International Journal of Software Innovation
Volume 11 • Issue 1

Cyber-Physical Urban Mobility Systems: Opportunities and Challenges in Developing Countries

Dénis Awé Samalna, University of Maroua, Cameroon
Justin Moskolai Ngossaha, Faculty of Science, University of Douala, Cameroon*
https://orcid.org/0000-0002-9228-4543
Ado Adamou Abba Ari, University of Versailles Saint-Quentin-en-Yvelines, France
Kolyang, University of Maroua, Cameroon

ABSTRACT

Rapid population growth and the number of vehicles in cities have complicated urban mobility management. Digitalization supported by the internet of things and wireless communication has allowed some cities to mitigate the problem by taking advantage of the multiple benefits offered. These are cyber-physical systems (CPS), which are systems where a number of devices collaborate for the control of physical entities. This recent technology finds its application in urban mobility. However, in the context of developing countries, there are many local specificities one needs to consider. How could the integration of cyber-physical systems help urban decision makers to design sustainable urban mobility systems that meet the needs of the population? The paper proposed not only a recent review of the literature, but also a framework of CPS of urban mobility to guide decision makers. The challenges, opportunities, and barriers to innovation of CPS in urban environments in developing countries have also been identified.

KEYWORDS

Architectural framework, Complex System, Cyber-Physical Systems (CPS), Decision support systems, Urban Mobility system

INTRODUCTION

According to United Nations projections, by 2050 almost 70% of the population will live in cities (Cohen, 2006; Van & Marston, 2021). Moreover, these cities suffer from congestion, road accidents, high travel times, and air pollution (Monios & Bergqvist, 2020). These urban mobility problems are common in both developed and developing countries. But in developing countries, the situation is

DOI: 10.4018/IJSI.315662
*Corresponding Author

alarming, simply because of the lack of quality transport infrastructure, the lack of application of new technologies to the transport system, and the impact of the mix of transport modes (Mfenjou et al., 2018; Abdel et al., 2020). City managers sometimes develop strategies such as building new roads, especially inexpensive paved roads, which do not have a positive impact on improving road safety. The use of new technologies for decision support is almost non-existent. The actions undertaken do not provide sustainable solutions and the requirements of users in urban areas are not met.

The authors (Ngossaha et al., 2020) contributed significantly to sustainable urban mobility to preserve the environment for future generations in the context of developing countries. For the authors, the new mobility should enable the reduction of air pollution, collaboration between actors and integration of mobility services. Thus, the new paradigms consider mobility as a service (MaaS) and envisage the application of artificial intelligence algorithms, connected objects and Big Data (Mishra, 2021). However, developing countries need a decision-making framework to manage the interactions in the mobility system which is now seen as a system of systems. Coupling the urban mobility system with the cyber-physical system (CPS) paradigm can help to reduce collisions, avoid traffic jams, control traffic lights intelligently, ensure a more efficient multimodality, and find a last mile solution and a sustainable solution. To this end, CPS technology combines communication, control and data processing due to the advent of the Internet of Things and advanced technologies, such as 5G, cloud computing, machine learning, Big data and data processing. Nowadays, CPS technology has strongly integrated the field of transport, in which research works present new solutions for intelligent and safe mobility, such as the Cyber-Physical bike, Vehicular Cyber-Physical and even Traffic control based Cyber- physical system. This same CPS technology has also interested many researchers in various other fields, from healthcare, manufacturing, sports, human-machine interface, agriculture and more (Gupta et al., 2022). CPS is a suitable solution for integrated and sustainable urban mobility system (Pundir et al., 2022).

Integrated urban mobility is an important factor in the socio-economic development of cities and also an effective solution to reduce road safety problems (Al-Thani et al., 2022). The integrated urban mobility system refers to the integration of components like information systems urbanization, optimization of existing road network, decision making coordination, motorized transport (vehicle technology), non-motorized transport (bicycle paths and walking abilities), transport demand management (parking, car sharing) and cloud computing for interoperability. For this purpose, mobility data is collected by sensors and roadside unit installed on the road network and stored in urban Big Data (Dogan & Gurcan, 2022). The permanent analysis of Big data will make it possible to anticipate the consequences of interactions on the road (Nandhini & Ramanathan, 2022), and to challenge stakeholders in real time such as pedestrians, drivers, firefighters, the road police, hospital, and public services in charge of road transport.

Despite the interest of this area of research, the integration of services or systems is almost non-existent in developing countries, particularly in urban transport with the use of 5G. So, the integration of services in poor countries is a big challenge, especially with the lack of digitalization and the poor quality of infrastructure. A serious architectural design problem arises, involving multidisciplinary fields, mathematics, computer science, transport engineering, civil engineering, economics, sociology, and more (Lee & Lim, 2021). The challenges in the context of developing countries are enormous and marked by the presence of disruptions, privatization of the transport sector, very low subsidies for urban roads, and above all the prevailing poverty (Nnamani et al., 2022). For example, various disruptions, such as livestock crossing the road and disrupting traffic, degraded road conditions, houses next to the road, forks caused by yellow taxis, non-compliance of two or three-wheelers with traffic regulations and driver behavior. Therefore, developing countries need: (1) transformation of the urban mobility system into a sustainable urban mobility system to meet the well-being of the population, (2) application of new technologies to improve urban mobility services, (3) improved decision making through complex interaction situations, (4) interoperability of systems for efficient control and improved mobility. To this end, this paper not only presented a recent synthesis of the