Evolution with constraints

3/ Coupling both EA & CSP

May 2020, É. Vareilles

Institut Supérieur de l'Aéronautique et de l'Espace
SUPAERO

Agenda / 3. Coupling both EA & CSP

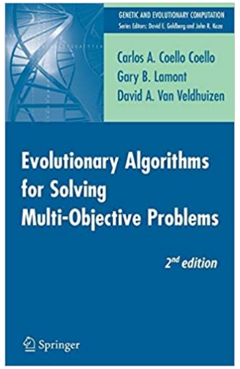
3.1. Various couplings

3.2. CSP as guarantee of individual viability

3.3. Toy problem

Carlos A. Coello Coello
Professor of Computer Science
Mexico

https://dblp.uni-trier.de/pers/c/Coello:Carlos_A=_Coello.html



3.1. Various couplings

Penalty function : Richardson et al. 1989
Constraint violation level added to the fitness function.

Drawbacks :
1/ no real boundaries between feasible and unfeasible spaces
2/ Weight to aggregate the violation of constraints .

Reparing method : Salcedo-Sanz 2009
Specific operator to redirect unfeasible individuals to the feasible space

Difficulty to elaborate the repairing algorithm to preserve the diversity of individuals.

Constraints as objective functions : Clevenger et al. 2005

Difficulty to preserve the diversity of individuals and to explore the search space.

Specific operators : Kowalczyk 1997
Preserve by construction individual viability during generation, crossover and mutation operations.

Drawbacks : time consumming because of backtracking.

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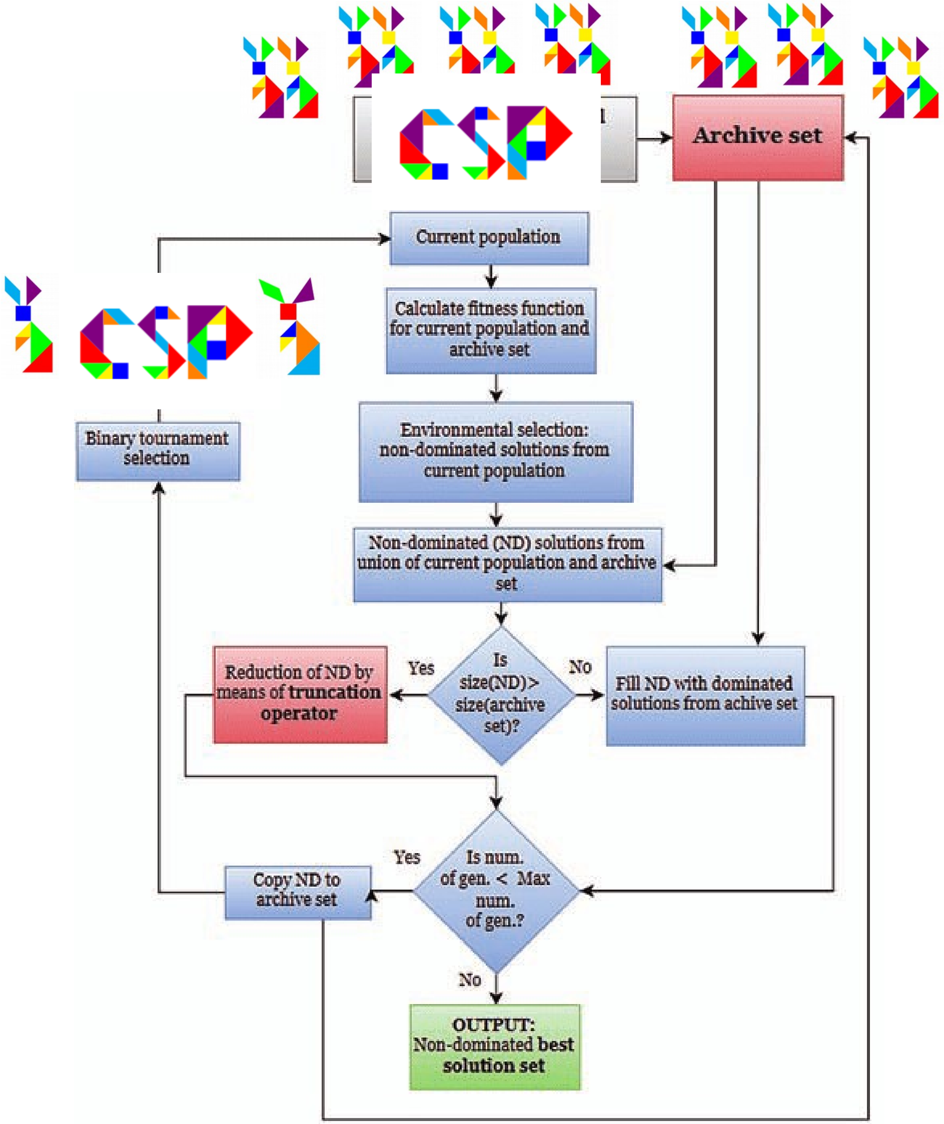
Specific operators : Kowalczyk 1997, Pitiot et al. 2011



Specific operators : Kowalczyk 1997, Pitiot et al. 2011

Crossover operator
Random selection of parents
Uniform crossover of their genes (P = 0.5)
Consistency check at each step

Locus	2	5	1	6	3	4
Parent 1	1	3	2	1	1	3
Parent 2	2	1	3	3	2	1
Child 1 Allele	{1,2,3}	{1,2,3}	{1,2,3}	{1,2,3}	{1,2,3}	{1,2,3}

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Locus	2	5	1	6	3	4
Parent 1	1	3	2	1	1	3
Parent 2	2	1	3	3	2	1
Child 1 Allele	1	{1,3}	{2,3}	{1,2,3}	{1,2}	{1,2,3}

Filter gene domains

Specific operators : Kowalczyk 1997, Pitiot et al. 2011

Crossover operator

Random selection of parents

Uniform crossover of their genes (P = 0.5)

Consistency check at each step

Locus	2	5	1	6	3	4
Parent 1	1	3	2	1	1	3
Parent 2	2	1	3	3	2	1
Child 1 Allele	1	1	{}	{1,2,3}	{1,2}	{1,2,3}

Filter gene domains

Specific operators : Kowalczyk 1997, Pitiot et al. 2011

Crossover operator

Random selection of parents

Uniform crossover of their genes (P = 0.5)

Consistency check at each step

Backtrack

Locus	2	5	1	6	3	4
Parent 1	1	3	2	1	1	3
Parent 2	2	1	3	3	2	1
Child 1 Allele	**1**	**3**	{2}	{1,2,3}	{1,2}	{1,2,3}

Filter gene domains

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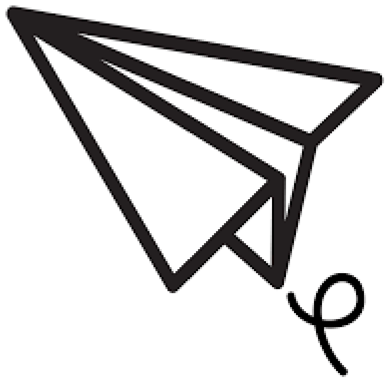
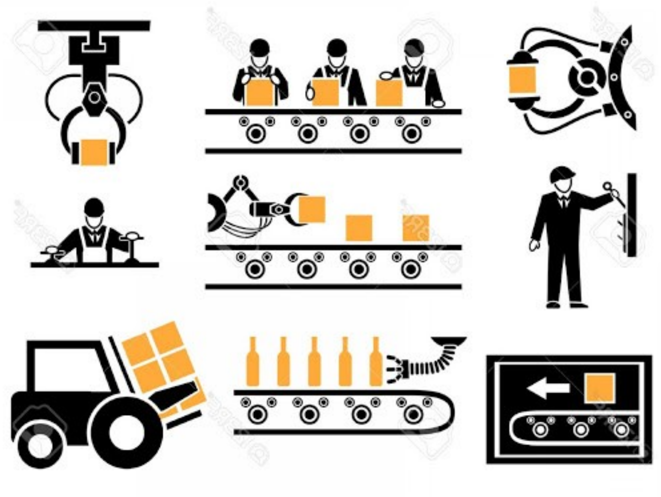
Concurrent optimization of systems and delivery process

P. Pitiot, et al., Concurrent product configuration and process planning: Some optimization experimental results, Comput. Industry (2014), http://dx.doi.org/10.1016/j.compind.2014.01.012



Parameters :
# of seats
Range

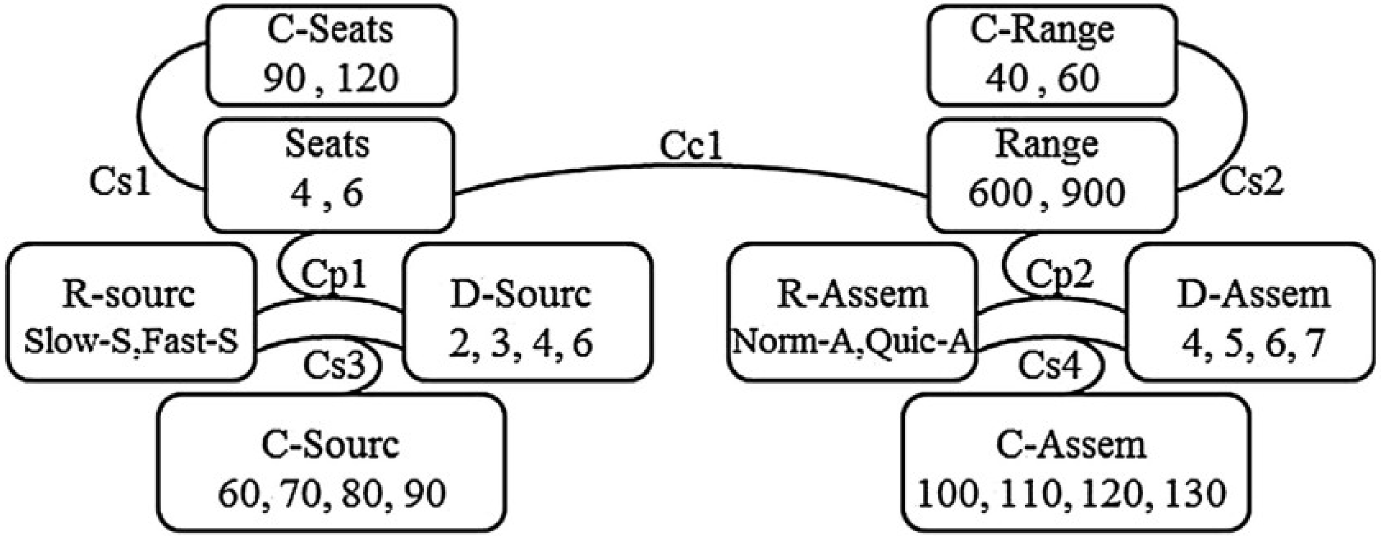
KPI :
Costs



Parameters :
Ressources

KPI :
Costs
Time

Concurrent optimization of systems and delivery process



C-Seats	Seats
90	4
120	6

Cs1 (C-Seats, Seats)

C-Range	Range
40	600
60	900

Cs2 (C-Range, Range)

C-Sourc	R-Sourc	D-Sourc
60	Slow-S	4
80	Fast-S	2
70	Slow-S	6
90	Fast-S	3

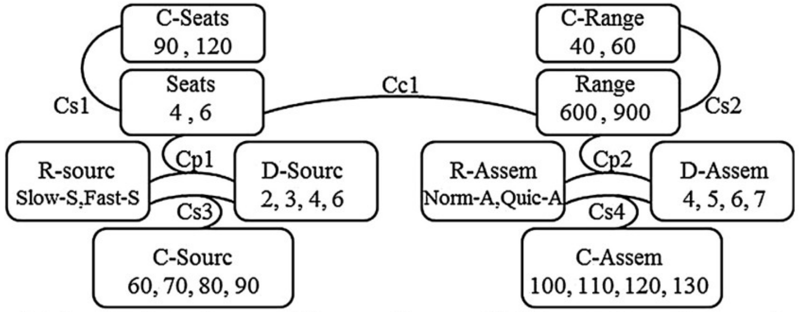
Cs3 (C-Sourc, R-Sourc, D-Sourc),

C-Assem	R-Assem	D-Assem
100	Norm-A	5
120	Quic-A	4
110	Norm-A	7
130	Quic-A	6

Cs4 (C-Assem, R-Assem, D-Assem)

3.3. Toy problem

Concurrent optimization of systems and delivery process



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100	Norm-A	5
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130	Quic-A	6

Cs4 (C-Assem, R-Assem, D-Assem)

Size of the solution space :

256 without constraints

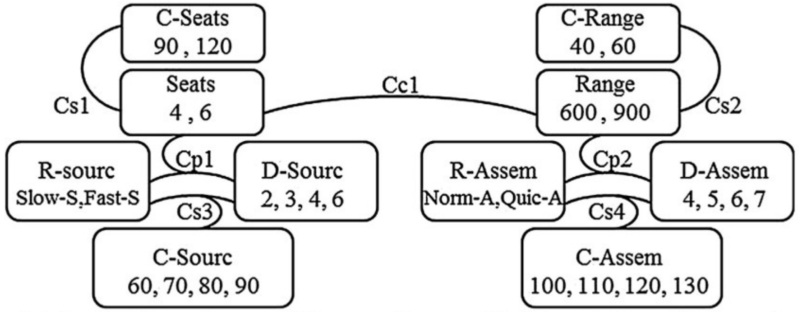
Number of solutions :

12 solutions

Number of Pareto-optimal solution :

7 Pareto-optimal solutions

Concurrent optimization of systems and delivery process



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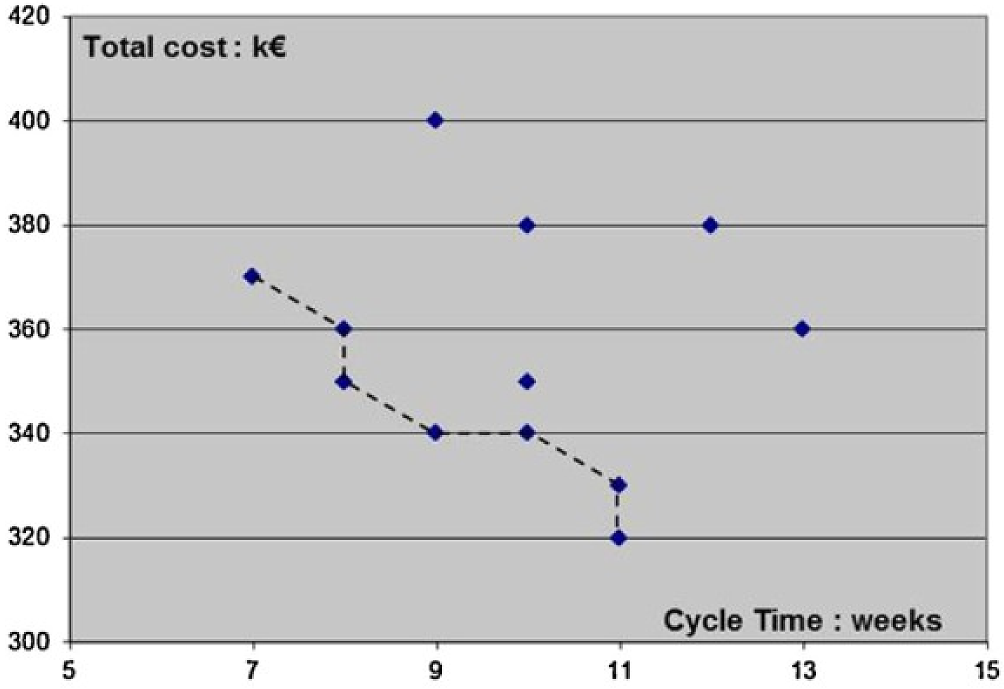


Fig. 4. Optimal solutions on the Pareto Front.

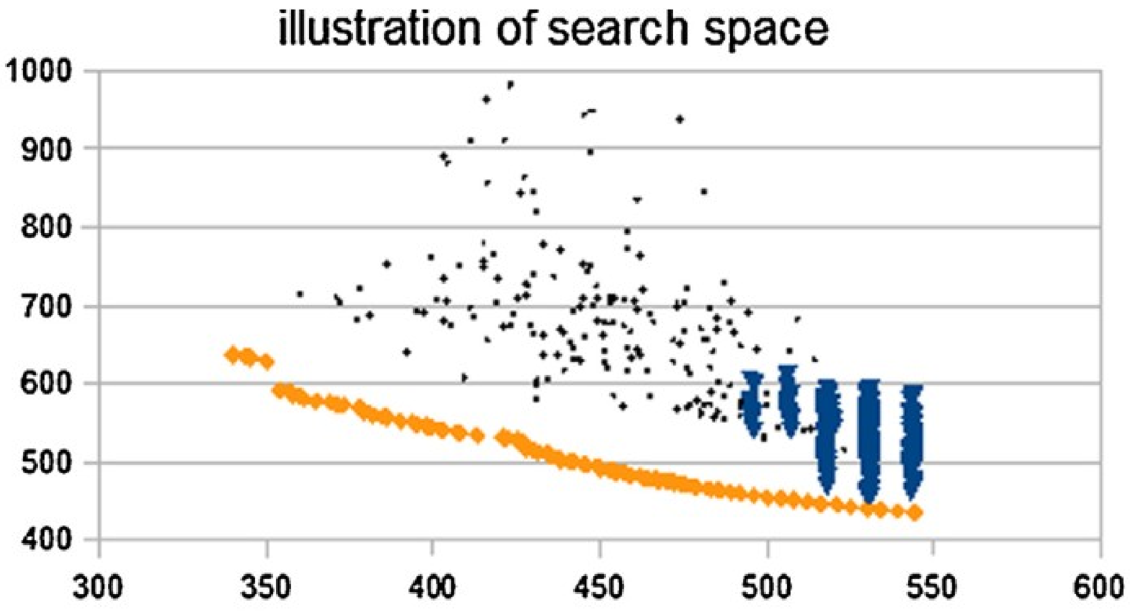
Concurrent optimization of systems and delivery process

On a bigger model :
92 variables linked by 67 constraints
21 decision variables manipulated by the optimization algorithms (chromosome in EA).

- 12 variables, with an average of six possible values for each,
- 9 variables, with an average of nine possible values for each,

Obj. Function : Min cost and min time

# of solutions : 10 ^18



Concurrent optimization of systems and delivery process

Table 5
Precision on behavior of EA approaches.

Model	CFB-EA		
	Average duration of a generation	Total number of solutions generated	% of time spend to generate and evaluate solutions
full_aircraft	570	14,577	98
full_aircraft_MC2	604	13,703	99
full_aircraft_MC3	504	16,439	98
full_aircraft_MC4	624	13,269	99
Model	FRB-EA		
	Average duration of a generation	Total number of solutions generated	% of time spend to evaluate solutions
full_aircraft	229	36,044	88
full_aircraft_MC2	240	34,314	88
full_aircraft_MC3	262	31,447	89
full_aircraft_MC4	220	34,440	86

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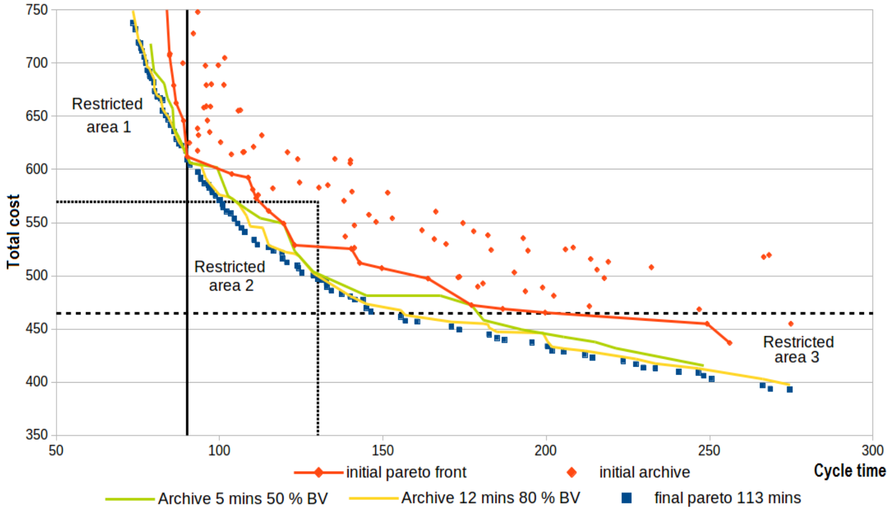
Conclusion

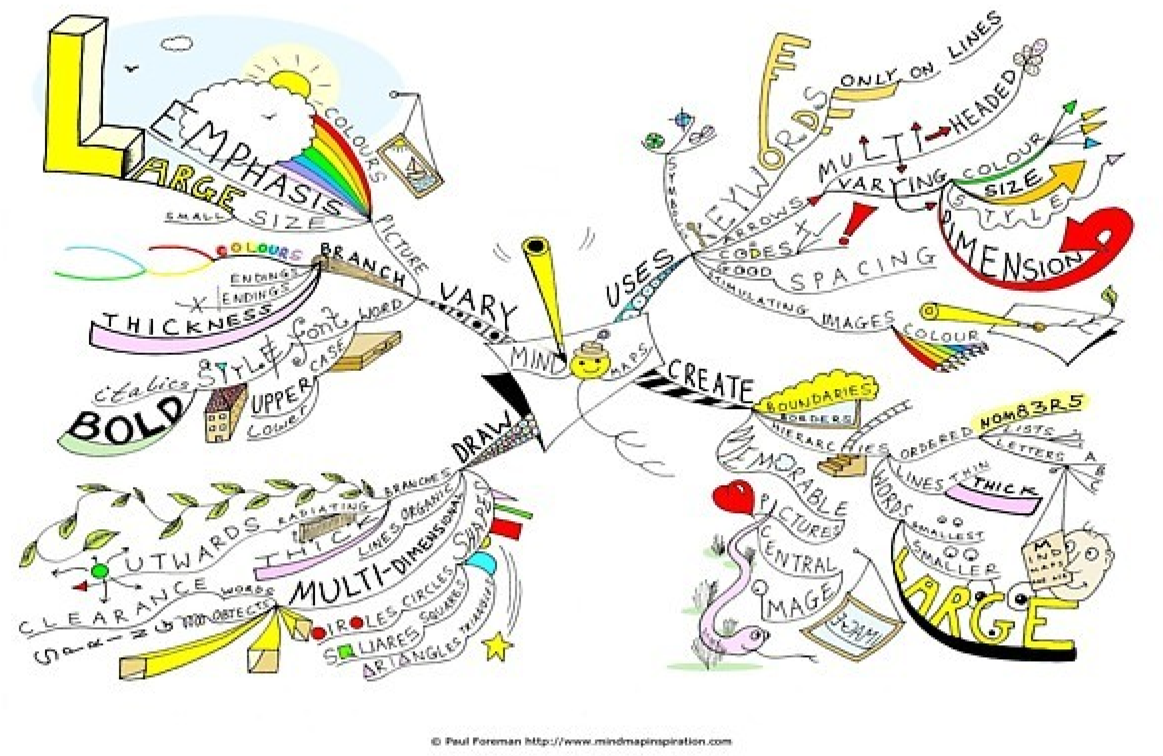
To go deeper on EA & CSP :

- Carlos A. Coello Coello, https://dblp.uni-trier.de/pers/c/Coello:Carlos_A=_Coello.html
- Travaux de M. Aldanondo, P. Pitiot and E. Vareilles

Future research : Clustering of promising solutions….
To converge faster



Now, it's your turn to work….



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