ASSIGNMENT 2 - FIT5216: SEMANTIC REPORT

1. Objective value and Run time statistics

Objective (Time limit: 100 seconds)								
	A1 off	**A2 off**	**B1 off**	**B2 off**	**D1 off**	**D2 off**	**E off**	**FULL**
nroster01	107	110	64	114	114	114	114	114
nroster02	106	110	78	112	112	112	111	112
nroster03	116	116	110	99	116	116	116	116
nroster04	366	362	352	298	362	366	366	366
nroster05	440	440	352	315	384	440	440	440
nroster06	686	689	673	567	685	695	691	695
nroster07	915	950	950	566	950	950	945	950
nroster08	375	400	318	410	409	410	399	410
nroster09	362	357	352	294	362	362	362	362
nroster10	398	388	355	359	382	395	384	398

Table 01: Best objective value in 100 seconds

Run Time (Time limit: 100 seconds)								
	A1 off	**A2 off**	**B1 off**	**B2 off**	**D1 off**	**D2 off**	**E off**	**FULL**
nroster01	2.06	0.10	3.00	0.28	0.58	1.17	0.91	0.51
nroster02	2.26	0.10	1.54	0.19	0.39	0.31	0.29	0.58
nroster03	1.40	0.12	5.06	5.19	2.51	1.38	1.80	1.49
nroster04	11.27	0.13	5.94	0.39	4.55	3.62	3.32	2.87
nroster05	2.41	0.13	4.98	3.44	2.74	2.64	2.28	2.51
nroster06	80.63	0.22	12.73	0.46	8.61	4.14	11.85	15.16
nroster07	93.74	6.65	28.57	53.52	4.09	1.87	17.55	16.08
nroster08	49.37	0.13	71.50	0.14	1.03	0.54	0.30	0.39
nroster09	77.82	5.92	15.99	4.41	4.63	3.75	17.34	16.72
nroster10	48.76	8.68	60.24	32.10	6.50	59.23	43.79	58.57

Table 02: Run time

(The red numbers indicate that the model cannot find the optimal value (minimal total cost) within the time limit, while yellow cells highlight valuable insights from the data compared to the rest).

2. Test data and constraint analysis

In the nroster01 test data, the order of constraints is B1 > A1 > A2 > B2 >= D1 >= D2 >= E. When tested with the 'B1 off' model (removing B1 from the complete model), there is a dramatic drop in the objective, from a base of 114 to 64 points, while the scores for A1 and A2 are 107 and 110, respectively. In contrast, the figures for the remaining models remain unchanged, which can be attributed to a trivial dataset featuring 1 WARD type (GEN) and 1 SKILL type (SENIOR) that all nurses possess. This highlights the significant impact of B1 on the model's performance in this specific dataset configuration.

The order is quite similar for nroster02: B1 > A1 > A2 > E > B2 >= D1 >= D2, with a slight difference in the objective of the 'E off' model, dropping from 112 to 111. Examining the model runtime, there are peaks at 'A1 off' with 2.259 and 'B1 off' with 1.537, at least three times higher than the median. It follows the same pattern for WARD and SKILL (as in nroster01), which are the main focus in parts D and E, respectively. Thus, the objectives of the corresponding models are similar to those of the FULL model, suggesting stability across different test conditions.

The ranking of importance among constraints differs in nroster03: B2 > B1 > A2 >= A1 >= D1 >= D2 >= E. In the objective table, every model scores the same at 116, except for 'B2 off' at 99 and 'B1 off' at 110. This is reasonable since the data are the same as in the first two test datasets, where the data is trivial for WARD and TYPE. Moreover, the rostered_off parameter is set as false for all NURSE and DAY, indicating that there are no fixed off shifts in the workforce. This results in no change in the total cost (objective) with or without part A1 (rostered_off = true <-> ward = OFF). The uniformity of the results except for B2 and B1 off indicates the specific importance of these constraints.

In nroster04, the order is B2 > B1 > A2 > D1 >= A1 > D2 > E. Again, as the SKILL set for NURSE is empty and no emergency ward is defined, part E does not affect the objective. By contrast, a significant decrease of 68 from the base can be seen when B2 is turned off, showing the importance of this part for this dataset. Also, A1 contributes greatly to model optimality, helping the model run twice as fast, from 11.27 in 'A1 off' to below 6 seconds for the rest. This shows that A1 plays a critical role in enhancing the efficiency of the model, particularly in scenarios where time is a constraint.

For nroster05, the ranking is B2 > B1 > D1 >= A1 >= A2 >= D2 >= E. Here, the rostered_off parameter is again set to fail for all NURSE and DAY, with 1 ward and 1 skill, resulting in no change in the total cost for A1, D2, and E. Nevertheless, the figures are 315 for 'B2 off', 352 for 'B1 off', and a smaller change in 'D1 off' from

440 to 384. The significant differences in objective scores when B2 and B1 are turned off highlight their critical roles in the overall effectiveness of the model in this test environment.

In the next dataset, nroster06, the order is B2 > B1 > D1 > A1 > A2 > E > D2. As the dataset becomes more complex, the number of working days increases to 27, and the existence of 2 different types in WARD causes the order to change quickly. Notably, 'A1 off' takes 80 seconds to finish, incredibly higher than the second highest of 'B1 off' with 12 seconds. This indicates that with a more complex scenario, A1 is an essential constraint for optimisation purposes. The presence of multiple ward types and an increased number of working days adds complexity to the dataset, further emphasizing the importance of managing constraints effectively.

In nroster07, B2 still stands out as the most important, followed by A1, then E. This is supported in the Objective table. The total costs for the rest are 950, but only 567 for 'B2 off'. In this case, E appears in the top 3 as the skill section is exploited, with 3 types of skills and different required skill sets for each nurse. The diversity in skill requirements and their impact on the model's performance illustrate the intricacies of workforce management in this scenario.

In nroster08, the order is B1 > A1 > E > A2 > D1 > D2 >= B2. Without B1 or A1, the model takes up to 71.5 seconds and 50 seconds, respectively, significantly higher than the rest of the models, which fluctuate around 1 second only. Moreover, the data for 'B1 off' and 'A1 off' are the lowest at 318 and 375. This significant increase in runtime for models without B1 and A1, coupled with the lower objective scores, underscores their crucial roles in maintaining model efficiency and effectiveness.

In nroster09, B2 then B1 followed by A2 are the most important constraints. From the table of objective scores, removing B2, B1, and A2 leads to drops in total cost from 362 to 294, 252, and 257, respectively. However, without the A1 constraint, the model runtime is 77.8 seconds, at least 5 times higher than the others. The extended runtimes and significant drops in total cost, when key constraints are removed, highlight their essential roles in achieving optimal results in this model setup.

Finally, in nroster10, 'B2 off' is the most important, followed by A1 and B1. The 'B2 off' model has the smallest objective score at 359 in a limited time. Meanwhile, without A1 or B1, the model cannot present the final minimal solution within 100 seconds, indicating that these constraints are needed to improve the model's efficiency in time running. The inability of the model to deliver optimal solutions

without these key constraints within the allotted time frame points to their critical importance in the model's overall performance and efficiency.

In conclusion, the most critical constraints of the model overall are B1, followed by B2, and then A1. From the objective table, the 'B2 off' model registers the lowest score six times, while B1 does so four times across the ten datasets. This indicates the most significant changes in the model's ability to raise the objective. In contrast, the removal of D1, D2, and E results in minimal fluctuations around the lowest total cost, underscoring their lesser importance in terms of impacting the objective. Nevertheless, A1 also contributes to the objective score, but its primary significance lies in boosting model speed. Among the ten tests, without A1, the model runs at least twice as slow in seven tests, notably in nroster06, where the runtime is 80 seconds, six times higher than the average. This highlights A1's role in enhancing operational efficiency.