Key Challenges of Smart Railway Station

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Abstract. This paper introduces the main concepts of establishing a smart railway station under the context of smart city. In the recent years, cities are digitally developing to enhance the all aspects of the urban life including economic, social and environmental aspects. These three aspects are considered to be the main pillars of sustainable development of a smart city. A core element in the smart city development is the mobility. This might include the physical mobility of people or the economic mobility. Introducing the smartness concept in the transportation infrastructure will influence the population growth and business needs. Railway points of contact such as the stations that can offer excellent economics development, environmental performance, and punctuality for passengers are recognized as a fundamental component of urban development. Stations are always considered the interconnection between different transportation modes which had to be adapted to the urbanisation growth. The proposed work presents a state of the art review for rail smart station design and illustrates the key challenges that can be faced when thinking in establishment of smart railway station.

Keywords: Rail station · Smart station · Smart mobility · Intelligent transportation · Smart city

1 Introduction

Population growth, enormous level of industrialization and urbanization are constantly pushing in the infrastructure and creating a jostling situation for the consumption of resources. Cities have an important role in the economic and environmental aspects all over the world [1]. The concept of smart cities became popular in the scientific literature in the last two decades [2]. Currently, all cities should find all innovative solutions and ways in order to face and manage the new challenges they exposed to. These challenges may include urban planning, mobility, security, energy, transportation, healthcare, utility usage and governance. Various researchers have studied the smart city definition [3–5].

The concept of smart cities was discussed in different ways in academic articles. The main common aspects between these studies is that, smart cities considers the basic elements of sustainable urban communities including: environmental, social, economic and cultural aspects. A smart city is sustainable city as it takes into account all the

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aforementioned aspects in addition to enhancing the quality of life and fairness for all citizens [6].

A smart city uses digital technologies or information and communication technologies to enhance the quality and performance of urban facilities by carrying out the control over the delivered services to the urban residents [7, 8]. In a smart city, researchers highlighted that all various system should work in an integrated form and no system works in isolation of the others, especially in dens environments. In the literature, many researchers defined various dimensions of the smart cities [9–12]. By investigating all dimensions of smart cities, it can be noticed that transportation and infrastructure present a crucial axes of a smart city. Rail stations form a connection between these two axes.

Rail stations are considered to be the point of trust between the passengers and the service providers. As it can be defined the point of interest in the end-to-end journey, stations should be designed to better accommodate all modes of transportation to increase the passenger comfort and decrease the time wasted during the journey. Congestion is a major problem for all exiting railway stations especially at peak hours. Recent studies by the department for transport in UK predicted that the rail demand will increase by around 85 billion passenger kilometers in 2033. It was also found that 40% of trains are required during the peak period which can be enabled by the digitalization of the provided railway services.

The present paper discuss the main challenges facing the implementation of smart rail station with in the context of smart cities. The paper introduces an overview analysis on one of the important axes of the design of smart cities, that is, smart rail transportation system that supports the economic growth and urban planning of smart cities.

2 Smart Transportation Systems

Smart transportation systems form a major element in the smart city model. Fig. 1, indicates the major elements of a smart city model. As it can be noticed, the transportation module within the model is subsequently based on smart mobility, smart connectivity and smart energy consumption. Smart transportation is needed for the proper and efficient mobility of people, freight and services. The future of transportation systems lies not only on the construction of new stations, roads, tunnels and bridges, but also on the use of intelligent transportation system (ITS) [13].

The main idea of using ITS, is to provide the traveller or the transport service user with all necessary information to increase the service reliability as well as sustainability. This can be done by the application of computer, microchips, electronics, information and communication technologies (ICT) and management strategies in an integrated manner. Implementing ITS solutions will definitely develop the way that people commute which directly influence the quality of life in modern hi-tech cities. These solutions can also provide consumers an access to a smarter, safer, and faster way to travelling [13, 14].

Smart mobility, energy and connectivity are considered to be the triangle of the smart transportation systems with in a smart city Fig. 1. To solve part of the traffic

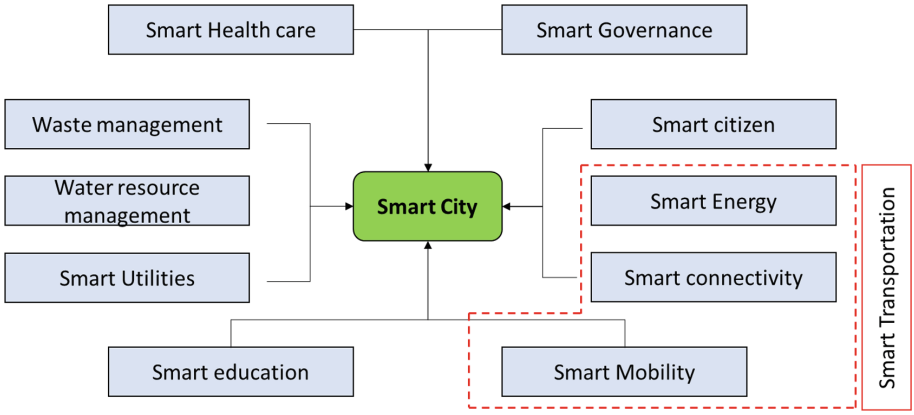

Fig. 1. Smart transportation system in the smart city model

congestion problems, efficient public transportation system may be applied. But, the smart mobility concept searches for innovative solutions for people mobility in smart cities. For example, smart mobility solutions implements the advances and technology and proactive passenger behaviour. Mobility has many aspects rather than the people behaviour, it also includes economic and environmental aspects. Smart connectivity supports both mobility and energy concept in the transportation system by the application of ICTs in optimizing the traffic flow and efficient energy consumption. This will have a significant environmental impact of implementing smart energy solutions in reducing CO_2 emissions.

3 Smart Station Concept

Railway transport is always in continuous growth and development. Rail stations form also part of this revolution in the rail industry. Since the rail stations already exist since the beginning of 19th century, they have influenced by the recent advances in the transportation sector by introducing the concept of intelligent transportation systems. The importance of rail stations comes from its role and services provided to the station users and the whole environment surrounding the station. There is no unique criteria for defining the concept of smart stations, however it should be defined by the same criteria used for the definition of smart city.

Smart stations are designed in a revolutionary way to make use of available data and technologies to increase the rail transportation's reliability and sustainability. All infrastructure managers and political organizations devote for the importance of renovating rail stations to maximize the role they play beyond being only a transportation hub (Fig. 2).

Modern design of smart stations should built on the basis of smart infrastructure, smart mobility, smart management and sustainability. Therefore, rail station can be smart by promoting its important place in smart city. The main three pillars of sustainability targeted by the smart station design are: *1)* Environmental targets-including

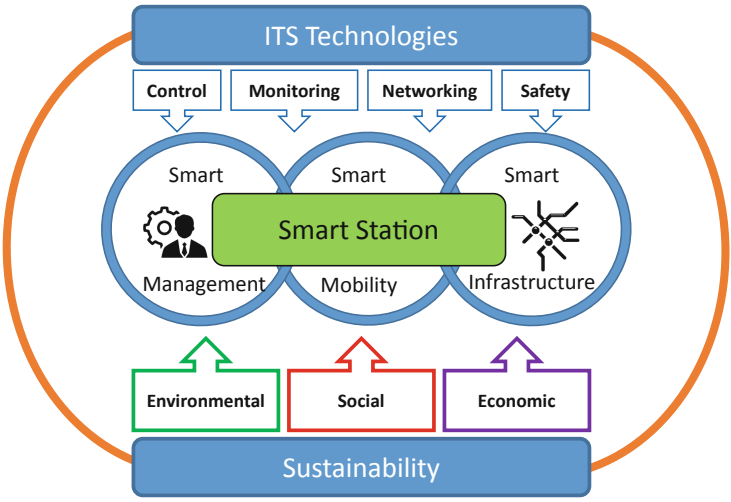

Fig. 2. Smart station concept

the use of a low carbon power source (i.e., a renewable energy source based on solar capturing technologies as well as noise reduction by improved preventive maintenance system through monitoring of the railway system parameters; *2)* Social targets-including the improvement of safety inside the rail stations and regaining the mode share concept for increased urban mobility objectives; *3)* Economic targets–including the reduction of track maintenance and operation costs as well as reduction of overall life cycle cost (LCC) of the rail system.

4 Smart Station Challenges

Stations present a key role in the rail transportation as they are considered the point of interaction between the transportation authority, operators and passengers. Smart rail stations have a direct impact on the smart city planning and design. In the following subsections, the key challenges that might face the design and commissioning of rail station will be stated.

4.1 Safety and security

People safety is the number one priority in rail transportation. The safety and security challenges in the rail stations may include: terrorism act prevention; suicide attacks; fire and explosion risks; abandoned bags identification, control of access points and bomb threats. When these challenges are managed successfully by the smart security and monitoring systems in rail stations, all rail users and employees will have a confidence in the rail stations' safety and the overall railway system safety. Smart Railway Stations transport systems have benefited from innovative technologies for railway

infrastructure managers and train operating organizations to help them make more effective decisions and improve railway station security and safety.

Embedded computing systems have been used for rail station surveillance and monitoring [15]. Those systems are made for checking system status from a physical-security perspective, so as to distinguish interruptions and other natural occasions. Embedded systems (ES) also are utilized in cyber-physical checking and control applications highlight progressively unpredictable architectures and strict requirements about security, privacy and dependability.

4.2 Intermodality

Stations acts as a key point in the intermodal concept. A recent UK study including 10000 respondents showed that the pain points for passengers are at the points at which they shift their mode of transport. It was found that 75% of UK journeys are affected by pain points. This percent increase to 86% when rail transport is involved. Smart rail stations should be designed in such form that evolves the following aspect: Improving the speed of passenger interchange; Reducing the complications associated to multi-modal journeys planning and execution; Improving the reliability and connectivity offered to modal shift users.

4.3 Connectivity

Connectivity is more than just a pillar in smart cities, connectivity is the foundation of smart planning. One of the main items in connectivity is Internet of Things (IOT) sensors which rely inertly on their ability to transmit data in real time, which help in smart planning decision making. Smart rail stations implement sensors that can be added to the vehicle and station infrastructure. The data transmission is done by using efficient connection and communication system design that implement low-power, short-range wireless network (such as Zigbee) with a local data collection unit (or 'gateway') for condition monitoring of the rail system [16]. The collected data can then be processed and transmitted in real time to the driver, operator, control room, entities in charge of maintenance and even to the station users. The challenge is to define possible solutions for data transmission and communication using either wayside devices (density of wayside readers for effective coverage is not known). This will be based on the density of data transferred.

4.4 Energy Consumption

In the recent years the energy efficiency gained a lot of attention due to its significant impact on the reduction of CO_2 emissions. It was found that, in 2010 transportation is emitting almost 14% of the total amount of greenhouse gas emissions and this percent is forecasted to be increased by the double in 2050 [17]. Electric railway systems (ERSs) is one of the biggest consumers of energy in the transportation sector. It is also considered the first targeted candidate in the reduction of CO_2 emissions by using alternative energy resources and maximizing the energy efficiency. Smart rail stations present a key role in such initiatives.

Energy storage systems can be fitted in rail stations to store the amount of energy produced from alternative resources such as Photo Voltaic panels (PV) and Regenerative Braking (RB) which can reduce the total energy consumption of ERSs by 1 - to 40% [18]. In addition to the use of smart and energy efficient systems inside the stations like (efficient escalators and lightening systems), smart stations also should use the smart grid concept which provide a new prospective of energy management strategies in ERSs [19, 20].

4.5 Governance

Under the context of smart cities, the concept of smart governance has an utmost importance. Smart governance meaning is the use of Internet and Computer Technologies (ICTs) in crafting a progressive public-government partnership [21, 22].

By investigating the different models of smart governance which include: Government to Citizen (G2C); Government to Business (G2B); Government to Government (G2G) and Government to Employee (G2E), smart stations are most likely to be affected by the C2C and C2B models. The smart governance opens a direct communication channels between the government and individuals. It will allow station users to directly report their feedback and can easily get a response from the infrastructure managers about the provided service in the stations. This might include safety and security problems, data protection issues and regulation of the relationship between rail customers, rail operators and authorities that manage the stations like the infrastructure managers [7, 22, 23].

Reducing the problems faced by entrepreneurs and business leaders in the interaction with the government will always help in the economic growth. It will encourage private sector in investing in smart stations and will foster the implementation of new technologies in the transportation sector in general towards a better mobility and provide real time monitoring, save cost and time. This can be also beneficial to companies that needs a direct knowledge about the latest policies regulations and even get an access to data collected by the government which can be used for economic forecasting and planning.

4.6 Integrity and Social Recognition

At the governmental level, a clear transportation strategy should be adopted throughout an innovative techniques and measures that provide decreasing all levels of barriers for investors and innovators to implement the new technologies in the design, construction and operation of futuristic rail stations. A pilot station model can be adopted by the transportation authorities with the help of other transportation modes operators to act as a measure for the advances in the smart rail station design and it compatibility with the other modes. This can be considered as a framework towards the analysis of the impact of new technological advances implemented in the stations.

5 Conclusions

The present paper highlights the challenges that might face the smart rail stations within the context of smart city concept. Rail stations became a point of interest as it considered the point of interactions between passengers and transportation authorities all over the world. It is necessary to increase the volume of investments in smart stations to decrease the level of congestions and overcrowding.

All rail resources must be aligned to encourage innovators and endorsement of industrial partners to provide a proof of concept of the technologies and innovations that can increase the performance of rail station as well as the rail competition.

Smart stations should be designed in away that maximizes the role it plays in a smart city rather than being a simple transportation hub. By making stations smart, its influence will be translated to a successful business model.

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