An Adaptive Quantum-based Evolutionary Algorithm for Multiobjective Optimization

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Abstract: - An Adaptive Quantum-based Multi-criterion Evolutionary Algorithm called AQMEA is a new paradigm of decision making for complex systems. Quantum-based algorithms utilize a new representation for the smallest unit of information, called a *Q*-bit, for the probabilistic representation that is based on the concept of qubits. Evolutionary computing with Q-bit chromosomes has a better characteristic of population diversity than other representations, since it can represent linear superposition of states probabilistically. Moreover, we consider the three-criterion problem of task assignment.

Key-Words: - Quantum algorithms, multi-criterion optimization, distributed systems

1 Introduction

The foundations of infinite dimensional ordered spaces create the base for decision making among several criteria. They were statued at the turn of the century XIX and XX by Georg Cantor and Felix Hausdorff. In complex decision situation, some goals, criteria or players are in conflict. In fact, John von Neumann and Oskar Morgenstern noticed that an optimization problems in the context of a social exchange economy are "*a mixture of several conflicting problems*" that are "*nowhere dealt with in classical mathematics*" in their *Theory of Games and Economic Behavior* in 1944 [1].

Nowadays, there are several artificial intelligence techniques that can be applied to solve some multi-criterion optimization problems [6]. Genetic algorithms, artificial neural networks, fuzzy logic algorithms, simulated annealing, tabu search, swarm approach and artificial immunological systems are crucial paradigms for a computer decision making [27].

On the other hand, a quantum-inspired algorithm is relatively new paradigm that can be applied for computer decision aid. Benioff considered a computer as a physical system and constructed a microscopic quantum mechanical Hamiltonian model of computer as represented by Turing machine [7]. It should be stressed that the Turing machine is a quite different approach for development of data processing than the von Neumann's paradigm. Feynman studied simulation models of physics for computer implementations what was the milestone to build quantum algorithms [13].

David Deutsch established the principles of quantum theory, and verified the Church-Turing principle to the universal quantum computer that is based on a theoretical model named the quantum Turing machine [8]. Moreover, he introduced some quantum computational networks. Quantum computers accelerate the efficiency of calculations and do not allow computing functions that are not theoretically computable by classical computers due to the Church-Turing thesis: "*Every function which would naturally be regarded as computable can be computed by the universal Turing machine*" [9].

Shor proposed algorithms for quantum computation related to discrete logarithms and factoring [24]. In the factoring problem, it is given a composite number N like 4, 6, 8, 9, 10, 12, and we want to find an integer p, strictly between 1 and N, that divides N. Shor's algorithm consists of a reduction of the factoring problem to the problem of order-finding what can be done on a classical computer. Then, a quantum algorithm is used to solve the order-finding problem. This approach is exponentially faster than the most efficient known classical factoring algorithm, and what is more, it can be applied to solve the widely used public-key cryptography method RSA that is based on the assumption that factoring large numbers is computationally infeasible for classical computers because no algorithm is known that can factor in polynomial time. However, Shor's algorithm shows that factoring could be efficient on a quantum computer. It was also a motivator for the development quantum computers and quantum algorithms.

In this paper, we consider a multi-criterion problem of task assignment, where a workload of a bottleneck computer and the cost of system are minimized. Furthermore, there are constraints for the performance of the distributed systems and the probability that all tasks meet their deadlines.