

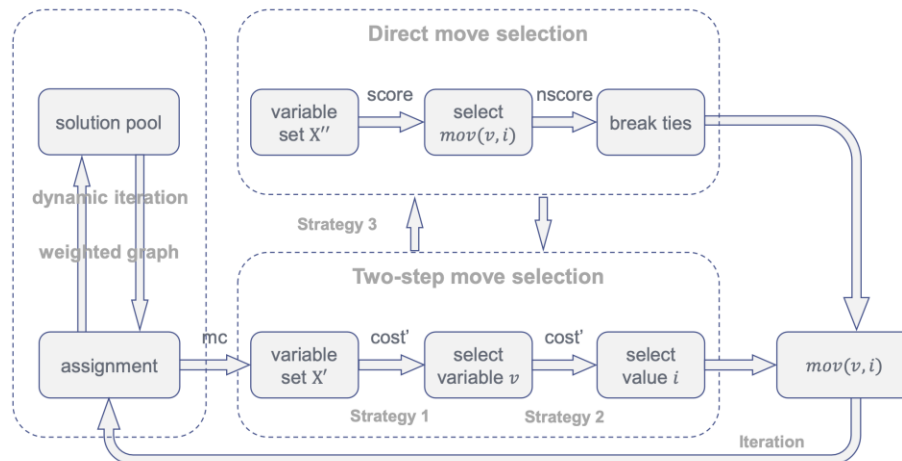
AllDiff-LS: Solving Alldifferent Constraints with Efficient Local Search

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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	ACS	ILS	CPLEX	Choco	Kissat	AllDiff-LS	Instance	ACS	ILS	CPLEX	Choco	Kissat	AllDiff-LS												
family	R(%)	time	R(%)	time	R(%)	time	family	R(%)	time	R(%)	time	R(%)	time												
S-4-0	100	0.04	100	0.08	100	18.50	1.11	100	0.03	100	-0.01	S-7-0	94.1	550.37	100	51.60	0	100	2.85	100	88.60	100	0.11		
S-4-10	100	0.03	100	0.10	100	18.18	1.09	100	0.04	100	-0.01	S-7-10	92.2	559.82	29.2	544.69	1	814.81	90	58.82	95	264.54	100	0.13	
S-4-20	100	0.03	100	0.15	100	17.15	1.09	100	0.04	100	-0.01	S-7-20	94.9	665.38	0	0	0	0	68	163.23	83	307.86	100	0.15	
S-4-30	100	0.03	100	0.71	100	16.48	1.08	100	0.03	100	-0.01	S-7-30	93.3	798.53	0	0	0	0	4	226.72	42	289.48	100	0.24	
S-4-40	100	0.02	100	1.52	100	16.79	1.08	100	0.03	100	-0.01	S-7-40	0	0	0	0	0	0	0	0	0	0	100	0.83	
S-4-50	100	-0.01	100	0.04	100	14.01	1.03	100	0.03	100	-0.01	S-7-50	0	0	0	0	0	0	0	0	0	0	100	103.05	
S-4-60	100	-0.01	100	-0.01	100	9.59	1.03	100	0.04	100	-0.01	S-7-60	99.2	832	68.3	271.46	49	619.98	100	1.48	100	2.75	100	0.06	
S-4-70	100	-0.01	100	-0.01	100	7.40	1.02	100	0.03	100	-0.01	S-7-70	100	-0.01	100	3.14	100	30.86	100	1.32	100	1.75	100	-0.01	
S-4-80	100	-0.01	100	-0.01	100	5.96	1.09	100	0.03	100	-0.01	S-7-80	100	-0.01	100	0.52	100	17.94	100	1.29	100	1.75	100	-0.01	
S-4-90	100	-0.01	100	-0.01	100	5.39	1.05	100	0.03	100	-0.01	S-7-90	100	-0.01	100	0.20	100	9.60	100	1.27	100	1.75	100	-0.01	
S-5-0	100	0.75	100	0.47	100	34.93	1.24	100	0.33	100	0.01	S-8-0	0	0	0	0	0	0	0	0	100	5.05	100	0.45	
S-5-10	100	1.18	100	0.72	100	31.87	1.55	100	0.36	100	0.01	S-8-10	0	0	0	0	0	0	0	0	6	106.90	0	100	0.56
S-5-20	100	2.25	100	2.27	100	29.28	1.26	100	0.65	100	0.01	S-8-20	0	0	0	0	0	0	0	0	0	0	100	0.66	
S-5-30	100	3.93	100	61.2	17.20	35.53	1.60	1.60	0.72	100	0.01	S-8-30	0	0	0	0	0	0	0	0	0	0	100	0.93	
S-5-40	98.7	9.31	68.9	47.15	100	130.53	2.58	100	1.40	100	0.01	S-8-40	0	0	0	0	0	0	0	0	0	0	100	3.19	
S-5-50	96.4	2.99	41.2	13.67	100	88.06	1.80	100	0.52	100	0.25	S-8-50	0	0	0	0	0	0	0	0	0	0	100	168.75	
S-5-60	100	-0.01	100	0.08	100	15.73	1.01	100	0.13	100	-0.01	S-8-60	0	0	0	0	0	0	0	0	0	0	62	258.15	
S-5-70	100	-0.01	100	0.02	100	10.23	1.04	100	0.13	100	-0.01	S-8-70	-0.01	100	18.24	100	90.17	100	1.28	100	5.03	100	-0.01		
S-5-80	100	-0.01	100	-0.01	100	6.63	1.09	100	0.13	100	-0.01	S-8-80	-0.01	100	1.62	100	33.06	100	1.24	100	5.10	100	-0.01		
S-5-90	100	-0.01	100	-0.01	100	5.58	1.03	100	0.13	100	-0.01	S-8-90	-0.01	100	0.47	100	5.90	100	1.12	100	5.03	100	-0.01		
S-6-0	100	42.61	100	230.08	100	200.11	2.09	100	3.51	100	0.05	S-9-0	0	0	0	0	0	0	0	0	0	100	1.74		
S-6-10	100	45.56	100	28.75	100	159.55	1.89	100	12.90	100	0.04	S-9-10	0	0	0	0	0	0	0	0	0	0	100	2.03	
S-6-20	100	67.08	97.1	240.98	100	264.67	1.99	100	5.16	100	0.04	S-9-20	0	0	0	0	0	0	0	0	0	0	100	3.50	
S-6-30	100	175.89	20.7	574.28	37	610.38	1.95	78.67	100	11.45	100	0.06	S-9-30	0	0	0	0	0	0	0	0	0	100	7.60	
S-6-40	5.4	320.93	3.9	487.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	23.47		
S-6-50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	629.96		
S-6-60	-0.01	100	4.49	100	40.45	100	1.24	100	0.52	100	-0.01	S-9-60	0	0	0	0	0	0	0	0	0	0	100	0	
S-6-70	-0.01	100	0.54	100	16.78	100	1.20	100	0.52	100	-0.01	S-9-70	-0.01	100	109.72	100	114.35	100	1.64	100	24.34	100	-0.01		
S-6-80	-0.01	100	0.16	100	11.56	100	1.19	100	0.52	100	-0.01	S-9-80	-0.01	100	5.19	100	39.13	100	1.59	100	39.73	100	-0.01		
S-6-90	-0.01	100	0.08	100	8.80	100	1.17	100	0.52	100	-0.01	S-9-90	-0.01	100	1.18	100	10.92	100	1.57	100	19.68	100	-0.01		

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	time	time	time	R(%)	time						
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
\mathcal{A} -12	0.56	1.51	153.68	1.58	100	0.14	100	<0.01	100	\mathcal{A} -20	76.51	-	-	64.10	100	0.22	100	1.13	100
\mathcal{A} -14	0.62	19.24	-	2.56	100	0.14	100	<0.01	100	\mathcal{A} -22	217.25	-	-	565.35	100	0.23	100	6.01	100
\mathcal{A} -16	2.86	174.36	-	6.84	100	0.20	100	0.01	100	\mathcal{A} -24	164.58	-	-	-	0	0.25	100	42.31	100
\mathcal{A} -18	3.24	276.35	-	52.44	100	0.22	100	0.23	100	\mathcal{A} -26	-	-	-	-	0	0.24	100	214.75	90
\mathcal{L} -3	1.80	2.62	0.02	3.31	100	0.15	100	<0.01	100	\mathcal{L} -7	14.38	-	3.96	-	0	17.55	100	3.86	100
\mathcal{L} -4	2.16	0.95	0.02	2.71	100	0.16	100	<0.01	100	\mathcal{L} -8	-	-	6.70	-	0	-	0	345.53	90
\mathcal{L} -5	3.20	1.22	0.15	29.27	100	0.20	100	<0.01	100	\mathcal{L} -9	-	-	-	-	0	-	0	-	0

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