Report on

Constraint Satisfaction Problem

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Overview: **Constraint satisfaction problems** (**CSPs**) are mathematical questions defined as a set of objects whose state must satisfy a number of constraints or limitations. In this assignment, we have solved Latin Square Completion problem formatted as CSP. We have solved the problem using different criteria and thereby found the best possible way.

Variable Order Heuristics:

VAH1: The variable chosen is the one with the smallest domain.

VAH2: The variable chosen is the one with the maximum degree to unassigned variables. Also, called max-forward-degree.

VAH3: The variable chosen by VAH1; Ties are broken by VAH2.

VAH4: The variable chosen is the one that minimizes the VAH1 / VAH2.

VAH5: A random unassigned variable is chosen.

Value Order Heuristic:

Least Constraining Value First: Value that shrinks others' domain the least is taken first.

Justification:

Firstly, if we consider random pick up, the domains are being shrunk almost randomly here with no predictability.

Secondly, let us consider hot takes. In hot takes, we take the most used values till now. But to implement that we would have to alter our algorithm by a fair amount.

Therefore, we decided on taking the Least Constraining Value next as it clearly gives us most flexibility . If we keep constraining our neighbors by assigning values that would shrink their domain the most, we surely would deviate from the solution by a big amount. Giving them the chance to keep the largest possible domain possible will result to us getting the solution early.

Result:

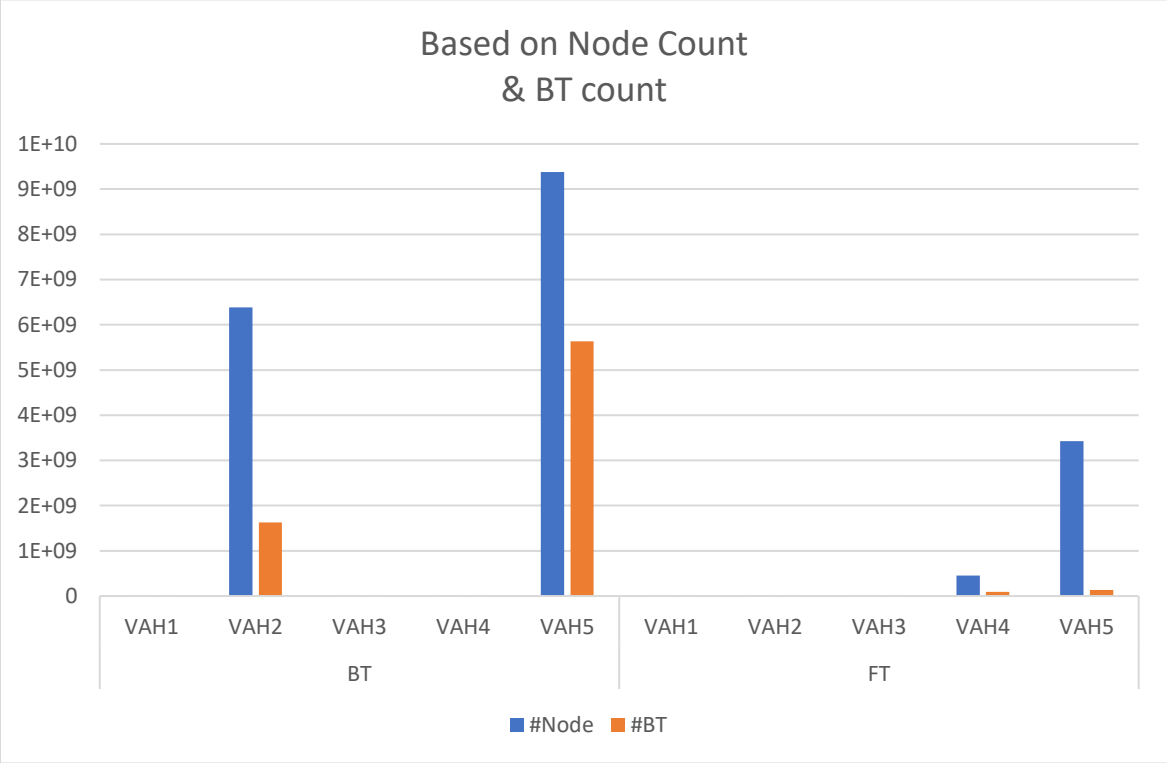
Problem	Solver	VAH	#Node	#BT	Runtime
d-10-01	BT	VAH1	195	69	4
		VAH2	4564327821	786098346	456092
		VAH3	57	0	4
		VAH4	6913035	3456489	11778
		VAH5	*	*	*
	FT	VAH1	191	65	7
		VAH2	56563	22157	120
		VAH3	57	0	4
		VAH4	71011	27900	204
		VAH5	262650	96157	340
d-10-06	BT	VAH1	57	0	3
		VAH2	6754356782	2123745986	543794
		VAH3	57	0	3
		VAH4	47598675	34576288	376234
		VAH5	*	*	*
	FT	VAH1	57	0	1
		VAH2	121463	45818	190
		VAH3	57	0	2
		VAH4	3075775	1061594	3327
		VAH5	2573	934	21
d-10-07	BT	VAH1	97	20	3
		VAH2	7823915578	1984562004	945937
		VAH3	71	7	2
		VAH4	1569236	1043621	76311
		VAH5	3565236	1343321	96461
	FT	VAH1	118	30	4
		VAH2	10094	3802	55
		VAH3	69	5	4
		VAH4	308985	117841	540
		VAH5	368309	135278	474
d-10-08	BT	VAH1	107	25	2
		VAH2	*	*	*
		VAH3	85	14	4
		VAH4	872665	665154	11430
		VAH5	*	*	*
	FT	VAH1	103	21	4

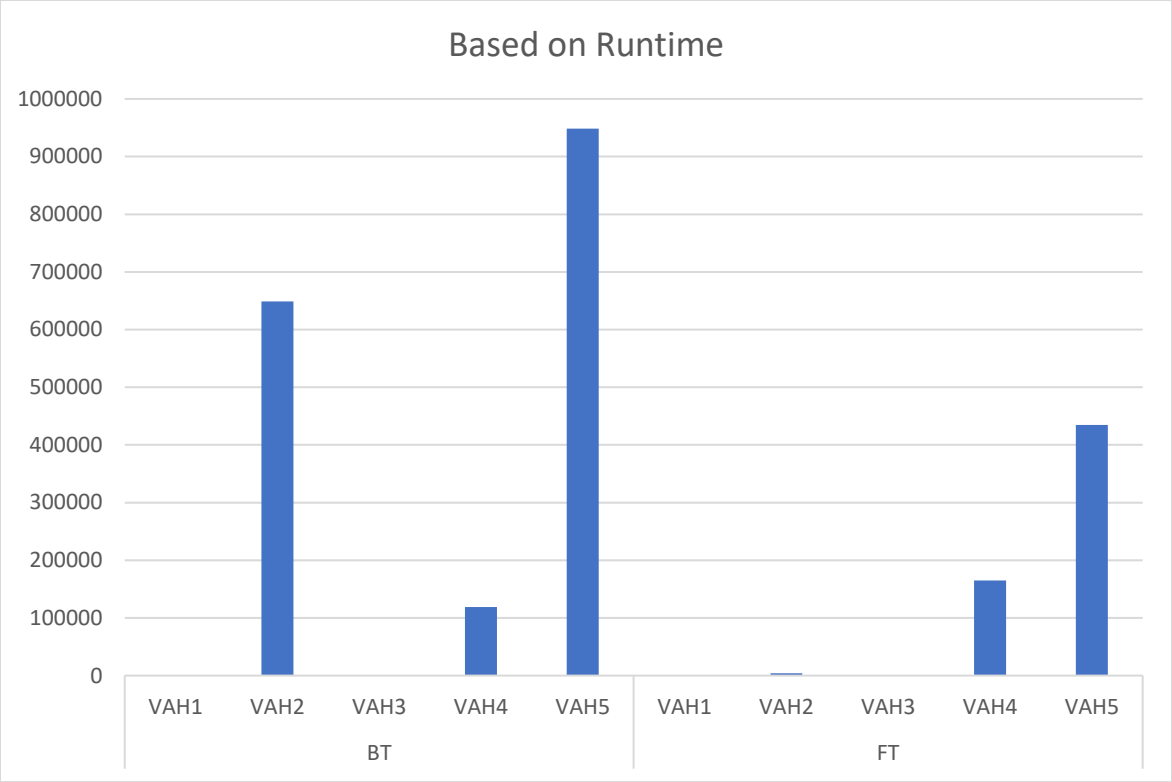
		VAH2	31968	12667	106
		VAH3	127	33	5
		VAH4	732665	265154	1143
		VAH5	15374	5667	59
d-10-09	BT	VAH1	57	0	2
		VAH2	*	*	*
		VAH3	57	0	3
		VAH4	*	*	*
		VAH5	*	*	*
	FT	VAH1	57	0	1
		VAH2	1247	434	11
		VAH3	57	0	3
		VAH4	2554909	864069	2805
		VAH5	127856407	46031824	157716
d-15-01	BT	VAH1	74818	37356	432
		VAH2	*	*	*
		VAH3	767588	383741	3903
		VAH4	*	*	*
		VAH5	*	*	*
	FT	VAH1	70167	32740	405
		VAH2	83453624	3965871	24456
		VAH3	337787	159970	2406
		VAH4	3167342097	563980143	981367
		VAH5	*	*	*

Aggregated Results:

Solver	VAH	#Node	#BT	Runtime
BT	VAH1	12555	6245	74
	VAH2	6380866727	1631468779	648607.7
	VAH3	127985.833	63960.3333	653.1667
	VAH4	14238402.8	9935388	118938.3
	VAH5	9380866727	5631468779	948607.7
FT	VAH1	11782.1667	5476	70.33333
	VAH2	13945826.5	675124.833	4156.333
	VAH3	56359	26668	404
	VAH4	454428354	94386116.8	164897.7
	VAH5	3425701063	134384516	434767

Graphical Representation:





Observation: In general, Forward Checking performs way better than Backtracking. Some of the Heuristics works better with FC and some with BT. Analyzing the tables and graphs, Forward checking with VAH3 is the best method.