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Exploring the Potential of IoST for Smart City Development

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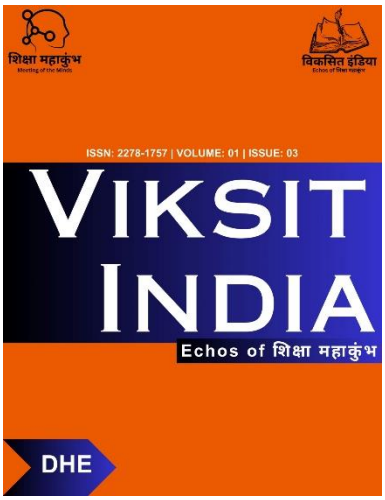

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Abstract
As the Internet of Things (IoT) emerges as the next phase of Internet evolution, it is essential to identify the domains where IoT can be applied and the research challenges associated with these applications. From smart cities, healthcare, and smart agriculture, to logistics, retail, smart living, and intelligent environments, IoT is expected to play a significant role in all aspects of daily life. Despite substantial improvements in IoT-enabling technologies in recent years, many challenges still require attention. Transformation of an existing city to a 'smart city' is a very challenging task, and with the help of the Internet of Smart Things (IoST)-enabling technologies, it can lead to a successful transformation. Since the IoT concept has evolved from heterogeneous end systems, many research challenges are bound to arise. This paper hence presents how the development of smart cities will be carried out by enhancing general infrastructure with the help of IOT and what the challenges are associated with this application

Keywords: IOT, Smart Cities, Services and Management, Network.

Introduction
The term IoT referred to as the 'Internet of things', is a network of various digital devices embedded with software, sensors and connectivity that communicates with other devices and networks over the internet and shares data between them seamlessly. No human intervention is needed for the working of these devices. The primary goal of the Internet of Smart Things (IoST) is to enable objects and individuals to connect at any time, from anywhere, using any network, pathway, or service. With IoST, the concept of smart cities is rapidly gaining importance day by day [1]. The urban population has grown nearly six times since 1950, reaching over 4 billion people. This figure is expected to surge by an additional 2.5 billion by 2050 [2], [3]. By utilizing sensors to gather data and generate insights, the smart city, in conjunction with IoST technologies, can enhance the management of assets, resources, and services with greater efficiency. The challenges that future cities can overcome are expanding to numerous new fields, ranging from traffic management and energy conservation to safety protection and environmental monitoring. The widespread adoption of Internet of Things (IoT) technologies is making all of this possible. The concept of smart cities is underscored by the potential for IoT to enhance safety, reduce pollution, optimize energy utilization, and improve urban quality of life [4].

The Smart City
1. Definition and Objective
A Smart City refers to a sophisticated urban environment that leverages information and communication technologies to enhance the quality of its services and infrastructure, providing residents with a more efficient and streamlined way of life. Smart Cities aim to tackle the challenges of rapid urbanization, such as public safety, traffic management, and environmental concerns [5]. Sustainable development practices are promoted and implemented through interconnected devices that collaborate to streamline daily activities, enabling more efficient solutions to these issues.

2. Need of Smart City
With a projected population surge that would make it the world's most populous nation by 2030, India is poised to become the most significant and untapped market for global manufacturers and service providers. This emerging demographic is choosing to relocate to the country's top-tier cities, giving rise to new mega-cities anticipated to generate 80% of the country's economic growth. The potential exists to leverage cutting-edge technologies and infrastructure to encourage better utilization of scarce resources [6], [7]. Figure 1 shows various aspects of a smart city that are explained in further sub sections.

3. Smart City Technologies

To offer intelligent services to citizens, smart cities employ a range of technologies, including IoT, big data and analytics, cloud computing, Fog computing, block chain, 5G networks, regional data centers, edge computing, AI and ML, and robotics [8], [9].

Fg. 1. Smart city

4. Objectives of the study

This research paper aims to understand the components and features of Smart cities, evaluate the current status and performance of these cities, and identify the challenges associated with implementing Smart cities.

IoT in Smart City Development

1. ***Definition and Its Role***

The Internet of Things (IoT) is a system of interconnected devices, sensors, and other items that collect and exchange data. Through the use of IoT technology, devices can communicate with each other and transfer data to a centralized system. IoT has revolutionized how we interact with our environment and open up a world of possibilities for developing smart cities. In Smart City Development, IoST technology can efficiently manage resources and infrastructure and provide valuable data for decision-making. IoT-enabled systems can control traffic flow, monitor air quality, and optimize energy usage. Additionally, IoST technology can be used for public safety and security, such as surveillance cameras and smart lighting systems.

2. ***Backend working of IoT devices***

The Internet of Things (IoT) ecosystem comprises smart devices equipped with embedded systems, including processors, sensors, and communication hardware. These devices can gather data from their surroundings, transmit it, and decide based on it. IoT devices connect to an edge device or an IoT gateway to share the sensor data they gather. Data can either be sent to the cloud for analysis or analyzed locally. Occasionally, these devices communicate with other interconnected devices and respond to the information they receive from one another. These devices function mainly without human involvement, though individuals may interact with them, for example, to configure them, issue commands, or access the data. The way these internet-connected devices communicate, connect, and interact with each other is mostly determined by the specific IoT applications that are used. Furthermore, IoT can take advantage of AI and machine learning to make data collection more efficient and versatile [9].

3. **Key benefits of IoT in the development of smart cities** The use of IoT technology in smart city development can provide a wide range of benefits, such as:

- Improved public safety and security
- Improved efficiency of resources and infrastructure
- Reduced traffic congestion
- Improved air quality
- More accurate and timely decision-making
- Improved customer service

IoST Based Smart City Architecture

Smart city architecture is an integrated approach to urban planning and development that uses digital technologies and data to create more efficient and sustainable cities. It is designed to improve citizens' quality of life by providing more efficient services, better infrastructure, and more opportunities for economic growth. Smart city architecture typically includes intelligent transportation systems, smart grids, smart buildings, intelligent public safety systems, and smart waste management systems. Additionally, it can include initiatives such as smart governance, smart mobility, and open data systems.

This figure 2 shows the architecture of the connectivity of the devices and the data it collects which leads to the formation of a smart city. There are three layers over which the whole working takes place.

1. **Physical Layer**

This layer contains physical devices, such as sensors, meters, gadgets, alarms, etc., that gathers and exchanges data over the internet. This data is sent to other devices and further utilized for many applications. For example, a fire alarm used in the house can detect the smoke particles in the surrounding and alerts everyone living thereby activating and giving its alarming sound.

2. **Communication Layer**

The data received from the physical layer needs to be transferred and processed. For that, we have proper infrastructure which contains several components like wireless networks, cloud applications, Fog computing nodes, user-interface, system gateways, etc. Where the data is transferred and processed, it is utilized for the real-time applications.

3. **Application Layer**

This is the layer where the real work of the devices takes place. It provides various services to their users, such as smart homes, smart lights, smart healthcare, smart environment, etc.

Areas to Focus in Smart City Approach

Smart city services and the Internet of Things are improving the lives of people around the world. From making roads safer to reducing travel times to providing cleaner air, the effects of IoT applications can be seen in cities around the world. Smart urban planning, water management,

transportation, energy management, buildings, healthcare, and security are some of the major areas where IoT is being utilized.

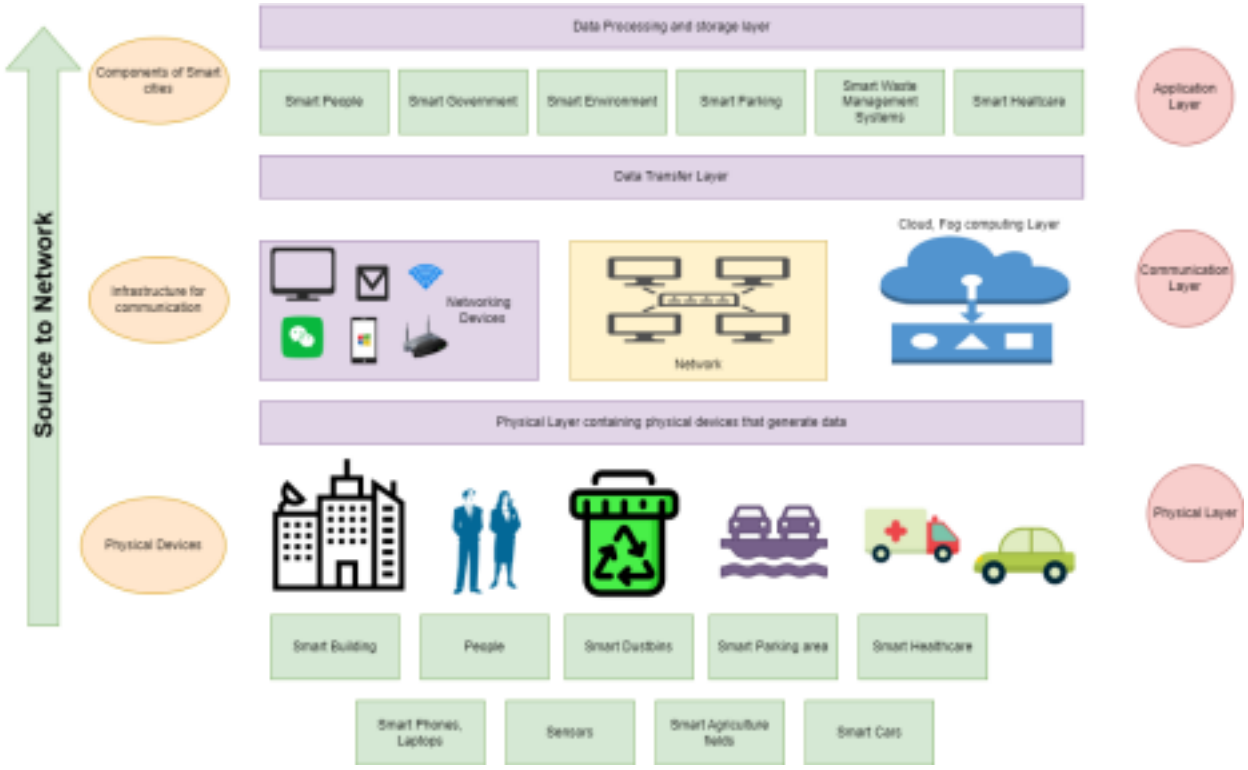

Fig. 2. Proposed Smart City Architecture

1. **GIS based urban planning**
   Cities can keep track of resources, services, infrastructure, and utilities both underneath and above ground thanks to GIS technology. GIS may combine databases to collect three-dimensional information by fusing modeling methods, software, and satellite data, improving urban planning by considering a wider range of issues. Municipal authorities are better able to identify service gaps, monitor revenue collection, and stay current on changes in the attributes of a property or plot when GIS data is connected with other land-use information, such as ownership, type of property, legal status, and tax information. This allows for the delivery of targeted public services online. Additionally, by promoting improved communication of plans and activities across parties, GIS contributes to creating and managing cities more inclusive.
2. **Water Management**
   One of the main issues in the current situation is the effective use and conservation of water. We can accomplish this effectively with IOT. Smart water management relies heavily on devices with embedded sensors that operate through networks. These technologies can also help government agen cies manage the water distribution system and water quality effectively while lowering water use and waste in industries like agriculture and landscaping. It is used in smart cities like Singapore, where a proper water supply network has been established for supply and management needs [10].
3. **Transportation**
   IOT has achieved major success in this field. Nowadays, there are GPS systems that manage all of the routes and also help people to find the shortest distance to their destination and suggest fewer traffic areas which ultimately helps in providing the most convenient way for travelling anywhere and also results in the reduction of accidents. Also, there are means for contactless transactions for transportation charges, having the facility to pay road taxes via Fast Tags or any other QR codes [11], [12].
4. **Energy Management**
   Approximately three-quarters of the world's energy are utilized by cities, responsible for 50 to 60 percent of all greenhouse gas discharges. When the people living in these urban areas are considered, the figure rises to 80 percent. To help with energy management, the Internet of Things has been a major help in forming strategies. Researchers have come up with terms such as "Energy 3.0" and "the Energy Cloud" because of the quick advancement of digital innovation and changes in the way energy is created and used. These are words usually used to refer to IoT-powered technologies which can help in attaining desired energy objectives, such as smart grids, demand electrification, demand visualization, and flexible production [13].

In 2013, IBM began a project in India with Tata Power Delhi Distribution to create and implement a modern smart grid system to improve energy output and reduce outages (Source: National Institute of Urban Affairs (NIUA)). The IT Company utilizes their expertise to collect and analyse real-time data from smart meters and information technology infrastructure. This project provides a great chance for pilot projects to show the potential of smart energy management. There is smart metres account for just 1% of India's 200 million energy meters.

5. **Smart Buildings**
   Constructing energy-efficient residential and business com plexes in our cities is an important issue. It is estimated that the construction industry in India makes up 40% of energy usage, 30% of raw material usage, 20% of water usage, and 20% of land usage in cities. Thus, it is essential to develop solutions that can help comply with regulations such as the Energy Conservation Building Codes. Technologies such as simulation, modeling, analysis, monitoring, and visualisation, which are all essential for an all-encompassing method of designing and running buildings, can be used by the ICT sector to help construct sustainable structures. This is necessary because India's microclimate is very different from that of Western nations [14].
6. **Healthcare**
   The utilization of connected technology in the healthcare industry has advanced significantly compared to other Indus tries associated with the"smart city" concept. Today, various applications, programs, and technology are accessible to the public, patients, and healthcare workers. These tools offer various health, fitness, and lifestyle education services, as well as monitoring and managing vital metrics (such as heart rate, perspiration, and blood oxygen levels). Furthermore, they as sist with daily living and resources for continuing professional education and public health surveillance. This can be seen in Gartner's observation that in February 2010; more than 4,000 health-related and patient-oriented apps were available in the Apple App Store. [15]. The SPHERE project in Bristol [16] is just one of the many examples of"smart healthcare" initiatives that are being promoted. This initiative is part of the larger "Connect Bristol" smart city plan, which involves introducing Machine-to-Machine (M2M) technologies into residential settings to allow for remote patient health and behavior monitoring. Wearable sensors and 3D cameras are being used to collect data, and big-data and pattern recognition are then being used to provide cost-effective and energy efficient healthcare solutions [17]. This is being accomplished by utilizing existing Small Area Networks, Home Area Net works, Wide Area Networks, and Wireless Control systems. The advantages of smart healthcare in a smart city are not just limited to cost savings but also include time savings for medical personnel and patients, reduced risks of exposure to hospital infections, and decreased travel. It is projected that through monitoring systems and interactive data communication, face-to-face visits can be reduced by 40%. This is especially beneficial for cities in India which are seeing an increase in conditions such as diabetes and other communicable diseases due to lifestyle changes [18].
7. **Security**
   A surveillance system that utilizes smart city technology is a type of technology-based security system that involves the use of digital communication, CCTVs (closed-circuit television cameras), sensors, controllers, and data analysis to monitor and protect public areas. These devices capture images and videos that are then transmitted to a central monitoring station. At the station, the data is analyzed using sophisticated software to detect suspicious activity, identify potential threats, and alert the appropriate authorities [19]. The system can also be used to monitor traffic flows and other public conditions to aid in the prevention of crime. Additionally, it can be used to provide emergency services with real-time information to help them respond faster and more efficiently to emergencies. Smart city technology is an effective way to improve public security and provide citizens with a greater sense of safety [20].

Literature Review

Lnenicka, Martin, et al. [21] provides a comprehensive review of the transparency of open data ecosystems in smart cities. The authors define and assess the maturity of transparency in 22 smart cities based on the analysis of the Open Data Index and the Open Data Maturity Model. The authors also identify the key challenges and opportunities for increasing the transparency of open data ecosystems in the smart cities studied.

Lynn Vosman, et al. [22] provides an insightful examination of the potential for collaboration and innovation in the infrastructure sector by adopting an ecosystem perspective. The authors provide an overview of the concept of an ecosystem perspective, which offers a new way of looking at collaboration and innovation beyond the boundaries of individual projects. They also present a case study of their work in the Netherlands, which provides an example of how an ecosystem perspective can facilitate collaboration and innovation in the infrastructure sector. Overall, the article provides an informative overview of the potential of an ecosystem perspective in the infrastructure sector.

P. Rosayyan, et al., [23] proposed a novel optimal control strategy for an emergency vehicle priority system based on edge computing and Internet of Things (IoT) sensors. The proposed system is suitable for applications in smart cities and can provide emergency vehicle priority to reduce traffic congestion and improve the safety of vehicles. The proposed architecture utilizes edge computing and IoT sensors to collect data regarding the current traffic conditions. This data is then used to calculate the optimal path for the emergency vehicle and provide it with priority.

M. Kaur, et al., [4] proposed a novel load-balancing technique for smart applications in a fog computing environment. The proposed technique is based on the concept of a self organizing map (SOM) which is used to identify the optimal load distribution in the fog nodes. The authors conducted extensive simulations to analyze the performance of the proposed technique and compared it to other existing load balancing techniques. The results showed that the proposed technique outperformed the existing techniques in terms of load balancing accuracy, as well as in latency and throughput.

Challenges of IoT in Smart City Development

The use of IOT technology has the potential to revolutionize the way we interact with our environment and has opened up a world of possibilities for the development of smart cities. IoST technology provides a wide range of benefits. However, there are also several challenges associated with the implementation of IOT in smart cities that need to be addressed. These include:

- Privacy and security concerns
- Cost and complexity of implementation
- Lack of standardization
- Reliability of IOT systems

Conclusion

The main focus of this paper is on the vast potential in India to establish an efficient ecosystem that employs digital technology to transform our rapidly growing urban areas into smart cities. This will not only create job opportunities but also stimulate innovation, leading to economic growth. As our cities become the predominant centers of human habitation, how intelligently we construct, oversee, and run them will be the most critical factor influencing the future of our citizens. The article also proposed an IoST-based smart city architecture that can be further implemented in future works. In the future, more constructs of Smart cities will be explored.

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