Chapter 15

Dot Net Platform for Distributed Evolutionary Algorithms with Application in Hydroinformatics

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ABSTRACT

Real-world problems often contain nonlinearities, relationships, and uncertainties that are too complex to be modeled analytically. In these scenarios, simulation-based optimization is a powerful tool to determine optimal system parameters. Evolutionary Algorithms (EAs) are robust and powerful techniques for optimization of complex systems that perfectly fit into this concept. Since evolutionary algorithms require a large number of time expensive evaluations of candidate solutions, the whole process of optimization can take huge CPU time. In this chapter, .NET platform for distributed evaluation using WCF (Windows Communication Foundation) Web services is presented in order to reduce computational time. This concept provides parallelization of evolutionary algorithms independently of geographic location and platform where evaluation is performed. Hydroinformatics is a typical representative of fields where complex systems with many uncertainties are studied. Application of the developed platform in hydroinformatics is also presented in this chapter.

1. INTRODUCTION

The evolutionary algorithms (EAs) are stochastic search methods that simulate the process of natural evolution. These algorithms have proven themselves as a robust and powerful mechanism when it comes to solving challenging optimization problems.

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Evolutionary algorithm mimics the process of natural evolution, by modifying the set of potential solutions, called population, through selection, crossover and mutation of individuals. In order to select best candidates for reproduction, one has to determine the fitness of each individual in the population by evaluating it with respect to each objective. Each evaluation of the solution for the real-world problem usually requires running a complex, time consuming computer simulation, and so the use of distributed computing is a necessity.

Different approaches for the use of parallelism in evolutionary algorithms for optimization have been proposed in the literature and surveys have been written (Jaimes & Coello, 2009; Talbi et al., 2008). Three major parallel models of EAs exist: the master-slave model, the island model and the diffusion model.

In the master-slave model the objective functions evaluations are distributed among several slave processors, while a master processor executes the rest of EA. In the island model, the population is divided into several sub-populations (islands) and serial EA is executed in each of these islands for a number of generations called an epoch. At the end of each epoch, the individuals migrate between the neighboring islands along migration paths. Inter-processor communication frequency in this model is low, but modeling requires many parameters and design decisions. In the diffusion model, the population is spatially distributed onto a neighborhood structure which is usually a two-dimensional rectangular grid. There is a single individual per grid point and ideally, one processor per individual. Therefore, this model is called fine grained. The selection and mating is confined to a small neighborhood around each individual, and since individuals which take part in the selection are distributed among several processors, the communication costs tend to be high.

The purpose of this chapter is to introduce a platform for distributed evaluation of individuals in evolutionary algorithms based on the master-slave model. The evaluations of the individuals are performed by Windows Communication Foundation (WCF) web services. WCF is a part of .NET Framework which provides unified programming model for rapidly building service-oriented applications that communicate across the web. Although the platform is developed using .NET technology, mainly as a support to the existing .NET hidroinformation system widely used in leading hydro-energetic institutions in Serbia and Republic of Srpska, it can be seamlessly integrated into any existing evolutionary framework.

The rest of the hapter is organized as follows: in section 2 we review related work, while section 3 describes the proposed platform. Application of the platform in hydroinformatics and discussion of achieved performances improvements are given in Section 4. Some concluding remarks are presented in the last section.

2. RELATED WORK

There are several protocols and libraries which provide aid in the development of parallel systems, by hiding some of the network connection and transmission details. The most important are MPI and OpenMP. MPI, the Message Passing Interface, is the standard for development of parallel codes on the distributed memory systems, whereas OpenMP (Open Multi-Processing) is the standard in shared memory systems (Dagum & Menon, 1998; Message Passing Interface Forum, 2009). The parallelization and distribution functionality in evolutionary software packages is often built on top of libraries implementing MPI, like in Simdist (Hoverstad, 2010) and ParadisEO (Cahon, Melab, & Talbi, 2004).

Grid technologies support the sharing and coordinated use of diverse resources in dynamic virtual organizations. The Globus toolkit is an open-source, community-based set of software tools to enable the aggregation of compute, data, and other resources to form computational grids. Multi population algorithm using master-slave parallel model in a Globus toolkit based grid environment was implemented in (Limmer & Fey, 2010). Implementation of the framework requires selection of certain parameters: the number of subpopulations, the size of the subpopulations, the number of migrants in an optimization step, and the number of the generations that are computed in a single optimization step. ParadisEO-CMW (Cahon, Melab, & Talbi, 2005), which is