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Course "Organizing for Digital Transformation"
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Problem Description

Scheduling of patients in emergency departments

It is given a time horizon starting at time 0 and ending at time T (e.g., a large value of 1080) minutes.

There is a single doctor to service patients.

- The doctor can service at most 1 patient per time.
- It is not allowed to have more than 1 patient inside the doctor's room at the same time.
- Once a doctor starts servicing a patient, she cannot stop the service, be idle, or consider another patient, i.e., the doctor must finish processing/servicing the patient (her current action) before to take another action.
- After finishing the current action, the doctor can continue her schedule as planned, be idle for some time, or consider serving a new released patient.

There is a set R of patients. For each patient r in R:

- She is known/released at time a_r, i.e., the time she is revealed on the time horizon.
- She has a processing/service time p_r in minutes, specifying how much time she will be receiving care of the doctor.
- She has a due date of $d_r = 15w_r$ minutes, where w_r is the patient's urgency level with 1 (most urgent), 2, 3, or 4 (less urgent). That is, she should receive care within (15 *x* w_r) minutes of her release time $[a_r, d_r]$. For example, a patient with $w_r = 4$, has $d_r = 60$ minutes.
- If she is not serviced within her time window, a weighted tardiness is incurred where t is the time she starts receiving care, i.e., $w\_tard_r = w_r \times \max\{0, t - d_r\}$.
- The doctor cannot take any action regarding the patient before her release time a_r.
- The doctor has no access or knowledge of future requests, i.e., at the current time t, only the patients r who release time is $a_r \leq t$ are known and can start receiving care from the doctor.

During the time horizon an event occurs when:

- The doctor finishes her current action (processing/servicing a patient, idle time, etc.) and is waiting for the next decision.

The objective of the problem is:

- Minimize the total weighted tardiness considering all patients: $TT = w\_tard_1 + w\_tard_2 + \ldots + w\_tard_r$

- If a patient r is served within her time window, the weighted tardiness value is $w\_tard_r = 0$, and it is not impacting the objective function.
- A solution contains the decisions performed by the doctor over the time horizon: it gives the patients without and with tardiness, and the total weighted tardiness.

When an event occurs, all known information is collected (known patients, the current action of the doctor, patients that are waiting for service, etc.), and an optimization heuristic is invoked to take the next decision.

- The heuristic returns a scheduling plan each time it is invoked.
- A scheduling plan is a partial solution to the dynamic problem, which might be later modified/integrated according to new information revealed.

A re-optimization algorithm is a dynamic algorithm that works as follows:

- First, an empty solution s is created and all known information at the beginning of the time horizon are added to s.
- Second, s is optimized by a heuristic and the next decision is taken.
- Each time there is an event, all actions that were performed prior to the current time and all those being currently performed are locked in plan s.
- The possible newly revealed patients are added to s and another call to the heuristic is performed to adjust/optimize s.
- Once all events have been considered, the algorithm terminates with a final plan containing all decisions taken over the time horizon.

A paper that handles a similar, more general problem is:
https://www.sciencedirect.com/science/article/pii/S0377221723001996?via%3Dihub