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Viewpoint

A methodological framework for benchmarking smart transport cities

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ABSTRACT

Besides responding to challenges of rapid urbanization and growing traffic congestion, the development of smart transport systems has attracted much attention in recent times. Many promising initiatives have emerged over the years. Despite these initiatives, there is still a lack of understanding about an appropriate definition of smart transport system. As such, it is challenging to identify the appropriate indicators of 'smartness'. This paper proposes a comprehensive and practical framework to benchmark cities according to the smartness in their transportation systems. The proposed methodology was illustrated using a set of data collected from 26 cities across the world through web search and contacting relevant transport authorities and agencies. Results showed that London, Seattle and Sydney were among the world's top smart transport cities. In particular, Seattle and Paris ranked high in smart private transport services while London and Singapore scored high on public transport services. London also appeared to be the smartest in terms of emergency transport services. The key value of the proposed innovative framework lies in a comparative analysis among cities, facilitating city-to-city learning.

Introduction

The world's urban population has increased from 29% in 1950 to 50% in 2008 and is projected to increase further to 70% by 2050 (UnitedNations, 2008). This rapid growth has increased demand for transportation facilities. While providing more transport services might be an easy option to meet the increased demand, the increase in supply is often associated with undesirable outcomes like traffic congestion. According to a study on 75 US cities in 2000, a total of 3.6 billon vehicle-hours and 5.7 billion US gallons of fuel were wasted due to congestion-related delays, resulting in a congestion cost of $67.5 billion (Shaheen & Finson, 2004). In a parallel vein, Goodwin (2004) has projected that the annual congestion cost in UK would reach GBP30 billion by 2010 and keep increasing thereafter.

Better management of transportation services with controlled increase in supply would be a useful alternative strategy to meet the increased demand. A common strategy is to introduce smart technologies to better manage urban transport systems. The idea of making a transport system smarter is not new. Garcia-Ortiz, Amin, and Wootton (1995), for example, has discussed how various cities have developed smarter transport systems by introducing smart technologies. More recently, the Research and Innovation Technology Administration (RITA) has defined an architectural structure for deployment of smart technologies in USA (RITA, 2007). The smart transportation guidebook (NJDOT, 2008) has outlined different policies for making smart transportation systems for New Jersey and Pennsylvania, while IBM (2009) has suggested a number of ways for improving mobility by introducing smart technologies. Debnath, Haque, Chin, and Yuen (2011) have discussed the smart technology initiatives in Singapore.

Despite various initiatives promoting smartness in urban transport systems, little is known about how these systems and their host cities are performing, and even less, as to which is a model city for smart transportation if one exists. Without a proper concept of smart transport system and specific indicators of smartness, it is difficult to determine if a transport system is becoming smarter or indeed, what needs to be done to make it smarter. Arguably, the lack of proper concepts and indicators could be a reason for not performing comprehensive benchmarking studies on smart transport cities.

Such a benchmarking study would allow comparative studies among cities. The most important aspect of such comparative studies is that cities can learn from each other and take appropriate initiatives to move towards becoming smarter. Notwithstanding criticisms (e.g., raising competitiveness, accuracy of ratings, etc.), the ranking of smart transport cities could open opportunities for cities to assess a city's growth potential and to sharpen its profile among other cities. It could be used by transport authorities in

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public engagement to draw public attention to the major problems and underdeveloped sectors of transport systems, thus, initiating a broad discussion on potential growth issues, helping the authorities to learn what public opinions and desires are. Ranking would also motivate the authorities to make their decisions more transparent and comprehensible.

A review of the extant literature has yielded two regional studies that have attempted to benchmark cities according to the smartness in transport systems. First, Giffinger et al. (2007), Giffinger, Haindlmaier, and Kramar (2010) have ranked European medium-sized cities according to the smartness in mobility (transportation and information communication technology) along with five other dimensions (economy, people, governance, environment, and living). Smart transport has been defined and measured by using indicators of local/international accessibility (e.g., public transport network per inhabitant, satisfaction with access and quality of public transport), availability of ICT infrastructure (computers and broadband internet access in households), sustainable, innovative, and safe transport systems (e.g., non-motorized traffic share, use of economical cars). While these indicators could reflect the performance level of a smart transport system, the study fails to identify many true indicators of smartness and hence the question remains how a transport system becomes smart. For example, the indicators of 'local/international accessibility' could measure 'accessibility' of transport facilities, but not for measuring 'smartness' in transport systems. The indicators of ICT infrastructure availability represent how accessible computers and internet are in households, but do not specifically represent how smart a transport system is. True indicators of smart transport systems should be based on transport-related ICT infrastructure (e.g., sensing technology used for tracking vehicles en-route). Moreover, sustainability, safety, and smartness are considered three components of a transport system which support each other (see Haque, Chin, & Debnath, 2013), but sustainability and safety are not indicators of smartness, rather these are indicators of the performance of a transport system.

Second, a study by the RITA on 108 cities in the USA, which is more robust than the Giffinger study in terms of using more appropriate indicators of smartness in transportation systems, has conducted a survey on the deployment of intelligent transportation systems in the years 2007 and 2010 (RITA, 2010). While this survey has provided a good opportunity for US cities to learn from others on the use of smart technologies, the concept of smart transport system is not well demonstrated. The deployment statistics have showed the extent of the smart technology usage, but have not explained how smart the technologies are. A comprehensive benchmarking of smart transport cities should not only measure the smartness of an urban transport system but also consider the extent of smart technology usage as well as their levels of smartness.

Review of the two studies reveals two important gaps in literature: (1) inability to utilize true indicators of smartness in transportation systems, and (2) utilizing indicators without considering the smartness levels of the indicators. Arguably, lack of a proper concept of smart transport system, which consequently leads to not obtaining specific indicators of smartness, is the primary source of these gaps in the current literature. Therefore, a comprehensive benchmarking methodology needs to be developed which will address these gaps by developing indicators based on a proper concept of smartness in a transportation system.

This paper proposes a comprehensive and practical framework for benchmarking cities according to the smartness in their transportation systems. The methodology of the framework includes: formulating a proper concept of smartness, generating a generic matrix of indicators of smartness for an urban transport system, measuring smartness indices of different sub-systems of urban transport system, and taking into consideration the usage of smart technologies. The proposed innovative framework, particularly the generic matrix of indicators and the process of developing the matrix by utilizing a proper concept of smartness in urban transport systems, is the key contribution of this paper and mark the advancement in the methodology of benchmarking smart transport systems. In the succeeding sections, the framework, its methodology, assumptions and data sources will be explicated, followed by an illustrative example, which benchmarks 26 major cities across the world. The illustrative example on benchmarking smart transport cities is limited to large cities in terms of population.

Framework of benchmarking

The framework involves three key steps: formulating a proper concept of smartness in the context of urban transport system, generating a generic matrix of indicators of smartness, and measuring smartness indices from scores of the indicators. These three steps are discussed in the following sections.

The concept of smartness

The concept of smartness is fundamental to any benchmarking exercise among smart cities. A recent review of the 'smart city' concept has revealed diversified ideas and definitions of 'smart city' and the associated concept of smartness among service providers, city authorities, governments, and researchers (Chin, Debnath, & Yuen, 2010). In general, a smart city is characterized by its Information and Communication Technology (ICT) infrastructures, facilitating an urban system which is increasingly smart, inter-connected, and sustainable (Giffinger, Haindlmaier, & Kramar, 2010; Giffinger et al., 2007; Lazaroiu & Roscia, 2012; Lee, Phaal, & Lee, 2013).

In the context of an urban transport system, several researchers (e.g., Goldman & Gorham, 2006; Santos, Behrendt, & Teytelboym, 2010) have identified the implementation of smart technologies as the central element in achieving smartness and sustainability. Some (e.g., Debnath et al., 2011; Haque et al., 2013) have illustrated how smart technologies can support sustainability by achieving greater economic and environmental efficiency. A smart urban transport system is often viewed as one which utilizes smart technologies in its operation and management. A smart technology is a self-operative and corrective system that requires little or no human intervention. Typically, it has three elements: sensors, command and control unit (CCU), and actuators to provide the basic capabilities: sensing, processing and decision making, acting (control), and communicating (Akhras, 2000).

To have sensing ability, a system should be able to extract information from its sensors and communicate with its CCU or with external systems. Typically, sensors collect information regarding the state of the system, which are transmitted to the CCU for processing. The CCU interprets the information, takes decisions and transmits those to actuators, which execute the decisions into actions. Thereafter, the sensors again collect information and transmit to CCU, reinforcing a closed-loop monitoring and action taking process. The essential idea of a smart system is that it reduces human involvement and makes the system self-operational.

In summary, a smart system should possess the above mentioned basic capabilities. In addition, there could be some other advanced or higher-order capabilities as shown in Fig. 1. The higher-order capabilities include: predictability, healing and preventability. Predictability is the advanced level of basic sensing and processing, which refers to how accurately a system can predict a potential problem or scenario. Healing is the advanced level