Title: Dynamic Location Planning For Student Urban Carpool Hubs

Scientific fields: Operational research, optimization model, Location-allocation problems

Key words: Student mobility, carpool hub location, optimization, sustainability

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Abstract

The aim of this internship is to develop an optimization model to decide dynamically the location of Urban Carpool Hubs (UCH) serving university campuses. The model should guarantee the effective allocation of students to these UCHs taking into account different options such as face-to-face or distance courses. Considering the campus timetable constraints, the main objective is to identify the most sustainable location minimizing the travel cost and the environmental impact. Given the dynamic nature of urban environments, the location model should incorporate variables such as transportation disruptions and be flexible enough to evolve in response to the changing needs of students.

1. Internship project

1.1. Scientific Context

This internship is part of CESI's MobE program. This program aims to understand and optimize student mobility in favor of energy savings, and to engage higher education establishments in a transformation of student mobility via an integrated approach of analysis, methodological input and wide dissemination to students and higher education establishments. Our aim is to reduce the carbon footprint of student travel, while proposing efficient alternatives based on soft mobility (walking, cycling, scootering, etc.) and any other means of mobility, whether collective or individual, that contribute to a reduction in CO2 emissions (such as public transport or car-sharing).

1.2. Subject Description

The growing urban population in urbanized areas is causing a surge in congestion and environmental pollution. In response to this challenge, the European Commission promotes Sustainable Urban Mobility Plans (SUMPs) as a comprehensive planning approach that addresses all transportation modes within cities and their surrounding regions [3]. This concept has also been applied to smaller areas, such as university campuses, recognizing universities as ecosystems where people cover significant distances to access various locations throughout the day. Internationally, diverse transportation policies and plans have been implemented to improve overall mobility quality within university campuses. Notable examples include the integration of university planning with city transportation planning, as observed in Barcelona's implementation of superblocks. The University of Bristol has interconnected its facilities across the city through a comprehensive travel plan for both staff and students. Similarly, the Polytechnic University of Turin has devised a strategy for regulating cycle lanes and parking based on the transportation behaviors and mobility needs of its university community [1]. In the [2], the authors presented a detailed study on the development of the Sapienza Sustainable University Mobility Plan (SUMP to enhance the sustainability of transportation methods for both students and staff.

In this context of urban mobility, carpooling (based on a shared use of private cars) is considered as an alternative transport system, which may contribute to enhance the sustainability of student mobility. Some studies dealt with this problem in the literature. In [6], authors studied a car-pooling service for Università Statale and Politecnico di Milano universities aiming to maximize the number of served users, minimize the total route length, and maximize the satisfied user preferences. In [7], a carpooling system is studied as an alternative mean of transportation to solve a parking problem encountered by the Binghamton University.

In this internship, we aim to develop an optimization model to minimize the cost and environmental impacts of the student move from their homes to their university campuses through carpooling. Considering constraints related to the timetables scheduling, it is about studying urban carpool hub locations and student allocation to these shared hubs. One of the major goals is to contribute to more sustainable mobility by reducing the predominance of private cars and helping to change mobility behaviors toward more sustainable practices. Selecting an optimal location for an urban carpool hub should consider aspects like the outstanding connectivity to diverse transportations modes, the proximity to educational institutions and the respect of the timetables scheduling constraints. Given the dynamic nature of urban environments, dynamic planning location of these hubs is crucial to ensure efficiency and accessibility [5]. The term "dynamic" emphasizes the need for responsiveness to changing patterns in student population distribution, in commuting availability, and modifications in urban infrastructure over time. Critical factors, such as the distribution of student populations, proximity to educational institutions, traffic patterns, and potential pick-up/drop-off points, are meticulously considered in dynamic location planning. Studying the dynamic location planning for urban student carpool hubs involves strategically identifying and adapting suitable locations to establish hubs tailored specifically for students in urban areas. This takes into account the evolving needs of students and the dynamic nature of urban transportation, with the ultimate aim of optimizing the placement of carpool hubs to enhance efficiency, accessibility, and convenience for students engaged in carpooling arrangements.

In this work, the intern will formulate the dynamic location planning of urban mobility hub as a mixed integer linear/nonlinear program incorporating objectives like cost reduction and pollution limitation. Experimentations and sensitivity analysis will be used to evaluate the model performance under uncertainty and identify key decision drivers.

1.3. Work schedule

This internship lasts 6 months and will be scheduled as follows:

1. [First month] Literature review part 01: Undertaking an in-depth literature review that explores urban mobility within university campuses and particularly emphasizes the planning of Urban Carpool Hubs locations.
2. [Second & Third months] Literature review part 02 and Mathematical model design: Conducting a comprehensive review of the current state of the art on multi-objective optimization models and designing the mathematical model to address the identified objectives and challenges attended in this step.
3. [Fourth month] Algorithm development and testing: Exploring advanced optimization algorithms and implementing the most suitable for the considered problem to enhance the model's efficiency, ensuring its applicability to real world and large-scale instances.
4. [Fifth month] Model validation: Examining results and assessing model robustness through a sensitivity study involves testing the developed mathematical model and the utilized algorithm with real-world data. This approach provides valuable insights into both the model's performance and its limitations.
5. [Sixth month] Deliverables' redaction: synthesizing the comprehensive findings into a well-documented final report. Additionally, the intern has the opportunity to share their insights, methodologies, and outcomes with the broader academic community through a conference presentation, contributing to the ongoing discourse and advancement of knowledge in the field of sustainable student mobility.

1.4. Expected scientific/technical production

By the end of the internship, two deliverables are attended:

- A conference paper on the developed model and computational results.
- A final report detailing the full methodology, implementation, case study application and conclusions.

2. Context

2.1. Laboratory presentation

CESI LINEACT (EA 7527), Digital Innovation Laboratory for Business and Learning at the service of the Competitiveness of Territories, anticipates and accompanies the technological mutations of the sectors and services related to industry and construction. CESI's historical proximity to companies is a determining factor for our research activities, and has led us to focus our efforts on applied research close to companies and in partnership with them. A human-centered approach coupled with the use of technologies, as well as the territorial network and the links with training, have allowed us to build a transversal research; it puts the human being, his needs and his uses, at the center of its problems and approaches the technological angle through these contributions.

Its research is organized according to two interdisciplinary scientific themes and two application areas.

1. Theme 1 "Learning and Innovation" is mainly concerned with Cognitive Sciences, Social Sciences and Management Sciences, Training Sciences and Techniques and Innovation Sciences. The main scientific objectives of this theme are to understand the effects of the environment, and more particularly of situations instrumented by technical objects (platforms, prototyping workshops, immersive systems, etc.) on the learning, creativity and innovation processes.
2. Theme 2 "Engineering and Digital Tools" is mainly concerned with Digital Sciences and Engineering. The main scientific objectives of this theme concern the modeling, simulation, optimization and data analysis of industrial or urban systems. The research work also focuses on the associated decision support tools and on the study of digital twins coupled with virtual or augmented environments.

These two themes develop and cross their research in the two application areas of the Industry of the Future and the City of the Future, supported by research platforms, mainly the one in Rouen dedicated to the Factory of the Future and the one in Nanterre dedicated to the Factory and Building of the Future.
Link to the laboratory website: https://lineact.cesi.fr/en/

2.2. Positioning within the laboratory's research themes

This internship is proposed in the MobE project.

It is also part of the research topics developed in Sub-axis 2 - Management and decision of Axis 1 – Cyber Physical Production Systems (CPPS) of CESI LINEACT Research Theme 2 - Engineering and Digital Tools.

2.3. Internship organization

- Financing : MobE program
- Workplace: CESI Lyon
- Starting date: January 2024
- Duration: 6 months

3. Your recruitment

3.1. Conditions: application and interview.

Please send your application to: htlahig@cesi.fr with subject line: ***« [Candidature] Titre présent en page 1 »***

Your application must include:

- A detailed Curriculum Vita.
- A cover letter explaining your motivations.

- MASTER 1 and 2 results (to be adapted to the level of the internship) and corresponding transcripts.
- Recommendation letters if available
- Any other documents you consider useful.

*Please send all documents in a zip file entitled: **NOM prénom.zip**.*

3.2. Your skills

Scientific and technical skills:

- Mathematical modeling,
- Operations research skills,
- Python programming,

Soft skills:

- Autonomy, initiative and curiosity,
- Ability to work as part of a team, and good interpersonal skills,
- Rigorous

References.

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