Two Models for Parallel Differential Evolution

**María Laura Tardivo, Paola Caymes Scutari,
Miguel Méndez Garabetti, Germán Bianchini**

LICPaD

UTN-FRM

We present two parallel models for parallelize the **Differential Evolution** (DE) algorithm, based on an island model, a ring interconnection topology and a population migration strategy:

- Subpopulation-based Model
- Island Model

Goal: Analyze the performance of both models, with regard to solutions quality versus computing time.

Test Cases: The models have been proved with a set of benchmark functions considering different configurations for the parameters of DE.

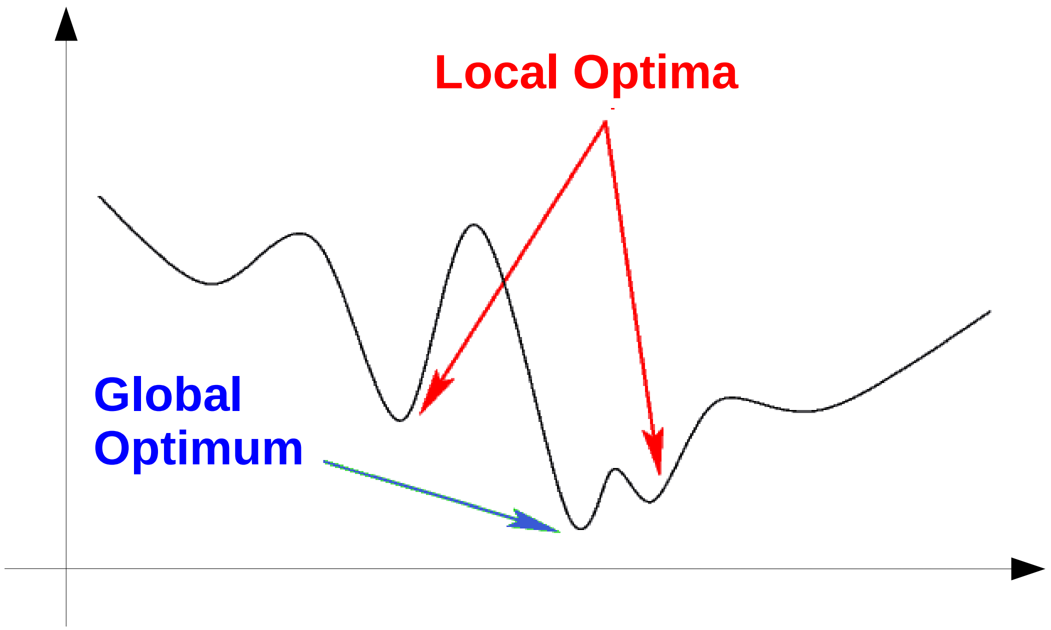
An optimization problem is defined (Talbi, 2009) by a couple ***(S,f):***

- ***S*** represents the set of possible solutions
- ***f: S*** $\longrightarrow$ ***R*** is the objective function to optimize.

The ***objective function f*** assigns to every solution ***s*** in ***S*** of the search space a real number indicating its worth.

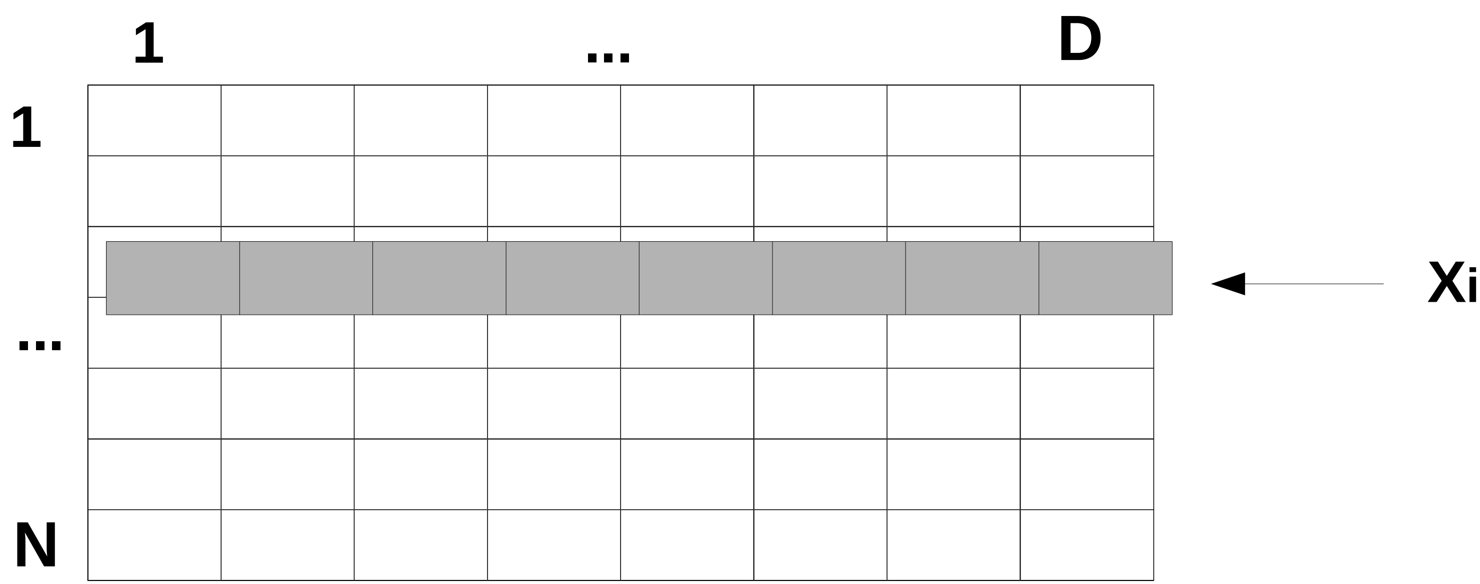
The main goal is to find a solution ***s**** in ***S***, called ***global optimum***

2-D problem

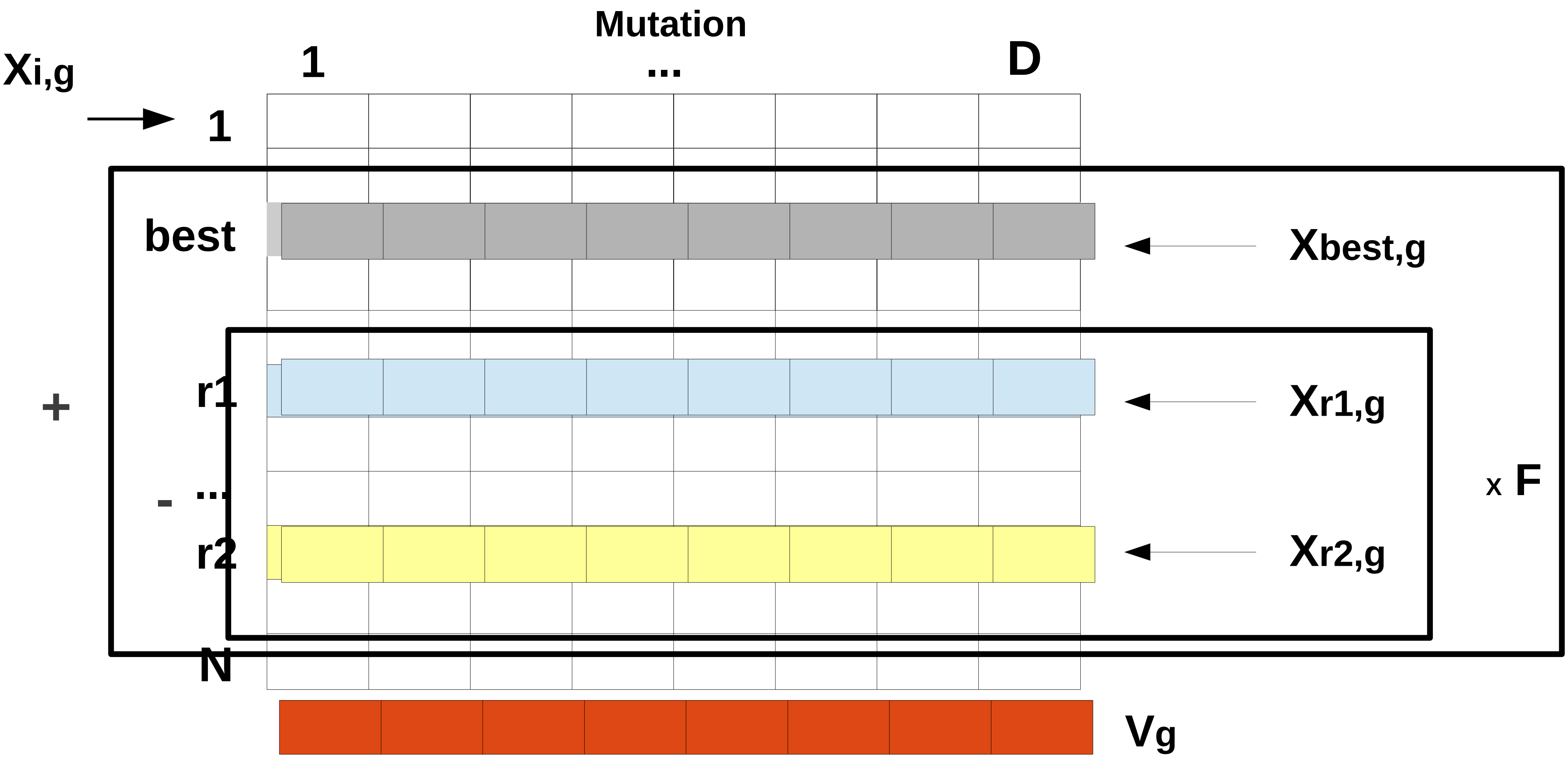


Metaheuristics: optimization techniques that provide good solutions to complex problems computed in a reasonable time.

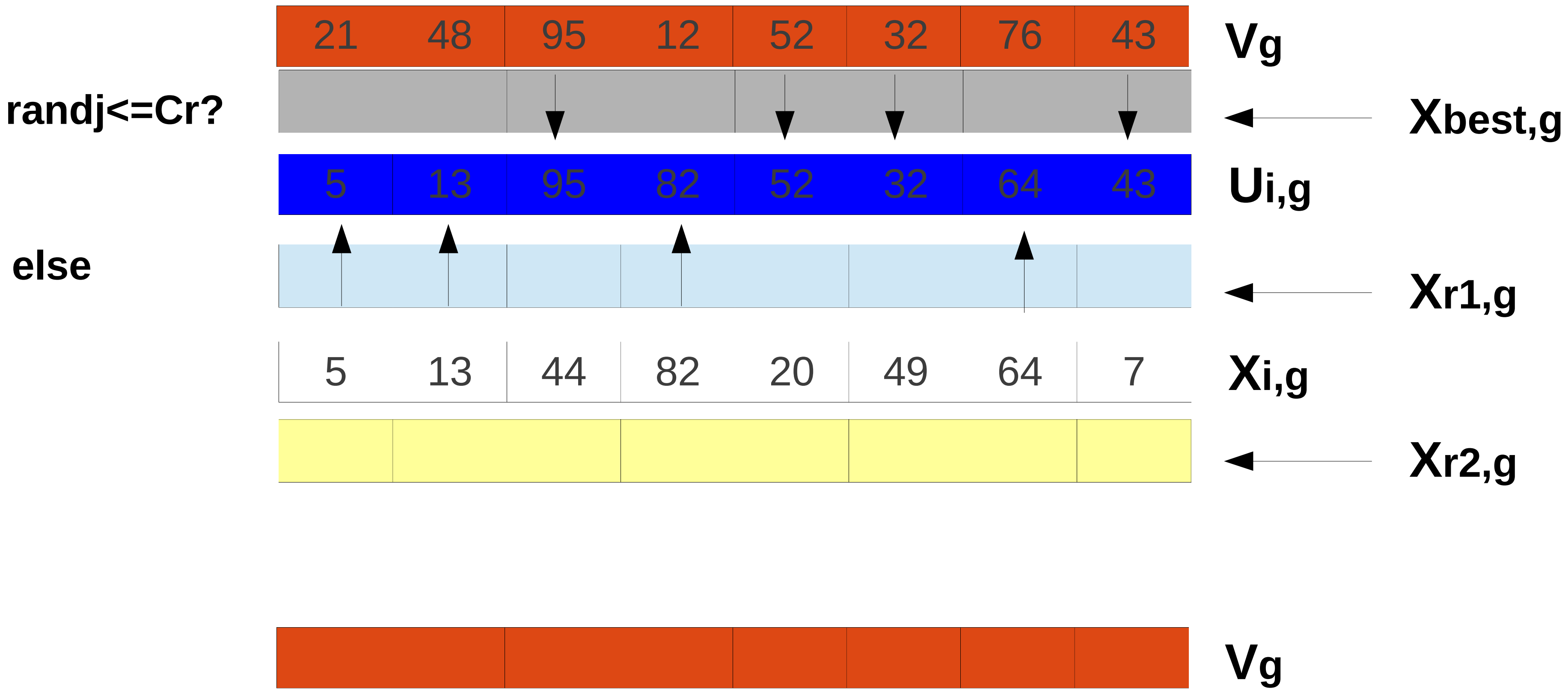
Differential Evolution (Rainer Storn & Kenneth Price, 1995)



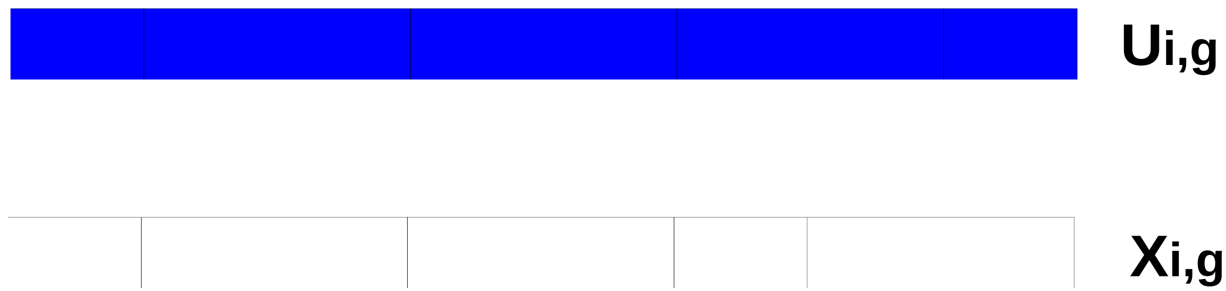
$$X_{i,g} = (x^{1}_{1,g}, \ldots, x^{D}_{N,g})$$


Mutation
Xi,g
1
...
D
1
best
Xbest,g
+
r1
Xr1,g
- ...
x F
r2
Xr2,g
N
Vg

Crossover

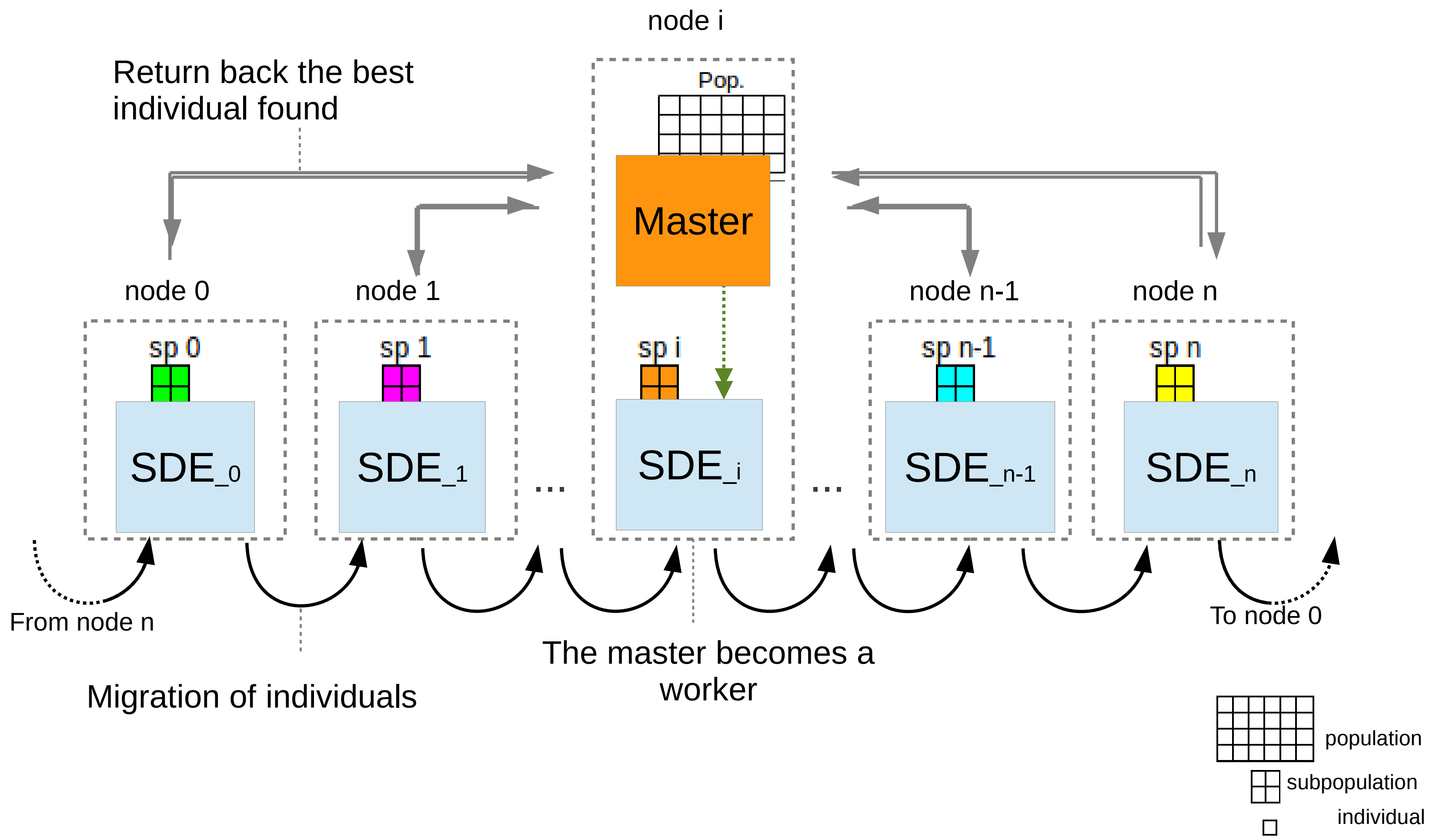

21 48 95 12 52 32 76 43
Vg
randj<=Cr?
Xbest,g
5 13 95 82 52 32 64 43
Ui,g
else
Xr1,g
5 13 44 82 20 49 64 7
Xi,g
Xr2,g
Vg

Selection

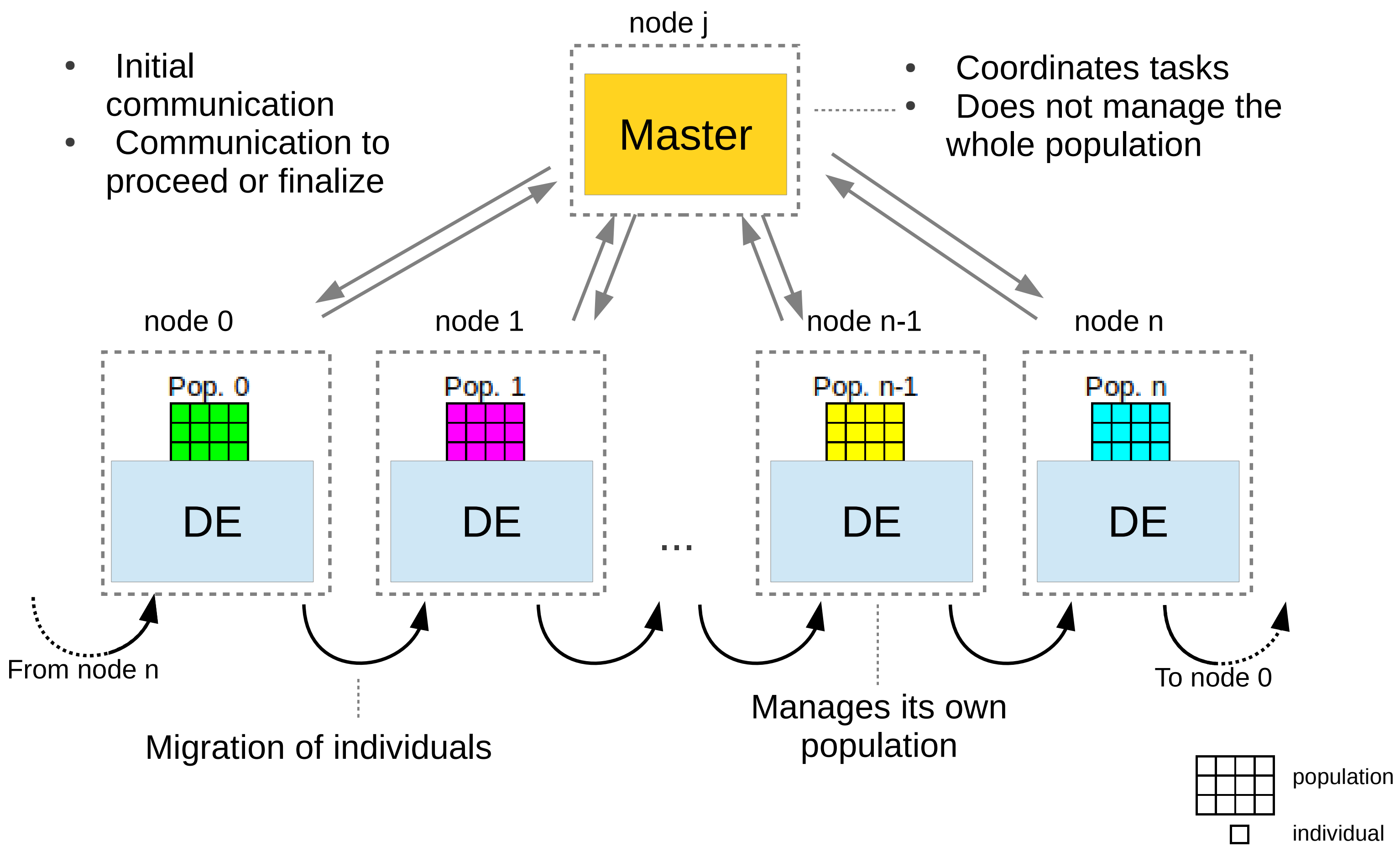


$$X_{i,g+1} = \begin{cases} U_{i,g} & \text{if } f(U_{i,g}) \le f(X_{i,g}) \\ X_{i,g} & \text{other case} \end{cases}$$

Subpopulation-based Model



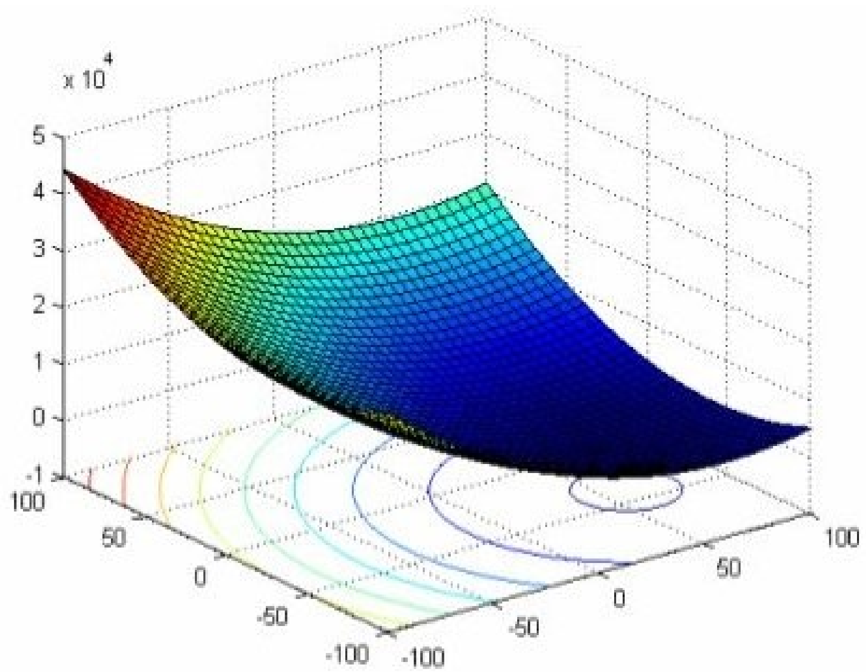
Island Model



Suganthan et all, from the CEC'2008 Special Session and Competition on Large Scale Global Optimization.

Shifted Sphere Function

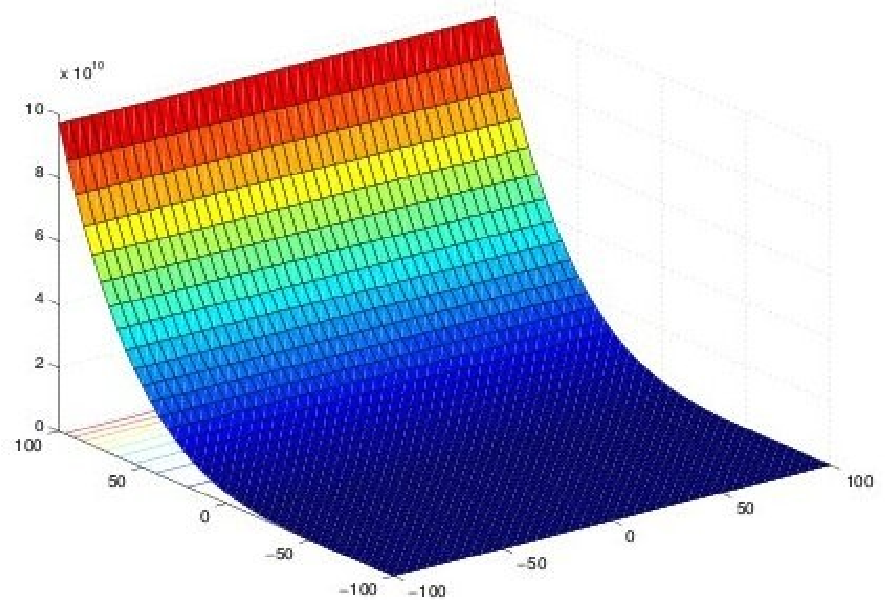
$$F_1(x) = \sum_{i=1}^{D} {z_i}^2 + f\_bias_1$$



$$Global\ optimum : x^* = 0,$$
$$F_1(x^*) = f\_bias_1 = -450$$

Shifted Rosenbrock Function

$$F_2(x) = \sum_{i=1}^{D-1} (100({z_i}^2 - z_{i+1})^2 + (z_i - 1)^2) + f\_bias_2$$

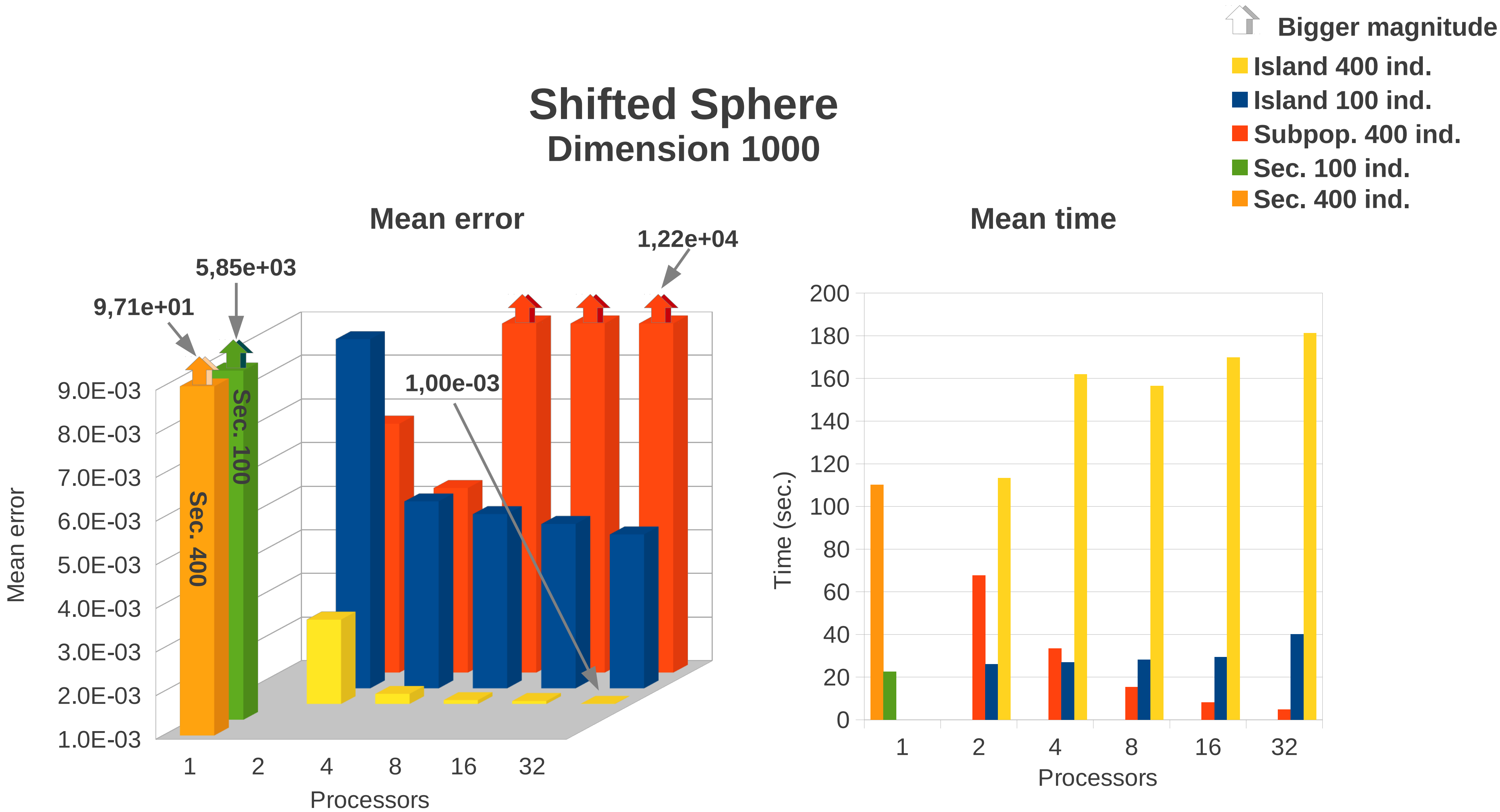


$$Global\ optimum : x^* = 0,$$
$$F_2(x^*) = f\_bias_2 = 390$$

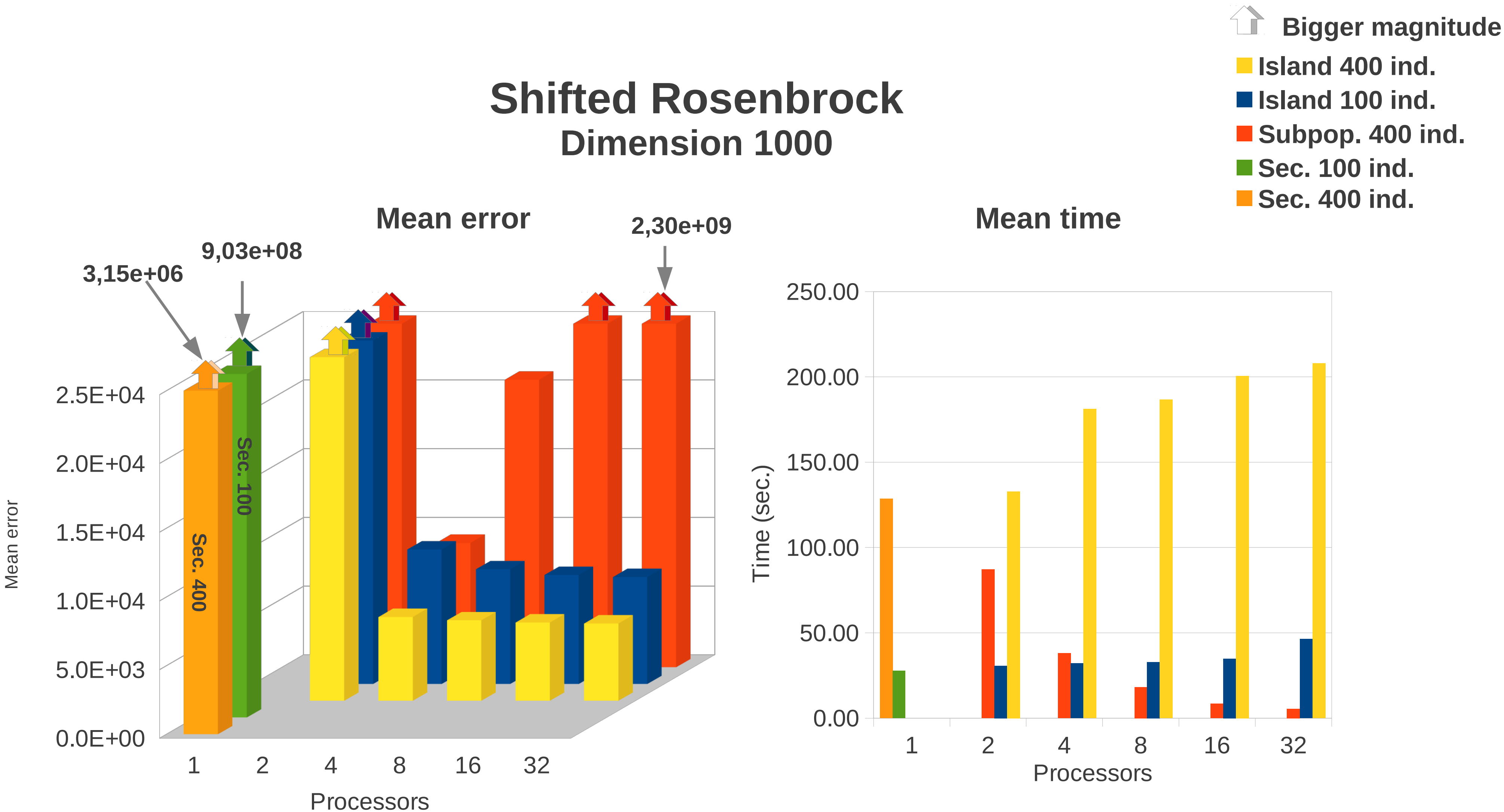
The experiments where carried out considering:

- Problems of dimension 100, 500 and 1000.
- Average of 30 executions (mean error).
- Population: 100 and 400 individuals.
- Cr= 0.3, F =0.5.
- Migration of 15% of the population, every 500 iterations.
- The finalization condition was established to reaching 6000 iterations.
- Ring interconnection topology.
- Scalability measures: 2, 4, 8, 16 and 32 processors dedicated to the workers processes, and a separate processor for the master process for the Island Model.
- The replacement strategy is semi-elitist.

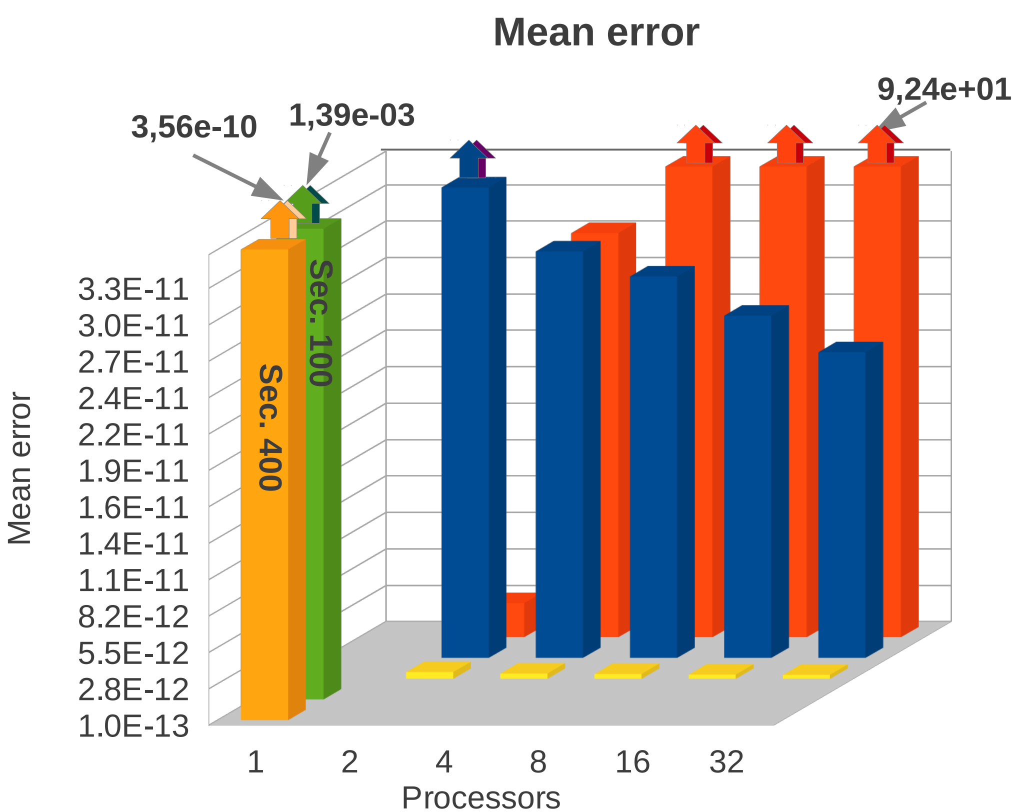
Numeric results

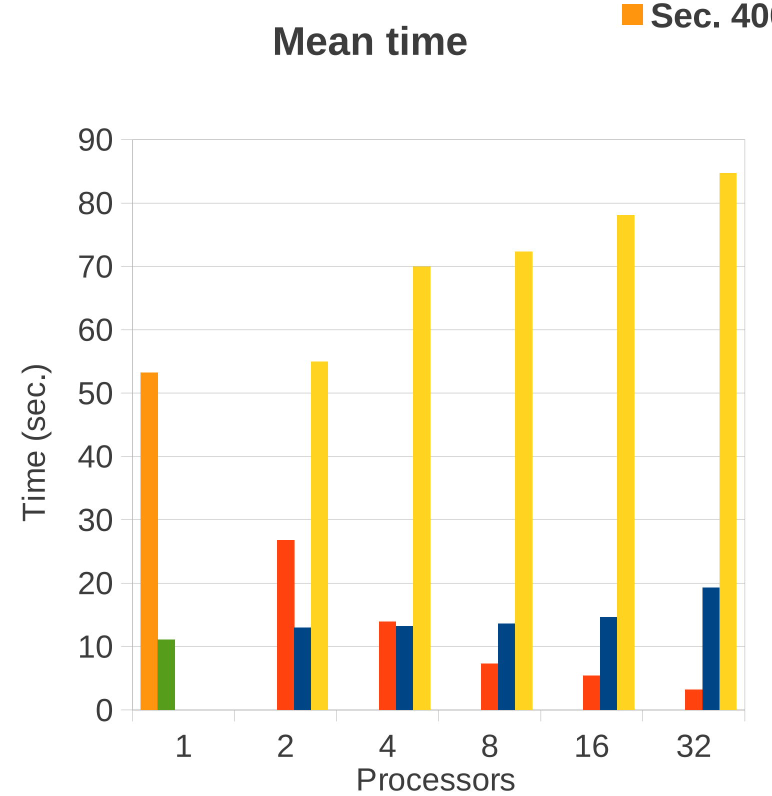


Numeric results

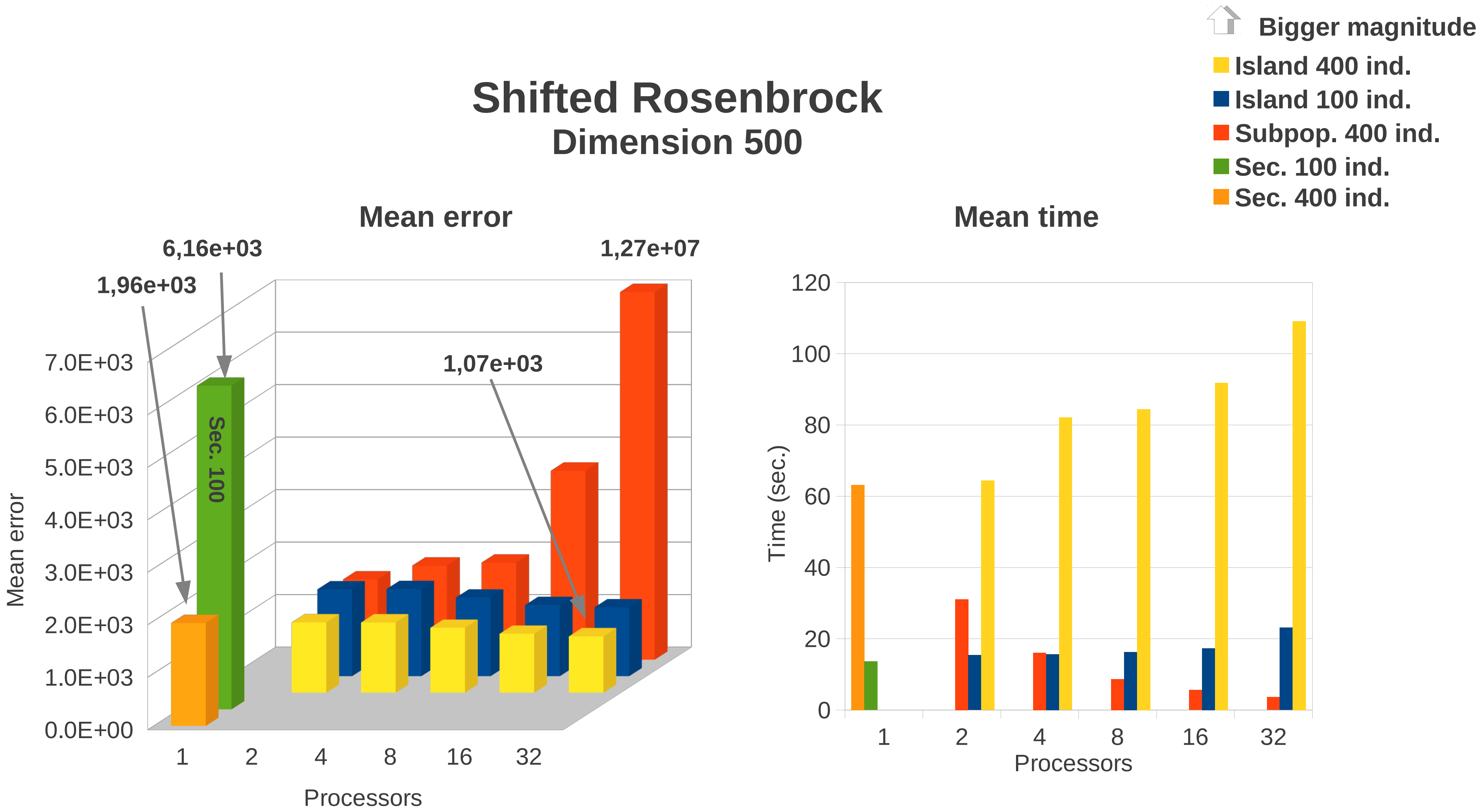


Shifted Sphere
Dimension 500

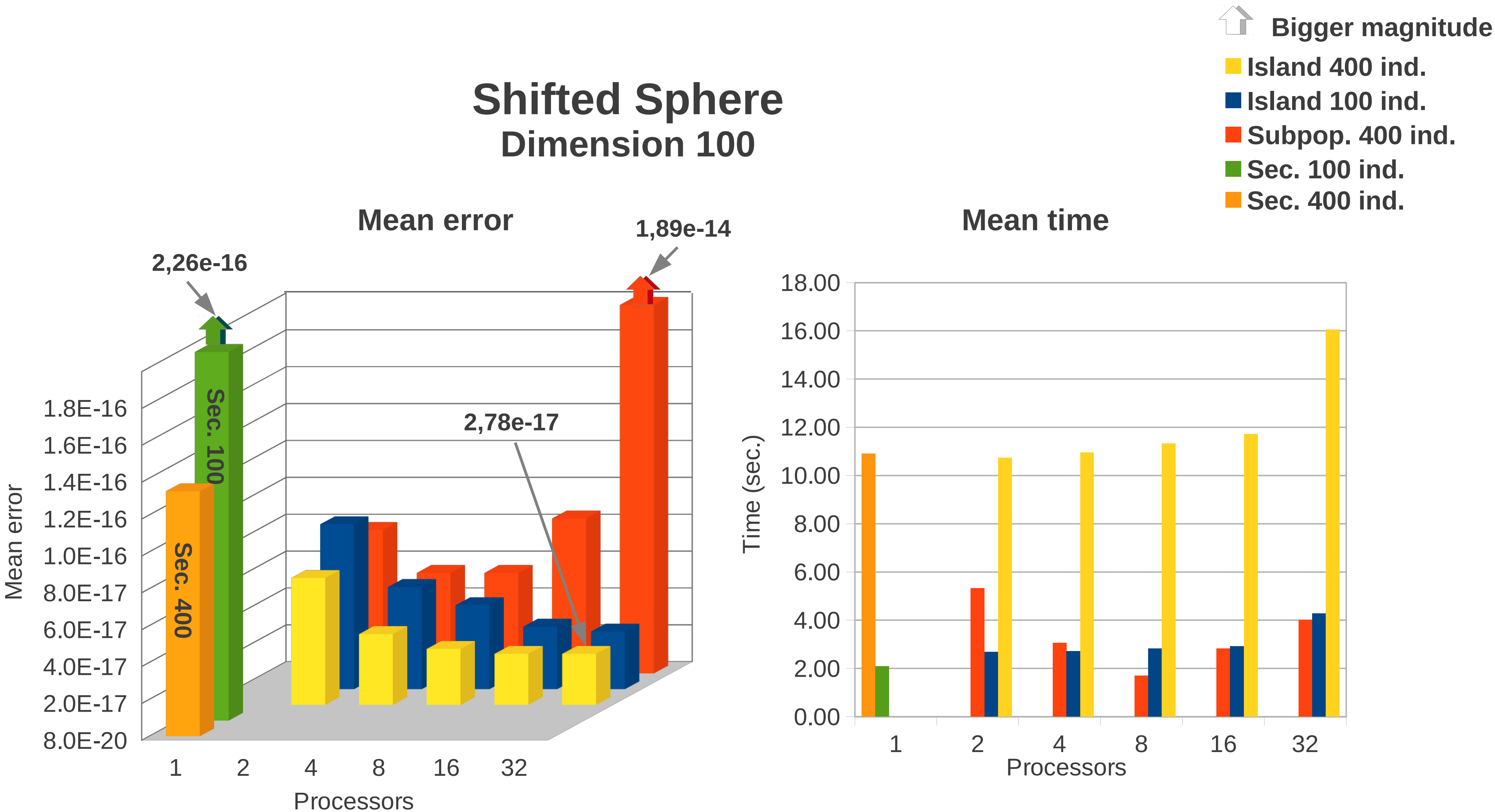




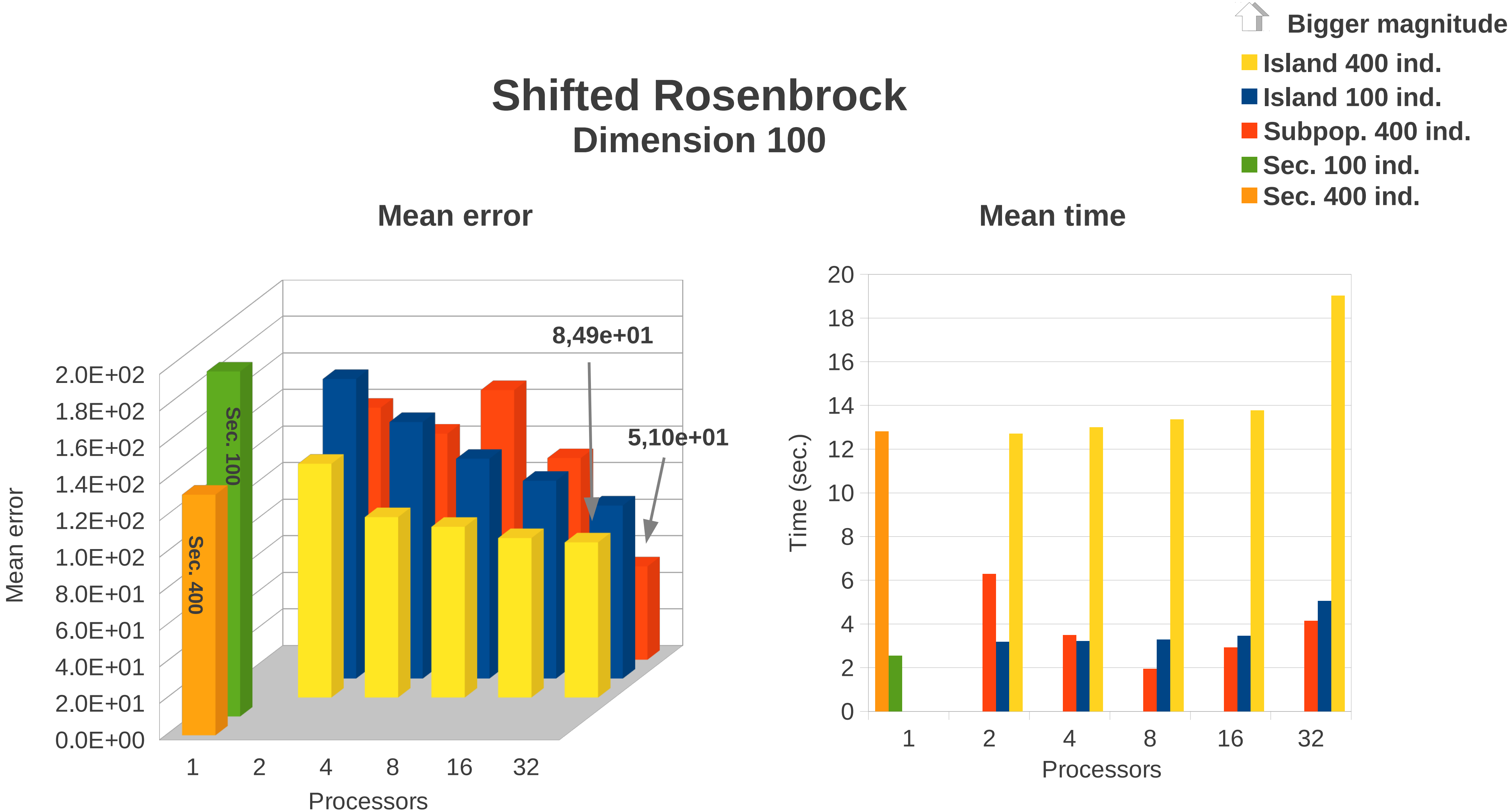
Numeric results



Numeric results



Shifted Rosenbrock
Dimension 100



Through the results analysis it was found that:

- The subpopulation model reduces significantly the computing time, but the quality of the solutions is not the optimal that can be achieved.
- With the island model, the computing time is not reduced, because of the model characteristics, but the solutions quality is improved significantly. This feature reflects the fact that the model explores a greater search space, since each island is configured with a different initial seed.

As future works we plan to employ these parallelization models to replace the sequential DE scheme in a hybrid metaheuristic that combines DE with Local Search.

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