Laboratoire des Sciences du Numérique de Nantes

3iL INGENIEURS

IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

Nantes, 1 March 2025.

Ph.D. Thesis Subject

Thesis Title: **Control of Hospital Logistics Systems using Dioid Theory**

Keywords: Discrete-Event Systems, Logistics, Healthcare, Modelling and Control, Dioids, Switching Systems, Petri Nets.

- **General Information**: Ph.D. (50 % funded by 3iL Ingénieurs, and 50% by IMT Atlantique) of 36 months, starting in September 2025.
- **Application details**: interested candidates are invited to submit to `naly.rakoto@imt-atlantique.fr`, `claude.martinez@univ-nantes.fr` and `olivier.boutin@ls2n.fr` a complete CV, a motivation letter, transcripts of the grades and rankings for the past 2 years, a certificate of level in English, 2 reference letters, and a research statement. Selected candidates will be invited to an interview.
- **Deadline for Application**: 30 March 2025 (23h, Paris time).
- **Supervisors**:
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  - Dr. Olivier Boutin (3iL Ingénieurs / LS2N) e-mail: olivier.boutin@ls2n.fr
  - Dr. Claude Martinez (IUT de Nantes / LS2N) e-mail: claude.martinez@univ-nantes.fr

Summary: The logistics flows associated with hospital centers are undergoing partial automation nowadays. This trend of applying proven solutions from the industry has allowed hospital staff to free up time while simultaneously ensuring the availability of materials and information necessary for care operations. From the perspective of healthcare system reliability, this logistics automation also ensures a certain traceability of specific medications and materials.
Thus, successive experiments in hospital settings involving automated logistics, whether for linen, cleaning and sterilization of specific equipment, or the transfer of medical records between services contribute to the coexistence of heterogeneous logistic systems. However, these systems use shared resources such as corridors and elevators. Furthermore, despite the fact that these logistic systems share critical segments, it is noteworthy that they are generally acquired from specialized suppliers, and their successive integration into the hospital center's environment occurs without necessarily reconsidering pre-existing logistics systems, imposing additional operational constraints that need to be tackled.
In summary, hospital logistics systems, both internal [9, 4, 8] and external [2], generally include shared sections allowing the crossing of flows or a choice between different routes, but these aspects must be regulated either *a priori* or, at the latest, upon the arrival of a carrier, to avoid the risk of collision, for instance. A relevant research direction for supervising these conflict zones would be to use the framework of switching dioids [1].

The identified study subjects include

- the robustness of trajectories for members of different fleets. The duration of a mission for vehicles and robots related to logistics may be altered due to stops for public safety or circumvention of obstacles. Thus, in the case of urgent missions with deadlines to meet, it is essential to find a route ensuring the deadline is effectively met or, at the very least, to quantify the expected delay;
- the rules for assigning different missions to fleet elements based on criteria established by managers of hospital systems;
- the possibility of breaking down the fleet management problem and using modular local control or iterative constraint integration. Dealing with supervisory control theory [7], the modular local partitionning has already been tackled [6], as well as the iterative integration [5]. But these contributions appear to be missing in the particular case of dioid frameworks and promising tracks, such as the one presented by [1], whose application cases exhibit characteristics similar to those of shared sections.



Figure 1: Examples of automated systems, used in hospitals

The application cases will initially be theoretical. The PyMinMaxGD library [3], developed by the supervisors, may be used to illustrate the results on cases of intermediate size. Following a necessary simulation phase on dedicated software, scaling up will normally take place in the future premises - still under construction - of the new 225,000 m2 complex that will house the new CHU (Centre Hospitalier Universitaire, or university hospital centre in English) of Nantes (see Figure 2), as part of an emerging research consortium dedicated to hospital intra-logistics. This consortium brings together two industrial companies, the logistics department of the CHU of Nantes, and the LS2N Lab (Laboratoire des Sciences du Numérique de Nantes) as the academic partner (involving the three members of the supervising team for this doctoral project).

References

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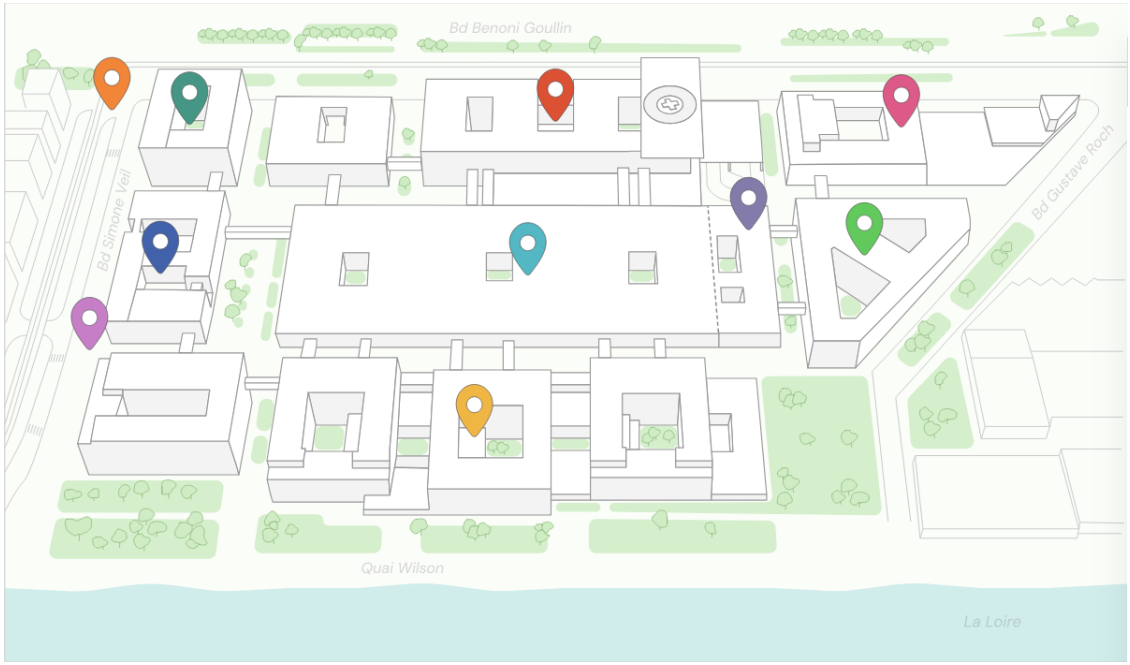


Figure 2: Map of the new CHU of Nantes – www.nouvelhopital-chu-nantes.fr

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