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# INTERNET OF THINGS IN SMART CITY: A BRIEF OVERVIEW

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**Abstract**

The world desperately needs smarter and more sustainable cities, and IoT has already proven that this can be achieved. A smart city uses Internet of Things (IoT) sensors in urban areas to collect data and automate systems such as traffic, energy use, and waste management. A smart city will help and uplift its residents, attract tourists and investors, and ease living and doing business. It offers a wide range of solutions to present-day challenges such as increasing urbanization, climate change, growing traffic and pollution, etc. This paper presents a short overview on the uses of the Internet of Things in smart cities.

**Keywords:** Internet of things, IoT, IoT devices, smart city, IoT in smart city.

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## INTRODUCTION

The number of people living in urban areas worldwide has increased almost six-fold since 1950 to over 4 billion. As the world's population increases, urban areas will have to go through many transformations. The huge number of people living in these urban centers puts an enormous pressure on the environment and resources. This has caused scientists and politicians to start devising means of transforming urban areas into smart cities.

The smart city ( also known as digital cities, intelligent cities, and wired cities), along with the Internet of things, is one of the most promising technologies to address the solution to the rapid population growth. The Internet of things (also known as Internet of everything) has the potential to tame the pressure of urbanization, create new experience for city residents, and make day-to-day living more comfortable and secure [1].

The Internet of things (IoT) is about installing sensors (RFID, IR, GPS, laser scanners, etc.) and connecting them to the Internet through specific protocols for information exchange and communications. IoT allows devices to communicate with the Internet. Data acquired from these devices are kept on servers or in the cloud. The server takes decisions based on the information received from the devices. The system is termed "smart" because it can take decisions without human intervention. When this "smart" technology is applied to collect different parameters in a city, the system is called "smart city." As shown in Figure 1, a smart city comprises of smart infrastructure, smart homes, smart buildings, smart energy, smart mobility, and more [2].

## WHAT IS INTERNET OF THINGS?

The term "Internet of things" was introduced by Kevin Ashton from the United Kingdom in 1999. Internet of Things (IoT) is a network of connecting devices embedded with sensors. It is a collection of identifiable things with the ability to communicate over wired or wireless networks. The devices or

things can be connected to the Internet through three main technology components: physical devices and sensors (connected things), connection and infrastructure, and analytics and applications.

The IoT is a worldwide network that connects devices to the Internet and to each other using wireless technology. IoT is expanding rapidly and it has been estimated that 50 billion devices will be connected to the Internet by 2020. These include smart phones, tablets, desktop computers, autonomous vehicles, refrigerators, toasters, thermostats, cameras, pet monitors, alarm systems, home appliances, insulin pumps, industrial machines, intelligent wheelchairs, wireless sensors, mobile robots, etc.

There are four main technologies that enable IoT [3]:

(1) Radio-frequency identification (RFID) and near-field communication.

(2) Optical tags and quick response codes: This is used for low cost tagging.

(3) Bluetooth low energy (BLE).

(4) Wireless sensor network: They are usually connected as wireless sensor networks to monitor physical properties in specific environments.

Other related technologies are cloud computing, machine learning, and big data.

The Internet of things (IoT) technology enables people and objects to interact with each other. It is employed in many areas such as smart transportation, smart cities, smart energy, emergency services, healthcare, data security, industrial control, logistics, retails, government, traffic congestion, manufacturing, industry, security, agriculture, environment, and waste management. Figure 2 shows the most widely used areas of IoT [4].

IoT supports many input-output devices such as camera, microphone, keyboard, speaker, displays, microcontrollers, and transceivers. It is the most promising trend in the healthcare industry. This rapidly proliferating collection of Internet-connected devices, including wearables, implants, skin sensors, smart scales, smart bandages, and home monitoring tools has the potential to connect patients and their providers in a unique way.

Today, smartphone acts as the main driver of IoT. The smartphone is provided with healthcare applications.

The narrowband version of IoT is known as narrowband IoT (NBIoT). This is an attractive technology for many sectors including healthcare because it has been standardized [5]. The main feature of NBIoT is that it can be easily deployed within the current cellular infrastructure with a software upgrade.

## WHY IOT IS IMPORTANT IN SMART CITIES

The Internet of Things (IoT) refers to the network of physical objects, such as devices, vehicles, and buildings, embedded with sensors which enable them to collect and exchange data. These connected devices can communicate with other devices and systems. With the use of the IoT, communities can distribute energy more efficiently, streamline the waste collection, relieve traffic congestion, and enhance air quality. Many municipal governments are leveraging cellular and wireless technologies to connect and improve infrastructure, efficiency, convenience, and quality of life for residents and visitors.

IoT is important for every smart city. IoT technology has been a key pillar of smart city development. It can create smart solutions, which can solve problems, increase the quality of life for a city's residents, and lower the consumption of resources.The following areas are the top priorities for city governments that embark on developing smart cities [6]:

- Connected public transport
- Traffic monitoring and management
- Water level / Flood monitoring

- Video surveillance and analytics
- Connected streetlights
- Weather monitoring
- Air quality / Pollution monitoring
- Smart metering – water
- Fire / Smoke detection
- Water quality monitoring

## EXAMPLES OF SMART CITIES

Around the world there are a number of smart cities, each pursuing their own smart city initiatives. Europe is leading the world in smart city development. It has been proactive in encouraging its member nations to develop smart cities. Some popular smart cities include the following [7,8]:

- *Singapore*: This is a world leader when it comes to smart city implementation. It operates a city-wide network of sensors and cameras to monitor traffic, weather, and pollution.
- *London:* In 2014 Westminster, London deployed a smart parking project, SmartPark, that allows drivers to quickly locate parking spaces. This alleviates urban traffic congestion.
- *New York City:* The city is piloting a connected vehicle (CTV) project to help NYC eliminate traffic related deaths and reduce crash related injuries. The CTV infrastructure is primarily focused on safety applications—relying on vehicle-to-vehicle, vehicle-to-infrastructure, and infrastructure-to-pedestrian communications.
- *Copenhagen:* This is known as one of the smartest cities in the world and it mobilizes expertise worldwide. The city aims to become the first carbon-neutral smart city by 2025. Its Nordhavn district uses heating and smart-grid integration to show how electricity and heat, energy-efficient buildings, and electric transport can be integrated into one energy system.
- *Amsterdam:* This is a shining example of a well-connected smart city reaping the rewards of opening the data vault. It uses a digital twin to simulate and test urban planning decisions before they are implemented in the real world. The city built autonomous delivery boats to keep things moving in a timely fashion.

## APPLICATIONS OF IOT IN SMART CITIES

IoT and smart city initiatives are being applied to the improvement of traffic management, energy consumption, public safety, healthcare, etc. Major IoT applications for smart cities are smart urban mobility, urban sustainability, smart infrastructure, smart parking, smart lighting, smart buildings, smart grid, and smart waste management. Some of these applications are explained as follows [1,9-11]:

- *Smart Infrastructure*: A city's infrastructure is an important area where IoT can be implemented. Physical infrastructure refers to transport, energy, water, telecommunications, and waste. Cities need to have an infrastructure that supports Internet of things. Figure 3 shows an implementation of smart infrastructure [1].
- *Smart Traffic:* This can also be used to smooth out the public transportation traffic during rush hours. Smart traffic can ensure that every bus gets through the "green wave" thus significantly improving the traffic flow.
- *Smart Parking:* Smart parking is an IoT application that can drastically improve everyone's lives. Smart parking technology with IoT connectivity helps to diminish the parking problems that people face. Many smart cities have implemented intelligent parking solutions that can monitor available public parking spaces. Cities can save drivers the hassle of hunting for parking spaces, while reducing emissions and traffic.

- *Smart Waste Management:* Urban waste management consists of various sub-processes such as collection, transportation, processing, disposal, managing, reuse, and monitoring of waste materials. IoT-based waste management solutions are designed to optimize waste collection processes, reduce the operational costs, increase the efficiency of waste management, and mitigate environmental issues related to waste disposal efforts.
- *Smart Street Lightning:* IoT-based connected lighting helps municipalities increase energy efficiency and reduce energy and maintenance costs. Smart lights automatically adjust their brightness levels based on street activity.
- *Smart Meters:* Utility companies are installing IoT-based solutions for automating and optimizing city-wide energy use. Smart utility meters attached to city buildings are connected to a smart energy grid and enable the utility company to track energy consumption and improve energy flow management.
- *Smart Environment Monitoring:* The environmental hazards that we are currently facing is a serious concern. Different types of monitoring and controlling systems can be set up by the use of IoT for monitoring important parameters such as air, water, pollution, etc. It helps in tracking on animals without disturbing their normal life.
- *Smart grid:* This is a combination of electrical network and communication network. A smart grid comprises power network with "intelligent" entities that can operate, communicate, and interact automatically, in order to deliver electricity to the consumer efficiently. It is a part of smart cities framework by which all the monitoring systems right from smart lighting, smart traffic management, smart parking, smart roads, smart environment monitoring can be controlled in a single smart grid. A smart grid is shown in Figure 4 [11].

## BENEFITS

IoT is used in creating smart cities to set up a connection between the sensors, devices, and networks that are used in setting up a smart city. A smart city is designed to manage urban planning and enhance the interaction of the city and its people, reducing costs and resource consumption. Any nation which contains smart cities will be well developed socially and economically, while the living standards of the nation will be improved a lot. The quality of their knowledge and living will be developed. The people can be protected from any disaster, natural calamities, and any difficult situations by smart city ecosystem. The primary objective of IoT in smart cities is to entice businesses to locate their operations in our country. IoT in smart cities also brings about sustainable development [12].

## CHALLENGES

Smart city development is not without its challenges. As with any new technology, there are concerns and challenges associated with the implementation of smart cities. Different people have different definitions for what constitutes a smart city. The concept of smart city may differ from nation to nation, government to government, place to place, and people to people. IoT implementation in large urban areas will take time, effort, strategy, and significant funds. Other challenges include the following [1]:

- *Security:* This is the biggest concern at present. The interconnectedness of IoT devices creates new vulnerabilities for cyberattacks, data breaches, and unauthorized access.
- *Privacy:* Privacy of the citizens is a big concern as making a city "smart" starts with the collection of data and processing it. Privacy concerns and fear of security breaches have far outweighed the perceived value of sharing information among devices.
- *Public Safety:* This is one of the most important tasks faced by all the governments worldwide. Public officials need as much help as they can when it comes to providing public safety to citizens. Applications that are safe, secure, resilient, reliable, and privacy-enhancing are essential to effective smart city solutions.

- *Complexity:* Smart city may have sophisticated interconnectivity. The Internet of things ecosystem is quite robust and complex. Its implementation of is a highly complex process due to the fact that an IoT system consists of many different components and enormous number of devices.
- *Sensors:* The challenges faced by the sensors used in IoT systems include interoperability, security, reliability, accuracy, and power consumption.
- *Data Analysis:* The challenges faced by data analysis are the inability to manage a real-time data stream, restricted ability to analyze unstructured data, and inability to analyze data that does not fit in with the predicted data model
- *Talent Shortage*: IoT companies are faced with a shortage of talent able to plan, execute and maintain IoT systems.

## CONCLUSION

The smart city is a city that uses IoT, sensors, and data to improve infrastructure, energy use, utilities, public services, and more. It use IoT devices to collect and analyze data.

It is a concept that will change the way we think and live. Cities around the world are turning to technology and advanced networks to help them manage resource constraints.

If IoT techniques are properly integrated in the construction of smart cities, we will get highest quality environment in future. We will see more and more smart cities in the future. The city of the future is more connected, sustainable, cleaner, safer, and more intelligent than ever before. More information about IoT in smart cities can be found in the books in [13-16] and the following devoted to IoT: *IEEE Internet of Things Journal.*

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Figure 1 Components of a smart city [2].

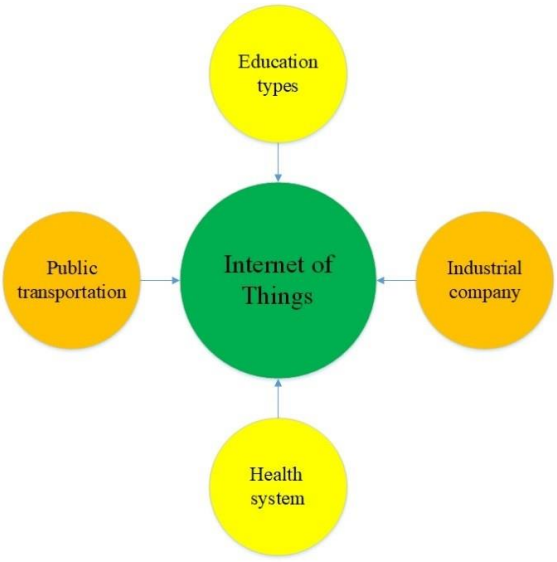


Figure 2 The most widely used IoT application areas [4].

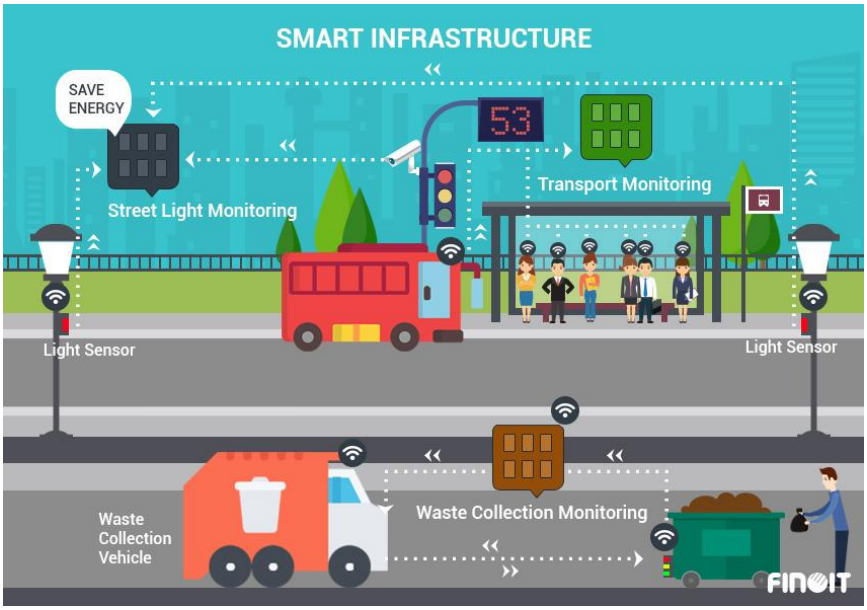


Figure 3 Smart infrastructure [1].

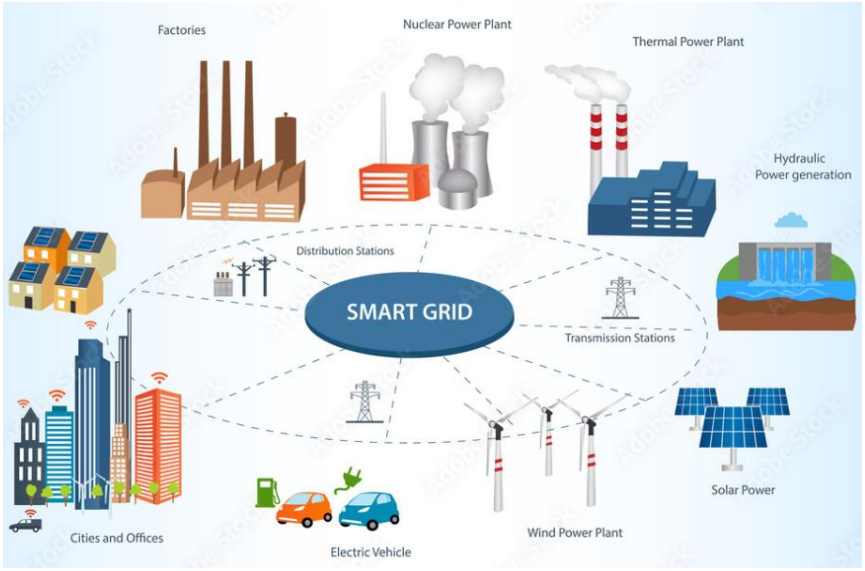


Figure 4 A smart grid [11].