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Extended abstract

Unicity of the solution is an important issue in the Dynamic Traffic Assignment (DTA) problem (Beckmann *et al.* (1956)). The conditions of unicity have been properly reviewed by Iryo (2013) for flow-based DTA by considering the different approach to solving the DTA problem. Moreover, many researches have been done to prove the unicity of DTA solutions on flow-based dynamic traffic model with several assumptions and limitations on traffic network model (Mounce (2007); Mounce & Smith (2007); Iryo (2011); Iryo (2015); Iryo & Smith (2017)). This study adapts the conditions to trip-based DTA wherein each traveler is defined as an individual. A key argument for unicity is strictly monotone path travel time function with respect to the number of travelers that use the path. However, for some systems like multimodal urban transportation networks (Mounce (2001)), the monotonicity condition simply not hold. In such cases, the final equilibrium depends on the initial network states and the network history, i.e. evolution of it's design. This study aims to investigate the end result of the evolution of a transportation system over a long-term day to day learning process. Specifically, and mathematically speaking, we are going to address the impact of initial solutions in the day-to-day multimodal DTA.

Learning curve contains the predictive Travel Time (TT) (by dynamic traffic model) and perceived TT (by simulator) based on the topology of the network and available modes for users. It helps the user to select the path for the next day using the experiments accumulated up to the present day (Smith *et al.* (2014)). Travelers in the traffic network attempt to minimize their own TT. The solution of assignment problem is called User Equilibrium (UE). If travelers have an indifference bound for minimization, the solution will be Bounded Rational User Equilibrium (BRUE). For non-unicity of UE, the most likely situation is when we have heterogeneous travel behaviors, e.g. distributed values of time. Because generally multi-class network equilibrium is expressed as a nonmonotone problem (Marcotte & Wynter (2004)). In order to analyze the impact of non-unicity, we are going to work on the learning process when the network facilities (in this work, metro lines) are introduced in the different order during the day-to-day process.

Urban public transportation facilities are costly to create and have impacts on traffic network equilibrium. Opening the new metro line is an example of changing equilibrium in the network. We are looking for the impact of the opening order of three metro lines on unicity of UE and BRUE. We can open three metro lines at the same time and calculate the equilibrium or successively open one metro line every 100 days and look for equilibrium in the day-to-day process. From the optimization point of view, it means we change the initial assignment pattern to find the equilibrium. There are three main questions that we are going to address in this study:

- Is the network UE/BRUE unique when we have different scenarios for opening the metro lines (different initial point) with homogenous users?
- Do we have unicity in case of UE conditions and multi-class users?
- The practical question would be also if there is no unicity, which order has the minimum total travel time? Are we precise enough when we predict total travel time by simulator?

In this work, we use Symuvia as a trip-based simulator for calculating the needed variables in the network. Symuvia has been developed by the LICIT laboratory in IFSTTAR. It is a microscopic simulator based on the Lagrangian resolution of the LWR model (Leclercq *et al.* (2007)). The day-to-day DTA is applied to the large-scale network of Lyon 6e + Villeurbanne with 1,883 Nodes, 3,383 Links, 94 Origins, 227 Destinations and 54,190 trips. Walking, buses and private cars are the initial available transportation modes in the network. There are three metro lines (A, B and C) and 25 metro stations in the network (figure 1).

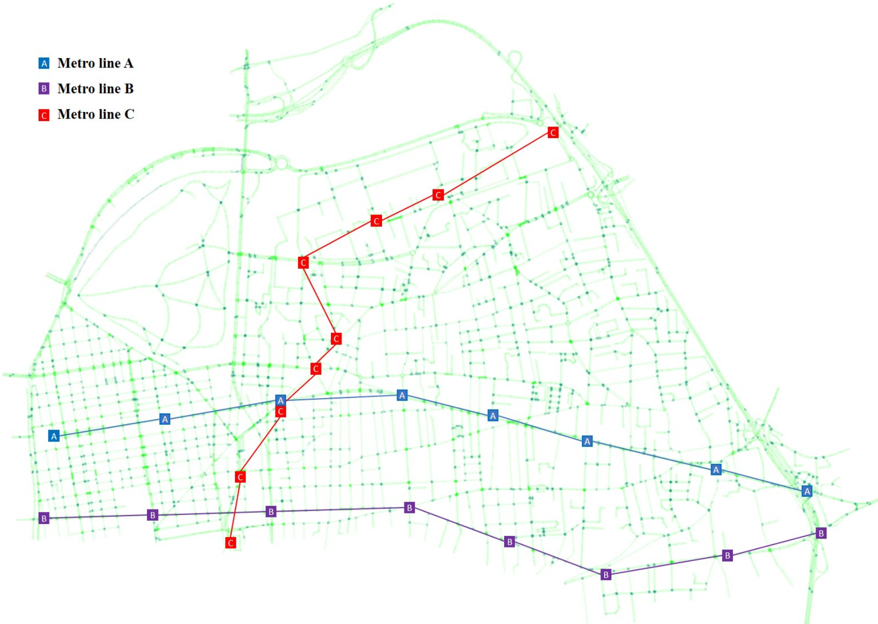

FIG. 1 – *Traffic network of Lyon 6e + Villeurbanne with three metro lines*

Each metro station has a parking. Parkings are the connectors between the metro grid and traffic network. Therefore, the traveler can start their trip with the private car then use the parking to take the train. All mode changes during the trip have a walking time for connection and possibly a waiting time for the next bus or metro to arrive to the station. There are 7 scenarios to activate the metro lines (figure 2). For each scenario, we run the day-to-day DTA for 300 days to represent the peak one and half hour of the network. In the primary results, we allow all travelers to choose between a private car and public transportation and we converged to different UE solutions for 7 scenarios with homogenous travelers. Table 1 shows the number of travelers who use the metro lines in the UE solution for each scenario. Moreover, the total travel time is different for each scenario at the optimal solutions. The results show that not only do we have non-unicity but also, that we can save at least around 150 hours on total travel time by opening the metro lines in the optimal order (ACB).

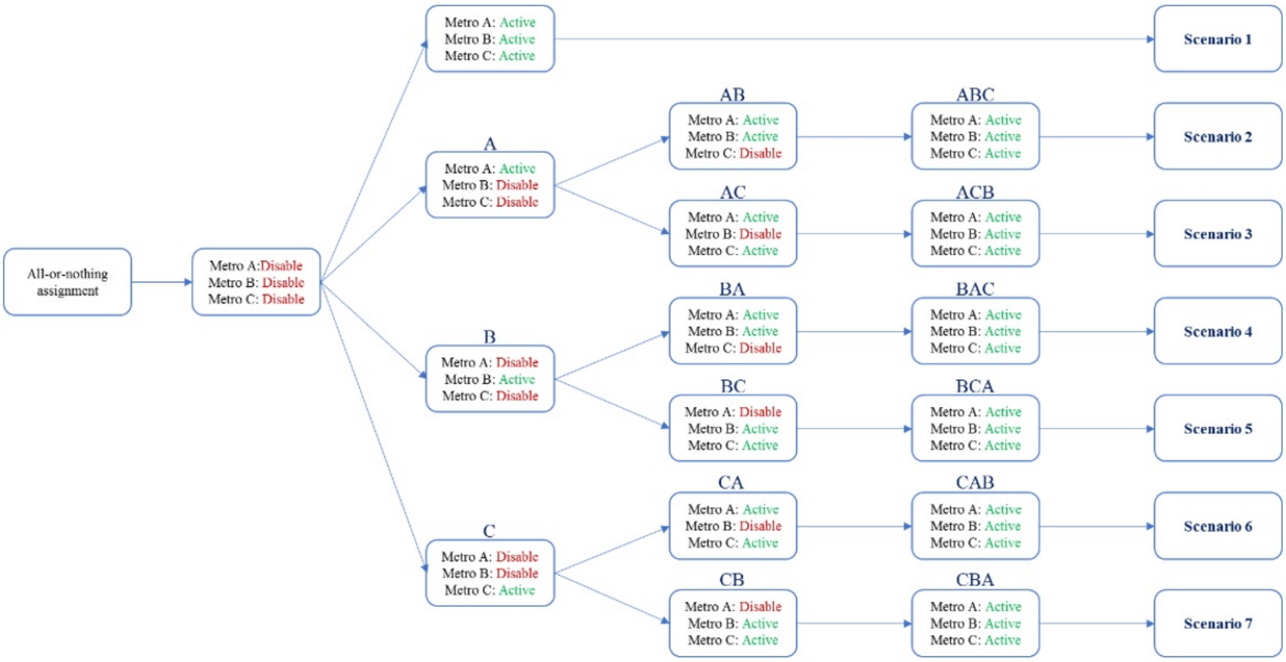

FIG. 2 – *Chart of experiments*

TAB. 1 – *Primary results*

Scenario	Sequence	Number of users used Metro line			Total travel time (hour)
		A	B	C	
1	A&B&C	480	138	9	6723.64
2	ABC	844	282	6	6821.81
3	ACB	590	132	15	6574.00
4	BAC	560	210	84	6969.03
5	BCA	391	225	27	6761.89
6	CAB	697	168	15	6729.28
7	CBA	633	360	9	6798.39

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