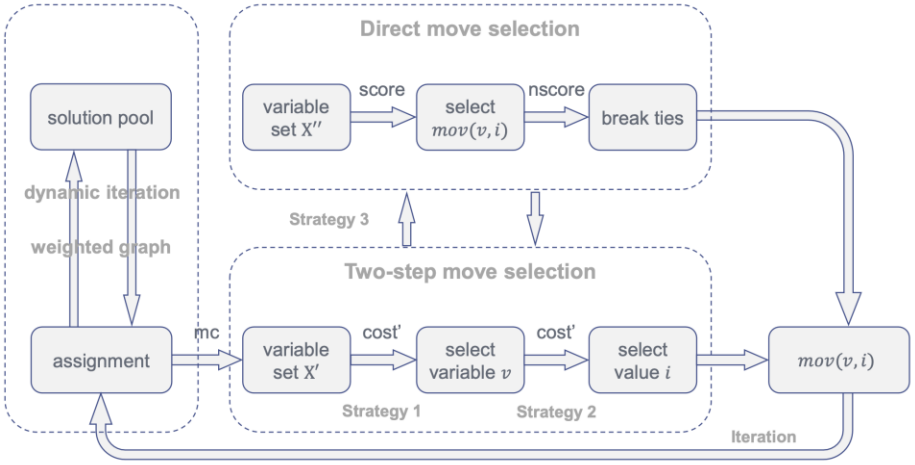
AllDiff-LS: Solving Alldifferent Constraints with Efficient Local Search

Rui HAN, Minghao LIU, Yuhang DONG, Fuqi JIA, Yiyuan WANG, Feifei MA, Minghao YIN, Jian ZHANG

Frontiers of Computer Science, DOI: 10.1007/s11704-025-41190-x

Problems & Ideas

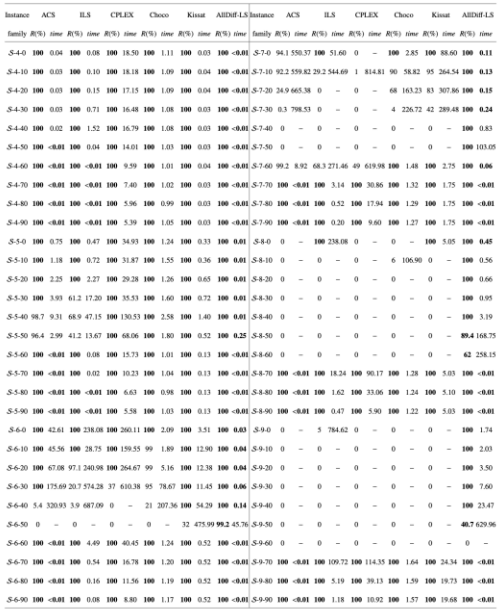
- Problems of Alldifferent constraints solving approaches:
  - Existing backtracking-based solvers struggle with large-scale alldifferent constraints due to exponential search complexity.
  - General-purpose local search methods lack specialized designs for alldifferent constraints, leading to suboptimal performance.
- Ideas: Proposes an bipartite Alldifferent constraint graph and polynomial-time simplification rules, combined with a two-step move selection strategy and adaptive tabu/restart mechanisms to efficiently solve large-scale CSPs.



Overall flowchart of the Alldiff-LS method.

Main Contributions

- Contributions:
  - Alldifferent Constraint Graph: Represents constraints as a bipartite graph for efficient conflict detection. Simplifies it via two polynomial-time reduction rules.
  - Two-Step Move Selection: Combines variable and value selection to reduce search space complexity.
  - Adaptive Strategies: Tabu mechanisms and dynamic restart policies to escape local optima.



Instance	CPLEX	Choco	Kissat	Yuck		LocalSolver		AllDiff-LS		Instance	CPLEX	Choco	Kissat	Yuck		LocalSolver		AllDiff-LS	
family	*time*	*time*	*time*	*time*	*R*(%)	*time*	*R*(%)	*time*	*R*(%)	family	*time*	*time*	*time*	*time*	*R*(%)	*time*	*R*(%)	*time*	*R*(%)
Q-500	8.33	–	408.43	896.07	100	212.35	100	**0.09**	100	*Q*-3500	837.99	–	–	–	0	–	0	**39.70**	100
Q-1000	69.93	–	–	–	0	–	0	**1.08**	100	*Q*-4000	–	–	–	–	0	–	0	**60.98**	100
Q-1500	138.22	–	–	–	0	–	0	**2.94**	100	*Q*-4500	–	–	–	–	0	–	0	**80.13**	100
Q-2000	272.83	–	–	–	0	–	0	**8.48**	100	*Q*-5000	–	–	–	–	0	–	0	**119.18**	100
Q-2500	436.40	–	–	–	0	–	0	**14.98**	100	*Q*-5500	–	–	–	–	0	–	0	**135.37**	100
Q-3000	624.28	–	–	–	0	–	0	**28.03**	100	*Q*-6000	–	–	–	–	0	–	0	**167.59**	100
A-12	0.56	1.51	153.68	1.58	100	0.14	**100**	**<0.01**	**100**	*A*-20	76.51	–	–	64.10	100	**0.22**	**100**	1.13	**100**
A-14	0.62	19.24	–	2.56	100	0.14	**100**	**<0.01**	**100**	*A*-22	217.25	–	–	565.35	100	**0.23**	**100**	6.01	**100**
A-16	2.86	174.36	–	6.84	100	0.20	**100**	**0.01**	**100**	*A*-24	164.58	–	–	–	0	**0.25**	**100**	42.31	**100**
A-18	3.24	276.35	–	52.44	100	**0.22**	**100**	0.23	**100**	*A*-26	–	–	–	–	0	0.24	**100**	214.75	90
L-3	1.80	2.62	0.02	3.31	100	0.15	**100**	**<0.01**	**100**	*L*-7	14.38	–	3.96	–	0	17.55	**100**	**3.86**	**100**
L-4	2.16	0.95	0.02	2.71	100	0.16	**100**	**<0.01**	**100**	*L*-8	–	–	**6.70**	–	0	–	0	345.53	90
L-5	3.20	1.22	0.15	29.27	100	0.20	**100**	**<0.01**	**100**	*L*-9	–	–	–	–	0	–	0	–	0

Comparison of the solution results of Alldiff-LS and other methods on four types of CSPs.