Peer-to-Peer Neighbor Selection Using Single and Multi-objective Population-Based Meta-heuristics

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Summary. Peer-to-peer (P2P) topology has significant influence on the performance, search efficiency and functionality, and scalability of the application. In this Chapter, we introduce the problem of neighbor selection in peer-to-peer networks using two population based meta-heuristics: Particle Swarm Optimization (PSO) algorithms and Genetic Algorithms (GAs). Both a single objective and a multi-objective problem are formulated, and then the P2P neighbor selection problem is defined. We present the neighbor selection strategy based on PSO and GA algorithm. Each particle encodes the upper half of the peer-connection matrix through the undirected graph, which reduces the search space dimension. We also discuss the characteristics of ergodicity during particle swarm searching process. We also illustrate the algorithm performance and trace its feasibility and effectiveness with the help of some examples.

Keywords: P2P computing, Neighbor selection, Multi-objective optimization, Population-based meta-heuristics, Genetic Algorithms, Particle Swarm Optimization.

12.1 Introduction

Peer-to-peer computing has attracted great interest and attention of the computing industry and gained popularity among computer users and their networked virtual communities [1]. It is no longer just used for sharing music files over the Internet. Many P2P systems have already been built for some new purposes and are being used. An increasing number of P2P systems are used in corporate networks or for public welfare (e.g. providing processing power to fight cancer) [2].
P2P comprises peers and the connections between these peers. These connections may be directed, may have different weights and are comparable to a graph with nodes and vertices connecting these nodes. Defining how these nodes are connected affects many properties of an architecture that is based on a P2P topology, which significantly influences the performance, search efficiency and functionality, and scalability of a system. A common difficulty in the current P2P systems is caused by the dynamic membership of peer hosts. This results in a constant reorganization of the topology [3,4,5,6,7].

Kurmanowytsch et al. [8] developed the P2P middleware systems to provide an abstraction between the P2P topology and the applications that are built on top of it. These middleware systems offer higher-level services such as distributed P2P searches and support for direct communication among peers. The systems often provide a pre-defined topology that is suitable for a certain task (e.g., for exchanging files). Koulouris et al. [9] presented a framework and an implementation technique for a flexible management of peer-to-peer overlays. The framework provides means for self-organization to yield an enhanced flexibility in instantiating control architectures in dynamic environments, which is regarded as being essential for P2P services to access, routing, topology forming, and application layer resource management. In these P2P applications, a central tracker decides about which peer becomes a neighbor to which other peers.

Genetic Algorithms (GAs) are adaptive heuristic search algorithm premised on the evolutionary ideas of natural selection. GAs have been widely studied, experimented and applied in many fields in engineering worlds. Finding optimal parameters for many real world problems prove difficult for traditional methods but is suitable for GAs [10]. PSO (PSO) algorithm is inspired by social behavior patterns of organisms that live and interact within large groups. In particular, PSO incorporates swarming behaviors observed in flocks of birds, schools of fish, or swarms of bees, and even human social behavior, from which the Swarm Intelligence(SI) paradigm has emerged [11, 12]. It could be implemented and applied easily to solve various function optimization problems, or the problems that can be transformed to function optimization problems. As an algorithm, the main strength of PSO is its fast convergence, which compares favorably with many global optimization algorithms [13, 14]. In this chapter, we introduce the P2P neighbor-selection problem based GA and PSO for P2P networks.

This chapter is organized as follows. We formulate the problem in Section 12.2. The considered approaches based on GAs and PSO algorithms are presented in Section 12.3. In Section 12.4, experiment results and discussions are provided in detail, followed by some conclusions in Section 12.5.

12.2 Neighbor-Selection Problem in P2P Networks

Based on existing research [15, 16, 17, 18, 19, 20], we formulate the neighbor-selection problem for P2P networks. We introduce first the model of P2P networks, and then discuss metrics for measuring neighbor selection.