Science, Engineering & Education, 9, (1), 2024, 17-24

Intelligent System for Improving the Urban Environment of the Municipality of Vratsa - Smart City Vratsa

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Received 08 July 2024, Accepted 10 October 2024
DOI: 10.59957/see.v9.i1.2024.3

ABSTRACT

Smart City Vratsa is a project initiated by the municipality of Vratsa to transform the city into one of the leading smart cities in Bulgaria. The project encompasses an intelligent system aimed at enhancing the urban environment by implementing modern technologies in various aspects of life. Supported by Invipo and executed by Lead Vision in consortium with Syscom Engineering, the project showcases advanced solutions for urban development and improving the quality of life for residents.

Keywords: urban environment, smart city platform, IoT sensors, citizen engagement tools, air quality monitoring, real-time data, smart parking system, environmental sensors, weather stations, quality of life.

INTRODUCTION

A smart city embodies innovations in urban environment management, integrating modern technologies into various aspects of life. The project combines essential components such as sustainable development, intelligent resource utilization, and improving residents' quality of life. The goal is to achieve efficient management of urban services, enhance safety, and create a healthier and more convenient urban environment using the latest technological advancements [1].

Smart city platform

Smart City is a platform that enables the integration of various intelligent systems for management, monitoring and analysis of the urban environment and the technologies implemented in it. The platform is a comprehensive tool for monitoring both historical data and current status and trends. It enables operators to monitor and manage urban technologies, devices and systems from a single location [1 - 3].

Key Features of the Smart City Platform

1. IoT Sensors and Devices
2. Data Analytics
3. Connectivity
4. Centralized Data Platform
5. Citizen Engagement Tools

Benefits of the Smart City Platform

1. Improved Efficiency

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2. Enhanced Quality of Life
3. Sustainability
4. Economic Growth
5. Data-Driven Decision Making

The platform enables data aggregation, monitoring, integration, consolidation and visualization. The user interface is coherent and easy to use, providing online information on traffic status, air pollution, environmental status and urban services [2, 4, 5].

EXPERIMENTAL

The implementation in Vratsa

The project, supported by Invipo and executed by Lead Vision, includes the creation of an interactive platform, vratza-smart.bg, to showcase Vratsa's transformation into a smart city. This platform integrates various functions such as up-to-date information on the environment, parking, buses, and points of interest [6, 7].

The Invipo integration platform is powered by numerous sensors collecting data ranging from traffic to air quality. These data are then used to optimize traffic, manage emergencies, improve urban infrastructure and services, optimize resources, enhance safety, and even develop sustainability. Invipo connects various urban services and systems, allowing them to work together [3, 6].

The platform

The platform (Fig. 1) contains seven modules: environment, weather, city information, parking, parking spaces, points of interest, and buses. It offers both light and dark themes. The application is developed in both Bulgarian and English, with a responsive design [2, 7].

Environment

To track environmental quality in Vratsa, two stations, manufactured by Develiot (Fig. 2 and Fig. 3) have been installed in key locations. These stations are equipped with advanced sensors that measure key environmental parameters essential for managing urban air quality. Each station monitors a wide range of data, including air temperature, humidity, atmospheric pressure, fine particulate matter (PM2.5 and PM10), wind speed, and wind direction. The fine particulate matter sensors are especially important because these particles can penetrate deeply into the respiratory system, posing serious health risks

Fig. 1. Citizen view of the platform [4].

Fig. 2. Weather station located in the city [7].

Fig. 3. Weather station located in the city [7].

[3, 4, 8].

The sensors for temperature, humidity, and pressure are enclosed in a protective shield to ensure accurate readings by maintaining constant natural air convection. These sensors have a wide range: temperatures from -40°C to 80°C, humidity from 0 % to 100 % RH, and pressure from 300 to 1200 hPa. They offer high resolution and accuracy, with the temperature sensor providing a resolution of 0.015°C and accuracy of 0.2°C, the humidity sensor offering a resolution of 0.01 % RH and accuracy of 1.5 %, and the pressure sensor providing a resolution of 0.0016 hPa and accuracy of 0.5 hPa [8].

The particulate matter sensors use the laser scattering principle to detect dust particles in the air, available in both standard and high precision models. The standard precision sensor targets PM10 and PM2.5 particles, with a detection range of 0 to 1000 μg m^{-3}, a resolution of 0.1 μg m^{-3}, and a response time of less than 45 sec. The high precision sensor targets PM10, PM2.5, and PM1 particles, with a detection range of 0 to 1500 μg m^{-3}, a resolution of 0.1 μg m^{-3}, and a response time of less than 30 sec [8].

Weather stations also include slots for up to 8 gas sensors, covering both low and high concentration gas sensing. Low concentration sensors monitor gases like CO, NO_2, SO_2, and O_3, with detection ranges and resolutions tailored to each gas. For instance, the CO sensor detects from 0 to 10 ppm with a resolution of less than 10 ppb. High concentration sensors monitor gases such as NH_3, H_2S, Cl_2, HCl, HF, CH_2O, and H_2, with specific detection ranges and resolutions for each. For example, the high concentration CO sensor has a range of 0 to 1000 ppm and a resolution of 0.5 ppm [8].

Wind speed and direction sensors use a three-wind cup structure and a precise internal angle sensor for accurate measurements, measuring wind speeds from 0 to 45 m s^{-1} and directions from 0 to 359°, with high accuracy in both parameters. This extensive monitoring system provides real-time data crucial for assessing and managing the urban ecosystem in Vratsa, helping city planners and environmental managers make informed decisions to improve air quality, reduce pollution, and enhance residents' overall health and well-being. Continuous monitoring of key environmental parameters also aids in predicting and responding to weather-related events, ensuring a safer and healthier urban environment. The integration of these weather stations showcases a forward-thinking approach to urban management, leveraging technology to create a more liveable, sustainable, and resilient city [8].

RESULTS AND DISCUSSION

Smart parking

The smart parking system in Vratsa marks a significant improvement in urban mobility and traffic management, designed to help drivers find

Fig. 4. Parking information board located in the city [7].

Fig. 5. Platform parking integration [4].

Fig. 6. Platform parking integration [4].

available parking spaces easily (Fig. 4).

This advanced system, part of an integrated approach (Figs. 5 and 6), provides real-time information on the status of parking zones within the city. Parking spaces in different areas of the city are either paid or free at various times of the day, allowing for more flexible use of urban parking [4, 7].

The system categorizes parking availability into three main statuses: available, nearly full, and fully occupied, allowing drivers to make informed decisions about where to park. This reduces the time spent searching for an available spot, effectively decreasing traffic congestion. Additionally, the system includes information on the presence and locations of payment terminals, helping drivers quickly locate the nearest terminal to pay for their parking and streamlining the entire parking process [4].

The primary goal of the smart parking system in Vratsa is to promote efficient use of the city's parking resources. By providing real-time data and easy access to information, the system encourages better parking management and utilization, benefiting individual drivers and contributing to a broader positive impact on the urban environment. Reducing traffic congestion has several environmental benefits, such as lower emissions from idling and driving around in search of parking, which contributes to improved air quality. A more streamlined parking experience also leads to decreased stress and frustration for drivers, contributing to a more pleasant urban experience.

Public transport

The public transport page highlights significant improvements in the city's transportation system (Fig. 7), providing detailed information about bus stop locations and the presence of information boards. These enhancements make it easier and more efficient for residents to use public transport, facilitating their daily commutes [4].

Up-to-date information on bus stop locations

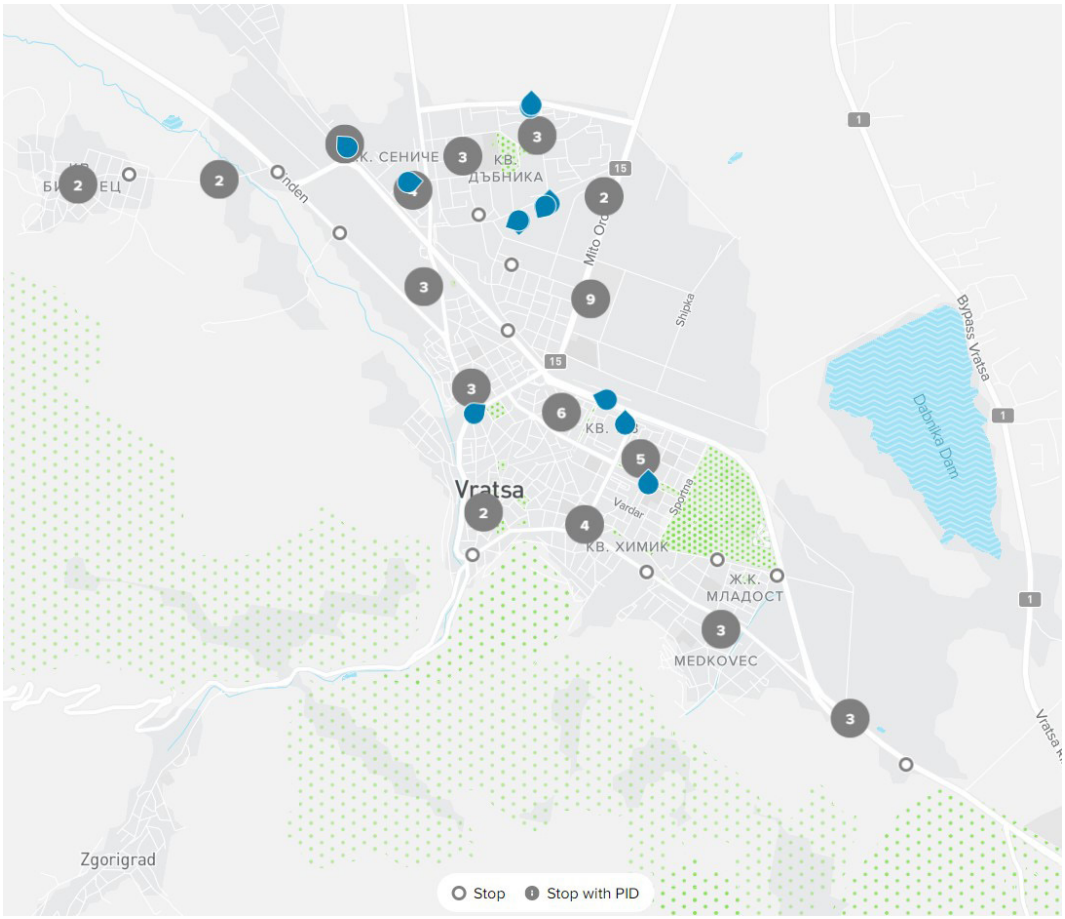

Fig. 7. Integrated urban transport system [4].

allows residents to plan their journeys more effectively. Knowing precisely where bus stops are situated helps commuters choose the most convenient routes and stops, minimizing the time spent walking or waiting for a bus. This is particularly beneficial for new residents or visitors who may not be familiar with the city's public transport network [4].

Information boards at bus stops provide real-time updates on bus schedules, including arrival and departure times, helping commuters make informed decisions about their travel. By knowing exactly when the next bus will arrive, passengers can reduce their waiting time and optimize their schedules. This feature is especially useful during peak hours or in adverse weather conditions when delays are more likely.

Together, these improvements significantly enhance the efficiency and convenience of using public transport in the city. They contribute to a more seamless commuting experience, reducing the stress and uncertainty often associated with public transportation. For residents who rely on buses for their daily commutes, these innovations make public transport a more viable and attractive option, potentially increasing its usage and reducing traffic congestion in the city.

Points of interest

The "Points of Interest" page is designed to showcase the most popular attractions in the city to both residents and tourists (Fig. 8). This page includes comprehensive information on a variety of points of interest, such as museums, historical

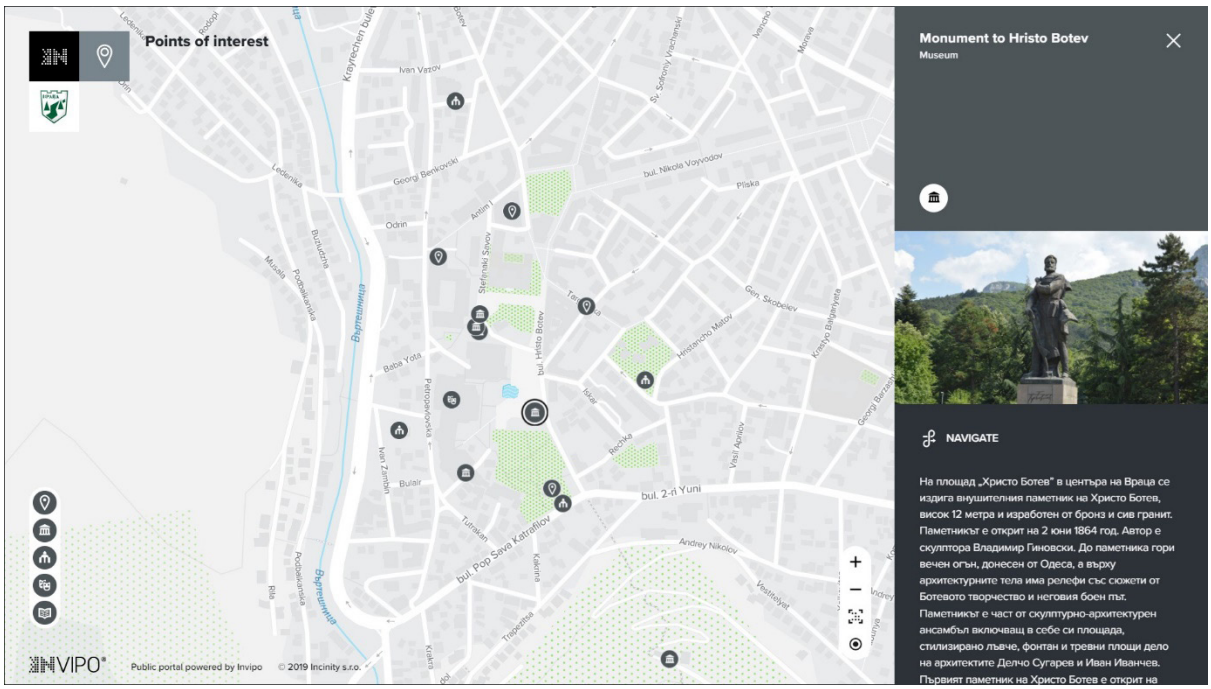

Fig. 8. Map with points of interest built into the platform [4].

sites, parks, and other significant places important to Vratsa's culture and history [4].

Detailed descriptions and relevant information about these attractions make the page a valuable resource for anyone wishing to learn more about the city and its landmarks. For example, museums highlighted on this page may include details about their exhibits, opening hours, and any special events or exhibitions. Historical sites are described with information about their historical significance, architectural features, and notable events that took place there [4].

Parks and recreational areas are also featured, providing information about the facilities available, such as walking trails, playgrounds, picnic areas, and any regular activities or festivals held in these green spaces. Other significant places, including cultural centers, theatres, and art galleries, are showcased with details about their contributions to the city's cultural landscape.

This page not only serves as a guide for tourists looking to explore Vratsa but also acts as a resource for residents to discover and appreciate the rich cultural and historical heritage of their city. By presenting all this information in an accessible and organized manner, the "Points of Interest" page helps promote local tourism, encourages cultural engagement, and fosters a deeper understanding and appreciation of Vratsa's unique identity.

CONCLUSIONS

The transformation of Vratsa into a smart city represents a significant leap forward in urban management, driven by the integration of modern technologies to enhance various aspects of urban life. The project aims to achieve sustainable development, efficient resource utilization, and an improved quality of life for residents. By employing the latest technological advancements, Vratsa's smart city initiative focuses on efficient urban service management, enhanced safety, and the creation of a healthier and more convenient urban environment.

The Smart City Platform is a pivotal tool in this transformation, offering a comprehensive system for the management, monitoring, and analysis of the urban environment. This platform enables the integration of various intelligent systems, allowing for centralized control and data-driven decision-making. Key features such as IoT sensors, data analytics, and citizen engagement tools collectively contribute to improved efficiency, enhanced quality of life, sustainability, economic growth, and informed decision-making.

In Vratsa, the implementation of the smart city project, supported by Invipo and executed by Lead Vision, includes the development of the interactive platform vratza-smart.bg. This platform integrates functions such as real-time information on the environment, parking, buses, and points of interest, enhancing the urban experience for both residents and visitors.

The environment module of the platform showcases an extensive network of weather stations equipped with state-of-the-art sensors that measure critical environmental parameters. This system provides real-time data that is essential for assessing and managing the urban ecosystem, thereby aiding in improving air quality, reducing pollution, and enhancing the overall health and well-being of residents.

The smart parking system represents a significant advancement in urban mobility, offering real-time information on parking availability and facilitating efficient parking management. This system reduces traffic congestion, lowers emissions, and improves the overall quality of life for residents by minimizing the time spent searching for parking.

Improvements in public transport are highlighted on the public transport page, which provides detailed information on bus stop locations and real-time updates on bus schedules. These enhancements make it easier and more efficient for residents to use public transport, thereby reducing stress and uncertainty in their daily commutes and potentially increasing public transport usage.

The "Points of Interest" page serves as a valuable resource for both residents and tourists, showcasing Vratsa's most popular attractions. By featuring detailed descriptions of museums, historical sites, parks, and other significant places, this page promotes local tourism, encourages cultural engagement, and fosters a deeper understanding and appreciation of Vratsa's rich heritage.

In summary, Vratsa's transformation into a smart city through the integration of modern technologies and the development of an interactive platform represents a forward-thinking approach to urban management. These initiatives collectively contribute to creating a more liveable, sustainable, and resilient city, enhancing the quality of life for its residents and making Vratsa an attractive destination for visitors.

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