

Clique Percolation Method (CPM)

1. Terminologies

1. Clique:

- A complete subgraph in which every node is directly connected to every other node. For example, in a graph, a triangle is a 3-clique, and a tetrahedron is a 4-clique.

2. Percolation:

- A process of traversing or spreading through a network based on specific rules. In CPM, it means propagating from one clique to another if they share common nodes.

3. k-Clique:

- A clique with exactly k nodes. For example, a 3-clique has three interconnected nodes, forming a triangle.

4. k-Clique Community:

- A group of overlapping k -cliques, where each pair of consecutive cliques shares at least $k-1$ nodes.

5. Community:

- A set of nodes in the graph that are densely interconnected and form a significant structure within the network.

2. Working of CPM

The Clique Percolation Method identifies communities in a graph by finding overlapping k -cliques and merging them into larger communities.

Steps:

1. Identify All k -Cliques:

- Use an algorithm to find all subsets of nodes that form a complete subgraph of size k .

2. Create a Clique Adjacency Graph:

- Represent cliques as nodes in a new graph and connect them if they share at least $k-1$ nodes.

3. Community Detection:

- Use graph traversal (e.g., BFS or DFS) on the clique adjacency graph to find connected components. Each connected component represents a community.

4. Output Communities:

- Map the cliques in the connected components back to the original graph and retrieve the nodes forming each community.

3. Example

Consider the graph below:

A---B---C---D

| | | |

E---F---G---H

- Suppose we want to find **3-clique communities**:
 1. Identify all **3-cliques**:
 - {A, B, E}, {B, C, F}, {E, F, G}, etc.
 2. Build a **Clique Adjacency Graph**:
 - Cliques sharing at least 2 nodes are connected.
 3. Find **Connected Components**:
 - Group connected cliques into communities.
 4. Result:
 - Communities: {A, B, C, F}, {E, F, G}.

4. Methods to Run the Application

Input:

- A graph represented as an adjacency matrix or adjacency list.
 - Parameter k specifying the size of the cliques to detect.
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5. Applications

- **Social Networks:**
 - Identifying groups of closely related individuals (e.g., friend circles).
 - **Biological Networks:**
 - Detecting functional modules in protein-protein interaction networks.
 - **Market Analysis:**
 - Finding groups of similar products or customer behaviour patterns.
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Conclusion

The Clique Percolation Method is a robust algorithm for detecting overlapping communities in complex networks. Its ability to identify k-clique based communities makes it suitable for various applications in social sciences, biology, and more.