CHALLENGES

Smart, green and integrated transport

The Industrial Problem

The problem is to reduce the operational costs of public transportation by optimizing vehicle and driver scheduling.

PUBLIC TRANSPORT

Research group

Discrete Optimization and DataMining Laboratory (DOMLAB)

Optimal scheduling of human resources

Vehicle scheduling problems

Discrete models and algorithms

Graph based data mining

Company

Budapest Transport Privately Held Corporation

BKV ZRT
BKV. ÖNNEK JÁR.

The Budapest Transport Privately Held Corporation (BKV) owned by the Municipality of Budapest runs most of the vehicles (bus, tram, metro and trolleybus) of the extensive network of public transportation in Budapest.

SZÉCHENYI 2020
MAGYARORSZÁG KORMÁNYA
Európai Unió Európai Strukturális és Beruházási Alapok
BEFEKTETÉS A JÖVŐBE

COMBINED VEHICLE AND DRIVER SCHEDULING WITH FUEL CONSUMPTION AND PARKING CONSTRAINTS: A CASE STUDY

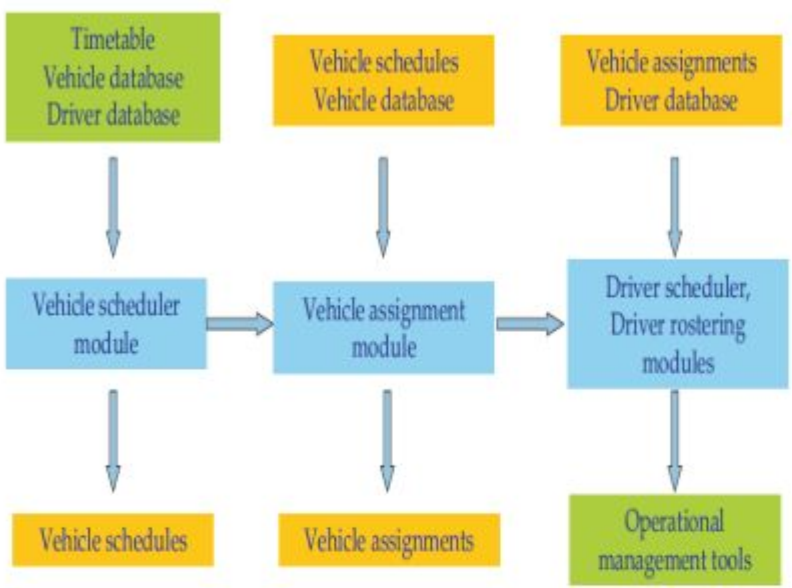
HU-MATHS-IN
Hungarian Service Network for Mathematics in Industry and Innovations

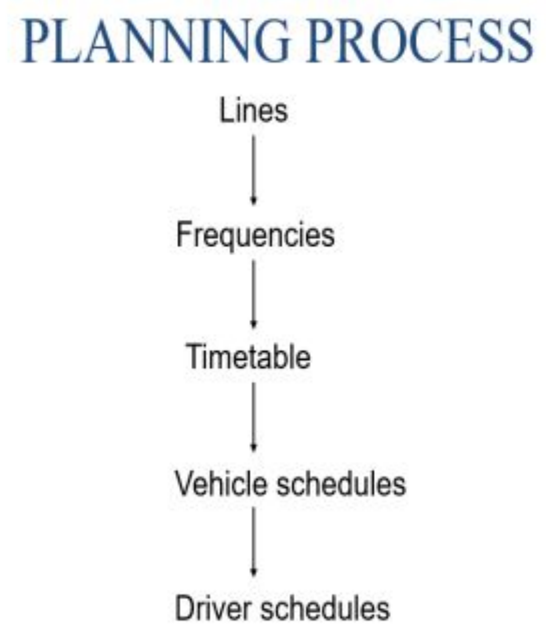
Public Transport

Optimal Schedules

Challenges & Goals

- To calculate optimal or approximately optimal schedules
- To reduce the operational cost of public transportation
- To automatize combined vehicle and driver scheduling
- To minimize the number of vehicles
- To reduce the time of schedule planning





Structure and planning process of the integrated scheduling system

Mathematical and computational methods and techniques applied

- Graph based mathematical modelling
- Discrete optimization
- Combined network flow and set partition model
- Linear and integer programming

Algorithm 1 Greedy Trip Grouper

```
procedure GROUPTRIPS(n:Integer, S : Set of Trips)
    for all T ∈ S do
        Next(T) ← The closest compatible trip to T
    for all T ∈ S do
        if Merged(T) = false then
            actTrip ← T
            MList ← ∅
            for i ← 1, n do
                Merged(actTrip) ← true
                MList ← MList ∪ actTrip
                if Next(actTrip) ≠ null then
                    actTrip ← Next(actTrip)
                else
                    Exit for
            Add MList to the output
```

Pseudocode for trip grouping

Distribution of the minimum number of required vehicles in a day

Results & Benefits to the company

- Results

The problems are given by packages
Fuel consumption and parking place capacities are taken into consideration
Labour regulations can be defined by several parameters

- Benefits

Automatic combined vehicle and driver scheduling
Optimal or approximately optimal schedules
Relatively fast calculations comparing to manual planning
Integrated service to the company’s information system

	Graph			IP Model	
Problem	Vertices	Edges	Driver schedules	Columns	Rows
1	164	3698	6448	10394	5720
2	108*	11023	127432	138947	27977
3	91	4164	46608	51038	9595
4	157*	4427	1053086	1057822	10600
5	99	1604	46947	48701	3978
6	209	22850	510926	534540	57263
7	349	10459	85869	97909	26709
8	142	5808	11495	17712	14249
9	233	8330	502702	511724	20834
10	118	781	91756	92720	1997
11	142	5808	11495	17712	14249
12	177	4309	57875	62791	10771
13	212	22612	19337	42940	48478
14	102	9836	119306	129443	24910
15	247	4374	160352	165221	9488
16	216*	12734	264298	278084	29791
17	133	9032	279244	288527	21386
18	216*	12499	369327	382253	31219
19	166	3763	27973	32065	9869
20	153	6440	91561	98304	16010

Properties of the models (= Trip grouper is used)*

Based on the results this method can automate manual vehicle and driver scheduling in large part.