# Improved LCD-SN Algorithm Overview

The improved LCD-SN algorithm demonstrates remarkable computational efficiency, making it particularly suitable for large-scale social networks. In Phase 1, which focuses on initial community formation, the importance scores of all nodes are initialized and iteratively updated. This involves traversing the neighbors of every node, resulting in a time complexity of O(γ ⋅ n ⋅ k), where n is the number of nodes, k is the average degree, and γ is the number of iterations. Although sorting nodes by importance incurs an additional O(n log n) complexity, this phase is primarily dominated by O(γ ⋅ n ⋅ k). In Phase 2, which addresses overlapping node assignment, the algorithm calculates similarity scores between overlapping nodes and their respective communities, requiring O(v ⋅ C ⋅ k) for each overlapping node v, where C is the average number of communities containing the node. Phase 3 focuses on community integration, ensuring effective merging of small and weak communities, with complexities of O(L ⋅ k) for small communities (where L is the number of such communities) and O(n ⋅ k) for weak communities based on edge densities. Combining the complexities of all phases, the overall time complexity of the algorithm is O(n ⋅ k), ensuring linear scalability with network size. The space complexity is O(n + m), where m is the number of edges, accounting for the storage of graph structures, importance scores, and community assignments. Overall, the improved LCD-SN algorithm efficiently handles overlapping nodes and fragmented communities while maintaining low computational overhead, providing a highly scalable and practical solution for real-world social networks.