Scheduling in Anylogic

System: Parts arrive at a manufacturing shop throughout the day at varying rates as shown:

Hour	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4
Average arrivals per hr	22	35	40	31	35	43	29	22

All parts are first processed at the Manual Preparation Station followed by the Machining Station 1, and Machining Station 2 with processing times of TRIA(2, 4, 6), TRIA(1, 3, 5) and TRIA(1, 4, 5) minutes respectively. At the Manual Station two operators work in parallel: operator A works from 8-3, and the other operator B works from 9-4 (That is, the part can be processed by any one of the Operator). Machining Station 1 has one machine. However, the machine needs to be serviced (maintenance) after every 30 parts processed. Maintenance time is 20 minutes. Machining Station 2 has one machine. However, the machine fails every 2.5 hours, with repair times uniformly distributed between 10 to 20 minutes.

Run simulation model for 8 hours. Model the above system in Anylogic.

Let's break down the problem

<table>
<tr>
<td>System: Parts arrive at a manufacturing shop throughout the day at varying rates as shown:
<table>
<tr><td>Hour</td><td>8-9</td><td>9-10</td><td>10-11</td><td>11-12</td><td>12-1</td><td>1-2</td><td>2-3</td><td>3-4</td></tr>
<tr><td>Average arrivals per hr</td><td>22</td><td>35</td><td>40</td><td>31</td><td>35</td><td>43</td><td>29</td><td>22</td></tr>
</table>
</td>
<td>The part arrival rate vary with hour of the day. Arrival process is time variant, typically modelled as a non-stationary Poisson Process. We schedule rate changes for each hour.</td>
</tr>
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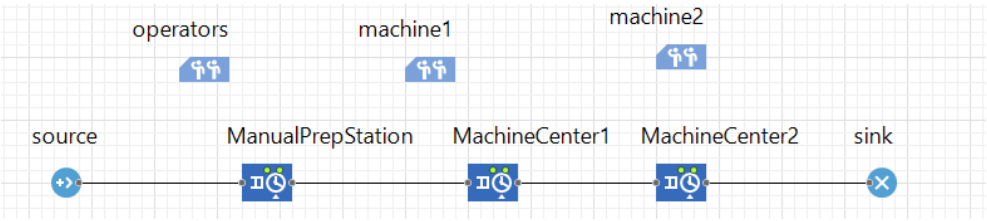
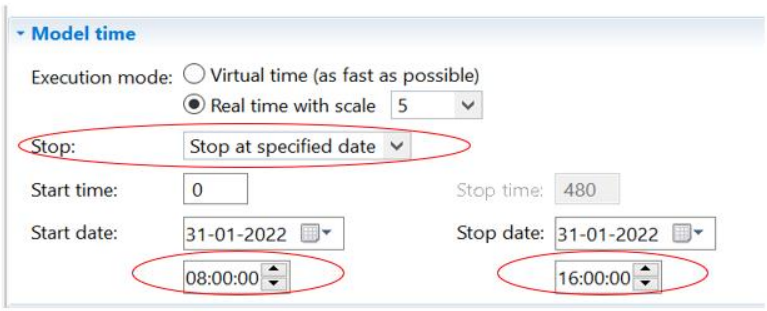
<td>All parts are first processed at the Manual Preparation Station followed by the Machining Station 1, and Machining Station 2 with processing times of TRIA(2, 4, 6), TRIA(1, 3, 5) and TRIA(1, 4, 5) minutes respectively.</td>
<td>This we know how to model.</td>
</tr>
<tr>
<td>At the Manual Station two operators work in parallel: operator A works from 8-3, and the other operator B works from 9-4 (That is, the part can be processed by any one of the Operator).</td>
<td>The Manual station works on a schedule, with a capacity of one operator from 8-9; two from 9-3 and one from 3-4.</td>
</tr>
<tr>
<td>Machining Station 1 has one machine. However, the machine needs to be serviced (maintenance) after every 30 parts processed. Maintenance time is 20 minutes.
Machining Station 2 has one machine. However, the machine fails every 2.5 hours, with repair times uniformly distributed between 10 to 20 minutes.
Run simulation model for 8 hours. Model the above system in Anylogic.</td>
<td>There is a scheduled maintenance for machine 1 during which time no parts to be processed.
There is a random machine failure for machine 2, and during repair time no part to be processed.</td>
</tr>
</table>

Build the model

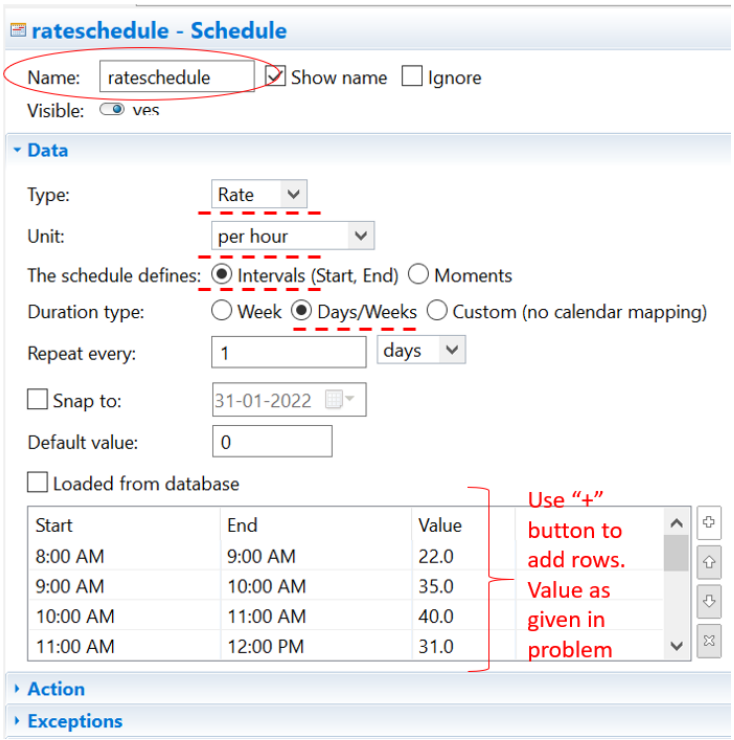
Create the base model as shown in figure below. Use model time units as minutes. Ensure *ManualPrepStation* seize and use 1 *operators*, and *MachineCenter* seize and use 1 *machine*. Enter delay duration as given in problem statement.



In **Simulation: Main** *Properties* change the *Model time* settings as follows.



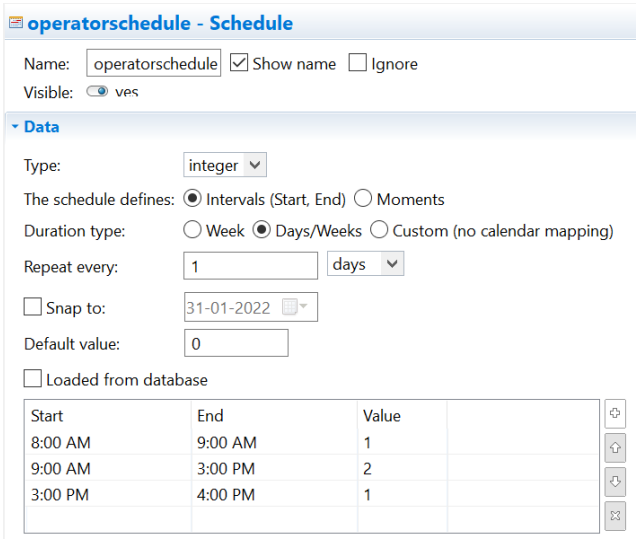
1. **Let's add change of rates for arrivals using schedule**
   - Drag-drop a *schedule* module from Process Modeling Template.
   - In Properties of schedule, set details as shown in figure



   - Next, go to Source module, Properties, and update as follows:
     - Set 'Arrivals Defined by' as *Rate Schedule* and 'Rate schedule' as *rateschedule*

Run your model to see the arrival rates changing over time.

2. **Operator Schedule "***At the Manual Station two operators work in parallel: operator A works from 8-3, and the other operator B works from 9-4"*
    - Drag-drop another *schedule* module from Process Modeling Template.
    - In Properties of the schedule, set details as shown in figure



    - In *operator* ResourcePool Properties, set details as:
        - Capacity defined: 'By Schedule'
        - Capacity Schedule: operatorschedule

➔ *When you **run the model**, you can observe that the ManualPrepStation will serve only 1 for the first hour and then 2 since capacity increases.*

3. **Maintenance Schedule** *"the machine needs to be serviced (maintenance) after every 30 parts processed. Maintenance time is 20 minutes"*
    - Drag-drop a *downtime* module from Process Modeling Template.
    - In Properties of the *downtime*, set details as:
        - Type: 'Maintenance'
        - Cycles between occurrences: 30
        - Task type: 'Delay(timeout/schedule)'
        - Task Duration: 20 minutes
    - In *machine1* ResourcePool Properties:
        - Downtime block(s): 'downtime'

➔ *When you **run the model**, you can observe that the MachineCenter1 will serve NOT any part (you will see a 0 above the block) for 20 mins when exactly 30 entities (or its multiples) have exited the block. The queue will grow, but during that downtime no part will be processed.*

4. **Failure Schedule** *"the machine fails every 2.5 hours, with repair times uniformly distributed between 10 to 20 minutes"*
    - We can model this directly in ResourcePool Properties, under '*Maintenance, failures, shifts, breaks*'
        - Specified by: 'ResourcePool Properties
        - Failures/ Repairs: Check it
        - Initial time to failure: 2.5 hours
        - Time to next failure: 2.5 hours
        - Time to repair: uniform(10,30) minutes

➔ *When you **run the model**, you can observe that the MachineCenter2 will serve NOT any part (you will see a 0 above the block) for 10-30 mins starting at time 150 minutes. The queue will grow, but during that repair time no part will be processed.*

Now, go over the full model to understand how various logics were implemented.

Other points FYI:

- In Source we can also define Arrival by 'Arrival schedule'. Here agents are generated using arrival schedule - a schedule defining how many agents should be generated at particular moments of time.
    - See the 'Source Arrival Modes' example Anylogic file (you can search for these example models from Help menu) for see other arrivals options.
- Use Anylogic Help to understand and try out other options to make Schedule.