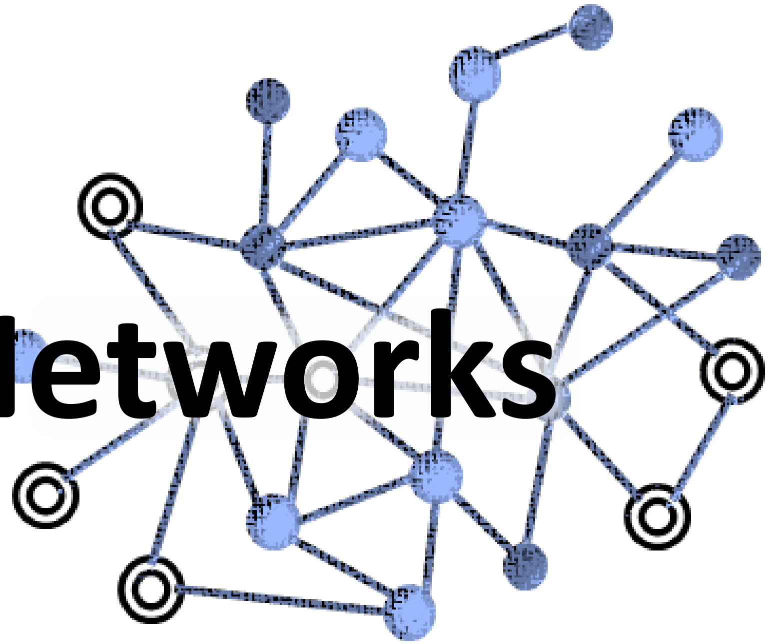
선문대학교
SUN MOON UNIVERSITY

Lecture 05

Social & Information Networks



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Outline – Last Lecture

- **Measuring Networks**
  - Degree Distribution
  - Average Path Length
  - Average Clustering Coefficient
  - Component Distribution
- **Examples: Measuring Real-world Networks**

Describing Networks – Revisited

- Fundamental Step: describing **network features**

Quantifying Structural Properties:

What does **local-level structure** look like?	Microscopic View
What does **large-scale structure** look like?	Macroscopic View
How does **structure constrain** network **functionality**?	Holistic View

Outline

Network Characteristics – Node

- **Structural Importance**
  - Geometric
  - Connectedness

Which Vertices are Important in Networks?

- What do you mean by '***important***'?
  - Define an importance function f:
    - A graph $G(\boldsymbol{V}, \boldsymbol{E})$ as an input
    - A vector $\vec{v}$, consisting of ranks/importance scores of vertices $\boldsymbol{V}$

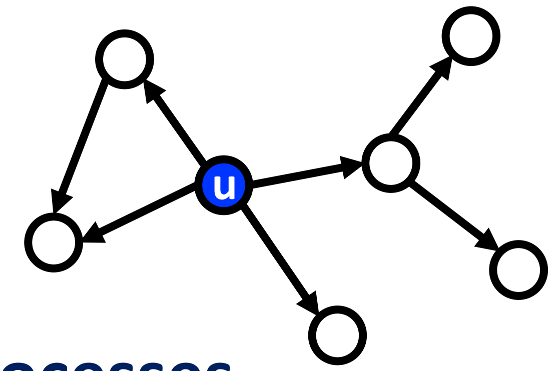
$$f : G \rightarrow \vec{v}$$

Unsupervised Learning Setting

Which Vertices are Important in Networks?

Structural Importance

- Define a node's importance w.r.t. the **network's structure**



Dynamical Importance

- Define a node's importance based on **dynamic processes** over the network structure
- Behavioral change of the node *u* influences its neighbors

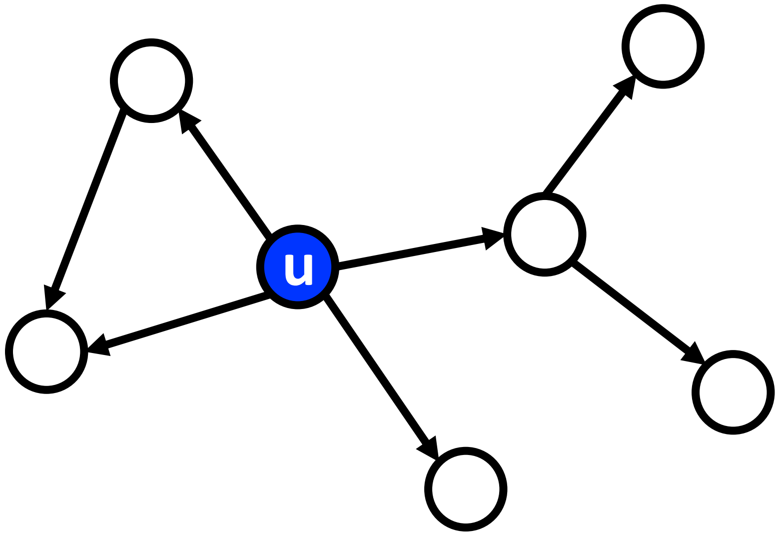
Which Vertices are Important in Networks?

Structural Importance

- Define a node's importance w.r.t. the network's structure
- Foundation of dynamical or functional importance
- Often called ***centrality measures*** (originally from sociology)
  - More central vertices are more structurally important
  - Need to consider the meaning of 'importance' that an application domain defines

Structural Importance

- Measures of positional importance for each node in the network



Geometric
- Closeness Centrality
- Harmonic Centrality
- Betweenness Centrality

Connectedness
- Degree Centrality
- Eigenvector Centrality
- PageRank

Geometric Centrality – Closeness

- The measure of **a node's closeness to all other nodes** in a network:
  - Who are in the center?
- Central vertices can be connected to others with minimum steps.
  - Efficient to exchange information with others or to spread innovation
  - Do not need brokers: independent and autonomous

Geometric Centrality – Closeness

- A node's closeness centrality can be defined **in a connected component** as:

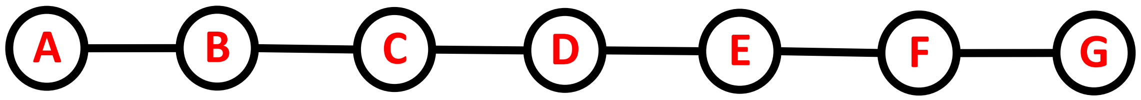
$$C_i = \frac{n-1}{\sum_{j=1}^{n} d_{ij}}$$

  - where d_{ij} denotes the geodesic distance between vertices i and j, and C_i is the inverse of the average distance from i to all other vertices.
  - Closeness is only referred in specific contexts, since $d_{ij} = \infty$ results in $C_i = 0$.

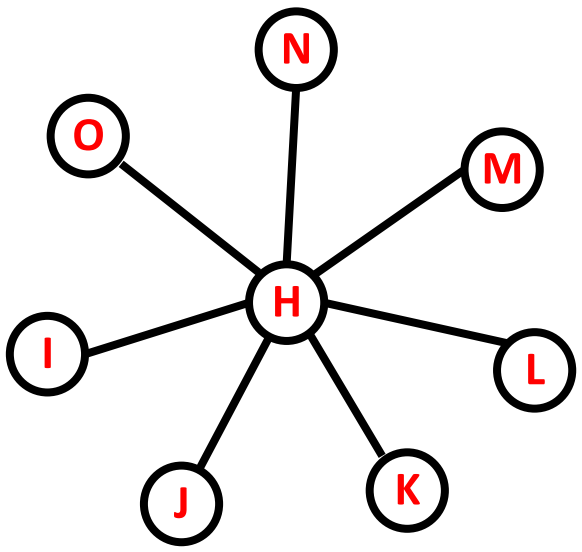
Geometric Centrality – Closeness

- Which vertex shows the highest closeness centrality?

$$C_i = \frac{n-1}{\sum_{j=1}^{n} d_{ij}}$$



$$C_D = \frac{7-1}{(1+2+3)\times 2} = \frac{6}{12} = \frac{1}{2}$$



$$C_H = \frac{8-1}{1\times 7} = \frac{7}{7} = 1$$

Geometric Centrality – Closeness

- Calculate the normalized closeness centrality

$$C_i = \frac{n-1}{\sum_{j=1}^{n} d_{ij}}$$