Urban mobility systems: complexity, models and eco-rational choices

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1. Urban mobility as a global challenge

Urban mobility allows cities to be such. From the beginning of urbanism, transport systems literally shaped cities, from compact walking and horse-cities to multi-polar rail-cities to sprawled car-cities. On the other hand moving people and goods absorbs substantial resources: money (about 20% of households available income is devoted to mobility), space and energy (about 25% of overall urban energy consumption is related to mobility). The external costs resulting from urban mobility are also rather high, with a severe impact on people health both directly, approximately 40% of road accidents and 25% of casualties are in urban areas, and indirectly, through pollution (approximately 25% of fine particles in urban atmosphere result from fossil fuel driven vehicles). The challenge for the future is to combine adequate levels of accessibility and livability with a reduction of costs and externalities. The dimension of this challenge is obviously different for different cities around the world, according to their history and development path, but given the world wide trends of urbanization, especially in developing Countries, the challenge is qualified as a global one. The challenge can be faced with a combination of technological innovation, capital investments and regulatory policies both for the mobility and the land use systems. However the intrinsic complexity of urban mobility and the “wickedness” of decision-making processes are such that the end result of a set of policies doesn’t necessarily improve on the “ecology” of the city, squandering precious resources and, in some cases, even worsening things. Avoiding these problems requires both a scientific approach to the understanding and modeling of mobility systems and a “rational” decision making process.

2. Urban mobility as a complex system

Urban mobility is the result of the interactions of several elements of different nature. Some are technical like transport infrastructures (e.g. metro and roads), vehicles (e.g. buses and cars), technologies (e.g. traffic control systems). Other elements are organizations, such as companies providing transport-related services and institutions responsible for planning and managing urban mobility. Finally there are individuals and firms making decisions directly connected to movements (trips of people and shipments of freight) or impacting on them (vehicle ownership, residential location, etc.). All these elements interact with each other in an urban mobility system. These systems have long been studied and are seen as complex systems with several non-linear interactions and feed-back loops. In several respects they are similar to other urban lifeline systems, such as energy and water, but they are more complex since not only the demand for services is strictly related to human needs, but the same elements moving in the systems are humans with an extra-layer of difficulty in modeling and understanding. A general representation of urban mobility systems is discussed, introducing the main sub-systems, supply, demand, land use and physical environment, their interactions and main feed-back loops. The urban mobility system shares many properties of complex systems including unintended and side effects.

3. Modeling urban mobility systems

The presentation introduces the main mathematical models which have been adopted to simulate urban mobility systems. On the demand side these models are based on the simulation of travelers’ behavior, possibly as part of more complex activity participation patterns. They have traditionally been developed under the paradigm of random utility theory and are applied to individuals (agents) or groups of individuals. Transport supply models can have different levels of detail in simulating traffic phenomena and performances for travelers. They range from microscopic models simulating the interactions of individual vehicles (or pedestrians) to mesoscopic models
simulating groups of users up to macroscopic models simulating traffic as a partially compressible fluid. Supply models are typically based on applications of network theory to transport supply systems. Supply-demand interaction models typically follow either an equilibrium approach or model system evolution over successive observation periods as dynamic deterministic or stochastic processes. The models built over the years have different levels of realism and complexity and simulate the system in both time-constant (within-day static) and time varying (within-day dynamic) frameworks.

4. Decision making in urban mobility as a further layer of complexity

The final part introduces the complexity of decision making in urban mobility systems. As a matter of facts different decisions regarding urban mobility can be made by different subjects in order to reach their objectives. Some decision makers are “public” and may decide to modify transport supply, including infrastructures, technologies, services, prices, regulations, in order to increase accessibility (reduce travel costs for users) and/or reduce externalities. Lately, “private” operators are increasingly entering the market of urban mobility ranging from providers of tolled infrastructures to providers of new transport services such as car sharing. Decisions significantly altering urban transport supply and/or demand can be seen from the system point of view as a further feed-back loop connecting decisions to flows and system performances (see Figure 1). However, in spite of the spectacular advances in the science of urban mobility systems, decisions on them are often the result of compromises among several and often contrasting interests of several decision makers and stakeholders. Decisions of this type can be non-rational in several ways, producing results contradicting with the stated objectives. The presentation concludes with some examples of decisions, such as the implementation of Limited Traffic Zones (LTZ), of real-time informative systems, or of road expansion policies, meant to reduce congestion, pollution and energy consumption, which could induce counterintuitive results. Conclusions address the challenges to be faced in reconciling the research progress in urban mobility systems analysis, mobility and ICT technologies with effective decision-making on these systems.

Figure 1 – Decision-making in Transportation Systems.
References


