Application of Stackelberg games to avoid fare evasion

About the research centre or Inria department

The Inria Lille - Nord Europe Research Centre was founded in 2008 and employs a staff of 360, including 300 scientists working in sixteen research teams. Recognised for its outstanding contribution the socio-economic development of the Nord - Pas-de-Calais Region, the Inria Lille - Nord Europe Research Centre undertakes research in the field of computer science in collaboration with a range of academic, institutional and industrial partners.

The strategy of the Centre is to develop an internationally renowned centre of excellence with a significant impact on the City of Lille and its surrounding area. It works to achieve this by pursuing a range of ambitious research projects in such fields of computer science as the intelligence of data and adaptive software systems. Building on the synergies between research and industry, Inria is a major contributor to skills and technology transfer in the field of computer science.

Context

Job environments

In the class of games known as Stackelberg games, one agent, the leader, must commit to a strategy that can be observed by several other agents, the followers, before he/she commits to a strategy of his/her own. The leader wishes to find an optimal payoff-maximizing mixed strategy to commit to, under the assumption that the followers will have knowledge of the leader’s mixed strategy and will best-respond to it. The problem in such games consists thus in finding a payoff-maximizing mixed strategy for the leader and corresponds to a bilevel problem with bilinear objectives.

Stackelberg games can be modeled as a bilinear bilevel optimization problem that can be reformulated as a single level mixed integer nonlinear program (MINLP) (Conitzer and Sandholm 2006; Paruchuri et al. 2008; Kiekintveld et al. 2009). Recently, new stronger models have been proposed by members the INOCS team (Casorran-Amilburu et al. 2016).

Research environment

The INOCS team aims to develop new models, algorithmic techniques and implementations for optimization problems with complex structure (CS). More precisely, we consider that an optimization problem presents a CS when for example it involves some hierarchical leader-follower structure (bilevel optimization). Luce Brotcorne and Martine LABBE are specialists in bilevel optimization with a particular expertise to solve Stackelberg games, while Bernard Fortz has also a strong experience in decomposition methods that will be at the core of algorithms developed in the project. This joint experience was already applied in the context of pricing problems (Fortz, Labbé, and Violin 2013).

More information : https://www.inria.fr/equipes/inocs

Assignment

Assignments

In this project, we will consider a specific application of Stackelberg games in the context of fare evasion avoidance in transportation systems. Many transportation system require passengers to purchase tickets before entering, but they are not physically forced to do so because the lack of infrastructure (e.g. no automatic doors to grant access). Therefore, to avoid fare evasion, patrol units move in the transit system to inspect passengers. One objective for the authority organizing the patrols is to catch the maximum number of fare evaders (and to collect a maximum amount of fines), while passengers have to make a choice between buying a ticket or taking the risk of paying the fine if they are controlled.

The problem can be seen as a Stackelberg game in which the leader has to establish a mixed (randomized) strategy for the patrols, and the passengers, observing this strategy, decide to buy a ticket or not, maximizing their cost (depending on the probability of being fined).
To the best of our knowledge, the only approach to the problem using mixed integer programming tool provides a heuristic solution that overestimates the objective of the leader (Yin et al. 2012).

Collaboration:
Supervisors: Luce Brotcorne, Bernard Fortz, Martine Labbé.

References


Main activities
Main activities:
In this research proposal, we plan to:
- establish the computational complexity of the problem;
- propose extended formulations to model exactly the objective of the leader;
- develop decomposition methods based on column generation to solve the problem effectively.

Additional activities:
- write scientific reports and articles,
- give presentations at scientific meeting.

Skills
Skills
Candidates should hold a PhD Thesis in Operations research, mathematics, computer science, or similar fields and should ideally have a solid background in discrete optimization, integer programming, decomposition techniques. Computer science skills in algorithmic and C/C++ development are also welcome.

Knowledge of French is not required, but good communication skills and a solid knowledge of English are essential.

Benefits package
Benefits

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Sports facilities
- Flexible working hours

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Remuneration

Remunerating

The gross monthly salary is 2653€