

## Generator settings

The instances are generated based on the input settings of the generator, where structural properties, resource environment and activities are defined using the set of attributes listed below. We use the uniform random distribution inside the generator. There are three types of parameters - common for both types of problems, specific for the RCPSP problems and specific for the IPPS problems.

### Common parameters

The common parameters are listed below:

**ProblemType**  $\in \{RCPSP, IPPS\}$  - determines the type of the problem to be generated.

**OutputDirectory** - directory in which the instances should be generated.

**MaxValue**  $\in \langle 1, +2^{31} - 1 \rangle$  - value to be used as  $+\infty$

**MinValue**  $\in \langle -2^{31}, -1 \rangle$  - value to be used as  $-\infty$

**ProcessingTimeMin**  $\in \langle 0, \text{ProcessingTimeMax} \rangle$  - minimal processing time of operations (activities).

**ProcessingTimeMax**  $\in \langle \text{ProcessingTimeMin}, \text{MaxValue} \rangle$  - maximal processing time of operations.

**ReleaseTimeFactor**  $\in \langle 0, \text{MaxValue} \rangle$  - factor used for the generation of release times.

**DueDateFactor**  $\in \langle 0, \text{MaxValue} \rangle$  - factor used for the generation of due dates.

**TardinessCostLow**  $\in \langle 0, \text{TardinessCostMiddle} \rangle$  - the tardiness cost assigned to the activities (RCPSP) and orders (IPPS) with the low priority.

**TardinessCostMiddle**  $\in \langle \text{TardinessCostLow}, \text{TardinessCostHigh} \rangle$  - the tardiness cost assigned to the activities (RCPSP) and orders (IPPS) with the middle priority.

**TardinessCostHigh**  $\in \langle \text{TardinessCostMiddle}, \text{MaxValue} \rangle$  - the tardiness cost assigned to the activities (RCPSP) and orders (IPPS) with the high priority.

**SequenceRatio**  $\in \langle 0, 100 \rangle$  - the ratio of the sequence parts in the NTNA instance (RCPSP) or in the generated BOMs (IPPS).

Values assigned to **ProblemType** and **OutputDirectory** are strings, values for **ReleaseTimeFactor** and **DueDateFactor** are real numbers and the rest of the values are integers. Generator accepts either slash (/), backslash (\), double slash (//) or double backslash (\\) for separation of folders. If the folder does not exist, it is created automatically by the generator.

Release time factor is used as follows: First, the critical path length *CPL* is calculated based on the temporal constraints in the NTNA instance and then the release times of activities are generated from the interval  $\langle 0, \text{ReleaseTimeFactor} \cdot \text{CPL} \rangle$ . Similarly, the due dates are generated from the interval  $\langle 0, \text{DueDateFactor} \cdot \text{CPL} \rangle$ . Both release times and due dates are assigned to the activities according to the topological order of nodes in the NTNA instance. The lowest release time (due date) is always assigned to the first activity and the highest to the last activity.

The tardiness costs are assigned as follows: The value of **TardinessCostLow** is assigned to 20% of activities, **TardinessCostMiddle** value is assigned to 60% of activities and **TardinessCostHigh** value is assigned to 20% of activities. The tardiness costs are assigned to activities randomly, only the total number of activities with a given value satisfies the proposed distribution. For more details, the reader is referred to Pinedo and Singer (1999). In case of RCPSP, parameter **SequenceRatio** determines the ratio of serial parts in

the resulting instance. If `SequenceRatio=100`, then the instance will be formed only by a simple chain of activities and if `SequenceRatio=0`, then all the precedences are a part of some parallel or alternative branching. With respect to the IPPS, this parameter influences the generation of BOMs for each product. If `SequenceRatio = 100`, then all BOMs within each product are represented as simple chains of parts. If `SequenceRatio = 0` then each BOM is represented as a graph where one selected node is a direct successor of any other node in the BOM and no additional precedence constraints are implied.

### Specific RCPSP parameters

The parameters specific for the RCPSP problems are as follows:

`NumberOfActivities`  $\in \langle 1, \text{MaxValue} \rangle$  - the number of activities per instance.

`NumberOfResourcesMin`  $\in \langle 1, \text{NumberOfResourcesMax} \rangle$  - the minimal number of resources per instance.

`NumberOfResourcesMax`  $\in \langle \text{NumberOfResourcesMin}, \text{MaxValue} \rangle$  - the maximal number of resources per instance.

`CapacityMin`  $\in \langle 1, \text{CapacityMax} \rangle$  - the minimal capacity of each resource in the instance.

`CapacityMax`  $\in \langle \text{CapacityMin}, \text{MaxValue} \rangle$  - the maximal capacity of each resource in the instance.

`DeadlineFactor`  $\in \langle 0, \text{MaxValue} \rangle$  - factor used for the generation of deadlines.

`DemandMin`  $\in \langle 0, \text{CapacityMin} \rangle$  - the minimal demand of each activity for the assigned resource in the instance.

`DemandMax`  $\in \langle \text{DemandMin}, \text{MaxValue} \rangle$  - the maximal demand of each activity for the assigned resource in the instance.

`ProcessingCostMin`  $\in \langle 0, \text{ProcessingCostMax} \rangle$  - minimal processing cost of each activity.

`ProcessingCostMax`  $\in \langle \text{ProcessingCostMin}, \text{MaxValue} \rangle$  - maximal processing cost of each activity.

`ParallelBranchesMin`  $\in \langle 1, \text{ParallelBranchesMax} \rangle$  - the minimal number of branches in each parallel branching.

`ParallelBranchesMax`  $\in \langle \text{ParallelBranchesMin}, \text{NumberOfActivities}-2 \rangle$  - the maximal number of branches in each parallel branching.

`AlternativeBranchesMin`  $\in \langle 1, \text{AlternativeBranchesMax} \rangle$  - the minimal number of branches in each alternative branching.

`AlternativeBranchesMax`  $\in \langle \text{AlternativeBranchesMin}, \text{NumberOfActivities}-2 \rangle$  - the maximal number of branches in each alternative branching.

`AlternativeRatio`  $\in \langle 0, 100 \rangle$  - the ratio of the alternative branchings in the NTNA instance.

`PositiveTimeLagsRatio`  $\in \langle 0, 100 \rangle$  - determines the number of additional positive time-lags in the instance.

`NegativeTimeLagsRatio`  $\in \langle 0, 100 \rangle$  - determines the number of additional negative time-lags in the instance.

`PositiveTimeLagMin`  $\in \langle 0, \text{PositiveTimeLagMax} \rangle$  - the minimal length of the positive time-lag.

`PositiveTimeLagMax`  $\in \langle \text{PositiveTimeLagMin}, \text{MaxValue} \rangle$  - the maximal length of the positive time-lag.

**NegativeTimeLagMin**  $\in \langle \text{MinValue}, \text{NegativeTimeLagMax} \rangle$  - the minimal length of the negative time-lag.

**NegativeTimeLagMax**  $\in \langle \text{NegativeTimeLagMin}, 0 \rangle$  - the maximal length of the negative time-lag.

Apart from **DeadlineFactor**, which is a real number, all other values are integers. The deadlines are generated in the same way as due dates from the interval  $\langle 0, \text{DeadlineFactor} \cdot \text{CPL} \rangle$

Value of **AlternativeRatio** then determines the ratio of the alternative branchings in the instance. If **AlternativeRatio**=0, then all the branchings will be only parallel and vice versa if **AlternativeRatio**=100, then all the branchings will be alternative.

Parameters **PositiveTimeLagsRatio** and **NegativeTimeLagsRatio** determine the number of additional positive and negative time-lags, which will be defined for the pairs of activities not constrained by a direct precedence relation in the NTNA instance. The actual number of the additional positive time-lags is calculated as  $(\text{NumberOfActivities} \cdot \text{PositiveTimeLagsRatio})/100$  and similarly for negative time-lags.

### Specific IPPS parameters

Finally, the parameters specific for the IPPS problems are the following:

**NumberOfMachineGroups**  $\in \langle 1, \text{MaxValue} \rangle$  - the number of machine groups. It is assumed that all machines of within the same machine group have identical functionality.

**NumberOfMachinesPerGroupMin**  $\in \langle 0, \text{NumberOfMachinesPerGroupMax} \rangle$  - the minimal number of machines within each machine group.

**NumberOfMachinesPerGroupMax**  $\in \langle \text{NumberOfMachinesPerGroupMin}, \text{MaxValue} \rangle$  - the maximal number of machines within each machine group.

**MachineGroupType**  $\in \{Pm, Qm, Rm\}$  - type of the generated machine groups as proposed in Pinedo (2008).

**NumberOfOperations**  $\langle 1, \text{MaxValue} \rangle$  - the number of different operations which can be executed by the resources.

**NumberOfPartTypes**  $\in \langle 1, \text{MaxValue} \rangle$  - the number of different parts which can be produced.

**OperationsPerPartMin**  $\in \langle 1, \text{OperationsPerPartMax} \rangle$  - the minimal number of operations which any part can consist of.

**OperationsPerPartMax**  $\in \langle \text{OperationsPerPartMin}, \text{MaxValue} \rangle$  - the maximal number of operations which any part can consist of.

**RoutesPerPartMin**  $\in \langle 1, \text{RoutesPerPartMax} \rangle$  - the minimal number of alternative routes for any part.

**RoutesPerPartMax**  $\in \langle \text{RoutesPerPartMin}, \text{MaxValue} \rangle$  - the maximal number of alternative routes for any part.

**NumberOfProducts**  $\in \langle 1, \text{MaxValue} \rangle$  - the number of products produced by the considered manufacturing system.

**PartTypesPerProductMin**  $\in \langle 1, \text{PartTypesPerProductMax} \rangle$  - the minimal number of different parts which can be used for building any product.

**PartTypesPerProductMax**  $\in \langle \text{PartTypesPerProductMin}, \text{MaxValue} \rangle$  - the maximal number of different parts which can be used for building any product.

$BOMsPerProductMin \in \langle 1, BOMsPerProductMax \rangle$  - the minimal number of alternative bills of materials for any product.

$BOMsPerProductMax \in \langle BOMsPerProductMin, MaxValue \rangle$  - the maximal number of alternative bills of materials for any product.

$PartsPerBOMMin \in \langle 1, PartsPerBOMMax \rangle$  - the minimal number of parts in any BOM. There can be multiple parts of the same type within any BOM.

$PartsPerBOMMax \in \langle PartsPerBOMMin, MaxValue \rangle$  - the maximal number of parts in any BOM.

$NumberOfOrdersPerProduct \in N_0^{NoP}$  - a numeric array which defines the number of orders for each product. Here,  $NoP$  is equal to  $NumberOfProducts$ .

### Example of the file content

An example of the settings file content is shown in Figure 1.

<pre> % Common parameters ProblemType=IPPS OutputDirectory=c:\Data\Instances NumberOfInstances=50 MaxValue=1000000000 MinValue=-1000000000 ProcessingTimeMin=1 ProcessingTimeMax=10 ReleaseTimeFactor=0.2 DuedateFactor=5 TardinessCostLow=1 TardinessCostMiddle=2 TardinessCostHigh=4 SequenceRatio=50  % RCPSP specific parameters NumberOfActivities=100 NumberOfResourcesMin=1 NumberOfResourcesMax=4 CapacityMin=1 CapacityMax=5 DeadlineFactor=5 DemandMin=1 DemandMax=3 ProcessingCostMin=10 ProcessingCostMax=50 ParallelBranchesMin=5 ParallelBranchesMax=10 AlternativeBranchesMin=2 AlternativeBranchesMax=4 </pre>	<pre> (continued) AlternativeRatio=25 PositiveTimeLagsRatio=0 NegativeTimeLagsRatio=0 PositiveTimeLagMin=0 PositiveTimeLagMax=30 NegativeTimeLagMin=-60 NegativeTimeLagMax=-20  % IPPS specific parameters NumberOfMachineGroups=5 NumberOfMachinesPerGroupMin=2 NumberOfMachinesPerGroupMax=6 MachineGroupType=Rm NumberOfOperations=20 NumberOfPartTypes=10 OperationsPerPartMin=1 OperationsPerPartMax=10 RoutesPerPartMin=1 RoutesPerPartMax=2 PartTypesPerProductMin=5 PartTypesPerProductMax=7 BOMsPerProductMin=2 BOMsPerProductMax=2 PartsPerBOMMin=5 PartsPerBOMMax=5 NumberOfProducts=3 NumberOfOrdersPerProduct=1 2 3 </pre>
--	---

Figure 1: Example of the settings file content

## References

- Pinedo, M., Singer, M.. A shifting bottleneck heuristic for minimizing the total weighted tardiness in a job shop. *Naval Research Logistics* 1999;46(1):1-17.
- Pinedo, M.. *Scheduling : Theory, Algorithms, and Systems*. Springer Science+Business Media, Third edition; 2008.