# IBM CP Optimizer Model of The Generalized Flexible Job Shop Scheduling Problem

For further details on the Generalized Flexible Job Shop Scheduling Problem, please refer to the following article:

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| **Title** | **:** | The Generalized Flexible Job Shop Scheduling Problem |
| **Journal** | **:** | International Journal of Production Research |
| **Authors** | **:** | Boyer, Vincent - Devassia, Jobish - Cantú-Rodríguez, Xavier - Salazar-Aguilar, M. Angélica |

## 1 Parameters

| | |
|---|---|
| $M$ | : machines set |
| $O$ | : operations set |
| $C_m$ | : capacity of machine $m$ (in terms of weight or number of units) |
| $\underline{l}_{ij}$ | : minimum lag between the starting time of operation $j$ and the ending time of operation $i$ ($\underline{l}_{ij} = -\infty$ if there is no precedence relationship between operations $i$ and $j$) |
| $\bar{l}_{ij}$ | : maximum lag time between the starting time of operation $j$ and the ending time of operation $i$ ($\bar{l}_{ij} = +\infty$ if there is no precedence relationship between operations $i$ and $j$) |
| $p_{im}$ | : processing time of operation $i$ in machine $m$ ($p_{im} = +\infty$ if machine $m$ cannot process operation $i$) |
| $h_{im}$ | : maximum holding time of operation $i$ in machine $m$ |
| $w_{im}$ | : weight of operation $i$ in machine $m$ (weight or number of units) |
| $\delta_m$ | : input/output delay time between two consecutive operations in machine $m$ |
| $a_{ijm}$ | : setup time of machine $m$ when processing operation $i$ before $j$ ($a_{ijm} = -\infty$ if there is no setups). |

## 2 Decision Variables

- $O_i$: interval variable associated with operation $i$
- $A_{im}$: optional interval variable representing the assignment of operation $i$ on machine $m$

## 3 Model

$$Min\ z = \max_{i \in O} endOf(o_i) \tag{1}$$

subject to:

$$alternative(O_i, [A_{im}]_{m \in M}), \qquad \forall i \in O \tag{2}$$

$$noOverlap([A_{im}]_{i \in O}), \qquad \forall m \in M \tag{3}$$

$$endBeforeStart(O_i, O_j, \underline{l}_{ij}), \qquad \forall i, j \in O \tag{4}$$

$$startBeforeEnd(O_i, O_j, -\bar{l}_{ij}), \qquad \forall i, j \in O \tag{5}$$

$$\begin{aligned} presenceOf(A_{im}) \wedge presenceOf(A_{jm}) \implies \\ startOf(O_j) \geq endOf(O_i) + a_{mij} \vee \\ startOf(o_i) \geq endOf(o_j) + a_{mji}, \end{aligned} \qquad \forall i, j \in O,\ \forall m \in M \tag{6}$$

$$\begin{aligned} presenceOf(A_{im}) \wedge presenceOf(A_{jm}) \implies \\ startOf(O_j) \geq startOf(O_i) + \max\{0, (sizeOf(O_i) - sizeOf(O_j)\} + \delta_m \vee \\ startOf(O_i) \geq startOf(O_j) + \max\{0, (sizeOf(O_j) - sizeOf(O_i)\} + \delta_m, \end{aligned} \qquad \forall i, j \in O,\ \forall m \in M \tag{7}$$

$$\sum_{i \in O} pulse(A_{im}, w_{im}) \leq C_m, \qquad \forall m \in M \tag{8}$$

$$interval\ O_i, \qquad i \in O \tag{9}$$

$$interval\ A_{im}, opt, size \in [p_{im},\ p_{im} + h_{im}], \qquad \forall i \in O, \forall m \in M \tag{10}$$

Constraints (2) state that an operation must be assigned to only one machine. Constraints (3) prevent operation overlapping on a machine. Constraints (4) and (5) assure the time lag constraint satisfaction. Setup times and queue constraints are modeled with constraints (6) and (7) respectively. Constraints (8) guarantee that the machine capacity is not exceeded. Finally, constraints (9) and (10) describe the interval variables.