

# ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: **Dr. Radha Thanga Raj**  
Visited Location: **University of Luxembourg, Luxembourg**  
Duration of Visit: **April 07, 2010 – April 06, 2011 (12 months)**

## **I - Scientific activity**

During my fellowship, I worked on a project with the team of Prof. Pascal Bouvry, University of Luxembourg. One of the objectives of the project was the development and validation of efficient evolutionary algorithm for solving Grid Scheduling problem.

Evolutionary Algorithms (EAs) are a broad class of stochastic optimization algorithms inspired by biology and, in particular, by those biological processes that allow populations of organisms to adapt to their surrounding environments, genetic inheritance and survival of the fittest. EAs have certain prominent advantages over other types of numerical methods; the two are the most important being: (i) Their application to problems that consist of discontinuous, non-differentiable and non-convex objective functions and/or constraints (ii) Their efficiency in escaping the local optima. EAs have been applied to a wide range of benchmark functions (single and multi-objective) and real life problems. Some common EAs are Genetic Algorithms, Evolutionary Programming, Particle Swarm Optimization, Differential Evolution etc.

Initial phase of my stay has been devoted in literature survey and to learn about grid scheduling problem. Task scheduling in computational grids is a family of problems that capture the most important needs of grid applications for efficiently allocating tasks to resources in a global and dynamic environment. After a detailed study of the problem and the related available research papers, I developed my own C++ code for grid scheduling problem using Differential Evolution algorithm.

I had also developed new improved Differential Evolution Algorithms and validated the algorithms with standard benchmark problems, which were taken from the literature, and a real life problem. The results were communicated in an International reputed journal. Since my previous year research (during my Ph.D) was solving mono (single) objective optimization problems, I concentrated on multi-objective optimization during my stay at University of Luxembourg. I solved some multi-objective stochastic linear as well as fractional programming problems and published the results in one international reputed journal and two international conferences.

In addition with the above, the ERCIM fellowship allowed me to concentrate on the completion of work that I had initiated in previous years and submit it to international journals.

During the past 12 months, apart from working on projects of personal interest, I also reviewed journal papers for the Knowledge Based Systems, Elsevier Science, as well as conference papers for the 2010 IEEE International Conference on Systems, Man and Cybernetics, the 2010 International Conference on Hybrid Intelligent Systems, the 2010 International Conference on Parallel Problem Solving from Nature and the 2011 Genetic and Evolutionary Computing Conference.

## **II- Publication(s) during your fellowship**

### **Book Chapter:**

1. **Title:** Applications of Nature Inspired Algorithms in Electrical Engineering  
**Authors:** Radha Thangaraj, Thangaraj Chelliah, Millie Pant, Pascal Bouvry and Ajith Abraham  
**Forum:** Handbook of Optimization, Intelligent Systems Series, Springer Verlag, Germany, Accepted for publication.  
**Abstract:** This chapter presents an application of two popular Nature Inspired Algorithms; Particle Swarm Optimization and Differential Evolution algorithms in electrical engineering field. The main focus is on the reliability and efficiency of transmission and utilization of electrical energy, the most important fields of optimization in electrical engineering having nonconvex characteristics with heavy equality and inequality constraints. The optimization algorithms are applied to various electrical engineering problems including over-current relay settings in transmission lines, design and control of induction motors serving to process industries, proportional-integral controller tuning in variable speed drives and in-situ parameter estimation of electric motors. The effectiveness of the algorithms is discussed.

### **Peer Reviewed International Journal Papers:**

2. **Title:** Solving Stochastic Programming Problems Using Modified Differential Evolution Algorithms  
**Authors:** Radha Thangaraj, Millie Pant, Pascal Bouvry and Ajith Abraham  
**Forum:** Logic Journal of the IGPL, Oxford Journals Press, 2011, In Press, [doi:10.1093/jigpal/jzr017](https://doi.org/10.1093/jigpal/jzr017). Impact factor: 0.326  
**Abstract:** Stochastic (or probabilistic) programming (SP) is an optimization technique in which the constraints and/or the objective function of an optimization problem contain random variables. The mathematical models of these problems may follow any particular probability distribution for model coefficients. The objective here is to determine the proper values for model parameters influenced by random events. In this study, two modified Differential Evolution algorithms namely, LDE1 and LDE2 are used for solving SP problems. Two models of SP problems are considered; Stochastic Fractional Programming Problems and Multi Objective Stochastic Linear Programming Problems. The numerical results obtained by the LDE algorithms are compared with the results of basic DE, basic PSO and the available results from where it is observed that the LDE algorithms significantly improve the quality of solution of the considered problem in comparison with the quoted results in the literature.
3. **Title:** Particle Swarm Optimization: A Survey on Hybridization Perspectives  
**Authors:** Radha Thangaraj, Millie Pant, Ajith Abraham and Pascal Bouvry  
**Forum:** Applied Mathematics and Computation, Elsevier Science, Vol. 217 (12), pp. 5208 – 5226, 2011. Impact factor: 1.124  
**Abstract:** Metaheuristic optimization algorithms have become popular choice for solving complex and intricate problems which are otherwise difficult to solve by traditional methods. In the present study an attempt is made to review the hybrid optimization techniques in which one main algorithm is a well known metaheuristic; Particle Swarm Optimization or PSO. Hybridization is a method of combining two (or more) techniques in a judicious manner such that the resulting algorithm contains the positive features of both (or all) the algorithms. Depending on the algorithm/s used we made three classifications as (i) Hybridization of PSO and Genetic Algorithms (ii) Hybridization of PSO with Differential Evolution and (iii) Hybridization of PSO with other techniques. Where, other

techniques include various local and global search methods. Besides giving the review we also show a comparison of three hybrid PSO algorithms; Hybrid Differential Evolution Particle Swarm Optimization (DE-PSO), Adaptive Mutation Particle Swarm Optimization (AMPSO) and Hybrid Genetic Algorithm Particle Swarm Optimization (GA-PSO) on a test suite of nine conventional benchmark problems.

4. **Title:** Differential Evolution Algorithms using Localized Mutation operators and Their Applications

**Authors:** Radha Thangaraj, Millie Pant, Pascal Bouvry and Ajith Abraham

**Forum:** Knowledge Based Systems, Elsevier Science, Revised Manuscript Submitted, 2011.

**Abstract:** In the present study, a modified DE framework based on local neighborhood search (LNS) is proposed. The process of LNS is done by exploring the vicinity of the particle having the best fitness function value (global best particle) with the help of mutation operators based on different probability distributions viz. Laplace, Cauchy and Gaussian. The proposed schemes named as LMDE-G, CMDE-G and GMDE-G help in enhancing the exploration and exploitation capabilities of DE without imposing any serious threat on the number of function evaluations. Their performance is analyzed on a set of traditional and nontraditional benchmark problems. Statistical and empirical analyses show that the proposed variants are better or at least comparable with basic DE and other contemporary algorithms. Further, the performance of the proposed DE variants is also investigated for solving a real life problem dealing with the optimization of directional over-current relay settings. It is a highly complex, nonlinear constrained optimization problem occurring frequently in the field of electrical engineering.

#### **Peer Reviewed International Conferences**

5. **Title:** Evolutionary Algorithms for Solving Stochastic Programming Problems  
**Authors:** Radha Thangaraj, Millie Pant, Pascal Bouvry and Ajith Abraham  
**Forum:** Int. Conf. on Computational Intelligence Communication Networks (CICN 2010), India, IEEE Computer Society Press, 2010, pp. 628 - 632.
6. **Title:** Optimal Design of Induction Motor for a Spinning Machine Using Population Based Metaheuristics  
**Authors:** Radha Thangaraj, Thangaraj Chelliah, Pascal Bouvry, Millie Pant and Ajith Abraham  
**Forum:** 9<sup>th</sup> Int. Conf. on Computer Information Systems and Industrial Management Applications (CISIM'10), Poland, IEEE Computer Society Press, 2010, pp. 341 - 346.
7. **Title:** Solving Multi Objective Stochastic Programming Problems Using Differential Evolution  
**Authors:** Radha Thangaraj, Millie Pant, Pascal Bouvry and Ajith Abraham  
**Forum:** Int. Conf. on Swarm, Evolutionary and Memetic Computing, Lecturer Notes on Computer Science, Springer Verlag, 2010, pp. 54 - 61.

#### **III -Attended Seminars, Workshops, and Conferences**

1. Int. Conference on Computer Information Systems and Industrial Management Applications, 8 - 10 October, 2010, Krakow, Poland.  
Within this conference I presented a paper and I was session chair for the session Web Intelligence, Computer and Network Security, Communication Networks, Production / Operation Management.
2. Int. Conference on Computational Intelligence and Communication Networks, 26 - 28 November, 2010, Bhopal, India.  
Within this conference I presented a paper.

#### **IV – Research Exchange Programme (12 months scheme)**

**First ERCIM Institute:** Norwegian University of Science and Technology, Trondheim, Norway

**Scientific Contact:** Prof. Ilangko Balasingham

**Duration:** 20/09/2010 to 24/09/2010

**Description:** The research discussions during the visit were focused on how the Evolutionary algorithms could be used for medical signal processing.

**Second ERCIM Institute:** INRIA, Lille, France

**Scientific contact:** Prof. E-G. Talbi

**Duration:** 07/03/2011 to 11/03/2011

**Description:** I had the opportunity to individually meet with many of the researchers of the team of Prof. Talbi resulting in inspiring discussions. I discussed several aspects and details of multi-objective optimization using evolutionary algorithms with the members of the group.