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Article

Web-based Efficiency of Distributed Systems and IoT on Functionality of Smart City Applications

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Abstract: In the current technological environment, the Internet of Things (IoT) has arisen as a significant subject of research because of its importance. A robust cloud computing framework is established via the collaboration of sensors and actuators. This framework has the potential to be used in the creation of autonomous object networks in real-time systems. The Internet of Things (IoT) is playing a significant role in the redefinition of other significant ideas, such as urbanism and smart cities. The Internet of Things (IoT) technology has the potential to improve the quality of life for inhabitants of smart cities, which are relatively new developments. This might be accomplished by providing people with enhanced facilities and services. The Internet of Things is seeing a fast expansion in a variety of sectors, including smart cities, everyday life, and other fields. Through the use of home automation, smart wearables, security solutions, and smart healthcare, the Internet of Things makes it possible to create intelligent environments. In the realm of the Internet of Things, some of the possible topics of study include intelligent transportation systems for cities and intelligent electrical systems. This article offers a succinct summary of the most recent advancements in the Internet of Things (IoT) and the influence those advancements have had on the lives of humans in their day-to-day activities. In addition to this, the Internet of Things (IoT) is also considered in connection to artificial intelligence, autonomous control, and cloud computing. It is important to synchronise a number of technologies, such as wireless sensors, actuators, the internet, and distributed computing, in order to successfully allow upcoming Internet of Things technologies.

Keywords: IoT, Web, Distributed Systems, Internet of Things, Smart City.

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1. Introduction

It is very important to know how web-based distributed systems and the Internet of Things (IoT) power the functionality of smart city applications. Imagine a futuristic metropolis where traffic lights respond to real-time data, waste management adapts to citizen needs, and energy flows like a well-oiled machine[1]. This research explores the technology behind this urban orchestra,

investigating:

a. Web as the unifying platform:

How the web acts as the central nervous system, facilitating communication and data exchange between diverse smart city systems in real-time. How web technologies like cloud computing and APIs enable scalability and flexibility for smart city infrastructure [2].

b. Distributed systems for improved efficiency:

How specialized, web-based distributed systems handle diverse tasks like traffic management, energy optimization, and environmental monitoring. How innovations in distributed systems enhance performance, resilience, and fault tolerance of smart city applications[3].

c. IoT weaving the data fabric:

How sensors and devices embedded in the city landscape feed real-time data into the system, providing crucial insights for decision-making. How IoT integration enhances functionalities like dynamic traffic routing, personalized public services, and predictive maintenance of infrastructure.

d. Elevating smart city applications:

How optimized data collection and analysis, enabled by web and distributed systems, empower smarter and more responsive applications. How the research investigates the impact of these technologies on specific functionalities like traffic flow optimization, energy efficiency, and environmental monitoring[4].

e. Challenges and future directions:

- Cybersecurity:

Cybersecurity in smart cities refers to the measures and practices taken to protect critical infrastructure, networks, and data from unauthorized access, cyberattacks, and digital threats. This includes protecting: Physical infrastructure: Sensors, cameras, traffic control systems, energy grids, and other connected devices. Networks: Communication channels carrying data between these devices and control centers. Data: Sensitive information collected by the city, such as traffic patterns, energy consumption, and citizen data. Effective cybersecurity in smart cities involves implementing robust security measures like firewalls, intrusion detection systems, data encryption, and security awareness training for personnel[4].

- Data Privacy:

Data privacy in smart cities concerns the responsible collection, use, and storage of citizen data generated by sensors, cameras, and other systems. This includes ensuring: Transparency: Citizens understand what data is being collected, why it's collected, and how it's used. Control: Citizens have the right to access, correct, or delete their data. Security: Data is protected from unauthorized access, misuse, and breaches. Accountability: City authorities are accountable for responsible data governance and ethical use of citizen data. Achieving data privacy in smart cities necessitates clear data privacy policies, secure data storage practices, and citizen engagement in data governance processes [5].

- Equitable Access to Technology:

Equitable access to technology in smart cities means ensuring all citizens, regardless of socioeconomic background, have equal opportunities to benefit from and participate in the digital transformation of the city. This includes addressing: Digital divide: Bridging the gap between those who have access to technology and those who don't. This can involve providing affordable internet access, training programs, and subsidized devices. Accessibility: Ensuring technology is designed and implemented in a way that is accessible to people with disabilities. Inclusion: Making sure all communities and voices are represented in the planning and development of smart city initiatives.

Achieving equitable access to technology in smart cities requires proactive policies, community engagement, and investments in digital literacy programs and infrastructure. Potential future directions in web-based distributed systems and IoT for further enhancing smart city functionalities and addressing existing challenges will be explored [6].

The Internet of Things (IoT) is a network that is comprised of systems, networks, and sensing devices that are all connected to one another. This network comes under the umbrella term "Internet of Things." In order to facilitate the sharing and updating of data, the use of sensors and actuators is necessary . The Internet of Things is a phenomena that has emerged as a newly found phenomenon over the course of the last ten years. It has the potential to affect a range of ideas, including intelligent cities, urban planning, and public transit, among others. Internet of Things (IoT) devices, which include linked sensors, lights, and meters, are used in smart cities for the purpose of data collection and analysis. Once that time has passed, communities will make use of the data to enhance their infrastructure, public utilities, and services, in addition to other facets of city life. In the present day, the Internet of Things (IoT) and smart cities are coming together, resulting in the introduction of technologies that have the potential to bring about a profound revolution in the urbanization process. The spread of smart cities, which has been made possible by the Internet of Things, has significantly enhanced the influence that these cities have on the lives of individuals on a daily basis. This is because more and more people are living in these cities. A "smart city" is a city that has achieved a greater degree of intelligence and efficiency via the use of the Internet of Things [7]. The phrase "smart city" is used to describe such a city.

It is extremely probable that a number of cities will turn to technology and sophisticated networks as a means of effectively supervising resource management in light of the anticipated population growth and urbanization trends. This notion is supported by the fact that it is highly probable that this will occur. It is quite likely that this is the case. To provide a more concrete example, it is possible that urban areas may grow to rely more and more on a subset of the Internet of Things that is known as smart city solutions (IoT). The Internet of Things (IoT) is now experiencing a period of fast expansion and broad acceptance, which is the primary focus of the research that is currently being carried out. Many different organizations are now working on a wide range of projects that are connected to the Internet of Things. These initiatives include a wide variety of ideas and projects. Quite a few of the most significant industries have launched a number of initiatives that are associated with the Internet of Things (IoT). The whole population of the globe is expected to be surrounded by a network of Internet of Things (IoT) devices and intelligent power grids by the year 2025, according to our projections. Internet of Things (IoT) encompasses a wide range of issues, including but not limited to: security problems, difficulty in data management as a consequence of enormous volumes of data, restricted network capacity, a high necessity for bandwidth, and health concerns [8]. Taking into consideration the manner in which these conceptual concepts are actually put into practice is very necessary in order to conduct an accurate assessment of the influence that these ideas have on the day-to-day lives of the people who live there. It is possible that this phenomenon might be attributed to the emergence of new opportunities that have come about as a result of the ongoing growth in technical advancements, in particular the expanding utilization of devices and entities that are driven by Internet of Things (IoT) technology .

The rest of the paper is organized as follows. The second section mentions the Internet of Things and Smart Cities. In Section 3 Related Work on Smart Cities Technologies and the Prototypes of Smart Cities. Section 4 presents the Discussion and Comparison. Finally the Conclusion in Section 5.

2. Internet of Things (IoT) And the Smart Cities

a. Application of IoT

In the realm of the Internet of Things, there is a wide range of applications that may be classified as belonging to the umbrella[8]. Retail management, healthcare systems, transportation systems, human activities, smartwatches, and smart wristbands are some examples of the applications that fall under this category. The 1TSensor is responsible for monitoring a variety of aspects, including the cleanliness of the air, the state of the sewage system, and the collection of rubbish. An earthquake detector that is very sensitive is able to detect the movement that takes place in close proximity to the epicenter of an earthquake. Before the earthquake occurs, this detector will then send a notification to the communication networks that are located in the surrounding region. Different frequency ranges include: For the purpose of achieving a broad variety of objectives, a wide range of frequencies may be used. Among the many types of services that are offered, some examples are healthcare services, military services that are focused on protecting and safeguarding, services for monitoring and observing crowds, and services for controlling traffic. Infrastructure services and water services are the two types of services that are included in this category[9].



Figure 1: Smart City Components[10].

b. Future directions for IoT

It is possible that the adoption of smart cities, which represent a tremendous amount of potential, would result in a major improvement in the efficiency of urban planning, urbanism, and administration. In order to adequately prepare for the future, urban planners are necessary to take into consideration a wide range of concerns. This is because the introduction of new technologies and challenges has resulted in the need for urban planners to take into account a wide variety of issues[11]. There is a potential that research in urbanization will be diverted into areas that have not been examined since the beginning of this process. This is because of the difficulties that have been brought up. As per the advice that is contained in , the conventional method of urban planning need to be substituted with the idea of smart cities and the components that constitute smart cities.

- Intelligent automobiles are a desirable feature. • Bikes that have been designed with intelligence.
- The design of urban centers is influenced by intelligent cities in that they have an effect.
- Establishing connections with the many urban services as they exist.
- Detection of crowds using mobile devices.

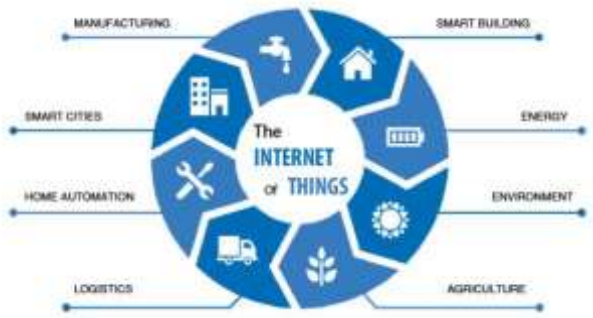


Figure 2: IoT applications for a variety of purposes [12].

c. Future Aspects of IoT and Environment

The phrase "Internet of Things" refers to a set of technologies that include a broad variety of different sorts of various kinds of technologies. The technologies that are included in this category include, but are not limited to, sensors, wireless networking, embedded systems, real-time analytics, machine learning, and cloud computing[13]. A full method that facilitates the design, management, integration, and development of corporate data and Internet of Things infrastructure is provided by a number of companies, including IBM, General Electric, Cisco, and Amazon, to name just a few of these companies. Companies such as Cisco, Amazon, and General Electric are all examples of businesses that provide this method. It will be easier to create, manage, and build these infrastructures with the assistance of this strategy, which will simplify the process. For the purpose of accelerating the creation, administration, connection, and security of systems that are enabled by the Internet of Things [14], the adoption of this solution helps to reduce risks and provides assistance to other governments and businesses in their efforts to speed up the process. This is done in order to achieve the goal of accelerating the process.

d. Smart Cities

A "smart city" is a term that is used to characterize the intersection of urban planning with information and communication technology (ICT), despite the fact that it is a relatively new idea. The crossroads in question is usually referred to as a "smart city." It has come to our attention that over the course of the last few years, there has been a significant increase in the number of individuals who are using this tactic. Several academic and industrial organizations, as well as governments, organizations, and people based on their own personal experiences and points of view, have defined this new paradigm in a variety of different ways. These descriptions have been based on the individuals' own personal experiences and perspectives[15]. Over the course of the last several years, this new paradigm has grown in popularity and acceptability. This new paradigm has seen a rise in popularity and interest over the course of the last several years, and it is becoming more appealing. Concerns have been raised in recent years regarding the fact that the concept of a smart city frequently places an excessive amount of emphasis on technology and is driven by the interests of businesses that deal with information technology on the one hand, while simultaneously neglecting the requirements of the government and the people who live in the city on the other hand. This is a concern that has been brought up in recent years. As an immediate and direct result of this, there is an urgent need for a strategy that is more comprehensive and less destructive to the environment[16].

The objective of a city is to become a smart sustainable city, and in order for the city to reach this goal, it must increase its attractiveness, sustainability, inclusivity, and balance for its residents, workers, and visitors. It is imperative that this be done in order for the city to realize its objective of being a smart and sustainable metropolis. For the city to be successful in achieving the goals it

has set for itself, it is essential that this be carried out as a general practice[17]. For this reason, it is feasible that the active participation of businesses, multi-utility groups, and stakeholders in the public transportation sector might be deemed to be of utmost importance for the accomplishment of these objectives. In light of the fact that this is the situation, this is the reason. An effective solution would be the formation of cross-sectoral working groups that include individuals from a variety of industries (for example, energy, urban planning, transportation, and information and communication technology)[18]. Not only would this be something that would be desired, but it would also be something that would be effective. At the same time as these organizations would be accountable for the integration of urban policy, these institutions would also be responsible for the implementation of the transition towards a smart city [14, 19].

e. Smart City Challenges

To properly manage the ecology of a smart city, it is vitally important to make use of technology as a fundamental component. This is required in order to achieve the desired results. One of the most important aspects of the procedure is making sure that one takes into consideration the social and human resources that are available to them. Currently, there is a significant number of smart city projects that are being implemented, and the majority of these efforts are based on individualized systems and methods of carrying out certain tasks[20]. On the other hand, it is possible that they are not always appropriate for diverse cities all over the world, and in other instances, just a percentage of the many different aspects that need to be handled are taken into consideration. When it comes to the process of building a smart city, it is of the utmost importance to take into account the perspectives of the people who live there and to place an emphasis on the quality of life that they lead. In order to do this, it is necessary to handle the privacy problems that come up when dealing with personally identifiable information and data relating to the residences of people who live there. In light of the fact that there are some people who could be concerned about the use of cutting-edge technology or who might perceive it to be intrusive, this is a very important aspect that should be taken into account. This is because the concept of equality is an essential component that guarantees that every single member of the society will be able to take advantage of the benefits that are brought about by technological advancements in smart cities. In addition, it seeks to preclude the likelihood of any metropolitan area being excluded or incurring a disadvantage, with the ultimate purpose of simultaneously narrowing the gap that exists between rural and urban regions [21].

3. Related Work

3.1 Related Work on Smart City Technologies

Smart city devices are designed to simplify and expedite daily tasks, while simultaneously addressing issues about public safety, traffic, and the environment. The following are many of the most popular smart city technologies:

a. Smart waste management solutions

Using the Internet of Things, Khan and Kumar Agrawal [22] were able to boost the potential of a smart city's Bin to Track Dustbin and Public Complaint Management System. This was accomplished by increasing the potential of the system. Through the use of this technology, it is feasible to keep track of trash cans and record complaints. They developed a mobile application for smartphones that enables them to keep track of the appropriate positioning of trash cans and determine the overall number of trash cans that have been positioned in the neighbourhood for the benefit of the general public. In an effort to resolve the concerns that were brought up, this action was taken. Additionally, individuals utilise this Android application to communicate their own concerns and challenges that they are experiencing in their own lives. When individuals make use of this initiative, they are provided with the opportunity to file complaints with the regulatory

agency that is most relevant to their particular circumstances. in order to discover a solution to the situation that a person is experiencing. Providing residents with the capacity to give better service and enabling the execution of a technique that is more efficient are two of the ways in which this Android application brings about the outcomes that are wanted.

b. Smart air quality monitors

During the course of their study, which was published in [23], other researchers, such as Ramalingam and Baskaran, used sensor technologies and a Raspberry Pi device. It is possible for the Internet of Things (IoT) system that is being suggested to detect the amount of carbon dioxide (CO2) that is emitted by industrial processes. This capability is in addition to the monitoring of temperature and humidity levels. In addition to temperature and humidity levels, this is something that should be monitored. As a consequence of this, each and every stage will be meticulously watched and regulated independently of the others. By establishing a connection with a BLYNK native server mobile application, the device will be able to provide data in real time on the levels of environmental contamination that are present in rural areas or industrial settings. It is possible for the gadget to have access to this information. By using the concept of the Internet of Things, it is now feasible to establish connections between information and locations that are not often visited all over the globe. As the major goal of the implementation effort, the construction of a management system that is fully automated and operates in real time is the primary purpose. This purpose will be done via the use of technology that is associated with the Internet of Things (IoT).

The system that Ghoneim and Hamed [24] designed is one that is both beneficial to the environment and friendly to the environment. The Internet of Things serves as the system's base. With the help of this technology, pollution in the air outdoors may be identified and monitored in a manner that is not only efficient but also effective. In order to provide power to the system, the major source of electricity that is used is renewable energy sources. Monitoring the levels of pollution and reporting the authorities if the levels of pollution surpass a threshold that is authorised is the responsibility of the system, which is responsible for this monitoring. Subsequently, the data that was obtained may be employed by the authorities in order to build proactive interventions and put plans into action in order to alleviate the adverse affects of air pollution and to hamper its spread.

For the purpose of monitoring air pollution in smart cities, Ul Samee, Jilani, and their colleagues [25]suggested the use of methods that make use of machine learning and the Internet of Things (IoT). This was done with the objective of achieving the desired results. In order to determine whether or not there is a connection that can be regarded statistically significant between pollutants and climatic conditions, the Pearson correlation coefficient is used. This is done in order to determine whether or not there is a relationship. The study in question makes use of a middleware architecture for the Internet of Things that is based on the cloud. This is done in order to differentiate itself from traditional sensor networks. For the purpose of gathering information from both the weather sensors and the air pollution sensors that are already in existence, this architecture is employed. As a result of this, the cost is cut down by a large amount, and the reliability is increased by a factor of two. In addition to that, the savings are rather significant. An Artificial Neural Network (ANN) was used in order to produce forecasts about the levels of Sulphur Dioxide (SO2) and Particulate Matter (PM2.5). These forecasts were able to be made. According to the favourable results that have been obtained, it would seem that artificial neural networks have the potential to serve as a viable alternative to air pollution monitoring and prediction systems. This is based on the fact that they have the ability to anticipate air pollution. When it comes to SO2 and PM2.5, the Root Mean Squared Errors calculated by our models range anywhere from 0.0128 to 0.0001 depending on the particular model being considered. Tests were used to determine these values, which were then set.

c. Intelligent Conditioning system

The most significant downsides of refrigerant gases were noted by Al-Khalidy and Ahmed [26]. These drawbacks include the fact that they contribute to the phenomenon of global warming and that they produce dangerous gases. In terms of disadvantages, they are the two most essential ones. There are a number of potential solutions that may be adopted to meet these challenges. One of these solutions is the use of thermoelectric modules as a means of ensuring the preservation of the environment. Through the use of the Peltier effect as the source of power, thermoelectric modules are provided with the energy that they need. During the summer, the air conditioning system that is being supplied has the capability of functioning as a cooling unit, and during the winter, it may function as a heating device. The accomplishment of this goal is performed without the emission of any potentially harmful compounds, such as hydrochlorofluorocarbons. Performing each of these things at the same time is an option that deserves consideration. With the help of this project, it became possible to regulate an air conditioner in a manner that was both simple and efficient in terms of time by using applications for smartphones. The use of cutting-edge technology, such as the Internet of Things (IoT), proved to be the means by which this was accomplished.

d. Healthcare

Yue and Li, along with a few other individuals, are among the authors of [27]. We shall endeavour to address the following in order to achieve our goal: It might be challenging to get accurate readings of heart rate due to the fact that the lighting conditions are not consistent and the facial expressions are constantly changing. This is because the heart rate is being monitored, which is the reason for this change. A new method that does not need any kind of physical contact is mentioned as being used in the process of calculating the rate at which the heart functions. It is necessary to take note that colour signals are recovered, and approaches for deconstructing into low-rank and sparse components are used. This is done in order to guarantee that key characteristics are not obscured by interference and noise. For the purpose of ensuring that essential traits are adequately reflected, this is done. There is a link between the gateway and the server, which allows the information to be accessed successfully. As a result of the use of the health-centric cloud, individuals now have the capacity to get immediate information on their current state of health. The suggested technique has been proven to give a range of advantages, as proved by empirical data, as compared to face-based alternatives. All of these benefits have been demonstrated. Some of the advantages that are linked with this technique include the elimination of the need for specialist equipment, the reduction of the amount of discomfort experienced by the patient, and the quickening of the healing process after the operation. There is also the possibility that the technique of measurement that has been described has the capacity to make the process of developing intelligent urban environments more straightforward.

e. Smoke Sense System

The researchers Wang, Su, and their colleagues [28]developed an autonomous alarm system that makes use of NBIOT (narrowband Internet of things) technology to detect smoke, temperature, and humidity. This alarm system is able to detect all three of these factors simultaneously. Taking this action was done with the intention of finding a solution to the issues that are now being experienced. It can identify damage to equipment, it can measure the amount of electric power, it can conduct multi-party detection, and it can give unified deployment management. All of these may be attributed to the fact that it is cost-effective, it consumes very little power, and it can measure the amount of electric power. Taking all of these factors into consideration, the system is favourable. An accurate assessment of the fire scene may be obtained by the workers via the process of combining data on temperature, humidity, and smoke. This makes it possible for them to evaluate the situation more precisely. This consideration will make it easier for them to create opinions based

on trustworthy information, which will simplify their capacity to make decisions. After the testing phase is over, there is a possibility that the system may continue to operate in standby mode for about five years. This is a possibility. As a result, this provides a high degree of usability and makes it possible to provide enough warning in a variety of locations that are rather tiny.

f. Automated Power Management

It is feasible to utilise a technique that can be used to adjust the overall utility function by taking into consideration the unique relevance of each individual appliance, as stated by the theory that was proposed by Tittaferrante and Yassine [29]. This theory states that it is possible to apply this way. According to the findings, it is possible to attain a higher level of customer satisfaction by establishing the target function in accordance with the relevancy of the appliances. This conclusion was reached as a consequence of studying the results. Following the completion of the study, this result was arrived at. Within the framework of an automated energy management system, the purpose of this study was to investigate the influence that priority scaling has on the capabilities of individual appliances in terms of their utility functions. The researchers focused the majority of their attention on a wide range of items of machinery that had energy consumption indicators that were in a condition of continuously shifting. In order to classify appliances in accordance with the memory needs of the utility services that they provide, there are three categories that are used. Full-memory appliances, partial-memory appliances, and memoryless utility appliances are the many types of appliances that fall under this category. Convex optimisation is a challenge that has to be addressed on a regular basis in order to achieve the goal of determining the settings for appliances that are the most optimal. It will be necessary to find a solution to this challenge in order to adequately manage energy.

g. Smart Parking and Traffic Management system

The technology that is referred to as the Internet of Things (IoT) was used in the investigation of a smart parking system that was carried out by Al Mamari, Al Mamari, and other individuals [30]. The whole of this system is comprised of distance measuring devices, which are sometimes referred to as sensors in certain circumstances. These devices are used to measure distances. It is necessary to create a connection between these sensors and a connected device that is equipped with Wi-Fi in order to do this. Furthermore, it is a component of a cloud service and an application for mobile phones that gives aid to the user in identifying a parking place that is not now being utilised by another person for parking reasons. Using this method is something that may be done by any and all educational institutions that are of a higher degree, including colleges and universities. The installation of this solution is relevant to any organisation that has suffered traffic congestion and difficulties identifying parking spots, which has resulted in a drop in productivity and workers coming late to their places of work. As a consequence of these challenges, the company has seen a decrease in production.

In the course of their study, the researchers Ikpehai, Adebisi, and others [31] investigated the influence that limited equipment has on the life expectancy of data traffic characteristics in smart cities. Specifically, they focused on the phenomenon of restricted equipment. Long-range wide area network (LoRaWAN) and Sigfox are two technologies that deserve special mention as examples of low-power wide-area network (LP-WAN) technologies. It is common knowledge that both of these technologies are used. Both of these technologies were included into the architecture of the access network, which was designed with a star topology as its main structure. According to the results, both Sigfox and LoRaWAN have the ability to support device lifespans of around 5.82 years and 13.25 years, respectively, within the European region. This is the case for both technologies. These technologies are especially well-suited for lightweight applications such as smart street lighting, which only convey a marginal amount of data on a daily basis. Intelligent street lighting is one example of such an application. Consider the implementation of intelligent

street lighting as an example of such a use case. In the event that the number of messages that are sent on a daily basis is raised from one to one hundred forty, the lifetime of a Sigfox device is reduced from four and forty-three years to eight and a half years. In contrast, the lifespan of a LoRaWAN device decreases from thirteen and a half years to ten minutes and forty-eight years when the number of messages broadcast each day is increased from one to one hundred forty. This is because the number of messages broadcast each day increases from one to one hundred forty.

h. video surveillance

[32]Gallo, Pongnumkul, and a few other individuals collaborated to build a video surveillance application. Additionally, the technology that underpins blockchain was used in the construction of the system. If anything were to happen, it would be feasible for authorised persons to quickly access the surveillance footage and camera settings that have been examined and stored in a secure manner. This would be possible in the event that something unforeseen were to take place. The discoveries that BlockSee has uncovered are encouraging, and they pave the way for the development of distributed surveillance systems that will be implemented in the near future throughout the whole of the city.

3.2 Related Work of Smart Cities Prototypes

a. India

Along with Ravindra and Devi, as well as their coworkers [33] Instance of a proposition that is suggested It is now being analysed and put into action that the Internet of Things (IoT) solution for intelligent waste management is being implemented. The "Smart Cities Mission" is a testament to the commitment that the Indian government has given to the establishment of the mission. A proportionate rise in the quantity of garbage that is being created has been brought about as a result of the exponential development of the population. This has major ramifications for both the health of the general population and the environment. The concept of a "smart bin" offers a solution that is both practical and effective for this issue. Industrialization, urbanisation, and economic progress are the key causes that are accountable for the creation of this trash that is being generated. trash is being produced, and it is being produced. There have been several instances of garbage overflowing in India, which may be attributed to the inefficiency of the waste management systems that are presently in place in the country. When it comes to having a living space that is both healthy and sanitary, the existence of a clean and hygienic atmosphere is quite vital.

b. Hamburg - Germany

In the findings of their research, Meiling, Purnomo, and their colleagues [34]investigated a number of Internet of Things (IoT) platforms, technologies, and network protocols that have the potential to speed up the process of developing Smart City environments. Every single one of these platforms, technologies, and protocols have the capability to do this. Additionally, the MONICA project, which is being carried out by the European Union, was the topic of discussion that took place throughout the course of many talks. In the course of these discussions, the primary emphasis was put on the purpose of the project, which was to exhibit significant Internet of Things (IoT) installations at public events that were hosted in metropolitan areas. Another item that was brought up for discussion was the architecture of the Internet of Things platform that was going to be used for the project. Furthermore, they presented a complete study of the Smart City initiatives that the City of Hamburg has been working on. This was additional to the previous point. These activities include the continued field testing of an Internet of Things sensor application that includes everything.

c. Msheireb Downtown - Doha

With reference number [35], Al-Fadala & Fadli conducted an investigation into the

architectural features and the objectives that are intended to be served by the public open spaces (POS) that are a component of the Msheireb Downtown Project. This inquiry was carried out in order to determine the purpose of the POS. In order to construct a sustainable smart city specification for Msheireb Downtown that places a premium on the comfort, health, and well-being of potential residents, the purpose of this research is to identify their duties within the smart city design system. This will allow for the construction of a smart city standard that is sustainable. The creation of a smart city standard that is environmentally friendly will be made possible as a result of this. Additionally, they offer light on the technical solutions that have been implemented in order to address a wide variety of environmental issues. In this regard, they have been responsible for this. The history of Msheireb Downtown served as the foundation for the process, which was implemented with the intention of establishing and testing a method for evaluating criteria. To record, synthesise, and evaluate the open spaces in Msheireb and their impact on user comfort, health, and well-being, a wide range of quantitative and qualitative methods, as well as physical and perceptual methodologies, were used. These techniques included both quantitative and qualitative approaches. Using a mix of these approaches allowed us to successfully complete this task. The choice to carry out this action was motivated by the aforementioned goals, which could be found in the previous sentence.

d. Malaysia

The notion of conducting a research project with the purpose of discovering the elements that impact the adoption of smart metres among residential customers was conceived by Alkawsi and Baashar [36], who came up with the decision to carry out the study. Furthermore, it is likely that their achievements might be attributed to the fact that they used the second generation of the unified theory of technology acceptance and utilisation (UTAUT2) in conjunction with their understanding of strategies for conserving power and being conscious of the environment. As a consequence of the findings of the research, a significant correlation was found to exist between the behavioural objectives of users and the activities that they participated in thereafter. There are a number of well-established acceptance theories, such as the technology acceptance model (TAM) and the ultimate technology acceptance and utilisation theory (UTAUT), that include the behavioural intention variable into the nomological network of technology adoption determinants. This is done in order to take into consideration the many elements that have an impact on the amount of technology that is introduced. On the basis of the results of this study, it was revealed that the influence of consumers' behavioural aims on their consuming behaviour was identified. One of the aspects that had not been examined in any of the smart metre acceptance models that had been established in the past was this particular dimension. Undoubtedly, this was a finding that ought to be noted. There are a total of 318 residential smart metre users that have provided their information for collection, and Putrajaya and Malacca, both of which are situated in Malaysia, are each home to these consumers. For the purpose of conducting statistical analysis on the data that was obtained, the SME-PLS approach was selected as the method of choice. The findings of the research suggest that the incorporation of information on the conservation of energy and the duty towards the environment into the UTAUT2 model significantly amplifies the degree to which the adoption of smart metres by customers can be explained at a higher level. According on the findings of the study, this is the recommendation that was made.

e. Spain

In their study, Santos, Jiménez, and their colleagues [37] provided an explanation of the essential principles that underpin the triggering mechanisms that are used in the Send-On-Delta, Send-On-Area, Send-On-Energy, and Send-On-Prediction methods. These mechanisms are employed to send information to the respective recipients. These techniques are intended to cut down on the number of communications that take place between the sensor node and the supervisory or monitoring node, while at the same time ensuring that an accurate tracking of the

variable that is being sensed is maintained. This irregular strategy, on the other hand, helps to cut down on the quantity of energy that is used by the electrical apparatus that is situated at sensor nodes. An investigation into the typical battery life of sensor node batteries was carried out with the intention of determining the amount of energy that was conserved based on the findings of the investigation. In order to carry out a case study on the primary pollutants that have an impact on the air quality in metropolitan areas, namely SO2, NO2, O3, and PM10, the data that was gathered from Smart City tools in Santander, Spain, was used. This was done in order to perform the case study. They came to the conclusion that event-based sensing techniques have the ability to decrease sensor node consumption by as much as fifty percent, which is in contrast to the standard periodic sensing approaches that are now in use.

f. Bangladesh

Ahmed, Rahaman, and a few other individuals [38]conducted a study with the intention of achieving the aim of fish farming. In this study, they investigated the water quality requirements in a number of ponds that were situated in Bangladesh. The objective of the study was to evaluate the environmental factors that are associated with these water quality indicators and the ways in which these factors influence the health of fish. When it came to predicting the relevance of water level, a number of different machine learning approaches were evaluated that were evaluated based on how accurate they were and how high of an error rate they had. It was decided to apply logistic regression in order to achieve the goal of enhancing the fit between the train segments and the test segments. In order to establish whether or not the water quality in the new pond is acceptable for fish farming, the prediction was carried out based on the values of quality parameters. This was done in order to assess whether or not the water quality is suitable. A comparative analysis of future projections was carried out with the assistance of an empirical system design that was based on the Internet of Things (IoT). In order to determine the environmental circumstances and standards that are suitable for fish development, as well as the factors and potential dangers that lead to fish mortality, the objective of this study was to investigate the pace at which fish grow by analysing the measures of water quality.

g. China

In order to examine the variables that impact the adoption of Internet of Things (IoT) technologies in China's agricultural supply chain, Lin, Lee, and their colleagues [39] build a technological organisational environment (TOE). This environment is designed to facilitate the investigation of these elements. Following that, the analysis of the data was carried out with the use of structural equation modelling. It was via the use of statistical analysis that the important components were revealed, and the TOE model was revised in the appropriate way. Based on the results of the research, it can be concluded that resistance and uncertainty on the part of workers do not significantly hinder the adoption of the Internet of Things. There are a variety of technological obstacles that must be overcome before the Internet of Things can be used in agriculture. These obstacles include complexity, compatibility, perceived benefit, and cost. In addition to the factors that were mentioned before, these explanations explain why. There are a number of organisational characteristics that have an effect on the adoption of the Internet of Things. These characteristics include the size of the firm, the support of the executive team, the amount of trust among supply chain organisations, and the level of technical knowledge. Furthermore, the adoption of the Internet of Things is also driven by environmental variables such as pressure from the outside world and help from the government. These aspects might be considered environmental influences.

h. United Arab Emirates (UAE)

The approach that was proposed by Abdulrahim, Mahmoud, and others [40] is constructed on the foundations of a comprehension of the mechanisms of failure, the collection of real-time data via the utilisation of the technology of the Internet of Things (IoT), and the use of methods that are

linked with machine learning. It was with the intention of forecasting and categorising the condition of the equipment as either operating or malfunctioning that this method was developed. Case studies are conducted with the intention of providing evidence that the strategy in question is useful. The case study was conducted at a hospital that is situated in the United Arab Emirates (UAE), which comprises the United Arab Emirates. Following an assessment into maintenance events and criticality, it was concluded that the Vitros-Immunoassay analyzer is a viable candidate for moving from corrective maintenance to predictive maintenance. This conclusion was reached after the research was carried out. It was only after the study had been completed that this was found out. Following the completion of the study, this conclusion was arrived at after taking into account the findings. When it comes to failures, the belt slippage that occurs on the measuring arm is the most prevalent kind that may be seen. Through the examination of the vibration signals that are associated with this kind of failure, it is feasible to make a prediction about it. Wireless accelerometers are used for the goal of gathering information about vibrations that occur in the immediate proximity of the individual being measured. This data is subsequently sent to a signal analyzer, which may be located in the cloud or on-site, depending on the circumstances. The location of the signal analyzer is determined solely by the circumstances. An evaluation of the characteristics that have been acquired and selected in order to identify the issue scenario is carried out with the assistance of a Support Vector Machine, which is also written as an SVM. This evaluation is carried out in order to identify the problem scenario. It is necessary to carry out this examination in order to determine the nature of the issue situation. A payback time of one year was established by the technique that was offered, which proved the potential for cost savings of up to twenty-five percent in expenditures associated to diagnostic and repair work. The payback opportunity was demonstrated by the approach. It has been shown that this is accurate with regard to the present situation of the finances. In addition to being highly adaptable, the technique that has been stated is also capable of being utilised for a large range of medical equipment, which is something that is commonly seen in major medical facilities.

i. Saudi Arabia

One of the goals of the study that Masmali and Miah [41] conducted was to explore the first-hand experiences of healthcare administrators who have used Internet of Things (IoT) devices in the delivery of healthcare services. This was one of the aims of the research. The purpose of the research that was carried out with the intention of gaining that understanding was to get a more profound grasp of situations that were experienced firsthand. There were a total of five individuals who participated in the semi-structured interviews that were carried out primarily for the purpose of carrying out the interviews. These individuals came from Jazan hospitals and clinics. Throughout the course of these discussions, the idea of innovation permeating all corners of the world was taken into consideration. According to the findings, a discussion is currently taking place regarding the capabilities of the Saudi healthcare sector to effectively integrate and use the most recent information technology and internet of things technologies, as well as the opportunities that exist between these technologies. This conversation is taking place in Saudi Arabia.

4. Discussion and Comparison

Table 1. Shows a Summary of Comparison for Related Work on Smart City Technologies.

Within the context of [22], the researchers made an effort to provide some light on the scenario that they were investigating. Waste management is characterised by inefficiency, there is a connection between waste management and high expenditures, and waste management has the ability to make traffic congestion even worse; all of these qualities are linked to trash management. Intelligent waste management systems have the potential to address these concerns by continually monitoring the quantity of rubbish that is contained inside garbage cans and communicating this information to enterprises who are responsible for waste management. Under these circumstances, it would be possible to eliminate these challenges. The companies are permitted to make modifications to the

routes that they travel in order to collect garbage in order to achieve the highest possible level of organizational effectiveness. In addition, a number of cutting-edge trash cans, such as the EvoEco, have the capacity to train customers on the procedures that must be followed in order to dispose of certain items, such as recycling or composting, and even show instructional messages while the process is being carried out. A huge step forward has been taken in the realm of waste management with this development.

Monitoring of indoor air quality (IAQ) may send push notifications or indicator lights to the mobile devices of customers, such as their smartphones or tablets, in order to give customers with information on potentially harmful pollutant levels. This is done in order to offer customers with information. When one takes into consideration the fact that a wide variety of airborne particles, dust, filth, and cleaning chemicals are constantly present in the air of residential and commercial buildings, it is indisputable that this specific element be taken into consideration. In accordance with the findings of the study paper titled "Smart air quality monitors" [23-25], sophisticated air quality monitors are able to identify pollutants and provide consumers with information about them. This information was mentioned in the phrase that came before this one.

According to the findings of the empirical demonstration of the intelligent air conditioning system [26], the Peltier (TEC) module is not only small, but it also functions without producing any vibrations, is free from vibrations, and is compatible with environmentally friendly energy sources such as solar energy. Additionally, the module does not make use of any vibrations. Because there are no pollutants involved in the process, this results in a reduction in the amount of energy that is used, and it is also more ecologically friendly than other methods. On the other hand, in contrast to air conditioning that employs vapour pressure, it has a decreased capacity for chilling and a lesser efficiency; yet, it shows to be excellent when it comes to heating the air. Furthermore, as comparison to standard air conditioners, it provides a variety of advantages, including the lack of chlorofluorocarbons, the capacity to make minute adjustments to the temperature by fractions of a degree, and the simplicity with which it can be maintained.

Through the use of the Noncontact Imaging photo plethysmography Cloud platform, users are provided with the opportunity to monitor their current state of health in real time. The use of cloud technology is what makes this a feasible option. Through the incorporation of NBIOT technology into the smoke, temperature, and humidity sensor alarm system described in [28], it is now possible to carry out a more precise assessment of the fire scene, and it is also made easier to take the appropriate actions. The system is described in this [28]. In addition, we developed a system that is capable of managing energy in an automatic manner. This system can be found in reference [29], by the way. The features of variable energy consumption that are included into this system make it possible for the utility function as a whole to be modified in accordance with the relative relevance of each individual appliance. The incorporation of these characteristics allowed for the realization of this possibility.

Utilizing intelligent street lighting that transmits minute data packets on a daily basis, the Smart Parking system provides clients with assistance in locating parking places that are currently available. This is accomplished via the use of information. This enables the system to successfully detect parking places that are not currently being used. It is possible for the monitoring device solution to examine and securely record camera settings as well as surveillance video in a way that is permanent and cannot be altered within a certain range of [30-32]. Utilizing blockchain technology allows for the successful completion of this task.

Table 1: Comparison for Smart City Technologies

Ref. No.	Smart City Technologies		
	IoT Technology	**Microcontroller**	**Efficient Results**
[23] 2019	Smart Industrial Pollution Monitoring	Sensor Technology & Raspberry pi	Show real-time updates on industry environmental pollution or remote space
[24] 2019	Air Pollution Detection	Powered by renewable energy	Detecting & monitoring outdoor air pollution
[25] 2019	Air Pollution Monitoring	Pearson Correlation	High association between contaminants and weather parameters
[42] 2019	Intelligent Peltier Cold / Hot Air Conditioning	Thermoelectric modules	Summer air cooler & winter heater and does not release hazardous or toxic gases
[27] 2019	Noncontact Imaging photo- plethysmo-graghy	Cloud platform	User can use the cloud to monitor their health condition in real time
[28] 2019	Smoke, temperature, and humidity sensing alarm system	NBIOT technology	Staff can form a more accurate assessment of the fire scene and then make appropriate decisions
[29] 2019	automated energy management system	variable energy consumption settings	scaling the overall utility function based on the relative importance of individual appliances
[30] 2019	Smart Parking system	cloud service	helping the user to locate an available parking space
[31] 2018	Traffic Management system	Sigfox and LoRaWAN	Provide intelligent street lighting that transmits modest payloads on a daily basis.
[32] 2018	Monitoring device system	blockchain-based video surveillance	validates and immutably records camera settings and surveillance videos
[22] 2018	Smart waste - bin	Android App	Keep track of the location of dustbins and the areas where rubbish decomposes.

A comparison of the numerous smart city prototypes that have been investigated in related research is shown in Table 2, which gives a succinct overview of the comparison. There have been research conducted that compare and contrast the two. Smart cities have adopted apps that make use of the Internet of Things, which has resulted in significant changes to the urban environment on account of the acceptance of these applications. Smart cities have also benefited from the adoption of these applications. We analyzed and assessed a number of areas in which modern cities focus their efforts to improve resource management and service supply as part of our efforts to turn

modern cities into intelligent and sustainable urban centers. This was done as part of our efforts to increase the quality of life in modern cities. In order to get a greater understanding of how contemporary cities may successfully enhance these regions, this project was carried out. The purpose of these efforts is to meet the expectations of people by providing a selection of services and procedures that are better adapted to meet their needs. These efforts include a wide range of areas of urban life and are meant to fill the expectations of persons.

This becomes clearer when one takes into consideration the research projects that have been carried out by a number of cities throughout the world, including Msheireb Downtown – Doha [35], Malaysia [36], United Arab Emirates [40] Spain [37], Bangladesh [38], Saudi Arabia [23], Hamburg – Germany [34], India[33], and China [39]. A broad variety of Internet of Things (IoT) technologies have been used in these municipalities in order to improve the core capabilities of the municipalities as well as the quality of the services that they provide. Implementing these concepts and solutions will be of great assistance in the future development of smart cities, which will be a big growth opportunity.

Table 2: Comparison for Smart City Prototypes

Ref. No.	Smart City Prototypes			
	The country	**IoT project**	**Purpose**	**Results**
[35] 2020	Msheireb Downtown - Doha	Examining the design characteristics and intended uses of Msheireb Downtown's public open spaces (POS)	To develop a sustainable smart city specification for Msheireb Downtown that places a premium on user convenience, health, and well-being.	The application of a mix of quantitative and qualitative/physical and perceptual methodologies to document, synthesize, and evaluate Msheireb's open spaces and their effect on user comfort, health, and well-being.
[36] 2020	Malaysia	Demonstration of the effect of users' behavioral intention on their usage behavior	To ascertain the parameters that influence the acceptance of smart meters by residential consumers.	By incorporating information about energy conservation and environmental stewardship into the UTAUT2, the explained variation in consumer acceptance of smart meters is dramatically increased.
[40] 2020	United Arab of Emirates	Understanding the physics of failure, collecting pertinent parameters in real time using Internet of Things (IoT) technologies, and	To predict and classify equipment status as healthy or faulty.	The proposed technique resulted in considerable diagnostic and repair cost savings of up to 25% with a payback period of one year. Additionally, it can be used to describe a

Ref. No.	Smart City Prototypes			
	The country	IoT project	Purpose	Results
		utilizing machine learning technologies		wide array of medical equipment seen in large medical institutes.
[37] 2019	Spain	The Send-On-Delta, Send-On-Area, Send-On-Energy, and Send-On-Prediction techniques are detailed in detail.	To reduce the number of communications between the sensor node and the supervisory or monitoring node without compromising the tracking of the detected variable.	The event-based sensing strategies can reduce sensor node consumption by up to 50%.
[38] 2019	Bangladesh	Examining the water quality standards in different ponds of Bangladesh for fish farming and looking at the fish health parameters related to those water quality measurements	To determine whether the water quality of the new pond is suitable for fish farming in terms of the values of quality parameters.	Determine the risk associated parameters for Fish survival, growth, and breed identification, as well as classify the Water level significance for Fish farming.
[41] 2019	Saudi Arabia	Saudi Arabia's healthcare sector's capacity	To examine healthcare administrators' lived experiences with IoT devices in the delivery of healthcare services.	Capacity of the Saudi healthcare sector to absorb and integrate new IT with IoT technologies and their integrations continues to be a point of contention.
[34] 2018	Hamburg-Germany	1. Series of IoT platforms, technologies, and network standards. 2. European Union's MONICA project.	1. To help in promoting the environment of Smart City. 2. to demonstrate large-scale IoT deployments at public, inner-city events, as well as a high-level overview	How to connect a restricted Internet of Things network to the public Internet through a CoAP-to-HTTP proxy, enabling end-to-end data flow between an embedded Internet of Things sensor and the Hamburg Urban Platform.

Ref. No.	Smart City Prototypes			
	The country	**IoT project**	**Purpose**	**Results**
			of the project's IoT platform architecture.	
[33] 2018	India	Intelligent waste management system	To Decrease waste production which will positively affect public health and the environment	The existing waste management systems in India are not so efficient that they can lead in the majority of cases to waste overflow. For a healthy and clean-living space, a clean hygienically environment is essential.
[39] 2018	China	Building a technology organizational environment (TOE), application of Internet of Things (IoT) technology in China's agriculture supply chain	To Investigate the effects factors in the adoption.	The employee resistance and uncertainty are not significant factors influencing IoT adoption.

5. Conclusion

In recent years, technological advancements have revolutionized urban infrastructure, affecting a wide number of subjects of study. Technological advancements will also have an effect on urban studies. Technology has disrupted the old conceptions of cities, which were characterized as a stable and unchanging structure. At each level, the procedures of urban developments will experience a full makeover. The collection, aggregation, filtering, classification, and analysis of data will be based on real-time data from a variety of sensors and indications. Along with intelligent citizens' engagement, the availability of intelligent components such as smart automobiles and intelligent urban features will have an impact on plans and policies. The vast majority of programs and policies geared at sustainability, a high standard of living, reducing air pollution, and addressing environmental challenges will be implemented in IoT-enabled smart cities. Urbanism and IoT-enabled smart cities will coexist. Increased citizen participation will have a substantial effect on how policies and decisions are embedded. Real-time data and the appropriate reaction of smart elements will enable efficient results in IoT-based smart cities. As previously said, getting all real-time data will take into account the privacy of individuals. These data will assist urban planners in guaranteeing social equity and equality in IoT-enabled smart cities. It is reasonable to suggest that urban planners include smart cities powered by the Internet of Things into their designs, as they will improve everyone's quality of life.

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