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

PhD offer: Transportation Optimization in Smart Cities

HEC Montréal and IMT Atlantique are looking for outstanding candidates to start a PhD on Transport Optimization in Smart cities.

1. **General information**

   - Laboratory : LS2N, Nantes, France - CIRRELT, Montreal, Canada
   - Start: Autumn 2021 in Montréal for 18 months, followed by 18 months in Nantes
   - Funded by: HEC Montréal (1st 18 Months) and IMT Atlantique (2nd 18 months)
   - PhD delivered by IMT Atlantique, Nantes, France
   - Thesis supervisors:
     - RESTREPO-RUIZ, Maria-Isabel, IMT Atlantique, LS2N, maria-isabel.restrepo-ruiz@imt-atlantique.fr
     - MENDOZA, Jorge, HEC Montréal, IVADO, CIRRELT, jorge.mendoza@hec.ca
     - LEHUÉDÉ, Fabien, IMT Atlantique, LS2N, fabien.lehuede@imt-atlantique.fr
   - Keywords: Vehicle routing optimization; Optimization under uncertainty; Smart cities; Dynamic decision making; Sustainable transport options.

2. **Context and expected impact**

   Context: More and more, modern cities are moving towards the concept of smart cities as instrumented, interconnected, and intelligent systems. Instrumented refers to the capability of capturing and integrating live real-world data through the use of appliances, personal devices, and other similar sensors. Interconnected refers to the integration of these data into a computing platform that allows the communication of such information among the various city services. Intelligent refers to the inclusion of complex analytics, modeling, optimization, visualization services and artificial intelligence to make better operational decisions [5]. This approach enables the adaptation of city services to the behavior of the inhabitants, which permits the optimal use of the available physical infrastructure and resources [6], as well as the improvement of the quality of life of its inhabitants.

   Since one of the most significant components for proper functioning of cities is their mobility, the development of methods that exploit real-world data to optimize the operation of transportation systems (TS) becomes highly important. Typically, important applications include on-demand transit services, city logistics, attended home delivery, and home care services.

   This thesis is proposed in the frame of a long term collaboration between the Nantes Logistics and Production System team and researchers from the CIRRELT (Interuniversity Research Center on Enterprise Networks, Logistics and Transportation) in Montréal. It also falls into the Atlanstic 2020 - IVADO partnership.

   Socio economical impact of the thesis: the thesis objectives are to develop efficient optimization algorithms that will exploit real-world data to improve the decision-making process in intelligent transportation systems (ITS). As highlighted by [4], ITS are now attracting a great deal of attention from academia and industry because such systems not only improve vehicle traffic conditions but may ultimately make the transportation sector safer, more sustainable and efficient, helping to ease traffic flow in cities by reducing the time spent in traffic jams. Hence, reducing fuel consumption and carbon emissions, among others. For instance, on-demand transit services are emerging as a more affordable option to traditional transportation systems, as they can utilize the existing transit network, which is efficient and sustainable [15].

3. **Positioning, originality and objectives**

Transportation problems with stochastic service requests underlie many operational challenges in logistics and supply chain management [10]. These challenges are characterized by the need to design routes for vehicles to meet customer service requests arriving randomly over a given time horizon and geographical area. For instance, in an on-demand transit service context, riders book a trip by calling or using a mobile app when needed; hence routes are dynamically optimized in real-time according to the riders' trip requests. Similarly, last-mile delivery firms usually begin their working day with a set of know service requests and may dynamically adjust vehicle routes to accommodate additional demand arriving throughout the day [11].

The study and optimization of flexible transportation systems in smart cities have recently attracted a large body of research [14]. For on-demand transit systems, some contributions include the use of meta-heuristics [8], heuristics [7], and a dynamic optimization algorithms using a Markov decision process [13]. Other examples include the flexible mobility on-demand system of [2]; the use of simulation to assess the impact of an on-demand system in [1]; or the utilization of bi-level optimization to integrate rider preferences in on-demand multi-modal transit systems in [3] and [9].

Although the cited works have provided important insights and the ground work for the optimization of transport systems in smart cities, there still many challenges to overcome. According to [12], information needs to be extracted and analyzed in real-time, calling for advanced and integrated analytics methods (e.g., integration of machine learning with optimization). In addition, embedding and effectively using high-quality information (e.g., dynamically updating distributions associated with demand, travel times, service times, etc.) in decision-support-systems for transport optimization is critical, but nontrivial. The proposed thesis aims at closing some of these gaps in the literature by: First, exploiting the availability of large amounts of data in order to optimize transportation systems in smart cities. Second, by designing efficient solution methods for transport optimization problems in smart cities. And third, by evaluating the impact of transport optimization in smart cities in their utilization and operational improvement.

According to opportunities, applications to on-demand transit, city logistics and home healthcare will be studied in contact with institutional and industrial partners.

4. **Candidate's required skills**

The candidate must have:

- A master's degree (equivalent to Bac+5) in operations research, industrial engineering, computer science or any related area.
- Knowledge and experience in operations research.
- Good computer programming skills.
- The ability to pursue research as part of a team.
- Good organizational and communication skills.
- Knowledge in descriptive and prescriptive analytics will be appreciated.

5. **How to apply**

Send your application (Motivation letter, CV, recommendation letters) to the following addresses:

- RESTREPO-RUIZ, Maria-Isabel, maria-isabel.restrepo-ruiz@imt-atlantique.fr
- MENDOZA, Jorge, jorge.mendoza@hec.ca
- LEHUÉDÉ, Fabien, fabien.lehuede@imt-atlantique.fr

6. **About IMT Atlantique**

IMT Atlantique is a top level engineering school, a technical university, under the aegis of the Ministry of Industry and the digital sector formed from the merger of two renowned schools (Télécom Bretagne and École des Mines de Nantes). It focuses on digital technology, energy and the environment with the objectives of contributing to economic development through education, outstanding research and innovation. Since its creation on January 1, 2017, IMT Atlantique has inherited all of the research and innovation activities of Télécom Bretagne and École des Mines de Nantes. This new establishment comprises 13 departments of teaching and research, involved in six research labs. With more than 1000 publications each year (400 of which are A Rank), the research at IMT Atlantique is carried out by 290 permanent researchers and lecturers, 110 non- permanent researchers and over 300 doctoral students.

The candidate will join the Logistics and Production Systems (SLP) research team at the Laboratoire des Sciences du Numérique de Nantes (LS2N). The SLP team is part of the Optimization and Decision

Support group of the Department of Automation, Production, and Computer Sciences. The team focuses on the design and optimization of production systems, logistic and transport networks, planning and scheduling of production activities, and risk management for industrial systems and services.

7. **About HEC Montréal**

HEC Montréal is a public Canadian business school located in Montreal, Canada. Founded in 1907, HEC Montréal is the graduate business school of the Université de Montréal and known as the first established school of management in Canada. HEC Montréal was ranked first by value among Canada's business schools for its MBA program by Canadian Business in 2016, 17th worldwide among non-US business schools by Forbes and among Top 30 international business schools by Bloomberg BusinessWeek in 2015.

During their stay in Montreal, the candidate will join the Interuniversity Research Centre on Entreprise Networks, Logistics and Transportation (CIRRELT) as a visitor member. The CIRRELT regroups the majority of researchers from Quebec working in the fields of engineering and managing logistics, company and transportation networks.

References

[1] C. Archetti, M. G. Speranza, and D. Weyland. On-demand public transportation. *Int. Trans. Oper. Res*, 2018.

[2] B. Atasoy, T. Ikeda, X. Song, and M. E. Ben-Akiva. The concept and impact analysis of a flexible mobility on demand system. *Transportation Research Part C: Emerging Technologies*, 56:373–392, 2015.

[3] B. Basciftci and P. Van Hentenryck. Bilevel optimization for on-demand multimodal transit systems. In *International Conference on Integration of Constraint Programming, Artificial Intelligence, and Operations Research*, pages 52–68. Springer, 2020.

[4] P. Brief. A policy brief from the policy learning platform on low-carbon economy renewable energy communities. *no. August*, 2018.

[5] S. Dirks and M. Keeling. A vision of smarter cities: How cities can lead the way into a prosperous and sustainable future. *IBM Institute for business Value*, 8, 2009.

[6] C. Harrison, B. Eckman, R. Hamilton, P. Hartswick, J. Kalagnanam, J. Paraszczak, and P. Williams. Foundations for smarter cities. *IBM Journal of research and development*, 54(4):1–16, 2010.

[7] N. Marković, R. Nair, P. Schonfeld, E. Miller-Hooks, and M. Mohebbi. Optimizing dial-a-ride services in maryland: benefits of computerized routing and scheduling. *Transportation Research Part C: Emerging Technologies*, 55:156–165, 2015.

[8] R. Masson, F. Lehuédé, and O. Péton. The dial-a-ride problem with transfers. *Computers & Operations Research*, 41:12–23, 2014.

[9] H. K. Pinto, M. F. Hyland, H. S. Mahmassani, and I. Ö. Verbas. Joint design of multimodal transit networks and shared autonomous mobility fleets. *Transportation Research Part C: Emerging Technologies*, 113:2–20, 2020.

[10] H. N. Psaraftis, M. Wen, and C. A. Kontovas. Dynamic vehicle routing problems: Three decades and counting. *Networks*, 67 (1):3–31, 2016.

[11] M. I. Restrepo, F. Semet, and T. Pocreau. Integrated shift scheduling and load assignment optimization for attended home delivery. *Transportation Science*, 53(4):1150–1174, 2019.

[12] M. Savelsbergh and T. Van Woensel. 50th anniversary invited article—city logistics: Challenges and opportunities. *Transportation Science*, 50(2):579–590, 2016.

[13] H. R. Sayarshad and H. O. Gao. A scalable non-myopic dynamic dial-a-ride and pricing problem for competitive on-demand mobility systems. *Transportation Research Part C: Emerging Technologies*, 91:192–208, 2018.

[14] M. G. Speranza. Trends in transportation and logistics. *European Journal of Operational Research*, 264(3):830–836, 2018.

[15] Y. Zhang, S. Farber, and M. Young. The benefits of on-demand transit in belleville: Findings from a user survey. 2020.