

Using Google OR Tools for Knapsack Problems: Need more computers instead of hard work!

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In this project, we conducted some experiments to measure and evaluate the solution and performance of OR Tools for Knapsack problems. Thus, we also learn how to use OR-Tools and install them for practical purposes. To set up the experiments, we need to clone the test-case set, read files, and get data from the clone folder. Besides, how to operate the experiments automatic and efficient is a challenge that we must face.

1 How to set up the experiments

To set up the experiments firstly, we install the or-tools module and clone the folder that contains the test-case set for experiments. We use guidelines from the home page to implement a solver for Knapsack problems. Besides, we also need to get all files from the repository and read and convert data from them. But, there are too many files in the repository, so with a leaf folder we will get a file. In total, we have **2x8x13** files as test cases for these experiments.

We want to operate the experiments automatic, so we abstracted all the above steps as functions of the pipeline: *get files from folder – get data from file – solve with or-tools and write results to backup and log file* in experiments process takes places.

Although we have a limited number of test cases and a set time limit for the solver is **180 seconds**, the number of test cases is also too large and we can spend up to 10 hours (not including wasted time) for experiments. This is a challenge that we must overcome.

The idea for this challenge is that we recognize each test-case group is independent and we can use more computers to run them parallel and then synthesize them together. Based on Kaggle's policy, We used 3 Kaggle sessions for running work with the experiments.

Finally, we use computer programs to create report tables automatically.

2 Statistics and Evaluation

Testcase: the name of files that contain the test case.

Nitems: the number of items in the test case.

Value: the total profit of the solution found.

Weight: the total weight of items in the solution found.

Time (second): the run time of solver programs.

Optimal: True, if it is an optimal solution. If False, it may not be an optimal solution.

The computers used for experiments are **Kaggle CPUs**.

Table 1: Statistics

testcase	Nitems	value	weight	time	optimal
/00Uncorrelated/n01000/R10000/s009.kp	1000	3932453	2555088	0	True
/00Uncorrelated/n01000/R01000/s009.kp	1000	393483	255729	0	True
/00Uncorrelated/n02000/R10000/s009.kp	2000	8160372	4851150	0	True
/00Uncorrelated/n02000/R01000/s009.kp	2000	816516	485559	0	True
/00Uncorrelated/n00100/R10000/s009.kp	100	364266	242347	0	True
/00Uncorrelated/n00100/R01000/s009.kp	100	36459	24262	0	True
/00Uncorrelated/n10000/R10000/s009.kp	10000	40249903	24771994	0	True
/00Uncorrelated/n10000/R01000/s009.kp	10000	4027410	2479420	0	True
/00Uncorrelated/n05000/R10000/s009.kp	5000	20128686	12220642	0	True
/00Uncorrelated/n05000/R01000/s009.kp	5000	2014059	1223184	0	True
/00Uncorrelated/n00200/R10000/s009.kp	200	784545	482744	0	True
/00Uncorrelated/n00200/R01000/s009.kp	200	78515	48331	0	True
/00Uncorrelated/n00050/R10000/s009.kp	50	183147	114430	0	True
/00Uncorrelated/n00050/R01000/s009.kp	50	18331	11457	0	True
/00Uncorrelated/n00500/R10000/s009.kp	500	1990637	1194207	0	True
/00Uncorrelated/n00500/R01000/s009.kp	500	199181	119530	0	True
/01WeaklyCorrelated/n01000/R10000/s009.kp	1000	2666130	2392259	0	True
/01WeaklyCorrelated/n01000/R01000/s009.kp	1000	266964	239451	0	True
/01WeaklyCorrelated/n02000/R10000/s009.kp	2000	5453334	4947358	0	True
/01WeaklyCorrelated/n02000/R01000/s009.kp	2000	546000	495187	0	True
/01WeaklyCorrelated/n00100/R10000/s009.kp	100	248539	222984	0	True
/01WeaklyCorrelated/n00100/R01000/s009.kp	100	24885	22316	0	True
/01WeaklyCorrelated/n10000/R10000/s009.kp	10000	27132774	24528449	0	True
/01WeaklyCorrelated/n10000/R01000/s009.kp	10000	2716776	2455079	0	True
/01WeaklyCorrelated/n05000/R10000/s009.kp	5000	13579520	12307795	0	True
/01WeaklyCorrelated/n05000/R01000/s009.kp	5000	1359652	1231894	0	True
/01WeaklyCorrelated/n00200/R10000/s009.kp	200	517905	465529	0	True
/01WeaklyCorrelated/n00200/R01000/s009.kp	200	51864	46603	0	True
/01WeaklyCorrelated/n00050/R10000/s009.kp	50	119733	108238	0	True
/01WeaklyCorrelated/n00050/R01000/s009.kp	50	11991	10836	0	True
/01WeaklyCorrelated/n00500/R10000/s009.kp	500	1323913	1198027	0	True
/01WeaklyCorrelated/n00500/R01000/s009.kp	500	132582	119918	0	True
/02StronglyCorrelated/n01000/R10000/s009.kp	1000	3100924	2388924	180	False
/02StronglyCorrelated/n01000/R01000/s009.kp	1000	310426	239226	180	False
/02StronglyCorrelated/n02000/R10000/s009.kp	2000	6349888	4942888	180	False
/02StronglyCorrelated/n02000/R01000/s009.kp	2000	635490	494790	180	False
/02StronglyCorrelated/n00100/R10000/s009.kp	100	294990	222990	2	True
/02StronglyCorrelated/n00100/R01000/s009.kp	100	29523	22323	1	True
/02StronglyCorrelated/n10000/R10000/s009.kp	10000	31577966	24523966	180	False
/02StronglyCorrelated/n10000/R01000/s009.kp	10000	3160178	2454878	180	False
/02StronglyCorrelated/n05000/R10000/s009.kp	5000	15829300	12303300	180	False
/02StronglyCorrelated/n05000/R01000/s009.kp	5000	1584494	1231894	180	False
/02StronglyCorrelated/n00200/R10000/s009.kp	200	608588	465588	37	True
/02StronglyCorrelated/n00200/R01000/s009.kp	200	60904	46604	9	True
/02StronglyCorrelated/n00050/R10000/s009.kp	50	144240	108240	0	True
/02StronglyCorrelated/n00050/R01000/s009.kp	50	14436	10836	0	True
/02StronglyCorrelated/n00500/R10000/s009.kp	500	1556033	1198033	180	False
/02StronglyCorrelated/n00500/R01000/s009.kp	500	155718	119918	180	False
/03InverseStronglyCorrelated/n01000/R10000/s009.kp	1000	2575844	2882844	180	False
/03InverseStronglyCorrelated/n01000/R01000/s009.kp	1000	258156	288956	180	False

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test case	Nitems	value	weight	time	optimal
/03InverseStronglyCorrelated/n02000/R10000/s009.kp	2000	5303326	5932326	180	False
/03InverseStronglyCorrelated/n02000/R01000/s009.kp	2000	531197	594197	180	False
/03InverseStronglyCorrelated/n00100/R10000/s009.kp	100	242494	272494	0	True
/03InverseStronglyCorrelated/n00100/R01000/s009.kp	100	24273	27273	0	True
/03InverseStronglyCorrelated/n10000/R10000/s009.kp	10000	26336830	29472830	180	False
/03InverseStronglyCorrelated/n10000/R01000/s009.kp	10000	2635794	2949494	180	False
/03InverseStronglyCorrelated/n05000/R10000/s009.kp	5000	13213919	14781919	180	False
/03InverseStronglyCorrelated/n05000/R01000/s009.kp	5000	1322116	1478916	180	False
/03InverseStronglyCorrelated/n00200/R10000/s009.kp	200	503570	564570	0	True
/03InverseStronglyCorrelated/n00200/R01000/s009.kp	200	50392	56492	0	True
/03InverseStronglyCorrelated/n00050/R10000/s009.kp	50	117989	132989	0	True
/03InverseStronglyCorrelated/n00050/R01000/s009.kp	50	11811	13311	0	True
/03InverseStronglyCorrelated/n00500/R10000/s009.kp	500	1292641	1444641	180	False
/03InverseStronglyCorrelated/n00500/R01000/s009.kp	500	129332	144532	180	False
/04AlmostStronglyCorrelated/n00200/R10000/s097.kp	200	654568	514576	0	True
/04AlmostStronglyCorrelated/n00200/R01000/s097.kp	200	65504	51501	0	True
/04AlmostStronglyCorrelated/n00050/R10000/s097.kp	50	151198	115092	0	True
/04AlmostStronglyCorrelated/n00050/R01000/s097.kp	50	15134	11519	0	True
/04AlmostStronglyCorrelated/n05000/R10000/s097.kp	5000	15871795	12367138	180	False
/04AlmostStronglyCorrelated/n05000/R01000/s097.kp	5000	1588106	1237716	180	False
/04AlmostStronglyCorrelated/n01000/R10000/s097.kp	1000	3188355	2484141	180	False
/04AlmostStronglyCorrelated/n01000/R01000/s097.kp	1000	319110	248678	180	False
/04AlmostStronglyCorrelated/n02000/R10000/s097.kp	2000	6363284	4963083	0	True
/04AlmostStronglyCorrelated/n02000/R01000/s097.kp	2000	636399	496434	180	False
/04AlmostStronglyCorrelated/n00500/R10000/s097.kp	500	1611108	1260301	180	False
/04AlmostStronglyCorrelated/n00500/R01000/s097.kp	500	161217	126139	180	False
/04AlmostStronglyCorrelated/n00100/R10000/s097.kp	100	319490	249272	0	True
/04AlmostStronglyCorrelated/n00100/R01000/s097.kp	100	31979	24950	0	True
/04AlmostStronglyCorrelated/n10000/R10000/s097.kp	10000	31799634	24775458	180	False
/04AlmostStronglyCorrelated/n10000/R01000/s097.kp	10000	3182496	2480115	11	True
/05SubsetSum/n01000/R01000/s084.kp	1000	254029	254029	0	True
/05SubsetSum/n01000/R10000/s084.kp	1000	2538064	2538064	0	True
/05SubsetSum/n00200/R01000/s084.kp	200	51896	51896	0	True
/05SubsetSum/n00200/R10000/s084.kp	200	518499	518499	0	True
/05SubsetSum/n00100/R01000/s084.kp	100	25500	25500	0	True
/05SubsetSum/n00100/R10000/s084.kp	100	254769	254769	0	True
/05SubsetSum/n10000/R01000/s084.kp	10000	2498215	2498215	0	True
/05SubsetSum/n10000/R10000/s084.kp	10000	24959783	24959783	0	True
/05SubsetSum/n00500/R01000/s084.kp	500	128452	128452	0	True
/05SubsetSum/n00500/R10000/s084.kp	500	1283388	1283388	0	True
/05SubsetSum/n00050/R01000/s084.kp	50	11705	11705	0	True
/05SubsetSum/n00050/R10000/s084.kp	50	116934	116934	0	True
/05SubsetSum/n02000/R01000/s084.kp	2000	495050	495050	0	True
/05SubsetSum/n02000/R10000/s084.kp	2000	4946057	4946057	0	True
/05SubsetSum/n05000/R01000/s084.kp	5000	1254329	1254329	0	True
/05SubsetSum/n05000/R10000/s084.kp	5000	12532088	12532088	0	True
/06UncorrelatedWithSimilarWeights/n01000/R10000/s009.kp	1000	367586	49525849	0	True
/06UncorrelatedWithSimilarWeights/n01000/R01000/s009.kp	1000	367586	49525849	0	True
/06UncorrelatedWithSimilarWeights/n02000/R10000/s009.kp	2000	746070	99047618	180	False
/06UncorrelatedWithSimilarWeights/n02000/R01000/s009.kp	2000	746070	99047618	180	False
/06UncorrelatedWithSimilarWeights/n00100/R10000/s009.kp	100	34671	4902529	0	True
/06UncorrelatedWithSimilarWeights/n00100/R01000/s009.kp	100	34671	4902529	0	True

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test case	Nitems	value	weight	time	optimal
/06UncorrelatedWithSimilarWeights/n10000/R10000/s009.kp	10000	3708622	495246594	180	False
/06UncorrelatedWithSimilarWeights/n10000/R01000/s009.kp	10000	3708622	495246594	180	False
/06UncorrelatedWithSimilarWeights/n05000/R10000/s009.kp	5000	1861639	247623037	180	False
/06UncorrelatedWithSimilarWeights/n05000/R01000/s009.kp	5000	1861639	247623037	180	False
/06UncorrelatedWithSimilarWeights/n00200/R10000/s009.kp	200	72026	9904722	0	True
/06UncorrelatedWithSimilarWeights/n00200/R01000/s009.kp	200	72026	9904722	0	True
/06UncorrelatedWithSimilarWeights/n00050/R10000/s009.kp	50	16781	2401092	0	True
/06UncorrelatedWithSimilarWeights/n00050/R01000/s009.kp	50	16781	2401092	0	True
/06UncorrelatedWithSimilarWeights/n00500/R10000/s009.kp	500	184485	24712110	180	False
/06UncorrelatedWithSimilarWeights/n00500/R01000/s009.kp	500	184485	24712110	180	False
/07SpannerUncorrelated/n00200/R10000/s039.kp	200	141320	135868	180	False
/07SpannerUncorrelated/n00200/R01000/s039.kp	200	14307	13424	180	False
/07SpannerUncorrelated/n00050/R10000/s039.kp	50	36080	35094	180	False
/07SpannerUncorrelated/n00050/R01000/s039.kp	50	3662	3492	1	True
/07SpannerUncorrelated/n10000/R10000/s039.kp	10000	7628020	7325730	180	False
/07SpannerUncorrelated/n10000/R01000/s039.kp	10000	773057	724280	180	False
/07SpannerUncorrelated/n05000/R10000/s039.kp	5000	3779510	3632933	180	False
/07SpannerUncorrelated/n05000/R01000/s039.kp	5000	382981	359254	180	False
/07SpannerUncorrelated/n01000/R10000/s039.kp	1000	724750	692591	180	False
/07SpannerUncorrelated/n01000/R01000/s039.kp	1000	73503	68389	180	False
/07SpannerUncorrelated/n00500/R10000/s039.kp	500	373290	358457	180	False
/07SpannerUncorrelated/n00500/R01000/s039.kp	500	37832	35447	180	False
/07SpannerUncorrelated/n00100/R10000/s039.kp	100	67980	65042	180	False
/07SpannerUncorrelated/n00100/R01000/s039.kp	100	6868	6398	180	False
/07SpannerUncorrelated/n02000/R10000/s039.kp	2000	1502400	1443556	180	False
/07SpannerUncorrelated/n02000/R01000/s039.kp	2000	152251	142745	180	False
/08SpannerWeaklyCorrelated/n00200/R10000/s053.kp	200	593307	372949	180	False
/08SpannerWeaklyCorrelated/n00200/R01000/s053.kp	200	59370	37322	180	False
/08SpannerWeaklyCorrelated/n02000/R10000/s053.kp	2000	5996133	3769131	180	False
/08SpannerWeaklyCorrelated/n02000/R01000/s053.kp	2000	600237	376893	180	False
/08SpannerWeaklyCorrelated/n00500/R10000/s053.kp	500	1491633	937631	180	False
/08SpannerWeaklyCorrelated/n00500/R01000/s053.kp	500	149382	93798	180	False
/08SpannerWeaklyCorrelated/n05000/R10000/s053.kp	5000	14906034	9369838	180	False
/08SpannerWeaklyCorrelated/n05000/R01000/s053.kp	5000	1492272	937008	180	False
/08SpannerWeaklyCorrelated/n00100/R10000/s053.kp	100	291001	183147	180	False
/08SpannerWeaklyCorrelated/n00100/R01000/s053.kp	100	29154	18306	180	False
/08SpannerWeaklyCorrelated/n10000/R10000/s053.kp	10000	29934333	18816531	180	False
/08SpannerWeaklyCorrelated/n10000/R01000/s053.kp	10000	2996799	1881711	180	False
/08SpannerWeaklyCorrelated/n01000/R10000/s053.kp	1000	3021876	1899532	180	False
/08SpannerWeaklyCorrelated/n01000/R01000/s053.kp	1000	302535	190007	180	False
/08SpannerWeaklyCorrelated/n00050/R10000/s053.kp	50	137709	86563	0	True
/08SpannerWeaklyCorrelated/n00050/R01000/s053.kp	50	13746	8642	0	True
/09SpannerStronglyCorrelated/n00200/R10000/s039.kp	200	755330	136330	184	False
/09SpannerStronglyCorrelated/n00200/R01000/s039.kp	200	75533	13633	180	False
/09SpannerStronglyCorrelated/n00050/R10000/s039.kp	50	179590	34590	3	True
/09SpannerStronglyCorrelated/n00050/R01000/s039.kp	50	17959	3459	3	True
/09SpannerStronglyCorrelated/n10000/R10000/s039.kp	10000	41214640	7382640	180	False
/09SpannerStronglyCorrelated/n10000/R01000/s039.kp	10000	4121464	738264	180	False
/09SpannerStronglyCorrelated/n05000/R10000/s039.kp	5000	20345300	3659300	180	False
/09SpannerStronglyCorrelated/n05000/R01000/s039.kp	5000	2034530	365930	180	False
/09SpannerStronglyCorrelated/n01000/R10000/s039.kp	1000	3994880	698880	180	False
/09SpannerStronglyCorrelated/n01000/R01000/s039.kp	1000	399488	69888	180	False

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test case	Nitems	value	weight	time	optimal
/09SpannerStronglyCorrelated/n00500/R10000/s039.kp	500	2016720	360720	180	False
/09SpannerStronglyCorrelated/n00500/R01000/s039.kp	500	201672	36072	180	False
/09SpannerStronglyCorrelated/n00100/R10000/s039.kp	100	372530	65530	180	False
/09SpannerStronglyCorrelated/n00100/R01000/s039.kp	100	37253	6553	180	False
/09SpannerStronglyCorrelated/n02000/R10000/s039.kp	2000	8102480	1454480	180	False
/09SpannerStronglyCorrelated/n02000/R01000/s039.kp	2000	810248	145448	180	False
/10MultipleStronglyCorrelated/n10000/R01000/s095.kp	10000	4032348	2483748	180	False
/10MultipleStronglyCorrelated/n10000/R10000/s095.kp	10000	40288426	24814426	180	False
/10MultipleStronglyCorrelated/n00500/R01000/s095.kp	500	202090	123090	180	False
/10MultipleStronglyCorrelated/n00500/R10000/s095.kp	500	2000825	1229825	0	True
/10MultipleStronglyCorrelated/n05000/R01000/s095.kp	5000	2005003	1231503	180	False
/10MultipleStronglyCorrelated/n05000/R10000/s095.kp	5000	20066897	12303897	180	False
/10MultipleStronglyCorrelated/n00100/R01000/s095.kp	100	40138	25038	0	True
/10MultipleStronglyCorrelated/n00100/R10000/s095.kp	100	402182	250182	2	True
/10MultipleStronglyCorrelated/n02000/R01000/s095.kp	2000	804622	495822	180	False
/10MultipleStronglyCorrelated/n02000/R10000/s095.kp	2000	8043326	4953326	180	False
/10MultipleStronglyCorrelated/n00200/R01000/s095.kp	200	79502	47802	0	True
/10MultipleStronglyCorrelated/n00200/R10000/s095.kp	200	784648	477648	180	False
/10MultipleStronglyCorrelated/n00050/R01000/s095.kp	50	19242	11442	0	True
/10MultipleStronglyCorrelated/n00050/R10000/s095.kp	50	194328	114328	0	True
/10MultipleStronglyCorrelated/n01000/R01000/s095.kp	1000	400426	244026	180	False
/10MultipleStronglyCorrelated/n01000/R10000/s095.kp	1000	3988028	2438028	180	False
/11ProfitCeiling/n10000/R01000/s095.kp	10000	2482824	2483750	180	False
/11ProfitCeiling/n10000/R10000/s095.kp	10000	24814254	24815167	180	False
/11ProfitCeiling/n00500/R01000/s095.kp	500	123063	123094	180	False
/11ProfitCeiling/n00500/R10000/s095.kp	500	1229793	1229831	180	False
/11ProfitCeiling/n05000/R01000/s095.kp	5000	1231149	1231624	180	False
/11ProfitCeiling/n05000/R10000/s095.kp	5000	12304590	12305048	180	False
/11ProfitCeiling/n00100/R01000/s095.kp	100	25029	25040	0	True
/11ProfitCeiling/n00100/R10000/s095.kp	100	250182	250187	0	True
/11ProfitCeiling/n02000/R01000/s095.kp	2000	495624	495824	180	False
/11ProfitCeiling/n02000/R10000/s095.kp	2000	4953603	4953787	180	False
/11ProfitCeiling/n00200/R01000/s095.kp	200	47793	47807	0	True
/11ProfitCeiling/n00200/R10000/s095.kp	200	477633	477649	122	True
/11ProfitCeiling/n00050/R01000/s095.kp	50	11439	11444	0	True
/11ProfitCeiling/n00050/R10000/s095.kp	50	114336	114336	11	True
/11ProfitCeiling/n01000/R01000/s095.kp	1000	243945	244026	180	False
/11ProfitCeiling/n01000/R10000/s095.kp	1000	2437947	2438032	180	False
/12Circle/n10000/R01000/s095.kp	10000	52334995	2483752	180	False
/12Circle/n10000/R10000/s095.kp	10000	1654260902	24815168	180	False
/12Circle/n00500/R01000/s095.kp	500	2593724	123095	180	False
/12Circle/n00500/R10000/s095.kp	500	81984649	1229832	180	False
/12Circle/n05000/R01000/s095.kp	5000	25951469	1231624	180	False
/12Circle/n05000/R10000/s095.kp	5000	820295200	12305050	180	False
/12Circle/n00100/R01000/s095.kp	100	527616	25040	0	True
/12Circle/n00100/R10000/s095.kp	100	16678289	250187	0	True
/12Circle/n02000/R01000/s095.kp	2000	10447467	495824	180	False
/12Circle/n02000/R10000/s095.kp	2000	330235769	4953787	180	False
/12Circle/n00200/R01000/s095.kp	200	1007338	47807	180	False
/12Circle/n00200/R10000/s095.kp	200	31841721	477650	180	False
/12Circle/n00050/R01000/s095.kp	50	241156	11445	1	True
/12Circle/n00050/R10000/s095.kp	50	7622148	114338	0	True

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test case	Nitems	value	weight	time	optimal
/12Circle/n01000/R01000/s095.kp	1000	5141874	244027	180	False
/12Circle/n01000/R10000/s095.kp	1000	162527317	2438033	179	True

2.1 Evaluate Test Group Difficulty

Table 2: Evaluate Test Group Difficulty

test group	total time	rate optimal
00	0	1.000000
01	0	1.000000
02	1849	0.375000
03	1800	0.375000
04	1451	0.500000
05	0	1.000000
06	1440	0.500000
07	2701	0.062500
08	2520	0.125000
09	2530	0.125000
10	1802	0.375000
11	1933	0.375000
12	2160	0.312500

To evaluate the difficulty of test group, there are many different way, but in this context we assume a test group is ease if the solver can easily find an optimal solution in half of test cases in that group.

Thus, **group 00, 01 04, 05, and 06 are easy and the rest is difficult**. Special, group 07, 08, and 09 are very difficult.

3 Conclusion

In practical terms, we should use solver tools to solve optimization problems.

In general, using multiple computers is an effective way to operate experiments, and using programming language to automatically generate reports is intelligent.

4 References

- All about source code, experiment process documentation, and YouTube demo (if there) in this GitHub link: [github](#) to visit our website.
 - homepage to visit the home page' s guidelines.
 - repository to visit the repository of the test case set.
- Author: Quan Hoang Ngoc. Thank you for your reading.