# CPS - Linear Programming

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## 1 Optimal solution bounds

I applied the same preprocessing step as in the previous assignment. I refer the reader to its respective document.

## 2 Model

I have modeled the problem with 3 variables for each box. A pair of variables, namely $p_i^x$ and $p_i^y$, determines the position of the box $i$, and another variable named $d_i$ (dir) specifies the orientation of box $i$.

In the previous assignment I used one unique variable to represent the position of a box, and applying the modulo and the integer division to obtain the $x$-$y$-coordinates. This way, I was optimizing the number of variables and easing the job of the solver. In this assignment, this strategy could also be possible since, by introducing auxiliary variables we can also extract the coordinates:

$$
\begin{gathered}
p_i = p_i^x W + r \\
p_i / W \geq p_i^y \geq p_i / W - 0.\hat{9} \\
r \in \{0 \ldots W - 1\}
\end{gathered}
$$

But in this case, this doesn't imply an improvement on performance since we are still adding auxiliary variables (even more than without this strategy).

To model the non-overlapping constraint of the boxes, I have used the expressive functionalities offered by CPLEX to express a disjunction of 4 conditions. This is equivalent to the overlapping constraints from the previous assignment that uses the big-M method.

## 3 Results

My proposed model of the problem offers good results. From the 108 given instances, it successfully finds the optimal solution of 106 instances within 60 seconds each. It also obtains the same result with a much sorter timeout.