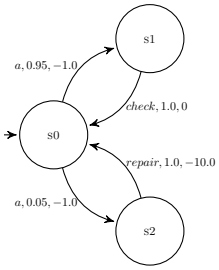
In order to carry out the exercise, we first introduce you to some fundamental concepts.

In our study, we represent manufacturing assets, e.g., machinery and operators, as services. Such services are represented as Finite State Machines, where we specify the states the asset is characterized of and the list of actions the asset is able to perform. Additionally to such information, we also model advanced information related to the actions. In particular, we model the probabilities connected to the actions, the costs of executing these actions, and a set of preconditions to be satisfied before the execution of an action and the effects upon their execution.

An example of a high-level representation of a manufacturing asset is the following:



where, the service has three states ($s0$, $s1$, $s2$) and has two types of transitions (a, $check$), which have different probabilities and rewards depending on the state they are executed on. Ex. $a, 0.95, -1.0$ represents the transition of the action a executed with a probability 0.95 with a reward of -1.0. Note that in this picture we are not providing the preconditions and the effects of executing an action.

We have realized Industrial API Editor, a prototype python application and a modeling tool to describe states and transitions of manufacturing assets as Finite State Machines. With the help of a GUI allow the user to perform the graphical tasks necessary to model states and transitions of assets involved in manufacturing processes. Once the asset has been modeled in this way, it is possible to automatically derive a stub implementation of the Industrial 4.0 API wrapper.

At the following link you can find a video tutorial about Industrial API Editor: Tutorial

At the following link you can find the Github repository of Industrial API Editor: GitHub

Exercise: Given the following process description model, using Industrial API Editor, model the *High bay Warehouse* asset involved in the process, specifying the operations over the transitions. Please do not focus on the process itself.

In the Amazonia smart factory different kind of processes are carried on, processes such as ordering, packaging, and delivery, all carried out in digitized and interconnected steps.

The system comprises factory modules like storage and retrieval stations, vacuum grippers (VGR), a high-bay warehouse (HBW), a multi-processing station (MPO), a sorting line with label detection (SLD), an environmental sensor, and a pivoting camera. We focus, for the scope of this user study, on the HBW module. The high-bay warehouse is a highly efficient and automated solution for storing and retrieving packages, especially in environments with high inventory turnover or limited storage space. In particular the HBW module perform, inside the factory processes, two operations:

- in carrying out the ordering packages task: The transport arm of the high-bay warehouse moves into the insert position of an ordered package. The transport arm picks this up and puts it in the high-bay warehouse's in-/output station. From there, it is transported to the receiving position on the VGR.

- in carrying out the store packages task: The high-bay warehouse provides an empty container to hold the package. For the package to be placed in the empty container, the gripper arm moves into the position for an empty container, picks it up with its slider and deposits it on the input/output device. The container is transported via container to the input position.

  The input/output device then transports the container with the package to the high-bay warehouse gripper arm's receiving position. At this point, the container is picked up, transported to the storage location in the high bay and stored there.

The assets used in these manufacturing processes are subject to ruptures that affect the ability to perform. The HBW operates in four phases i.e., ready, outsource operation completed, store operation completed, broken and can transition between these phases based on certain probabilities that you can invent.

Once you have completed the modeling on the Industrial API Editor, please fill out the questionnaire at the following URL: link