Chapter 21
A Multi-Objective Fuzzy Ant Colony Optimization Algorithm for Virtual Machine Placement

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ABSTRACT

In cloud computing, the most important challenge is to enforce proper utilization of physical resources. To accomplish the mentioned challenge, the cloud providers need to take care of optimal mapping of virtual machines to a set of physical machines. In this paper, the authors address the mapping problem as a multi-objective virtual machine placement problem (VMP) and propose to apply multi-objective fuzzy ant colony optimization (F-ACO) technique for optimal placing of virtual machines in the physical servers. VMP-F-ACO is a combination of fuzzy logic and ACO, where we use fuzzy transition probability rule to simulate the behaviour of the ants and the authors apply the same for virtual machine placement problem. The results of fuzzy ACO techniques are compared with five variants of classical ACO, three bin packing heuristics and two evolutionary algorithms. The results show that the fuzzy ACO techniques are better than the other optimization and heuristic techniques considered.

INTRODUCTION

Cloud computing is a recent paradigm for computing and delivering services over the Internet. Based on the service request raised, the resources are provided to the cloud users. From a cloud user's point of view, the cloud appears unbounded and they have the freedom to purchase as much or as little computing power as required, without having to worry about legal rights or the ability to manage and maintain those resources. But for a cloud provider, it incurs substantial costs and huge environmental impacts on purchasing, operating, and maintaining the underlying physical resources. To achieve more utilization of physical resources and reduce hardware costs and operational expenses, virtualization based resource

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provisioning is practiced. Among the various cloud computing service models like Infrastructure as a Service (IaaS), Software as a Service (SaaS) and Platform as a Service (PaaS) (Liu et al., 2012; Mell & Grance, 2009; Voorsluys et al., 2011), virtualized computing resources over the internet is achieved using IaaS.

Virtualization is one of the core technologies in cloud computing which hosts an abstraction layer between an operating system and hardware thus separating the resources and services from the underlying physical delivery environment (Anand et al., 2013). Virtualization is achieved by partitioning the available physical resources into a number of remote execution environments for Virtual Machines (VMs). This creates a view to the user as if each VM accommodates an individual operating system and henceforth a dedicated physical resource of its own. With an increasing trend towards virtualization based data centers becoming the host platform for wide range of applications, virtual machine placement has become a key research area in cloud computing environment. The mapping of a set of virtual machines to a set of physical machines (VM-PM mapping) is called virtual machine placement and the process of finding optimal placement solution is considered here as virtual machine placement problem. Mechanized way of placing a set of virtual machines onto a set of physical machines leads to a large number of VM assignment strategies (Cardosa et al, 2009; Grit et al., 2006, Mishra & Sahoo, 2011). Such a large solution space makes the virtual machine placement (VMP) problem a NP problem and it is almost impossible for any VM-PM mapping algorithm to provide exact placement plans within suitable time period. Hence, quick and intelligent placement heuristics are required to find a near-optimal VM placement plans.

The problem of VM placement is addressed in literature by many researchers. In 2009, Agarwal et al. proposed a group genetic algorithm to solve server consolidation problem as a vector packing problem with conflicts and has shown that they achieve better results compared to other approaches. As a further improvement to grouping genetic algorithm, a reordering grouping genetic algorithm is proposed by David et al. (2011). Eugen et al. (2011) used a new version of ant colony optimization (ACO) approach to address VM consolidation and has shown that ACO gives better results than First Fit Decreasing (FFD). However, their evaluation was simplified to one-dimensional resource as they varied only the number of cores demanded by VM and retained resource demands unchanged. Mills et al. (2011) proposed methods for initial VM placements and compared against 18 initial placement algorithms. Anand et al., (2013) enumerated modifications to virtual machine placement problem to include VM specific virtualization overhead and VM migration overheads based on resource requirement vector so as to ensure performance SLA guarantees for the applications hosted inside the VM. Wu et al., (2012) proposed a genetic algorithm approach for the virtual machine placement problem that considers minimizing the energy consumption in both the servers as well as in the communication network in the data center. Wu et al. (2012) gave a simulated annealing technique for VM placement. Luke (2013) designed new mutation and cross over operations where swap, move and remove are considered for mutation and these operations are applied to the steady state genetic algorithm for VM placement. Few other research articles considered single objective for virtual machine placement problem are by Jiang et al. (2012), Jin et al. (2102), Kantrci et al. (2012), Hong et al. (2013), Shigeta et al. (2013), Wang et al. (2012), Wang et al. (2014), etc.

Adamuthe et al. (2013) formulated VM placement as a multi-objective optimization problem. They compared the results of genetic algorithms, non-dominated sorting genetic algorithm (NSGA)–I and NSGA-II and conclude that NSGA-II provides diversified good solutions. Chen et al. (2013) provided cost aware two phase metaheuristic algorithms to capture the intrinsic trade-off between electricity and WAN communication costs. Dong et al. (2013a; 2013b; 2013c) came up with strategy to optimize