Intelligent Bus Shelter as an Example of the Novel Smart City Technology Integration

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***Abstract*— In this comprehensive study, an in-depth overview of a multi-stage development project is presented, focusing on the creation of a Demonstrative Version of an Interactive Multimedia Bus Shelter as a component of a novel concept in Smart City infrastructure. The project aimed to address various interesting challenges inherent in developing intelligent bus shelters, encompassing aspects like cost constraints, susceptibility to vandalism, power supply stability, and seamless retrofitting into existing infrastructure. Emphasizing a holistic approach, the designed bus shelter showcased high interactivity, low energy demand through environmentally friendly solutions, and superior functionality. The integrated modules encompassed an intelligent LED (Light Emitting Diode) matrix, LTE (Long Term Evolution) gateway, portable device charger, image acquisition camera, environmental sensor eco-monitor, photovoltaic array, among others. Notably, all these elements were orchestrated through artificial intelligence algorithms, highlighting the system's advanced technological foundation. The investigation results provide a roadmap for the implementation of individual solutions, including an efficient power supply system, a secured and high-performance internal and external communication infrastructure, and an AI (Artificial Intelligence)-based human interactive system. The integration of above elements is likely to represent a solution in creating the intelligent bus shelters of the future - shelters that will be technologically advanced, but also energy efficient, secure, and responsive to the needs of both passengers and the broader Smart City ecosystem.**

Keywords- bus shelter; smart city infrastructure; artificial intelligence.

I. INTRODUCTION

Intelligent bus shelters stand at the forefront of modern urban development, embodying a transformative fusion of technology and public infrastructure. In the evolving landscape of Smart Cities, these shelters play a pivotal role in redefining public transit experiences while showcasing the seamless integration of technology into the very fabric of urban living [1]. Serving as connectivity hubs, these shelters not only enhance accessibility through amenities like Wi-Fi and USB charging, but also seek to meet the digital needs of urban populations in an era characterized by connectivity and convenience [2]. Moreover, their eco-friendly features contribute to sustainability goals, aligning with efforts to create environmentally responsible urban ecosystems [3][4].

This short paper is structured as follows. In Section II, we present our methodology. Section III presents the results and discussion, and we conclude in Section IV with potential applications.

II. METHODOLOGY

This comprehensive study focuses on the multi-stage development of a Demonstrative Version of an Interactive Multimedia Bus Shelter—an integral component of a novel Smart City infrastructure concept. The project addresses various challenges associated with the development of intelligent bus shelters, including cost constraints, susceptibility to vandalism, power supply stability, and seamless retrofitting into existing urban infrastructure.

Emphasizing a holistic approach, the designed bus shelter showcased high interactivity, low energy demand through environmentally friendly solutions, and superior functionality. The integrated modules, driven by artificial intelligence algorithms, included an intelligent LED matrix, LTE gateway, portable device charger, image acquisition camera, environmental sensor eco-monitor, and a photovoltaic array. This integration not only highlights the technological prowess of the system, but also underscores its potential to contribute significantly to the efficiency, connectivity, and forward-thinking nature of Smart Cities.

This study delves into the rigorous testing of the complementary systems, offering valuable insights and guidance for technological solutions. The investigation results provide a roadmap for the implementation of individual solutions, including an efficient and island power supply system [5], a secured and high-performance internal and external communication infrastructure [6], and an AI-

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based human interactive system [7]. The integration of these elements represents a significant stride in creating intelligent bus shelters that are not only technologically advanced but also efficient, secure, and responsive to the needs of both passengers and the broader Smart City ecosystem.

III. Results and Discussion

Within the studies discussed in Section II, the construction and smart systems of the Intelligent Bus Shelter was developed and integrated (see Figure 1).

Figure 1. Bus shelter developed within the project.

The entire system considered the following elements and functionalities:

- Internet access point,
- Charging point for mobile devices and personal urban transportation means (e.g., scooters),
- Timetable information, taking into account the estimated current travel time, depending on traffic intensity and unforeseen events, including transfers, with a search function for the fastest connections,
- Line number information for approaching public transport vehicles,
- Information on the current load of approaching public transport vehicles, especially during peak hours,
- Stop request signal and taxi service call feature,
- Assistant for people with disabilities, providing additional information and warnings, as well as conveying the need for assistance during boarding a vehicle.
- Tourist guide, facilitating access to places of historical and architectural significance in the city,
- Ticket vending machine offering electronic tickets for travel,
- Weather station with air quality monitoring and warnings about approaching atmospheric phenomena,
- Monitoring station controlling urban lighting in a specified area, also serving as part of the notification system for medical and law enforcement services,
- Other reporting and information services, with the possibility of future implementation.

In addition, the roof surface of the shelter was used to install photovoltaic panels, providing additional power to electronic systems, thereby reducing the burden on the power grid and contributing to environmental protection.

All the systems were tested for their efficiency and durability in the environmental conditions to prove their applicability for the outdoor operation.

IV. Potential Applications

Due to the diverse and unique functionality, a varied user group is anticipated, extending beyond the commonly understood group of passengers. These groups can be preliminarily identified as:

- Passengers, with special consideration for amenities aimed at individuals with a certain degree of disability,
- Operators of public transportation vehicle networks, including the drivers of these vehicles,
- Meteorological and environmental services (remote weather station, air solution monitoring),
- Rescue and medical services (Automated External Defibrillator - AED, First Aid Kit),
- Traffic control and transportation safety management centers,
- Municipal services - audience measuring capabilities using smart cameras combined with Artificial Intelligence used to strictly define types of potential end users (gender, age, focus time etc.).

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