Mining communities or clusters in networks is valuable in analyzing, designing, and optimizing many natural and engineering complex systems, e.g., protein networks, power grid, and transportation systems. Most of the existing techniques view the community mining problem as an optimization problem based on a given quality function (e.g., modularity), however none of them are grounded with a systematic theory to identify the central nodes in the network. Moreover, how to reconcile the mining efficiency and the community quality still remains an open problem. In this paper, we attempt to address the above challenges by introducing a novel algorithm. First, a kernel function with a tunable influence factor is proposed to measure the leadership of each node, those nodes with highest local leadership can be viewed as the candidate central nodes. Then, we use a discrete-time dynamical system to describe the dynamical assignment of community membership; and formulate the servable conditions to guarantee the convergence of each node’s dynamic trajectory, by which the hierarchical community structure of the network can be revealed. The proposed dynamical system is independent of the quality function used, so could also be applied in other community mining models. Our algorithm is highly efficient: the computational complexity analysis shows that the execution time is nearly linearly dependent on the number of nodes in sparse networks. We finally give demonstrative applications of the algorithm to a set of synthetic benchmark networks and also real-world networks to verify the algorithmic performance.