

# 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
<b>Macro</b>	Entire network	How big? How centralized? How connected?
<b>Meso</b>	Groups/Communities	Are there clusters of nodes? How modular?
<b>Micro/Node</b>	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

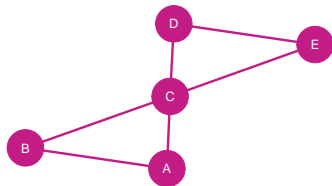
## Example: Network Size and Density

**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

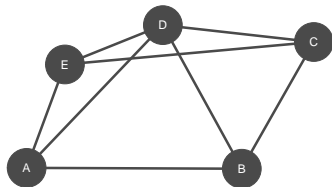
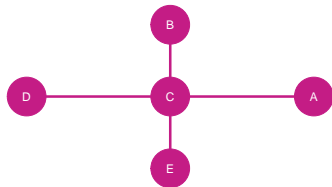
### Business Example: Communication Patterns

**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

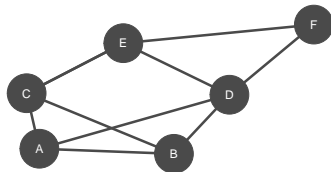
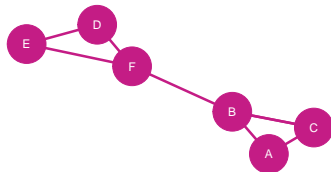
### Business Example: Corporate R&D Network

#### 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



#### **i** Note

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

# 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

**i** Note



# 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