Università di Genova | DIPARTIMENTO INFORMATICA, BIOINGEGNERIA, ROBOTICA E INGEGNERIA DEI SISTEMI

**Computer Science Workshop**
*PhD program in Computer Science and Systems Engineering*

# Planning and Scheduling in Digital Health with Answer Set Programming

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## Motivation and Context

In the hospital world there are several complex combinatory problems, and solving these problems is important to increase the degree of patients' satisfaction and the quality of care offered. The problems in the healthcare are complex since to solve them several constraints and different type of resources should be taken into account. Moreover, the solutions must be evaluated in a small amount of time to ensure the usability in real scenarios. The usage of Answer Set Programming has proved to be a viable solutions to many healthcare problems thanks to the availability of efficient solvers and the rich syntax. For example: the **Chemotherapy Treatment Scheduling** (CTS) problem and the **Pre-Operative Assessment Clinic** (PAC) scheduling problem.
Common problems we want to address are:

- Modern hospitals are characterized by **long waiting lists** (CTS and PAC).
- **Delay in treatments** has adverse impact on the care of the cancer patients (CTS).
- Hospitals are **complex systems** thus the scheduler must take care of other departments (CTS) and **shared resources** (PAC).

## Chemotherapy Treatment Scheduling

The **CTS** problem consists of scheduling for patients requiring chemotherapy treatments, and to assign to each patient a chair or a bed if required. Patients can need different treatments and we identify four phases for each of them: 1) the registration to the Hospital reception; 2) a blood collection; 3) a medical check; and 4) the therapy. The duration of each phase can be different for each patient. A solution to the problem is represented by a schedule of registrations to time slots for a given day (representing the beginning of phase 4). An optimal solution to the problem maximizes the number of patients that are assigned to the preferred resource (chair or bed). Ties are broken by minimizing the number of concurrent patients in phase 2 to have a more uniform usage of resources during the day. Differently from other works, we defined the requirements according to the indications of the S. Martino Hospital in Genova, Italy. Moreover, we used real data for the empirical analysis.

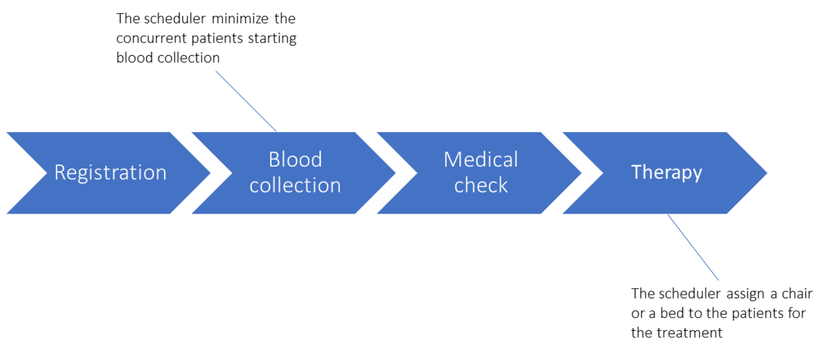


**Figure 1:** Schematic representation of the CTS problem

## Pre-Operative Assessment Clinic

The problem of scheduling Pre-Operative Assessment Clinic (PAC) consists of assigning patients to a day for the exams needed before a surgical procedure, taking into account patients with different priority levels, due dates, and operators availability. The problem is divided into two sub-problems: in the first sub-problem, patients are assigned to a day taking into account a default list of exams, and the solution has to schedule patients before their due date and prioritizing the assignments to patients with higher priority. In the second sub-problem, the scheduler assigns a starting time to each exam needed by patients, considering the available operators and the duration of the exams. A proper solution to the PAC scheduling problem is vital to improve the degree of patients' satisfaction and to reduce surgical complications. In the solution of first sub-problem, the scheduler minimizes the number of unassigned patients, starting from the patients with the highest priority. Then, we propose a solution to the second sub-problem, using as input of the problem the results of the first one and minimizing the time each patient stays at the hospital

## Results

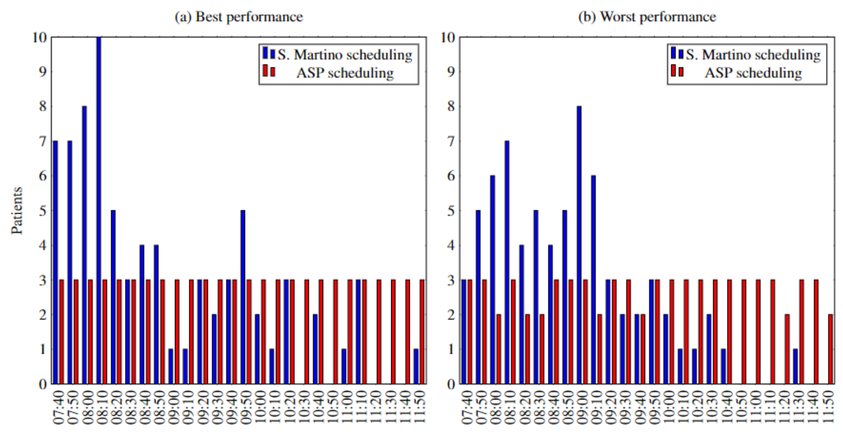


**Figure 2:** Comparison between results obtained by the Hospital and the automatic one

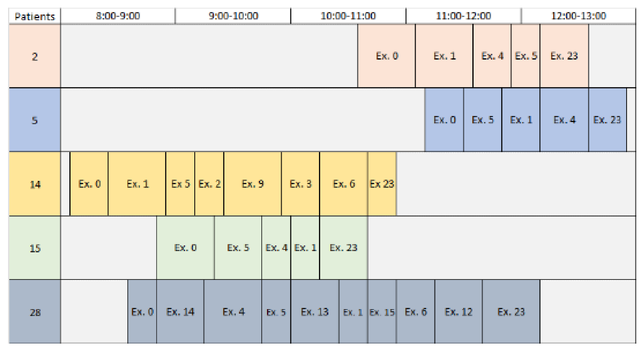


**Figure 3:** Patients' exam assignments

## Conclusions

Concerning CTS problem:

- Reduced to 0 the number of patients assigned to the wrong resource.
- Greatly reduced the number of patients starting blood collection concurrently.

Concerning PAC:

- The scheduler is able to assign all or all but one patient with the highest priority in 12 out of 15 instances tested.
- In 13 out of 15 instances the scheduler assigns no waiting times between the exams of the patients.

## Forthcoming Research

- Test our solution with real data
- Extend the use of ASP in other Digital Health problems
- Integrate Explainability techniques in the solutions

## References

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[2] C. Dodaro, G. Galatà, A. Grioni, M. Maratea, M. Mochi, and I. Porro. An asp-based solution to the chemotherapy treatment scheduling problem. *Theory and Practice of Logic Programming*, 21(6):835–851, 2021.

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