Pervasive Real-Time Mobility Data: Implications for Transportation Strategy

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Introduction

Most passenger travel decisions are made *individually*. Moreover, individuals tend to travel quickly and unpredictably, whether by automobile, train, or foot. Their decisions result in complex, emergent travel patterns that change often over short time intervals (i.e., minutes) in magnitude and direction. By contrast, infrastructure investment and management decisions are made *collectively*, typically by governments such as countries, regions, cities, or even neighborhood associations. The resulting physical infrastructures (roads, railroads, sidewalks, etc.) change infrequently over long time intervals (i.e., years). The result is a mismatch between users and their infrastructures, in both the timing and level (or "geography") of decision-making.

Much of the research in, and development of, applications for Intelligent Transportation Systems (ITS) focuses on real-time, *operational* decision-making of users and system operators, essentially taking the underlying infrastructures for granted. For example, applications have been developed to improve users' experiences, enhance safety, moderate congestion, and reduce emissions. Rapidly-evolving, increasingly-ubiquitous data sources associated with information and communication technologies (ICTs) not only offer the possibility to enhance system performance operationally (the traditional ITS focus); these *pervasive* sensor networks also enable changes in longer-term *strategic* mobility system decision-making, whether by supporting existing decision-making processes or by enabling the creation of entirely new processes.

Evolving Decision-making Contexts

Mobility infrastructure investment decision-making varies from place to place. Influencing factors include political and cultural legacies, economic and social conditions, etc. Ultimately, these approaches produce some collection of investment and management decisions. Historically, the processes were engineering-driven, top-down in nature, based on assumptions of rational choice – ostensibly technocratic. Over time, the relevant procedures have tended towards increased transparency, pluralism, and participation – essentially more complicated in numerous dimensions. From an institutional perspective, the physical and operational scope of mobility systems have expanded, often increasing the number of political jurisdictions and institutions (public and private) involved. This evolution coincides with global trends towards decentralization – providing more political and financial authority to lower levels of government – and greater concern for sustainability – the need to maintain and/or enhance financial and economic assets, natural resources, and social equity.

Enhancing Current Decision-making Processes

In this context, pervasive ICTs play an increasingly crucial role in mobility system strategic decision-making. For example, traditional transportation planning approaches have relied on analog approaches to collect information on travel demand (via in-home or telephone surveys), implying significant time and resource costs, impairing the accuracy and timeliness of the information ultimately delivered, and slowing the pace of planning and investment decision-making. Now, however, system planners and managers (as well as the ever-more-involved private sector) increasingly turn to new data sources to support infrastructure decision-making processes, such as: smartphones and/or GPS devices to improve travel surveys; probe vehicle (GPS- and cellular signal-based) deployments and in-vehicle transponders for real-time traffic information; in-vehicle devices to explore new approaches to pricing infrastructure use and/or insurance; public transport smart card and automated passenger counters to, for example, derive origin-destination matrices; environmental sensors to monitor emissions and pollutant concentrations; and, fusion of data from a range of these and "traditional" sources to generate new forms of knowledge about the system. The emerging possibility to observe and accurately measure all four steps of the traditional transportation planning process (trip generation, distribution, mode choice, route assignment) can improve its application, leading us from the conventional "predict and provide" approach towards one based on "observe and improve." This raises a number of areas of promising research related to: implementing potential planning improvements and ensuring that they will actually lead to "better" outcomes; devising systems to handle the massive data storage and management implications for relevant agencies; capitalizing on new possibilities for direct public involvement in the planning process; and so on.

Challenging Convention

In addition to supporting existing decision-making processes, the availability of distributed, real-time data from transportation network users allows us to conceive of new approaches. Specifically, the web of ubiquitous real-time sensors can theoretically support more responsiveness and decentralization. Such information may, in fact, help to accelerate and improve political and financial decentralization – the allocation of relevant responsibilities to the "best" governance level. For example, more data more accurately reflecting local demands, costs, and revenues could improve the possibilities that our mobility systems more closely adhere to the public finance principles of *fiscal equivalency* and *subsidiarity* – matching system beneficiaries with a corresponding political jurisdiction and delegating relevant responsibilities to the lowest possible level of government without sacrificing efficiency and equity. Utilizing new and/or improved sources of revenues and system information, we can design decision-making processes with shorter time horizons and smaller geographic scales. We can also implement more precise financing mechanisms while improving their administrative ease and their assignment to adequate agencies. These changes may lead to more "responsive" and sustainable systems.

Perhaps the most extreme case of decentralization would reduce the geographic scale for infrastructure decision-making to the level of the individual, somewhat akin to a purely voluntary, market-based approach. The open source movement in computing offers, perhaps, an analogy. Instead of giving a single decision-making entity control for infrastructure decisions for, say, a metropolitan area, extreme decentralization would build from the infrastructure decisions/preferences made/expressed by all individuals as measured precisely via distributed data collection systems. The observed, emergent patterns may well allow the arrangement of wholly new institutional architectures, via a user-driven approach more closely aligning user preferences with mobility networks – a promising area for theoretical and experimental research.

In short, we suggest that the important intellectual energy and research effort going into pervasive ICT-enabled next-generation ITS applications needs to be matched by an effort to understand and fully capture the value of technological innovation for institutional innovations, and vice versa. It's a two-way street: institutional innovations will accelerate the adoption of advanced ICTs; next generation ICT innovations will also enable a new generation of institutional architectures. The result will be higher quality and more responsive mobility system planning, financing, and operations.