

## H2020 SOCIETAL CHALLENGES

Smart, green and integrated transport

### The Industrial Problem

Let us consider a bus line with two terminals, where the set of tasks between the two terminals is given. The goal is to find the minimum number of bus drivers such that all tasks are assigned to a driver and the shifts of the drivers satisfy a set of constraints given by labour laws and the bus company.

## TRANSPORTATION SECTOR

### BME Optimization Research Group



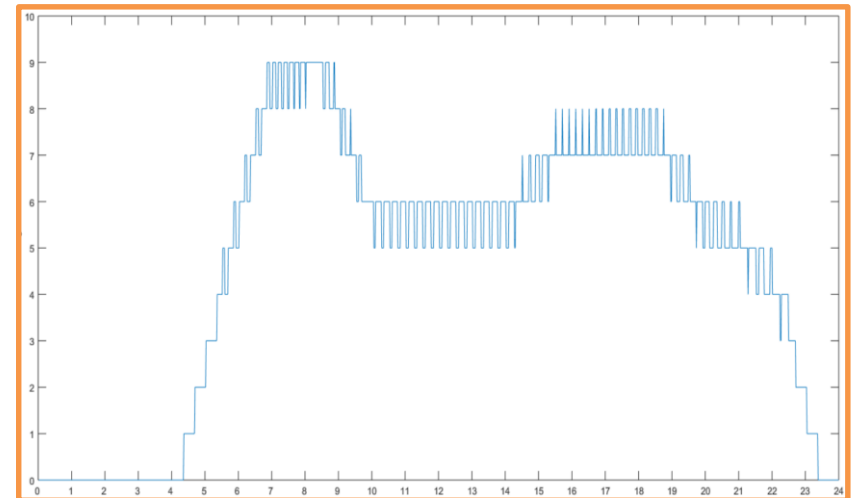
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Developing optimization models, specialized algorithms for industrial applications in the area of public transportation, supply chain and human resource management.

## Challenges & Goals



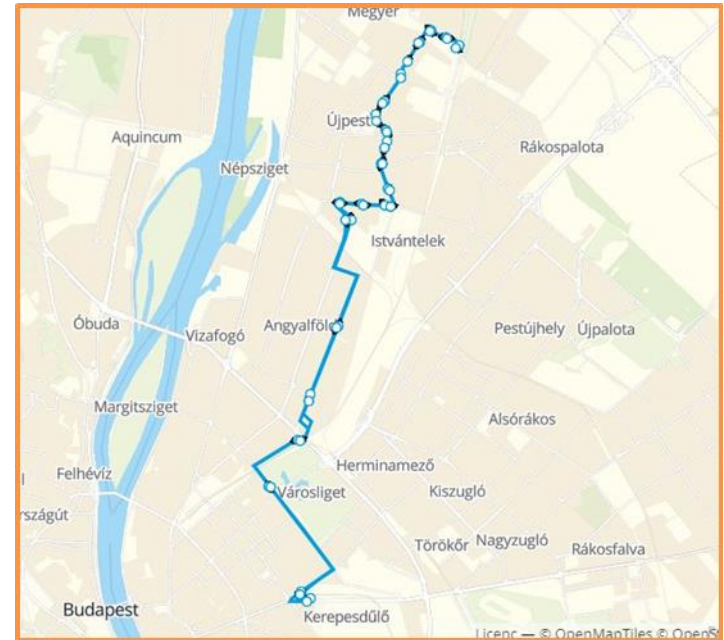
- To introduce new mixed integer programming models for the bus driver scheduling problem
- To build complex, detail-oriented models that can guarantee the fulfilling of special constraints that have not been handled in the literature before (breaks, split shifts etc.)
- To bring theoretical models closer to real-life applications
- To develop efficient implementations and produce good quality feasible solutions



*Bus 20E (Budapest, Hungary)  
Number of drivers needed over the time horizon*

## Mathematical and computational methods and techniques applied

- Different **mixed integer programming models** have been introduced to solve the problem.
- A two-phase algorithm has been developed based on the mixed integer programming formulations of two subproblems.
- The models and algorithms have been implemented using the **XPRESS-Mosel Optimization Software**.
- Numerical computations were carried out using the data from **bus line 20E** between Keleti pályaudvar and Káposztásmegyer in Budapest, Hungary. The total number of tasks for a day was 81.
- The computations were performed on a laptop with processor i5-8400 and with 8GB RAM.



*Bus line 20E (Budapest, Hungary)*

## Results & Benefits to the company

- We have developed new, complex mixed integer programming models that describe the real-life problem better than the previous models from the literature.
- Due to the applied reformulations the new models and algorithms produce high quality feasible solutions in reasonable time.

|              |   | Number of drivers |      |      |      |      |
|--------------|---|-------------------|------|------|------|------|
|              |   | 18                | 19   | 20   | 21   | 22   |
| Split shifts | 1 | -                 | -    | 8512 | 8399 | 9034 |
|              | 2 | -                 | -    | 8193 | 8320 | 8546 |
|              | 3 | -                 | 8061 | 8137 | 8334 | 8320 |
|              | 4 | -                 | 8188 | 8286 | 8282 | 7934 |
|              | 5 | 7981              | 7887 | 8993 | 7817 | 8405 |
|              | 6 | 7840              | 8113 | 7914 | 8010 | 8389 |

*Numerical results (total working time of all drivers together within a day in minutes) for different parameter values (bus line 20E, Budapest)*

A complex, detail-oriented description of a real-life problem; efficient solution algorithms

