Capítulo 1

Conclusions

The Evolvable Agent is a spatially structured model designed for Evolutionary Computation in P2P infrastructures. The model defines the population structure by means of the gossiping protocol newscast that behaves asymptotically as a small-world graph. The influence of such kind of structures in the environmental selection pressure of EAs is close to that in panmictic populations used by default in canonical GA approaches. Nevertheless, as it has been shown in this paper the inhomogeneities of small-world structured population play an important role in the preservation of the genetic diversity, and have, therefore, a positive effect on scalability.

This chapter reviews the main issues in distributed EAs over P2P systems such as decentralization, scalability or fault tolerance, the state of the art solutions to deal with them and some promising fields of application as DOPs.

To that end, the *EvAg* model has been presented and assessed empirically under different scenarios using trap-functions as a benchmark. Given that trap-functions have been designed to be difficult for EAs, the results should be easily extended to more general discrete or combinatorial optimization problems.

The evolution takes place among a population of EvAgs in which the population structure is managed by the gossiping protocol newscast. The population size scales with a complexity order of $O(L^{(1,0,1,1)})$ which demands for a big amount of resources. Besides, the expected runtime scales with fractional order which makes the algorithm efficient. Investigating scalability is of extreme importance when changing from a "toy problem"test environment to real-world problems which may require very large chromosomes to codify the solutions. Additionally, the approach shows to be robust under *churn*, once that an adequate population size guarantees a reliable convergence to the optimum, the departure of nodes does not inflict a penalization in the runtime.

Finally, this kind of topology preserves well the genetic diversity by relaxing the environmental selection pressure at the small-world relationships between individuals. This might be one of the reasons for the good results in DOPs. The EvAg model responds to changes outperforming standard GAs and SORIGA, one of the state of the art algorithms in DOPs.

In order to deploy the algorithm in real P2P platforms, the future challenges of P2P EAs focus on engineering issues rather than design ones. For instance, the impact of the latency between peers will have to be assessed on the run-time performance, it might be expected that the idle processing time decreases as the problem instances scale (i.e. bigger instances require a bigger computational time while the communication time can be assumed as fixed). Additionally, the bootstrapping of the system (i.e. the way an experiment is spread from a single peer to the rest of the system) or the fact that P2P systems are composed of heterogeneous nodes will have to be taken into account.

The following papers were published during the development of this thesis:

Peer reviewed journal papers:

1. Juan Luis Jimenez Laredo, Agoston E. Eiben, Maarten van Steen, and Juan Julian Merelo. Evag: A scalable peer-to-peer evolutionary algorithm. Genetic Programming and Evolvable Machines, 2010. http://dx.doi.org/10.1007/s10710-009-9096-z.
2. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio M. Mora, Juan Julian Merelo, and Carlos Fernandes. Resilience to churn of a peer-to-peer evolutionary algorithm. Int. J. High Performance Systems Architecture, 1(4):260-268, 2009.
3. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio Miguel Mora, and Juan Julian Merelo Guervos. Evolvable agents, a fine grained approach for distributed evolutionary computing: walking towards the peer-to-peer computing frontiers. Soft Computing - A Fusion of Foundations, Methodologies and Applications, 12(12):1145-1156, 2008.

Peer reviewed conference papers and book chapters:

1. Juan Luis Jimenez Laredo, Juan Julian Merelo Guervos, and Pedro An- gel Castillo Valdivieso. Paral. and Distrib. Comp. Intel., volume 269 of SCI, chapter Evolvable Agents: A Framework for Peer-to-Peer Evo- lutionary Algorithms, pages 43-62. Springer-Verlag Berlin Heidelberg, 2010.

2. Juan Luis Jimenez Laredo, Carlos Fernandes, Juan Julian Merelo, and Christian Gagne. Improving genetic algorithms performance via deterministic population shrinkage. In GECCOÓ9: Proceedings of the 11th Annual conference on Genetic and evolutionary computation, pages 819-826, New York, NY, USA, ACM, 2009.

3. Juan Luis Jimenez Laredo, Carlos Fernandes, Antonio Mora, Pedro A. Castillo, Pablo Garcia-Sanchez, and Juan Julian Merelo. Studying the cache size in a gossip-based evolutionary algorithm. In G.A. Papadopoulos and C. Badica, editors, Proceedings of the 3rd International Symposium on Intelligent Distributed Computing, volume 237 of Studies in Computational Intelligence, pages 131-140. Springer-Verlag Berlin Heidelberg, 2009.

4. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio M. Mora, Carlos Fernandes, and Juan Julian Merelo. Addressing Churn in a Peer-to-Peer Evolutionary Algorithm. In Juan Lanchares, Francisco Fernandez, and Jose L. Risco-Martin, editors, WPABAÓ8 - First International Workshop on Parallel Architectures and Bioinspired Algorithms, Toronto, Canada, pages 5-12. Complutense University Of Madrid, 2008.

5. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio Miguel Mora, Juan Julian Merelo Guervos, Agostinho Claudio da Rosa, and Carlos Fernandes. Evolvable agents in static and dynamic optimization problems. In Rudolph et al., editors. Parallel Problem Solving from Nature - PPSN X, 10th International Conference Dortmund, Germany, Proceedings, volume 5199 of Lecture Notes in Computer Science, pages 488-497. Springer, 2008

6. Juan Luis Jimenez Laredo, Agoston E. Eiben, Maarten van Steen, and Juan Julian Merelo Guervos. On the run-time dynamics of a peer-to-peer evolutionary algorithm. In Rudolph et al., editors. Parallel Problem Solving from Nature - PPSN X, 10th International Conference Dortmund, Germany, Proceedings, volume 5199 of Lecture Notes in Computer Science, pages 236-245. Springer, 2008.

7. Juan Luis Jimenez Laredo, Agoston E. Eiben, Maarten van Steen, Pedro A. Castillo, Antonio Miguel Mora, and Juan Julian Merelo Guervos. P2P evolutionary algorithms: A suitable approach for tackling large instances in hard optimization problems. In Emilio Luque et al., editors, Euro-Par, volume 5168 of Lecture Notes in Computer Science, pages 622-631. Springer, 2008.

8. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio M. Mora, and Juan Julian Merelo. Exploring population structures for locally concurrent and massively parallel evolutionary algorithms. In IEEE Congress on Evolutionary Computation (CEC2008), WCCI2008 Proceedings, pages 2610-2617. IEEE Press, Hong Kong, June 2008.

9. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio M. Mora, and Juan Julian Merelo. Escalado con un sistema de agentes evolutivos distribuido. In Francisco Almeida-Rodriguez et al., editors, Actas MAEB 2007, pages 111-118, 2007.

10. Agoston E. Eiben, Marc Schoenauer, Juan Luis Jimenez Laredo, Pedro A. Castillo Valdivieso, Antonio Miguel Mora, and Juan Julian Merelo. Exploring selection mechanisms for an agent-based distributed evolutionary algorithm. In Dirk Thierens, editor, GECCO, pages 2801-2808. ACM, 2007.

11. Juan Luis Jimenez Laredo, Pedro A. Castillo Valdivieso, Ben Paechter, Antonio Miguel Mora, Eva Alfaro-Cid, Anna Esparcia-Alcazar, and Juan Julian Merelo Guervos. Empirical validation of a gossiping communication mechanism for parallel EAs. In Mario Giacobini et al., editors, EvoWorkshops, volume 4448 of Lecture Notes in Computer Science, pages 129-136. Springer, 2007.

12. Juan Luis Jimenez Laredo, Pedro A. Castillo, Gustavo Romero, Antonio M. Mora, Juan Julian Merelo, and Maribel G. Arenas. Validacion de un sistema computacional P2P mediante un estudio empirico. In XVII Jornadas de Paralelismo - XVII JP, pages 235-240, September 2006.

13. Juan Luis Jimenez Laredo, Pedro A. Castillo, Antonio M. Mora, and Juan Julian Merelo. Estudio preliminar sobre autoadaptacion en agentes evolutivos sobre arquitecturas heterogeneas. In XVII Jornadas de Paralelismo - XVII JP, pages 389-394, September 2006.