A Suboptimal Heuristic Algorithm for Solving the Assembly Line Worker Assignment and Balancing Problem ALWABP

Lamia A. Shihata

Abstract— **The assembly line worker assignment and balancing problem (ALWABP) is an extension of the SALBP in which task execution times are worker-dependent. Beside the fact that all types of balancing problems fall into the NP-hard class of combinatorial optimization problems; there is an additional complexity of respecting workers' incompatibilities when assigning tasks to these workers at stations. The aim of this paper is to introduce a heuristic algorithm that can help assembly line managers to cope with this additional complexity and maintain high productivity levels by minimizing the number of workstations needed to reach a given output while managing a set of heterogeneous workers that can be assigned to tasks at stations such that the total cost is minimized. The proposed heuristic algorithm is capable to acquire near optimal solutions in a very short computational time when applied to ALWABP instances. A real life industrial case study was implemented to test the applicability and validity of the proposed heuristic algorithm.**

Index Terms— **Assembly line worker assignment and balancing problem, heterogeneous workers, heuristic algorithms.**

I. INTRODUCTION

Assembly line balancing research had traditionally focused on the Simple Assembly Line Balancing Problem SALBP which had some restricting assumptions. Traditional approaches to the optimization of assembly lines assume that workers have similar abilities and are capable of executing the tasks in the same time. When the cycle time is given, and the objective is to optimize the number of necessary workstations, the problem is called SALBP-1. Whereas, when there is a given number of workstations and the goal is to minimize the cycle time, the problem is called SALBP-2.

Recently, a lot of research work had been performed in order to describe and solve more realistic generalized problems. A trend in assembly line research has been to narrow the gap between the theoretical proposals and the industrial reality. One of these realities that have high relevance in practice is the heterogeneous nature of workers that can be assigned to tasks at stations. The assembly Line Worker Assignment and Balancing Problem ALWABP appears in real assembly lines where tasks are assigned to workers considering that the operation time for every task is different depending on who executes the task; and where there are some task- worker incompatibilities.

Lamia A. Shihata, Design and Production Engineering Department, Ain Shams University/ Faculty of Engineering, Cairo, Egypt, +20226782044/ +201227363598.

Miralles et al [1] defined ALWABP as an extension of the SALBP, but in addition of the assignment of tasks to stations, each task has a worker dependent processing time. By analogy with SALBP, when it is required to minimize the number of workstations, the problem is called ALWABP-1, while when the objective is to minimize the cycle time given a set of workstations, the problem is called ALWABP-2. As first introduced by Guthar and Nemhauser (1964); SALBP is known to be NP hard. SALBP is considered to be a special case of ALWABP where every task has a predetermined time. Consequently ALWABP is NP hard where exact solutions fail to solve in a reasonable time (limited number of tasks). Heuristics and meta-heuristic approaches were applied in order to achieve good results in a reasonable computational time.

Miralles et al.(2008) presented and mathematically modeled ALWABP including most of the desirable circumstances. The problem consists of providing a simultaneous solution to a double assignment: tasks to stations; and available workers to stations. After defining the mathematical model for this problem, a basic Branch and Bound approach with three possible search strategies and different parameters was presented. They also proposed the use of a branch and bound based heuristic for large problems and analyzed the behavior of both exact and heuristic methods through experimental studies. Tamás Koltai / Viola Tatay (2011) revealed how basic assembly line balancing models can be completed with simple workforce skill constraints; however they didn't consider different levels of skill for high, low, and exclusive skill situations.

Christian Blum, Cristobal Miralles (2014), presented an iterative algorithm based on beam search for the assembly line worker assignment and balancing problem with the objective of minimizing the cycle time (ALWABP-2). Starting from a lower bound for the optimal cycle time, the proposed algorithm first aims to identify an initial cycle time for which it can solve the corresponding problem. This is done in a first algorithm phase. In a second phase, the proposed algorithm step-by-step reduces the considered cycle time until the problem cannot be solved for the considered cycle time. Both algorithm phases make use of beam search. Their work was mainly dedicated to facilitating the integration of disabled workers into the labor market. Mariona Vilà , Jordi Pereira (2014) presents an exact enumeration algorithm for solving the assembly line worker assignment and the line balancing problem. The algorithm uses a station-oriented branching method under the relatively new branch, bound and remember scheme. The resulting procedure is capable of optimally solving type-2 instances from the reference set with up to 75 tasks. The problem of sequencing mixed model assembly lines operating in which stations are highly heterogeneous is attempted by Cortez and Costa (2015) and a mathematical mixed integer model and heuristic procedures are proposed.

This research deals with the hierarchical worker assignment problem which was first introduced in the literature by Emmons and Burns (1991). Subsequently, hierarchical worker assignment problems were studied. Narasimhan (1997) presented an exact algorithm for finding the optimal solution of single-shift hierarchical workforce scheduling problem in seven-day-a-week industries. Nicholas Beaumont (1997) described the solution of a problem of scheduling a workforce so as to meet demand which varies markedly with the time of day and moderately with the day of week. Billionnet [3] practiced integer programming to solve the problem of a hierarchical workforce in which a higher qualified worker can substitute for a lower qualified one, but not vice versa. Hopp et al. (2004) presented a study in which workers' speed can vary and this speed is benchmarked by defining a speed factor for each worker relative to a standard worker. Corominas et al.(2008) presented a linear programing model to minimize the number of temporary workers required, given a cycle time and the team of workers on staff. Again, Corominas et al. proposed a bi-criteria integer programming model, in which the first criteria is the labor cost and the second one is the suitability of task assignment to individual workers. Yasmine et al. (2014), claimed to introduce for the first time a formal definition and mathematical model for assembly line balancing with hierarchical worker assignment.

This paper contributes to the existing literature by modeling and solving the assembly line worker assignment and balancing problem (ALWABP) with high relevance in practice; which up to the execution of this work and to the best of our knowledge; still caused a void in the related literature. This is the first time this problem has been tackled using a heuristic approach which is capable of finding a near to optimum solution on an assembly line with a large number of stations and in the same time considers the hierarchical workforce and the cost of the heterogeneous workers. The introduced heuristic is easily applicable in numerous industries especially those that incorporate extreme levels of worker skill. Within the mentioned framework, the paper is organized as follows: in section 2, the problem definition and mathematical model are presented; section 3 introduces the main steps of the proposed heuristic algorithm; in section 4 the computational results are presented and discussed to illustrate the algorithm in addition to the case study on which the proposed algorithm was applied. Finally, concluding remarks are presented in section 5.

II. Problem Definition and Mathematical Model

In this section, a proposed heuristic algorithm for solving ALWABP-1 is presented. The algorithm aims at assigning a number of tasks to a number of heterogeneous workers; different levels of skills; considering that the operation time for each task is different depending on the cost of each worker and his ability to do it. The main objective is to achieve minimum number of work stations with minimum number of workers such that the total cost is minimized while the precedence constraints are respected. In the proposed approach the workers are hierarchically classified into h types according to their skill.Type-1 represents the most qualified tasks/workers. In the hierarchical workforce structure, task i can be performed only by type-h workers. The task time increases as the qualification levels of the worker decreases, while the workers' cost is directly proportional to their qualification level.

III. Assumptions of ALWABP

The assumptions of ALWABP differ from SALBP assumptions which are not valid in this case.

1) Task processing times and precedence relationships are known deterministically.
2) A single product is assembled on the line.
3) Since the workers have different abilities and capabilities, the task processing time differs depending on which type of the workers executes the task. Worker with the minimum processing time is considered as the most qualified worker with rating 100% and will be known in this paper as Type 1 worker.
4) There are not generally slow or speedy workers. Instead, workers can be very slow, or even incapable when executing some tasks, but may be very efficient when executing some others.
5) Every worker is assigned to only one workstation.
6) Each task is assigned to only one workstation, provided that the worker selected for that station is capable of performing the task, and that the precedence relations are satisfied.

A. Notation

i, j	Tasks ($i, j \in T$)
T	Set of tasks
S	Set of stations
W	Set of workers with different types $\|W\| \leq \|S\|$
ns	Number of stations
nt	Number of tasks to be assigned
nw	Number of workers
swt	Set of worker types
h	Worker types ($type_1$ $type_2$ ... ... $type_h$); $h \in swt$
TC	Total Cost
t_i	Task processing time of task i then assigned to a qualified worker Type 1
t_{iw}	Task processing time of task i when assigned to other types of workers w in condition that they are compatible to do the task
$Candt_s \subseteq T$	Set of all candidate tasks to be assigned to station s ; $s \in S$
$UT_w \subseteq Candt_s$	Set of compatible tasks to worker w
C	Cycle time

A. Main Steps of the Algorithm

The main steps of the proposed heuristic algorithm are described as follows

1) The algorithm starts by neglecting the heterogeneity of the types of workers and relaxing the task processing times to their minimum

$$t_i = \min\{ t_{iw} \mid w \in W\};\ \ i = 1, \dots nt \qquad (1)$$

By this way, the problem is reduced to SALBP-1. This step permit for further use of calculating the bounds on the earliest and latest possible station of task i for a given cycle time C.

2) Determine the earliest work station ES and latest work stations LS for each task i at the pre-determined cycle time.

$$ES_i = ns - \left\lceil \frac{t_i + \sum_{j=i+1}^{nt} (p_{ij} * t_j)}{c} \right\rceil \qquad (2)$$

$$LS_i = \left\lceil \frac{t_i + \sum_{i=1}^{j-1} (p_{ij} * t_j)}{c} \right\rceil,\ 1 \le i \le nt ; j > 1 \qquad (3)$$

Where

$\lceil x \rceil$ denotes the larger integer greater than or equal to x

$$p_{ij} = \begin{cases} 1 \text{ if task i precede task j} \\ 0 \ \text{ if task i and j are not related} \end{cases}$$

3) Determine the set of all candidate tasks; $Candt_s$; to be assigned to station s after determining the fixed tasks at each station s, where $ES_i = LS_i$
4) Determine the remaining time for each workstation
5) Determine the remaining time on each workstation after assigning the fixed tasks.
6) For each station , start assigning possible candidate tasks UT_w to the worker's type swt
7) Start assigning a worker to the 1st workstation by applying the following algorithm:
8) From the set of workers W choose a worker h where $h \in swt$ that could be assigned to this station.
9) For each worker, refine the candidate compatible task which can be performed according to the following heuristic:
   - Exclude the non-compatible tasks and tasks that have non-compatible predecessors with this task.
   - Start with tasks in UT_w and give the priority to the tasks that can be performed exclusively by this worker.
   - Set the tasks in a descending order according to the sum of its time and the times of all its predecessor tasks. This ensures the precedence constraints.
   - Chose the task with the maximum total time.
   - Make necessary modifications to update another appropriate candidate tasks to be assigned.
10) Repeat steps 7 to 9 for other types of workers.
11) Choose the worker with the minimum idle time, if the idle times are equal for two workers; choose the one with minimum cost.
12) Update the remaining candidate tasks for the following workstations
13) Continue to the next station repeating steps 3 to 12

B. Computational Results

For the verification and validation of the algorithm, the heuristic algorithm has been applied on a modified SALP-1 instance proposed by Otto et al. with 11 and 148 tasks in addition to a case study in one of the assembly lines in an Egyptian industry. The proposed approach has been illustrated on the well-known example of Jackson with n = 11 tasks and cycle time = 10. The modified precedence graph for the Jackson example was used as modified by Sungur B, Yavuz Y [11]. The solution given in Table 1 was obtained; and generated a total cost of 438, and an idle time of 2 which is considerably less than the solution generated when applying the SALB-1 procedure where all workers are assumed to be homogeneous with respect to task time and cost (total cost was 500 and the idle time was 3).

For further proof of the applicability and efficiency of the proposed algorithm in solving large assembly lines, the 148 tasks problem adopted from Otto et al. was also solved and the results are given in table 2.

Table I Solution for Jackson's problem

Station	worker type	idle time	tasks
1	3	0	1
2	1	0	5,4,2
3	2	0	7,3
4	2	1	9,6
5	3	0	8
6	1	1	10,11

When the candidates' tasks at each workstation increase, the problem is more complicated. The proposed heuristic algorithm enables solving/ assigning 148 tasks to workstations in short time; nearly 30seconds. All computations were performed on an Intel (R) Core (TM) 2 duo, 2 GHZ, 2GB memory ram computer.

Table II Solution for 148 tasks problem

ct^1 = 2562 nt^2 = 148 ns^3 = 2

Final Results
st^4 w^5 idle tasks
==================
Columns 1 through 20

1 1 0 126 1 2 3 4 5 6 7 8 9 10 14 15
16 17 18 19
2 1 0 11 12 13 30 42 43 44 48 51 52 53 54
57 60 61 62 63
Columns 21 through 40
20 21 22 23 24 25 26 27 28 29 31 32 33 34
35 36 37 38 39 40
65 66 67 68 69 70 71 72 76 77 78 79 80 81
82 83 84 85 86 89
Columns 41 through 60
45 46 47 55 56 59 73 74 75 88 111 112 113 116
117 118 120 121 122 144
90 93 95 97 98 99 100 101 102 103 104 105 106
107 108 109 110 115 119 123
Columns 61 through 80
141 91 58 87 41 49 94 132 92 50 64 96 114 0
0 0 0 0 0 0
124 125 127 128 129 130 131 133 134 135 136 137 138
139 140 142 143 145 146 147
Column 81
0
148

Where:
[1]ct: cycle time [2]nt: number of tasks [3]ns: number of stations
[4]st: station number [5]w: worker's type

IV. CASE STUDY

In order to validate the algorithm and demonstrate the result of considering heterogeneous workers in addition to their costs, a simple assembly line with 91 tasks is considered. The assembly line is available in a home appliances industry in Egypt.

The company in which the case study is performed will be referred to by (I) for confidentiality. Company (I) is a member of a group of industrial facilities; which is one of the largest public sector manufacturing companies in Egypt. Company (I) enhanced a leadership position in white goods especially refrigerators. The company is eager to provide the utmost degree of care and attention to its customers as to become the most prevalent and credible brand in the market. The company is one of the leading adopters of the different quality improvement techniques and is looking forward to enhance its performance through the application of assembly line balancing to fulfill its goals. One of the main problems in the technological area of the company is the excessive number of stations and workers on the final assembly line. These problems contribute to less productivity, less profit and unutilized areas which lead to poor synchronization between workplaces. The assembly line under study includes n=91 tasks. A precedence analysis of the line is conducted and task times for all 91 tasks were recorded. The Assembly Line Balancing Problem for refrigerators' assembly is not a simple process. It encounters a huge number of tasks; 92 tasks performed on 78 stations and one worker is assigned to each station, to complete one product. Each task is performed by a worker and all workers were of the same skill, although there were simple tasks that required workers of low and moderate skills and other technical tasks that necessitate highly trained workers.

A. Application of the Proposed Algorithm

The ALBHW problem has been illustrated on the gathered data presented in the appendix. The tasks are categorized into three types similarly was the workers. Workers were categorized according to their skill. The type-1 tasks can be performed only by type-1 workers (highly skilled). The type-2 tasks can be performed by type-1(highly skilled) and type-2 workers (medium skilled), while the remaining type-3 tasks can be performed by all types of workers. The task times, task type and workers' type are all given in table 1 in the appendix. The cost of workers per day are c1= L.E100, c2= L.E70 and c3= L.E.50 respectively. The optimal solution generated by the proposed heuristic has been applied, where the number stations decreased from 72 to 54 and the total cost is $C = L.E.3980$ compared to a total cost of L.E. 5400 when the problem was solved with homogeneous workers.
The detailed computational results for this problem are presented in the appendix.

V. CONCLUSION

The hierarchical workforce assignment case exists in several practical applications, however, it has not been considered in the assembly line balancing literature as a heuristic approach. This paper contributes to the literature by introducing, an assembly line balancing problem with hierarchical worker assignment solved by a heuristic algorithm for the first time. Two approaches for computation have been applied to verify and validate the algorithm.

The model proposed in this research was applied on an assembly line in one of the largest appliance manufacturing companies in Egypt. A case study was chosen to validate this model as the studied ALBHW problem is unique from one industry to another. Neither can the type of workers, their skills, their capabilities nor their cost be generalized. There isn't a realistic benchmarking problem that can be used. The previous few articles that dealt with a similar problem relied on hypothetical data specially tailored to attempt the suggested models. The time consumed to solve the ALBHW problem using the proposed algorithm is considerably shorter than other exact approaches used previously. One of these approaches used to take 7200 seconds to solve the problems, our approach takes a single unit seconds to solve the problem on a regular PC.

The case study pointed out that the advantage behind using the proposed approach is that the total cost is highly affected by the worker type. The influence of the hierarchical workforce assignment problems is more effective when the number of stations increase.

This analysis leads us to conclude that it is very important to analyze the real nature of the assembly line problem and analyze the most appropriate model that can be used to solve the problem. The literature presented exact methods, and here is the first attempt, as far as we know, to the heuristic methods.

ACKNOWLEDGMENT

The author is very much thankful for the continuous support and valuable guidance of Prof. Dr. Nahid H. Afia, Faculty of Engineering, Ain Shans University

REFERENCES

[1]Miralles C, Garcia-SabaterJP, AndresC, CardosM. (2007)"Advantages of assembly lines in Sheltered Work Centres for Disabled: a case study". Int J ProdE con; 110:187–97.]

[2]Cristobal Miralles, Jose P. Garcia-Sabater, Carlos Andres, Manuel Cardos (2008) "Branch and bound procedures for solving the Assembly Line Worker Assignment and Balancing Problem: Application to Sheltered Work centres for Disabled". Discrete Applied Mathematics Vol.156, pp.352–367 from www.elsevier.com/locate/dam.

[3]Tamás Koltai, Viola Tatay (2011) "Formulation of simple workforce skill constraints in assembly line balancing models", Period. Polytech. Soc. Man. Sci., Vol. 19, No. 1 (2011), pp. 43-50.

[4]Christian Blum, Cristobal Miralles, (2011) ,"On solving the assembly line worker assignment and balancing problem via beam search Computers & Operations Research Volume 38, Issue 1, January 2011, Pages 328–339

[5]Mariona Vilà , Jordi Pereira ,(2014), "A branch-and-bound algorithm for assembly line worker assignment and balancing problems, Computers & Operations Research 44 (2014) 105–114"

[6]Pâmela M.C. Cortez & Alysson M. Costa, (2015), "Sequencing mixed-model assembly lines operating with a heterogeneous workforce", International Journal of Production Research Volume 53, Issue 11, pages 3419-3432

[7]Emmons H, Burns RN, (1991), "Off-day scheduling with hierarchical worker categories".Oper Res 1991; 39:484–95.Rangarajan Narasimhan, (1997), " An algorithm for single shift scheduling of hierarchical workforce", European Journal of Operational Research Volume 96, Issue 1, 10 January 1997, Pages 113–121

[8]Billionnet A. Integer programming to schedule a hierarchical workforce with variable demands. Eur. J. Oper. Res. 1999; 114:105–14.

[9]Hopp WJ, Tekin E, Van Oyen MP. Benefits of skill chaining in serial production lines with cross-trained workers. Management Science 2004; 50; 83-98

[10] Albert Corominas, Rafael Pastor, Joan Plans, Balancing assembly line with skilled and unskilled workers, Omega 36 (2008) 1126 – 1132

Sungur B, Yavuz Y. Assembly line balancing with hierarchical worker assignment. J Manuf Syst (2014)

Lamia A. Shihata, Ph.D is an Assistant Professor at the "Design and Production Engineering" Department, Ain Shams University, Cairo, Egypt. The main research interests lie in the field of Design of Experiments, Statistical Process Control, Production Planning and Control, Product Development and Continuous Improvement. Lamia A. Shihata has several national and international publications in the above mentioned fields.

Appendix

TableA.I Tasks, predecessors and cycle times

	Activity	predecessor	Time (sec)	side (F-B-E)
1	Feed the line with injected refrigerators	-	13	Face
2	Clean plastic cabinet	1	19	Face
3	Fit freezer fan	2	25	Face
4	Fixing freezer fan by (2 screws)	3	26	Face
5	Fit freezer thermostat harness	2	15	Face
6	Fix freezer thermostat harness (by 2 screws)	5	20	Face
7	Fitting freezer back (Foam)	4,6	15	Face
8	Fitting freezer back (plastic)	7	15	Face
9	Fitting damper	2	6	Face
10	Fix damper (by screws)	9	12	Face
11	fit air duct	2	7	Face
12	Fixing air duct	11	9	Face
13	Fix meat drawer rollers	8	16	Face
14	Bulb switch	2	14	Face
15	Damper cover	10	8	Face
16	Fitting door lock	2	12	Face
17	Fitting middle hinge	2	6	Face
18	Fixing lower hinge	2	15	Face
19	Fitting Vegetables Drawer cover + Drawer	2	12	Face
20	Washer for lower hinge	18	5	Face
21	Put 2 plastic shelves inside cabinet + 1 inside freezer	2	10	Face
22	Fit meat drawer + its cover	13	22	Face
23	Fitting cabinet door + Fixing middle hinge	12,15,22,14,16, 17,20,19,21	18	Face
24	Fitting freezer door	23	5	Face
25	A. Flow sticker	24	6	Face
26	ideal sticker	24	4	Face
27	Fix upper hinge by 3 screws	24	12	Face
28	Fit hinge cover	27	5	Face
29	Adjust freezer & cabinet doors	24,28	24	Face
30	Fit Egg & Butter Shelves	23	19	Face
31	Fit bottles shelves in door (2 small + 2 large)	23	18	Face
32	Fitting freezer door shelves	27	16	Face
33	Cleaning freezer	32	21	Face
34	Cleaning Cabinet	30,31	24	Face
35	Putting silicon on lower painted plate	34,29,33	15	Face
36	Fit 4 rubber cushions for compressor base	1	9	Back
37	Fitting compressor to refrigerator	36	8	Back
38	Fitting 4 clips to compressor	37	16	Back
39	Fit drain tub + fix it by 2 screws	1	14	Back
40	Fit condenser to refrigerator	1	13	Back
41	Fix condenser to refrigerator	40	17	Back
42	Removing plugs from compressor & condenser	41,38	12	Back
43	Cleaning cooling circuit by nitrogen	1	4	Back
44	Cut hot gas ends	43	6	Back

45	Fitting charging	42	5	Back
46	Fitting return	42	7	Back
47	fitting copper connection pipes	42	5	Back
48	Forming capillary	45,46,47	7	Back
49	Fitting filter	48	14	Back
50	vac. Pipe	49	6	Back
51	Weld filter (upper points) & charging pipe	50	10	Back
52	Weld condenser end to hot gas + condenser end to connection pipe (black)	50	12	Back
53	Weld copper connection bet. Return pipe & compressor	50	8	Back
54	Weld copper connection (black) with compressor + weld capillary with filter	50	15	Back
55	Fit 2 valves to charging pipe	51,52,53,54	20	Back
56	Fit vacuum pipe	55	4	Back
57	Leakage Test	56	21	Back
58	Fit compressor electrical harness	57	7	Back
59	fix cover	58	15	Back
60	Fitting refrigerator cable	58	8	Back
61	Fitting connectors	58	10	Back
62	Collect wires ends together	58	6	Back
63	Fit 3 clips to wire ends	58	18	Back
64	Collect electrical ends by plastic bag + seal by tape	61	13	Back
65	Fit timer	62,63	14	Back
66	Fixing timer & +ve	65	15	Back
67	Fit tie wrap on wires	58	7	Back
68	Prepare catalog & guarantee	-	15	Back
69	Stick barcode & wiring diagram on refrigerator back	1	6	Back
70	Vacuum clean refrigerators	26,35,69,59,60, 64,66,67	23	Either
71	Removing valve from Vacuum pipe	70	20	Either
72	Close Vacuum pipe by welding	71	21	Either
73	Charge refrigerator with fereon	72	26	Either
74	Removing valve from charging pipe	73	20	Either
75	Close charging pipe by welding	74	21	Either
76	CPT	75	23	Either
77	Clean cabinet	76	24	Either
78	Hang key + Fitting screw cap	77	21	Either
79	Clean freezer	76	21	Either
80	Put silicon on middle painted bracket	76	15	Either
81	Adjust freezer & cabinet doors	76	29	Either
82	Paint pipes & welded joints	76	19	Either
83	Prepare carton base	78,79,80,81,82	24	Either
84	Load Ref. from wooden base to carton base	83	23	Either
85	Put plastic bag on refrigerator top	84	14	Either
86	Scan barcode & record refrigerator	85	10	Either
87	Fit handle foam	86	22	Either
88	Fit packaging carton	87	24	Either
89	Fit side foam	88	18	Either
90	Fit front foam	89	4	Either
91	Fit upper foam	90	21	Either
92	Carton wrapping machine	91	21	Either

TableA.II Computational results for the case study

ct=30; nt=91; ns=54;

Final Results

st	w	idle	tasks		
1	1	0	37	1	36
2	1	0	41	40	0
3	1	1	21	2	0
4	2	0	20	18	17
5	3	0	44	43	16
6	3	0	39	19	0
7	1	2	42	38	0
8	3	0	46	68	45
9	1	4	15	9	10
19	2	1	63	67	0
20	1	2	65	62	60
21	1	10	6	0	0
22	1	0	8	7	0
23	3	12	13	0	0
24	3	4	22	0	0
25	1	1	25	23	24
26	2	0	32	27	0
27	1	1	29	28	0
37	1	4	72	0	0
38	3	6	73	0	0
39	1	9	74	0	0
40	3	3	75	0	0
41	1	1	80	0	0
42	3	2	76	0	0
43	3	5	77	0	0
44	3	5	78	0	0
45	3	7	81	0	0

10	1	4	49	47	48	28	2	2	33	26	0	46	1	15	79	0	0
11	1	5	3	0	0	29	3	8	30	0	0	47	3	2	82	0	0
12	3	0	4	0	0	30	3	10	31	0	0	48	3	3	83	0	0
13	1	1	54	50	53	31	3	2	34	0	0	49	3	2	85	84	0
14	1	0	12	11	14	32	1	0	35	59	0	50	3	4	86	0	0
15	1	3	5	52	0	33	3	13	66	0	0	51	3	2	87	0	0
16	1	0	55	51	0	34	3	3	69	0	0	52	3	3	88	89	0
17	1	5	57	56	0	35	3	6	70	0	0	53	3	5	90	0	0
18	1	0	64	58	61	36	1	9	71	0	0	54	3	5	91	0	0