Universidad de Granada

MULTI AGENTS AND DYNAMIC OPTIMIZATION PROBLEMS: SIMPLE RULES FOR IMPROVING PERFORMANCE

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EPSRC BTG Workshop on Dynamic Optimisation

Outline of the talk

- Who we are
- What we have now
  - multiswarms & DOP
  - Cooperative Strategies for DOP
- What we are doing and some open questions

Who we are

- Models of Decision and Optimization Research Group (modo.ugr.es)
- 7 Phd + 3 Phd Students
- Research lines
  - Decision making under uncertainty
  - Optimization with metaheuristics (cooperative methods)
  - Adversarial Domains
  - Car racing videogames ☺
  - **Intelligent Optimization Strategies in Uncertain and Dynamic Environments**

Intelligent Optimization Strategies in Uncertain and Dynamic Environments

Current social-technological context

Telecommunication | Users | Infrastructures | Services

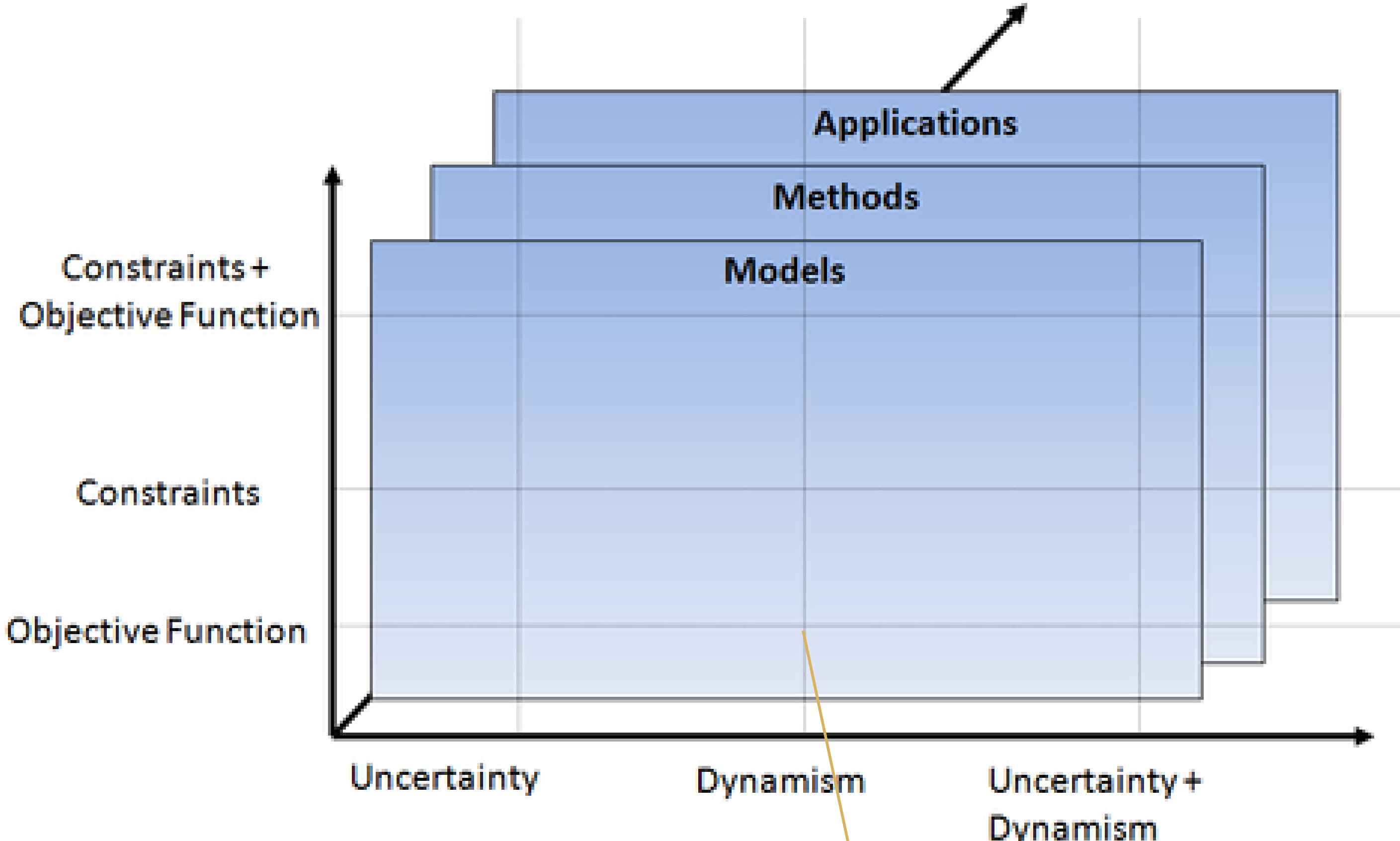
New Scenarios

Uncertainty | **Dynamism**

Soft Computing Techniques

Fuzzy Sets & Systems | **Metaheuristics**

Intelligent Optimization Strategies in Uncertain and Dynamic Environments

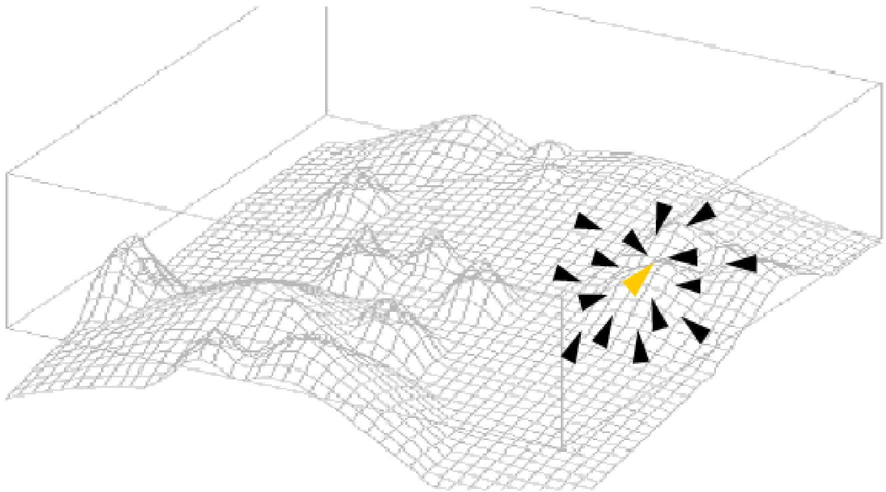


The core of my talk will be here

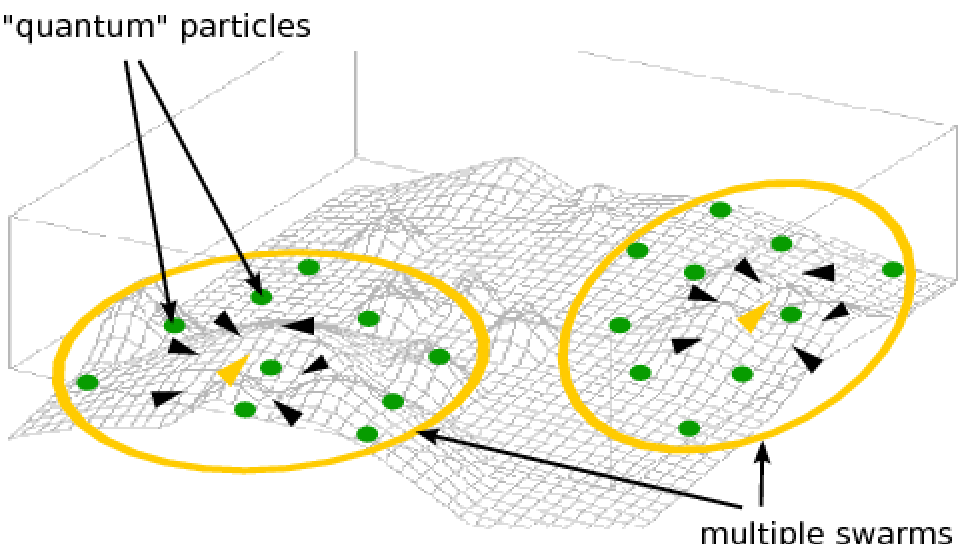
Dynamic Optimization Problems

- What are we talking about ?
- Let's see some videos

Swarms and Multiswarms in DOP



- Outdated memory
- Diversity loss
- Locality after a change
- Slow response to changes in the environment



“Atomic” scheme

Charged or quantum particles

Multiple swarm

Simultaneous exploration

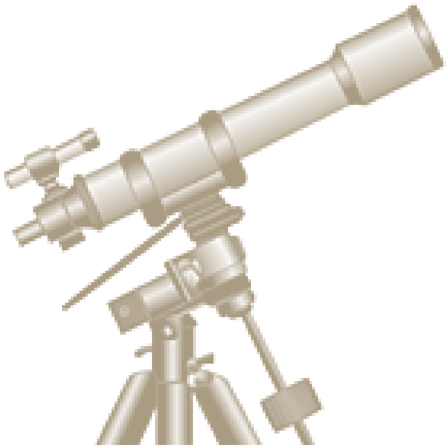
Exclusión, anti-convergence properties

T. Blackwell and J. Branke, IEEE TEC, vol. 10, no. 4, pp. 459–472, 2006.

Simple ways to improve

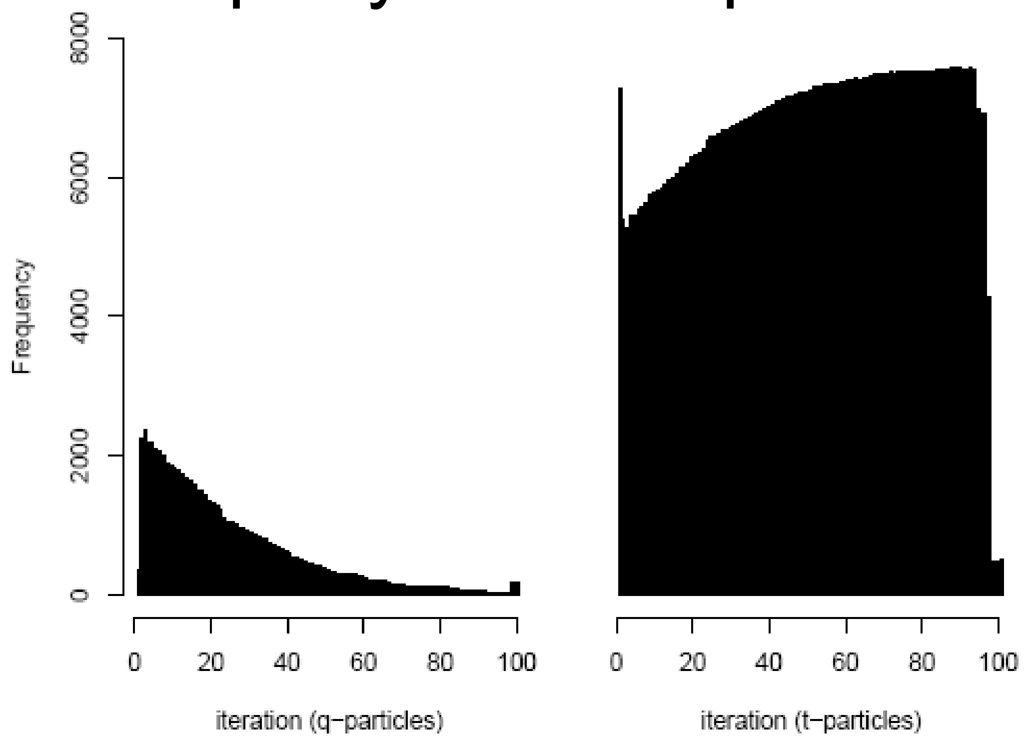
Adapting the types of the particles

Changing the behaviour of some swarms



Particles Control

- The particles (quantum, trajectory) do not contribute equally to the improvements



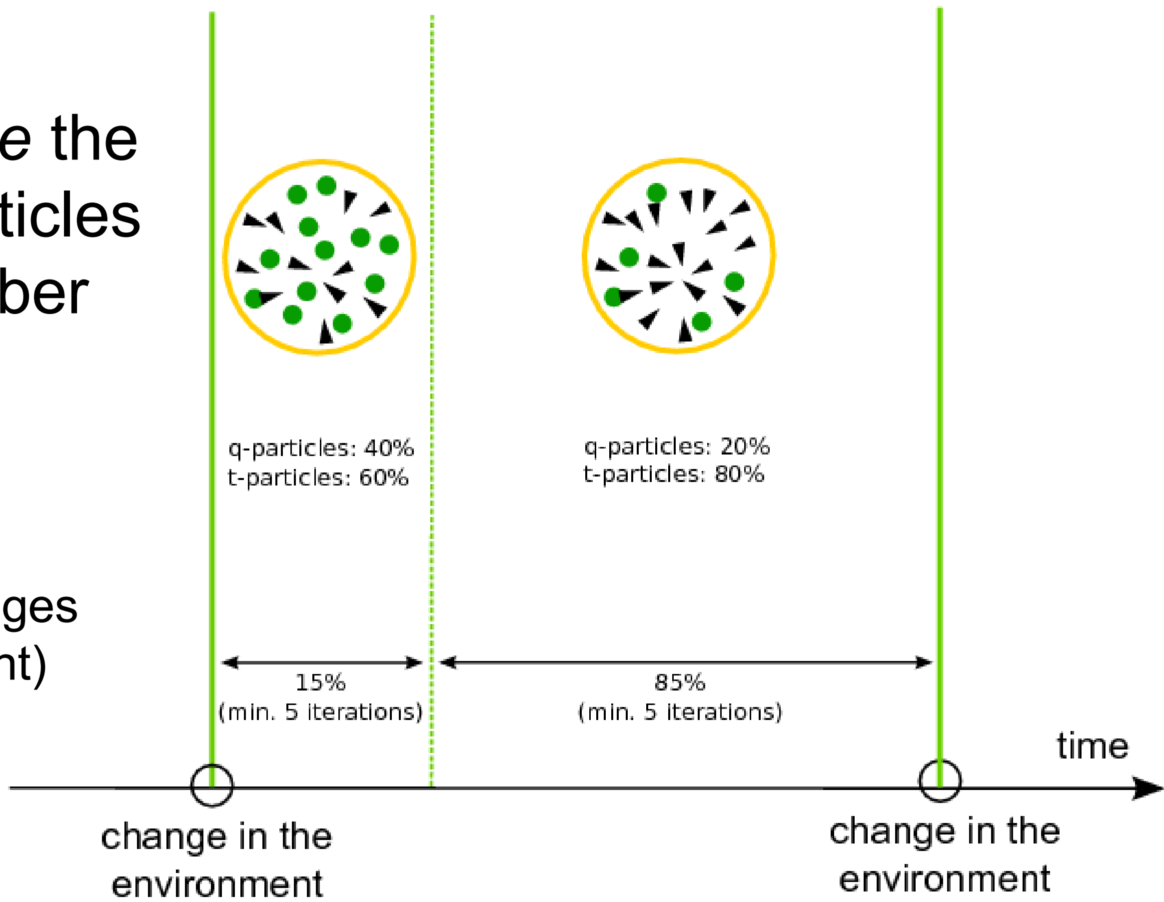
I. G. del Amo, D. A. Pelta, J. R. González, and P. Novoa, "*An Analysis of Particle Properties on a Multi-Swarm PSO for Dynamic Optimization Problems*," in CAEPIA 2009, ser. LNAI, P. Meseguer, L. Mandow, and R. M. Gasca, Eds., vol. 5988. Springer, Heidelberg, 2010, pp. 32–41.

Rule 1: "Change Rule"

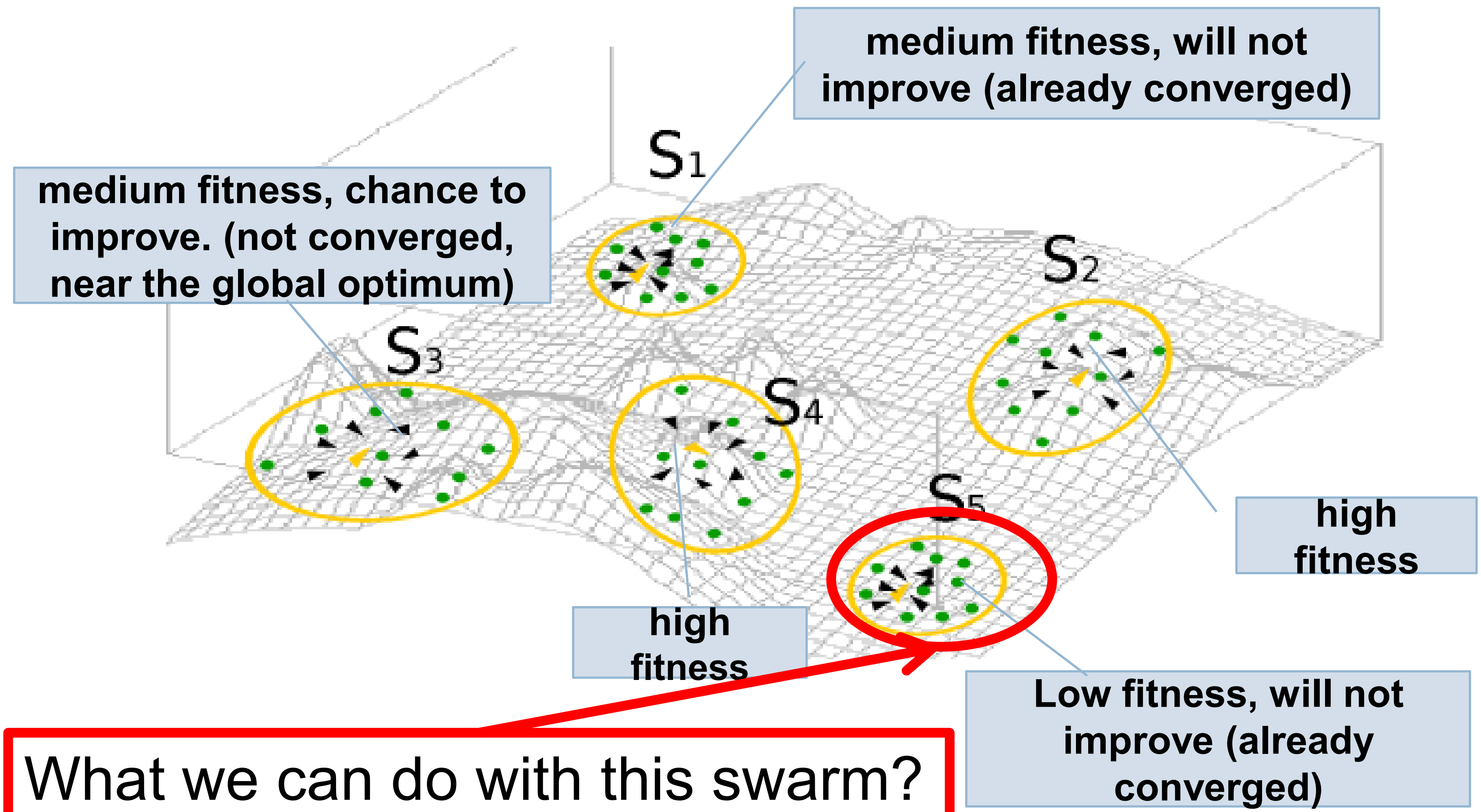
IF a change in the environment has occurred recently

THEN temporarily *increase* the number of *quantum* particles AND *decrease* the number of *trajectory* particles

The length of period between changes is estimated (and assumed constant)



Swarm Control: Efficiency improvement



What we can do with this swarm?

Rule 2: “Rand Rule”

IF a swarm is showing bad performance

THEN relocate the swarm randomly OR
stop it if there is not enough time

Bad Performance means that the Swarm has

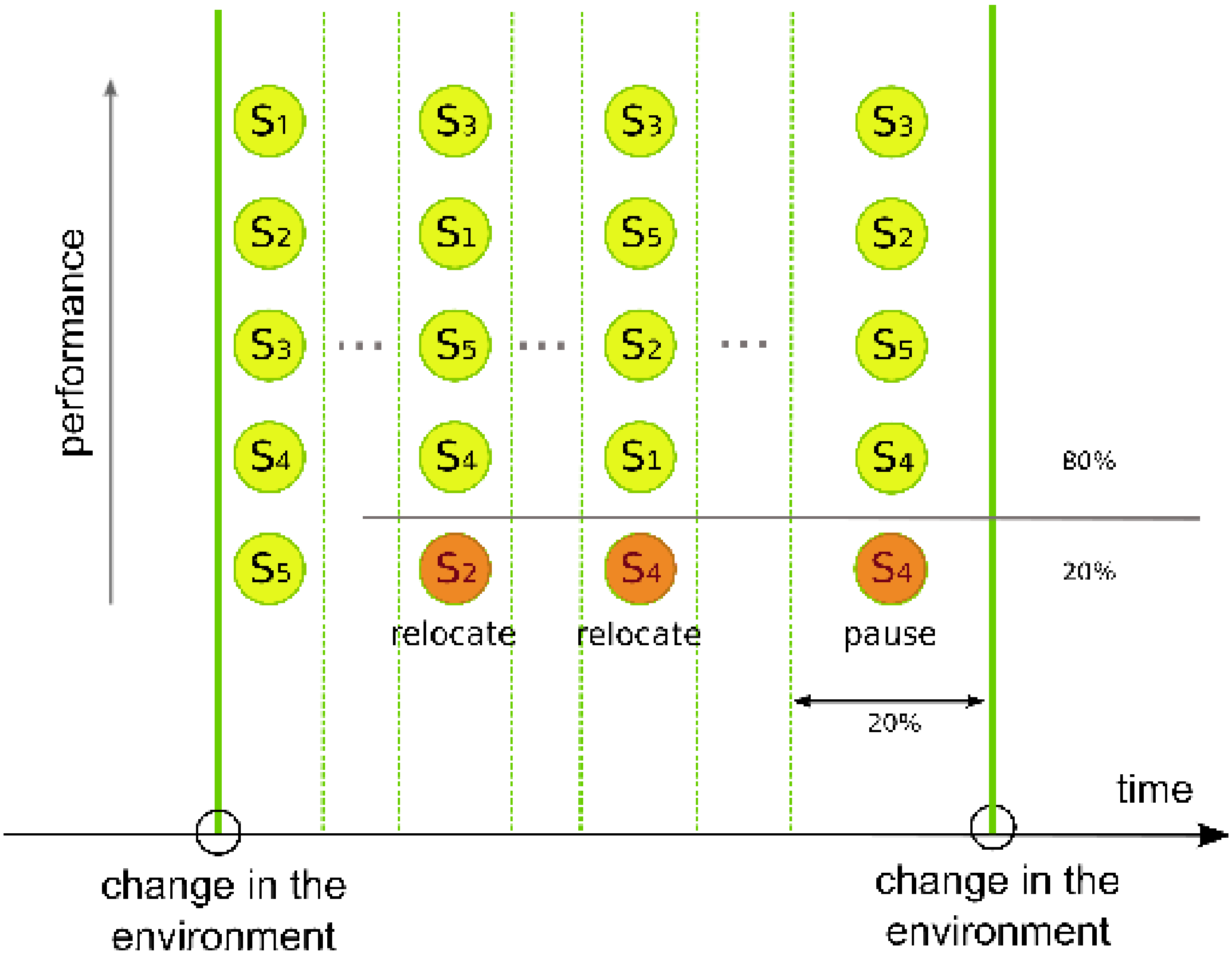
already converged and its **fitness is low**

Local Information related with rate of improvement

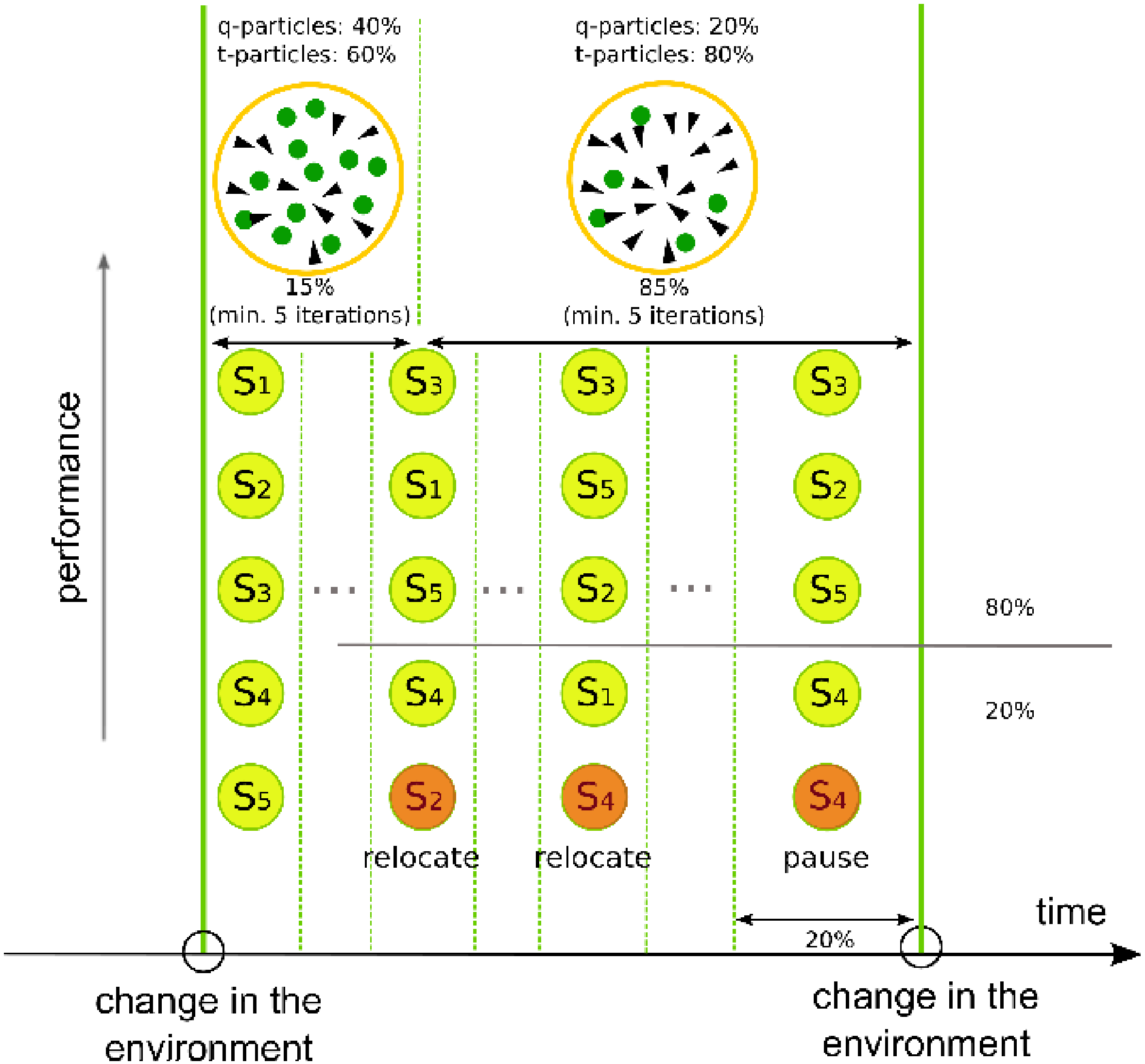
Global Information related with the fitnesses of all of the other swarms (the g_bests)

We also have definitions using measures of diversity

Rule 2: “Rand Rule”

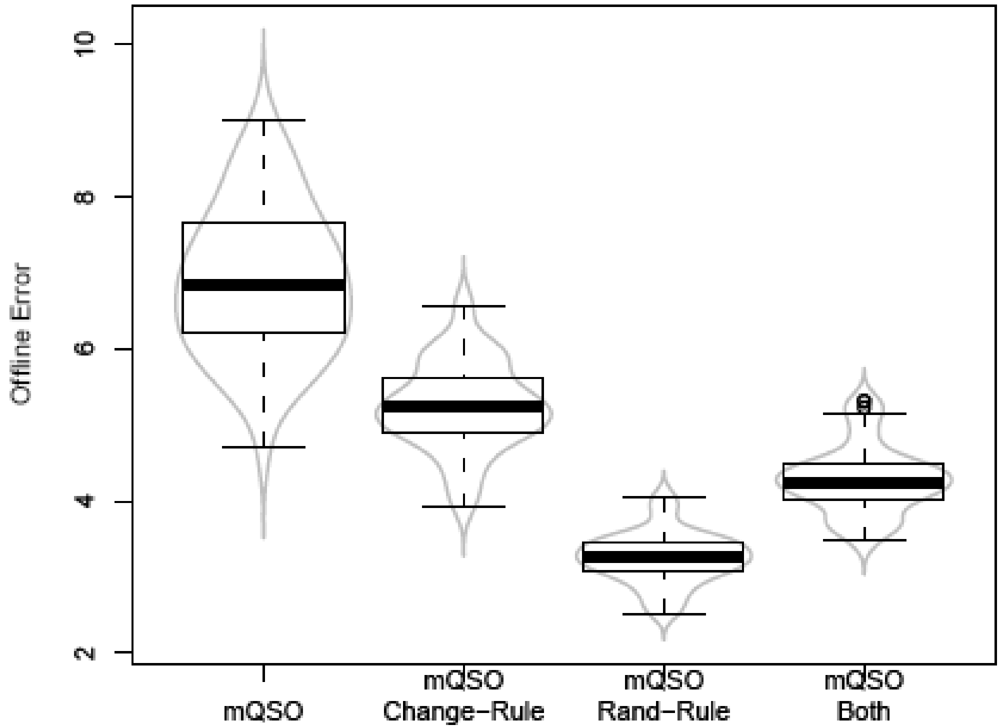


Rule 3: Change + Rand Rule



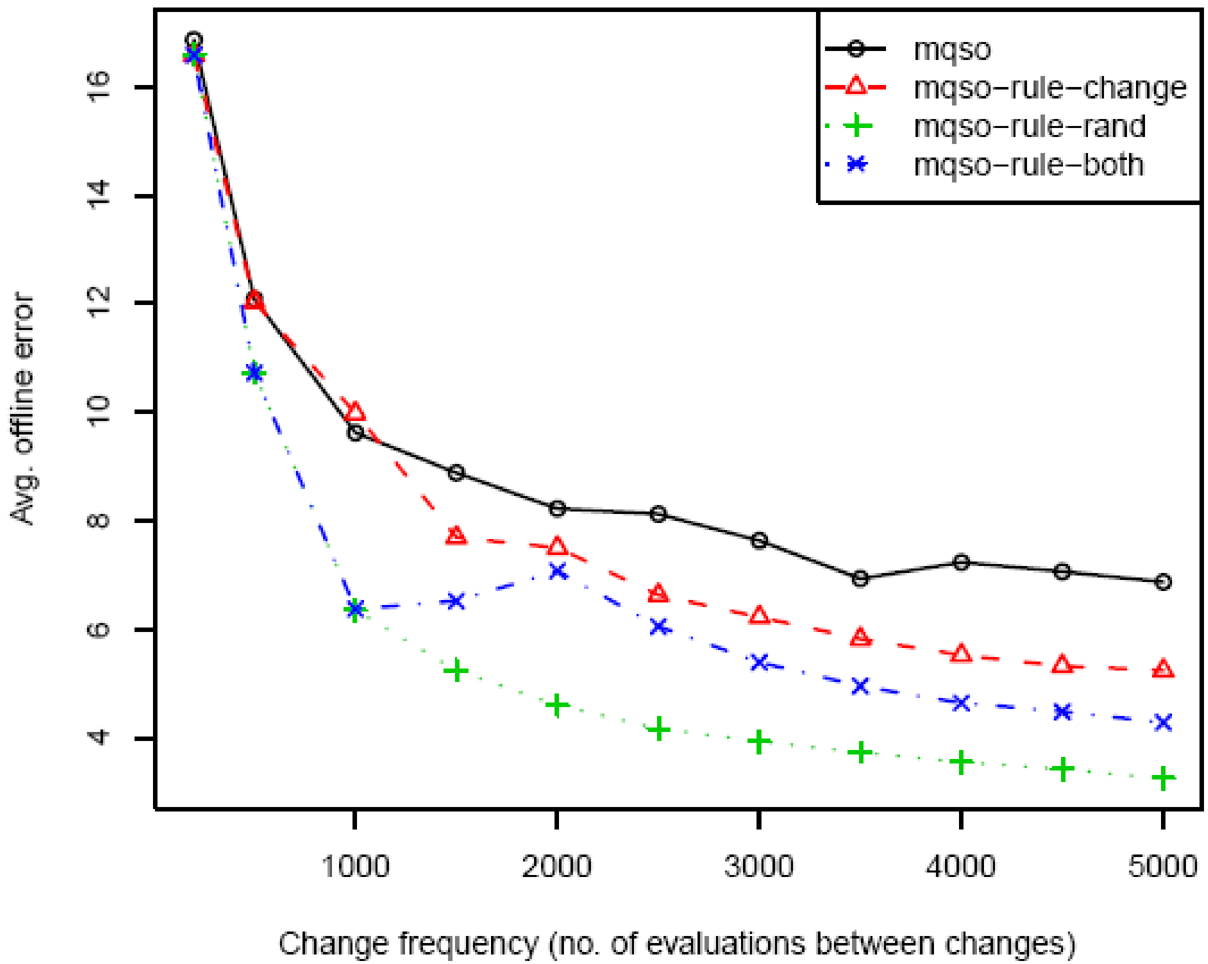
Illustrative Examples (I)

- Experiments with scenario 2 of MPB (100 peaks, five dimensions) and Ackley (dim = 5)
- Offline error, change frequency, change severity
- Overview on MPB



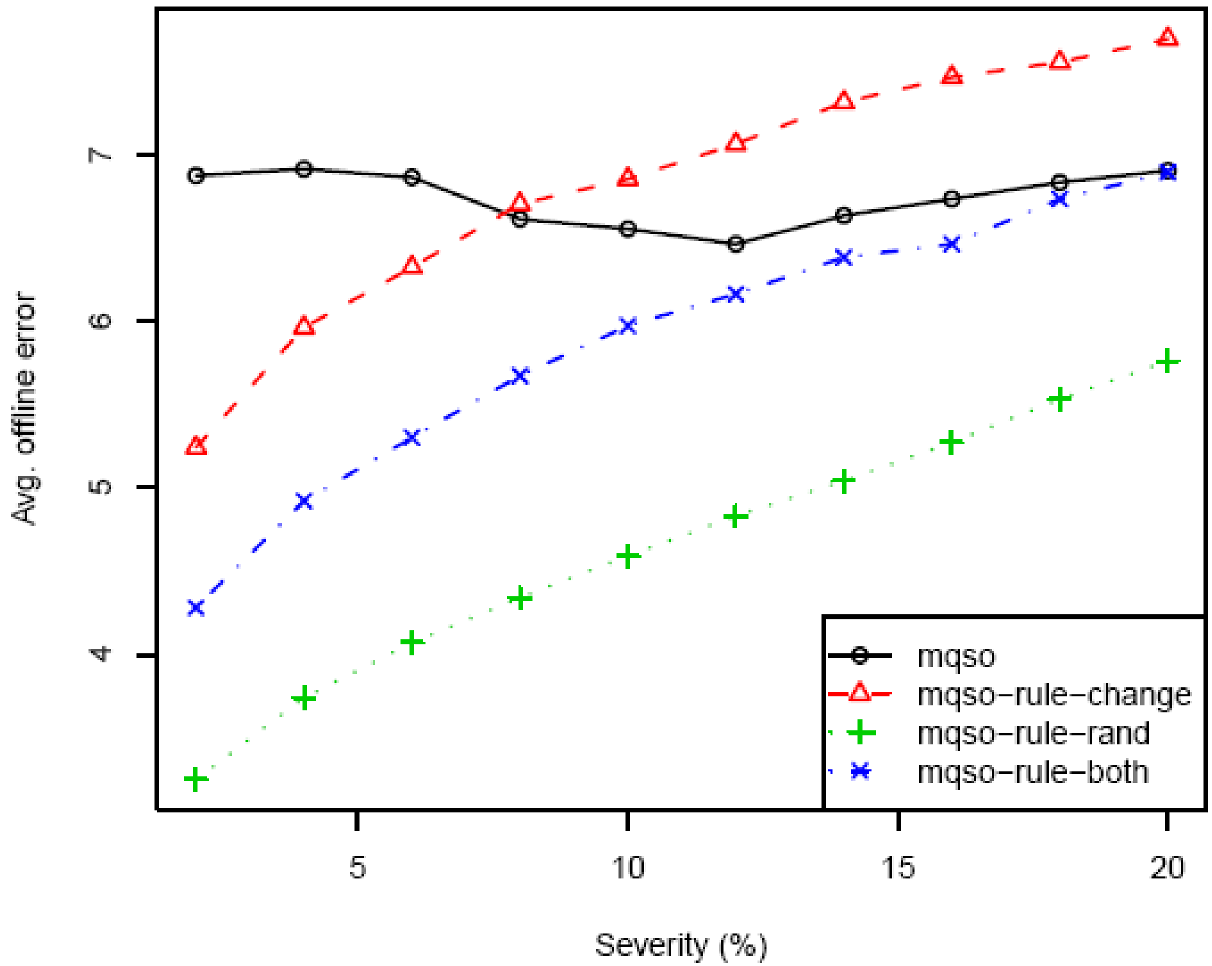
Illustrative Examples (II)

- Impact of frecuency



Illustrative Examples (II)

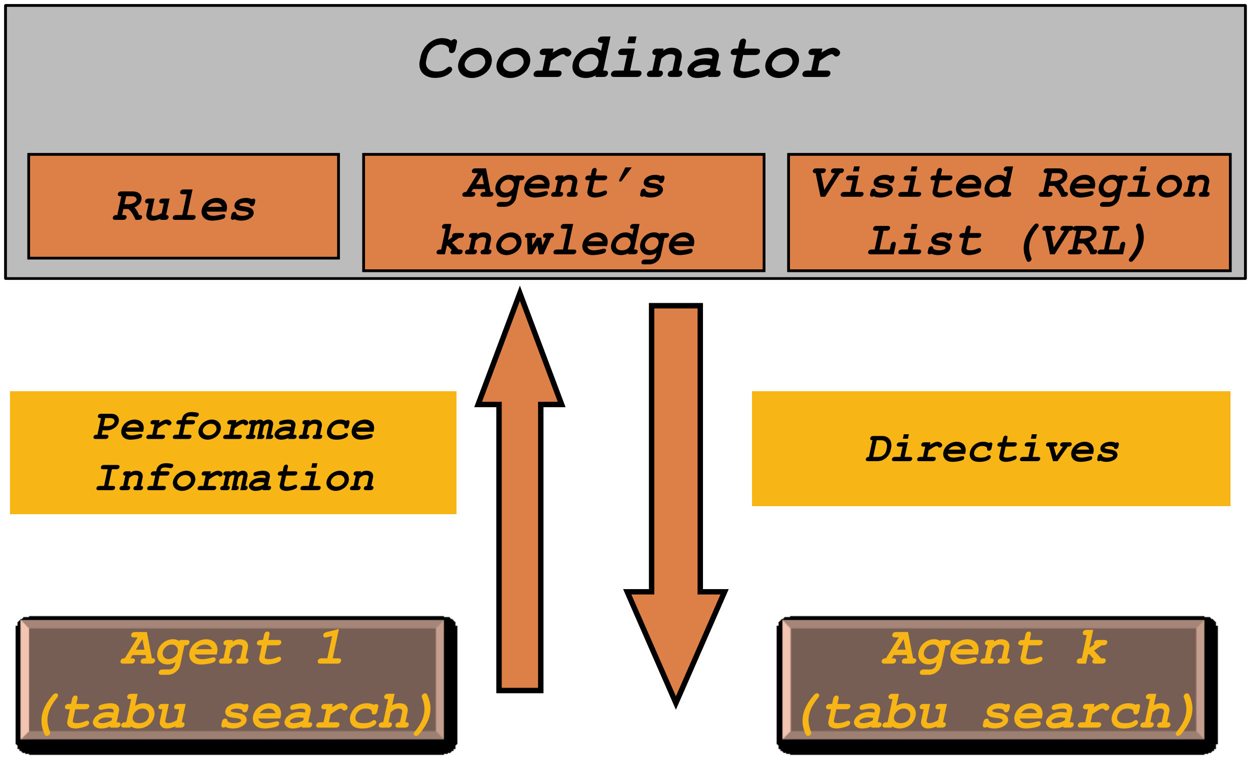
- Impact of Severity



A different approach

- Most of the methods used are population-based (PSO, EAs, . . .).
- Quite assumed that several solutions are needed to avoid local minima and to better react when the problem changes
- ***Little attention has been put on trajectory-based methods.***
- Our previous work showed that they can obtain good results (at least when coupled with a cooperation strategy).

Cooperative Strategy for DOP



- Specifically designed to deal with continuous optimization
- They know how to detect a change and inform it to the Coordinator

Coordinator Control

IF the number of last local minimum visited
by *agent_i* is bigger than λ-reaction
THEN *perform an action*

- The threshold λ-reaction regulates rule activation
- The antecedent allows to the coordinator to determine if a solver is trapped in a local minimun or has fallen many times in a previously visited optimum
- *"perform an action"* will relocate the agent in a new point of the search space (they are local search-based techniques)

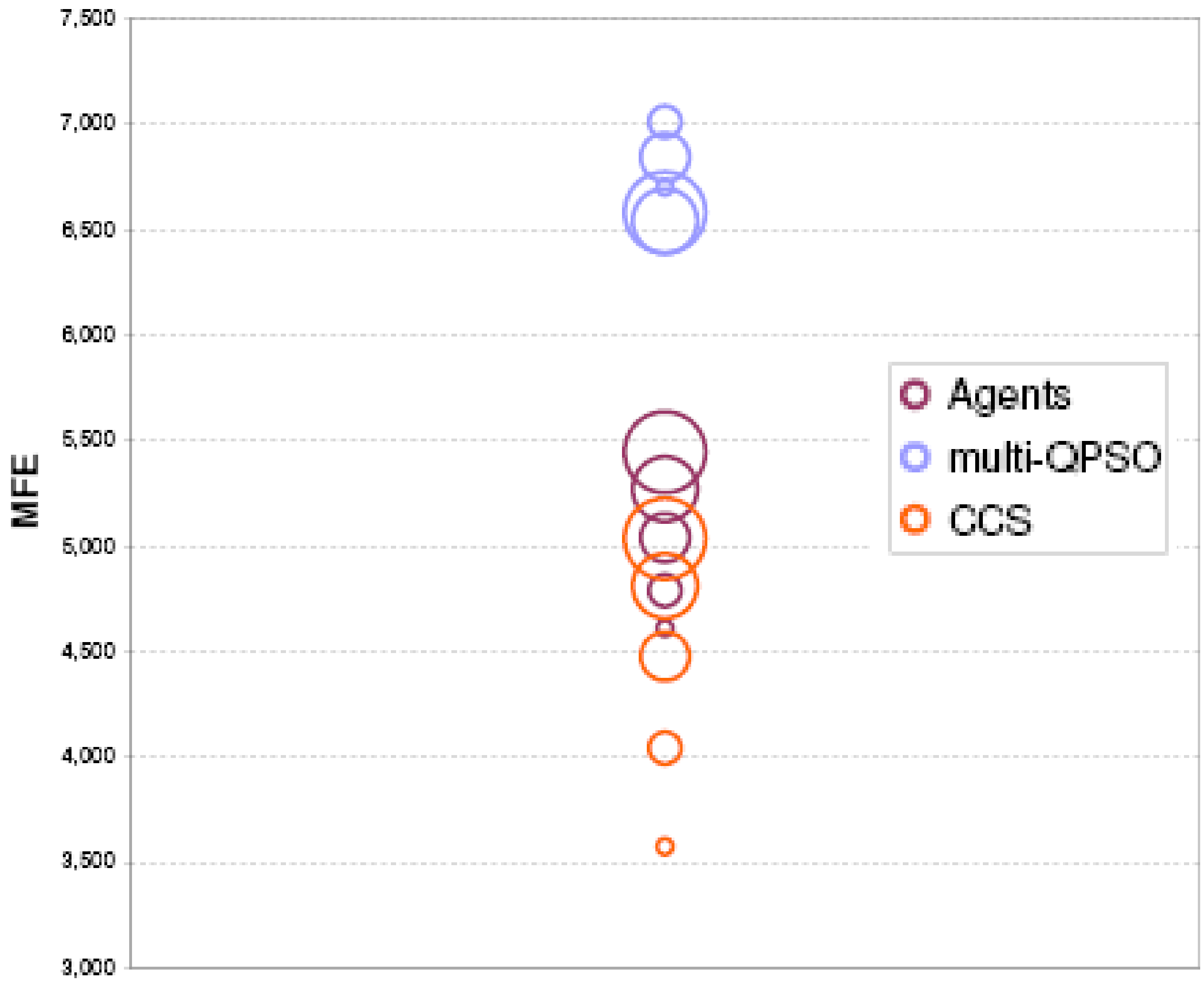
“Perform an action”

- **Best solution (BS):** Send the best global solution to the agent with a slight modification.
- **Approaching (AP):** Reallocate the agent in a intermediate point between the solver’s and coordinator’s best solution.
- **Reactive (R):** Send the best global solution perturbed by a certain degree
- **Visited Region List (VRL):** Uses the VRL to reallocate the solver outside the previously visited regions.

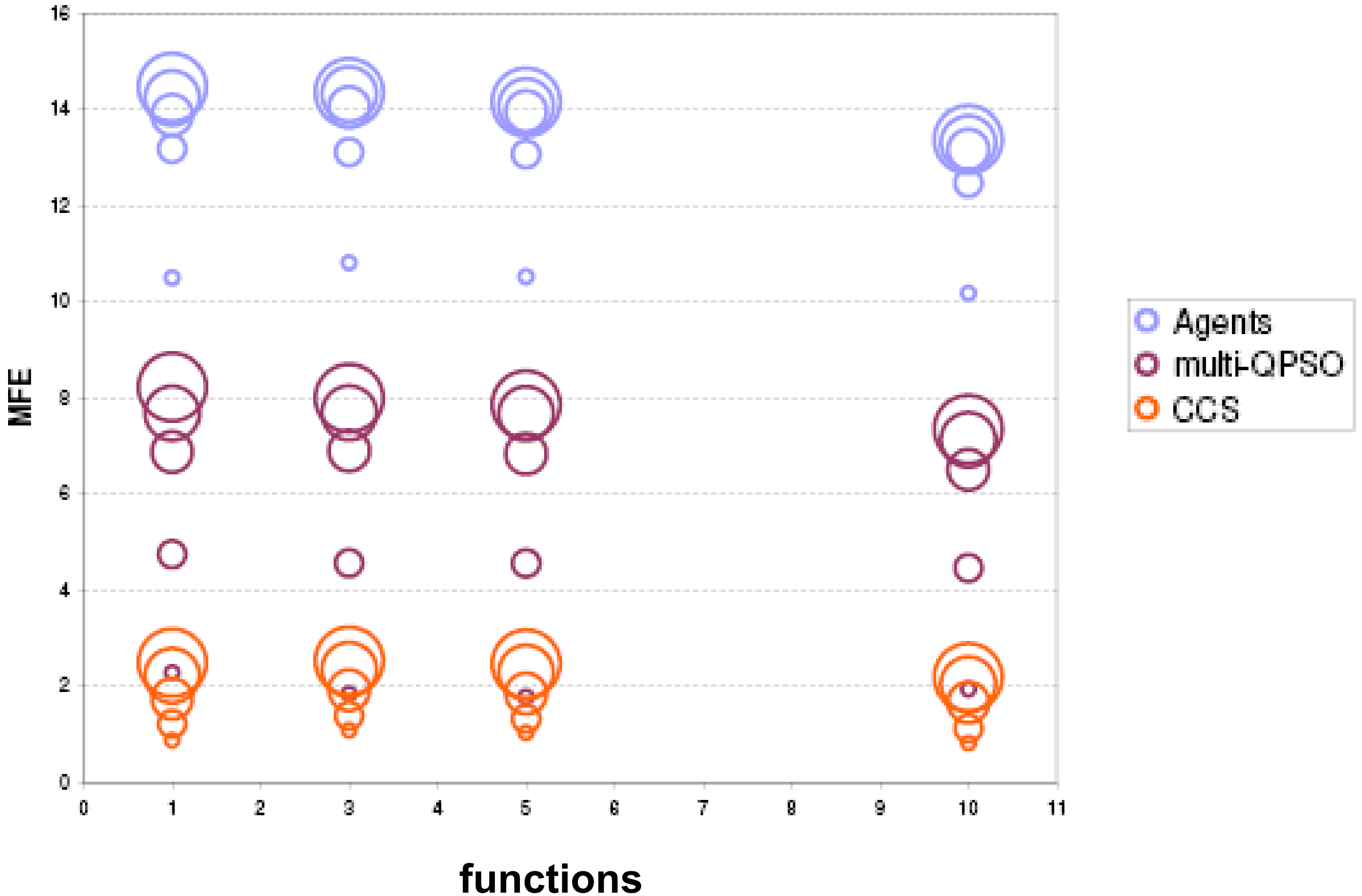
Experiments and Illustrative results

- DOPs are defined as the composition of *m* functions of the same type (Cone, Ackley, Griewank or Rastrigin):
- $F(x) = min\{f_1(x), f_2(x), \ldots. , f_m(x)\}$
- 12 heterogeneous solvers in the cooperative strategy (12 solutions are kept along the time)
- Severity changes, number of functions

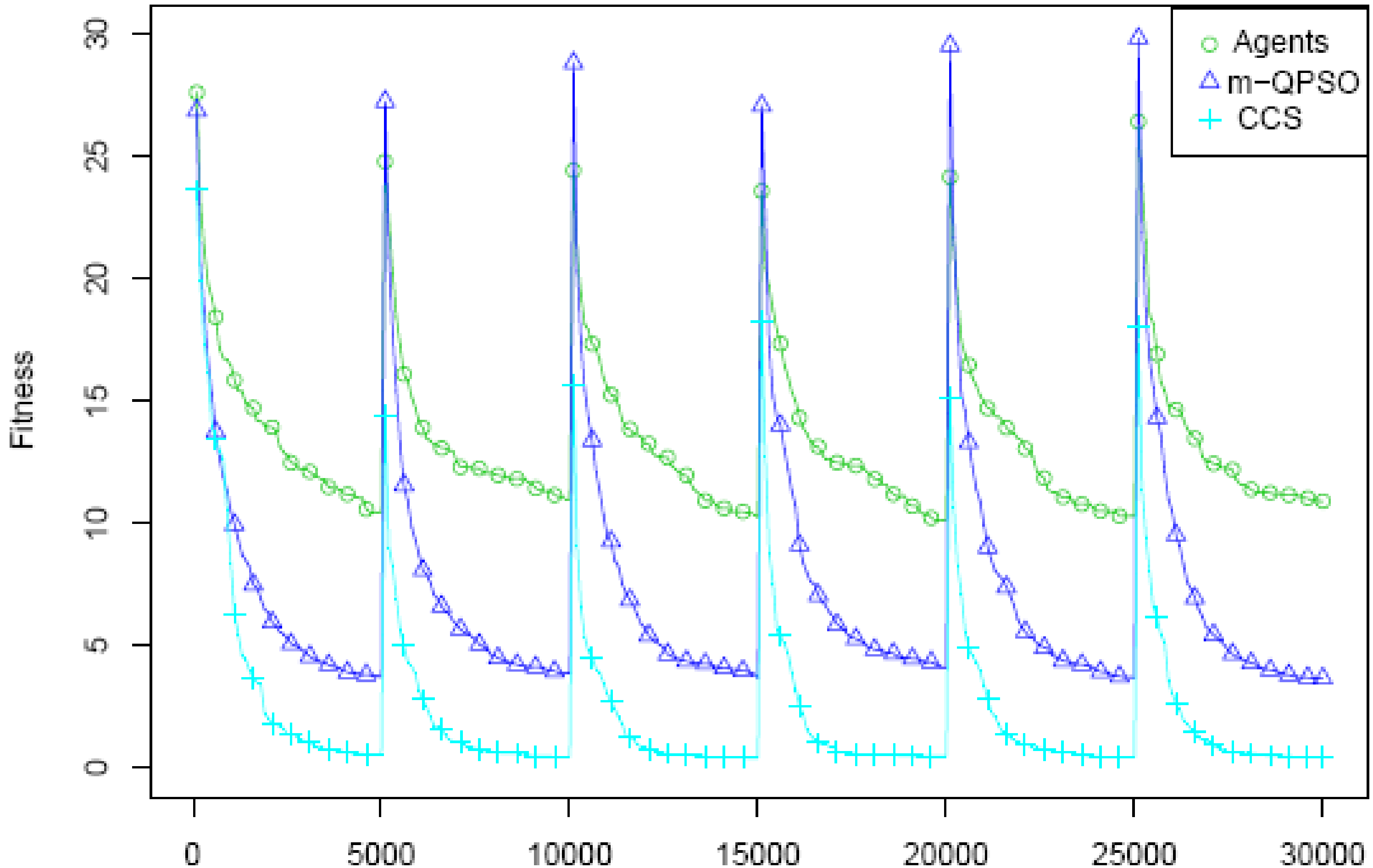
MPB (cones), 10 peaks, n=5, different severities (larger circle, higher severity)



Rastringin. Variable number of functions and severities



Convergence (an idea)



Conclusions & Future Work

- Simple ideas may lead to great improvements (stop the swarms with “bad behaviour”)
- Cooperative strategies are a promising approach
- Problem generator development
  - dynamic objective function
  - dynamic restrictions
  - uncertainty in the variables
  - uncertainty in fitness

Open questions

- self-adaptation ?
- new measures of perfomance ?
- what is an instance of the problem?
- how we can ensure reproducibility?
- how we can detect, for example, cyclic changes?

Intelligent Optimization Strategies in Uncertain and Dynamic Environments

- Recent paper

Optimization in dynamic environments: a survey on problems, methods and measures, C. Cruz, J. R. González and D. Pelta. Soft Computing In Press

- www.dynamic-optimization.org
- Contributions welcome!

Just a bibtex file + a set of tags for every entry

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David Pelta, Carlos Cruz, Jose L. Verdegay
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THANK YOU VERY MUCH FOR YOUR ATTENTION

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http://modo.ugr.es

http://www.dynamic-optimization.org

http://decsai.ugr.es/~dpelta