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State of Art Survey for IoT Effects on Smart City Technology: Challenges, Opportunities, and Solutions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Automation frees workers from excessive human involvement to promote ease of use while still reducing their input of labor. There are about 2 billion people on Earth who live in cities, which means about half of the human population lives in an urban environment. This number is rising which places great problems for a greater number of people, increased traffic, increased noise, increased energy consumption, increased water use, and land pollution, and waste. Thus, the issue of security, coupled with sustainability, is expected to be addressed in cities that use their brain. One of the most often used methodologies for creating a smart city is the Internet of Things (IoT). IoT connectivity is understood to be the very heart of the city of what makes a smart city. such as sensor networks, wearables, mobile apps, and smart grids that have been developed to harness the city's most innovative connectivity technology to provide services and better control its citizens The focus of this research is to clarify and showcase ways in which IoT technology can be used in infrastructure projects for enhancing both productivity and responsiveness.

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1. INTRODUCTION

IoT applications consist of a series of connected physical objects, buildings, sensors, and electrical devices over the Internet to transfer data between them. Moreover, anything connected to the Internet and gathers data and transfers data is part of the IoT in short [1,2]. IoT has numerous uses such as home automation, mobile pharmacy, first assistance, automotive, waste management, traffic management, surveillance systems [3]. As a strategy for implementing the IoT in the smart city attempts to transform the lives of its residents, it employs various implementations of the new IoT model to enhancements to meet new social needs [4]. A smart city relies on data and providing applications to a large amount based on big data collected by smart things everywhere [5]. Most of the technological advances in current wireless networks are IoT. In any part of the world, people can connect to the Internet through the IoT. Through the middle of the 1970s, there was an increasing reliance on integrated circuit (IC) technologies and greater use of radio transmission systems, as well as the development of the miniaturization of electronics [6]. As a result, many firms turned to microelectronics. Although the node prices are very low, these nodes provide the flexibility of both signal processing, and good signal transmission [7]. A smart city is made up of a significant number and many different types of IoT sensors, engines, and, most importantly, people. A smart city aims to improve daily operation. The Smart City concept refers to the use of Information Communication Technology (ICT) and the improvement of various urban services. In the Smart City, ICTs are used for Improving the consistency, performance, and interaction of urban services, reduce costs and resource consumption and improve communication between citizens and city stakeholders [8].

In reality, however, there are still problems that impede prefabricated structural efficiency. Firstly, according to our investigations, the scope of IT implementation is deficient in most prefabricated building projects. Incorrect, unreliable, incomplete, and bug-prone approaches continue to dominate traditional data processing and transmission. Such deficiencies prevent prompt reactions in the event of modifications or interruptions [9]. Second, information is distributed and divided between different parties such as prefabricated product suppliers (or manufacturers of prefabricated components), logistic enterprises, contractors, and consumers. This will hinder good teamwork and collaboration between the two, leading to improper stockpiling, lengthy lead times, late distribution, and erroneous prefabrications. It is already recognized as a significant productivity obstacle and could demonstrate a countervailing force against the advantages of manufactured buildings [10].

Cloud-Edge can share many security risks as an addition to the cloud, thus including the latest features. Increased security compliance points can be enabled on the one side by Cloud-Edge, enabling local data processing nearer to IoT sources [11]. On the other hand, modern facilities will face new challenges in terms of their physical vulnerability. Application installation of Cloud-Edge infrastructures also includes open (Edge or IoT) computers, which can easily be compromised, destroyed, or even stolen by malicious users [12].

The paper is organized as follows: Section 2 Internet of things, Section 3 Cloud Relations to IoT Application, Section 4 Smart city characteristics, Section 5 Smart city Opportunities and Applications, Section 6 Reviews some new researches about the smart city based IoT, Section 7 discussion. Finally, in Section 8, the paper is ended with a conclusion.

2. INTERNET OF THINGS

The Internet of Things has three layers: the vision layer, the network layer, and the device layer [13], as is seen in Fig. 1 The Internet of Things layer includes various devices capable of discovering and monitoring things, and communicating information over the Internet, as well as the information it's inventory and the way in which things are organized [14]. Radio Frequency Identification Devices (RFID), cameras, sensors, Global Positioning Systems (GPS) are some examples of perception layer devices [15-17]. The task of the network layer is to transition data from the collection capability to the applicable capability under the limits of equipment capacity, network constraints, and device limitations [18]. IoT networks use a combination of short-term network technology including zigbee and bluetooth to transmit information on the basis of parties' connectivity skills from vision systems to the next gates [19]. Internet systems such as wifi, 2G, 3G, 4G, and Power Line Connectivity (PLC) offer long-distance information depending on the use [20,21]. The latest level of deployment layer is where information is stored and obtained, as applications are intended to build clever homes, intelligent towns, electricity grids regulation, energy efficiency on the demand side, synchronized distributed energy storage and the integration of renewable energy generators [22]. The physical layer uses an IoT enhancement and a real-time data streaming catalog. The layer of services includes application creation tools. The platform layer provides a graphical user interface (GUI) [23]. The Fog Computing Gateway Layer is also used to link the sensor to cloud providers. This architecture allows data collection and provides instructions to connect the fog layer gates with quick, faster reacting time. Solutions have been identified using this architecture for different networking, latency and fragmentation problems [24].

IoT systems have historically discharged cloud providers for computing and permanent storage. If the number of Things increases, though, these services do not meet the need for IoT devices in real time [26]. These systems run in physical settings, need low latency response times over wide areas, and have specifications for high throughput data intake/bandwidths. Fog/Edge computing extends cloud system boundaries by decentralizing resource orchestration from datacenters to edge networks. They were organized as hierarchal networks of Fog nodes or cloudlets providing deployment of ingestion, processing, and management services, Fig. 2. shown different layers of (Cloud/Fog/IoT) [27].

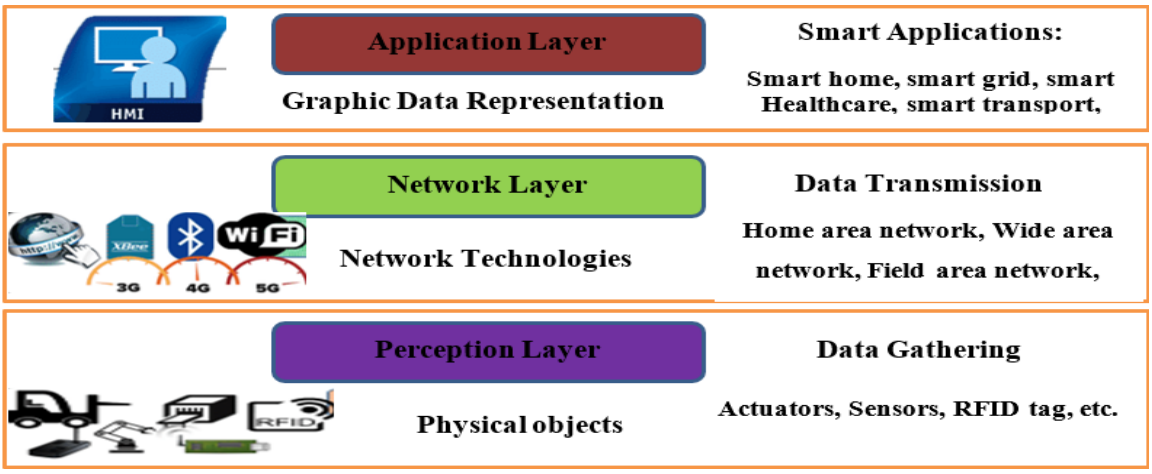

Fig. 1. IoT Layers [25]

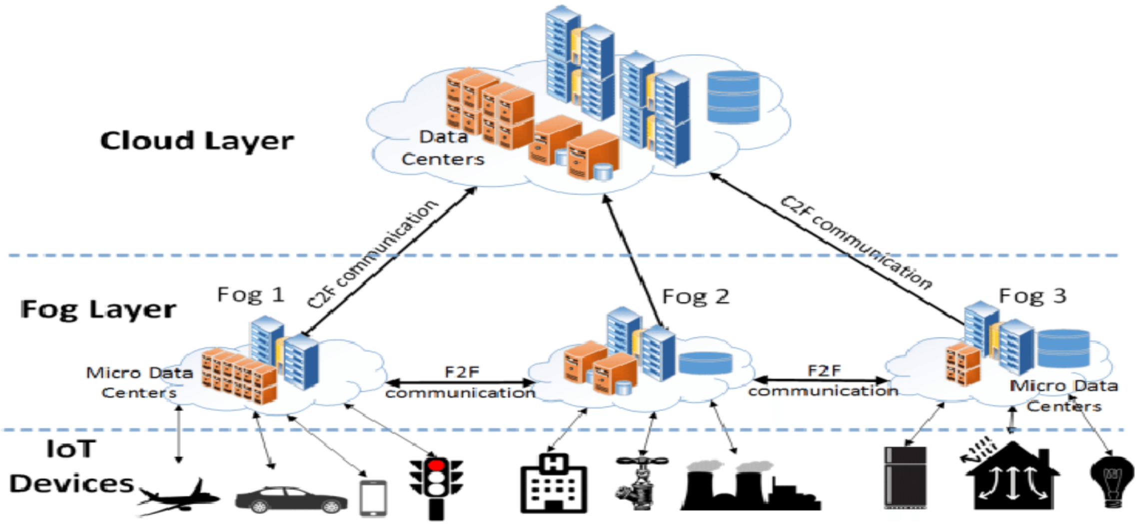

Fig. 2. Fog-Cloud Architecture [27]

Geographic locality allows lower response latencies and increase's ingestion bandwidth by horizontally scaling resources while reduce energy use and enable movement of resources relative to cloud providers [28]. These qualities make it possible for IoT applications to scale according to a reasonable scale and geographical spectrum and to have latencies in real time. The potential design of IoT applications Fog/Edge computer can be seen as [29].

3. CLOUD RELATIONS TO IOT APPLICATION

Several reports recently have suggested IoT Data Analysis Technologies and Applications leveraging different fog and cloud-related architectures. The cloud computing model offers guidance to meet these demands [30]. An attractive aspect is that cloud customers share configurable and flexible services at minimum costs, primarily through pay-per-use. The model is widely embraced in all walks of life, including computing, Storage, resources sharing, logistics service sharing, and sharing medical services [31]. Inaccessible person IoT expenditure, knowledge separation, inadequate co-operation, and various device needs should also be dealt with in the prefabricated building. To this end, CIMSS proposes the introduction of IoT technologies for prefabricated buildings including the distribution of IoT facilities and information management systems by pay peruse between all prefabricated building firms, as shown in Fig. 3 [10].

As demonstrated by Fig. 1 for hierarchical confidence management, IoT-Hit rust is designed on top of a 3-stage mobile cloud architecture. At the lowest tier of the ladder are IoT devices (labeled as d's) [32]. At the center, the level is cloudlets (labeled CLs). A public cloud with many clouds' "house" servers is on the highest level (labeled "CS") [33]. Because of load balance considerations, the user is allocated to a fixed cloud "home" account. After this assignment has been completed, a user cannot modify their home cloud service dynamically [34]. An IoT computer runs IoT-Hit rust by building VMs that operate on the local cloud and on its home cloud server to solve problems related to the platform/operating system [35].

All requests and reports from the user are sent to the VM of their local cloud, which then transfers them to the VM's home cloud server [36]. In Cloudlets, either IoT computers (e.g., pcs, server, laptop, etc.) with modest connectivity, calculation, and Storage capabilities may be "high weight" colloquialized with wifi hotspots or strong base stations with the mobile operator [37]. Communication between an IoT and a nearby computer The Cloud-Cloudlet-Device Architecture 3-tier information flow. Therefore, cloudlet is usually by formal wifi hotspots and the latter by mobile base stations. We take into account the former situation in this article as a whole. The server and cloud contact is through the Internet. Using IoT-Hit rust, a cloud will regularly assess all the IoT units' reliability in a cloud area and pick a cloud group of IoT units

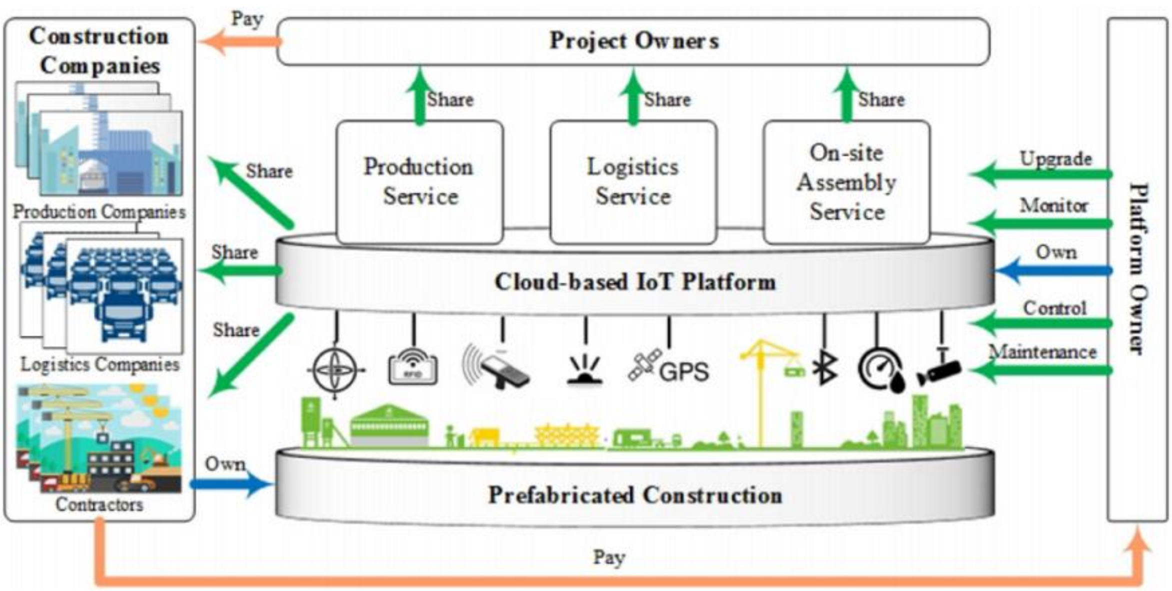

Fig. 3. Working principle of CIMSS [10]

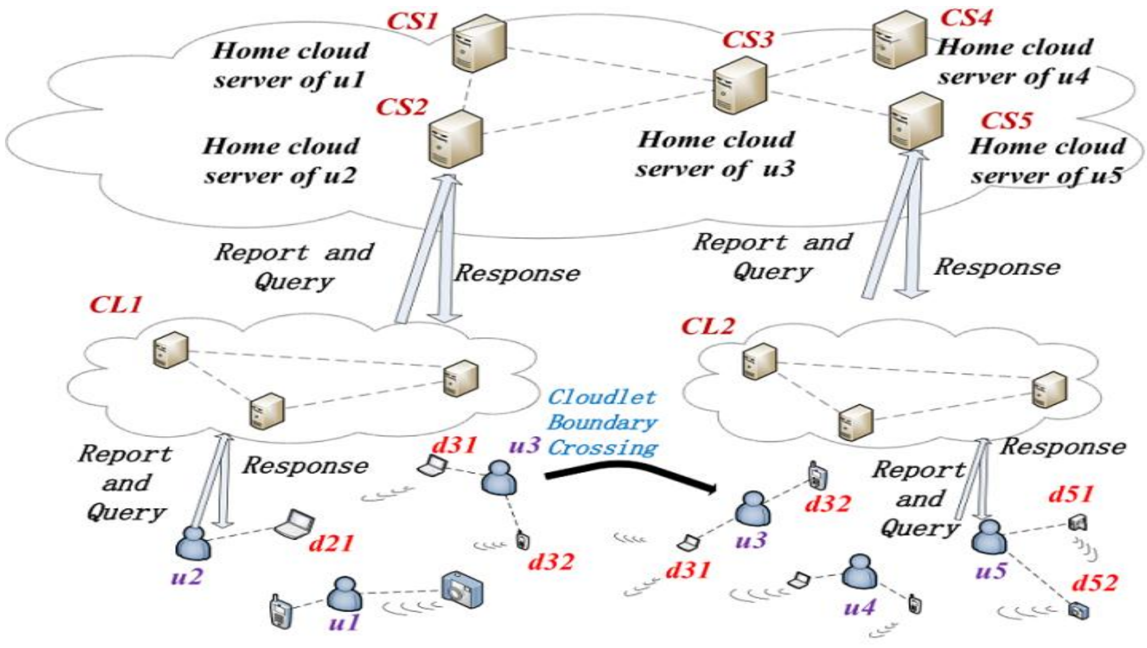

Fig. 4. Information flow in the 3-tier cloud-cloudlet-device architecture [39]

[38]. These IoT devices may have cloud storage rights in exchange for the surrogate services offered by these IoT devices [32]. These IoT devices are called "cloudlet devices," which we can use to control a regional cloudlet, knowing that cloudlet devices are hefty IoT devices only. Two cloudlets, the CL1 and the CL2, each with a weight of three IoT devices, are shown in Fig. 4 [39].

The technical developments in IoT and cloud computing have led to the developing of a new generation of applications using IoT and cloud computing technology, which offer many advantages for clever home management [40]. Kau et al. proposes a cloud-based technology to remotely access and monitor electrical devices on the Internet, with domestic electricity growth and efficiency. Use ZigBee energy metering modules to track home appliances' energy consumption and PLC-based solar energy gateway to monitor renewable energy production [41]. While recognizing these proposals, which effectively address the issue of enabling efficient interaction and transparency on heterogeneous devices/services of different vendors in IoT-based smart homes, a new layered cloud architectural model is being proposed [42].

4. SMART CITY CHARACTERISTICS

Increasing the standard and building more effective technical solutions within various urban networking services of the city life is a highlight of the Smart Cities philosophy[43]. Internet Of Things (IoT) is one of the best-known models for making a clever city and it is an IoT capability for creating and managing smart applications for intelligent communities. The design of IoT integrates sensors in ordinary objects and interconnects them across the internet to communicate and share information in order to deliver a number of services to urban residents [44]. IoT is a great variety of items communicating over a networking or the Internet. Internet of Things (IoT) These items combine electronics, sensors and software for controlling the way other parts of the item perform. Each object produces, captures and transfers data from its environment through sensors to other objects or the central channel. It is one of the biggest challenges in IoT today to keep this data produced and its transition and is one of the biggest issues for all companies using IoT technology [45].

The Internet of Things (IoT) and cloud computer technology are very different and play a major role in our lives [46]. Adopting and using them is expected to become increasingly popular, making them important components for the future Internet (FI). With the existence of IoT, the next Internet-related movement is almost here. IoT enables connections to share ideas, expertise and data between tons of devices that facilitate the quality of our everyday life [47]. Alternatively, Cloud Computing makes it possible to contribute computing services that enables dynamic data integration from a number of data sources upon request and adaptable network connectivity. Cloud Computing is also available. Cloud computing and IoT in FI cannot, however, be applied without a wealth of complications and challenges [48].

The Internet of Things (IoT) is a collection of objects such as sensors, actuators and processors that are interconnected to carry out a mission collaboratively within a given network. In recent years, IoT is one of the most popular inventions. It has rapidly evolved. His credibility stems from his importance and position in best-in-class use, from smartphones that open new horizons for control technology to new concepts on cloud computing services [49]. In IoT applications that allow connectivity between the network layer and the pervasive network layer, an intelligent gateway plays an important role. IoT gateways are methods that serve as a point of interaction for users and powerful data centres. IoT gateways bind and achieve multiple computing project activities with heterogeneous computers [50].

Smart City is used in manufacturing, education, governmental sectors to create intelligence without ignoring new technology in everyday life. The cities can be defined as competent if they have the following characteristics, as shown in Fig. 5 [51].

4.1 Mobility

Urban mobility needs to be identified and analyzed as a critical resource and utility for different companies and urban operations, not just by offering transport services to different consumers. The critical components of urban structures may be based on transport or mobility, such as an enclosed school structure concerning transport and mobility, citizens' isolation can lead to educational and social exclusion [52].

4.2 Economy

Recently, in the era of the digital revolution and emerging technology transforming today's needs of many jobs, intelligent communities will need to build potential workforce plans to drive manufacturing and the intelligent economy [53]. Technological advances can also further simplify government processes and provide companies with a streamlined experience. Ongoing private funding is essential for new industries to make the Smart City appealing and what it means for an intelligent economy. This is built on the concept of a Smart City that offers a creative spirit, especially valuable to businesses, making a Smart City a business city that offers new business opportunities [54].

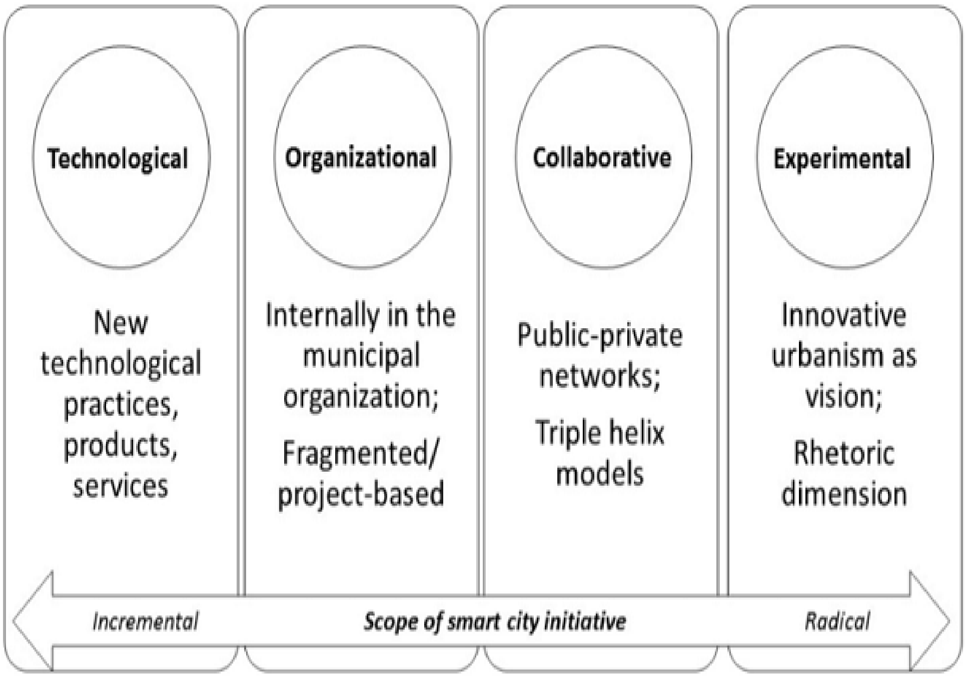

Fig. 5 Smart city initiatives as multifaceted urban innovation [51]

4.3 People

Most people now concentrate on intelligent educational styles that make job choices, openings, jobs, and lifetime learning easier to follow for all ages and people. As an increasingly significant factor in economic development, talent growth also plays an important role [55].

4.4 Living

Citizens create intelligent ways of living through technologies through the correlation of all aspects addressed. All are linked, so many activities are faster, simpler, and cheaper for wired appliances. Innovative development solutions tended to make people's lives more productive, sustainable, and effective in recent years. The work of intelligent buildings, for example, has become exciting, and Connecting Building Systems, a component and technical device part of new construction, aims at creating a pearl of collective wisdom and bringing in several features to increase efficiency, protection, and convenience of the inhabitants. As a series of building managers, traditional Automation for collecting, analyzing, surveillance, and managing data aligns with the IoT paradigm [56].

4.5 Environment

The city must work on environmental facilities: waterways, waterways, and green areas to improve its biodiversity. The smart city should also be a city that follows all principles of sustainability. It should also be focused on leveraging natural and green energy tools. Smart cities are transformed implicitly into healthy green cities. Smart City is also an environmentally sound, green, and sustainable city [57].

4.6 Governance

Many players are included in the collection of Smart City programs. Cities need to enhance the level of government in order to handle these schemes and programs properly. Traditional governance, in general, is "as systems of legislation, administrative regulations, court decisions, and practices restricting, prescribing, and enabling government activities in which that activity is widely described as the development and distribution of goods and services which receive support from the government. With the advent of ICTs, cities are trying to promote their governments, so all technology-based governance practices are innovative governance. It contains a range of technology, persons, laws, processes, services, social standards, and knowledge that sustain city governance. It strengthens IT and collaboration processes and utilizes creative strategies, technologies, and business models [56].

5. SMART CITY OPPORTUNITIES AND APPLICATIONS

In order to achieve resilience demanded by intelligent city components and to increase living standards, many decision makers envisage using a neighborhood model and big data technologies [58]. Intelligent cities use various technologies to make the wellness, infrastructure, power, learning and water supply more efficient for their inhabitants. This means lowering costs and the use of energy and making communications with our staff more efficient and innovative. Comprehensive analyzes of data are a comparably new technology that will extend smart urban infrastructure [59]. Data mining has led to the processing of large numbers, and can be used in a number of important ways, as a key element of everyday life is digitalisation. Effective exploitation and multiple data usage are important in many enterprises and utilities, including the smart urban realm [60].

If the Industrial Internet of Things (IIoT) grows exponentially, many sources generate a huge amount of data continuously [61]. Since the energy of the terminal devices is solely limited by self-organization and micro-organisms, it is unwise to store all the raw data locally on the IIoT equipment. Io T networks allow the aggregation and storing of outsourced data regardless of how resource-constrained the IoT is [62]. There will be a series of unknown protections for IoT and cloud integration issues for the next chapter of the observations. Cloud supply is highly effective, storage is becoming increasingly up-to-date and some groups are now changing their data from the Cloud computing supplier in-house documents. Cloud processing tools are challenged in extensive IoT implementations for workloads and records [63].

The widespread use of IoT in nearly all areas of our lives has made it possible, without any human involvement, to simplify everyday activities. This promising technology has enormous potential to facilitate life and to open up new markets for new technologies [64]. The diverse demands of the various applications on quality of service (QoS) remain a formidable issue, however, due to the diverse patterns of traffic, volatile network traffic and resource limitations of IoT devices. In this sense, the main subject of academic study was application-specific QoS provisioning mechanisms [65].

The design of the distributed energy grid (DES) is confused about the boundaries of clean energy, energy production and the expense of energy companies [66]. The on-demand role of the end-users in the intelligent energy management sense is important for the grid to use intermittent power sources. End-user involvement can affect device management and energy price fluctuations [67]. Consumers can help grid operators by providing auxiliary resources using demand-side-resource to improve device stability, robust planning, restriction management and scheduling. The streamlined approach to energy resource management integrally improves demand reactions to renewable sources, regulates the demand curve as required by the system, with load flexibility. Choosing a specific platform allows you to adjust/control the charging profile [68].

5.1 Smart Transportation

Smart mobility comprises modern technologies and services to enhance and innovate urban transport experience, fix traffic problems such as traffic congestion, and reduce injuries. The evolution of urban transport sizes and trends has caused issues that affect urban well-being [69]. Most analysis in this field shows that the use of private automobiles is still dominated by urban transport. Nevertheless, car cities are the alternative that satisfies citizens' needs for confidentiality, independence, equality, flexibility, etc [70]. On the other hand, this means of transportation has a significant impact on the atmosphere of a city: large-scale energy use of vehicles causing noise and air pollution, which leads to climate change and damages the atmosphere [56].

5.2 Smart Energy System

Digital networks for clean and green energies are some of the most attractive prospects for smart cities. For example, smart solar or wind power plants may become an essential part of the smart city's ecosystem [24].

5.3 Smart Healthcare

Intelligent healthcare is a combination of technologies aimed at maximizing survival and the population's quality of life. Smart healthcare networks use mobile, IoT, and computer technology to ensure accurate diagnostics and transform healthcare [71].

5.4 Smart Parking System

Parking concerns are some of the world's problems that prominent city residents often face, but they are no less daunting. Smart urban technologies help drivers immediately find open parking spaces and reduce the time and confusion commonly associated with a parking lot in a busy metropolis. Companies such as T-Mobile and VW have also developed these applications in urban environments worldwide [72].

6. RELATED WORKS

Numerous research on smart cities and IoT automation design systems were performed a few years ago. The contributions of researchers in this area and some insights are given below:

Whai-En Chen et al. [73] proposed a smart system using IoT technology to detect the status of the waste bins. Waste goods and food have become a big problem in cities since the bins are not managed well and poorly smelt in public places. They used IoT devices (micro control unit MCU), a color LED, a gas sensor, a 3-six compass, an infrared sensor, an ultrasonic sensor within the suggested system. They also utilized 802.11 wireless LAN to transfer the sensing data to the server and the MYSQL database. Through these devices and data, the warning subsystem monitors the state (waste and smell levels) and informs the manager if the value of the waste crosses the specified.

M. Srinivas et al. [74] introduced a smart bin garbage-collection system using the Arduino-Uno board, Ultrasonic sensor, ESP8266 wifi, Jumper wires, and Public cloud connectivity. The set of sensors attached to smart bins of smart cities. These sensors submit the status of the bins to the cloud. Then the cloud services make some analytics, and it concerned the city authorities. In this way, the system will alert the innovative city authorities to specify where and when waste should be collected.

S. Meiling et al. [75] MONICA project launched. The EU project MONICA and its large-scale IoT implementation network architecture will be presented. The MONICA project forms part of the program of IoT European Pilot Projects. For example, it seeks to demonstrate a large-scale IoT ecosystem built on a number of current and new Smarter Living IoT technologies. In Hamburg, a MONICA pilot spot, you can also get a rundown of the smart city events. Their work is based on the IoT RIOT operating system currently in commercial IoT environments. This experimental configuration shows how the IoT limit network can be connected to the mainstream Internet with a CoAP proxy for the HTTP so that the integrated IoT sensor can provide direct end-to-end data flow to the Hamburg Urban Plateform.

S. D. Nagowah et al. [76] proposed a smart parking ontology terminology in a university campus considering modern paradigms based on IoT technology. The ontology reuses existing ontologies like Wise-IoT, SSN, and FOAF. Ontologies provide a common terminology and meaningful knowledge on the interaction between (things, data, information) and IoT devices. So, the platforms and applications enable the drivers to park their vehicles.

P. K. Sharma et al. [77] Used Machine Learning (ML) model to predict the availability of parking in a smart city IoT environment. This theoretical approach discriminated against each other on weekdays. Following the application of the CJSD (Chisinau-Jensen-Shannon Divergence) for the SVM classification of weekdays with high classification precision, outperformeed RBF kernels and a high-layer deep neural network model, the data suggests. SVM classification of weekdays based on car-parking occupancy. In addition, a number of clustering algorithms were studied and showed that the best results for each cluster of weekdays are not the Gaussian mixture distribution methods.

A. Somani et al. [78] presented that many parking areas connected to the cloud will be implemented with Smart Parking devices which update real-time sensors from UHF built for accessible user parking areas. The device's purpose is to make it more realistic and efficient to remove simple issues, such as traffic congestion. The proposed method is an "originality" since the concept of innovative city strategies has not yet been applied in crowded neighborhoods or areas where parking facilities are challenging. There are only a few criteria available. The proposed system is an "originality." A user-friendly app is introduced for user activities, from locating a verified car park to booking parking. For the companies, the circuits used in both processes are conveniently designed and cost-effective.

Cheng et al. [79] developed fog computing and the need for IoT services programming. Undeniably, in terms of transparency and interoperability, most of the current fog computing systems are somewhat restricted. Thus, in this article, a standard-oriented methodology was proposed to develop and introduce a new fog computing-based system, namely Fog Flow, based on Data-flow (de facto standard) and NGSI (official standard) specifications. This architecture enables IoT application developers to program scalable IoT services over the cloud and edges conveniently.

Nagamani et al. [80] suggested a new response smart system for streetlight systems and avoided significant injuries. It is made up of wireless technologies that a base server can manage by merely transmitting the data and working according to the weather. The primary aim of the study is to eliminate energy waste and save people's lives from injuries.

Kasat et al. [81] introduced a system that uses some sensor modules and Node-MCU as a chip system to track hazardous sewage gases and slurry and lid levels constantly. The proposed system is an IoT-based system with an on-site buzzer and warning alarm facility. The municipal authority will track the real-time data from the connected sensors on an ongoing basis and take action if appropriate. The machine is cost-effective and does not use bulky or extra circuits at all.

Kumar et al. [82] introduced a product to make home gardening very simple and comfortable. In this system, various sensors have been used to read the soil and environmental conditions. Soil moisture sensor (YL-69), temperature and humidity sensor (DHT-11) are used. At that time of the year, the customer is recommended the best crops to sow for his/her region, irrigation is made hassle-free, and an e-retail site has been placed for group sharing, ensuring that the organic yield is never wasted.

H. Singh et al. [83] proposed a home automation system, Automation at home is enhanced with a wireless node. In a clever household, numerous electrical instruments are built into the house and streamlined with little to no service. The smart home tracks and advises the systems to operate according to the consumer's needs. It not only automates daily home appliances but often nidificates the user periodically about the price of the electric bill and automatically reserves the gas cylinder when the amount of gas is less than thru. Taking the above features into consideration, they built and tested the prototype. Through using the IoT technology, they managed to build a Smart House. The experiment shows that they could make the intelligent home safer, greener future cost-effective, scalable, and energy-efficient.

J. Parmar et al. [84] suggested a method for compiling climate parameters for weather intelligence. The node MCU system also integrates it with various sensors such as temperature, humidity, noise, CO, and rain. This benefits the rising population and even users' lives. The project's benefit is that it is cost-effective and energy-saving. The project scope is a particular region that can be mounted everywhere to track the environment. Since the cost is minimal, device improvements can be made simply by adding additional parts. By tracking the city's temperature regularly, the device allows users to choose the right place for living and safe environments. It would also raise people's understanding of good health.

K. M. Mehata et al. [85] proposed a safety and health monitoring system. Create intelligent wearable gadgets, such as bands and casks, using different sensors to help track employees' health and safety. Devices developed using IoT help diagnose employees' fall and give urgent help by submitting an SMS alert. Also, critical staff such as cardiac rhythms and temperatures are tracked and warned of abnormal conditions. The initiative seeks to provide staff with a clean and stable work environment, reducing the number of deaths at hospitals. The built prototype was tested under different conditions and demonstrated good performance accuracy.

G. Carrion et al. [86] presented an embedded system Using the IoT and the collection of sensors and actuators to allow temperature variables and urban garden irrigation to be tracked in the Universidad Polita Unica Salesiana parking facilities. ATMEL micro-controlled sensor tests soil humidity and temperature parameters, carbon levels, luminosity, and seed presence, making decisions about irrigation based on crop requirements. ATMEL's sensor is processed with the microcontroller. The remote server collects this information via the wifi protocol, which stores it in the cloud and sends it to the client computer or mobile device, which can access this information in real-time from any spot where it has Internet access.

7. SURVEY DISCUSSION AND ANALYSIS

IoT's vision is to create an intelligent world. It uses smart objects, data, and technologies to link the natural environment to the virtual world to smarten all urban industries. It is a transition that will transform the world by making more networking possible. In the ICTs portion, the IoT pattern is the focus that futurists and researchers considered to be the primary driver of this transaction. Infrastructure-based involves smartphones, wireless sensors, cameras, and other instruments for data processing and dissemination using networking technology to be processed, collected, and distributed via web providers. As a result, several IoT implementation scenarios have been planned and developed to make the Smart City idea a reality. In summary, the studies presented earlier in section V showed that they had devised techniques and methods to design innovative city applications to improve and increase the intelligent city systems functions to some extent, using various processing methods and technologies as summarized in Table 1.

The important outcomes of the critical studies can be summerzed by the following points:

- Using IoT features for monitoring different smart city appliocations including (Waste management, Home Automation, Monitoring and irrigation of an urban garden, Weather intelligence, implement a new fog computing, Smart parking, Smart Street Light Management, Smart Reservation, and Safety and health) systems.
- Different Network Communications are depended, such as (802.11 wireless LAN, LoRa, IEEE 802.15.4, 6LoWPAN, ESP8266 WIFI, ESP32 WIFI, and GSM/GPRS).

Table.1 Critical analysis of existing studies

Ref	Smart City Services	Micro controllers	Tool	Sensors	Network Communication	Significant Results
[73]	Waste management	Arduino Uno	Arduino (IDE)	Infrared, Ultrasonic, Gass, 3-six compass	802.11 wireless LAN, LoRa	Maintenance of a safe and negative atmosphere that damages public health.
[75]	Monitoring system	-----	------	Set of sensors	IEEE 802.15.4 and 6LoWPAN	Using a CoAP-to-HTTP proxy, the data flow from the IoT sensor to the Hamburg urban platform can be transparent and integrated.
[82]	Smart Kitchen Garden	WeMos D1 mini	Arduino (IDE)	DHT-11, YL-69	ESP8266 wifi	Making home gardens simple and convenient.
[83]	Home Automation System	Arduino Uno,nodeMCU ESP8266	Arduino (IDE)	LDR sensor, IR sensor, temperature sensor	ESP8266 Wifi	Track domestic appliances like lighting, fan, door boxes, energy consumption and level of the gas cylinder.
[84]	Weather intelligence	NodeMCU Wi-Fi Arduino	C/C++, PHP	DHT11 sensor, MQ9 gas sensor, FC37 rain sensor	ESP8266 Wifi	Choose and conserve healthy health by daily temperature control for the best surroundings environment.
[86]	Monitoring and irrigation of an urban garden	Arduino Uno	Arduino (IDE), PHP	DHT22, MQ135, BH1750, SHT10, YL 69, GP2YA21	Wifi	Monitoring temperature factors and agriculture in the urban greenhouse and minimizing energy consumption
[79]	Propose a standard-based approach to design and implement a new fog computing-based framework for a smart city	---	----	----	Wifi	Introduce a new fog computing-based system, namely Fog Flow, based on Data-flow (de facto standard) and NGSI (official standard) specifications
[76]	Smart parking	----	----	Sensor Location,	Wifi	Finding a parking area for people's cars

Ref	Smart City Services	Micro controllers	Tool	Sensors	Network Communication	Significant Results
				Sensor Type, and Sensor Observation Value		was a significant problem whether in a town or on campus.
[74]	Smart bin system	Arduino Atmega328	Arduino (IDE)	Ultrasonic sensor	ESP8266 WIFI	Maintaining a safe environment and removing unpleasant smells that damage public health
[77]	Smart parking	----	----	Location Sensor	Wifi	Develop a model to predict the availability of parking in the smart cities IoT environment.
[80]	Smart Street Light Management System	Arduino Uno R3	Arduino (IDE)	LDR, IR	ESP8266 WIFI	Enabling substantial energy efficiency and protecting people's lives from incidents
[81]	Unused Well and Garbage Alerting System for Human Safety	NodeMCU	Arduino (IDE)	MQ-4, MQ-7, MQ-135, Ultrasonic	ESP32 WIFI	for protecting each person and the person cleaning. The presence of different harmful gases will be monitored and viewed by individuals via the IoT App.
[78]	Smart Reservation Based Parking System	NodeMCU ESP8266	Arduino (IDE)	HC-SR04 ultrasonic	ESP8266 wifi	For more realistic and purposeful solutions to provide ease and eradicate common issues such as traffic congestion.
[85]	Safety and health monitoring	Arduino Uno	Arduino (IDE)	LM35, HB, IR, accelerometer	GSM/GPRS, wifi	To provide a healthier and safer work environment for workers, reducing the number of deaths occurring in construction sites.

8. CONCLUSION

The objective of this paper is to examine and to some extent the literature supporting the role of IoT in smart cities. According to this report, the number of articles in this area has increased substantially in the last few years. These studies have shown that IoT has been proven to also to be the biggest enabler and driver of smart city initiatives. It is a key step in the ongoing transformation of traditional public facilities into intelligent services and the creation of new ones. Big data and cloud computing play a central roles in the advancement of these new projects, because of their capacity to amplify existing work by offering an ever-expanding amount of information and computational power. However, also in cities where it has already been shown that smart city systems are excellent, the deployment of IoT in those services is in early stages.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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