# Problem Definition

The problem involves the efficient assignment of qualified technicians to machines requiring different maintenance types. Given a set of machines, maintenance types, technician qualifications, technician working hour shifts, and skip cost data, the objective is to determine the optimal technician assignments and identify any skipped maintenance, while minimizing the overall cost and maximizing the number of tasks assigned.

# Current Model’s capabilities / limitations

The major problem we are facing in the current model's structure is optimizing the multiple objectives at the same time.

* The first objective is to minimize the total estimated cost incurred after assigning technicians to tasks. The total cost equals to the summation of skip costs of unassigned tasks.
* The second objective is to maximize the number of assigment for tasks that have high skipping costs.
* The third objective is to maximize the total number of tasks assigned.

The first objective is easy to satisfy with quality metric component of the library. So there is no need to focus on that.

# Demonstration of the problem Test Case 2:

If we run the model on Test Data 2, we observe that there are 10 total tasks but no plan found for assigning 10 and 9 tasks. After that, the replanner finds that the maximum number of tasks that can be possibly assigned is 8 and provides the action and plan outputs.

It is seen that the remaining tasks among the 10 tasks are m2\_mt3 and m3\_mt3, but as we know from the maintenance\_data,

'mt3': {'skip\_cost': 436, 'duration': 6}

these are the tasks that have high skipping costs. So why does the model behave like that?

The reason the model is behaving like that is that with the Replanner loop, we are iteratively decreasing the targeted number of tasks to be assigned and trying to find the plan of the maximum number of tasks that can be assigned. By doing this, we are forcing the model to optimize the third objective while giving the goal condition of the assign counter. In doing so, we clearly observe that there is a loss for the second objective.

# Explanation of the problem on Test Case 2:

In order to better understand the behavior of the model, let's look at other data of remaining tasks:

* mt\_3 maintenance type has a higher cost: we don't want to skip
* mt\_3 maintenance type can only be performed by technician 3
* the duration of this task is 6
* the total shift time of technician 3 is 7 hours
* there are two mt\_3 type tasks in the tasks data: m2\_mt3, m3\_mt3

In the best possible scenario for satisfying the second objective, we would assign a technician to one of the mt\_3 type tasks due to shift time constraints. In a 7-hour shift, he can only perform one 6-hour-long task.

Let's look at what model decides to assign technician 3 to:

* we observe from the taken actions: technician 3 is assigned to t3\_m9\_mt6 and t3\_m10\_mt2
* remember he had a 7-hour-long shift

With this assignment combination, the model actually optimized the maximum task assignment objective. Because now there are two assignments on technician 3 with tasks that have two and five hours of duration, respectively.

# Conclusion

While satisfying the maximum number of tasks to be assigned objective, we lost some points on assigning the tasks that have the highest amount of skip cost. Since there are multiple objectives in our problem, we want to find a way to prioritize the objectives for a model to find a desired plan.

# Our Ideas

In order to solve this problem, we have some ideas:

* As we force the model to find the plan that satisfies the maximum task assignment with the goal condition, we can also force the model to satisfy the second objective while losing some points on the third objective.
* In order to do this, we think there is another iterative loop for the replanner that tries to put the goal of assigning remaining tasks that have higher skip cost. But we are not sure if this approach is correct or not.
* The second idea is to focus on the second objective first with replanner, then try to maximize the total number of tasks assigned.

# Questions for Oscar

We would like to get some assistance/ideas about how we can satisfy the multiple objectives at the same time. We think that objectives should have a priority level that indicates their importance. It is clear that there should be some losing points for other objectives while focusing on one objective at a time, but we couldn't actually figure out how we can do it in the Unified Planning library.