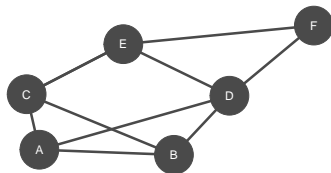
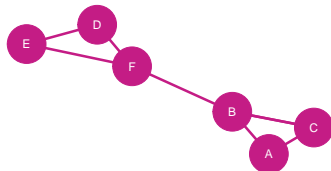
Business Example: Corporate R&D Network

Higher Modularity

- ▶ Clear separation: Chemistry, Biology, Engineering teams
- ▶ Limited cross-disciplinary collaboration
- ▶ Potential for siloed innovation

Lower Modularity

- ▶ Extensive cross-team connections
- ▶ Interdisciplinary collaboration
- ▶ Potential for breakthrough innovation but coordination



Note

The top network seems to have two communities ($\{A, B, C\}$ and $\{D, E, F\}$ triads)
The bottom net-

Node-Level Indicators

Individual Position and Influence

Characterize actor positions within the network

Major Categories:

1. **Centrality Measures:** Various ways to measure importance
 - ▶ Degree, Closeness, Betweenness, Eigenvector
2. **Structural Position:** Role in network architecture
 - ▶ Bridges, Brokers, Isolates, Cliques
3. **Local Clustering:** Cohesion of immediate neighborhood
4. **Embeddedness:** Integration into network structure

Purpose: Identify influential actors, structural advantages, and vulnerabilities

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Much more to follow on node level indicators today

Summary: Levels in Practice

Integrated Analysis Framework:

Macro Level → Strategic organizational design

- ▶ Should we have a centralized or distributed structure?
- ▶ How connected is our organization overall?

Meso Level → Team and department dynamics

- ▶ Are we too siloed or too integrated?
- ▶ Where are the boundaries between groups?

Micro Level → Individual talent management

- ▶ Who are our key connectors and influencers?
- ▶ Who has structural advantages or disadvantages?

! Important

Best Practice: Analyze networks at multiple levels simultaneously for comprehensive insights