UNIVERSITY OF FERRARA
DEPARTMENT OF ENGINEERING

Path Relinking for a Team Scheduling Problem Arising in Hydroinformatics

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- What is a contamination event?
- Problem modellization (feasible region + objective function)
- State of the art

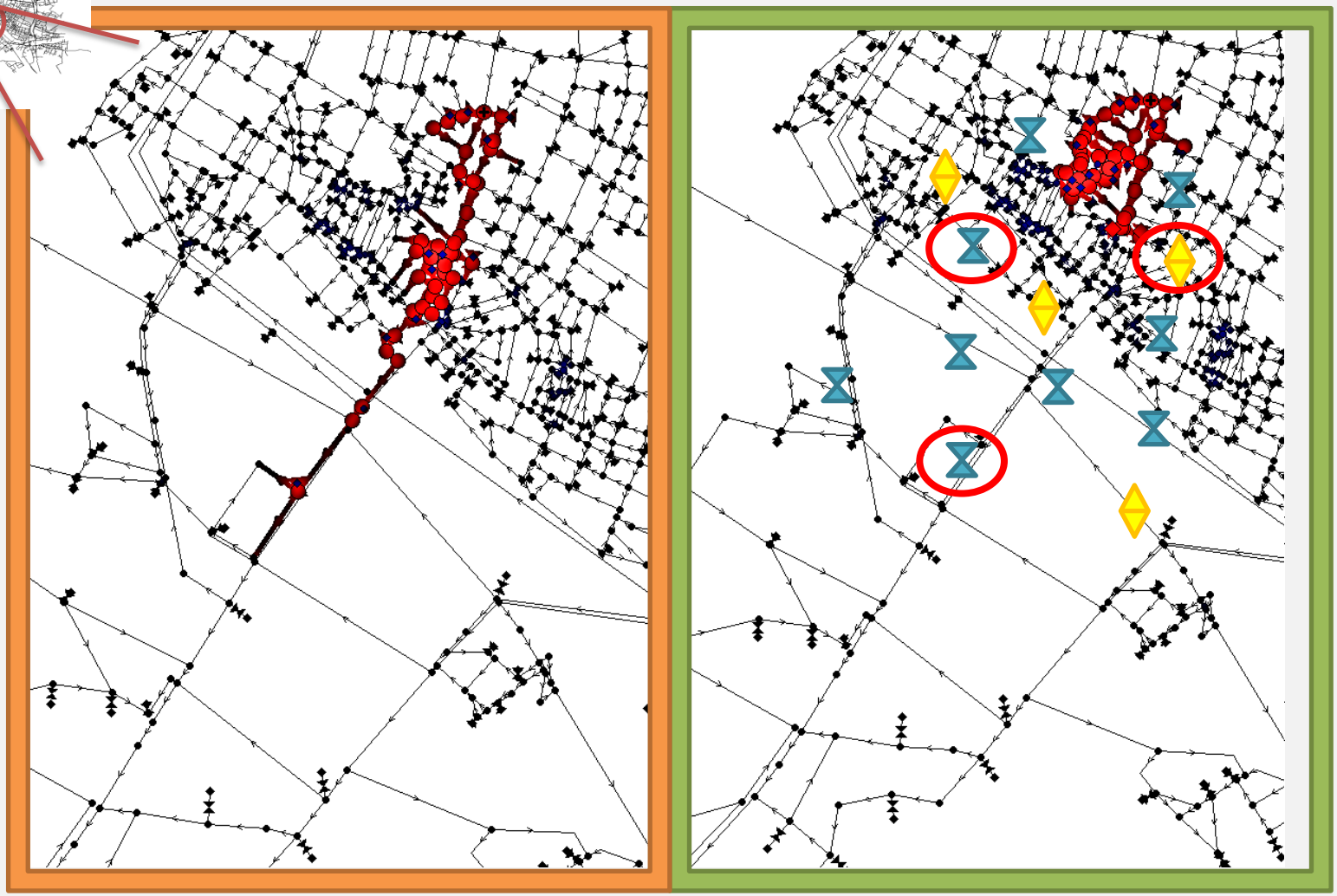
- Path relinking strategies
  - Route based PR
  - Hybrid PR

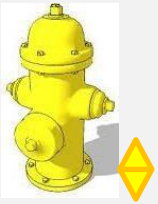
- Results
- Conclusions and future work

Injection of contaminant into the hydraulic network. Contaminant is spreading…

Hydraulic simulations

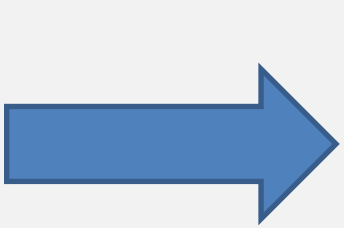
No reaction | **3h after the injection** | Device activation

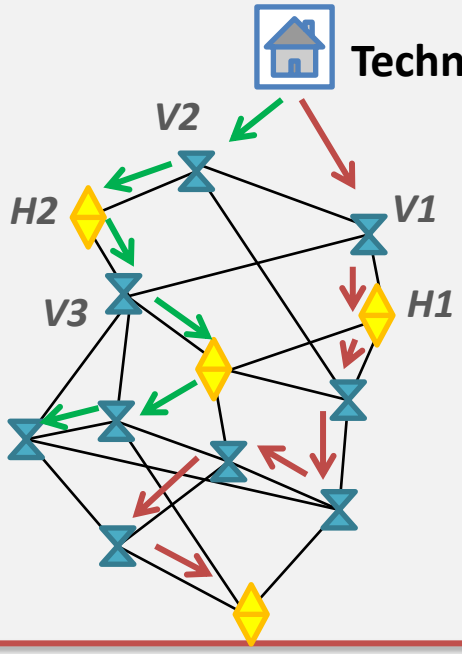




Optimizing the schedule

Device	Time
V1	t_1
V2	t_2
V3	t_3
H1	t_4
H2	t_5
...	...

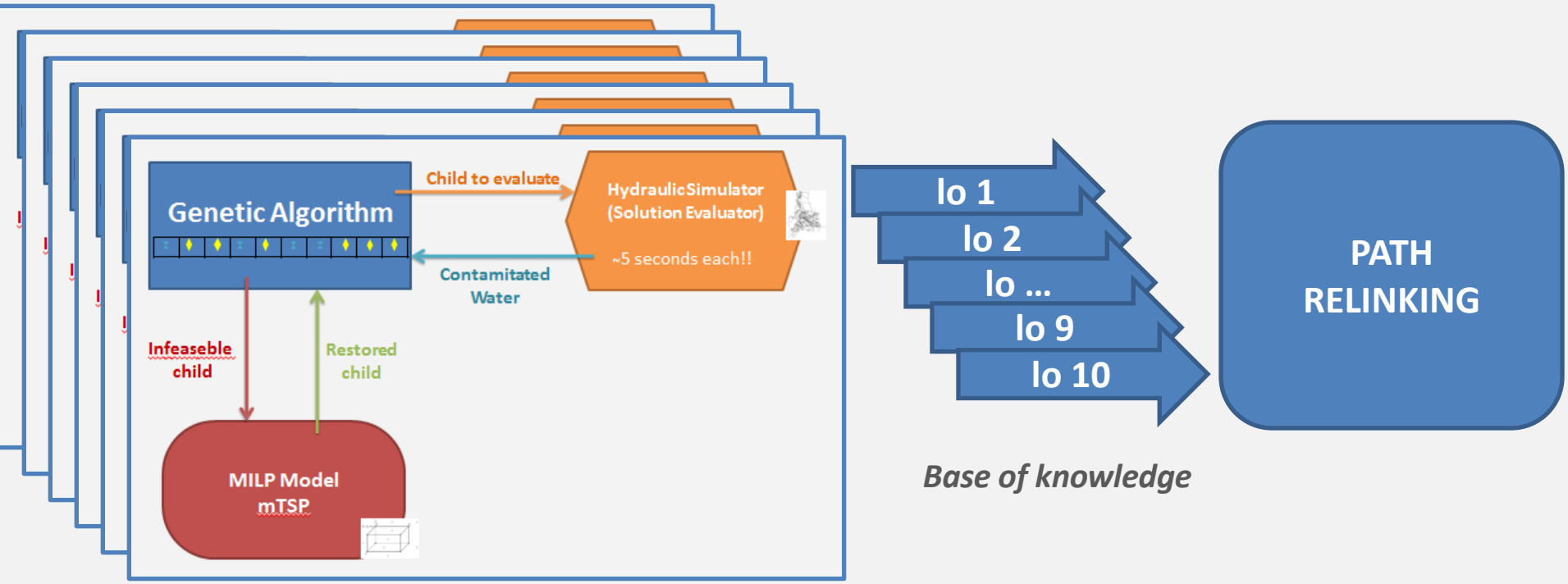




Multiple
Travelling Salesman Problem

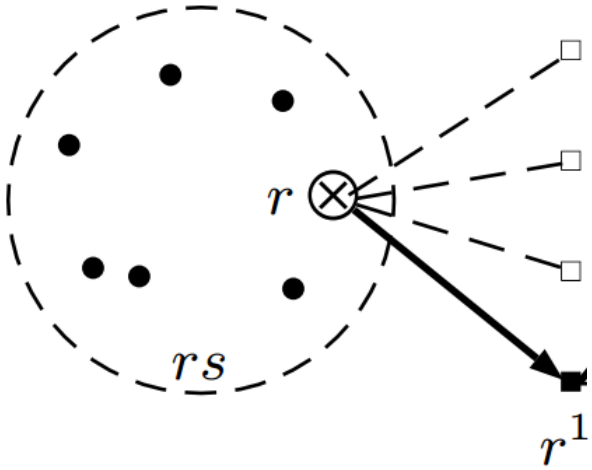
Solving architecture:

- Parallel GAs, plus a
- Intensification step by "Path Relinking"



Path Relinking

by Glover et al. 2000

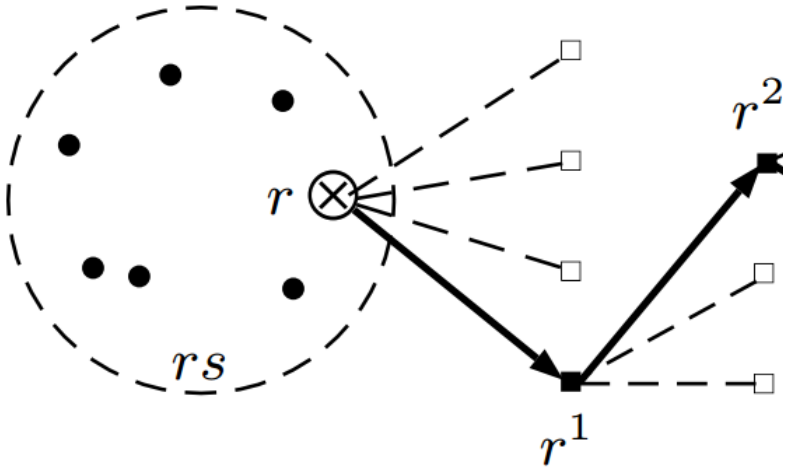


Legend

- ● reference solution
- ⊗ initial solution
- □ possible move
- ■ selected move
- ⊕ guiding solution

Path Relinking

by Glover et al. 2000



$\oplus\ g$

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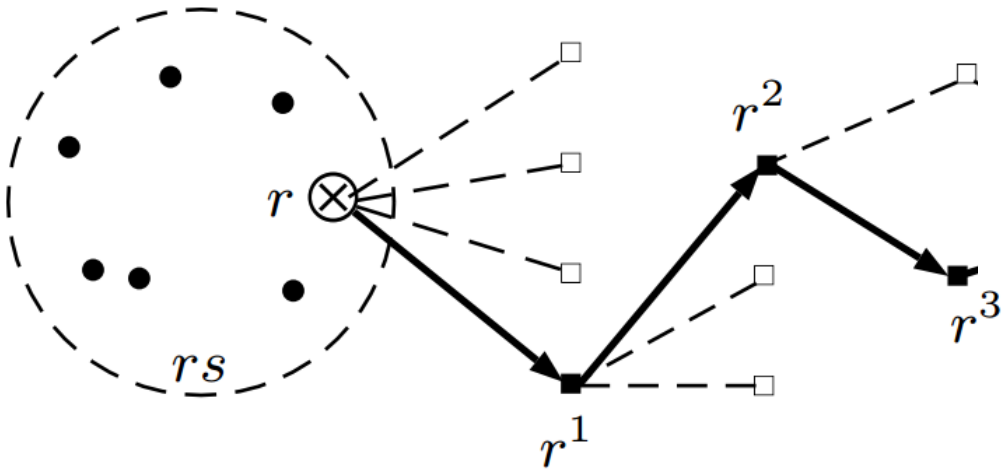
Path Relinking

by Glover et al. 2000



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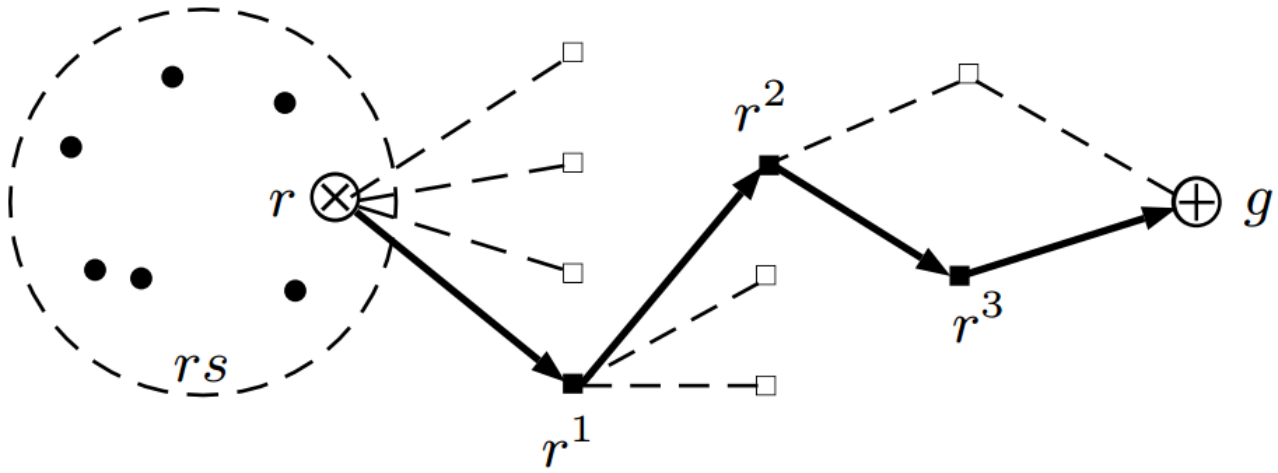

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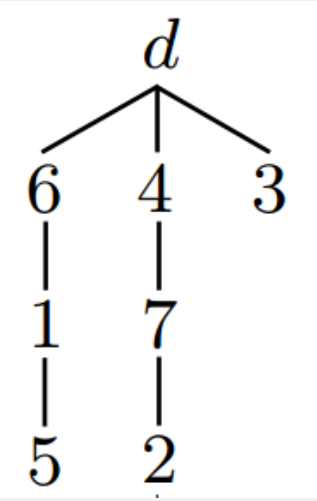
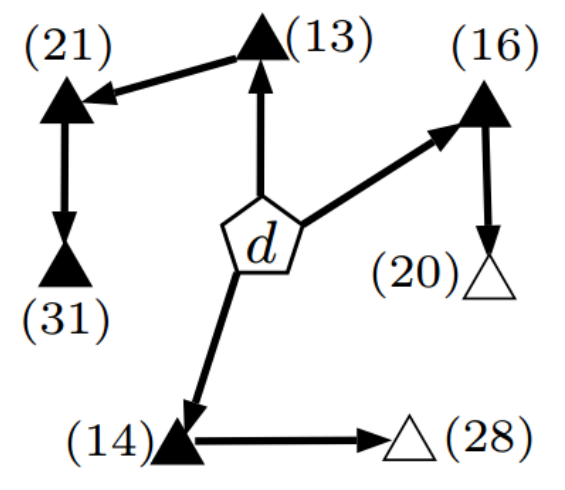
Path Relinking: solution representations

Route based



PRr

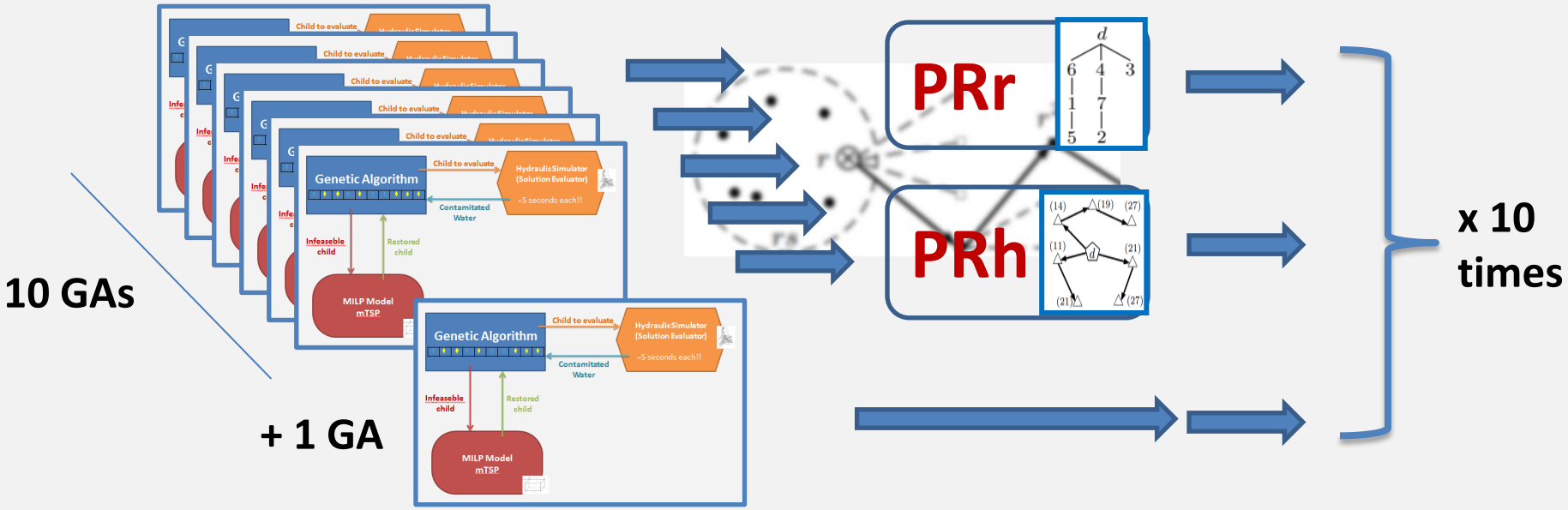
Time based



PRh

Experimental framework

- Ferrara's hydraulic network (about 120'000 users)
- 20 contamination scenarios
- Reference set is built up from 10 final population of the GA
- **GA, PRr and PRh were limited to 500 simulations**



Results (*Maddalena Nonato and Andrea Peano. 2015*)

scen	10 GA (sorting key) ave l	$\frac{var}{ave}$	best (s^*) l	+1 GA best l	impr. ♯	impr. ave l	PRr best l	impr. ♯	impr. ave l	PRh best l	impr. ♯	impr. ave l
A	6,022	0.04	6,000	6,000	0	0	**5,997**	**8**	**9**	6,000	7	**9**
B	7,170	0.10	7,170	7,170	0	0	7,170	1	2	**7,156**	**5**	**14**
C	10,868	1.51	10,672	10,672	0	0	**10,569**	3	**49**	10,623	**7**	47
D	11,229	1.16	11,021	11,021	0	0	11,021	0	0	**10,993**	**7**	**44**
E	12,732	0.21	**12,698**	**12,698**	1	5	**12,698**	1	4	**12,698**	**3**	**15**
F	13,938	0.76	13,793	13,793	1	2	**13,624**	4	**69**	13,723	**7**	44
G	15,841	0.22	15,758	15,758	0	0	15,758	4	29	**15,692**	**8**	**57**
H	16,991	2.44	16,571	16,571	1	3	**15,708**	7	**207**	16,351	**9**	137
I	20,792	7.21	**20,122**	**20,122**	0	0	**20,122**	2	**50**	**20,122**	**5**	22
J	22,273	0.39	22,164	22,164	0	0	22,164	2	8	**22,105**	**9**	**85**
K	25,138	0.56	**25,043**	**25,043**	0	0	**25,043**	2	21	**25,043**	**7**	**68**
L	35,067	1.00	34,662	34,662	0	0	34,662	4	**136**	**34,536**	**7**	120
M	36,706	0.52	**36,706**	**36,706**	0	0	**36,706**	1	2	**36,706**	**5**	**103**
N	40,121	4.74	39,230	39,230	1	21	39,230	4	121	**39,128**	**10**	**215**
O	42,019	1.68	**41,595**	**41,595**	0	0	**41,595**	0	0	**41,595**	**6**	**79**
P	44,470	0.34	44,286	44,286	1	10	44,286	0	0	**44,188**	**2**	**13**
Q	46,452	1.11	46,175	46,175	1	2	46,175	0	0	**46,144**	**8**	**137**
R	52,531	1.47	52,210	52,210	1	15	52,210	3	57	**52,205**	**5**	**77**
S	77,397	0.16	77,232	77,232	0	0	77,232	2	21	**76,999**	**6**	**123**
T	144,622	0.07	144,409	144,409	1	8	144,409	2	24	**144,350**	**8**	**82**
ave					0	3		3	38		**7**	**76**

Conclusions

- 2 new Path Relinking neighbourood structures for the response to contamination problem (and for the mTSP)
- Common PRs are effective as intensification strategies

Current work:

- intensificating GAs
- Design of a new concurrent PR algorithm
- Preliminary results show this novel strategy overcomes GA

Journals

[J2] *Marco Gavanelli, Maddalena Nonato, Andrea Peano, Stefano Alvisi, Marco Franchini.* **Scheduling countermeasures to contamination events by genetic algorithms. AI Communication**s. Doi: 10.3233/AIC-140638, vol. 28, no. 2, pp. 259–282, 2015. Doi:10.1093/logcom/ext065. ISI: 000349156700007. Scopus: 2-s2.0-84922560199.

Proceedings of international conferences

[C1] *Marco Gavanelli, Maddalena Nonato, Andrea Peano, Stefano Alvisi, and Marco Franchini.* **Genetic algorithms for scheduling devices operation in a water distribution system in response to contamination events**. In J.-K. Hao and M. Middendorf, editors, Evolutionary Computation in Combinatorial Optimization, volume 7245 of Lecture Notes in Computer Science, pages 124–135. Springer Berlin / Heidelberg, 2012. Scopus: 2-s2.0-84859138145.

[C2] *Maddalena Nonato and Andrea Peano.* **Path Relinking for a Constrained Simulation-Optimization Team Scheduling Problem Arising in Hydroinformatics**. In M. Gavanelli et al. (Eds.): AI*IA 2015, LNAI 9336, pp. 31–44, 2015.