Advantages and Disadvantages of using IoT for Smart Cities

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***Abstract*—The rapid growth of urbanization has led to increasing challenges in city management, including traffic congestion, energy consumption, healthcare accessibility, and environmental sustainability. The Internet of Things (IoT) presents a promising solution by enabling real-time data collection and intelligent decision-making across various domains of urban life. This paper explores the advantages and disadvantages of using IoT technologies in smart cities through a systematic literature review. Key benefits include improvements in traffic flow, energy efficiency, public health, education, and waste management. At the same time, the study highlights significant challenges such as high implementation costs, privacy concerns, interoperability issues, and scalability limitations. The findings suggest that while IoT can greatly enhance the functionality of smart cities, addressing these obstacles is essential to ensure secure, efficient, and inclusive urban development.**

***Index Terms*—IoT, smart cities, advantages, disadvantages, challenges, opportunities**

I. Introduction

Due to the rapid growth of urbanization, cities are facing numerous challenges, e.g. traffic congestions and safety issues [1]. IoT has emerged as a promising solution to overcome these challenges along with data analytics and artificial intelligence [1].

The IoT refers to the interconnection between physical and virtual objects through the internet, enabling them to collect and exchange data [2]. The identification of these devices in the internet is done through the use of unique identifiers, such as IP addresses [2]. Talking about IoT devices, they can be anything from smart home appliances to sensors and actuators used to collect data and execute actions.

[3] emphasises the importance of meeting the rising urbanization with the development of smart cities. Smart cities are urban areas that leverage internet and communication technologies (ICT), such as IoT to enhance the quality of life, improve the economy, and promote sustainability [3].

II. Research Methodology

This study adopts a Systematic Literature Review (SLR) approach to examine the advantages and disadvantages of using IoT technologies in smart cities. The reason for this approach is to provide a comprehensive unbiased overview of the current state of research on this topic.

To identify relevant papers, a structured search string was developed to capture a broad range of perspectives on the topic. The following search query was used in academic databases:

> TI (iot OR "internet of things") AND (smart cities OR "smart city") AND (advantages OR benefits OR pros OR strengths OR disadvantages OR cons OR risks OR challenges OR drawbacks OR weaknesses)

The search was limited to peer-reviewed journal articles and conference papers published in English. As a database for the search, Google Scholar and EBSCO were used.

III. Advantages of IoT in Smart Cities

A. Traffic Management

The integration of IoT in traffic management systems has shown significant improvements in urban mobility. IoT-enabled traffic lights can adapt in real-time to traffic conditions, reducing congestion, improving travel times, reducing emissions and fuel consumption [1]. For instance, smart traffic lights can adjust their timing based on real-time data from observed car movements through cameras and sensors [1].

[4] highlights that smart traffic management systems have even more benefits, such as notifying citizens about traffic conditions, other transportation options and routes, which can help them make informed decisions about their travel plans. A similar system is illustrated in [5], where the authors describe a smart traffic mobility management system for users to get real-time information about traffic conditions, like "[...] speed, occupancy degree [...], CO2, NO2, O3, and noise.".

B. Energy Management

With the increasing demand for energy in urban areas, IoT technologies can play a crucial role in optimizing energy consumption of electricity, thermal and gas in smart cities [3]. [1] states that IoT-enabled smart grids can monitor and analyze energy usage patterns, allowing for better load balancing and demand response so that the energy is distributed to areas with the highest demand. This can lead to reduced energy waste and lower emissions [1].

C. Healthcare

In [4], the authors explain that IoT technologies can be used to monitor patients' health in real-time through sensors measuring for example "[...] pulse, respiration rate, and skin temperature [...]". IoT technologies can also facilitate the secure sharing of sensitive patient information with authorized personnel [4]. Those measures enables more effective monitoring and timely decision-making regarding patients' health conditions [4].

Another important aspect which is being discussed in [3] is that the application of IoT in healthcare can lead to improved healthcare accessibility for citizens, especially in remote areas. This is achieved through telemedicine and remote monitoring, which allows patients to receive medical care without the need for physical visits to healthcare facilities [3].

D. Community

IoT systems can contribute to the quality of life by improving the financial, ecological, and social aspects of a community [3]. For instance, [5] describes a system that allows citizens to find events in their area in order to engage with their community. Other than that, the authors of [5] also present a scenario, which they call "Citizen Activity Enhancer" that allows citizens to share their activities with others, such as "[...] sports activity or shopping activities [...]" and to find other citizens with similar interests.

E. Waste Management

Waste bins equipped with IoT sensors send fill-level data to a central system, allowing waste management companies to optimize collection routes and schedules [1]. This not only reduces operational costs but also minimizes the environmental impact of waste collection by reducing fuel consumption and emissions due to unnecessary trips [1].

F. E-Learning

The integration of IoT technologies into smart cities has significantly transformed the landscape of e-learning. By enabling real-time interaction between physical and virtual educational components, IoT allows for a more immersive and flexible learning experience [2]. Smart devices, such as RFID-enabled whiteboards, wireless sensor networks, and cloud-based platforms, facilitate seamless communication between students, educators, and learning resources, regardless of geographic constraints [2].

IoT enhances accessibility by enabling students to participate in educational activities anytime and anywhere. Learners can remotely access labs, perform virtual experiments, retrieve data, and submit assignments in real time [2]. Similarly, global access to digital libraries and educational materials becomes possible through interconnected systems, allowing students and teachers to engage with vast knowledge bases without physical limitations [2].

Moreover, IoT promotes smart collaboration by creating interconnected networks of educational entities — students, teachers, and devices — supporting real-time group work and fostering efficient knowledge exchange. This collaborative infrastructure not only improves the learning process but also encourages student motivation and participation in digital communities [2].

G. Smart Homes

Smart homes leverage IoT sensors to automate appliances and monitor environmental conditions, enhancing convenience, safety, and energy efficiency [4]. Devices like surveillance cameras, smart lighting, and temperature controls transmit real-time data to a central system, allowing homeowners to manage their homes remotely [4]. Additionally, connected homes can form networks, sharing information (e.g., outdoor surveillance) to contribute to neighborhood safety and broader smart city infrastructure [4].

H. Safety and Security

[5] introduce a "City Safety and Accident Management System" that uses IoT to gather information about criminality and accidents. In this system the citizen is the main actor, who can report incidents, a so called "participatory sensor".

The other user scenario that is presented in [5] is a system for managing risks of natural disasters and alerting citizens. The data is collected from sensors and humans, which is then processed to provide information about the risk of weather events and send push notifications to citizens.

IV. Disadvantages of IoT in Smart Cities

A. Costs

One of the major barriers to implementing IoT in smart cities is the high initial investment required for sensors, infrastructure, and communication systems [1]. While long-term benefits such as improved energy efficiency and public safety can offset these costs, the upfront expenses remain a challenge, especially for smaller or developing cities [1].

Additionally, the overall cost includes not only design and installation but also ongoing operational and maintenance expenses, which must be managed carefully to ensure long-term sustainability [4].

B. Privacy and Security

As IoT systems in smart cities continuously collect personal data — such as movement patterns or energy usage — privacy and data protection have become critical concerns [1]. Without robust safeguards, unauthorized access could lead to serious breaches [1].

Securing the IoT ecosystem is particularly challenging due to the heterogeneity, scale, and ad-hoc nature of connected devices [3]. Researchers emphasize the need

for scalable and interoperable security measures, including encryption, access control, and blockchain-based solutions, to ensure data integrity and protect citizen privacy [3].

C. Interoperability

Smart cities rely on a wide range of heterogeneous IoT devices, sensors, and systems that must seamlessly communicate and work together. However, differences in standards, protocols, and data formats make interoperability a major challenge [3]. These mismatches can hinder integration at the application layer, complicating the deployment and management of IoT infrastructure [4].

To overcome this, smart city initiatives focus on adopting flexible architectures and selecting compatible technologies that support cross-platform integration and scalable communication frameworks [3].

D. Scalability

Scalability is a crucial factor for IoT in smart cities, as the number of connected devices is projected to exceed 100 billion by 2050 [3]. Current management protocols often struggle to accommodate the growing volume and complexity of IoT systems [3].

To address this, scalable architectures — such as peer-to-peer frameworks and edge computing — have been proposed to support expansion without compromising performance [3]. Additionally, energy-efficient scheduling algorithms can help manage data traffic and reduce packet loss in large-scale networks [3].

V. Conclusion

The IoT holds transformative potential for modern urban development, enabling the evolution of traditional cities into smart, responsive, and efficient environments. As this paper has shown, IoT technologies offer significant advantages in critical areas such as traffic management, energy optimization, healthcare, education, and community engagement. The integration of smart sensors and data analytics not only enhances urban services but also contributes to sustainability, citizen well-being, and quality of life.

However, despite these benefits, the implementation of IoT in smart cities presents notable challenges. High infrastructure and maintenance costs can hinder adoption, particularly in developing regions. Privacy and security risks remain a major concern, given the vast amounts of personal data collected by interconnected devices. Furthermore, issues like interoperability between heterogeneous systems and the scalability of IoT networks must be addressed to ensure long-term effectiveness.

Ultimately, realizing the full potential of IoT in smart cities requires a balanced approach — one that not only leverages the technological capabilities of IoT but also addresses its limitations through thoughtful design, regulation, and continued innovation. With careful planning and collaboration among stakeholders, smart cities powered by IoT can become more inclusive, adaptive, and future-ready.

VI. References

References

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