Project: Customized and Coordinated Solutions for Congestion Bottlenecks in our Infrastructure Networks ("COCONUT")

Project leader: Prof.dr. Rob van der Mei, co-supervisors: Prof.dr. Sandjai Bhulai and Prof.dr. Guido Schaefer

Position: We have <u>three vacancies</u> for full-time, fully funded, 4-year PhD positions in the Stochastics group at the Center for Mathematics and Computer Science (CWI) at the Science Park in Amsterdam. Starting date preferably in the Fall of 2021. The candidates will get their PhD degree from the Vrije Universiteit Amsterdam.

Requirements: M.Sc. degree in Business Analytics, Econometrics, Data Science or Operations research (or something comparable). Candidates should (1) have curiosity to solve complex mathematical problems, (2) be skilled in programming languages such as Python and R, (3) have excellent grades, (4) be interested in connecting theory to real-life applications and (5) be team workers. Proficiency in the Dutch language is preferred.

Collaboration: The project will be done with a team of three PhD students and their professors, a scientific programmer and with The Driving Force, a commercial company offering mobility solutions to the market.

Project outline:
The economic growth, the urbanization and the increasing demand for mobility of people have put a tremendous burden on our infrastructure networks (e.g., highways, public transportation, touristic attractions, communication networks). At the same time, due to safety, health and sustainability issues, policy making tends to slow down the growth of – and in some cases even reduce – the capacity of our infrastructure (e.g., the recent introduction of social distancing, enforcement of speed limitations at our road network). In practice, these developments manifest themselves in frequently occurring overload situations and excessive levels of congestion, which have a main impact on our daily lives, and on our economy at large. These developments raise the need for smart innovative solutions to prevent – and to properly deal with – congestion bottlenecks in our infrastructure.

The rapid expansion of digital information and communication systems enables a significant increase of the utilization of infrastructures, together with an improved user satisfaction. This vision is based on the insight that congestion problems occur in peak-hour situations where many people want to make use of the same infrastructure resources at the same time. We believe that (1) with smart **personalized** coordination, these overload situations can be avoided, and (2) the key to realizing **these** fundamental improvements in the use of our infrastructure is to couple modern algorithms and communication technology to advanced scheduling methods and capacity management based on the concept of Customization and Coordination ('CuCo').

The CuCo-concept is based on scheduling/routing of individual users (people, cars, trucks) over time and space on a customized basis in order to reduce congestion. This requires proper coordination of the routing/scheduling decisions depending on user-specific preferences (e.g., in terms of arrival times at the destination, waiting times, priority level, willingness to pay, flexibility) posed by individual users, and properly rewarding flexibility of users. An important aspect related to coordination is the possibility of direct real-time negotiations between the users and the system, facilitated by the possibility of real-time communication.

Research challenges: The CuCo-concept is generally perceived as highly promising and powerful, and the use of CuCo-based software solutions is rapidly gaining momentum. However, to exploit the full potential offered by CuCo, the following high-level research questions are to be answered:

1. How to develop quantitative models for customized and coordinated scheduling and routing of users in time and space to reduce congestion, explicitly taking into account the individual users' preferences and flexibility, the possibility of negotiations and the omnipresence of uncertainty?

2. How to develop fast, scalable and easy-to-deploy solution algorithms for these models to exploit the full potential of the CuCo-concept?

The goal of the project is to fully exploit the potential of the CuCo-concept by:
(1) developing new models and scalable and easy-to-deploy solution methods to realize customized, coordinated, tailor-made solutions to resolve congestion bottlenecks **and increase the user satisfaction at the same time,** and
(2) building Proof-of-Concept (PoC) implementations of the methods validated in a real-life pilot environment.

Contact: For questions, please feel free to contact Prof. Rob van der Mei for questions, mail "mei @cwi.nl".