New computational experiences on the Hoist Scheduling Problem for cyclic manufacturing of different products

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ABSTRACT: *Jobs of two products must receive the same treatments in a production line of tanks. If the size of both batches is equal, we propose a cyclic manufacturing composed of a job from batch 1 and a job from batch 2. A hoist ensures the transfer of the jobs between tanks. The problem consists in the scheduling of hoist movements, which is known as HSP (Hoist Scheduling Problem). There is a comparison between completely separated and mixed production for both batches. The objective is to determine a sequence which minimises the cycle time for two jobs from different products (2-product cycle). We propose a branch-and-bound procedure, which can also be applied to the 2-cycle case for a single product. The model can be extended to n-cycles.*

KEYWORDS: *Scheduling, branch-and-bound, n-cycle, Hoist Scheduling Problem.*

1. Introduction

This work, based on a real situation in the electroplating industry, can be included in the frame of the well-known *Hoist Scheduling Problem* (HSP). A small company wanted to improve the simultaneous manufacturing of several products through a single line, which consists of a sequence of tanks.

Some of the main features for the production are:

- The manufacturing system is composed of several tanks, in which the jobs are submerged to receive a certain treatment. The production is composed of a sequence of operations, done in a set of tanks (1, 2, ..., m).

- Each job has certain processing time windows, associated to the operations of the different stages through the production. Windows are defined as the difference between the maximum times b_i and the minimum times a_i, for the operation *i* to be carried out.
- Transportation of jobs among tanks is carried out by a hoist moving in the upper part of the installation. It picks up a job from a tank at any feasible time and transfers the job to the next processing tank. This is done from the loading station to the unloading station, moving sequentially the jobs through the *m* tanks. The jobs must always remain inside the baths within the predefined time limits.
- The idle time is spent by the hoist above a tank if it arrives earlier than the scheduled instant for getting the job.

The first model for the HSP was developed by Phillips and Unger (1976). Recently, Manier and Bloch (2003) grouped the different works on this problem and classified them taking into account the variants considered in each one of the papers. According to their notation, our case can be classified as: CHSP | mt/ /diss | /2,mt+2 | *Tmin*.

Generally, the problem to determine the scheduling for operations done by a hoist with the objective to optimize the productivity appears as a NP-complete problem (Lei and Wang, 1989), even for the simplest variant of CHSP (CHSP | mt/ /∅ | /1,mt | *Tmin*.). Considering these conditions, we face the CHSP with one hoist, tanks with capacity for only one job and no problems in the carriers' circulation.

2. Formulation of the problem

2.1. Cyclic problem for two products

A large number of jobs must be treated on a production line, in which we suppose each treatment will take place in a tank (i=1,2,...,m). The loading station is noted as i=0 and the unloading station as i=m+1. For any tank, there is a particular time window delimited by two values: a minimum a_i and a maximum b_i. Hoists require time to load a product from a tank *i*, and move it to the tank *i+1*, for the next operation. This full-hoist time will be noted as f_i (i=0,1,..,m). An empty-hoist travel, between two full-hoist movements, requires a time $e_{i,j}$ (i=0,...,m+1; j=0,...,m+1) from a tank *i* to another tank *j*.

Let **H**=(h_0,h_1,...,h_m) be a circular permutation of the scheduled full-hoist movements, where value $h_{[k]}=h_i$ (i,k=0,...,m) means that the tank *i* will be visited in the *k*-th position of the sequence. We assume, without loss of generality, $h_{[0]}=h_0$. There is also a vector **T** associated to each vector **H**, with the respective instants t_i, in which the hoist picks up a job from tank *i*. Without loss of generality, we fix $t_0=0$. The objective is to minimize the cycle time ($C = t_{[m+1]}$).

For a single product, a single hoist and a given **H**, the problem of minimizing the cycle time (Armstrong et al, 1994) can be defined, with parameters ka_i, $kb_i \in \{0,1\}$, as:

$$[MIN]\ C \qquad (1)$$

s. t.:

$$t_i - t_{i-1} \geq a_i + f_{i-1} - ka_i \cdot C \qquad i=1, ..., m \qquad (2)$$

$$t_{i-1} - t_i \geq - b_i - f_{i-1} + kb_i \cdot C \qquad i=1, ..., m \qquad (3)$$

$$t_{[k]} - t_{[k-1]} \geq f_{[k-1]} + e_{[k-1]+1,[k]} \qquad k=1, ..., m \qquad (4)$$

$$t_0 - t_{[m]} \geq f_{[m]} + e_{[m]+1,0} - C \qquad (5)$$

$$t_i \geq 0 \qquad i=0, ..., m \qquad (6)$$

$$C \geq 0 \qquad (7)$$

This work is based on a cyclic case for 2 products, of which the additional features are:

- Jobs of two products (j=1,2) must be manufactured.
- The amount of jobs of product *j* to be produced is u_j. In this paper, u_j is considered the same value for any product *j*.
- All the jobs follow the same sequence of tanks and go through the same *m* baths following the same route. The tanks (i=1,...,m) are used for a single operation and have capacity for only one job.

2.2. Solving 1-product and multiple-product cyclic sequences

The concept of **cyclic sequence** is introduced to study the case of identical or homogeneous jobs (all the jobs of the same product), as Phillips and Unger (1976) and Shapiro and Nuttle (1988) described. The hoist repeats cyclic movements to treat the input of jobs. The sequence is large enough to be considered infinite. The objective, according to that approach, is to minimise the cycle time, which is defined as the time consumed by the hoist to carry out a complete sequence of movements (Shapiro and Nuttle, 1988).

If a single job is introduced into the production system and another leaves the system during each cycle, it is referred to as **1-cycle** schedule or simple cyclic schedule. Otherwise, if more than one job is introduced and is removed from the system during each cycle, the optimum result is known as **n-cycle** schedule.

The 1-cycle, in which one job but not necessarily the same, is introduced into and removed from a tank during each cycle, is the most studied case in literature. Besides the above mentioned Phillips and Unger (1976) who used Mixed Integer Linear Programming, Constraint Logic Programming used by Baptiste et al (1992) and later in Baptiste et al (1993), or graphs used by Lei (1993), Armstrong et al (1994), Chen et al (1998) have followed studying the problem, among others.

Authors like Shapiro and Nuttle (1988) proposed that their algorithms could run on the n-cycle as well as on the 1-cycle, but they give no solutions. Lei and Wang (1989) affirm that the n-cycle scheduling problem is also NP-complete.

If the scheduling considers jobs from different products (what we call heterogeneous jobs), the hoist movements cannot be reduced to a cyclic sequence. For this purpose, the introduction of jobs into the production line is determined by the total number and the variety of jobs. For these problems, the objective is to minimize the total processing time after dealing with all the jobs, i.e. what is known as the makespan C_{max} in flow-shop problems.

But, if there are not many different products, a cyclic treatment may be convenient. Some advantages for this management could be the stock management, the production balancing, … For these problems, the objective is again the minimum cycle time to have any kind of job in the same positions at the beginning and at the end of that cycle.

2.3. A cycle for multiple-product jobs

For heterogeneous jobs, a model to determine the hoist movements requires a general sequence. Being $U=u_1+u_2$, the number of operations to be scheduled for the hoist is:

$$\#operations_1 = (m+1) \cdot U \tag{8}$$

Nevertheless, a model considering "multiproduct" tanks (with capacity for more than one job) can be developed, although in fact there are "monoproduct" tanks (with capacity for a single job). As the sequence can be repeated u_j times, the number of cyclic movements to be determined (considering any number *n* of products) is:

$$\#operations_2 = (m+1) \cdot n \tag{9}$$

The relation between equations (1) and (2), $U/n=n\cdot u_j/n$, shows that computational complexity can be proportionally reduced in the amount u_j. Other procedures could be applied to schedule the movements, but we think the quality of the solution obtained is good enough.

If the model considers "multiproduct tanks", the problem can be solved converting the usual *m* operations into $n\cdot m$, as the tank capacity is multiplied with respect to the usual for 1-product jobs. By means of a multiple-product cyclic model, it is sufficient to determine a cyclic sequence which alternates jobs of each product.

3. Definitions and hypothesis for the multiple-product cycle

For the n-cycle heterogeneous model, it is necessary to first define two concepts: **tank or bath** (associated to the real layout) and **stage or operation** (for the model).

Tank or bath is known as the physical element located in the production line, where all the operations for each product, relative to the same treatment, are carried out. As it was above commented, we consider there are as many tanks as treatments.

In order to solve the problem, **stage or operation** is defined. A stage is each one of the treatments received by any product in any tank of the line. In this way, our model is closer to the most widespread ones.

Let *k-1* and *k* be two consecutive stages in the line for the 2-cycle heterogeneous model. If *k* is even, both stages *k-1* and *k* belong to different tanks; if *k* is odd, they are assigned to a single tank.

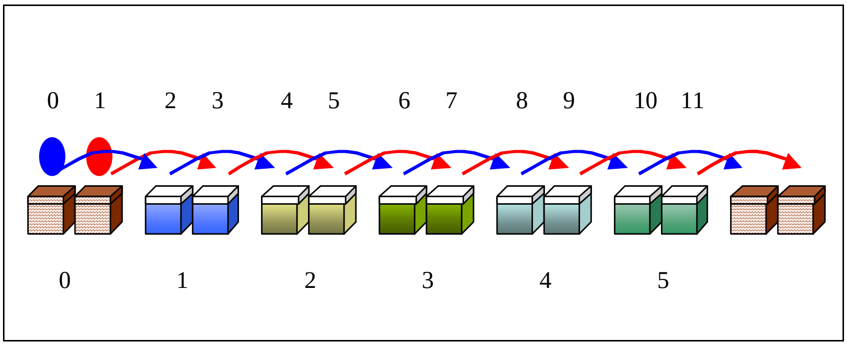


Figure 1. Representation of tanks and stages in the model

A line is composed of *p* stages associated to tanks. Considering stages s_0 and s_1 for the loading station, a vector **S** includes the set of stages: **S**=(s_0, s_1, ..., s_k, ..., s_p, s_{p+1}). Additionally, there are two last "stages" s_{p+2} and s_{p+3} associated to the unloading station. There is a single hoist, and two products must be produced (the jobs of product 1 flow along even stages and those of product 2, along odd stages). Therefore, the model for scheduling a 2-product cyclic sequence considers the following hypothesis:

1. After a job of product 1 is taken from stage s_0, it is processed in the stages s_2, s_4, ..., s_p and leaves the line at s_{p+2}; on the other hand, a job of product 2 starts from the stage s_1, it is later treated in the stages s_3, s_5, ..., s_{p+1} and leaves the line at s_{p+3}. Some usual conditions are considered: one treatment and single capacity for a tank.
2. A single hoist is scheduled to handle the movements of jobs between stages. The time required to move a job from the stage s_k to the stage s_{k+2} (k=0, ..., p+1) is f_k.

The time required by the hoist to travel empty from the stage k to another stage k' is $e_{k,k'}$. The time to carry out both movements does not depend on the product.

3. The processing time for job j at the stage k must be between the values $a_{i,j}$ and $b_{i,j}$, with $i=k/2$ for jobs of product 1 and $i=(k/2)+1$ for jobs of product 2.
4. The stages s_0 and s_1 are prepared with jobs when the hoist arrives to pick them up. Any stage s_k (k=2, ..., p+1) must be empty if a hoist is going to leave a job inside. At stages s_{P+2} and s_{p+3} the hoist can only leave jobs.

We will work on the steady state and omit the transitory state, which would be complementary and with a low relevance on the whole schedule.

4. Model for the 2-product cyclic sequence

4.1. Definition of cyclic sequences for movements, H, and times, T

A cyclic sequence is defined from two vectors (**H,T**), as it was introduced in Section 2:

- $\mathbf{h}_{[k]}$: k-th movement of the $p+2$ loaded hoist movements ($0 \le k \le 2m+1$ or equivalently $0 \le k \le p+1$); let $h_{[k]}=h_l$ be the movement with a job from stage s_l to s_{l+2}, corresponding to jobs of product 1 if l is even and jobs of product 2 if l is odd.
- $\mathbf{t}_{[k]}$: the starting time of the k-th movement ($0 \le k \le 2m+1$ or $0 \le k \le p+1$), considering $t_{[0]}=0$.

While **H** points out the order of the $p+2$ movements with transport of jobs which compose a working cycle for the hoist, $\mathbf{H}=(h_{[0]}, h_{[1]},..., h_{[p+1]})$ with $h_{[0]}=h_0$, a cycle will be defined by the sequence: $\mathbf{T}=(t_{[0]}, t_{[1]},..., t_{[p+1]})$ with $t_{[0]}=0$ and $t_{[0]}<t_{[1]}<...< t_{[p+1]}$.

A cyclic sequence (**H**, **T**) will be feasible if and only if:

- The hoist movement sequence with load can be done, i.e. if there is a job in the tank to be taken and the destination tank for the job is empty.
- The processing times into the tanks have values within the established time windows.

The particular mixture of jobs from two products leads us to call this case “2-product cyclic sequence”. This work is developed considering only 2 products, although it could be extended to *n* products (multiple-product cyclic sequence).

4.2. Model associated to a sequence for the 2-product cycle

The time required by the hoist to complete a whole cyclic sequence of movements is known as cycle time, C(**H**,**T**)= $t_{[p+2]}$. The objective of this hoist scheduling problem, the multiple-product cyclic sequence, is to determine the sequence of minimum cycle time in which there is a job of each product along the line, whose tank route is the same but with individual window constraints.

The input data are the time windows, the times for hoist movements and the vector of hoist sequence. Later, the variables and the constraints are defined.

Time windows. Given that the data for these constraints is initially related to product *j* and tank *i*, they must be converted into the defined stages *k*. Briefly, the time window constraints are defined as $[a_k,b_k]$ with k=2,...,p+1. Values for even stages *k* are valid for jobs of product 1; the other values are for jobs of product 2, which visit the odd stages.

Times for hoist movements. Let be f_k (k=0,...,p+1) the time for loaded hoist travelling between consecutive tanks and $e_{k,k'}$ the time for unloaded hoist travelling between the stages *k* and *k’* (k,k’=0,...,p+3).

Hoist sequence. The sequence **H**=(h_0,$h_{[1]}$,$h_{[2]}$,..., $h_{[P+1]}$) or any subsequence of the former can be evaluated.

Variables. A set of *p* variables arises from the values of vector **T**, because t_0 is fixed by hypothesis. There is an additional variable for the cycle time *C*.

Constraints for processing times in tanks. Let $h_{[i]}=h_{k-2}$ and $h_{[j]}=h_k$ be two consecutive movements on the same job, the first to deposit the job into the tank of stage *k* and the second to remove it from the tank after a feasible time period:

$$a_k \le t_{[j]} - (t_{[i]} + f_{k-2}) \le b_k \qquad k=2,3, ..., p+1 \qquad \text{if } j>i \qquad (10)$$

$$a_k \le t_{[j]} + C - (t_{[i]} + f_{k-2}) \le b_k \qquad k=2,3, ..., p+1 \qquad \text{if } j<i \qquad (11)$$

Constraints related to hoist times. Let $h_{[k]}$ and $h_{[k+1]}$ be two consecutive movements in the vector **H** (k=0,..., p):

$$t_{[k+1]} \ge t_{[k]} + f_{[k]} + e_{[k]+2,[k+1]} \qquad k=0,1, ..., p \qquad (12)$$

If one of these constraints is not accomplished with equality, the hoist must wait above the tank associated to hoist movement *k+1* until $t_{[k+1]}$. And for the last movement of a cycle, the cycle time C is included to join with the next one:

$$t_0 + C \ge t_{[p]} + f_{[p]} + e_{[p]+2,0} \qquad (13)$$

There are $2{\cdot}p$ constraints from (10) and (11), and $p+1$ more considering (12) and (13).

Coherent subsequences. If we consider two consecutive tanks (*i* and *i+1*) and the hoist movements associated to the four included stages (*k*, *k+1*, *k+2* and *k+3*), the order of movements is prefixed due to the general hypothesis of the model (Figure 2).

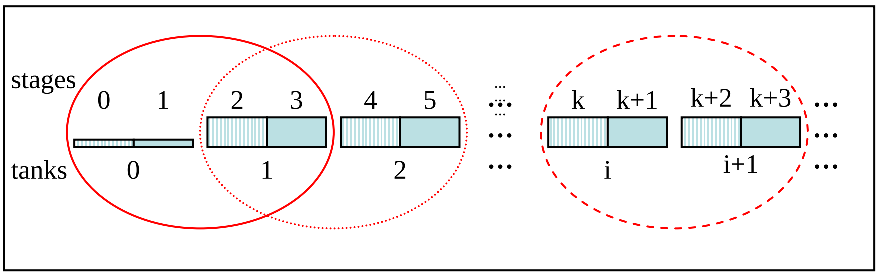


Figure 2. Relation between stages of consecutive tanks

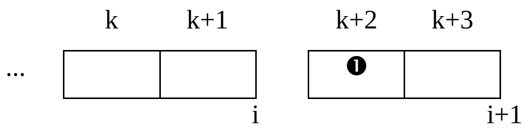
The relation of hoist movements between these four stages depends on the occupation of tank *i* by a job at the beginning of the cycle, i.e., it is necessary to define a vector **D** for the initial job distribution, as in Chen, Chu and Proth (1998): $\mathbf{D_{[m]}}=(d_{[0]}, d_{[1]},..., d_{[m]})$.

If we suppose the hoist only visits the loading station and tank 1, the only feasible sequence of movements is **H**=(h_0, h_2, h_1, h_3).

For the addition of a new tank to the model, the two following stages are added to the previous permutation of movements (with one less tank). Therefore, the last four stages in the considered part of the line must accomplish some suitable conditions. That relation follows the same condition as the one considering only tanks 0 and 1.

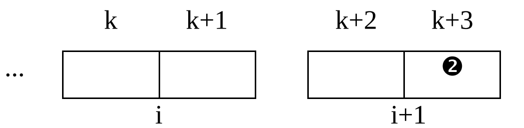
We can develop the following four cases, detailed in Mateo and Amorós (2002) and shown in Figure 3:

Case 1: Stage *k+2*, in tank *i+1*, with a job of product 1.



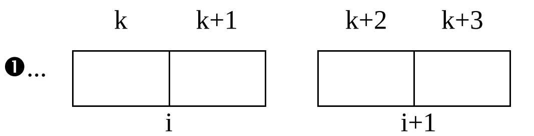
$t_{k+2} < t_{k+1} < t_{k+3} < t_k$

Case 2: Stage *k+3*, in tank *i+1*, with a job of product 2.



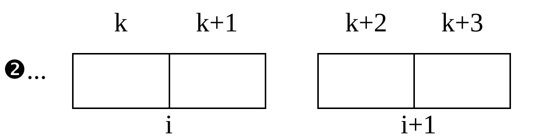
$t_{k+3} < t_k < t_{k+2} < t_{k+1}$

Case 3: Tank *i+1* without any job and the following is 1.



$t_k < t_{k+2} < t_{k+1} < t_{k+3}$

Case 4: Tank *i*+1 without any job and the following is 2.



$t_{k+1} < t_{k+3} < t_k < t_{k+2}$

Figure 3. The four cases with additional constraints for new coherent subsequences

Objective function. Being $t_{[0]}=0$, the value to be optimized is the length of the cycle:

$$[MIN]\ C \qquad (14)$$

4.3. A graph to solve a sequence for the multiple-product cycle

For the resolution of a model through a graph (Mateo et al, 2002), the constraints (10)-(13) can be rewritten grouping relevant information in a single form using four vectors, called respectively *Gfrom*, *Gto*, *Gtime* and *Gcycle*, similar to what Chen, Chu and Proth (1998) proposed. Being Gfrom(q), Gto(q)$\in$\{0, ..., p+1\}; Gtime(q) $\in$ Z (positive or negative) and Gcycle(q) $\in$ \{-1,0,1\}:

$$t_{Gto(q)} - t_{Gfrom(q)} \geq G_{time(q)} + G_{cycle(q)} \cdot C \qquad q=1, ..., 3p+1 \qquad (15)$$

A lower bound can be computed with the selection of circuits in the graph with a non-positive value. The evaluation of the optimum path in the graph can lead to converge (the lower bound is the expected cycle time) or not converge (the differences in successive iterations are used to check a new tentative cycle time, while this value does not exceed the upper bound).

Example

Two products must be manufactured in a line with 3 tanks. Each product must remain in a tank for a time between a minimum and a maximum value, shown in Table 1.

Product	**P1**			**P2**		
Tank	**1**	**2**	**3**	**1**	**2**	**3**
Minimum time	40	20	25	35	25	35
Maximum time	100	80	75	105	80	100

Table 1. Time windows of the example.

The time required to transport a product between tanks of successive treatments is 15. Without load, the hoist needs 10 units of time.

If we consider, for example **H**=(h_0, h_5, h_2, h_7, h_4, h_1, h_6, h_3), at the beginning of the cycle there is a job of product 1 at "tank" 0 (stage 0) and a job of product 2 at tank 2 (stage 5). After introducing a job of product 1 into the line, the hoist will take a job from tank 2 (product 2), from tank 1 (product 1), from tank 3 (product 2), … The associated graph to the sequence **H** is shown in Figure 4. Continuous arcs show the constraints for processing times in tanks, while discontinuous arcs show those for hoist times. A feasible solution exists for C=280 and the corresponding scheduling of hoist movements is: **T**=(0, 25, 60, 85, 110, 155, 190, 235).

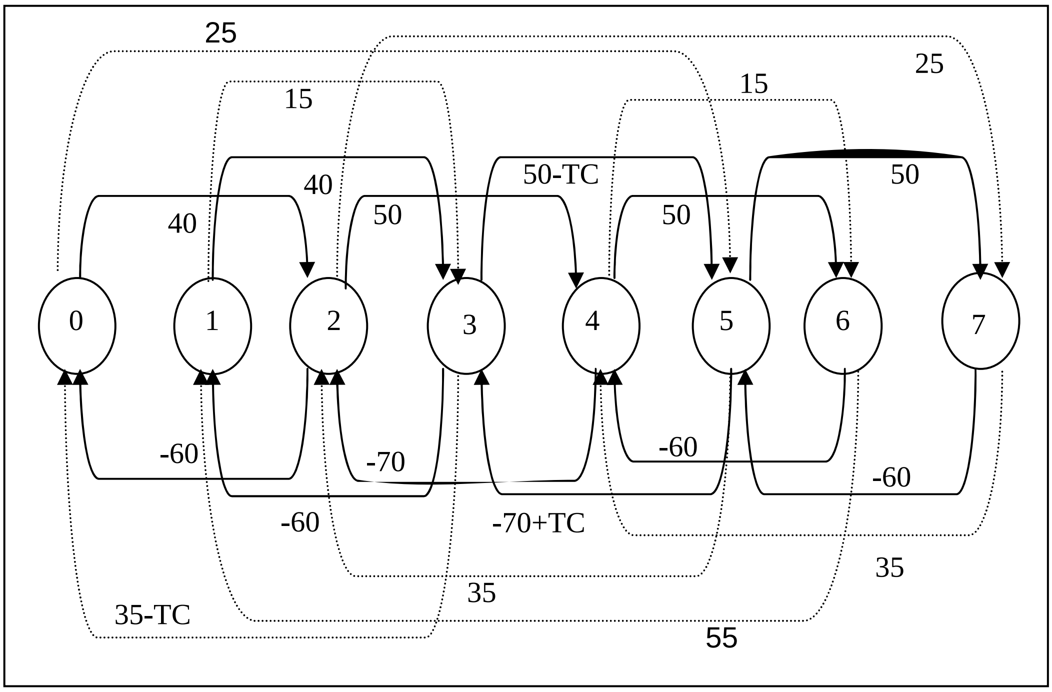


Figure 4. Graph associated to sequence **H**=(h_0, h_5, h_2, h_7, h_4, h_1, h_6, h_3).

5. The branch and bound procedure

One of the methods to obtain the optimum solution for a problem is *branch and bound*. In this case, the procedure is based on the physical exploration of the production line, and consists in the addition of the stages of one tank to the vector **H** in a node of the tree. This implies an enlargement of the line with a new tank with respect to the set in the immediately previous level. The solutions in the tree are constructed adding new tanks, which is called *branch and bound for tanks* according to Mateo (2001), and is inspired in Shapiro and Nuttle (1988) and Armstrong et al (1994).

5.1. Vertex definition

The number of levels in the tree is equal to the number of tanks along the system, *m*. For the root vertex, given that the sequence begins with the movement at stage 0, the movements on stages 1, 2 and 3 are automatically determined: **H**=(h_0, h_2, h_1, h_3). You can see the explanation about coherent subsequences in Section 4.

Let a vertex be at level *r* (r=2,…,m). The vertices are defined by a permutation of the movements assigned to the first *2·(r+1)* positions, or stages, in the sequence **H**. Once considered a vertex, the number of total sequences contained in this vertex and with the same subsequence for the initial components is *(r+1)·(r+2)*.

A vertex at level *r* is defined by $\mathbf{H}_{[v][r]}$ =($h_{[0]}$,...,h_l,...,$h_{[2(r+1)]}$), which corresponds to a permutation such that {$h_{[0]}$=h_0, h_l | l=1,...,2r+1} and h_l must respect the constraints on coherent subsequences, described for the branching procedure. The subindex *v* shows the appearance order of the vector in the algorithm.

At each vertex, a graph is developed following the structure of constraints (15), and then it is solved with a Ford algorithm. If the lower bound extracted from the graph for the cycle time cannot be feasible, a new value can be tried using the properties of dynamic programming (Mateo et al, 2002).

5.2 Branching procedure

The vector **D** is necessary to develop the branching procedure. If *v* is a non-leaf vertex of level *r* from which new vertices are generated, with a vector $\boldsymbol{D}_{[v][r]}$, the descendant vectors $\boldsymbol{D}_{[v][r+1]}$ are created adding two new stages, which correspond to the next tank. The last four stages in the considered part of the line must accomplish the suitable conditions, the same as the root vertex. It is also necessary to know the product of the closer job to the appended tank to know the value for the new tank in vector $\boldsymbol{D}_{[v][r+1]}$.

Then, the rules given for the coherent subsequences can be applied to accept or reject the descendant vertices.

5.3. Bounding procedure

Let a vertex *v* be at level r (with *r* tanks) defined by $\boldsymbol{H}_{[v][r]}$. A bound for the value C of all the included permutations can be determined, considering the movements included and, if necessary, an additional time for the movements that are still not fixed.

Besides some lower bounds from non-negative circuits in the associated graph (Chen et al, 1998), a lower bound for C considering no assigned movements ($h_l \in \mathbf{U}$) to $\boldsymbol{H}_{[v][r]}$, t_0=0 and trying to use the idle time for the hoist, is:

$$LB(\mathbf{H}_{[v][r]}) = C(\mathbf{H}_{[v][r]}) + \max\left\{ \left[\sum_{h_l \in \mathbf{U}} \left(f_l + e_{l,l+1}\right) - \sum_{h_k \in \mathbf{I}} \left(w_k\right) \right], 0 \right\} \quad (16)$$

where $C(\boldsymbol{H}_{[v][r]})$ is the cycle time for the hoist movement sequence of the vertex with $\boldsymbol{H}_{[v][r]}$, **U**={h_{r+1},..., h_{2m+1}} is the set of unassigned movements in the sequence $\boldsymbol{H}_{[v][r]}$, and w_k is the waiting time for hoist on the stage *k*.

If the vertex is a leaf, the value from (16) corresponds to the value C for the sequence, as usual. If that value is lower than the cycle time of the best known solution, the permutation $\boldsymbol{H}_{[v][m]}$ and the cycle time *C* will be the new best known solution. If the bound of any vertex is greater or equal to the best known solution, the vertex is pruned.

5.4. Search strategies

The algorithm gives priority to the unexplored vertex with a lower bound for C. For tie-breaks, a vertex with greater amount of movements, i.e. value *r*, has a higher priority. Figure 5 shows the explored tree for the *branch and bound* of the example in Section 4.

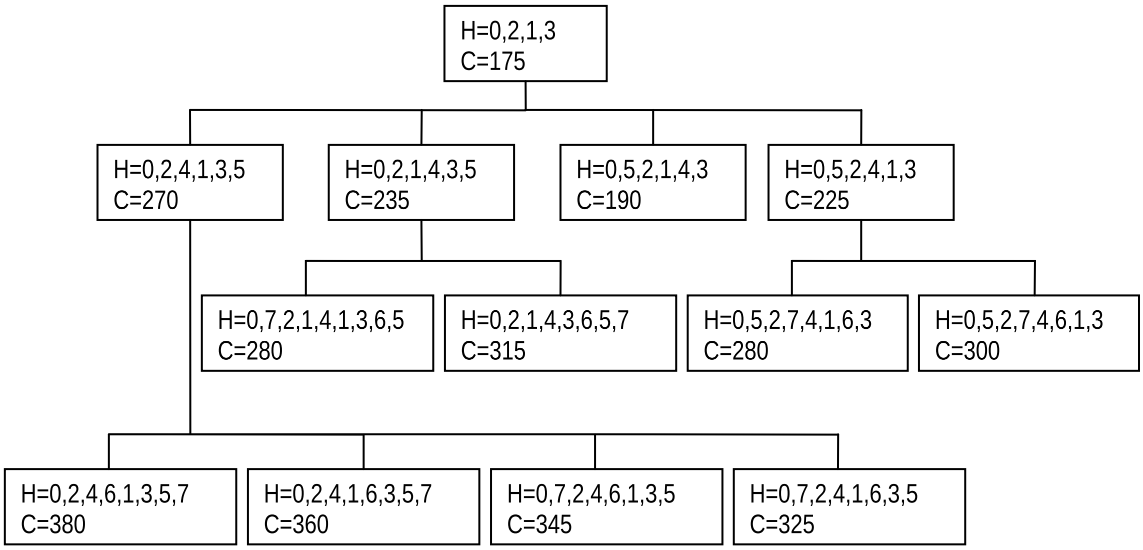


Figure 5. Branch-and-bound for the instance used as example

6. Computational results

6.1 Data and objectives

The computational experience is based on a set of 540 instances corresponding to different degrees in the width of time windows and the relation between loaded and unloaded hoist movements (Mateo, 2001).

Time windows can be classified according to the difference between the maximum and minimum times (b_k-a_k) for any stage. The minimum processing time for operations is randomly generated, as in Ng(1996), according to a uniform distribution: a_k=U[20;80]. Time windows in the tanks can be classified into three groups: *W1*, for b_k-a_k=U[1,2a_k; 2a_k]; *W2*, for b_k-a_k=U[2a_k; 3a_k]; *W3*, for b_k-a_k=U[3a_k; 10a_k].

The second classification takes into account the hoist speed, considering the quotient between the time of movements between two stages *k* and *k+2* with load f_k and the time without load $e_{k,k+2}$. In a similar way, three groups have been developed. Following Ng(1996), the time for unloaded hoist movements between two stages *k* and *k+2* is $e_{k,k+2}$=U[5;10]. Ng(1996) adds a constant value to obtain the loaded times f_k from the unloaded $e_{k,k+2}$; we prefer to group the instances according to relation between the loaded and unloaded hoist movements: *H1*, for $f_k < 2\ e_{k,k+2}$; *H2*, for $f_k = 2\ e_{k,k+2}$; *H3*, for $f_k > 2\ e_{k,k+2}$.

The objectives of the computational experience are basically two:

- Analyse and compare the results of 540 instances for the 1-product 1-cycle sequences with the 1-product 2-cycle sequences. As the input sequence for jobs in both situations is the same, the differences between cycle time in both the 1-cycle and the 2-cycle cases are determined.

- Analyse and compare the results of 270 instances for the 2-product 1-cycle case with those adding two 1-product 1-cycle cases. Given a mix sequence with the input of jobs of two different products, compare the cycle time in the 2-product sequence with the sum of two 1-product sequences.

6.2. The two parts of the computational experience

The computational experience has been developed in two parts:

- Part I: 1-product 1-cycle problem with respect to the 2-cycle.

  This part of the computational experience is formed by 540 instances (Mateo, 2001). Given 3 sets of time windows and 3 sets of hoist speeds developed, this leads to 9 different collections of instances. For each one, the instances consider between 5 and 10 tanks (or equivalently, between 11 and 21 stages). Each one of the 54 different patterns has 10 generated instances.

- Part II: 2-product 2-cycle problem with respect to addition of two 1-product 1-cycle.

  This computational experience is composed of 270 instances, with a uniform number of tanks *m* between 5 and 10 (30 problems for each number of baths). Taking into account the instances of Part I, instances of two different types are combined to obtain a hoist scheduling in which units of both batches are alternated. Both instances must accomplish two conditions: the same times for hoist movements (H1, H2 or H3) and the same number of tanks.

For each hoist speed, the combination of instances from 3 types of time windows leads to: combine an instance W1 with an instance W2; an instance W1 with an instance W3; and an instance W2 with an instance W3. If this is repeated for instances with H1, H2 and H3, 9 kinds of instances are developed. For each number of tanks, 5 different instances are generated, which implies 30 instances. The classification of instances for this part and some of the data are included in Mateo and Amorós (2002).

The algorithms were written in Visual C++ and run in a Pentium IV 2.60 Ghz, 256 Mb RAM.

6.3. Analysis of the results

6.3.1. Analysis of 1-product 1-cycle versus 1-product 2-cycle

Obviously, the expected result from Part I can be expressed with the relation (17):

$$2 \cdot C^*(\mathbf{H_1}) \geq C^*(\mathbf{H_2}) \qquad (17)$$

$C^*(\mathbf{H_1})$ corresponds to the value of the optimum cycle time when only one job is introduced and taken from the production line within a cycle; $C^*(\mathbf{H_2})$ corresponds to the same value if two jobs are introduced and taken within a cycle. Two reasons justify the inequality (17):

- Any value for $C^*(\mathbf{H}_2)$ higher than $2 \cdot C^*(\mathbf{H}_1)$ makes no sense. Any sequence **H** in a chemical line with *m* tanks for the 2-cycle case can be formed repeating two identical sequences **H** for the 1-cycle case.
- For the 1-cycle case, after the movements $m+1$ and $2 \cdot m+2$ the hoist must go to the loading station (constraint 5); on the other hand, for the 2-cycle case it is only compulsory in the last movement, $2m+2$ (constraint 13). There are two fixed movements in the 1-cycle case for each in the 2-cycle case.

A direct relation between the potential reduction of value C and the number of tanks can be stated. The time is reduced by less than 5% for lines with only 5 tanks, but with greater instances, for 10 tanks, the improvement can reach up to 30%. Table 2 includes results classified by number of tanks (columns) and window and hoist speed (rows).

Window	Hoist	Tanks					
		5	**6**	**7**	**8**	**9**	**10**
W1	**H1**	5.05	8.94	10.79	11.17	29.48	25.91
	H2	4.43	8.73	14.16	25.84	26.64	19.82
	H3	6.31	17.26	12.92	18.93	24.24	33.00
W2	**H1**	0.62	4.50	5.09	9.96	18.25	22.45
	H2	2.28	8.43	11.90	14.05	9.63	26.86
	H3	5.34	8.59	10.64	26.2	23.48	24.97
W3	**H1**	0	0	0	2.22	0.48*	0.90*
	H2	0	0.41	0.25	0	1.70*	1.48*
	H3	0.67	1.09	0.45	1.58	0.88*	2.60*

Table 2. Reduction (%) of cycle time between 1-product 1-cycle and 2-cycle cases (* means that the branch-and-bound has been truncated after 10^6 explored vertices)

The conclusions on the values of Table 2 are:

- For instances with windows W1 and W2, a relation between the number of tanks and the reduction with respect to $2 \cdot C^*(\mathbf{H}_1)$ as a 2-cycle is proportional.
- For the windows W3, no improvement is obtained in the cycle time and, therefore, both values are quite similar for any number of tanks: $C^*_1 \cong C^*_2$

The instance detailed in Phillips and Unger (1976), with 12 tanks, has been solved as the 1-product 2-cycle case. We obtained a cycle time C=1004, which implies a reduction of time with respect to the 1-product 1-cycle (C=521), value given by Chen, Chu and Proth (1998) among others. The result is obtained in less than 20 seconds. And if the optimum cycle time for 1-cycle is given as initial upper bound, then only 5 seconds are required. The optimal sequence (in tanks) is: 0, 7, 9, 8, 1, 0, 10, 2, 9, 11, 1, 12, 3, 2, 10, 4, 5, 3, 11, 6, 12, 4, 7, 5, 8, 6.

6.3.2. Analysis of two 1-product 1-cycle versus one 2-product 1-cycle

For the case with two alternated products, the objective is to establish a relation between the minimum cycle time in which two jobs of different products are introduced and taken from the line, $C^*(\mathbf{H_2})$, and the addition of this products alone $C^*(\mathbf{H_1})^{p1}+C^*(\mathbf{H_1})^{p2}$.

The relation (18) is often accomplished, but sometimes is not due to the possibility of falling in an incompatibility when the 1-cycle sequences from the two products are merged. This happens in 9 instances with 5 tanks, 7 with 6 tanks, 5 with 7 tanks, 3 with 9 tanks and only one with 10 tanks. A relation for the efficiency in the transport can be found for the 2-cycle case according to the number of tanks (Table 3).

$$C^*(\mathbf{H_1})^{p1} + C^*(\mathbf{H_1})^{p2} \geq C^*(\mathbf{H_2}) \qquad (18)$$

The results for the cycle time C when the 2-product cyclic case is compared with the disjunctive 1-product cyclic cases are shown in Table 3. They are divided according to the kind of speed hoists (H1, H2, H3) and the combinations of different kinds of windows (W1/W2, W1/W3 and W2/W3).

Hoist	**Window**	**Tanks**					
		5	**6**	**7**	**8**	**9**	**10**
H1	**W1/W2**	2.09	-0.75	13.61	14.18	30.03	21.38
	W1/W3	0.55	4.93	3.55	3.20	19.24	13.25
	W2/W3	0.84	3.84	0.85	10.72	14.86	23.44
H2	**W1/W2**	2.74	12.11	9.83	23.01	14.15	27.58
	W1/W3	4.91	4.46	6.99	17.93	22.86	10.76
	W2/W3	4.46	9.09	2.02	10.66	8.36	12.16
H3	**W1/W2**	11.14	21.11	16.24	23.42	31.92	36.56
	W1/W3	3.36	13.66	13.95	7.03	19.75	25.71
	W2/W3	1.36	7.43	4.12	12.61	10.24	16.22

Table 3. Reduction of time (%) between 2-product 1-cycle and two 1-product 1-cycle cases

While for only 5 tanks the reduction is less than 4%, the behaviour differs for instances of W1/W2 or W1/W3 considering a higher number of tanks. For the instances of W1/W2, with 10 tanks, reduction values of around 30% are achieved whereas only 20% is reached for the W1/W3 and around 17% for the W2/W3. The instances with time windows W3, with wider ranges, prevent bigger improvements for the 2-product cycle. Nevertheless, a proportional relation between the reduction of time and the number of tanks can be stated, which is higher when instances are W1/W2.

The explored nodes for reduced instances are about 33% of the initial potential nodes, without considering the relations for coherent subsequences. We suppose this percentage can be maintained for instances with greater dimensions.

6.4. Computing times

The computing times are included in a range of less than 1 second, for instances with 5 tanks, and around 30 minutes, for the most complex instances of 10 tanks (when the amount of subsequences can be higher). The mean computing times of both parts are shown in Table 4.

Part	**Tanks**					
	5	**6**	**7**	**8**	**9**	**10**
I	<1s	<1s	6.93s	2'26s	4'47s	8'51s
II	<1s	<1s	3.94s	31.44s	1'21s	5'40s

Table 4. Mean computing times for both parts of the computational experience

The instances of the 1-product 2-cycle case (in part I) usually require more time than those for the 2-product cyclic case (par II), although there are also some exceptions.

7. Conclusions

The proposed model is built on the difference between the concepts of tanks and stages, as stage is known as each one of the operations (one for each kind of product) which happen in a tank.

The idea of assigning multiple stages to each tank brings us closer to the widespread models and reduces the complexity of solving the problem. This way, the kind of product is avoided when dealing with the variables. This model opens new paths to study more complex cases, with jobs of multiple products, reduced to procedures usually considered for jobs of a single product. Then, the number of variables for the problem does not increase considerably.

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ANNEX 1. Analysis of 1-product 1-cycle versus 1-product 2-cycle

Set 1 (W1, H1)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
10105	**214**	**423**	1,17%	493	664	0	0	862.284
10205	**185**	**333**	10,00%	324	540	0	0	103.586
10305	**240**	**457**	4,79%	718	1173	0	0	187.604
10405	**198**	**396**	0,00%	525	1424	0	0	945.927
10505	**158**	**316**	0,00%	290	906	0	0	857.833
10605	**172**	**330**	4,07%	259	916	0	0	626.816
10705	**195**	**390**	0,00%	605	1441	0	0	118.429
10805	**123**	**242**	1,63%	203	252	0	0	367.734
10905	**252**	**504**	0,00%	178	347	0	0	373.727
11005	**348**	**495**	28,88%	494	835	0	0	115.134
11106	**220**	**440**	0,00%	1933	3702	0	0	920.848
11206	**413**	**588**	28,81%	367	474	0	0	642.912
11306	**410**	**575**	29,88%	290	364	0	0	487.428
11406	**137**	**274**	0,00%	2430	6022	0	0	936.043
11506	**451**	**625**	30,71%	302	362	0	0	604.967
11606	**171**	**342**	0,00%	3802	4040	0	1	910.976
11706	**189**	**378**	0,00%	4041	5708	0	1	538.975
11806	**162**	**324**	0,00%	519	976	0	0	159.558
11906	**194**	**388**	0,00%	4341	8504	0	1	931.130
12006	**144**	**288**	0,00%	2566	10059	0	0	705.472
12107	**479**	**644**	32,78%	1302	1513	0	0	269.716
12207	**166**	**332**	0,00%	19711	26912	0	12	463.892
12307	**208**	**416**	0,00%	24766	57899	0	9	953.933
12407	**200**	**400**	0,00%	1408	2508	0	0	597.947
12507	**371**	**702**	5,39%	16119	24524	0	7	633.637
12607	**471**	**630**	33,12%	905	1008	0	0	213.160
12707	**480**	**673**	29,90%	533	685	0	0	840.296
12807	**216**	**432**	0,00%	8149	17008	0	3	502.442
12907	**232**	**433**	6,68%	9012	13697	0	5	160.184
13007	**220**	**440**	0,00%	13334	24681	0	7	893.723
13108	**330**	**660**	0,00%	51709	61589	0	28	307.434
13208	**378**	**719**	4,89%	30833	37516	0	15	660.886
13308	**407**	**609**	25,18%	8781	11371	0	3	168.965
13408	**569**	**709**	37,70%	6929	8241	0	2	394.614
13508	**323**	**646**	0,00%	111764	120046	1	5	958.440
13608	**416**	**755**	9,25%	7121	8737	0	2	763.478
13708	**368**	**654**	11,14%	21053	22981	0	6	461.052
13808	**225**	**405**	10,00%	79391	131029	0	44	854.829
13908	**238**	**464**	2,52%	59305	97571	0	37	788.156
14008	**374**	**666**	10,96%	59734	66158	0	36	309.661
14109	**479**	**624**	34,86%	9860	11092	0	2	738.049
14209	**664**	**832**	37,35%	2224	2726	0	0	540.680
14309	**475**	**748**	21,26%	47828	54089	0	24	652.986
14409	**610**	**790**	35,25%	797	860	0	0	160.884
14509	**677**	**797**	41,14%	18102	24307	0	7	599.626
14609	**659**	**779**	40,90%	4186	5242	0	1	683.032
14709	**605**	**782**	35,37%	7397	7942	0	1	918.939
14809	**482**	**738**	23,44%	58838	71073	0	29	917.715
14909	**248**	**462**	6,85%	347205	781082	7	29	937.024

15009	**436**	**712**	18,35%	17013	20446	0	7	430.067
15110	**771**	**928**	39,82%	32913	38067	0	10	904.280
15210	**532**	**905**	14,94%	131820	151018	1	15	397.976
15310	**653**	**791**	39,43%	17665	19639	0	6	360.223
15410	**653**	**753**	42,34%	110399	118983	1	1	623.972
15510	**486**	**751**	22,74%	65442	77229	0	30	504.064
15610	**689**	**875**	36,50%	1595	2236	0	0	348.336
15710	**268**	**536**	0,00%	703837	929550	22	55	667.769
15810	**770**	**915**	40,58%	5824	6990	0	1	463.290
15910	**448**	**765**	14,62%	116377	126165	1	15	145.742
16010	**456**	**838**	8,11%	343278	391281	4	35	300.714

Set 2 (W1, H2)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
20105	**346**	**511**	26,16%	84	111	0	0	10.318
20205	**224**	**418**	6,70%	390	790	0	0	136.896
20305	**140**	**271**	3,21%	301	686	0	0	643.843
20405	**182**	**364**	0,00%	333	393	0	0	549.696
20505	**224**	**441**	1,56%	449	1149	0	0	122.874
20605	**182**	**364**	0,00%	230	874	0	0	654.459
20705	**224**	**446**	0,45%	396	771	0	0	112.804
20805	**196**	**387**	1,28%	319	483	0	0	110.383
20905	**201**	**382**	4,98%	751	1578	0	0	135.522
21005	**280**	**560**	0,00%	532	816	0	0	181.168
21106	**499**	**652**	34,67%	2506	2966	0	0	670.937
21206	**293**	**572**	2,39%	1506	2090	0	0	522.726
21306	**287**	**501**	12,72%	697	1157	0	0	188.654
21406	**245**	**490**	0,00%	1525	2360	0	0	606.450
21506	**351**	**659**	6,13%	1126	2111	0	0	410.378
21606	**342**	**635**	7,16%	894	1252	0	0	229.323
21706	**331**	**630**	4,83%	2625	4309	0	0	938.868
21806	**286**	**550**	3,85%	2522	3785	0	0	976.753
21906	**231**	**443**	4,11%	2039	4298	0	1	824.632
22006	**351**	**622**	11,40%	2074	3349	0	0	691.834
22107	**180**	**360**	0,00%	9627	16886	0	4	812.323
22207	**593**	**763**	35,67%	1877	2654	0	0	463.873
22307	**403**	**662**	17,87%	4313	6817	0	1	537.528
22407	**577**	**745**	35,44%	5125	6194	0	1	440.332
22507	**400**	**739**	7,63%	1827	2448	0	0	578.160
22607	**217**	**404**	6,91%	28518	40056	0	18	862.974
22707	**256**	**504**	1,56%	19541	28092	0	11	696.934
22807	**322**	**596**	7,45%	7023	9478	0	2	576.026
22907	**429**	**765**	10,84%	3097	4985	0	1	821.958
23007	**504**	**824**	18,25%	3944	5342	0	1	437.068
23108	**648**	**784**	39,51%	6989	7880	0	2	273.469
23208	**532**	**698**	34,40%	2880	3781	0	0	617.549
23308	**623**	**809**	35,07%	497	637	0	0	958.701
23408	**619**	**772**	37,64%	5594	7052	0	1	735.743
23508	**718**	**880**	38,72%	5045	6521	0	1	583.350
23608	**498**	**637**	36,04%	11005	12471	0	3	628.959
23708	**344**	**655**	4,80%	19348	23263	0	10	628.278
23808	**412**	**639**	22,45%	6341	7896	0	2	845.954
23908	**342**	**684**	0,00%	29473	31034	0	11	953.045

24008	**307**	**554**	9,77%	46517	50879	0	28	906.921
24109	**386**	**676**	12,44%	25446	27945	0	10	587.978
24209	**435**	**788**	9,43%	258636	291711	3	13	289.697
24309	**683**	**868**	36,46%	8251	9552	0	2	248.732
24409	**684**	**857**	37,35%	5730	7400	0	1	475.161
24509	**560**	**721**	35,63%	4947	6476	0	1	221.674
24609	**652**	**840**	35,58%	2178	2230	0	0	448.433
24709	**446**	**777**	12,89%	155372	179871	1	50	644.627
24809	**360**	**630**	12,50%	70335	86818	0	40	160.361
24909	**787**	**992**	36,98%	1029	1214	0	0	260.095
25009	**662**	**832**	37,16%	7363	9473	0	1	881.991
25110	**347**	**694**	0,00%	173287	186835	2	3	785.062
25210	**771**	**964**	37,48%	17980	21808	0	5	510.819
25310	**357**	**714**	0,00%	109940	134747	1	30	826.827
25410	**687**	**897**	34,72%	1565	1687	0	0	344.247
25510	**828**	**1656**	0,00%	7861	7993	0	2	192.137
25610	**494**	**851**	13,87%	140873	177118	1	28	129.765
25710	**885**	**1037**	41,41%	6861	10305	0	1	893.507
25810	**831**	**1034**	37,79%	4808	6274	0	1	151.258
25910	**405**	**722**	10,86%	82389	94679	0	44	127.861
26010	**571**	**890**	22,07%	36823	44509	0	16	935.139

Set 3 (W1, H3)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
30105	**314**	**610**	2,87%	401	1033	0	0	101.676
30205	**192**	**384**	0,00%	316	917	0	0	106.131
30305	**160**	**320**	0,00%	199	432	0	0	518.176
30405	**409**	**592**	27,63%	139	212	0	0	208.405
30505	**262**	**524**	0,00%	652	807	0	0	105.692
30605	**310**	**612**	1,29%	528	840	0	0	142.603
30705	**250**	**488**	2,40%	713	1210	0	0	241.209
30805	**192**	**384**	0,00%	223	743	0	0	688.892
30905	**284**	**512**	9,86%	227	830	0	0	728.049
31005	**323**	**523**	19,04%	439	697	0	0	669.702
31106	**491**	**659**	32,89%	1564	1957	0	0	343.320
31206	**207**	**410**	0,97%	2588	6421	0	0	858.554
31306	**350**	**628**	10,29%	1413	3163	0	0	433.717
31406	**602**	**792**	34,22%	616	805	0	0	134.894
31506	**472**	**680**	27,97%	462	508	0	0	947.297
31606	**383**	**545**	28,85%	157	176	0	0	21.604
31706	**294**	**574**	2,38%	2036	4210	0	0	965.916
31806	**284**	**564**	0,70%	2379	3204	0	0	585.723
31906	**421**	**578**	31,35%	540	787	0	0	100.551
32006	**266**	**516**	3,01%	3468	4494	0	1	747.117
32107	**529**	**1058**	0,00%	747	769	0	0	141.721
32207	**595**	**801**	32,69%	725	910	0	0	138.635
32307	**658**	**1316**	0,00%	473	483	0	0	613.728
32407	**236**	**466**	1,27%	22457	49614	0	15	397.981
32507	**589**	**1178**	0,00%	954	978	0	0	194.891
32607	**519**	**688**	33,72%	1429	1700	0	0	317.843
32707	**260**	**479**	7,88%	13742	21429	0	9	511.361
32807	**473**	**795**	15,96%	2636	3879	0	0	886.511
32907	**590**	**806**	31,69%	1523	2021	0	0	333.912

33007	**250**	**470**	6,00%	10060	11018	0	6	104.618
33108	**628**	**901**	28,26%	2843	3659	0	0	955.543
33208	**392**	**717**	8,55%	9817	11822	0	3	831.771
33308	**527**	**653**	38,05%	3211	4368	0	0	905.042
33408	**443**	**749**	15,46%	8721	11943	0	3	877.528
33508	**603**	**979**	18,82%	646	719	0	0	119.830
33608	**544**	**970**	10,85%	15659	21377	0	6	920.545
33708	**601**	**860**	28,45%	652	1185	0	0	145.475
33808	**410**	**770**	6,10%	20263	27800	0	10	474.863
33908	**609**	**794**	34,81%	721	932	0	0	144.277
34008	**289**	**578**	0,00%	68224	123770	0	46	336.941
34109	**606**	**861**	28,96%	17155	21359	0	6	198.282
34209	**861**	**1137**	33,97%	1200	1374	0	0	246.597
34309	**818**	**1083**	33,80%	1947	2771	0	0	412.268
34409	**461**	**850**	7,81%	30738	34183	0	15	808.711
34509	**580**	**914**	21,21%	19203	22988	0	7	406.756
34609	**715**	**896**	37,34%	2378	2889	0	0	622.055
34709	**344**	**688**	0,00%	20173	29091	0	12	533.177
34809	**700**	**935**	33,21%	3517	4644	0	1	156.960
34909	**424**	**800**	5,66%	527839	587887	8	23	779.703
35009	**880**	**1048**	40,45%	8861	10808	0	2	697.182
35110	**737**	**922**	37,45%	94012	100098	0	40	833.944
35210	**559**	**939**	16,01%	49586	55564	0	26	310.784
35310	**825**	**1024**	37,94%	20162	26596	0	5	884.516
35410	**693**	**869**	37,30%	11512	12859	0	3	325.117
35510	**934**	**1188**	36,40%	1232	1449	0	0	268.918
35610	**856**	**1070**	37,50%	25365	31012	0	8	811.995
35710	**804**	**1024**	36,32%	16632	18368	0	5	781.287
35810	**866**	**1051**	39,32%	2858	3770	0	0	733.557
35910	**752**	**921**	38,76%	25803	30177	0	9	546.019
36010	**571**	**994**	12,96%	64196	74601	0	37	615.194

Set 4 (W2, H1)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
40105	**138**	**276**	0,00%	177	794	0	0	434.805
40205	**194**	**364**	6,19%	288	687	0	0	728.113
40305	**230**	**460**	0,00%	308	1406	0	0	715.605
40405	**138**	**276**	0,00%	225	1014	0	0	431.516
40505	**254**	**508**	0,00%	455	959	0	0	714.483
40605	**144**	**288**	0,00%	199	326	0	0	505.889
40705	**184**	**368**	0,00%	386	1928	0	0	123.485
40805	**214**	**428**	0,00%	326	965	0	0	719.797
40905	**155**	**310**	0,00%	173	548	0	0	388.837
41005	**138**	**276**	0,00%	323	1008	0	0	557.252
41106	**211**	**395**	6,40%	3827	12904	0	1	558.790
41206	**266**	**492**	7,52%	3122	8074	0	1	339.609
41306	**244**	**488**	0,00%	531	1082	0	0	163.805
41406	**316**	**524**	17,09%	4702	9599	0	1	863.328
41506	**287**	**546**	4,88%	3217	6577	0	0	971.528
41606	**221**	**442**	0,00%	2629	3054	0	0	953.478
41706	**165**	**330**	0,00%	1206	3400	0	0	238.414
41806	**160**	**320**	0,00%	1598	3997	0	0	572.238
41906	**211**	**412**	2,37%	2096	4223	0	0	561.860

42006	**236**	**440**	6,78%	1333	4122	0	0	533.496
42107	**204**	**401**	1,72%	14916	29274	0	9	151.220
42207	**282**	**564**	0,00%	8287	11718	0	3	168.190
42307	**423**	**686**	18,91%	7441	11089	0	2	768.784
42407	**204**	**408**	0,00%	27020	49804	0	15	104.445
42507	**288**	**576**	0,00%	5717	8761	0	1	877.063
42607	**249**	**455**	8,63%	11066	27240	0	6	229.429
42707	**220**	**440**	0,00%	8508	9675	0	5	451.742
42807	**431**	**728**	15,55%	11984	17837	0	4	416.047
42907	**304**	**608**	0,00%	14997	22418	0	7	836.030
43007	**361**	**678**	6,09%	3726	5652	0	1	449.107
43108	**370**	**594**	19,73%	12018	17724	0	3	771.396
43208	**537**	**771**	28,21%	29654	40738	0	12	608.075
43308	**532**	**732**	31,20%	1542	2631	0	0	263.445
43408	**244**	**488**	0,00%	53340	102756	0	35	157.630
43508	**265**	**448**	15,47%	60143	117538	0	37	147.583
43608	**273**	**544**	0,37%	50640	62885	0	30	664.517
43708	**208**	**397**	4,57%	154439	349869	1	59	975.119
43808	**194**	**388**	0,00%	98031	279839	1	1	317.297
43908	**250**	**500**	0,00%	157455	256918	1	24	964.464
44008	**188**	**376**	0,00%	348934	862885	4	39	669.158
44109	**357**	**631**	11,62%	850305	919927	11	8	615.698
44209	**254**	**508**	0,00%	836928	1864791	25	42	995.640
44309	**401**	**703**	12,34%	116622	124698	0	51	689.107
44409	**497**	**779**	21,63%	12588	17465	0	4	983.386
44509	**546**	**809**	25,92%	16677	19630	0	6	667.206
44609	**509**	**813**	20,14%	85649	95090	0	34	638.556
44709	**524**	**718**	31,49%	61130	80514	0	27	199.020
44809	**602**	**771**	35,96%	22963	29241	0	9	848.659
44909	**384**	**655**	14,71%	88949	103804	0	48	455.571
45009	**310**	**566**	8,71%	540801	962983	13	47	964.448
45110	**677**	**826**	39,00%	46415	51719	0	16	455.762
45210	**825**	**964**	41,58%	12855	16980	0	3	743.797
45310	**459**	**847**	7,73%	812651	1025619	15	0	650.105
45410	**451**	**804**	10,86%	281075	325906	2	46	121.459
45510	**320**	**552**	13,75%	1035269	1449472	28	19	370.472
45610	**748**	**931**	37,77%	32673	40449	0	9	569.519
45710	**312**	**608**	2,56%	1250780	1424454	22	51	80.708
45810	**568**	**871**	23,33%	65074	80716	0	24	981.231
45910	**376**	**601**	20,08%	501275	608834	9	51	566.306
46010	**643**	**928**	27,84%	19069	26065	0	6	410.382

Set 5 (W2, H2)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
50105	**156**	**312**	0,00%	204	809	0	0	41.062
50205	**294**	**502**	14,63%	145	259	0	0	207.014
50305	**300**	**564**	6,00%	433	910	0	0	899.827
50405	**130**	**260**	0,00%	254	669	0	0	442.055
50505	**270**	**528**	2,22%	465	688	0	0	101.149
50605	**208**	**416**	0,00%	691	1982	0	0	221.020
50705	**175**	**350**	0,00%	306	1091	0	0	760.255
50805	**156**	**312**	0,00%	292	1536	0	0	74.074
50905	**130**	**260**	0,00%	95	149	0	0	152.491

51005	**261**	**522**	0,00%	747	1372	0	0	200.500
51106	**217**	**420**	3,23%	587	1401	0	0	185.956
51206	**408**	**590**	27,70%	569	709	0	0	993.883
51306	**406**	**589**	27,46%	470	584	0	0	772.852
51406	**319**	**603**	5,49%	553	1234	0	0	123.207
51506	**174**	**348**	0,00%	1612	1808	0	0	502.685
51606	**186**	**372**	0,00%	2672	7396	0	0	761.933
51706	**155**	**310**	0,00%	2587	7045	0	0	664.643
51806	**297**	**594**	0,00%	2543	4804	0	1	268.298
51906	**382**	**632**	17,28%	1535	2143	0	0	436.555
52006	**206**	**399**	3,16%	1835	3360	0	0	738.556
52107	**216**	**432**	0,00%	7452	12702	0	3	442.296
52207	**266**	**532**	0,00%	26100	38595	0	16	842.766
52307	**317**	**605**	4,57%	3976	5576	0	1	914.074
52407	**374**	**641**	14,30%	10046	13721	0	4	197.446
52507	**180**	**360**	0,00%	5439	16145	0	1	544.887
52607	**266**	**532**	0,00%	29059	76978	0	12	714.336
52707	**442**	**753**	14,82%	4084	6574	0	1	331.364
52807	**499**	**673**	32,57%	1166	1906	0	0	223.114
52907	**349**	**562**	19,48%	4447	6706	0	1	292.333
53007	**525**	**701**	33,24%	1332	1715	0	0	243.647
53108	**541**	**665**	38,54%	3615	5478	0	0	970.227
53208	**297**	**567**	4,55%	174956	327511	1	36	383.576
53308	**301**	**575**	4,49%	72277	163218	0	43	811.244
53408	**472**	**801**	15,15%	32087	43821	0	16	845.181
53508	**301**	**602**	0,00%	122795	176164	1	44	588.498
53608	**385**	**702**	8,83%	128198	224493	1	29	640.791
53708	**530**	**805**	24,06%	9847	12837	0	3	686.941
53808	**384**	**699**	8,98%	31993	62127	0	17	360.021
53908	**364**	**728**	0,00%	38898	78316	0	16	359.316
54008	**616**	**789**	35,96%	4315	4751	0	1	126.449
54109	**384**	**700**	8,85%	263038	366923	3	51	224.365
54209	**288**	**576**	0,00%	739851	1117609	17	54	926.862
54309	**601**	**808**	32,78%	2541	3434	0	0	473.878
54409	**366**	**705**	3,69%	149020	187541	1	35	471.283
54509	**271**	**530**	2,21%	1000012	1192043	35	30	973.986
54609	**542**	**880**	18,82%	90203	102916	0	34	407.742
54709	**350**	**690**	1,43%	869577	1246060	9	8	250.322
54809	**393**	**718**	8,65%	43928	63001	0	18	120.909
54909	**457**	**807**	11,71%	109275	141807	0	56	594.715
55009	**258**	**512**	0,78%	645107	1749054	9	2	655.538
55110	**762**	**957**	37,20%	7052	9920	0	2	527.478
55210	**553**	**940**	15,01%	417127	489127	4	6	371.331
55310	**825**	**999**	39,45%	13477	19929	0	4	201.104
55410	**750**	**1061**	29,27%	82839	123034	0	32	157.832
55510	**445**	**890**	0,00%	96509	163951	0	36	427.686
55610	**744**	**947**	36,36%	12490	23220	0	4	871.032
55710	**586**	**923**	21,25%	64546	83838	0	22	341.903
55810	**607**	**963**	20,68%	107416	163366	0	40	483.590
55910	**437**	**778**	10,98%	1000014	1059804	11	1	640.483
56010	**591**	**949**	19,71%	52284	69043	0	21	843.557

Set 6 (W2, H3)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
60105	**160**	**320**	0,00%	269	698	0	0	764.391
60205	**207**	**399**	3,62%	417	1605	0	0	110.415
60305	**160**	**320**	0,00%	268	1208	0	0	68.194
60405	**354**	**577**	18,50%	284	686	0	0	606.237
60505	**252**	**495**	1,79%	778	1390	0	0	145.251
60605	**238**	**460**	3,36%	459	1010	0	0	130.496
60705	**197**	**394**	0,00%	197	483	0	0	44.259
60805	**368**	**544**	26,09%	238	314	0	0	384.777
60905	**170**	**340**	0,00%	621	1437	0	0	105.377
61005	**272**	**544**	0,00%	620	1354	0	0	150.884
61106	**228**	**456**	0,00%	3501	4879	0	0	896.685
61206	**412**	**753**	8,62%	2852	5219	0	0	942.440
61306	**405**	**765**	5,56%	2836	4208	0	0	851.384
61406	**414**	**753**	9,06%	148	212	0	0	201.897
61506	**279**	**499**	10,57%	618	1352	0	0	138.030
61606	**442**	**730**	17,42%	936	1574	0	0	278.083
61706	**360**	**720**	0,00%	1963	2717	0	0	731.318
61806	**382**	**626**	18,06%	2021	3050	0	0	373.944
61906	**307**	**575**	6,35%	852	2012	0	0	247.699
62006	**395**	**709**	10,25%	1968	2737	0	0	351.138
62107	**252**	**504**	0,00%	7378	13537	0	3	554.220
62207	**233**	**464**	0,43%	32632	64303	0	14	152.719
62307	**400**	**798**	0,25%	9806	11932	0	3	451.689
62407	**518**	**880**	15,06%	4270	6023	0	1	182.702
62507	**448**	**798**	10,94%	12502	30359	0	5	649.299
62607	**324**	**588**	9,26%	11846	21793	0	5	953.745
62707	**435**	**817**	6,09%	9201	14739	0	3	750.840
62807	**334**	**611**	8,53%	8999	13876	0	4	614.174
62907	**502**	**804**	19,92%	555	1057	0	0	113.157
63007	**692**	**887**	35,91%	1334	2475	0	0	301.070
63108	**697**	**872**	37,45%	7854	9722	0	2	447.500
63208	**548**	**916**	16,42%	6373	7541	0	1	922.620
63308	**603**	**957**	20,65%	4011	5464	0	1	218.086
63408	**629**	**977**	22,34%	18418	28437	0	6	735.468
63508	**453**	**813**	10,26%	12542	15052	0	6	381.009
63608	**622**	**815**	34,49%	3293	4721	0	0	796.801
63708	**774**	**970**	37,34%	6585	13192	0	1	975.450
63808	**703**	**1030**	26,74%	315	411	0	0	486.114
63908	**544**	**836**	23,16%	5811	8104	0	2	228.309
64008	**755**	**1010**	33,11%	639	822	0	0	130.749
64109	**455**	**810**	10,99%	126944	148683	1	22	436.634
64209	**754**	**988**	34,48%	10069	11524	0	2	467.816
64309	**548**	**913**	16,70%	34535	45703	0	12	227.218
64409	**558**	**908**	18,64%	34330	44419	0	14	335.428
64509	**496**	**852**	14,11%	70284	89827	0	28	863.455
64609	**739**	**987**	33,22%	1611	2066	0	0	304.870
64709	**370**	**700**	5,41%	62984	78118	0	38	137.657
64809	**785**	**1039**	33,82%	21196	24227	0	6	768.310
64909	**603**	**841**	30,27%	554	709	0	0	94.560
65009	**851**	**1069**	37,19%	4703	6499	0	1	581.790
65110	**350**	**700**	0,00%	333358	366541	5	12	963.882

65210	**538**	**946**	12,08%	138193	170999	1	9	953.565
65310	**867**	**1098**	36,68%	12422	15013	0	3	675.128
65410	**732**	**963**	34,22%	807	1207	0	0	164.236
65510	**751**	**984**	34,49%	15161	18917	0	4	459.354
65610	**718**	**998**	30,50%	887	958	0	0	172.654
65710	**812**	**1077**	33,68%	1040	1129	0	0	181.233
65810	**899**	**1226**	31,81%	9899	14506	0	2	778.408
65910	**582**	**886**	23,88%	32329	42299	0	10	979.935
66010	**536**	**940**	12,31%	155030	174999	1	7	798.855

Set 7 (W3, H1)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
70105	**126**	**252**	0,00%	88	101	0	0	148.712
70205	**158**	**316**	0,00%	355	2298	0	0	87.312
70305	**126**	**252**	0,00%	204	411	0	0	267.292
70405	**168**	**336**	0,00%	439	2153	0	0	954.019
70505	**210**	**420**	0,00%	287	1060	0	0	475.548
70605	**210**	**420**	0,00%	337	1072	0	0	497.528
70705	**154**	**308**	0,00%	207	943	0	0	389.007
70805	**127**	**254**	0,00%	181	724	0	0	320.982
70905	**129**	**258**	0,00%	294	2271	0	0	842.273
71005	**211**	**422**	0,00%	424	3152	0	0	114.987
71106	**175**	**350**	0,00%	3803	16500	0	0	855.528
71206	**255**	**510**	0,00%	4070	18387	0	1	47.003
71306	**153**	**306**	0,00%	4316	12356	0	1	467.876
71406	**130**	**260**	0,00%	1896	11053	0	0	458.332
71506	**226**	**452**	0,00%	3341	8147	0	0	554.532
71606	**257**	**514**	0,00%	4927	28507	0	1	620.122
71706	**161**	**322**	0,00%	3682	19298	0	0	891.650
71806	**204**	**408**	0,00%	3891	21462	0	1	120.297
71906	**188**	**376**	0,00%	1010	2826	0	0	191.724
72006	**124**	**248**	0,00%	820	2005	0	0	120.438
72107	**180**	**360**	0,00%	16047	43303	0	4	488.688
72207	**206**	**412**	0,00%	30410	118250	0	20	547.675
72307	**224**	**448**	0,00%	10521	30271	0	2	934.173
72407	**224**	**448**	0,00%	10764	19414	0	3	374.396
72507	**203**	**406**	0,00%	42578	123540	0	20	173.344
72607	**226**	**452**	0,00%	23024	66982	0	8	408.502
72707	**195**	**390**	0,00%	17008	48648	0	5	656.123
72807	**224**	**448**	0,00%	10634	25172	0	3	437.566
72907	**206**	**412**	0,00%	35060	131964	0	24	239.107
73007	**248**	**496**	0,00%	10029	26953	0	3	118.488
73108	**229**	**458**	0,00%	171650	318019	6	26	497.747
73208	**322**	**560**	13,04%	250391	1336763	6	50	824.746
73308	**223**	**446**	0,00%	86382	142166	1	25	604.646
73408	**207**	**408**	1,45%	187225	714970	4	23	401.413
73508	**190**	**380**	0,00%	28532	57965	0	14	106.399
73608	**209**	**418**	0,00%	34560	61046	0	19	162.340
73708	**299**	**598**	0,00%	238503	1186477	6	33	501.575
73808	**270**	**540**	0,00%	89128	107032	1	57	551.554
73908	**277**	**554**	0,00%	165512	555449	2	20	489.895
74008	**394**	**727**	7,74%	350216	1248615	6	47	431.821
74109	**254**	**508**	0,00%	955868	3833872	15	42	752.158

*74209	**311**	**622**	0,00%	792513	4456408	19	55	615.361
74309	**378**	**756**	0,00%	216394	545201	1	17	588.476
74409	**222**	**444**	0,00%	661435	2192829	6	0	512.655
74509	**323**	**646**	0,00%	243421	846707	1	45	588.299
74609	**222**	**444**	0,00%	543907	2068188	4	37	660.990
74709	**422**	**844**	0,00%	**1000007**	1189265	7	2	584.745
74809	**254**	**508**	0,00%	974123	4015240	17	15	352.493
74909	**322**	**613**	4,81%	683685	2413623	8	36	393.352
75009	**365**	**730**	0,00%	277135	1313616	2	28	961.125
75110	**202**	**404**	0,00%	**1000011**	2372727	8	52	920.526
75210	**321**	**584**	9,03%	**1000006**	2778827	12	3	355.665
75310	**364**	**728**	0,00%	**1000050**	1124431	21	10	743.912
75410	**249**	**498**	0,00%	**1000005**	3175678	12	44	529.516
75510	**202**	**404**	0,00%	**1000004**	3083557	12	56	264.617
75610	**352**	**675**	0,00%	**800002**	3695312	16	4	428.735
75710	**425**	**850**	0,00%	**1000015**	1203856	18	51	599.504
*75810	**264**	**501**	0,00%	**1000028**	4149822	19	17	13.812
75910	**340**	**680**	0,00%	**1000040**	2598710	15	35	307.954
76010	**210**	**420**	0,00%	**1000009**	3190928	14	40	855.868

Set 8 (W3, H2)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
80105	**145**	**290**	0,00%	247	849	0	0	490.077
80205	**208**	**416**	0,00%	474	3338	0	0	149.914
80305	**168**	**336**	0,00%	336	894	0	0	471.895
80405	**240**	**480**	0,00%	496	3201	0	0	138.431
80505	**234**	**468**	0,00%	534	3806	0	0	151.659
80605	**192**	**384**	0,00%	537	3712	0	0	135.599
80705	**130**	**260**	0,00%	126	953	0	0	346.594
80805	**120**	**240**	0,00%	201	359	0	0	297.156
80905	**156**	**312**	0,00%	310	2206	0	0	110.383
81005	**234**	**468**	0,00%	433	3516	0	0	124.402
81106	**261**	**522**	0,00%	5639	25324	0	1	551.927
81206	**186**	**371**	0,27%	3377	20722	0	1	280.686
81306	**232**	**464**	0,00%	3611	11405	0	0	916.676
81406	**203**	**406**	0,00%	4145	13430	0	0	911.790
81506	**203**	**406**	0,00%	3296	9585	0	0	604.825
81606	**261**	**522**	0,00%	1204	4015	0	0	300.795
81706	**170**	**340**	0,00%	3137	6232	0	0	664.231
81806	**261**	**522**	0,00%	2590	7818	0	0	693.329
81906	**248**	**480**	3,23%	2965	11843	0	0	723.018
82006	**261**	**519**	0,57%	3231	25144	0	1	131.157
82107	**180**	**360**	0,00%	18375	58409	0	4	446.957
82207	**273**	**546**	0,00%	31902	81917	0	8	299.173
82307	**170**	**340**	0,00%	9924	21845	0	2	814.236
82407	**244**	**480**	1,64%	61601	363212	0	49	412.318
82507	**268**	**536**	0,00%	47152	151756	0	20	348.202
82607	**224**	**448**	0,00%	14362	16190	0	6	119.663
82707	**204**	**408**	0,00%	13599	40110	0	4	442.354
82807	**170**	**340**	0,00%	25039	52825	0	11	596.237
82907	**224**	**448**	0,00%	10328	21830	0	2	764.094
83007	**242**	**480**	0,83%	41873	251429	0	18	966.374
83108	**200**	**400**	0,00%	248294	739907	7	27	657.621

83208	**300**	**600**	0,00%	113057	397246	1	12	566.410
83308	**338**	**676**	0,00%	229883	970050	10	37	916.362
83408	**277**	**554**	0,00%	279985	1088177	9	6	469.487
83508	**358**	**716**	0,00%	105947	354592	1	53	852.544
83608	**296**	**592**	0,00%	100281	348947	0	58	925.855
83708	**336**	**672**	0,00%	125387	475598	0	54	248.240
83808	**195**	**390**	0,00%	279637	919008	9	54	333.261
83908	**372**	**744**	0,00%	211863	1005625	8	13	900.584
84008	**257**	**514**	0,00%	166959	309915	3	10	888.236
84109	**331**	**626**	5,44%	**1000016**	2946370	12	34	827.440
84209	**251**	**502**	0,00%	261760	897218	1	45	252.096
84309	**338**	**676**	0,00%	**1000012**	3853741	15	14	620.714
84409	**363**	**680**	6,34%	922523	3406453	13	46	371.961
84509	**475**	**858**	9,68%	**1000002**	1449911	7	12	625.363
84609	**252**	**504**	0,00%	699743	1856503	4	55	830.042
84709	**381**	**762**	0,00%	48463	318960	0	32	705.291
84809	**257**	**514**	0,00%	973443	2595981	8	49	504.387
84909	**251**	**502**	0,00%	497455	1278523	2	50	227.557
85009	**390**	**780**	0,00%	155491	615805	1	8	622.572
85110	**272**	**544**	0,00%	**1000002**	2743402	11	13	634.673
85210	**238**	**476**	0,00%	**1000029**	2998141	14	7	381.588
85310	**235**	**470**	0,00%	**1000025**	3058504	12	4	474.556
85410	**510**	**973**	4,61%	397295	3295198	11	43	613.264
85510	**270**	**540**	0,00%	**1000001**	3124013	14	25	502.308
85610	**317**	**634**	0,00%	**1000059**	1108823	16	31	948.727
85710	**234**	**468**	0,00%	**1000008**	2452501	10	22	179.660
85810	**531**	**954**	10,17%	**1000003**	4015590	20	29	625.528
85910	**329**	**658**	0,00%	**1000006**	1981058	21	41	751.781
86010	**415**	**830**	0,00%	**1000081**	1000081	24	19	780.451

Set 9 (W3, H1)

Instance	**TC1**	**TC2**	time red.	solved graphs	explored graphs	min	sec	msec
90105	**320**	**620**	3,13%	509	4362	0	0	155.938
90205	**186**	**372**	0,00%	244	1630	0	0	612.603
90305	**240**	**480**	0,00%	450	3198	0	0	123.882
90405	**270**	**540**	0,00%	398	1353	0	0	659.765
90505	**210**	**420**	0,00%	373	844	0	0	644.638
90605	**210**	**420**	0,00%	422	1282	0	0	615.815
90705	**263**	**507**	3,61%	486	2386	0	0	110.875
90805	**251**	**502**	0,00%	482	5253	0	0	177.329
90905	**160**	**320**	0,00%	287	1368	0	0	575.953
91005	**256**	**512**	0,00%	543	5420	0	0	194.199
91106	**368**	**656**	10,87%	1616	7492	0	0	415.135
91206	**216**	**432**	0,00%	2651	6106	0	0	567.350
91306	**297**	**594**	0,00%	5819	69043	0	2	844.633
91406	**288**	**576**	0,00%	5130	17858	0	1	307.067
91506	**252**	**504**	0,00%	4684	14575	0	1	327.929
91606	**216**	**432**	0,00%	5160	15723	0	1	246.259
91706	**190**	**380**	0,00%	3713	21278	0	1	239.097
91806	**293**	**586**	0,00%	5085	26135	0	1	553.597
91906	**252**	**504**	0,00%	1218	4821	0	0	292.469
92006	**204**	**408**	0,00%	535	638	0	0	138.976
92107	**210**	**420**	0,00%	42256	173675	0	20	443.396

92207	**240**	**480**	0,00%	8089	14385	0	1	722.839
92307	**200**	**400**	0,00%	12574	21217	0	4	175.679
92407	**401**	**802**	0,00%	15645	30213	0	3	539.603
92507	**420**	**840**	0,00%	41556	254884	0	23	618.246
92607	**210**	**420**	0,00%	38829	86996	0	19	215.039
92707	**360**	**720**	0,00%	32868	105541	0	10	178.733
92807	**291**	**582**	0,00%	32280	167325	0	13	485.613
92907	**320**	**640**	0,00%	48847	81418	0	26	805.014
93007	**352**	**672**	4,55%	27832	113828	0	9	251.585
93108	**275**	**550**	0,00%	138565	457955	2	45	620.357
93208	**230**	**460**	0,00%	163941	207409	3	45	661.938
93308	**365**	**709**	2,88%	539500	2409198	24	32	636.525
93408	**360**	**720**	0,00%	143043	293444	2	24	502.913
93508	**462**	**878**	4,98%	162558	339481	1	0	950.975
93608	**455**	**879**	3,41%	40046	210542	0	14	882.141
93708	**450**	**877**	2,56%	95946	332874	0	30	325.709
93808	**322**	**644**	0,00%	262411	912947	18	49	402.370
93908	**288**	**576**	0,00%	384614	1298067	13	5	770.520
94008	**400**	**784**	2,00%	620645	2582944	37	54	283.777
94109	**416**	**821**	1,32%	452028	1436620	12	11	122.815
94209	**455**	**871**	4,29%	**1000012**	1849092	9	57	737.303
94309	**312**	**624**	0,00%	**1000019**	3209868	14	22	193.289
94409	**483**	**966**	0,00%	**1000008**	1838689	11	21	306.390
94509	**270**	**530**	1,85%	**1000019**	3217672	15	15	224.812
94609	**350**	**700**	0,00%	61679	183271	0	22	356.107
94709	**454**	**908**	0,00%	485885	2866071	9	22	737.226
94809	**445**	**848**	4,72%	**1000033**	3257494	17	2	811.780
94909	**320**	**640**	0,00%	544815	3264601	11	9	769.562
95009	**392**	**757**	3,44%	969204	4238600	20	37	654.204
95110	**434**	**868**	0,00%	**1000043**	1135193	14	5	224.007
95210	**608**	**1066**	12,34%	868878	3313790	15	34	694.282
95310	**599**	**1088**	9,18%	**1000007**	2015806	9	25	688.112
95410	**464**	**928**	0,00%	**1000030**	2068728	16	36	585.848
95510	**384**	**768**	0,00%	**1000009**	1000009	38	49	389.406
95610	**654**	**1308**	0,00%	**1000004**	1000004	9	24	151.383
95710	**372**	**744**	0,00%	**1000046**	1591432	14	26	320.390
95810	**336**	**672**	0,00%	**1000008**	2708622	14	45	357.683
95910	**423**	**822**	2,84%	**1000032**	3369890	16	9	722.735
96010	**432**	**850**	1,62%	**1000010**	2673226	14	49	297.773

ANNEX 2

Set 1 (5 tanks)

	instance	**TC**	solved graphs	explored graphs		**TC1**		**TC2**	time reduction
1	104040705	**368**	296	1272	104	**198**	407	**184**	3,66%
2	105040905	**319**	225	734	105	**158**	409	**155**	-1,92%
3	109040505	**489**	156	309	109	**252**	405	**254**	3,36%
4	102040605	**347**	322	669	102	**185**	406	**144**	-5,47%
5	103040805	**405**	354	576	103	**240**	408	**214**	10,79%
6	107070405	**370**	520	2648	107	**195**	704	**168**	-1,93%
7	109070605	**466**	298	753	109	**252**	706	**210**	-0,87%
8	102070205	**333**	563	1472	102	**185**	702	**158**	2,92%
9	102070705	**338**	544	1060	102	**185**	707	**154**	0,29%
10	101070405	**373**	513	1582	101	**214**	704	**168**	2,36%
11	205050605	**432**	506	1336	205	**224**	506	**208**	0,00%
12	203050905	**260**	158	427	203	**140**	509	**130**	3,70%
13	208050705	**376**	260	438	208	**196**	507	**190**	2,59%
14	209050705	**377**	429	1208	209	**201**	507	**190**	3,58%
15	204050805	**325**	344	919	204	**182**	508	**156**	3,85%
16	201080405	**494**	115	175	201	**346**	804	**204**	10,18%
17	207080605	**384**	452	914	207	**224**	806	**192**	7,69%
18	209080305	**368**	568	2267	209	**201**	803	**168**	0,27%
19	205080205	**421**	570	2029	205	**224**	802	**208**	2,55%
20	204080905	**325**	562	1082	204	**182**	809	**156**	3,85%
21	308060205	**392**	574	1443	308	**192**	602	**207**	1,75%
22	301060405	**594**	329	544	301	**314**	604	**354**	11,08%
23	304060405	**576**	223	413	304	**409**	604	**354**	24,51%
24	303060905	**323**	344	862	303	**160**	609	**170**	2,12%
25	309060805	**546**	285	566	309	**284**	608	**368**	16,26%
26	309090705	**512**	364	1457	309	**284**	907	**263**	6,40%
27	308090205	**388**	366	1821	308	**192**	902	**186**	-2,65%
28	303090905	**331**	437	1202	303	**160**	909	**160**	-3,44%
29	302090205	**383**	289	1825	302	**192**	902	**186**	-1,32%
30	304090405	**558**	199	425	304	**409**	904	**270**	17,82%

Set 2 (6 tanks)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	**111041606**	450	1583	2952	**111**	220	**416**	221	-2,04%
2	**111042006**	440	1484	3057	**111**	220	**420**	236	3,51%
3	**116041806**	337	2249	3777	**116**	171	**418**	160	-1,81%
4	**116041706**	336	2007	3281	**116**	171	**417**	165	0,00%
5	**117041706**	366	3663	8223	**117**	189	**417**	165	-3,39%
6	**120072006**	269	1526	5088	**120**	144	**720**	124	-0,37%
7	**116071306**	316	3170	4994	**116**	171	**713**	153	2,47%
8	**119071306**	332	3467	9569	**119**	194	**713**	153	4,32%
9	**112071606**	525	1125	2169	**112**	413	**716**	257	21,64%
10	**117071706**	362	5342	12429	**117**	189	**717**	161	-3,43%
11	**213051106**	461	835	1495	**213**	287	**511**	217	8,53%
12	**217051806**	596	1942	3631	**217**	331	**518**	297	5,10%
13	**215051806**	621	1450	3249	**215**	351	**518**	297	4,17%
14	**211051406**	606	742	1140	**211**	499	**514**	319	25,92%

15	**211051806**	662	2322	3808	**211**	499	**518**	297	16,83%
16	**218081906**	499	3065	5456	**218**	286	**819**	248	6,55%
17	**217081606**	581	2649	5815	**217**	331	**816**	261	1,86%
18	**219081406**	420	2674	5903	**219**	231	**814**	203	3,23%
19	**215081106**	567	2134	6776	**215**	351	**811**	261	7,35%
20	**216081606**	583	1115	3879	**216**	342	**816**	261	3,32%
21	**314061406**	739	190	309	**314**	602	**614**	414	27,26%
22	**318061506**	510	1245	1530	**318**	284	**615**	279	9,41%
23	**316061906**	548	245	329	**316**	383	**619**	307	20,58%
24	**311062006**	653	816	1317	**311**	491	**620**	395	26,30%
25	**319061906**	568	858	1209	**319**	421	**619**	307	21,98%
26	**315091306**	586	689	2553	**315**	472	**913**	297	23,80%
27	**318091606**	477	3629	9473	**318**	284	**916**	216	4,60%
28	**311091306**	632	2625	5233	**311**	491	**913**	297	19,80%
29	**316091906**	525	251	489	**316**	383	**919**	252	17,32%
30	**312091706**	386	2349	10857	**312**	207	**917**	190	2,77%

Set 3 (7 tanks)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	**130042607**	446	9156	26220	**130**	220	**426**	249	4,90%
2	**125043007**	653	7058	10174	**125**	371	**430**	361	10,79%
3	**127042807**	690	1045	1562	**127**	480	**428**	431	24,26%
4	**128042407**	408	10874	23846	**128**	216	**424**	204	2,86%
5	**126043007**	622	1143	1527	**126**	471	**430**	361	25,24%
6	**130072707**	418	17600	51176	**130**	220	**727**	205	1,65%
7	**126073007**	598	2890	5953	**126**	471	**730**	248	16,83%
8	**130072507**	426	22932	58696	**130**	220	**725**	203	-0,71%
9	**228052607**	558	6616	11303	**228**	322	**526**	266	5,10%
10	**228052607**	558	6616	11303	**228**	322	**526**	266	5,10%
11	**223052407**	635	4575	6404	**223**	403	**524**	374	18,28%
12	**228052907**	578	5843	8647	**228**	322	**529**	349	13,86%
13	**226052507**	370	10856	22726	**226**	217	**525**	180	6,80%
14	**226082807**	360	22293	51552	**226**	217	**828**	170	6,98%
15	**223082207**	579	10779	20335	**223**	403	**822**	273	14,35%
16	**223082507**	600	13095	27558	**223**	403	**825**	268	10,58%
17	**227082707**	452	26464	60747	**227**	256	**827**	204	1,74%
18	**228082607**	539	12187	24068	**228**	322	**826**	224	1,28%
19	**325062907**	775	539	873	**325**	589	**629**	502	28,96%
20	**330062207**	460	14918	20324	**330**	250	**622**	233	4,76%
21	**328062307**	788	2584	3844	**328**	473	**623**	400	9,74%
22	**328062707**	784	2822	4438	**328**	473	**627**	435	13,66%
23	**329062707**	778	1613	2143	**329**	590	**627**	435	24,10%
24	**323092507**	910	1656	3511	**323**	658	**925**	420	15,58%
25	**326092807**	658	5996	10416	**326**	519	**928**	291	18,77%
26	**325092707**	741	3664	6178	**325**	589	**927**	360	21,92%
27	**328092907**	724	7508	18981	**328**	473	**929**	320	8,70%
28	**327092307**	438	20876	51300	**327**	260	**923**	200	4,78%

Set 4 (8 tanks)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	**139044008**	412	68470	102263	**139**	238	**440**	188	3,29%
2	**140043108**	585	15918	19589	**140**	374	**431**	370	21,37%
3	**133043108**	605	10056	13455	**133**	407	**431**	370	22,14%
4	**138043708**	390	95173	134113	**138**	225	**437**	208	9,93%
5	**137073308**	583	101570	183409	**137**	368	**733**	223	1,35%
6	**134073908**	645	48262	88166	**134**	569	**739**	277	23,76%
7	**136073908**	680	59786	108821	**136**	416	**739**	277	1,88%
8	**131073308**	579	251878	392683	**131**	330	**733**	223	-4,70%
9	**131073608**	573	294501	571552	**131**	330	**736**	209	-6,31%
10	**237053208**	582	53042	80330	**237**	344	**532**	297	9,20%
11	**236053208**	563	29303	39708	**236**	498	**532**	297	29,18%
12	**234053408**	776	11649	14513	**234**	619	**534**	472	28,87%
13	**232053108**	676	2294	3239	**232**	532	**531**	541	37,00%
14	**239053208**	570	56125	79122	**239**	342	**532**	297	10,80%
15	**232083608**	627	10550	20137	**232**	532	**836**	296	24,28%
16	**233083908**	805	2599	5639	**233**	623	**839**	372	19,10%
17	**240083108**	490	91434	127762	**240**	307	**831**	200	3,35%
18	**240083808**	410	36527	81239	**240**	307	**838**	195	18,33%
19	**231083608**	712	55816	117126	**231**	648	**836**	296	24,58%
20	**335063308**	1065	1096	1226	**335**	603	**633**	603	11,69%
21	**335063708**	1066	2236	2817	**335**	603	**637**	774	22,59%
22	**337063608**	831	1629	2607	**337**	601	**636**	622	32,05%
23	**336063608**	922	5839	7984	**336**	544	**636**	622	20,93%
24	**339063908**	809	932	1190	**339**	609	**639**	544	29,84%
25	**336094008**	878	112372	255822	**336**	544	**940**	400	6,99%
26	**340093208**	515	220353	317346	**340**	289	**932**	230	0,77%
27	**335093508**	980	3695	6108	**335**	603	**935**	462	7,98%
28	**335093708**	972	2409	3435	**335**	603	**937**	468	9,24%
29	**338093908**	627	114933	208752	**338**	410	**939**	288	10,17%

Set 5 (9 tanks)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	**144044509**	794	3216	3533	**144**	610	**445**	546	31,31%
2	**142044509**	799	5588	6636	**142**	664	**445**	546	33,97%
3	**148044309**	711	57982	67241	**148**	482	**443**	401	19,48%
4	**146044509**	793	8373	9817	**146**	659	**445**	546	34,19%
5	**148044709**	692	41225	55331	**148**	482	**447**	524	31,21%
6	**148074809**	660	611313	1104811	**148**	482	**748**	254	10,33%
7	**142074509**	773	15610	24192	**142**	664	**745**	323	21,68%
8	**141074409**	569	122243	196202	**141**	479	**744**	222	18,83%
9	**146074509**	723	22656	37769	**146**	659	**745**	323	26,37%
10	**141074609**	568	159443	240896	**141**	479	**746**	222	18,97%
11	**245054909**	793	8337	10150	**245**	560	**549**	457	22,03%
12	**247054709**	697	241539	317013	**247**	446	**547**	350	12,44%
13	**242054709**	712	413128	518839	**242**	435	**547**	350	9,30%
14	**246054609**	852	8011	9582	**246**	625	**546**	542	26,99%
15	**243084309**	786	81361	151102	**243**	683	**843**	338	23,02%
16	**249084509**	929	19529	28993	**249**	787	**845**	475	26,39%
17	**244084409**	759	79873	167913	**244**	684	**844**	363	27,51%

18	**244084309**	768	96020	188962	**244**	684	**843**	338	24,85%
19	**242084909**	600	720896	1029157	**242**	435	**849**	251	12,54%
20	**343064609**	991	1579	2125	**343**	818	**646**	739	36,35%
21	**350064809**	1026	9994	13246	**350**	880	**648**	785	38,38%
22	**346064309**	919	8638	13259	**346**	715	**643**	548	27,24%
23	**349064709**	628	91710	132759	**349**	424	**647**	370	20,91%
24	**343065009**	1056	2704	4024	**343**	818	**650**	851	36,73%
25	**350094809**	987	170718	324372	**350**	880	**948**	445	25,51%
26	**348094609**	849	24287	54936	**348**	700	**946**	350	19,14%
27	**344094909**	732	218796	371640	**344**	461	**949**	320	6,27%
28	**348095009**	847	31858	71495	**348**	700	**950**	392	22,44%
29	**343094409**	971	41089	70935	**343**	818	**944**	483	25,37%

Set 6 (10 tanks)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	**159045910**	737	314529	406440	**159**	448	**459**	376	10,56%
2	**152045310**	848	250542	320671	**152**	532	**453**	459	14,43%
3	**156045610**	875	6807	9610	**156**	689	**456**	748	39,11%
4	**156046010**	918	4820	6949	**156**	689	**460**	643	31,08%
5	**155045910**	761	222801	273564	**155**	486	**459**	376	11,72%
6	**159075810**	652	1742744	3088929	**159**	448	**758**	264	8,43%
7	**158075710**	910	64920	145844	**158**	770	**757**	425	23,85%
8	**152075210**	781	1842737	3089327	**152**	532	**752**	321	8,44%
9	**157075110**	456	863154	2365233	**157**	268	**751**	202	2,98%
10	**156075910**	797	30438	84728	**156**	689	**759**	340	22,55%
11	**252055710**	952	23135	28373	**252**	771	**557**	586	29,85%
12	**257055410**	1032	16734	24723	**257**	885	**554**	750	36,88%
13	**256055910**	781	305658	364808	**256**	494	**559**	437	16,11%
14	**260055210**	911	119056	141907	**260**	571	**552**	553	18,95%
15	**255055310**	1056	8837	11396	**255**	828	**553**	825	36,12%
16	**256085510**	756	**1000017**	1587813	**256**	494	**855**	270	1,05%
17	**259085210**	632	**1000026**	1536196	**259**	405	**852**	238	1,71%
18	**260085910**	805	864452	1539529	**260**	571	**859**	329	10,56%
19	**255085810**	1038	41090	58645	**255**	828	**858**	531	23,62%
20	**254086010**	916	42158	60579	**254**	687	**860**	415	16,88%
21	**359065910**	911	35360	44667	**359**	752	**659**	582	31,71%
22	**355065710**	1106	807	920	**355**	934	**657**	812	36,66%
23	**356065510**	1005	18227	23547	**356**	856	**655**	751	37,46%
24	**358065310**	1062	8208	12308	**358**	866	**653**	867	38,72%
25	**357065510**	960	12822	15491	**357**	804	**655**	751	38,26%
26	**355095210**	1093	8030	12440	**355**	934	**952**	608	29,12%
27	**358095410**	1004	58243	121324	**358**	866	**954**	464	24,51%
28	**353095910**	948	276989	533979	**353**	825	**959**	423	24,04%
29	**359095710**	828	504897	953675	**359**	752	**957**	372	26,33%
30	**359095810**	821	415843	817048	**359**	752	**958**	336	24,54%

ANNEX 3

Set 1 (W1, W2)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	10140205	**373**	403	647	10105	**214**	40205	**194**	8,58%
2	10240605	**347**	280	669	10205	**185**	40605	**144**	-5,47%
3	10340805	**405**	180	576	10305	**240**	40805	**214**	10,79%
4	10440705	**368**	349	1297	10405	**198**	40705	**184**	3,66%
5	10540605	**302**	162	542	10505	**158**	40605	**144**	0,00%
6	10640605	**318**	179	342	10605	**172**	40605	**144**	-0,63%
7	10740705	**395**	1123	2488	10705	**195**	40705	**184**	-4,22%
8	10940305	**466**	261	556	10905	**252**	40305	**230**	3,32%
9	11040305	**444**	516	855	11005	**348**	40305	**230**	23,18%
10	11141606	**450**	1867	3381	11106	**220**	41606	**221**	-2,04%
11	11641706	**336**	2026	3682	11606	**171**	41706	**165**	0,00%
12	11741706	**366**	4167	8250	11706	**189**	41706	**165**	-3,39%
13	11841806	**330**	1282	3972	11806	**162**	41806	**160**	-2,48%
14	11941706	**352**	1408	3587	11906	**194**	41706	**165**	1,95%
15	12143007	**640**	1439	2147	12107	**479**	43007	**361**	23,81%
16	12342407	**414**	27322	59229	12307	**208**	42407	**204**	-0,49%
17	12442407	**424**	6046	16487	12407	**200**	42407	**204**	-4,95%
18	12543007	**653**	5873	10408	12507	**371**	43007	**361**	10,79%
19	12643007	**622**	1037	1624	12607	**471**	43007	**361**	25,24%
20	12742807	**690**	973	1562	12707	**480**	42807	**431**	24,26%
21	12842107	**404**	10947	22171	12807	**216**	42107	**204**	3,81%
22	12942107	**423**	11701	21841	12907	**232**	42107	**204**	2,98%
23	13042607	**446**	11293	27042	13007	**220**	42607	**249**	4,90%
24	13143108	**630**	15727	20858	13108	**330**	43108	**370**	10,00%
25	13243108	**641**	11185	14832	13208	**378**	43108	**370**	14,30%
26	13343108	**605**	9755	13455	13308	**407**	43108	**370**	22,14%
27	13543108	**613**	24616	31195	13508	**323**	43108	**370**	11,54%
28	13743108	**624**	11657	14919	13708	**368**	43108	**370**	15,45%
29	13843808	**397**	91314	155331	13808	**225**	43808	**194**	5,25%
30	13944008	**412**	70896	105186	13908	**238**	44008	**188**	3,29%
31	14043108	**585**	16475	22177	14008	**374**	43108	**370**	21,37%
32	14144109	**615**	74994	81318	14109	**479**	44109	**357**	26,44%
33	14244509	**799**	5108	6681	14209	**664**	44509	**546**	33,97%
34	14344309	**746**	55545	67070	14309	**475**	44309	**401**	14,84%
35	14444509	**794**	2810	3533	14409	**610**	44509	**546**	31,31%
36	14544609	**809**	31799	40678	14509	**677**	44609	**509**	31,79%
37	14644509	**793**	7171	9817	14609	**659**	44509	**546**	34,19%
38	14744809	**757**	9585	11471	14709	**605**	44809	**602**	37,28%
39	14844309	**711**	53027	68534	14809	**482**	44309	**401**	19,48%
40	15044309	**692**	29225	34657	15009	**436**	44309	**401**	17,32%
41	15145610	**916**	32676	40115	15110	**771**	45610	**748**	39,70%
42	15245310	**848**	250542	320671	15210	**532**	45310	**459**	14,43%
43	15345310	**787**	62460	87046	15310	**653**	45310	**459**	29,23%
44	15445910	**742**	261460	323196	15410	**653**	45910	**376**	27,89%
45	15545910	**761**	222801	273564	15510	**486**	45910	**376**	11,72%
46	15645610	**875**	6807	9610	15610	**689**	45610	**748**	39,11%
47	15745710	**552**	936018	1212398	15710	**268**	45710	**312**	4,83%
48	15845210	**918**	8754	12852	15810	**770**	45210	**825**	42,45%
49	15945910	**737**	314529	406440	15910	**448**	45910	**376**	10,56%
50	16045910	**714**	485152	614006	16010	**456**	45910	**376**	14,18%

51	20150305	**534**	107	175	20105	**346**	50305	**300**	17,34%
52	20250605	**418**	597	1035	20205	**224**	50605	**208**	3,24%
53	20350405	**269**	299	701	20305	**140**	50405	**130**	0,37%
54	20450805	**325**	374	943	20405	**182**	50805	**156**	3,85%
55	20550605	**432**	481	1336	20505	**224**	50605	**208**	0,00%
56	20650705	**365**	353	972	20605	**182**	50705	**175**	-2,24%
57	20750605	**453**	603	1002	20705	**224**	50605	**208**	-4,86%
58	20850705	**376**	257	459	20805	**196**	50705	**175**	-1,35%
59	20950705	**377**	406	1208	20905	**201**	50705	**175**	-0,27%
60	21051005	**544**	622	1058	21005	**280**	51005	**261**	-0,55%
61	21151206	**619**	1051	1318	21106	**499**	51206	**408**	31,75%
62	21351106	**461**	886	1672	21306	**287**	51106	**217**	8,53%
63	21451106	**427**	854	1384	21406	**245**	51106	**217**	7,58%
64	21551806	**621**	1318	3296	21506	**351**	51806	**297**	4,17%
65	21651806	**606**	785	1828	21606	**342**	51806	**297**	5,16%
66	21751806	**596**	1923	3745	21706	**331**	51806	**297**	5,10%
67	21951106	**439**	968	2189	21906	**231**	51106	**217**	2,01%
68	22051206	**613**	1046	1505	22006	**351**	51206	**408**	19,24%
69	22152507	**370**	10001	30161	22107	**180**	52507	**180**	-2,78%
70	22352407	**635**	4219	6586	22307	**403**	52407	**374**	18,28%
71	22452707	**726**	3079	4910	22407	**577**	52707	**442**	28,75%
72	22552707	**741**	2198	3610	22507	**400**	52707	**442**	12,00%
73	22652507	**370**	11924	24359	22607	**217**	52507	**180**	6,80%
74	22752107	**477**	15708	28420	22707	**256**	52107	**216**	-1,06%
75	22852907	**578**	5376	8735	22807	**322**	52907	**349**	13,86%
76	22953007	**726**	1613	2359	22907	**429**	53007	**525**	23,90%
77	23053007	**774**	2613	4039	23007	**504**	53007	**525**	24,78%
78	23153108	**737**	4380	6509	23108	**648**	53108	**541**	38,02%
79	23253408	**758**	5261	6792	23208	**532**	53408	**472**	24,50%
80	23453408	**776**	10868	14513	23408	**619**	53408	**472**	28,87%
81	23653208	**563**	27565	39708	23608	**498**	53208	**297**	29,18%
82	23753208	**582**	45002	80822	23708	**344**	53208	**297**	9,20%
83	23853208	**542**	20917	38152	23808	**412**	53208	**297**	23,55%
84	23953208	**570**	55982	79177	23908	**342**	53208	**297**	10,80%
85	24154109	**640**	44988	66817	24109	**386**	54109	**384**	16,88%
86	24254209	**710**	557260	739388	24209	**435**	54209	**288**	1,80%
87	24354609	**849**	16652	21813	24309	**683**	54609	**542**	30,69%
88	24454609	**862**	16477	20006	24409	**684**	54609	**542**	29,69%
89	24554909	**793**	8103	10150	24509	**560**	54909	**457**	22,03%
90	24654609	**852**	7700	9638	24609	**652**	54609	**542**	28,64%
91	24754709	**697**	225078	330169	24709	**446**	54709	**350**	12,44%
92	24855009	**556**	145607	232650	24809	**360**	55009	**258**	10,03%
93	25054609	**845**	16619	20940	25009	**662**	54609	**542**	29,82%
94	25255710	**952**	23135	28373	25210	**771**	55710	**586**	29,85%
95	25455410	**994**	10072	13158	25410	**687**	55410	**750**	30,83%
96	25555310	**1056**	8837	11396	25510	**828**	55310	**825**	36,12%
97	25655910	**781**	305658	364808	25610	**494**	55910	**437**	16,11%
98	25755110	**980**	5495	8340	25710	**885**	55110	**762**	40,50%
99	25855110	**969**	3292	4159	25810	**831**	55110	**762**	39,17%
100	26055210	**911**	119056	141907	26010	**571**	55210	**553**	18,95%
101	30160405	**594**	348	544	30105	**314**	60405	**354**	11,08%
102	30260205	**392**	1232	1631	30205	**192**	60205	**207**	1,75%
103	30360305	**320**	304	849	30305	**160**	60305	**160**	0,00%
104	30460405	**576**	236	413	30405	**409**	60405	**354**	24,51%
105	30560505	**514**	664	931	30505	**262**	60505	**252**	0,00%
106	30660405	**590**	312	567	30605	**310**	60405	**354**	11,14%

107	30760505	**488**	470	821	30705	**250**	60505	**252**	2,79%
108	30860205	**392**	1364	1707	30805	**192**	60205	**207**	1,75%
109	30961005	**544**	321	858	30905	**284**	61005	**272**	2,16%
110	31060505	**500**	519	839	31005	**323**	60505	**252**	13,04%
111	31161806	**632**	1380	1987	31106	**491**	61806	**382**	27,61%
112	31361906	**596**	846	1813	31306	**350**	61906	**307**	9,28%
113	31461406	**739**	223	309	31406	**602**	61406	**414**	27,26%
114	31561806	**644**	385	788	31506	**472**	61806	**382**	24,59%
115	31661906	**548**	201	329	31606	**383**	61906	**307**	20,58%
116	31761906	**577**	1582	2772	31706	**294**	61906	**307**	3,99%
117	31861106	**506**	2412	3761	31806	**284**	61106	**228**	1,17%
118	31961906	**568**	855	1209	31906	**421**	61906	**307**	21,98%
119	32061106	**491**	2526	4085	32006	**266**	61106	**228**	0,61%
120	32162307	**805**	1482	1728	32107	**529**	62307	**400**	13,35%
121	32262407	**850**	1096	1760	32207	**595**	62407	**518**	23,63%
122	32363007	**936**	882	1136	32307	**658**	63007	**692**	30,67%
123	32462207	**444**	16059	29742	32407	**236**	62207	**233**	5,33%
124	32562907	**775**	569	873	32507	**589**	62907	**502**	28,96%
125	32762207	**478**	21420	43892	32707	**260**	62207	**233**	3,04%
126	32862307	**788**	2464	3844	32807	**473**	62307	**400**	9,74%
127	32962307	**782**	2019	2803	32907	**590**	62307	**400**	21,01%
128	33062207	**460**	13796	24639	33007	**250**	62207	**233**	4,76%
129	33163108	**886**	4492	6688	33108	**628**	63108	**697**	33,13%
130	33563708	**1066**	2047	2817	33508	**603**	63708	**774**	22,59%
131	33663608	**922**	5719	7984	33608	**544**	63608	**622**	20,93%
132	33763908	**848**	1550	2395	33708	**601**	63908	**544**	25,94%
133	33963908	**809**	845	1190	33908	**609**	63908	**544**	29,84%
134	34164109	**792**	36385	45908	34109	**606**	64109	**455**	25,35%
135	34364609	**991**	1513	2125	34309	**818**	64609	**739**	36,35%
136	34464509	**858**	46801	62759	34409	**461**	64509	**496**	10,34%
137	34564309	**909**	15278	20120	34509	**580**	64309	**548**	19,41%
138	34664309	**919**	8564	13259	34609	**715**	64309	**548**	27,24%
139	34764709	**719**	45416	58328	34709	**344**	64709	**370**	-0,70%
140	34864309	**927**	8965	12464	34809	**700**	64309	**548**	25,72%
141	34964709	**628**	89031	136112	34909	**424**	64709	**370**	20,91%
142	35064209	**1009**	8894	10917	35009	**880**	64209	**754**	38,25%
143	35165210	**939**	109272	140384	35110	**737**	65210	**538**	26,35%
144	35265210	**943**	60173	78019	35210	**559**	65210	**538**	14,04%
145	35365510	**969**	12516	15664	35310	**825**	65510	**751**	38,52%
146	35465910	**876**	10677	13264	35410	**693**	65910	**582**	31,29%
147	35565710	**1106**	807	920	35510	**934**	65710	**812**	36,66%
148	35665510	**1005**	18227	23547	35610	**856**	65510	**751**	37,46%
149	35765510	**960**	12822	15491	35710	**804**	65510	**751**	38,26%
150	35865310	**1062**	8208	12308	35810	**866**	65310	**867**	38,72%
151	35965910	**911**	35360	44667	35910	**752**	65910	**582**	31,71%
152	36066010	**968**	65492	75293	36010	**571**	66010	**536**	12,56%

Set 2 (W1, W3)

	instance	TC	solved graphs	explored graphs		TC1		TC2	time reduction
1	10170405	**373**	406	1582	10105	**214**	70405	**168**	2,36%
2	10270205	**333**	618	1472	10205	**185**	70205	**158**	2,92%
3	10470405	**352**	246	1552	10405	**198**	70405	**168**	3,83%
4	10570705	**302**	287	911	10505	**158**	70705	**154**	3,21%
5	10670705	**316**	170	1053	10605	**172**	70705	**154**	3,07%
6	10770405	**370**	629	2648	10705	**195**	70405	**168**	-1,93%
7	10971005	**446**	250	732	10905	**252**	71005	**211**	3,67%
8	11071005	**444**	694	1858	11005	**348**	71005	**211**	20,57%
9	11171806	**418**	3364	10633	11106	**220**	71806	**204**	1,42%
10	11271206	**534**	927	2255	11206	**413**	71206	**255**	20,06%
11	11371606	**542**	501	1374	11306	**410**	71606	**257**	18,74%
12	11471406	**270**	4913	11176	11406	**137**	71406	**130**	-1,12%
13	11571606	**547**	687	2092	11506	**451**	71606	**257**	22,74%
14	11671706	**331**	2913	6088	11606	**171**	71706	**161**	0,30%
15	11771706	**362**	5645	12511	11706	**189**	71706	**161**	-3,43%
16	11871306	**318**	1644	5540	11806	**162**	71306	**153**	-0,95%
17	11971306	**332**	3017	9992	11906	**194**	71306	**153**	4,32%
18	12072006	**269**	1624	5610	12006	**144**	72006	**124**	-0,37%
19	12173007	**586**	5767	13204	12107	**479**	73007	**248**	19,39%
20	12372107	**391**	46519	95035	12307	**208**	72107	**180**	-0,77%
21	12472107	**425**	13854	34643	12407	**200**	72107	**180**	-11,84%
22	12573007	**620**	35214	93833	12507	**371**	73007	**248**	-0,16%
23	12673007	**598**	2470	5986	12607	**471**	73007	**248**	16,83%
24	12872107	**394**	13926	30772	12807	**216**	72107	**180**	0,51%
25	12972107	**402**	14970	35413	12907	**232**	72107	**180**	2,43%
26	13072207	**436**	28960	88153	13007	**220**	72207	**206**	-2,35%
27	13173108	**584**	247924	452823	13108	**330**	73108	**229**	-4,47%
28	13273308	**608**	189851	423960	13208	**378**	73308	**223**	-1,16%
29	13373308	**554**	26089	48620	13308	**407**	73308	**223**	12,06%
30	13473908	**645**	44836	88977	13408	**569**	73908	**277**	23,76%
31	13573608	**501**	113365	315270	13508	**323**	73608	**209**	5,83%
32	13673908	**680**	61910	112802	13608	**416**	73908	**277**	1,88%
33	13773108	**590**	124543	225372	13708	**368**	73108	**229**	1,17%
34	14073108	**504**	85723	165754	14008	**374**	73108	**229**	16,42%
35	14174409	**569**	122764	198030	14109	**479**	74409	**222**	18,83%
36	14274509	**773**	14963	24192	14209	**664**	74509	**323**	21,68%
37	14374809	**666**	476079	876765	14309	**475**	74809	**254**	8,64%
38	14474509	**738**	6204	10574	14409	**610**	74509	**323**	20,90%
39	14574909	**713**	123036	239837	14509	**677**	74909	**322**	28,63%
40	14674509	**723**	18432	38006	14609	**659**	74509	**323**	26,37%
41	14774909	**725**	57237	82230	14709	**605**	74909	**322**	21,79%
42	14874809	**660**	527869	1134474	14809	**482**	74809	**254**	10,33%
43	15074109	**624**	181988	390702	15009	**436**	74109	**254**	9,57%
44	15175910	**856**	547401	986618	15110	**771**	75910	**340**	22,95%
45	15275210	**784**	1000001	1518253	15210	**532**	75210	**321**	8,09%
46	15375210	**687**	300969	554969	15310	**653**	75210	**321**	29,47%
47	15475410	**666**	1000012	1527509	15410	**653**	75410	**249**	26,16%
48	15575810	**660**	932371	1802393	15510	**486**	75810	**264**	12,00%
49	15675910	**797**	30438	84728	15610	**689**	75910	**340**	22,55%
50	15776010	**455**	1000008	2702234	15710	**268**	76010	**210**	4,81%
51	15875710	**910**	64920	145844	15810	**770**	75710	**425**	23,85%
52	15975410	**670**	1000031	1378130	15910	**448**	75410	**249**	3,87%

53	16075410	**622**	1000044	1761963	16010	**456**	75410	**249**	11,77%
54	20180405	**494**	101	175	20105	**346**	80405	**240**	15,70%
55	20280205	**418**	425	1356	20205	**224**	80205	**208**	3,24%
56	20380705	**260**	192	689	20305	**140**	80705	**130**	3,70%
57	20480905	**325**	716	1266	20405	**182**	80905	**156**	3,85%
58	20580605	**389**	262	1618	20505	**224**	80605	**192**	6,49%
59	20680305	**358**	235	1521	20605	**182**	80305	**168**	-2,29%
60	20780205	**416**	395	1165	20705	**224**	80205	**208**	3,70%
61	20880305	**369**	189	561	20805	**196**	80305	**168**	-1,37%
62	20980305	**368**	863	2373	20905	**201**	80305	**168**	0,27%
63	21080405	**498**	325	1386	21005	**280**	80405	**240**	4,23%
64	21181106	**569**	3533	11004	21106	**499**	81106	**261**	25,13%
65	21281306	**496**	869	3232	21206	**293**	81306	**232**	5,52%
66	21381406	**455**	1711	4188	21306	**287**	81406	**203**	7,14%
67	21481406	**445**	2077	8962	21406	**245**	81406	**203**	0,67%
68	21581606	**565**	968	2940	21506	**351**	81606	**261**	7,68%
69	21681606	**583**	1009	3879	21606	**342**	81606	**261**	3,32%
70	21781806	**583**	3886	9065	21706	**331**	81806	**261**	1,52%
71	21881906	**499**	2680	5523	21806	**286**	81906	**248**	6,55%
72	21981406	**420**	2310	7240	21906	**231**	81406	**203**	3,23%
73	22082006	**583**	4555	13314	22006	**351**	82006	**261**	4,74%
74	22182107	**360**	15260	41596	22107	**180**	82107	**180**	0,00%
75	22382507	**600**	11439	28192	22307	**403**	82507	**268**	10,58%
76	22682807	**360**	21281	53209	22607	**217**	82807	**170**	6,98%
77	22782707	**452**	24897	61974	22707	**256**	82707	**204**	1,74%
78	22882907	**547**	15994	36420	22807	**322**	82907	**224**	-0,18%
79	23183208	**720**	50018	129294	23108	**648**	83208	**300**	24,05%
80	23283208	**658**	10189	24985	23208	**532**	83208	**300**	20,91%
81	23383508	**796**	3065	9858	23308	**623**	83508	**358**	18,86%
82	23483608	**698**	36183	79541	23408	**619**	83608	**296**	23,72%
83	23583508	**806**	28181	75777	23508	**718**	83508	**358**	25,09%
84	24083108	**490**	94887	140090	24008	**307**	83108	**200**	3,35%
85	24184209	**615**	131763	297848	24109	**386**	84209	**251**	3,45%
86	24284209	**589**	314361	632819	24209	**435**	84209	**251**	14,14%
87	24384309	**786**	67999	151102	24309	**683**	84309	**338**	23,02%
88	24484409	**759**	77171	167913	24409	**684**	84409	**363**	27,51%
89	24584109	**666**	17457	30116	24509	**560**	84109	**331**	25,25%
90	24684309	**807**	18268	28467	24609	**652**	84309	**338**	18,48%
91	24784809	**614**	351772	697207	24709	**446**	84809	**257**	12,66%
92	24984509	**929**	16903	29565	24909	**787**	84509	**475**	26,39%
93	25084309	**776**	161097	336378	25009	**662**	84309	**338**	22,40%
94	25185210	**628**	1000022	1569779	25110	**347**	85210	**238**	-7,35%
95	25385310	**612**	1000001	1314594	25310	**357**	85310	**235**	-3,38%
96	25486010	**916**	42158	60579	25410	**687**	86010	**415**	16,88%
97	25585810	**1038**	41090	58645	25510	**828**	85810	**531**	23,62%
98	25685610	**747**	1000002	1685978	25610	**494**	85610	**317**	7,89%
99	25786010	**977**	247236	535809	25710	**885**	86010	**415**	24,85%
100	25886010	**975**	86394	186069	25810	**831**	86010	**415**	21,75%
101	25985210	**632**	1000026	1536196	25910	**405**	85210	**238**	1,71%
102	26085910	**805**	864452	1539529	26010	**571**	85910	**329**	10,56%
103	30190405	**592**	677	2704	30105	**314**	90405	**270**	-1,37%
104	30290205	**383**	379	1825	30205	**192**	90205	**186**	-1,32%
105	30390905	**331**	440	1218	30305	**160**	90905	**160**	-3,44%
106	30490405	**558**	155	425	30405	**409**	90405	**270**	17,82%
107	30590505	**472**	676	1626	30505	**262**	90505	**210**	0,00%
108	30690405	**576**	754	1870	30605	**310**	90405	**270**	0,69%

109	30790505	**460**	648	1350	30705	**250**	90505	**210**	0,00%
110	30890205	**388**	473	1845	30805	**192**	90205	**186**	-2,65%
111	30991005	**512**	460	1922	30905	**284**	91005	**256**	5,19%
112	31090505	**458**	343	915	31005	**323**	90505	**210**	14,07%
113	31191306	**632**	3584	5305	31106	**491**	91306	**297**	19,80%
114	31291706	**386**	2051	10857	31206	**207**	91706	**190**	2,77%
115	31391506	**552**	2513	6817	31306	**350**	91506	**252**	8,31%
116	31591806	**586**	514	1933	31506	**472**	91806	**293**	23,40%
117	31691906	**525**	228	516	31606	**383**	91906	**252**	17,32%
118	31791906	**540**	2806	8487	31706	**294**	91906	**252**	1,10%
119	31892006	**500**	2860	7140	31806	**284**	92006	**204**	-2,46%
120	31991906	**534**	746	1709	31906	**421**	91906	**252**	20,65%
121	32092006	**444**	1462	4658	32006	**266**	92006	**204**	5,53%
122	32192907	**723**	1746	2928	32107	**529**	92907	**320**	14,84%
123	32292407	**792**	1380	2365	32207	**595**	92407	**401**	20,48%
124	32392507	**928**	1948	3799	32307	**658**	92507	**420**	13,91%
125	32492607	**451**	33605	114634	32407	**236**	92607	**210**	-1,12%
126	32592707	**741**	2764	6178	32507	**589**	92707	**360**	21,92%
127	32692807	**658**	5672	10831	32607	**519**	92807	**291**	18,77%
128	32792107	**440**	19559	58100	32707	**260**	92107	**210**	6,38%
129	32892907	**724**	6358	19134	32807	**473**	92907	**320**	8,70%
130	32992907	**704**	2294	5616	32907	**590**	92907	**320**	22,64%
131	33092107	**420**	7514	21985	33007	**250**	92107	**210**	8,70%
132	33193408	**806**	13509	37019	33108	**628**	93408	**360**	18,42%
133	33293908	**635**	47539	96282	33208	**392**	93908	**288**	6,62%
134	33393908	**628**	25742	67954	33308	**527**	93908	**288**	22,94%
135	33493908	**670**	61090	164673	33408	**443**	93908	**288**	8,34%
136	33593508	**980**	3600	6108	33508	**603**	93508	**462**	7,98%
137	33694008	**878**	103420	255822	33608	**544**	94008	**400**	6,99%
138	33794008	**837**	7617	16779	33708	**601**	94008	**400**	16,38%
139	33893908	**627**	91331	230083	33808	**410**	93908	**288**	10,17%
140	33994008	**805**	2545	4968	33908	**609**	94008	**400**	20,22%
141	34093208	**515**	139308	318887	34008	**289**	93208	**230**	0,77%
142	34194309	**767**	369804	836024	34109	**606**	94309	**312**	16,45%
143	34394409	**971**	36573	73189	34309	**818**	94409	**483**	25,37%
144	34494909	**732**	169978	374073	34409	**461**	94909	**320**	6,27%
145	34594609	**825**	75811	179241	34509	**580**	94609	**350**	11,29%
146	34694609	**851**	19123	38842	34609	**715**	94609	**350**	20,09%
147	34794509	**625**	417919	902794	34709	**344**	94509	**270**	-1,79%
148	34895009	**847**	30247	74294	34809	**700**	95009	**392**	22,44%
149	34994509	**573**	788817	1799339	34909	**424**	94509	**270**	17,44%
150	35094109	**1001**	162527	295902	35009	**880**	94109	**416**	22,76%
151	35195510	**835**	904717	1364140	35110	**737**	95510	**384**	25,51%
152	35295510	**839**	648928	1171568	35210	**559**	95510	**384**	11,03%
153	35395910	**948**	276989	533979	35310	**825**	95910	**423**	24,04%
154	35495510	**824**	102733	158937	35410	**693**	95510	**384**	23,49%
155	35595210	**1093**	8030	12440	35510	**934**	95210	**608**	29,12%
156	35695910	**947**	350256	810375	35610	**856**	95910	**423**	25,96%
157	35795910	**912**	98128	170544	35710	**804**	95910	**423**	25,67%
158	35895410	**1004**	58243	121324	35810	**866**	95410	**464**	24,51%
159	35995510	**841**	418887	752240	35910	**752**	95510	**384**	25,97%
160	36095510	**885**	1000023	1591990	36010	**571**	95510	**384**	7,33%

Set 3 (W2, W3)

	instance	TC	solved graphs	explored graphs	TC1		TC2		time reduction
1	40170105	**286**	294	1095	40105	**138**	70105	**126**	-8,33%
2	40270405	**336**	334	1239	40205	**194**	70405	**168**	7,18%
3	40370505	**440**	568	2034	40305	**230**	70505	**210**	0,00%
4	40470805	**268**	164	1125	40405	**138**	70805	**127**	-1,13%
5	40570505	**434**	284	1109	40505	**254**	70505	**210**	6,47%
6	40670705	**298**	128	349	40605	**144**	70705	**154**	0,00%
7	40770405	**352**	353	2596	40705	**184**	70405	**168**	0,00%
8	40970205	**316**	187	887	40905	**155**	70205	**158**	-0,96%
9	41070105	**276**	207	1032	41005	**138**	70105	**126**	-4,55%
10	41171106	**354**	4114	12349	41106	**211**	71106	**175**	8,29%
11	41271506	**474**	3304	11070	41206	**266**	71506	**226**	3,66%
12	41371506	**488**	1020	3055	41306	**244**	71506	**226**	-3,83%
13	41471506	**503**	5969	22058	41406	**316**	71506	**226**	7,20%
14	41571506	**493**	1788	8085	41506	**287**	71506	**226**	3,90%
15	41671806	**425**	2337	7941	41606	**221**	71806	**204**	0,00%
16	41771706	**318**	1719	6471	41706	**165**	71706	**161**	2,45%
17	41871306	**314**	1892	7268	41806	**160**	71306	**153**	-0,32%
18	41971106	**378**	2498	13271	41906	**211**	71106	**175**	2,07%
19	42071806	**440**	2418	16803	42006	**236**	71806	**204**	0,00%
20	42172107	**391**	14712	42594	42107	**204**	72107	**180**	-1,82%
21	42272307	**503**	14926	44350	42207	**282**	72307	**224**	0,59%
22	42472107	**376**	15844	46842	42407	**204**	72107	**180**	2,08%
23	42572607	**530**	14664	48101	42507	**288**	72607	**226**	-3,11%
24	42672707	**415**	10264	49251	42607	**249**	72707	**195**	6,53%
25	42772707	**415**	8533	43386	42707	**220**	72707	**195**	0,00%
26	42972307	**474**	6232	21195	42907	**304**	72307	**224**	10,23%
27	43073007	**609**	15848	48056	43007	**361**	73007	**248**	0,00%
28	43173108	**559**	60129	131285	43108	**370**	73108	**229**	6,68%
29	43273708	**698**	102366	240632	43208	**537**	73708	**299**	16,51%
30	43374008	**716**	6843	13663	43308	**532**	74008	**394**	22,68%
31	43473408	**438**	93654	272054	43408	**244**	73408	**207**	2,88%
32	43573508	**433**	188333	439148	43508	**265**	73508	**190**	4,84%
33	43673408	**486**	151387	382219	43608	**273**	73408	**207**	-1,25%
34	43973408	**436**	137407	504962	43908	**250**	73408	**207**	4,60%
35	44174409	**511**	1000002	1636058	44109	**357**	74409	**222**	11,74%
36	44274409	**492**	1000030	1965730	44209	**254**	74409	**222**	-3,36%
37	44374809	**540**	191596	385264	44309	**401**	74809	**254**	17,56%
38	44474909	**705**	84454	181041	44409	**497**	74909	**322**	13,92%
39	44574509	**716**	45697	93476	44509	**546**	74509	**323**	17,61%
40	44674909	**740**	415397	759807	44609	**509**	74909	**322**	10,95%
41	44774809	**667**	354364	835290	44709	**524**	74809	**254**	14,27%
42	44874909	**700**	95073	240413	44809	**602**	74909	**322**	24,24%
43	44974409	**561**	480346	1036230	44909	**384**	74409	**222**	7,43%
44	45074409	**481**	473172	1532327	45009	**310**	74409	**222**	9,59%
45	45175310	**757**	418433	961959	45110	**677**	75310	**364**	27,28%
46	45275710	**886**	150538	333136	45210	**825**	75710	**425**	29,12%
47	45375210	**740**	1000031	1625767	45310	**459**	75210	**321**	5,13%
48	45475210	**600**	664039	1171608	45410	**451**	75210	**321**	22,28%
49	45575510	**486**	1000014	1877308	45510	**320**	75510	**202**	6,90%
50	45675910	**834**	389423	891251	45610	**748**	75910	**340**	23,35%
51	45776010	**559**	1000013	1115520	45710	**312**	76010	**210**	-7,09%
52	45875310	**792**	1000026	2257022	45810	**568**	75310	**364**	15,02%

53	45975410	**597**	1000008	2187707	45910	**376**	75410	**249**	4,48%
54	46075910	**834**	287019	692476	46010	**643**	75910	**340**	15,16%
55	50180105	**305**	254	1421	50105	**156**	80105	**145**	-1,33%
56	50280505	**468**	261	826	50205	**294**	80505	**234**	11,36%
57	50380405	**523**	491	2566	50305	**300**	80405	**240**	3,15%
58	50480705	**260**	198	918	50405	**130**	80705	**130**	0,00%
59	50580505	**458**	211	1106	50505	**270**	80505	**234**	9,13%
60	50680605	**400**	534	3221	50605	**208**	80605	**192**	0,00%
61	50780305	**363**	374	1966	50705	**175**	80305	**168**	-5,83%
62	50880905	**309**	242	1727	50805	**156**	80905	**156**	0,96%
63	50980705	**260**	93	385	50905	**130**	80705	**130**	0,00%
64	51080405	**504**	500	2967	51005	**261**	80405	**240**	-0,60%
65	51181406	**411**	1113	2718	51106	**217**	81406	**203**	2,14%
66	51281606	**537**	781	2448	51206	**408**	81606	**261**	19,73%
67	51381606	**549**	468	1595	51306	**406**	81606	**261**	17,69%
68	51481606	**546**	557	1878	51406	**319**	81606	**261**	5,86%
69	51581706	**344**	1385	3143	51506	**174**	81706	**170**	0,00%
70	51681706	**356**	2480	9189	51606	**186**	81706	**170**	0,00%
71	51881806	**579**	3176	13850	51806	**297**	81806	**261**	-3,76%
72	51982006	**566**	2105	11042	51906	**382**	82006	**261**	11,98%
73	52081206	**358**	1236	5065	52006	**206**	81206	**186**	8,67%
74	52182707	**432**	9281	31760	52107	**216**	82707	**204**	-2,86%
75	52282407	**510**	36636	129115	52207	**266**	82407	**244**	0,00%
76	52382407	**522**	13792	40702	52307	**317**	82407	**244**	6,95%
77	52482507	**585**	19902	54191	52407	**374**	82507	**268**	8,88%
78	52582807	**360**	15620	43676	52507	**180**	82807	**170**	-2,86%
79	52682607	**482**	18966	61007	52607	**266**	82607	**224**	1,63%
80	52982907	**546**	12615	39348	52907	**349**	82907	**224**	4,71%
81	53183208	**639**	13838	40616	53108	**541**	83208	**300**	24,02%
82	53483608	**711**	149534	331955	53408	**472**	83608	**296**	7,42%
83	53584008	**575**	242856	623484	53508	**301**	84008	**257**	-3,05%
84	53684008	**566**	195633	553795	53608	**385**	84008	**257**	11,84%
85	53783708	**753**	45513	114151	53708	**530**	83708	**336**	13,05%
86	53884008	**614**	163191	422463	53808	**384**	84008	**257**	4,21%
87	53984008	**600**	81980	198419	53908	**364**	84008	**257**	3,38%
88	54083308	**748**	25115	61489	54008	**616**	83308	**338**	21,59%
89	54184209	**565**	264129	637120	54109	**384**	84209	**251**	11,02%
90	54284209	**539**	845115	1827058	54209	**288**	84209	**251**	0,00%
91	54384709	**848**	6214	15530	54309	**601**	84709	**381**	13,65%
92	54484609	**562**	260259	553623	54409	**366**	84609	**252**	9,06%
93	54684309	**809**	701579	1355321	54609	**542**	84309	**338**	8,07%
94	54784809	**573**	897337	1977995	54709	**350**	84809	**257**	5,60%
95	54884809	**642**	414817	778436	54809	**393**	84809	**257**	1,23%
96	54984109	**724**	482187	749961	54909	**457**	84109	**331**	8,12%
97	55186010	**934**	66720	115562	55110	**762**	86010	**415**	20,65%
98	55285910	**855**	1000013	1186318	55210	**553**	85910	**329**	3,06%
99	55385410	**991**	65480	167940	55310	**825**	85410	**510**	25,77%
100	55486010	**991**	965335	2196143	55410	**750**	86010	**415**	14,94%
101	55585910	**810**	1000004	2015601	55510	**445**	85910	**329**	-4,65%
102	55686010	**878**	120231	336956	55610	**744**	86010	**415**	24,25%
103	55985110	**607**	1000004	1999488	**55910**	**437**	85110	**272**	14,39%
104	60190905	**320**	219	1068	60105	**160**	90905	**160**	0,00%
105	60290205	**392**	554	1946	60205	**207**	90205	**186**	0,25%
106	60390905	**320**	205	1416	60305	**160**	90905	**160**	0,00%
107	60490405	**594**	378	1046	60405	**354**	90405	**270**	4,81%
108	60590505	**454**	539	1328	60505	**252**	90505	**210**	1,73%

109	60690605	**434**	293	1506	60605	**238**	90605	**210**		3,13%
110	60790205	**390**	410	1453	60705	**197**	90205	**186**		-1,83%
111	60890805	**503**	209	1038	60805	**368**	90805	**251**		18,74%
112	60990905	**320**	167	1061	60905	**170**	90905	**160**		3,03%
113	61091005	**528**	695	2830	61005	**272**	91005	**256**		0,00%
114	61191206	**444**	2591	8231	61106	**228**	91206	**216**		0,00%
115	61291106	**697**	2119	6722	61206	**412**	91106	**368**		10,64%
116	61391106	**720**	2246	7017	61306	**405**	91106	**368**		6,86%
117	61591606	**468**	1467	4482	61506	**279**	91606	**216**		5,45%
118	61691106	**695**	1098	2779	61606	**442**	91106	**368**		14,20%
119	61791106	**738**	2067	5489	61706	**360**	91106	**368**		-1,37%
120	61891806	**608**	2873	7829	61806	**382**	91806	**293**		9,93%
121	61991906	**550**	914	3237	61906	**307**	91906	**252**		1,61%
122	62091306	**619**	1983	9641	62006	**395**	91306	**297**		10,55%
123	62192207	**516**	22840	49154	62107	**252**	92207	**240**		-4,88%
124	62292307	**420**	17023	41127	62207	**233**	92307	**240**		11,21%
125	62392907	**720**	15368	42921	62307	**400**	92907	**320**		0,00%
126	62492407	**850**	6166	15404	62407	**518**	92407	**401**		7,51%
127	62592907	**716**	22992	82958	62507	**448**	92907	**320**		6,77%
128	62692207	**540**	20390	42015	62607	**324**	92207	**240**		4,26%
129	62792907	**748**	30860	92792	62707	**435**	92907	**320**		0,93%
130	62892207	**571**	18489	40821	62807	**334**	92207	**240**		0,52%
131	62992407	**809**	2856	5090	62907	**502**	92407	**401**		10,41%
132	63092507	**859**	6206	20394	63007	**692**	92507	**420**		22,75%
133	63193408	**805**	44134	122164	63108	**697**	93408	**360**		23,84%
134	63293408	**832**	37230	102542	63208	**548**	93408	**360**		8,37%
135	63393508	**929**	16166	35722	63308	**603**	93508	**462**		12,77%
136	63493508	**960**	67840	120641	63408	**629**	93508	**462**		12,01%
137	63593808	**728**	66473	195488	63508	**453**	93808	**322**		6,06%
138	63694008	**798**	20462	49309	63608	**622**	94008	**400**		21,92%
139	63793708	**927**	21629	49108	63708	**774**	93708	**450**		24,26%
140	63994008	**786**	29556	86666	63908	**544**	94008	**400**		16,74%
141	64194309	**737**	826189	2024896	64109	**455**	94309	**312**		3,91%
142	64294209	**905**	63441	138502	64209	**754**	94209	**455**		25,14%
143	64394609	**847**	138180	298952	64309	**548**	94609	**350**		5,68%
144	64494609	**822**	118998	301190	64409	**558**	94609	**350**		9,47%
145	64594909	**759**	326738	771486	64509	**496**	94909	**320**		6,99%
146	64694709	**996**	10306	20267	64609	**739**	94709	**454**		16,51%
147	64794509	**590**	343745	956614	64709	**370**	94509	**270**		7,81%
148	64894809	**924**	106440	258272	64809	**785**	94809	**445**		24,88%
149	64994109	**862**	2783	5282	64909	**603**	94109	**416**		15,41%
150	65094409	**1013**	60697	172780	65009	**851**	94409	**483**		24,06%
151	65295510	**873**	1000030	1939419	65210	**538**	95510	**384**		5,31%
152	65395410	**1032**	168952	279226	65310	**867**	95410	**464**		22,46%
153	65495410	**1041**	11839	22543	65410	**732**	95410	**464**		12,96%
154	65595910	**888**	189771	467588	65510	**751**	95910	**423**		24,36%
155	65695410	**993**	17840	22024	65610	**718**	95410	**464**		15,99%
156	65795210	**1098**	8060	10542	65710	**812**	95210	**608**		22,68%
157	65895610	**1177**	51366	94722	65810	**899**	95610	**654**		24,21%
158	65995510	**849**	449157	844567	65910	**582**	95510	**384**		12,11%
159	66095510	**861**	1000021	1526618	66010	**536**	95510	**384**		6,41%