Generality Case Study Data

Data Vectors

The Generality Case Study Data Vectors.xls file contains information on task properties: durations of tasks for each product model and precedence relations between tasks. For example, the first data vector reads:

Task	M1	M2	M3	M4	M5
1	264	505	84	25	147
2	581	81	184	312	89
3	97	30	465	238	475
4	114	52	262	382	234
5	239	421	361	171	289
6	199	446	62	471	524
7	73	184	173	235	343
8	333	60	477	192	71
9	88	200	298	82	499
10	227	502	44	129	74
11	492	60	248	136	490
12	430	458	31	177	117
13	160	146	176	115	383
14	70	282	313	68	197
15	443	319	84	430	179
16	477	81	326	500	510
17	249	205	341	286	175
18	324	71	168	199	297
19	160	82	168	271	125
20	136	206	423	142	102

All five models are assumed to have equal demand rates. The data above refers to the duration of each of the 20 tasks for each of the product models. This is followed by the precedence relations.

Task1	Task2
1	8
2	9
3	11
4	10
6	12
8	15
9	13
10	14
11	15
12	16
13	17
14	17
15	18
17	19
17	20

This data states, for instance, that the task 1 must be performed in a station prior to task 8. Similarly, task 2 must precede task 9.

B-MALP Instance Generation and Cyclical Product Sequences

All mixed-model assembly line balancing problem (MALBP) instances were generated with **seven** workstations. Three buffer layouts were considered, as illustrated bellow:

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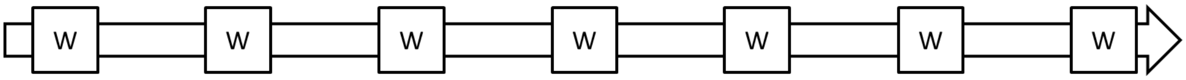
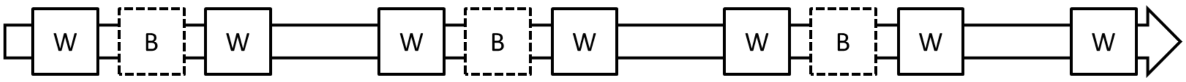
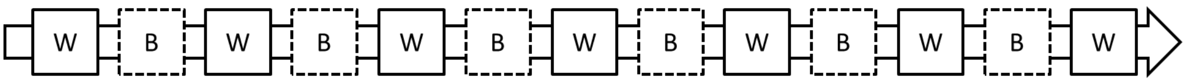


No Buffers between workstations – “Empty Layout”



Buffers after every odd workstation – “Half Layout”



Buffers between every workstation pair – “Full Layout”

This means that out of the 175 MALBP task property vectors, 525 Buffered MALBP (B-MALBP) instances can be generated. Given the demand rates (which are assumed to be equal for all models), these instances can be solved with any scheduling-unaware formulation. Both the Station Smoothing (SX) measure and the Vertical Balancing (VX) one were employed.

In order to use scheduling aware formulations (such as Makespan minimization and the proposed one) it is necessary to define a cyclical product sequence. Given that there are five product models with equal demand, the minimal part set is one unit of each product (**1**$\mathbf{M_1}$, **1**$\mathbf{M_2}$, **1**$\mathbf{M_3}$, **1**$\mathbf{M_4}$, **1**$\mathbf{M_5}$). Given that the product sequence is cyclical, any specific piece can be arbitrarily set as the first: the sequence (M_1,M_4,M_3,M_2,M_5) is equivalent to (M_4,M_3,M_2,M_5,M_1) in the steady-state. Following that reasoning, the first product in the sequence is arbitrarily picked as the first one, allowing 24 different cyclical sequences:

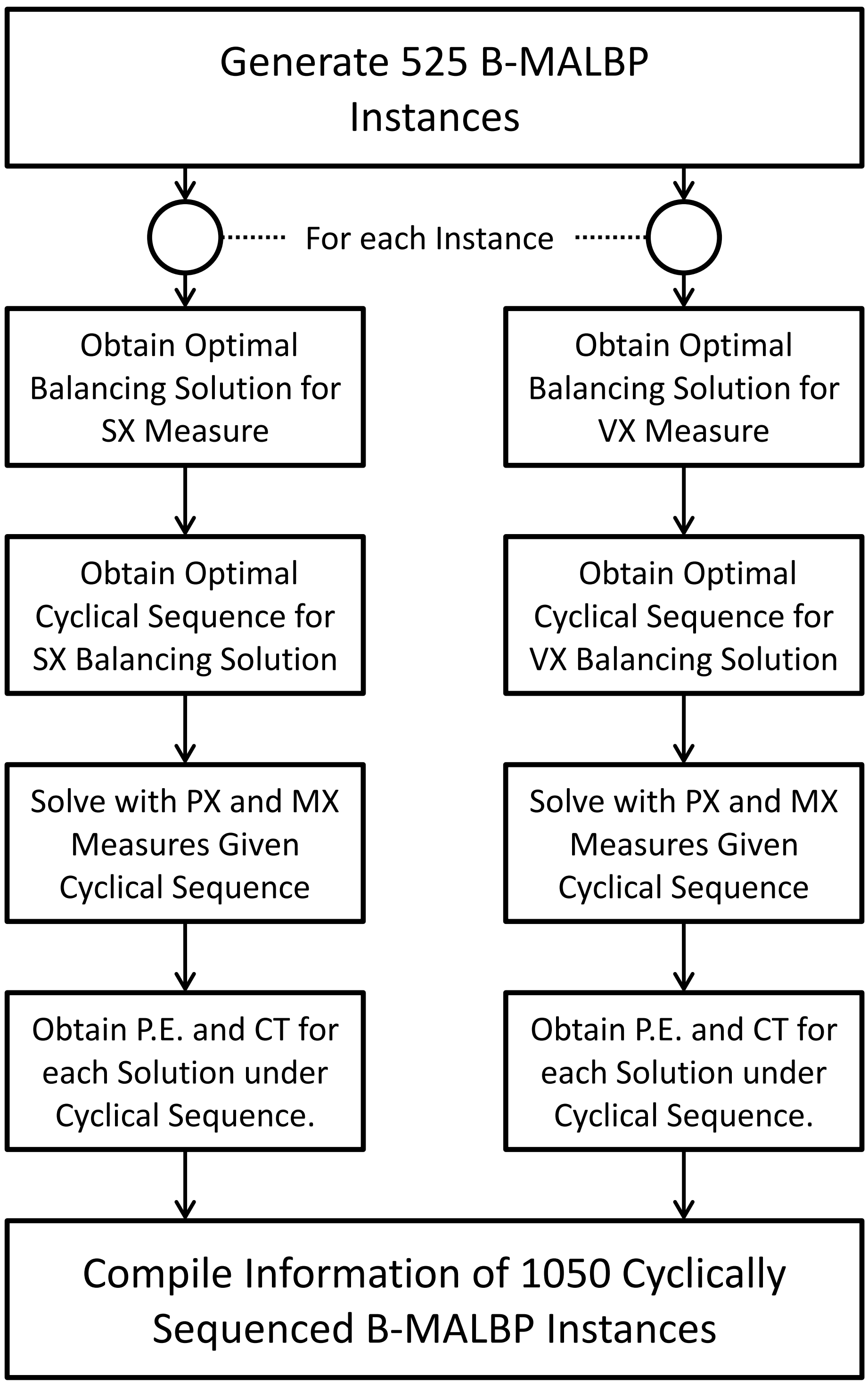
(M_1,M_2,M_3,M_4,M_5), (M_1,M_2,M_3,M_5,M_4), … , (M_1,M_5,M_4,M_2,M_3), and (M_1,M_5,M_4,M_3,M_2).

Once one of the sequences is chosen, the scheduling-aware formulations can be used to generate solutions whose cycle times can be compared to other formulations. Notice that, given a balancing solution, it is possible to define the optimal product sequence by running 24 deterministic simulations. Steady-state is expected to be reached with a few replications of the minimal part set and (given that the problem is deterministic) no complex statistical analysis is necessary.

The next section of this supporting information guide describes how the 525 B-MALBP instances were converted into 1050 B-MALBP instances with given cyclical sequences.

Generating Cyclical Sequences and Formulation Comparisons

The flow-chart presents the procedure designed to generate the 1050 instance comparisons. The very first step was to generate the 525 B-MALBP data vectors as described in the previous section.



For each of the 525 instances, two parallel and analogous sets of procedures are followed:

1. Each instance is solved with one scheduling-unaware formulation (SX and VX).
2. The balancing solution of this formulation is used to define an optimal cyclical sequence: out of 24 possible alternatives, the one with lowest realized cycle time is chosen.
3. The cyclical sequence is then used to solve the scheduling aware formulations: the proposed one (PX) and the Makespan minimization one (MX).
4. The realized average steady-state cycle time (CT) and the probabilistic measure mentioned in the paper (P.E.) are computed for each balancing solution.
5. This leads to a total 1050 comparisons between formulations:
    a. 525 Cases with the optimal sequence for SX, compared to PX and MX.
    b. 525 Cases with the optimal sequence for VX, compared to PX and MX.

The Generality Case Study Output.xls file presents the values of optimal answers to all instances. For example, the first MALBP data vector generates three B-MALBP instances (Buffer layouts), with six total comparison cases (one for SX and on for VX for each case).

Case	Task Properties	Buffer Layout	Sequence Unaware Goal (Bal 1)	Optimal Bal 1 Value	P.E. Bal 1	Global LB-CT	CT of Bal1 with Best Possible Cyclical Sequence for Bal 1 (Seq 1)	CT_{PX} Given Seq 1	P.E. CT_{PX}	Optimal MX Value Given Seq 1	CT of MX under Seq 1	P.E. MX
1	1	Empty	SX	2778	871	704	806	783	901	11689	799	917
2	1	Empty	VX	107	994	704	854	782	964	12016	829	928
3	1	Half	SX	2778	871	704	772	740	949	11482	772	917
4	1	Half	VX	107	994	704	820	734	985	11434	746	947
5	1	Full	SX	2778	871	704	772	704	1,000	11428	722	965
6	1	Full	VX	107	994	704	704	704	1,000	11428	722	965

Lastly, each MALBP data vector generates a value of LB-CT, the scheduling-independent lower bound on steady-state cycle time discussed in the paper. This can be computed independently and was added to the table to ease comparisons.

As mentioned in the paper, the CT value for the proposed formulation PX matched exactly with the proposed goal function. Therefore the table states only one value of CT_{PX}, which represent both the proposed formulation's goal function and the realized steady-state cycle time for the solution generated by that formulation.