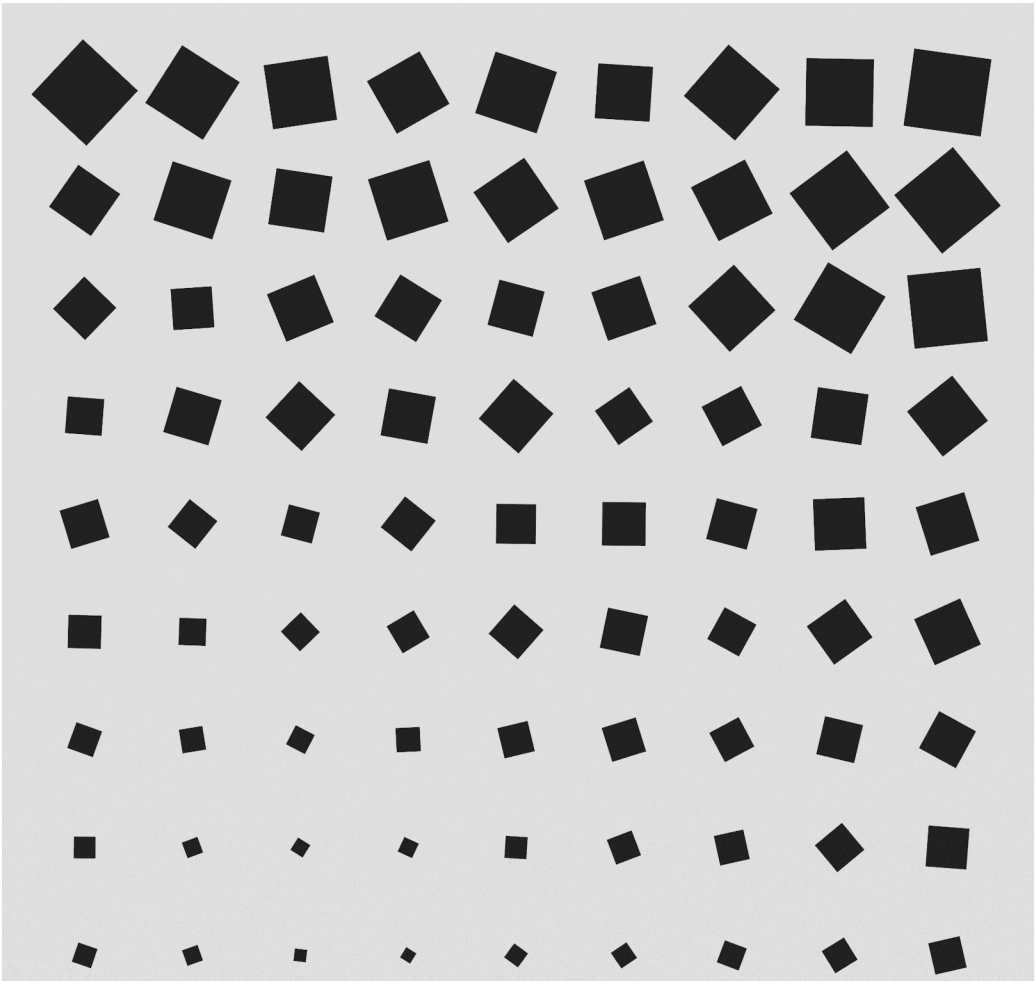
CHANGE-TRANSFORMATION AND CRITIQUE OF URBAN SPACES

URBAN SPACES:
TYPOLOGY, MEDIA, ART AND NEW PERSPECTIVES



ARCHITECTURAL SCIENCES

EDITORS
PROF.DR.SONAY ÇEVİK
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2023

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IOT TECHNOLOGIES IN URBAN SYSTEMS

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1. Introduction

The balance between rural and urban populations has shifted in favor of exponentially increasing urban populations around the world. As a result, cities have become difficult places to live and manage. Therefore, in today's cities, it is crucial to improve the quality of life. It is therefore imperative to design or update cities based on sustainability goals. As per UN estimates, 68% of the world's population will live in cities by 2050 (UN, 2018). There are many negative outcomes associated with population growth in cities that affect citizens, the economy, the ecology, and the environment, such as environmental pollution, waste management problems, epidemic diseases, stress-related health problems, traffic density, and difficulty in citizen participation (Zhang et al., 2016). A holistic approach is necessary to achieve sustainability goals today rather than focusing on each management domain individually, such as energy, mobility, food supply, security, and participation (Pera, 2020). Thus, it is necessary to take advantage of new technologies in the management of urban systems (USs) and their subsystems.

As determined by 18 indicators and 48 sub-indicators, the 2022 digital cities index (DCI) ranks Copenhagen, Amsterdam, Beijing, London, and Seoul as being the most digital cities in that order (DCI, 2022). Through technology, urban dwellers in these cities can increase benefits and reduce the harms associated with urbanization (Faldi et al., 2022).

"Smart cities (SCs), one of the hottest discourses of today, use models designed for this purpose and powered by the internet of things (IoT), big data (BD), and cloud technologies (Inkinen et al., 2019). SC models provide a means of achieving sustainability goals that are at the top of many city administration

agendas, to improve the quality of urban life, and to reduce environmental impacts (Wu, et al., 2021).

The problem in this study is that the current USs are struggling to cope with the needs of the ever-increasing urban population. The purpose of this study is to explore how IoT technologies can be deployed in urban systems to make cities more livable.

Additionally, there are several obstacles that prevent the widespread adoption of SC models. Among them are the security of the vast amount of data collected and analyzed, the financial cost that urban governments must bear to invest, and the unwillingness of municipal governments to support stakeholder engagement (Khan, 2022).

The research is limited to five USs: smart government, smart environment, public health, and well-being, public safety and security, and urban mobility. The following research questions were designed in this context:

Q1: What are IoT technologies, and how do they work?

Q2: What are the applications of IoT technologies in urban systems, and how do they benefit?

Q3: Which weaknesses are associated with IoT technologies used in urban systems?

Accordingly, a literature review was conducted in the context of IoT and IoT technologies that may be used in USs. The design of this study is represented in Figure 1.

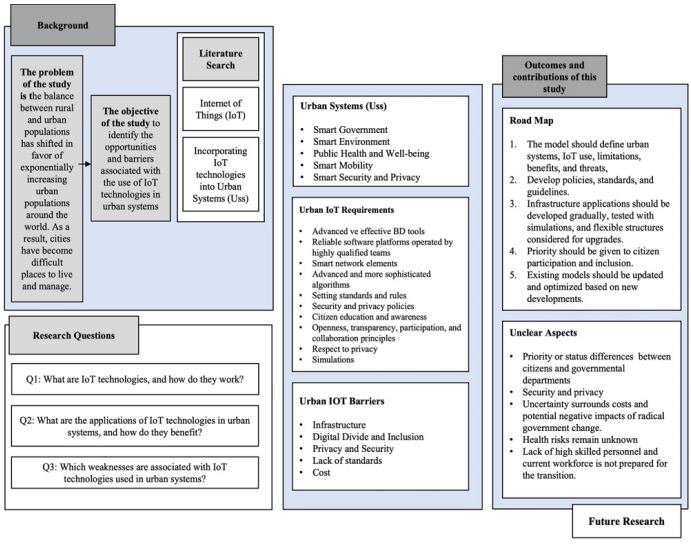


Figure 1. Research Design

In the conclusion, a roadmap for utilizing IoT technologies in the USs is outlined, and ongoing uncertainties are discussed regarding urban IoT.

2. Literature Research

The Smart City (SC) concept is all about creating urban environments with higher quality and a sustainable structure by combining IoT, big data, and cloud technologies (Inkinen et al., 2019). For this purpose, IoT devices, such as sensors and cameras, collect data, which is then analyzed by BD technologies and stored using cloud technologies. A SC model is designed to address the needs of a city and include the necessary USs (Noori et al., 2020). Vehicles, structures, and even systems used in-house are all interconnected in SC models. City dwellers use their smartphones, vehicles, and screens at home to access these systems. Thereby, a more interconnected environment reduces the negative effects of urbanization as well as energy costs. Governments are thus able to create more livable environments and achieve sustainability goals (Caird, 2018).

This study concentrates on IoT technologies underlying SC models. In the literature research section, IoT will first be explained, and then IoT technologies will be discussed in the context of USs.

2.1. Internet of Things

This section will explain how the Internet of Things (IoT) functions and how it interacts with other technologies. IoT is built on the principle of "interconnection of all things" (Wang et al., 2013). IoT systems are intelligent systems with features like perception, identification, and BD computing capabilities. IoT is the technology underlying a system in which all physical devices are connected to a network via sensors and software, which is managed by a central server, allowing everything connected to the network to be monitored, controlled, and data to be transferred (Hamdan et al., 2022). The widespread adoption of IoT technologies is seen as evidence of the third scientific and technological revolution's power (Feki et al., 2013). The IoT technology is currently connected to more than 10 billion devices, with that number expected to increase to 27 billion by 2025 (State of IoT, 2023). Providing seamless connectivity between embedded devices, people, processes, and objects, IoT has become one of the most important technologies in the 21st century. Each gadget connected to the network has its own IP (internet protocol) address, so they can all see each other, communicate, and exchange data (Cirani et al., 2015).

Developing an IoT architecture to meet a variety of needs requires a complex system due to the number of devices, layer technologies, and services involved. To utilize the Internet of Things, sensors are needed to determine the status of people and devices, as well as software architecture and networking for processing and transmitting the data to the appropriate location, and analytics tools for automating and predicting behavior (Silva et al., 2018).

Transducers, microcontrollers, transceivers, and power are needed in these systems for the sensors to function. Microcontrollers then process and store the electrical signals that sensors convert from physical sensations like pressure, vibration, motion, humidity, temperature, or even human or animal body functions. As soon as the transceiver receives a command from the central server, it acts both as a transmitter and receiver, transmitting the stored output for analysis. IoT stores, shares, and analyzes data generated by embedded devices on a central cloud server. Using their smart devices, users can access this data anywhere (Wu et al., 2020). IoT architecture relies heavily on data. IoT uses cloud technology to collect, analyze, and process BD. The complexity of data collection and storage in data-driven processes makes traditional tools insufficient. Data collected through big data technology can therefore be processed and analyzed (Chui et al., 2019). Technology like CoAP (Constrained Application Protocol), EXI (Efficient XML Interchange), 6LoWPAN (Low-Power Wireless Personal Area Networks IPv6), and network architectures are used in IoT applications (Silva et al., 2018).

2.2. Incorporating IoT technologies into Urban Systems

Incorporating IoT into urban systems due to this, collecting, storing, processing, analyzing, sharing, and making meaningful data is a challenging task for SCs (Nuaimi et al., 2015).

Systems theory explains how interconnected and independent elements can work together to achieve a common goal (Baecker, 2001). The USs approach aims to solve the complexity in cities by applying the logic of systems theory. According to the USs approach, the city is not seen as a whole system by itself, but as a system composed of many different systems such as urban traffic, housing, education, and management (Michiel van Meeteren, 2019).

The primary goal of a city is to provide a healthy environment for the well-being of society. As cities develop, air and water quality, waste management, and recycling systems are adversely affected, posing a health risk (Goldstein, 1990). Thus, urban planning should take into consideration not only each US

individually, but also their interrelationships. Designing, monitoring, managing, and developing these complex systems with a dense flow of people, data, and goods is difficult with conventional systems (Chen, 2008). As a result, SC models work with IoT technology to detect this complex structure and communicate and exchange data (Humayun et al., 2022).By using deep learning (DL), BDA algorithms, and digital twin technologies (DT), SC models optimize data-based decision-making and USs (Al Nuaimi et al., 2015).

Through IoT, machines, automation devices, sensors, actuators, radio frequency identification (RFID) tags, smartphones, and other smart appliances are linked together to allow cities to optimize their use of resources, improve efficiency, and enhance citizen quality of life (Martins et al., 2021). By using IoT in SCs, urban governance capacity can be improved, and traffic congestion and environmental pollution can be reduced. Devices based on IoT can provide real-time data in various areas, including governance, public health, mobility, energy management, safety, and security in cities. This can both provide economic benefits and reduce negative environmental effects (Bruno and Fontana, 2021). With the IoT, urban life can be made more convenient and smarter for city administrations and residents alike. The city with the most developed IoT infrastructure (Smart Infrastructure) today is Shanghai, followed by New York, Toronto, Seoul, and Shenzhen (Smart Cities Market, 2023).

The research is limited to five USs: smart government, smart environment, public health and well-being, public safety and security, and urban mobility. This section discusses how IoT technology can support these 5 USs and how they can benefit society.

Smart Government:

With Urban IoT, municipal services can be better delivered and local management improved. As part of SC models, city governments must adopt a communications, information, and technology platform as an initial step towards making the management system transparent, accessible, and fast (Yaghi and Al-Jenaibi, 2018). Government-driven mobile applications and web portals should be developed so that citizen participation in law-making and resolving local issues may be encouraged (Clement et al., 2022).

By integrating IoT technologies into city management processes, (1) citizens will have the opportunity to participate in matters such as health, social support, housing, education, and law enforcement. (2) New policies can be introduced for the benefit of citizens to improve government services.

(3) Operations can be more efficient, data can be used more effectively, and management environments can be strengthened (Nesti and Graziano, 2020).

Smart Environment:

Integrating IoT technology into SC models can optimize energy use and facilitate waste management. Thus, urban economic development as well as urban environment quality development are possible. Urban IoT enables easy monitoring of air quality, noise levels, and weather. Through IoT technology, it is possible to identify and manage pollution sources and potential risks, thereby ensuring a more sustainable city. Incorporating smart meters, smart grids, and energy management software into urban IoT systems allows real-time monitoring, optimization of energy use, and a reduction in carbon footprint (Guo et al., 2022).

As part of this research, six headings are presented that highlight the benefits that can be obtained in the area of smart environments using urban IoT. (1) The implementation of the Advanced Metering Infrastructure (AMI) allows the monitoring and measurement of energy consumption. An AMI is a device that provides real-time energy consumption data. Through this data, cities can optimize energy consumption, reduce waste, and increase overall efficiency in their energy infrastructure (Talari et al., 2017). (2) Weather data can be obtained, which helps the country's agricultural production. For example, with systems that notify citizens ahead of time of possible disasters, significant losses can be avoided. Furthermore, meaningful forecasts can help optimize agricultural production processes (Taylor, 2018). (3) Integrated green urban transportation models include user-friendly transportation models that use the cloud network, have schedules that reduces private vehicle use and work with electric power. It is possible to reduce carbon emissions and fuel consumption with these vehicles (Zhou et al., 2022). (4) Smart lighting systems can adjust the brightness to match occupancy and save energy (Alvarez et al., 2022). (5) IoT-enabled waste management systems can be both software and hardware-based. By sending the fill-level data of waste collection units equipped with sensors to the center, efficient waste management, and recycling can be achieved (Rybnytsk et al., 2018). (6) IoT has been shown to increase wastewater recovery and reduce waste gases emissions (Wang and Liu, 2023). Through IoT applications such as smart trams and urban exhaust gas monitoring systems, urban exhaust gas emissions can be efficiently reduced (Ropkins et al., 2009). As a result of these benefits, local governments should develop policies to promote the widespread use of

IoT-based devices for energy management and pollution control (Leroux and Pupion, 2022).

Public Health and Well-being

Healthcare is a costly service, which leads management to look for ways to reduce their costs. Over time, data science has advanced, and new hardware and software inventions have been made to improve citizens' health and well-being. Utilizing IoT technologies, governments aim to improve the health and well-being for their citizens (Bibri and Krogstie, 2017). A number of IoT devices have wearable features. It is possible to monitor people's physical activity and health through these wearable devices. Moreover, wearable devices can be used for diagnosing some health issues, thus reducing the burden on health care. In the medical field, we are entering a digital era as we acquire digital health data with wearable devices, use virtual meeting rooms to facilitate doctor meetings online and equip elderly and disabled housing with Internet of Things technology. Healthcare applications powered by the IoT provide (1) easy access to patient information, (2) remote health monitoring, and (3) analysis and storage of patient information (Jonek-Kowalska, 2022). As a result, possible health problems of people in need of care, like the elderly and the disabled, can be detected (Trencher and Karvonen, 2019). Hence, healthcare costs are reduced as health-related services and the citizen's overall health status improve (Goodspeed, 2015).

Smart Mobility

Using IoT-based solutions for mobility and transportation, urban transportation quality can be improved significantly. There are several IoT-based inventions that make transportation easier in SC, such as the optimization of energy use in public transportation, intelligent traffic management systems, smart parking, smart traffic lighting, platforms for real-time travel information, and public micro-mobility alternatives (Ceder, 2021). Benefits in this area can be categorized into four headings. (1) By utilizing urban IoT, public transportation vehicles can arrive at pickup points on time, which shortens the waiting and travel time for passengers and improves public transportation quality and saves time (Holmgren, 2020). As a result, private vehicle ownership will decrease, and public transport use will increase. (2) In large cities, Intelligent Traffic Management and Control (ITMC) systems can improve traffic flow, reduce

traffic density, and increase productivity (Reza et al., 2021). (1) As cities adopt high railway solutions, the population flow between cities accelerates, and relationships between cities become stronger. The possibility of working in big cities and living in small settlements arises. These systems support urban belt models and ensure balanced development throughout the region (Liu and Ye, 2023). (4) Through the sharing economy, public transportation becomes more affordable and accessible with micro-mobility vehicles (human- and electric-powered vehicles such as bicycles, scooters, and mopeds) (Montes et al., 2023). Almost all of these devices run on electricity, which is a renewable resource. It is possible to track vehicles' charging information and location with IoT technology (Ayfantopoulou et al., 2022).

Using IoT, smart transportation models collect data from cameras and sensors. In the process of processing this data, BD technology is also used. By installing various mobile applications on their smart devices, people can access data such as traffic congestion, excavations on the road, traffic accidents, etc. Consequently, traffic with higher densities can be avoided and transportation costs can be reduced (Oladimeji et al., 2023).

Public Safety and Security

Among the primary responsibilities of government is safety and security of citizens. There are a lot of security guards employed for this purpose, and they sometimes work under difficult circumstances. Benefits in this area can be categorized into three headings. (1) In cities, security and safety levels are being improved by installing CCTV cameras in public areas, providing verified access to the collected data, alerting emergency response teams, monitoring on a proactive basis, responding quickly to emergencies, and taking crime prevention measures (K.M, 2020). (2) Smart surveillance systems emit real-time alerts when they detect suspicious activity in public places. Moreover, emergency response systems integrate location tracking and sensors into their operations to provide faster and more efficient responses (Henchy et al., 2014). (3) Intelligent Traffic Management and Control (ITMC) systems improve traffic safety and quality of life. The systems use deep learning and image processing to forecast traffic and intersection signals (Reza et al., 2021).

The security of social data obtained with cameras or sensors integrated with Urban IoT technology or of instant decisions made based on real-time analytics is another challenge that needs to be explored.

The five USs, outputs, and gains discussed in this study are presented in Figure 2.

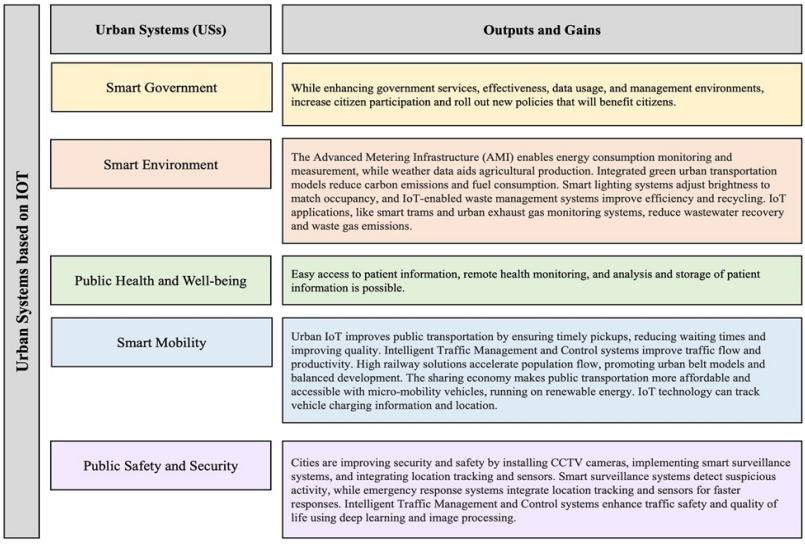


Figure 2. Urban Systems, Outputs and Gains

2.3. Urban IoT Architecture Requirements

Data is collected by sensors and electronic data readers in urban IoT applications. Real-time and offline use of the obtained data is possible. Applications involving real-time data require instant input and rapid analysis since a decision has to be made and implemented quickly. If not, this data will become dysfunctional, resulting in a decrease in system efficiency. Consequently, real-time data applications require advanced technology. Applications that manage traffic, air quality, energy, water, waste, and safety and security in cities use real-time data to promote sustainability and efficiency (Mohamed N, Al-Jaroodi J, 2014). To develop meaningful solutions using data collected from IoT devices, it is necessary to pay attention to some design and development priorities. Security and privacy should be considered when addressing these issues. According to Al Nuaimi et al. (2015) this process requires (1) Big Data Management, (2) Platforms, (3) Smart infrastructure, (4) Advanced Algorithms, (5) Standard Technology, (6) Security and Privacy, (7) Citizen Awareness, (8) Government Role, (9) Simulations.

For the USs explored in this study, the Urban IoT Architecture must include the following features:

(1) It is essential that IoT models that support USs are managed with **advanced and effective BD tools** in order to handle the large volume of data collected from many different sources in different formats (e.g., images, audio, tweets, video, server logs, etc.) (Chan et al., 2018).

(2) The data obtained from SCs requires **a huge capability of processing power on hardware and software platforms** that are reliable (Amović et al., 2021). The IoT technologies must be accompanied by reliable software platforms operated by highly qualified teams that have high-performance computing capabilities, support stream processing, and are error-resistant.

(3) Data collection is achieved through **smart network elements** such as vehicles, appliances, smartphones, and wearable devices in urban IoT. In real-time BD applications, quality of service (QoS) is crucial. It is possible to reduce the network traffic and speed up the flow by filtering, thus improving real-time big data management decision quality (Mohamed and Al-Jaroodi, 2014; Celic and Magjarevic, 2020).

(4) Due to the large volume, high speed, and wide variety of formats of data received from many devices in IoT models, standard algorithms may not be sufficient and efficient. **Advanced and sophisticated algorithms** in SCs support IoT technologies, increasing efficiency (Lawal and Rafsanjani, 2021). There should be some algorithms designed for real-time and some designed for offline processing. Moreover, these algorithms should be optimized for high data volumes, a wide range of data types, and IoT devices located in various geographical locations, while considering time constraints.

(5) USs and BD obtained from it are both large-scale and heterogeneous. In order to maximize the efficiency of the urban IoT, standards need to be established. Moreover, open standard technology offers flexibility for upgrading urban systems and adding new applications. **Setting standards and rules** is also necessary to facilitate the addition of new applications, devices, and stakeholders (government agencies, stakeholders, etc.) to existing SC models and IoT infrastructure (Komninos et al., 2019).

(6) As sensitive or private information is collected and processed through Urban IoT, security and privacy mechanisms are absolutely essential. Despite the many benefits SC models offer governments and citizens, there are some risks to data safety, well-being, and citizens' privacy. If these technological systems are illegally accessed or attacked at any point, adverse events may occur affecting the US itself, government agencies, and citizens. It is, therefore, necessary to design urban IoT models with **security and privacy policies** in mind and to formulate clear guidelines and requirements (Jacobs et al., 2022).

(7) As citizens are important actors in this process, they should be informed about smart USs and how they work. Furthermore, this awareness will increase the quality of the collected data and improve the efficiency of the applications. The administration must develop and implement programs for **citizen education and awareness** on safety, security, and privacy issues (Przeybilovicz et al., 2022). (8) To control the flow of IoT-based models, governments should adopt **openness, transparency, participation, and collaboration** principles (Bertot et al., 2014). In this context, management must use advanced systems for collecting, storing, and analyzing data, and should encourage action by taking decisions in this direction. Meanwhile, all these processes need to be managed with **respect to privacy** in terms of data access, protection, and archiving.

(9) It is possible to **design simulations** to increase the efficiency of Urban IoT models, to determine how USs behave from a realistic perspective, and to generate possible outcomes. The use of simulations in IoT models helps reduce costs, test the stages, and optimize resources (Henchey et al., 2014).

2.4. Urban IoT Barriers

IoT technology in urban systems may face some obstacles and challenges. This study identifies five difficulties encountered in urban IoT, including (1) infrastructure, (2) digital divide and inclusion, (3) privacy and security concerns, (4) lack of standards, and (5) cost implications.

Infrastructure

IoT-based USs face challenges harmonizing all this data, as it comes from different devices, different networks, and in different formats, volumes, and speeds. To make use of BD efficiently, city administrations need to develop high-scale strategies, and this data should be analyzed by advanced algorithms (Fan and Biffet, 2014). As Urban IoT requires reliable and uninterrupted connectivity, ensuring interoperability of devices with different bandwidth and coverage, integrating the whole city into a network, is a challenge. Providing efficient Urban IoT solutions requires the cooperation of different actors with a commitment to security, privacy, cost-effectiveness, and careful planning (Talari et al., 2017).

Digital Divide and Inclusion

The urban IoT offers many benefits, however it may also contribute to the rise of the digital divide. Technological use varies by age group (Markoc,

& Sari Haksever, 2019) and socioeconomic class (Markoc, 2020), making it difficult for all citizens to benefit equally from these advances. In this context, administration must make sure that all citizens are included and involved in the process, as well as benefiting from IoT support in urban systems. All actors must also ensure transparency, consent, and equality to ensure that the administrations are trusted and unethical practices are avoided.

As IoT technology is integrated into the US, devices and software will be able to carry out many of the tasks of working people. The unemployment rate will eventually rise significantly as a result. Thus, these systems should be designed by considering employment planning and social policies (Reveiu et al., 2022).

Privacy and Security Concerns

Vulnerability is the most significant flaw in urban IoT models. All data collected from devices connected to the network is transmitted to the server or cloud, creating a high level of vulnerability. As data has become so valuable in today's world, it is susceptible to misuse. This is why urban administrations should place a high priority on the security of data used in all of these USs and the privacy of all individuals (Fabrègue and Bogoni, 2023).

Lack of standards

Although IoT-based applications are becoming increasingly popular, there are few standards in this area, which creates a serious barrier to their use. There are no optimized standards set concerning the types of IoT devices; how and in what formats the data will be collected from these devices; how the data will be translated into a common language, transmitted, stored, and protected; and how it will affect the solutions developed for urban problems. This is why it is vital that these standards are studied and defined by the authorities (Komninos et al., 2019).

Cost

Despite the many benefits of urban IoT solutions, the technologies require a high-cost smart infrastructure. As part of the process, it is also necessary to update the existing infrastructure over time. Consequently, all these infrastructure costs can be managed within a significant budget (Habib et al., 2020). Smart energy management is a way to reduce city costs, but it is still a high cost for many city administrations today due to the pre-investment required to start using the

technology (Yigitcanlar, 2015). However, it is expected that this barrier will be removed over time as hardware production increases and costs decrease.

3. Conclusion

The first question we have asked at the beginning of the study was *"What are IoT technologies, how do they work?"* (Q1) to identify the technology and the main logic. Due to the fact that every device and person in the IoT ecosystem is connected, the technology is based on an interconnected environment. IoT works with a system logic involving a central server that monitors and controls all devices and people connected to the network and enables data transfer between them.

The second question of the study was "*What are the applications of IoT technologies in urban systems, and how do they benefit?"* (Q2) to seek out the Urban IoT opportunities. Urban IoT is revolutionizing the way cities are managed. With efficient use of urban resources, the quality of life and health of citizens can be enhanced, traffic congestion can be reduced, public transportation quality can be improved, emergency response processes can be accelerated, and participatory management can be adopted. Consequently, it helps administrations achieve sustainability goals.

Our third question was "*Which weaknesses are associated with IoT technologies used in urban systems?"* (Q3) to highlight the potential disadvantages. While IoT-based solutions promote efficiency in urban systems, they have some disadvantages as well. A key weakness of IoT-based urban models is the privacy of data and individuals. IoT technology relies heavily on data. The majority of this data is collected from individuals. As a technology that processes data collected from individuals, it is very difficult to maintain privacy at the same time. One weakness of these models is that they do not provide equal rights to all stakeholders with regards to data. Developing the software and hardware infrastructure for these systems, which in theory produce many solutions, and working with qualified personnel is quite costly both in terms of implementation costs and return on investment.

For local governments planning to integrate IoT technologies into USs, **the proposed roadmap includes the following steps (**Musa, 2016; Mattern, 2017; nordicinnovation.org, 2021)**:**

1. Clarification is required about a variety of factors, including the urban systems covered by the model, the aim and extent of IoT usage, restrictions, and predicted advantages and dangers. Determining the city's goals and directing the

administration's attention to the areas that would result in the greatest efficiency at the lowest possible cost are essential.

2. The use of Internet of Things (IoT) technologies requires the formulation of policies, the establishment of certain standards, and the creation of guidelines.

3. To integrate IoT technologies into urban systems, infrastructure applications should be developed gradually, tested with simulations, and flexible structures should be considered for system changes and upgrades.

4. To ensure that models are effective and improved, ensuring the participation and inclusion of citizens should be a top priority.

5. Existing models should be continually updated and optimized based on new developments.

The roadmap is illustrated in Figure 3.

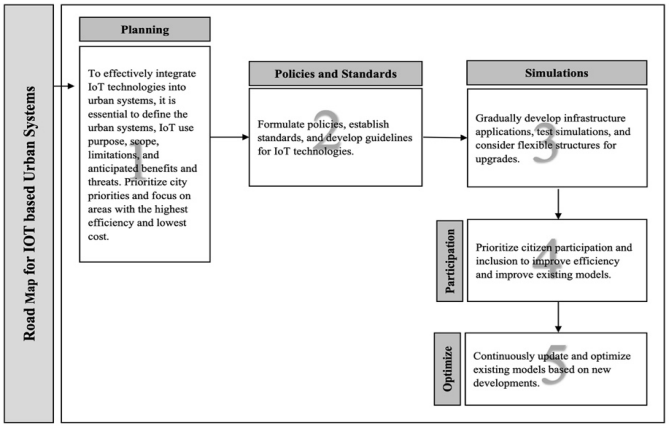


Figure 3. Roadmap

The following **aspects of urban IoT applications discussed in this study are still unclear** (Schaffers, 2018; Perić et al., 2022; Novák and Votruba, 2016):

1. Currently, the roles of different resources and actors in IoT-driven urban systems are not fully defined, so it remains unclear how *priority or status difference* between citizens and governmental department will be handled.

2. There will continue to be discussions over *what kind of solutions can be offered to this problem on what scale* for IoT-based urban models as security and privacy remain their biggest weaknesses.

3. It is unclear *what the material and moral costs* will be of a radical change in local or central government or of a different political stance taking over the administration or whether this will *negatively impact the citizens.*

4. Furthermore, *the health risks* associated with wirelessly connecting all IoT-compatible devices to a network are still unknown.

5. As IoT technology is being integrated into every aspect of our daily lives, high-skilled personnel will be needed for management, design, installation, operation, and maintenance. However, it remains unclear *whether the current workforce of countries is prepared for this transition*.

This study discusses how IoT-based applications can be applied to urban systems, what kinds of structures and approaches are needed, the strengths and weaknesses of these models, and unresolved issues. The study also highlights the potential benefits of incorporating IoT technology into urban systems, such as improved efficiency, sustainability, and quality of life. Additionally, it examines the challenges that may arise in implementing and managing these IoT-based applications, including privacy concerns and cybersecurity risks.

Urban IoT application areas demonstrate its revolutionary nature, but its weaknesses make it apparent that caution is required to ensure that these technologies do not pose a threat to the public. Future research on urban IoT simulations will provide opportunities to introduce these technologies to a broader audience and to develop potential problem-solving strategies.

References

Al Nuaimi, E., Al Neyadi, H., Mohamed, N., & Al-Jaroodi, J. (2015). Applications of big data to smart cities. Journal of Internet Services and Applications, 6(1). 10.1186/s13174-015-0041-5.

Almihat, M. G. M., Kahn, M. T. E., Aboalez, K., & Almaktoof, A. M. (2022). Energy and Sustainable Development in Smart Cities: An Overview. Smart Cities, 5(4), 1389–1408. 10.3390/smartcities5040071.

Alvarez, R., Duarte, F., Frenchman, D., & Ratti, C. (2022). Sensing Lights: The Challenges of Transforming Street Lights into an Urban Intelligence Platform. Journal of Urban Technology, 29(4), 25–40. 10.1080/10630732.2022.2082825.

Amović, M., Govedarica, M., Radulović, A., & Janković, I. (2021). Big Data in Smart City: Management Challenges. Applied Sciences, 11(10), 4557. 10.3390/app11104557.

Ayfantopoulou, G., Salanova Grau, J. M., Maleas, Z., & Siomos, A. (2022). Micro-Mobility User Pattern Analysis and Station Location in Thessaloniki. Sustainability, 14(11), 6715. 10.3390/su14116715.

Baecker, D. (2001). Why Systems? Theory, Culture & Society, 18(1), 59–74. 10.1177/026327601018001005.

Bertot, J. C., Gorham, U., Jaeger, P. T., Sarin, L. C., & Choi, H. (2014). Big data, open government and e-government: Issues, policies and recommendations. Information Polity, 19(1,2), 5–16. 10.3233/ip-140328.

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. Sustainable Cities and Society, 31, 183–212. 10.1016/j.scs.2017.02.016.

Bie, Z., Lin, Y., Li, G., Jin, X., & Hua, B. (2013). Smart Grid in China: a promising solution to China's energy and environmental issues. International Journal of Environmental Studies, 70(5), 702–718. 10.1080/00207233.2013.828442.

Bruno, A., & Fontana, F. (2020). Testing the Smart City Paradigm in Italian Mid-Sized Cities: An Empirical Analysis. Housing Policy Debate, 31(1), 151–170. 10.1080/10511482.2020.1800777.

Caird, S. (2017). City approaches to smart city evaluation and reporting: case studies in the United Kingdom. Urban Research & Practice, 11(2), 159–179. 10.1080/17535069.2017.1317828.

Ceder, A. A. (2020). Urban mobility and public transport: future perspectives and review. International Journal of Urban Sciences, 25(4), 455–479. 10.1080/12265934.2020.1799846.

Celic, L., & Magjarevic, R. (2019). Seamless connectivity architecture and methods for IoT and wearable devices. Automatika, 61(1), 21–34. 10.1080/00051144.2019.1660036.

Chan, K. Y., Wong, T. C., & Kwong, C. K. (2018). Special issue on affective design using big data. Journal of Engineering Design, 29(7), 353–357. 10.1080/09544828.2018.1477552.

Chen, B., Guo, H., Huang, G., Yin, Y., & Zhang, B. (2008). IFMEP: an interval fuzzy multiobjective environmental planning model for urban systems. Civil Engineering and Environmental Systems, 25(2), 99–125. 10.1080/10286600801908899.

Chui, K. T., Liu, R. W., Lytras, M. D., & Zhao, M. (2019). Big data and IoT solution for patient behaviour monitoring. Behaviour & Information Technology, 38(9), 940–949. 10.1080/0144929x.2019.1584245.

Cirani, S., Ferrari, G., Iotti, N., & Picone, M. (2015). The IoT hub: a fog node for seamless management of heterogeneous connected smart objects. 2015

12th Annual IEEE International Conference on Sensing, Communication, and Networking - Workshops (SECON Workshops). 10.1109/seconw.2015.7328145.

Clement, J., Manjon, M., & Crutzen, N. (2022). Factors for collaboration amongst smart city stakeholders: A local government perspective. Government Information Quarterly, 39(4), 101746. 10.1016/j.giq.2022.101746.

Digital Cities Index (2022). Making digital work for cities: A global benchmark of urban technology. Retrieved from https://impact.economist.com/projects/digital-cities/2022-executive-summary/ (Access date: 01.06.2023)

Fabrègue, B. F. G., & Bogoni, A. (2023). Privacy and Security Concerns in the Smart City. Smart Cities, 6(1), 586–613. 10.3390/smartcities6010027.

Faldi, G., Ranzato, M., & Moretto, L. (2022). Urban service co-production and technology: nine key issues. International Journal of Urban Sustainable Development, 14(1), 146–161. 10.1080/19463138.2022.2060237.

Fan, W., & Bifet, A. (2013). Mining big data. ACM SIGKDD Explorations Newsletter, 14(2), 1–5. 10.1145/2481244.2481246.

Feki, M. A., Kawsar, F., Boussard, M., & Trappeniers, L. (2013). The Internet of Things: The Next Technological Revolution. Computer, 46(2), 24–25. 10.1109/mc.2013.63.

Goldstein, G. (1990). Urbanization, Health and Well-Being: A Global Perspective. The Statistician, 39(2), 121. 10.2307/2348533.

Goodspeed, R. (2014). Smart cities: moving beyond urban cybernetics to tackle wicked problems: Figure 1. Cambridge Journal of Regions, Economy and Society, 8(1), 79–92. 10.1093/cjres/rsu013.

Guo, Q., Wang, Y., & Dong, X. (2022). Effects of smart city construction on energy saving and CO2 emission reduction: Evidence from China. Applied Energy, 313, 10.1016/j.apenergy.2022.118879.

Habib, A., Alsmadi, D., & Prybutok, V. R. (2019). Factors that determine residents' acceptance of smart city technologies. Behaviour & Information Technology, 39(6), 610–623. 10.1080/0144929x.2019.1693629.

Hamdan, A., Alareeni, B., Hamdan, R., & Dahlan, M. A. (2022). Incorporation of artificial intelligence, Big Data, and Internet of Things (IoT): an insight into the technological implementations in business success. Journal of Decision Systems, 1–4. 10.1080/12460125.2022.2143618.

Henchey, M. J., Batta, R., Blatt, A., Flanigan, M., & Majka, K. (2014). A simulation approach to study emergency response. Journal of Simulation, 8(2), 115–128. 10.1057/jos.2013.20.

Holmgren, J. (2020). The effect of public transport quality on car ownership – A source of wider benefits? Research in Transportation Economics, 83, 10.1016/j.retrec.2020.100957.

Humayun, M., Alsaqer, M. S., & Jhanjhi, N. (2022). Energy Optimization for Smart Cities Using IoT. Applied Artificial Intelligence, 36(1). 10.1080/08839514.2022.2037255.

Inkinen, T., Yigitcanlar, T., & Wilson, M. (2019). Smart Cities and Innovative Urban Technologies. Journal of Urban Technology, 26(2), 1–2. 10.1080/10630732.2019.1594698.

Jacobs, N., Loveday, F., Markovic, M., Cottrill, C. D., Zullo, R., & Edwards, P. (2022). Prototyping an IoT transparency toolkit to support communication, governance and policy in the smart city. The Design Journal, 25(3), 459–480. 10.1080/14606925.2022.2061775.

Jonek-Kowalska, I. (2022). Health Care in Cities Perceived as Smart in the Context of Population Aging—A Record from Poland. Smart Cities, 5(4), 1267–1292. 10.3390/smartcities5040065.

K.M, U. (2020). A Smart Approach to Provide the Women Safety by Using Smart Security Devices. International Journal of Psychosocial Rehabilitation, 24(4), 4039–4045. 10.37200/ijpr/v24i4/pr201516.

Khan, S. (2021). Barriers of big data analytics for smart cities development: a context of emerging economies. International Journal of Management Science and Engineering Management, 17(2), 123–131. 10.1080/17509653.2021.1997662.

Komninos, N., Kakderi, C., Panori, A., & Tsarchopoulos, P. (2018). Smart City Planning from an Evolutionary Perspective. Journal of Urban Technology, 26(2), 3–20. 10.1080/10630732.2018.1485368.

Lawal, K., & Rafsanjani, H. N. (2022). Trends, benefits, risks, and challenges of IoT implementation in residential and commercial buildings. Energy and Built Environment, 3(3), 251–266. 10.1016/j.enbenv.2021.01.009.

Leroux, E., & Pupion, P. C. (2022). Smart territories and IoT adoption by local authorities: A question of trust, efficiency, and relationship with the citizen-user-taxpayer. Technological Forecasting and Social Change, 174, 121195. 10.1016/j.techfore.2021.121195.

Liu, Y., & Ye, M. (2023). Application And Validity Analysis of IoT In Smart City Based On Entropy Method. Applied Artificial Intelligence, 37(1). 10.1080/08839514.2023.2166234.

Markoç, İ. & Sarı Haksever, T. (2019). An Investigation of the Sense of Place Attachment According to the Age Groups, KIE Congress Proceedings, Gaziantep.

Markoç, İ., (2020). Kadının Sosyal Medya Kullanımı ve Sosyal Yaşama Katılımında Konutun Rolü: Bağcılar, İstanbul. EKSEN Dokuz Eylül Üniversitesi Mimarlık Fakültesi Dergisi, 1(1), 26-41.

Martins, F., Patrão, C., Moura, P., & de Almeida, A. T. (2021). A Review of Energy Modeling Tools for Energy Efficiency in Smart Cities. Smart Cities, 4(4), 1420–1436. 10.3390/smartcities4040075.

Mattern, S. (2017). A City Is Not a Computer. Places Journal, (2017). 10.22269/170207.

Meeteren, M. (2019). Urban System. The Wiley Blackwell Encyclopedia of Urban and Regional Studies, 1–11. 10.1002/9781118568446.eurs0400.

Mohamed, N., & Al-Jaroodi, J. (2014). Real-time big data analytics: Applications and challenges. 2014 International Conference on High Performance Computing & Simulation (HPCS). 10.1109/hpcsim.2014.6903700.

Montes, A., Geržinic, N., Veeneman, W., van Oort, N., & Hoogendoorn, S. (2023). Shared micromobility and public transport integration - A mode choice study using stated preference data. Research in Transportation Economics, 99, 10.1016/j.retrec.2023.101302.

Musa, S. (2016). Smart Cities - A Roadmap for Development. Journal of Telecommunications System & Management, 05(03). 10.4172/2167-0919.1000144.

Nesti, G., & Graziano, P. R. (2019). The democratic anchorage of governance networks in smart cities: an empirical assessment. Public Management Review, 22(5), 648–667. 10.1080/14719037.2019.1588355.

Noori, N., de Jong, M., Janssen, M., Schraven, D., & Hoppe, T. (2020). Input-Output Modeling for Smart City Development. Journal of Urban Technology, 28(1–2), 71–92. 10.1080/10630732.2020.1794728.

Nordic Smart City Roadmap. (n.d.). Retrieved from https://www.nordicinnovation.org/2021/nordic-smart-city-roadmap (Access Date: 12.06.2023)

Novak, M., & Votruba, Z. (2016). Discussion of uncertainties factors in Smart Cities systems. 2016 Smart Cities Symposium Prague (SCSP). 10.1109/scsp.2016.7501012.

Oladimeji, D., Gupta, K., Kose, N. A., Gundogan, K., Ge, L., & Liang, F. (2023). Smart Transportation: An Overview of Technologies and Applications. Sensors, 23(8), 3880. 10.3390/s23083880.

Pera, A. (2020). Assessing Sustainability Behavior and Environmental Performance of Urban Systems: A Systematic Review. Sustainability, 12(17), 7164. 10.3390/su12177164.

Perić, K., Šimić, Z., & Jurić, E. (2022). Characterization of Uncertainties in Smart City Planning: A Case Study of the Smart Metering Deployment. Energies, 15(6), 2040. 10.3390/en15062040.

Przeybilovicz, E., Cunha, M. A., Geertman, S., Leleux, C., Michels, A., Tomor, Z., . . . Meijer, A. (2020). Citizen participation in the smart city: findings from an international comparative study. Local Government Studies, 48(1), 23–47. 10.1080/03003930.2020.1851204.

Reveiu, A., Vasilescu, M. D., & Banica, A. (2022). Digital divide across the European Union and labour market resilience. Regional Studies, 1–15. 10.1080/00343404.2022.2044465.

Reza, S., Oliveira, H. S., Machado, J. J. M., & Tavares, J. M. R. S. (2021). Urban Safety: An Image-Processing and Deep-Learning-Based Intelligent Traffic Management and Control System. Sensors, 21(22), 7705. 10.3390/s21227705.

Ropkins, K., Beebe, J., Li, H., Daham, B., Tate, J., Bell, M., & Andrews, G. (2009). Real-World Vehicle Exhaust Emissions Monitoring: Review and Critical Discussion. Critical Reviews in Environmental Science and Technology, 39(2), 79–152. 10.1080/10643380701413377.

Rybnytska, O., Burstein, F., Rybin, A. V., & Zaslavsky, A. (2018). Decision support for optimizing waste management. Journal of Decision Systems, 27(sup1), 68–78. 10.1080/12460125.2018.1464312.

Schaffers, H. (2018). The Future of Smart Cities: Open Issues and Research Challenges, Scienze Regionali, Italian Journal of Regional Science" 1/2018, 123-128, 10.14650/88821.

Silva, B. N., Khan, M., & Han, K. (2017). Internet of Things: A Comprehensive Review of Enabling Technologies, Architecture, and Challenges. IETE Technical Review, 35(2), 205–220. 10.1080/02564602.2016.1276416.

Smart Cities Market. (2023). Retrieved from https://www.juniperresearch.com/researchstore/sustainability-technology-iot/smart-cities-research-report (Access Date: 15.06.2023).

State of IoT 2023: Number of connected IoT devices growing 16% to 16.7 billion globally. (2023, May 24). Retrieved from https://iot-analytics.com/number-connected-iot-devices/ (Access Date: 05.06.2023)

Talari, S., Shafie-khah, M., Siano, P., Loia, V., Tommasetti, A., & Catalão, J. (2017). A Review of Smart Cities Based on the Internet of Things Concept. Energies, 10(4), 421. 10.3390/en10040421.

Taylor, M. (2017). Climate-smart agriculture: what is it good for? The Journal of Peasant Studies, 45(1), 89–107. 10.1080/03066150.2017.1312355.

Trencher, G., & Karvonen, A. (2017). Stretching "smart": advancing health and well-being through the smart city agenda. Local Environment, 24(7), 610–627. 10.1080/13549839.2017.1360264.

United Nations. (2018). 68% of the world population projected to live in urban areas by 2050, says UN; https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html (Access Date: 03.06.2023).

Wang, H., Zhang, T., Quan, Y., & Dong, R. (2013). Research on the framework of the Environmental Internet of Things. International Journal of Sustainable Development & World Ecology, 20(3), 199–204. 10.1080/13504509.2013.783517.

Wang, M., & Liu, Y. (2023). Recent advances in smart water technology of drainage systems in China. Water International, 48(3), 379–392. 10.1080/02508060.2023.2195724.

Wu, Z., Jiang, M., Li, H., & Zhang, X. (2020). Mapping the Knowledge Domain of Smart City Development to Urban Sustainability: A Scientometric Study. Journal of Urban Technology, 28(1–2), 29–53. 10.1080/10630732.2020.1777045.

Yaghi, A., & Al-Jenaibi, B. (2017). Happiness, Morality, Rationality, and Challenges in Implementing Smart Government Policy. Public Integrity, 20(3), 284–299. 10.1080/10999922.2017.1364947.

Yigitcanlar, T. (2015). Smart cities: an effective urban development and management model? Australian Planner, 52(1), 27–34. 10.1080/07293682.2015.1019752.

Zhang, C., Li, Y., Xiong, S., Lu, X., & Zhu, X. (2015). Regional environmental risk assessment and management guide for rapid urbanization process of a city cluster in China. Human and Ecological Risk Assessment: An International Journal, 22(2), 283–301. 10.1080/10807039.2015.1063040.

Zhou, Z., Liu, Y., & Du, J. (2022). Analysis on the constraint mechanism of transportation carbon emissions in the Pearl River Delta based on 'Dual carbon' goals. Systems Science & Control Engineering, 10(1), 854–864. 10.1080/21642583.2022.2107116.