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Review Article

Dimensions of Internet of Things: Technological Taxonomy Architecture Applications and Open Challenges—A Systematic Review

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We are traversing the growing emerging technology paradigms in today's advanced technological world. In this present era, the Internet of Things (IoT) is extensively used in all sectors. IoT is the ecosystem of smart devices which contains sensors, smart objects, networking, and processing units. These integrated devices provide better services to the end user. IoT is impacting our environment and is becoming one of the most popular technologies. The leading use of IoT in human life is to track activities anywhere at any time. The utmost utilities achieved by IoT applications are decision-making and monitoring for efficient and effective management. In this paper, an extensive literature review on IoT has been done using the systematic literature review (SLR) technique. The main focus areas include commercial, environmental, healthcare, industrial, and smart cities. The issues related to the IoT are also discussed in detail. The purpose of this review is to identify the major areas of applications, different popular architectures, and their challenges. The various IoT applications are compared in accordance with technical features such as quality of service and environmental evaluation. This study can be utilized by the researchers to understand the concept of IoT and provides a roadmap to develop strategies for their future research work.

1. Introduction

Kevin Ashton suggested the term IoT in the year 1999, but before that actual idea of connecting devices had been used since the later 1970s. At that time, this idea was called "embedded Internet or pervasive computing" [1]. IoT is a combination of interrelated computing devices that can transfer data over a network without human intervention. In the past few years, the Internet of things (IoT) has been sniggling in all areas of human life, such as hospitals, agriculture, the environment, industries, smart homes, and smart cities [2–7]. IoT improves daily life and eases the data production/consumption processes [8]. Smart devices are being used in the various applications and instruments operated in the IoT environment [9]. Increasing human desires give rise to innovative applications for automating, managing, and monitoring activities [10–12].

Additionally, IoT applications enabled with cloud computing promote proper composite services by merging current service applications [13, 14]. In different areas and activities, these smart devices help users to complete their day-to-day activities [15, 16]. Moreover, many applications enabled with IoT help the user to select the best prospects from environmental cloud resources in managing, decision-making, and monitoring [17]. The motivation behind all the applications of different domains common shared objective is to enhance the quality of life by providing intelligent and smart services [18, 19]. Achieving quality of service (QoS) metrics is the core apprehension of using applications based on IoT. Cost, reliability, security, availability, energy consumption, and service time are some of the QoS metrics which should be properly addressed by the smart applications and services based on IoT to fulfill the requirements of the users [20–23].

The use of the Internet within the last 20 years brought numerous benefits to all individuals as well as organizations. In real time, perhaps the foremost important benefit is the capability to consume and yield services and data. Currently, the IoT is likely to bring equivalent benefits to daily things, providing us a chance to change the surrounding environment and to expand our perception as well as our ability. IoT brings new prospects further than automation by merging it with machine learning algorithms [24], further making it easy for managers, policymakers, and owners for decisions planning.

Conventional areas of embedded systems, control systems, wireless sensor networks, and all others contribute to enabling the IoT. In the consumer industry, IoT technology is mostly associated with products that help common ecosystems and can be controlled by devices linked to that, such as smart speakers, smartphones, thermostats, lighting fixtures, home security systems, and other home appliances. There are several serious concerns, particularly privacy and security, and thus, researchers are working to address these concerns. Using “asymmetry” and “symmetry” properties, IoT-based wide-ranging smart systems have become most efficacious and efficient. Many researchers, industry people, and academicians are presently working on IoT technologies to develop advanced systems. There are many studies on IoT reviews, but currently, there is no study available that focuses on IoT applications in a systematic manner.

Internet of Things is becoming more popular than any other existing technology, such as the SCADA system. Basically, SCADA allows humans to interact remotely with a process, whereas IoT is generally used as a machine-to-machine communication tool.

The primary goal of this study is to conduct a survey on various IoT applications to better understand the variety of techniques that have recently been offered in IoT applications. Commercial, healthcare, smart city, environmental monitoring, industrial, and general aspects are among the initial applications of IoT which have been targeted in this article. SLR is used to overview the opportunities of IoT applications.

The following are the important outcomes of this study:

(i) Creating a technological taxonomy to categorize different IoT applications

(ii) Discuss the various popular IoT architectures

(iii) Provides the futuristic scope to identify the applications, problems, and their solutions

This paper is arranged according to systematic literature review methods and provides an overview of IoT opportunities, applications, and challenges. This paper is divided into the following sections: Section 2 represents the related work in the field of IoT. Section3 provides the sectional techniques for research articles and the SLR method. Section 4 presents the application areas of IoT. Section 5 describes the challenges in IoT, Section 6 provides the answers to the SLR questions, and Section 7 concludes the paper.

2. Literature Review

This section provides an overview of associated work in IoT applications. Mukherjee et al. [25] proposed an Internet of Health Things (IoHT) focused on fog computing for both outdoor and indoor scenarios. The weighted majority game theory has been applied in outdoor and indoor regions to pick a fog system. This reduces the energy consumption requirements, average waiting time, and average jitter relative to the current cloud-only healthcare network. The fog computing-based system has reduced the energy consumption, average delay, and average jitter by approximately by 15%, 20%, and 15%, respectively, than the existing cloud-only healthcare system.

Gushev [26] introduced the dew computing architecture for cyber-physical systems, elaborated on the features functionalities, and compared it to other related architectures. Figure 1 shows the architecture of dew computing and concludes that the impact of dew computing architecture is high. The independence and collaboration feature and adding autonomy make them unique from the conventional edge computing system.

Agyemang et al. [27] proposed a lightweight real-time algorithm that enables the identification of rogue access points for embedded IoT devices. The advantage of this technique is that when an attacker clones the channel and SSID of a legitimate AP, it will detect rogue access points and deauthenticate, and clients will be unable to connect to either the rogue or legitimate access point. Kounoudes and Kapitsaki [28] discussed the state-of-the-art insight into how these features are treated. The authors introduced four user privacy challenges in GDPR: (a) discrimination, profiling, and inference; (b) con-text-sensitive sharing of identity and control; (c) uncertainty and consent; and (d) trust, transparency, and honesty.

Karanja et al. [29] suggested an approach for the study and classification of IoT malware using Haralick’s image

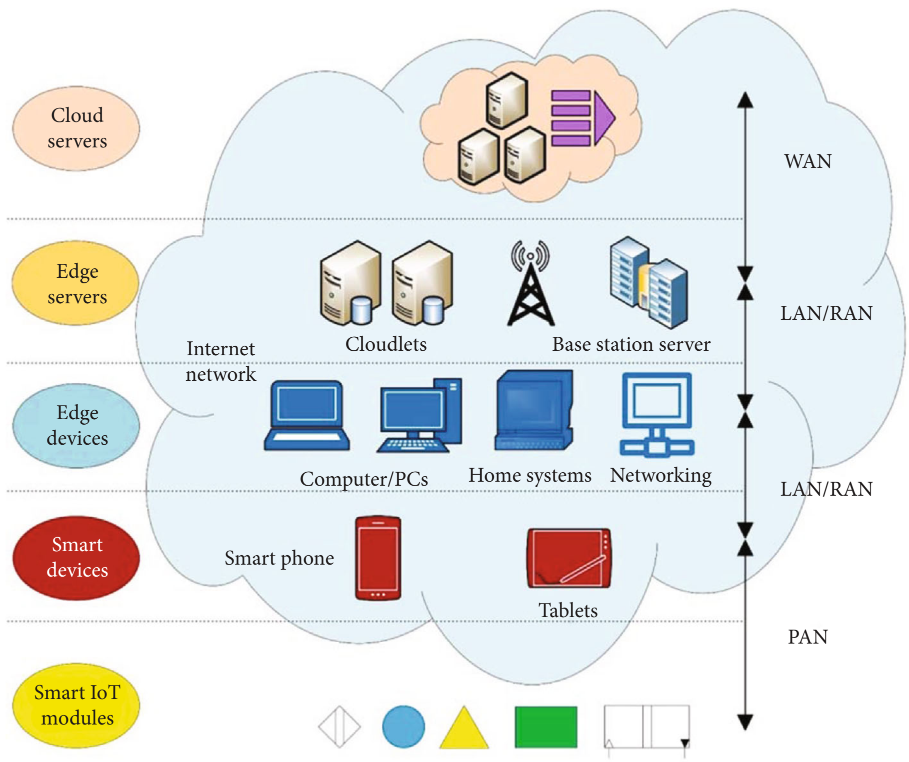

Figure 1: The architecture of dew computing [26].

texture features and machine learning classifiers, namely, K-nearest neighbor (KNN), Naïve Bayes (NB), and Random Forest (RF). On each of the extracted images, the gray level cooccurrence matrix (GLCM) has been computed. Uddin et al. [30] introduced a blockchain leveraged decentralized e-Health architecture for deploying multiple instances of software patient agent at three layers like sensing, near processing, and FAR processing layer on 5G architecture. Verma et al. [31] proposed an IoT application protocol congestion control algorithm for swiftly adapting the transmission rate to network conditions. It has been found that a combination of TCP variants based on loss and delay can give a better solution. This method is well suited for the MQTT protocol for IoT applications that works for lightweight smart home appliances, smart city monitoring systems, healthcare providers, and sensors that communicate to the server via a satellite connection.

Shukla et al. [32] implemented a scalable outlier detector that uses hierarchical clustering in combination with the neural network. Hierarchical clustering gives the outlier detector scalability by finding associated sensors. For different attack strengths, the simulation results have more than 90% accuracy, and the model parameter can be tuned according to the application requirement. Alli and Alam [33] surveyed the fog-edge computing for solutions proposed in studies involving IoT-fog-cloud ecosystems and predicted future growth patterns and raised open issues of the fog cloud of things and concluded that fogging offers a forum for providing services between resource-constrained and latency-sensitive connected devices. Jiao et al. [34] analyzed the resource scheduling to optimize the time-averaged network performance for uplink IoT systems based on OFDMA. An optimization problem has been solved by using the Lyapunov optimization theory and the Lagrangian technique of dual decomposition. An algorithm, known as TORS, has been developed that can arbitrarily move the device throughput close to the optimum without any prior knowledge of the CSI. Yin et al. [35] suggested a model for the two-vehicle partnership scenario, considering the circumstance of the evolving emergence. A bidding system enables vehicles to contribute their services, and the activities are arranged accordingly for those vehicles. A new time-window-based method was designed to manage the tasks between vehicles and enable the vehicles to participate and then establish a blockchain system to protect the exchange of information through the smart contract.

Chen et al. [36] focused on the request scheduling problem. An online algorithm, RSRP, has been used to reduce the expense of the program when the queuing delay was associated. RSRP can get a close-to-optimal system cost and make an arbitrary trade-off between system cost and the backlog of queues. Results from the simulation show that RSRP can effectively reduce the expense of the program and keep the queue backlog down. Rizvi et al. [37] evaluated the attack surface for networks using IoT devices to estimate the risks of new IoT devices being deployed while offering a way of defining potential solutions. The IoT architecture has several zones, as shown in Figure 2.

Fu et al. [38] maximized the energy efficiency of the system through cooperative computing in IoT networks based on blockchain and divided the program into data collection, database processing, processing for network optimization,

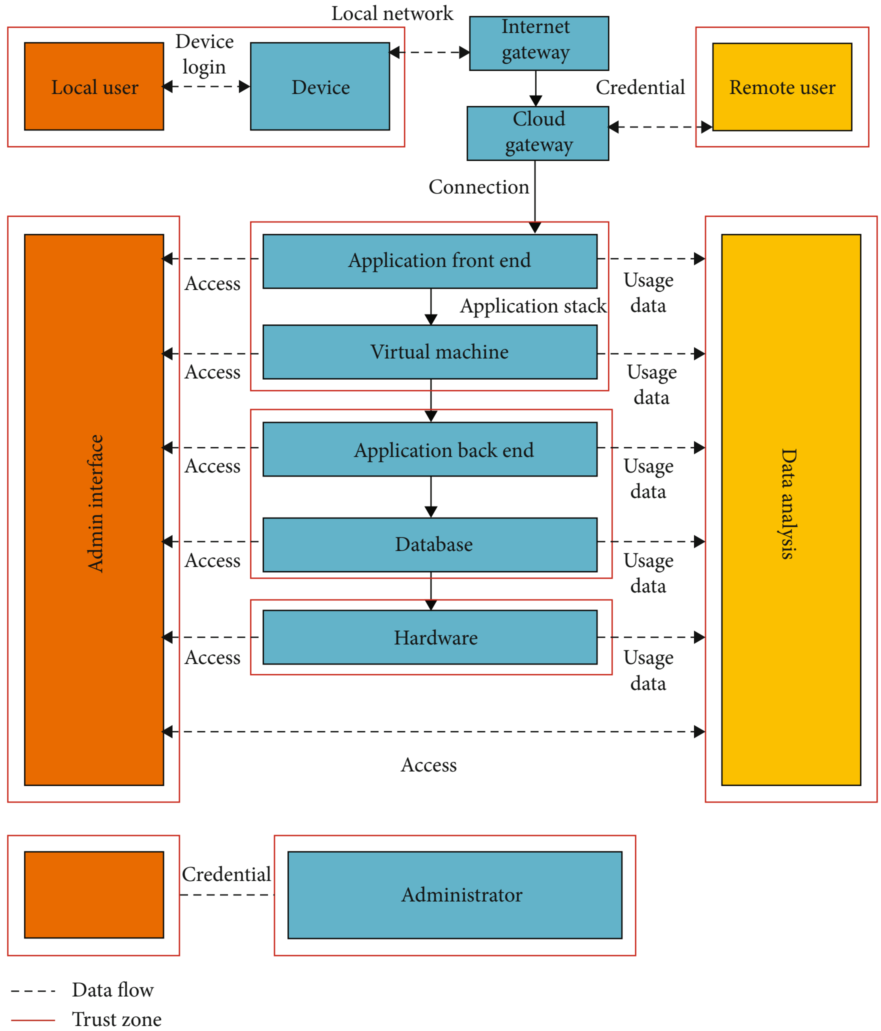

FIGURE 2: Network divided into zones based on trust [37].

and data transmission parts based on the optimization model considering power consumption in each segment using geometric programming method to maximize system energy efficiency. Chen et al. [39] proposed a quality-driven, auction-based incentive system based on a blockchain consortium that guarantees trust in both on-chain and off-chain data. A safe problem with data sharing for an IoV allowed by blockchain to optimize social welfare. The tamper-resistant consortium blockchain was implemented to tackle the on-chain data protection issue. The proposed algorithm performed better in both social welfare and computation time.

Duan et al. [40] suggested a JointRec system for the deep learning of mobile app video recommendations and introduced a federal recommendation strategy to cooperatively improve the weight of training for each distributed model of cloud trains based on local data. The model was validated on the real-world dataset, and the experimental results showed the effectiveness of the approach. Asheralieva and Niyato [41] introduced an unregulated hierarchy RL and profound educational background for a stochastic Stackelberg game with incomplete knowledge from many participants. This game formed the interactions between the IoT system leaders and partners with the help of BaaS-MEC and developed the hierarchical RL algorithm based on the MDP and POMDP models of the BSs and peers' decisions.

Chen et al. [42] introduced a time-conscious SIoT object model by bringing together the temporal effect of contact with user objects and the social resemblance of smart objects. The proposed model exploits usage events of the user object to uncover the user's preference over time with a latent probabilistic model. The experimental results over the real SIoT test bed show that the proposed method performs better than the existing one. Li et al. [43] studied the satellite-IoT system age-optimal redundancy problem. The optimum redundancy allocation issues were characterized by a minimum of the average age under a given error probability. The result shows that, at the explicit threshold of the propagation delay below, the IR-HARQ scheme is beneficial.

Liao et al. [44] proposed a multiuser authentication framework for PHY coindividuals to simultaneously identify high-end devices at low costs by integrating deep neural networks with DNN-based authentication methods and checking the efficiency of authentication of PHY in the two typical

IoT scenarios, OATS, and automotive factories. Pyoung and Baek [45] developed the LiTiChain blockchain with a finite lifetime, scalable, lightweight architecture. LiTiChain can easily delete obsolete transactions and blocks. Two graphs are incorporated into the LiTiChain structure: a tree that represents the expiry order and a linear graph that shows the order in which blocks are formed and concludes that construction not only maintains the chain continuity of block deletions but also helps preserve the block height of the shortened chain.

Lohachab et al. [46] discussed IoT's layered architecture along with the associated challenges and countermeasures. The IoT layered architecture with associated challenges, existing countermeasures, and the concept of quantum cryptography is shown in Figure 3.

Perez et al. [47] suggested a compact EDHOC in which security parameter negotiation was derived from the core protocol. It does a comprehensive evaluation using IoT hardware and simulation tools as well as providing end-to-end security properties. The tests showed that EDHOC-based recommendations were an accessible and reliable solution for the setup of an IoT-restricted security association. Qin et al. [48] implemented a revolutionary Green IoT Gateway (GIG) to reduce gateway energy usage while maintaining a cross-interface partnership to ensure a clear system delay requirement. While using coexisting ZigBee powerful radios, GIG programs the wake-up actions of powerful Wi-Fi radios for energy-efficient and time-bound D2G communications. The findings show that GIG's energy usage is 38.5% and 12.7% lower than that of the most state-of-the-art Wi-Fi communication system.

Li et al. [49] analyzed the swarm decision table in contrast with the conventional decision-making tree by introducing a new incremental learning model. A simulation was tested with an empirical dataset of energy consumption representing a typical IoT-linked BEDP scenario, and the SDT showed superior accuracy and time, and the results demonstrate it as the suited machine learner in the fog computing environment. Biswas et al. [50] presented a lightweight proof of block and trade (PoBT) IoT blockchain consensus algorithm and its integration structure. This approach allowed both trading and blocks with reduced calculation time to be validated. A system that reduces the memory demands of IoT nodes, security aspects review and assessment, calculation time, memory, and bandwidth requirements indicated substantial improvements in the overall device performance.

Alrawahi et al. [51] proposed a trading strategy for CoT resources consisting of a multiattribute classification model for trade priorities and business architecture. The CoT application development and hardware development require CoT resources to be considered commodities. Experimental evaluation validates the device's performance. An assessment was made of optimum resource prices, supplier lock-in, resource utilization, and provider benefit.

Lei et al. [52] introduced a group chain decentralized distributed blockchain with a 2-chain fog network framework for IoT services and concluded that the leader group's employability decreases consensus, including transactions and approval time, and leaders of a leading group are dynamically and publicly elected through a transparent PoW. Wang et al. [53] suggested a new method of learning to solve CAS. Many heterogeneous PER data were used in contrast to traditional CAS risk values to produce a strong predictive clinical risk model that depends on a small risk factor.

Diro et al. [54] proposed an authenticated encryption scheme for a resource-restricted IoT setting based on the publishing subscribe protocol. The system used a fog node as an intermediate broker, to collect real-time data on the workforce, devices, and parts associated with the task by adopting RFID and 2D data matrix code for identifying unexpected events.

Hu et al. [55] designed an IoT-based monitoring system. The collective management of the task's series, worker assignment, logistics preparation, and management take place when disruptions occur. The experimental findings had demonstrated a reduction in component and tool distribution defects, quality problems, and halt time to improve the efficiency and effective assembly of the turbine.

Cetinkaya et al. [56] introduced an IoMIMO that envisions an autonomous architecture that adopts single and double hop energy transitions as well as data transitions so that energy sharing and data traffic on networks can be efficient. Hybrid access points (HAPs) are conducted in single hops, whereas unmanaged aerial vehicles (UAVs) utilize double-hop relays. The HAPs handle energy and data with multiple-inputs multiple-outputs (MIMOs) as well as manage transfers network components.

Wu et al. [57] studied the wireless resource planning schedules of the MEC in IIoT by jointly optimizing wireless transmission, data storage, disposal, and offloading. The total device usefulness consisting of outputs, resources, and data age was maximized. A new online algorithm was developed with the Lyapunov optimization technique as an asymptotic optimization for the control of the difficult query.

Yuan et al. [58] provided a low complexity algorithm that needs no prior knowledge. Simulation results verified the effective detection of user activity and an estimate of CSIs between users and access points (APs) by the algorithm. A two-stage dynamic clustering for synchronized multipoint transmission using broad-scale fading (LSF) information to fulfill the requirements of heavy-cargo users for the throughput after UAD and CE had been used.

Wan et al. [59] developed an IoT authentication node model to increase Internet-to-roaming device security authentication. The authentication protocol uses the remote server for authentication on the roaming system in the local and remote areas, which raises the complexity of malicious nodes targeting or infecting multiple network areas. The security analysis indicated that the protocol protects from multiple network attacks and the protocol has a lower energy burden and authentication delay.

Souri et al. [60] implemented behavioral modeling of a multilayer perceptron (MLP) and particle swarm optimization (PSO) algorithm for a hybrid machine learning-based error prediction model. The developed behavioral models

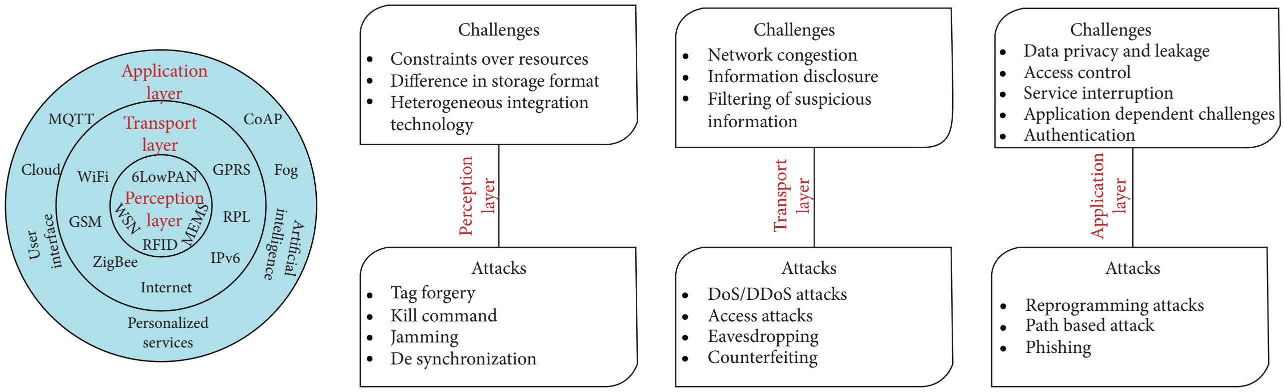

FIGURE 3: The layered architecture of IoT along with its possible challenges and attack [46].

were mapped into the LATS to evaluate behavioral models, and the Process Analysis Toolkit (PAT) model examiner was used. Qureshi et al. [61] suggested the SACBR protocol to allow the Cluster Heads (CH) to interact with other CHs. Every node of vehicles starts a self-evaluation approach based on more suitable routing metrics and selects the CH for each cluster and then collects data from the member nodes and transmits the data to other CHs. The CH manages its data transmission mechanism and its member nodes. Compared with the aggregation method, every node exchanges its data with the one-hop neighbor. Compared to the latest protocols, the experimental results showed a better performance of SACBR.

Yao et al. [62] explained the limitations of the manual labeling of traditional image matching technology. For solving this problem, a content-based medical image retrieval technique was used. The technique uses the visual attributes of the image to set the feature index to adopt CNN (Convolutional Neural Network) for sparse connectivity and weight sharing. Liu et al. [63] suggested an authentication scheme for a secure multifactor client, which requires the user identity, the password, and the client-server authenticated biometrics, which is a hidden key and is associated with key agreements chosen on the chaotic map because the size of the map is smaller and the computing overhead is lower.

Medina et al. [64] introduced a simple, adaptable, low-cost IoT system that allows viewing in graphical form on the website and the real-time temperature and humidity. When the temperature or moisture exceeds, the systems send a message to a mobile application. The temperature can be manually monitored in the data center based on the monitoring results. Results established the best location to position the sensors in the data center for temperature and humidity monitoring.

Lu et al. [65] proposed an IoMT health knowledge exchange scheme. The scheme allowed access for the approved users. The software also allowed for effective completeness checking by preventing the installation of corrupted data by users. From the results of tests and the study of reliability, it has been concluded that the program is more cost-efficient and reliable in the sharing of health data.

Shammari et al. [66] examined the latency of service embedding in the IoT network to reduce the energy traffic. The services are to be incorporated by a data topology (data nodes and associations) according to an SOA paradigm-determined business process workflow. The multitarget optimization demonstrates the ability to optimize the integration of BPs for both energy savings and traffic latencies with a high optimal level of 91%.

Liang et al. [67] used UAV as the main mobile network of the next generation to intermittently connect IoT devices and to promote data collection based on the DTN protocol. A Hilbert curve-based route planning algorithm decided the UAV flight direction and validated the effectiveness of the method in a network emulation environment with a series of quantitative experiments and confirmed its benefits compared to several baseline approaches.

Hu et al. [68] suggested a high-level structure, namely, Things2Vec. In Things2Vec, the graph to model the sequence of feature relationships by the interaction of things was formed. Since these relationship series were heterogeneous, a partial random walking process is tailored to capture node neighborhoods with different types of semantic relationships. Extensive experiments were performed, and findings showed that the proposed approach effectively captures semantical connections between context-conscious IoT data. He et al. [69] explored the question of fog preparation by analyzing total CAPEX, OPEX, and energy usage when the IoT tasks were given with scheduled. To meet IoT tasks timely and mobility requirements, two ILP models were proposed to minimize total cost and energy consumption.

Yao et al. [70] studied a heterogeneous IoT network of UAV-assisted downlinks consisting of macrocells and energy-saving IoTTs in the 3D space delivery models for the UAV swarms, MBSs, and IoTTs. The possible transmission of energy-constrained IoT's benefits from the one-slot and two-slot charging. The optimization of IoTT density maximizes energy efficiency. Network transmission and energy efficiency are distinguished both by the effect of the association factor and by the transmission power of the active IoTTs. Ti et al. [71] contrasted the performance of seven DSSE systems, including SPS, NPG, KPR, SPS, HK, CJJJ, and the new DSSE system called HDSSE. The developed scheme has its advantages and inconveniences from the results of the experiments. If only speed is measured, then HK is very good for file search adds and deletes. However, also certain considerations need to be taken when contrasting security programs. Some users need a higher degree of protection to avoid unauthorized access to sensitive information.

Tan et al. [72] proposed a multiradio multichannel deterministic transmission scheme. A combined multichannel, multislot scheduling problem has been developed for the tree hybrid topology of network monitoring. A lightweight, pseudopolynomial time transmission scheduling scheme has been proposed based on the greedy strategy. The heuristic algorithm achieves the optimum result under a topology hybrid tree. The experimental results illustrated that the proposed method has a lower packet loss rate and transmission delay compared to the traditional transmission scheme.

Yang et al. [73] suggested a new architecture for the delivery of hierarchical machine learning (ML) tasks for industrial IoT based on mobile edge computing (MEC). It was presumed to be carried out in a MEC environment where devices were restricted in computation while the MEC server was full of computation resources. Therefore, a small ML model for the system and a deep ML model for the MEC server were pretrained offline with historical data. The growing unit must determine the part of the tasks to be downloaded to reduce the processing time. As communications and ML computing cause data processing delays and errors, the overall delays are subject to the ML model complexity, inference error rate, data quality, and MEC server computing capacities.

Liu et al. [74] investigated a method for free coding control to achieve ultralow latency communications for both slow and quickly fading channels and compared the method of coding-free control and the traditional method of coding-based control numerically and found that the coding-free method is superior in a realistic range of signal to noise ratios. Fan et al. [75] used a wearable interface simulation system for the identification of human body attitude. The human phase period was divided along with the force analysis. It was not only possible to divide step position but also to determine the position of the still posture. The study and work of the human posture were carried out using the acceleration module and FFT transformation.

Farivar et al. [76] suggested a hybrid intelligent classical control approach for a nonlinear n-order CPS model while cyber-attacks were conducted only on the front channel. The neural network (NN) was developed as a smart attack assessment estimator and was built to compensate for attacks and regulate system output in tracking applications through a traditional nonlinear control system centered on a variable structure control process. Nonlinear control theories were incorporated into the proposed strategy to maintain system stability when attacks take place. Neural network has been used as a Gaussian radial base to estimate and restore cyber-attacks.

Eid et al. [77] introduced a compact, lightweight energy-harvesting system. The system used an integrated Schottky diode rectification system that includes a dual-tapered line-based matching network. This topology was illustrated by a 2.4 GHz system with an output of up to 58% over the input of 0 dBm. The output was compared to a referral corrector based on a regular open-circuit matching stub network. The rectifier and a miniature monopole antenna were then optimized for a versatile substratum with an input power of about 50% at 0 dBm. Despite large load fluctuations, the corrector had an almost flat efficiency over the range of 2.3-2.5 GHz. The suggested flexible harvester was shown no major variations in harvested power for various bent states.

Niu et al. [78] introduced an IoT enhanced cloud-computing data-sharing network based on blockchain. In addition to stable data management services, the data-sharing program supports successful search services. A key aggregation, searchable encryption scheme based on blockchain with an auxiliary entry system called BAI-KASE to guarantee data confidentiality and key protection had been used. It enables users to securely externalize information and search for it through BAI-KASE in the cloud. Cornetta et al. [79] presented a novel manufacturing concept using FaaS that improves existing capabilities by offering digital manufacturing equipment for interacting remotely to control manufacturing activities over the Internet. The manufacturing facilities were exposed to the Internet as software services that third-party applications can consume. The results of the study demonstrated the high performance and accuracy capacity of FaaS.

Cao et al. [80] proposed a distributed MAC protocol for IoT networks in the ambient backscatter communication framework, which allows each BD to freely switch between backscatter transmitting, receiving, and energy harvesting in a distributed manner. Also, the proposed MAC protocol adopts an ultralow-power sensing scheme and the dual-back-off method. Considering the sensing errors, an enhanced 3D discrete Markov chain model, including energy harvesting, was presented to analyze the standardized throughput of the proposed MAC protocol. An optimum comparator threshold had been derived from the upper bound of the normalized throughput. The numerical results show that the proposed MAC protocol functions well for IoT networks with low power consumption. Hu et al. [81] suggested a theoretical model for achieving the optimal number of items anchoring. BBIL had been assessed against existing methods and compared with them. The results of the simulation showed that BBIL's average localization error is less than 11.6%. It does well in anisotropic networks. Wei et al. [82] considered a UAV-enhanced edge computing scenario for IoT applications. In particular, the problem of smart task offloading at UAV-enhanced edge was first identified to address the generated big data. Final numerical tests confirmed the dominance of energy saving of the overall optimum job offloading scheme.

3. Adopted Research Methodology

This section presents a systematic literature review (SLR) method adopted to conduct this study [83–87]. A typical methodology for the SLR contains domain categorization, application area identification, opportunities, outcomes, and their future scope. All the related synonyms and the alternatives of the keywords are identified, and then, subsequential final search words are chosen [88–90]. The SLR method was applied to the Science Direct, IEEE Xplore, Wiley, ACM, and MDPI electronic databases, as shown in Table 1. Apart from the number of articles, all the research papers are indexed in SCI/SCIE, WoS, and Scopus index. Finally, 67 peer-reviewed research articles are selected totally on the basis of IoT applications in different sectors purely based on commercial, environmental, smart city, industry, and healthcare.

The principle of selection and evaluation flow diagram is shown in Figure 4. For the final mapping of the database, the inclusion principles are as follows.

Online database from year January 2010 to 2021:

(i) Studies included applications of IoTs in different fields

(ii) Technical Quality Method (TQM) in IoT applications

For the final mapping database, the exclusion principles are as follows:

(i) Research papers are not indexed in SCI/SCIE, WoS, and Scopus indexes

(ii) Research papers are not in the English language

(iii) The research papers are not processed through a peer-reviewed process

4. Application Areas of IoT

This section contains the existing research studies on selected IoT applications to prepare this technical review according to the SLR method. Taxonomy in Figure 5 presents a broad classification of the IoT applications, including various sectors like smart city, environmental, industrial, healthcare, and commercial sectors. Practically, in every IoT application, some glitches can emerge that can potentially affect the efficiency of IoT applications, focused, effective solutions to counter these technical.

This study has a major focus on IoT applications, challenges, and available opportunities. The subsequent sections exemplify the different methods in IoT applications.

4.1. IoT in Commercial Sector. The Internet of Things, as part of the "Future Internet," has evolved into a dynamic paradigm that is influenced by a diverse set of stakeholders. IoT enhanced the capabilities and serviceability of shopping and retail systems. To understand the applications in the commercial area, a more specific literature review has been presented.

Alodib [91] described a model-driven solution for automating the QoS-aware service composition process, which included real-time monitoring. The breach of SLAs set by various users in various places is a big problem, as stated in this article. As a result, the SLAs asserted by users across several sites were mapped into a Petri net, allowing the Petri net model to be integrated with the UML QoS model. Huo et al. [92] suggested a novel multiobjective model for service composition that takes into cost-effectiveness. Availability, response time, throughput, and reputation are among the QoS criteria. The proposed service composition model was created using an ABC algorithm with the goal of maximizing the given QoS criteria while lowering costs.

Liu et al. [93] suggested a cooperative solution for QoS that was implemented through PSO algorithms. Many algorithms were used, but the best-suggested algorithms were GA and PSO. The main advantage of this work is that it reduces time as well as cost. The limitation of this work is that it cannot be able to handle large-scale data. Hua and Wang [94] used the artificial bee colony algorithm for the composite services. The authors suggest that this proposed algorithm is much better than GA and other similar algorithms. The quality variables are analyzed in relation to the IP case study in order to arrive at the best optimum solution for the suggested composition method.

Kleinfeld et al. [95] described a framework for connecting data from Web-based IoT devices and web services. This study offered the glue-things concept as a Web of Things (WoT) center for mobiles, TVs, homes, and wearable appliances.

A summary of the research work available in the commercial sector is shown in Table 2.

4.2. IoT in Healthcare. The integration of IoT technology into healthcare systems is transforming the future of the health industry. The applications of IoT in the healthcare system, such as decreasing emergency room waiting time, telehealth, tracking of information, drug management, food management, determination of glucose level, and monitoring of electrocardiograms, are tabulated in Table 3. The architecture of IoT in healthcare is shown in Figure 6. Researchers across the world are working hard to enhance the healthcare system by bringing unique ideas, cutting-edge technology, and complex software. Security, privacy, authentication, energy consumption, processing power, resource management, QoSs, and other issues with IoT healthcare systems are all major problems. The IoT applications in healthcare are also shown in Figure 7.

4.3. IoT in Agriculture. Farming is very vital in today's globe, and it needs sufficient environmental and dietary protection. To remotely control and monitor an animal farm, a smart system is required. This system should give feed and water as needed, as well as exhaust excess biogas created by the animal waste and detect fires on the farm. Furthermore, this sophisticated system should monitor the entire farm. Memon et al. [128] used water level sensors, gas sensors, temperature, humidity sensors, ultrasonic sensors, microcontrollers, and an IP camera with Internet connectivity to create an IoT-based system. The architecture of IoT in agriculture is shown in Figure 8.

Billah et al. [129] develop a real-time water quality monitoring system. Three types of sensors, pH sensor, turbidity sensor, and temperature, were used to measure the quality of water. To regulate and monitor the Water Quality Index (WQI) parameters, the controller box contains a CC3200 Launchpad microcontroller, a DS18B20 temperature sensor, an SKU: SEN 0189 turbidity sensor, and an SKU: SEN 0161 pH sensor. The collected data would be saved in the cloud

Table 1: Information obtained from research publishers.

Publisher	Library type	Type
IEEE	Digital library	https://ieeexplore.ieee.org/Xplore/home.jsp
MDPI	Digital library	https://www.mdpi.com/
ACM	Digital library	https://www.acm.org/
Science Direct	Digital library	https://www.sciencedirect.com/
Wiley Online Library	Digital library	https://onlinelibrary.wiley.com/

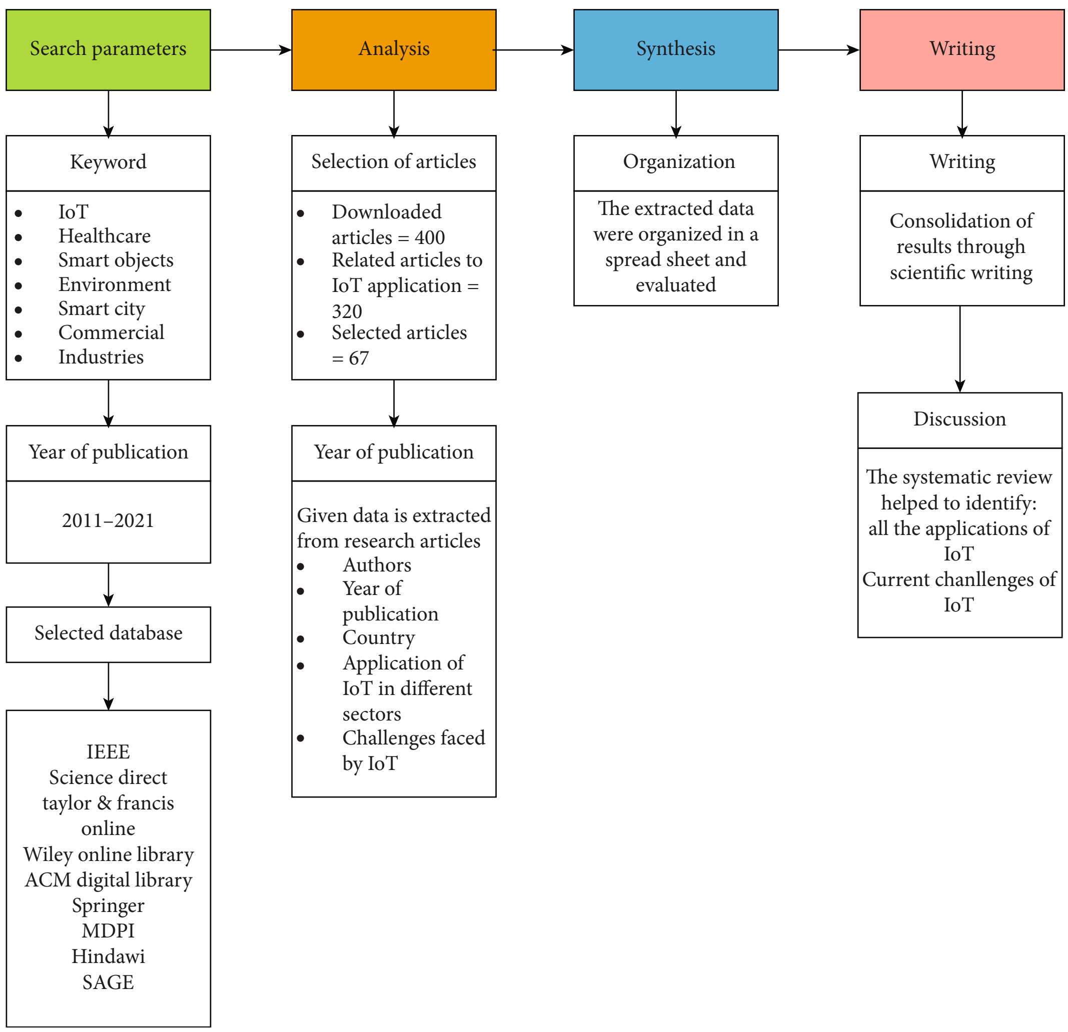

Figure 4: Selection criteria of research articles.

and accessible via any mobile device with access to the Internet or Wi-Fi.

In recent years, smart farming has paid greater emphasis to be effective and efficient animal illness diagnosis and control. Feng et al. [130] worked on mastitis detection and control in smart farms using IoT and social cattle behavior sensing. Data fusion techniques were used to combine data from different sources, and noisy data were filtered using GPS hardware-reported faults to make the gathered trajectories more robust and dependable.

Vaughan et al. [131] developed animal weight and gait sensors on the floor for precision livestock farming. The author suggested that pig farms may use low-cost, low-maintenance, and low-profile sensor mats to track the pigs' stride and weight. The primary goal was important for monitoring pregnant animals since this information is useful for detecting lameness early and planning for the next gestation period.

Pan et al. [132] evaluated two main web service technologies to see which one is best for creating an IoT

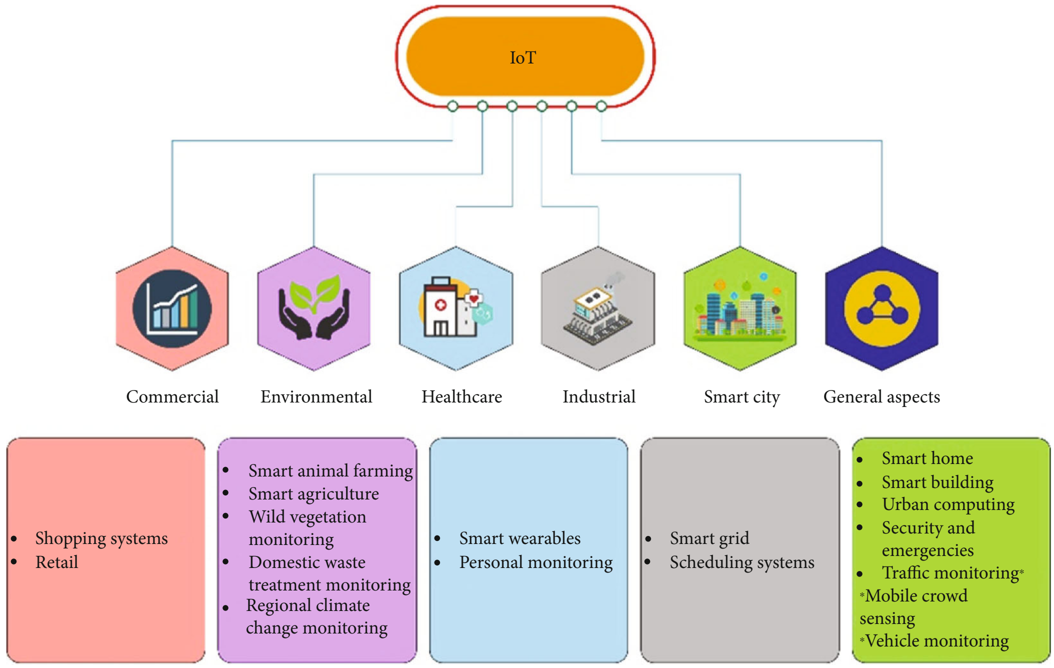

Figure 5: Applications of IoT in different sectors.

Table 2: Classification of IoT applications in commercial sector.

Reference	Application	Limitation	Used technology
[91]	QoS-service	Scalability is not possible	Service-oriented architecture
[92]	QoS-multiple service	Quick flow of data using clouds is not possible	Elite-guided, multiobjective artificial bee colony
[93]	QoS-service	Unable to support large scale data	Heuristic optimization
[94]	QoS-service	Serial optimization of nodes was not considered	Cross-modified, artificial bee colony
[95]	Join data from web base to IoT device	Not showing good efficiency	Web-friendly IoT technologies

system for animal farming. The author presented the RICS platform for constructing animal husbandry IoT systems based on the comparative results, which chose the RESTful framework. The RICS platform demonstrates the several benefits of RESTful architecture in IoT systems. To begin with, the unified protocols, as well as the streamlined techniques and data structure, make it easy to provide the improved caching capability. When the central management server and clients communicate, this greatly improves performance. Users may easily administer and maintain the system by employing the established HTTP methods, which include device monitoring and control, registering, and setting new features and hardware. Access control may be applied precisely and simply for security concerns.

In smart farming, the IoT is used in soil moisture monitoring, temperature monitoring, humidity monitoring, pressure monitoring, gas monitoring, and crop disease monitoring. Revolutions in the agricultural industry are presented in Figure 9.

Precision farming assists farmers in improving, automating, and optimizing all possible directions in order to increase agricultural production [133]. Various IoT sensors are used in harvesting operations. A correlation study between agricultural environment information and crop statistical analysis has been created to collect crop data in order to improve crop output [134]. Popović et al. [135] describe the development of IoT-based solutions for precision agriculture and ecological monitoring. Weather predictions based on IoT enhance production and do anticipatory analyses to prevent crop damage. Multiple monitoring sensors are utilized to forecast pest activity and plant growth and manage any looming pest problem. IoT-based irrigation systems are used to control and evaluate agricultural irrigation needs. Nakutis et al. [136] presented a remote agriculture monitoring platform. Watteyne et al. [137] presented a precision farming conceptual architecture based on cyber systems and software-defined works. IoT foundation climate condition monitoring, soil pattern monitoring, insect and crop disease monitoring, irrigation, determining the best

Table 3: Classification of IoT applications in healthcare.

Reference	Application	Limitation	Used technology
[96–99]	Blood pressure (BP)	Need Internet connection all the time	Field communication
[100–102]	Decreasing waiting time	Need to improve scalability	IoT-based special sensors, wireless sensors, MEDiSN
[103–106]	Drug supervision and management	Interruptions can be problematic	Wisepill technology, Aeris wireless connection
[107–112]	Electrocardiogram	Contextual data mining	COAP, MQTT, TCP, UDP
[113, 114]	Food management	Cost-effective sensor required	5-layer NN, weighing sensor, RFID
[115–117]	Glucose level	The operative methodology is required	IEEE 802.15.4, Bluetooth, ZigBee
[118, 119]	Oxygen saturation	Always connected to the Internet	Low-cost pulse oximeter, real-time monitoring required, CoAP, wearable device, wireless sensor device
[120–122]	Rehabilitation system	Good knowledge about training	Body sensors
[123–125]	Telehealth	Information security	CyberMed, telemetric systems
[126, 127]	Tracking of information	Information security	RIFD, ZigBee, GSM

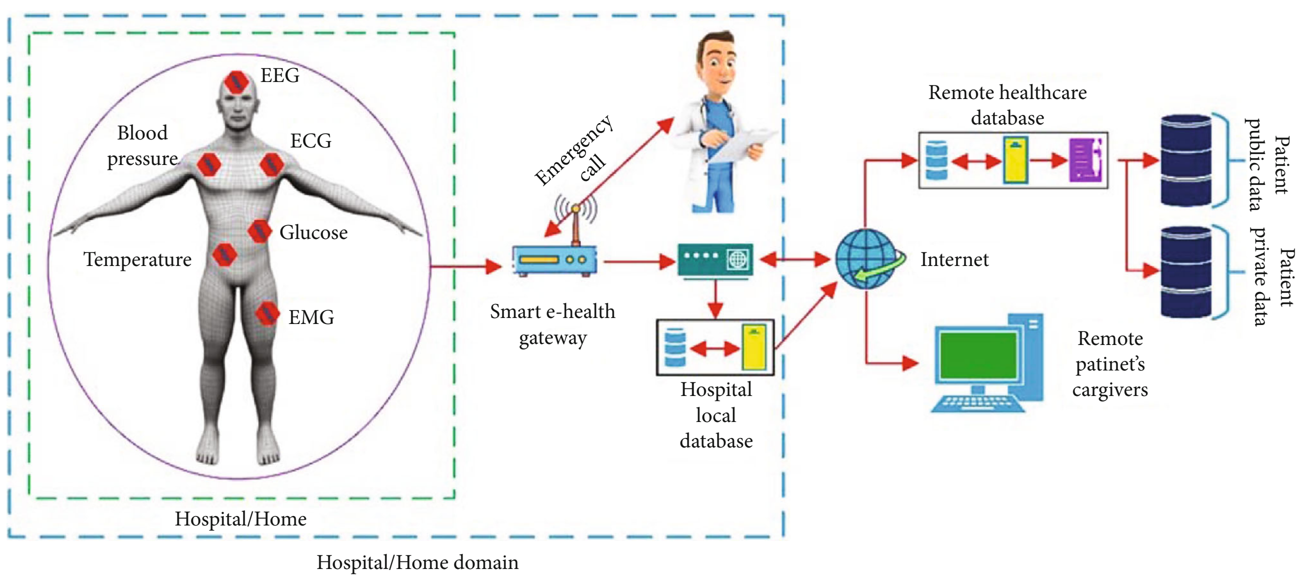

Figure 6: The architecture of IoT in healthcare.

time to sow and harvest, and tracking/tracing are examples of precision farming.

Plants are cultivated in greenhouses in a controlled atmosphere. By monitoring proper environmental conditions, this glasshouse technology aids growing plants anytime, everywhere. Because greenhouse cultivation is more intensive, it needs greater accuracy in terms of management and monitoring. Several researches on the usage of WSNs in greenhouses to monitor environmental or meteorological conditions have been conducted. Recent research has demonstrated how the IoT may be used in greenhouses to reduce human resources, accumulate energy, and give direct communication between ranchers and buyers [138–140].

Furthermore, there has been much research that combines metaprocessing structure with data to send it to remote infrastructures via the Internet for the goal of high accuracy. Assessment of crop status aids ranchers in making better decisions by using well-validated crop models [141]. Sensors can collect data which is subsequently sent to the main server for processing. The sensors and network for correct data transfer are the most important components in the physical implementation.

Growers put various sensors according to the individual requirements and then track or record the data. Agriculturists make better judgments by studying the data they get and acquiring the best data possible. Water management, plant monitoring, and climate monitoring are just a few examples

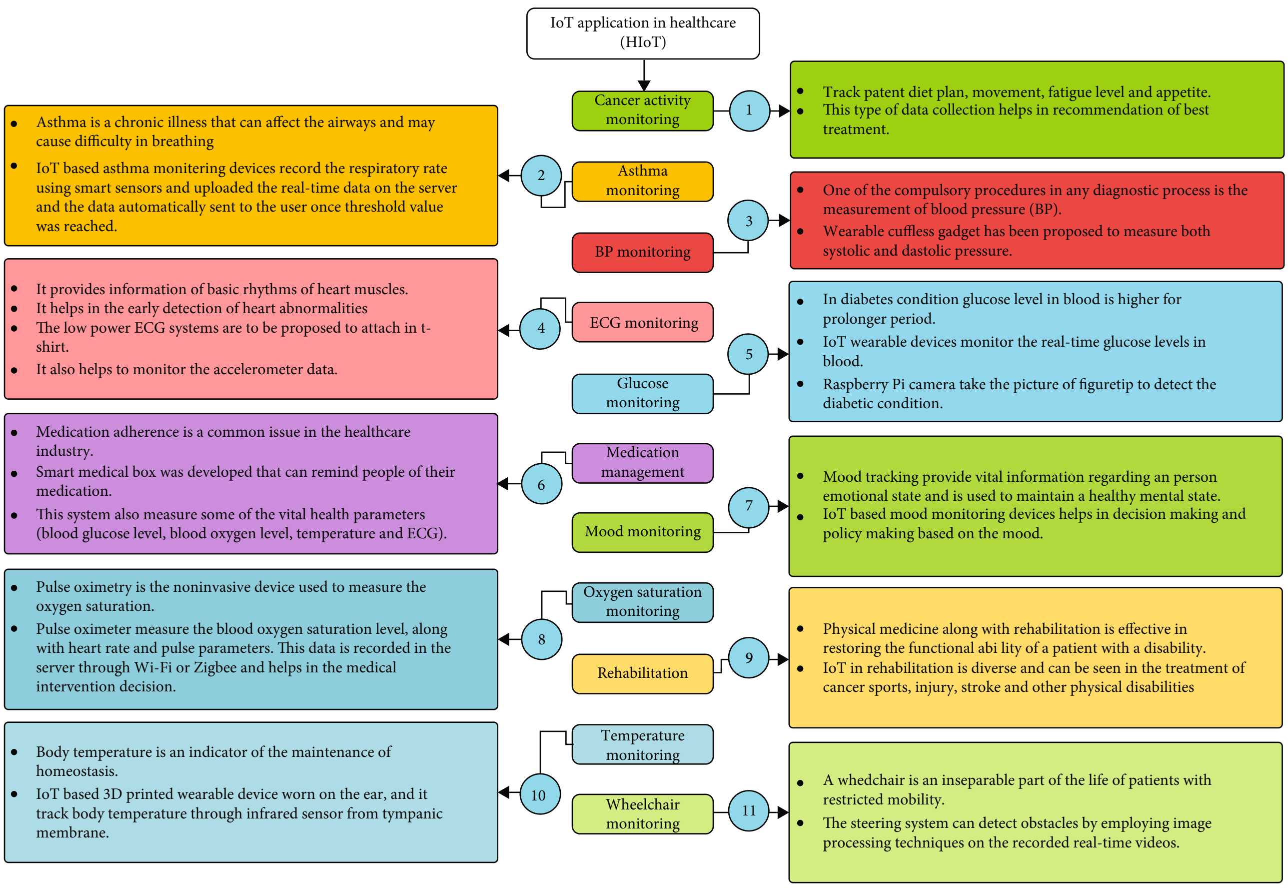

Figure 7: IoT in healthcare.

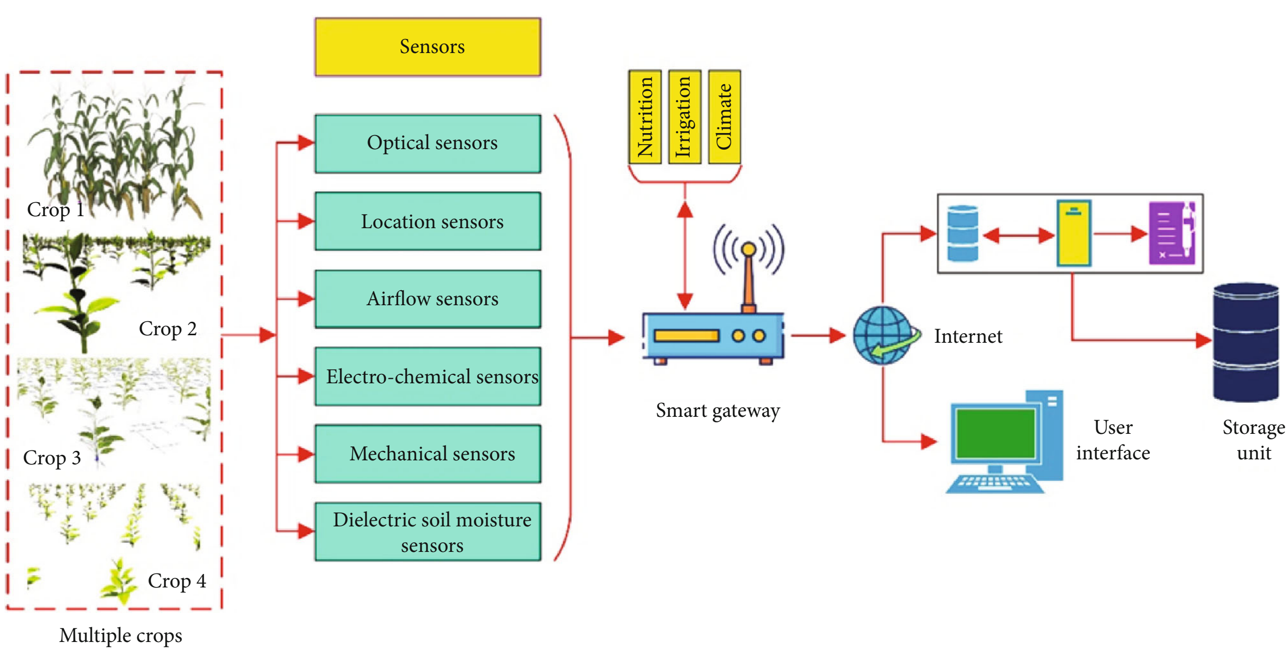

Figure 8: The architecture of IoT in agriculture.

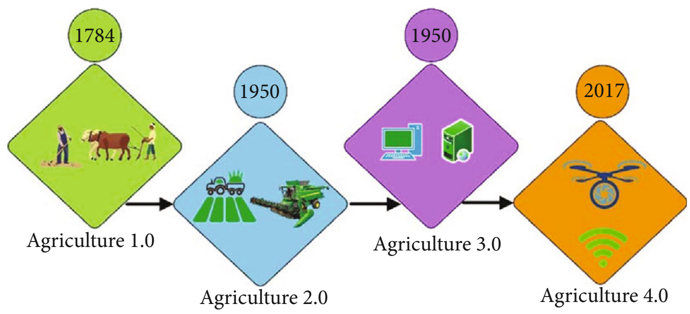

Figure 9: Revolutions in the agricultural industry.

Table 4: Summary of the IoT applications in agriculture.

Reference	Application	Limitation	Used technology
[128]	IoT in farming	ML techniques not used	Microcontroller, Arduino UNO
[130]	Smart farm	Collected data was noisy and contained errors	Somatic cell count (SCC) mastitis tests
[131]	Animal weight and gait for precision livestock farming	Weight can measure between 100 and 500 kg only	PGR-FB1000
[132]	Livestock farming	Energy consumption is not considered	RESTful style architecture
[133]	IoT precision agriculture	Not considering cost parameter	—
[134]	Smart agriculture decision-making system	Wireless connectivity is limited to up to 200 m only	NRF24L01
[136]	Efficient agro field monitoring and irrigation control system	Energy consumption is not considered	LoRa
[141]	Traceability system for greenhouse seedling crops	Energy consumption is not considered	Fuzzy-type PID

of IoT-based greenhouse applications. Everything in today's contemporary society must be automated in order to save time and manpower. A summary of the IoT applications in agriculture is given in Table 4.

4.4. IoT in the Environment. Due to the tremendous rise in population, industrialization, and urbanization, trash collection and segregation have become a key concern for all metropolitan areas throughout the world. At the household level, there is a dearth of information concerning trash segregation. The principal concerns that arise as a result of poor waste management are human health risks and environmental issues.

Hassan et al. [142] created an IoT-based garbage monitoring and collection system. The system's hardware consists of a NodeMCU coupled with two ultrasonic sensors and a Wi-Fi module mounted on the board. These sensors were used in the system to create an automatic lid opener as well as to update the waste level situation for monitoring purposes. The proposed system used a mobile application to monitor the waste level in the bin over the Internet application. The Wi-Fi module had restricted coverage, which is the restriction of the system.

Fang et al. [143] introduced a novel IIS that combines the Internet of Things (IoT), cloud computing, a global positioning system (GPS), geographical information system (GIS), and e-Science for environmental monitoring and management.

The "green consumer," a person who is aware that their consumption habits have an impact on the sustainable development of the region where they live and values their quality of life in terms of environmental respect, is one of the social megatrends that has had the most impact on changing people's minds. Furthermore, a green consumer is very supportive of environmental causes such as recycling, vehicle emissions control, and environmental care resources, among others. IoT technology has been indirectly involved in such activities by detecting environmental factors, identifying contaminants, and, in certain circumstances, conducting remedial steps in situations when considerable environmental harm has occurred [144].

4.5. IoT in Energy Sector. The steady rise in energy consumption that comes with population growth and the introduction of new technology has created substantial problems for consumers in terms of energy management. Smart meters (SMs) are no longer only instruments for measuring energy usage; they are now a key component of energy management systems. The benefits of using SM include correct billing data, the development of two-way communication, and remote control of user equipment. SM is the most important component of a smart power grid since it analyzes, monitors, regulate, implements, and communicates power allocation, usage, and consumption at both the single device and network level with the support of a smart energy management system (SEMS). Power supply businesses use the information through the SMs to revolutionize power distribution and consumption through strategies like nonintrusive load monitoring and demand-side management (DSM).

Smart meters and the Internet of Things (IoT) have been widely used to replace old analog meters in today's smart homes. The data may be delivered wirelessly, which decreases the amount of human labor required. The community of smart home networks, on the other hand, is vulnerable to energy theft. Li et al. [145] created machine learning and statistical-based models to reduce energy theft called smart energy theft systems (SETS). The prediction model, which employs a multimodal forecasting system, is the initial step of the decision-making modules. This system combines many machine learning algorithms into a single power consumption forecasting system. The secondary decision-making model, which utilizes a simple moving average (SMA) for aberrant filtering, is the second step. The third stage is the secondary decision-making model, which is used to arrive at the ultimate stage of the energy theft decision.

Zhang et al. [146] reviewed future IIoT core technologies, including complete sensing techniques and the broad range of communication devices, large-scale data treatment, and forecasting condition-based maintenance plans. Figure 10 shows the typical applications of future IIoT in power systems.

The smart energy grid becomes more dependable, durable, and efficient when IoT-based technologies are integrated. IoT technologies, on the other hand, provide additional issues for the smart energy grid system, such as security flaws. Some emerging technologies, such as blockchain, machine intelligence, high-performance computing, and distributed frameworks, can help to address these issues.

One of the key elements of IoT smart grid technology is energy consumption. It is a novel smart electricity distribution mechanism that focuses on enhancing renewable energy in power systems, grid operation control, and customer power consumption optimization [17]. Distribution and consumption management, transmission control, better metering design, integration of renewable resources, energy storage, and self-healing infrastructure are the services provided by smart grid technologies [147]. As a result, smart grid technologies are regarded as one of the foundational technology that can aid in the development of smart cities [148]. Furthermore, it employs a variety of approaches, including machine learning and deep learning, to create intelligent and efficient power management systems [149].

A summary of the applications of IoT in the energy sector is shown in Table 5.

4.6. IoT in Smart Cities

4.6.1. Eco-Smart Cities. Smart cities have been seen as a location that is both ecologically friendly and sustainable. Different factors such as air quality, water quality, and weather are measured by local governments using wireless sensor networks. Administrations have put permanent and mobile monitoring stations that measure some of these factors using sensors that are connected to a central communication device, which then sends the data to a central server for storage or analysis. The architecture of IoT in smart cities is presented in Figure 11.

In addition to sensor networks, IoT has enabled individuals to gain a better understanding of their daily energy and water use at home, as well as the creation of pollutants [150, 151], resulting in increased environmental consciousness and the consolidation of this mega societal trend.

4.6.2. Traffic Control. It is one of the major issues in the big cities, which occurs when road infrastructure is insufficient to meet mobility demand, and public transit services are overburdened. Smart city governments have developed Intelligent Transportation System (ITS) designs, which include video cameras, GPS devices, GIS systems, and sensor networks to monitor paths, bridges, and road infrastructure [152]. People may monitor from a transport control center and make judgments regarding transportation, such as rerouting, adding transport buses, optimizing traffic signals, and responding quickly [153].

4.6.3. Education. National and municipal governments are particularly interested in education-related innovation since a well-educated country is more competitive in many social, political, and economic areas. Virtual classrooms are increasingly quite widespread at schools and colleges, as educational techniques have altered drastically in recent years. It is now feasible to interconnect multiple venues where students may access common information to better their learning experience. Remote access control, lighting, air conditioning, projection displays, and automated detection of the presence of students in a classroom by RFID are all examples of IoT in schools [153].

4.6.4. E-Health. IoT technologies have various applications in healthcare innovation that may be incorporated into a smartphone or other device for monitoring health diagnosis factors like blood pressure, heart rate, and breathing rate to prevent and diagnose illnesses [154]. In hospitals, IoT technology provides a variety of services, including patient monitoring of physiological signals and surgical aid using Internet-connected medical tools that can be controlled remotely. IoT technology enables the monitoring and tracking of medications and pharmaceutical items in the pharmaceutical business [155].

5. Challenges in IoT Developments

Till now, a broad range of IoT applications as well as several IoT datasets produced for the evaluation of IoT systems has been discussed in detail. Despite the fact that our analysis explored many IoT concepts and infrastructure, there are still certain obstacles and research paths that need to be solved in order to match the IoT sector with real-world requirements. In this part, we outline some of the research gaps that may be used by researchers in the field of IoT systems to get insight into current trends and gaps, as well as how these gaps might be addressed.

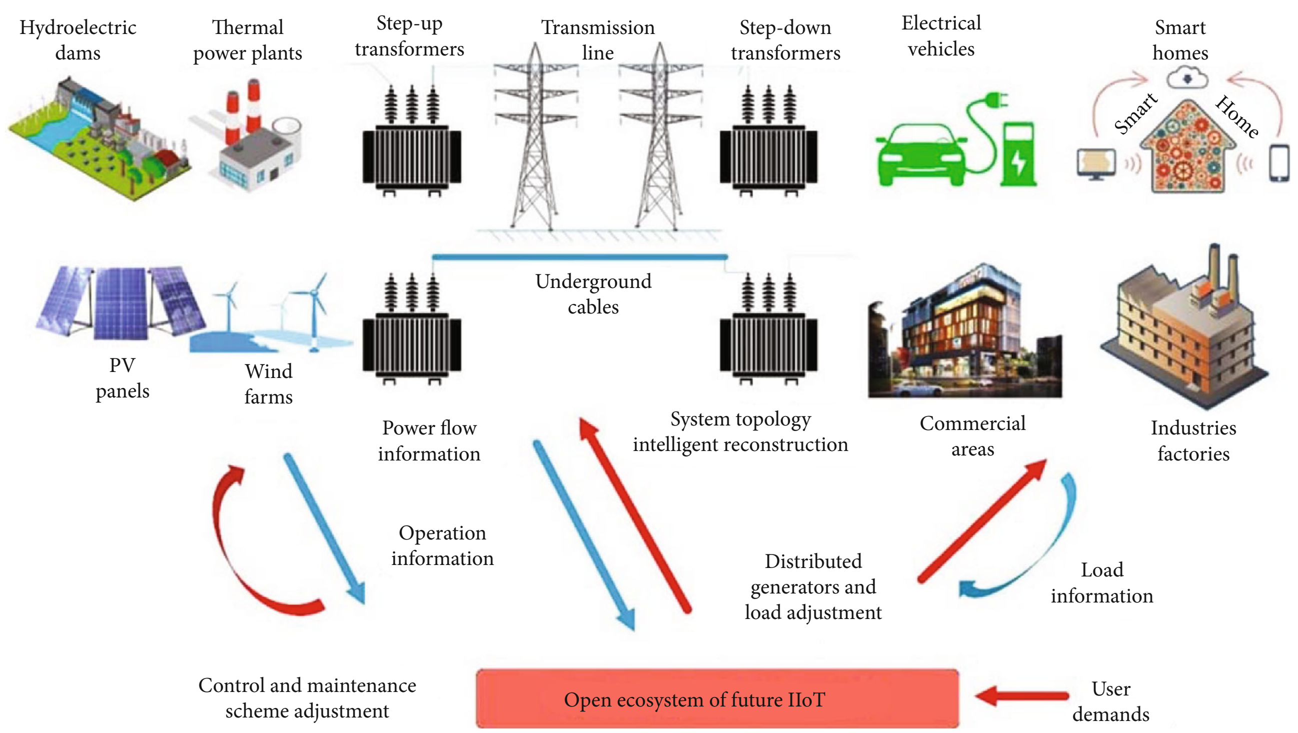

Figure 10: Typical applications of future IIoT in power systems [146].

Table 5: Classification of IoT applications in the industry.

Reference	Application	Limitation	New findings
[146]	QoS-based service	Not assessing real-time IoT	Algorithm
[17]	Management of energy	Not evaluating cost	Prototype
[147]	Electrical power network	Low availability	Framework
[148]	Smart grid applications	Not assessing real-time IoT	Algorithm
[149]	AI in energy demand	High response time	Algorithm

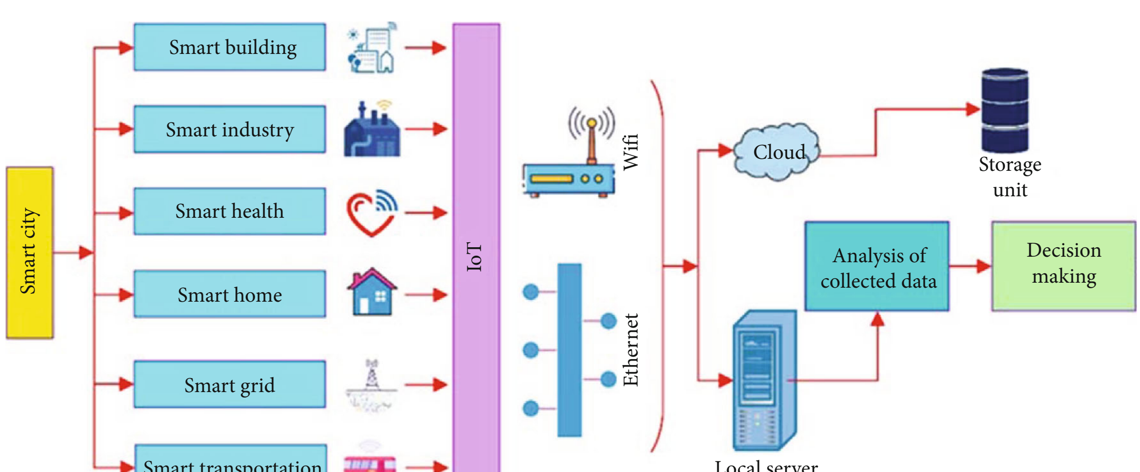

Figure 11: The architecture of IoT in a smart city.

5.1. Data Management. The data management issues in the healthcare industry are similar to other industries. Medical sensors attached to humans provide the e-Health data. The human body is a dynamic system that is constantly changing its condition. As a result, there will be a steady flow of data arriving from edge sensors via fog computing nodes. IoT e-Health needs to deal with the data's complexity in terms of volume, diversity, and velocity. For example, ECG data may be sent in XML format, but diagnosing skin illnesses using a camera-based IoT device would need handling picture formats.

5.2. Connectivity Issues. The core of the IoT is the creation of a network of interconnected devices that can share data. As a result, connecting several devices for communication is one of the most difficult challenges in developing IoT systems. The systems and technology should be able to handle the existing and additional infrastructure. A centralized client-server design is responsible for initiating communication across several nodes in the network that is not scalable enough to support billions of IoT devices in a single network. As a result, the centralized network will experience a bottleneck. The addition of additional devices to the network necessitates a significant investment in capital cost to maintain cloud servers for data storage.

5.3. Security. A large number of devices are connected across a vast region, and securing IoT systems is difficult and demanding. Intruders can readily compromise this information since these gadgets interact and exchange it. The security component of IoT systems is crucial since the data transferred among the devices might contain sensitive information such as a patient's health information, a company's trade secrets, or state government or military network classified information. Finding the intruder in the network who may infect or harm the entire communication network would be a difficult assignment.

The cost of extracting DNA sequencing procedures in e-healthcare applications to cure any illness has been extremely high for numerous decades. With the use of low-cost genetic sequencing, we can incorporate genomic analytics into normal medical treatment. This will assist us in receiving better and more timely care. The extraction of information from the genomic sequence is a time-consuming process. Genomic data also contains information on the patient's ancestors and relatives. As a result, information leaks and sharing produce creates lots of issues.

5.4. Software Applications. The ability of software applications to execute built-in IoT infrastructure is reliant on their innovativeness and intelligence in the IoT paradigm. IoT system developers vary on the functionality to be implemented. For example, edge developers are hired to create hardware drivers for various edge devices and those who provide interfaces for transmitting the acquired sensor data. Data analytics developers are the developers that are in charge of processing and aggregating data obtained from various sensors throughout the network. Application developers are the people that create the interface between the users and the hardware.

For each developer, the competence needs and environment are different. For example, a data analytics developer is familiar with the operation of underlying hardware devices and how data should be presented to a user. Based on the knowledge needs, IoT concepts and software applications must be developed and explored. Additionally, a generic programming interface can aid in the development of effective software applications.

The unavailability of storage devices might cause the system to shut down, putting a massive quantity of data being transmitted between network nodes at risk.

Because the consumer and business needs of IoT vary on a daily basis, the technology itself involves a large number of linked devices resulting in an increase in the cost of service and maintenance, which will further position itself while generating an imbalance in a country's economy. The development of sensors or devices that require very little or no maintenance is one answer to this challenge. This will lower the cost of maintenance and help to avoid certain economic difficulties.

Furthermore, most of the devices used here are battery-powered, and it is very hard to replace a sensor's battery after it has been deployed, resulting in high power consumption. As a result, another issue is to build sensors that do not require battery replacement over time, which may be accomplished by creating more gadgets that use renewable energy sources. As we know, the Internet is the heart of IoT. Issues with Internet connectivity will result in poor service and performance. Almost all base stations/gateways have a restriction on the number of users who may connect at the same time. If the number of users exceeds the limit, some users will be unable to connect. So, in order for IoT to be successful, the Internet needs to be fast, inexpensive, and hassle-free.

The establishment of a single communication standard is still a question. Because the goal of the Internet of Things is to make it more user-friendly and to make it easier to communicate with other connected devices, as a result, certain common communication protocols that facilitate network heterogeneity and interoperability must be implemented, making it substantially easier for users to contribute to its considerable development.

In addition, one of the most significant difficulties that IoT faces is the security, privacy, and control of personal data. Because IoT is a linked platform, all of your personal information is stored on the cloud, which is extremely susceptible. If there is a flaw in IoT security, it will clearly jeopardize a person's privacy and security. This might be mitigated by using a secure gateway and implementing secure algorithms and cryptographies to create a more secure environment.

6. Discussion

The review approach for the selected research in IoT applications was discussed in the previous sections. This section presents a "statistical analysis" of the suggested IoT

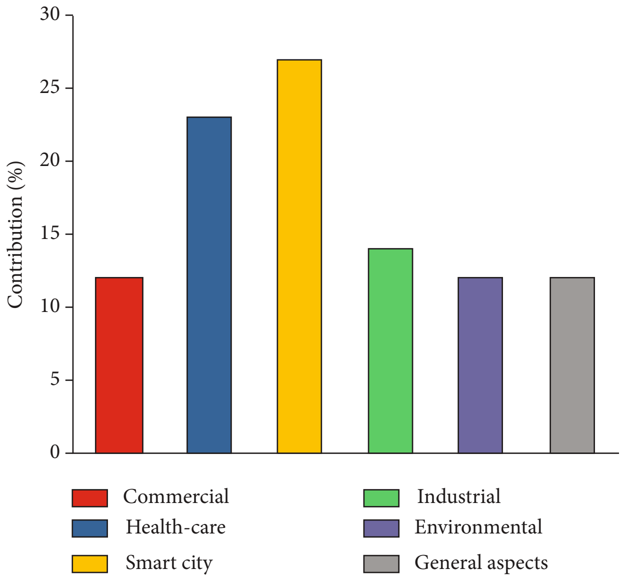

Figure 12: Contribution of IoT in different sectors.

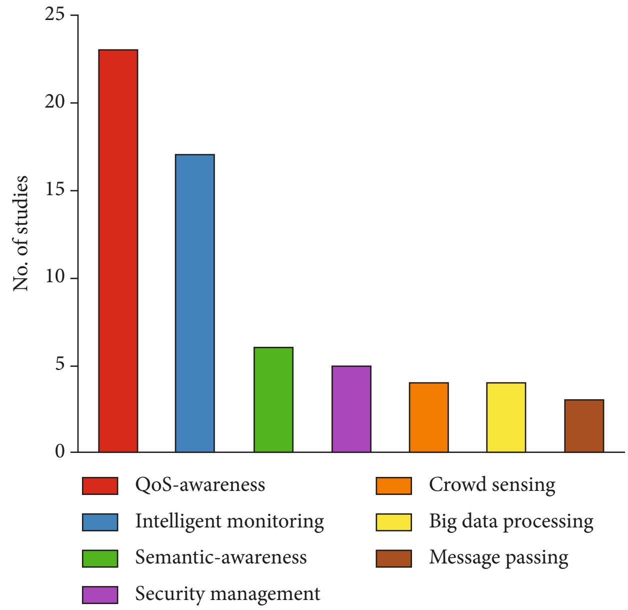

Figure 13: Study distribution in IoT application.

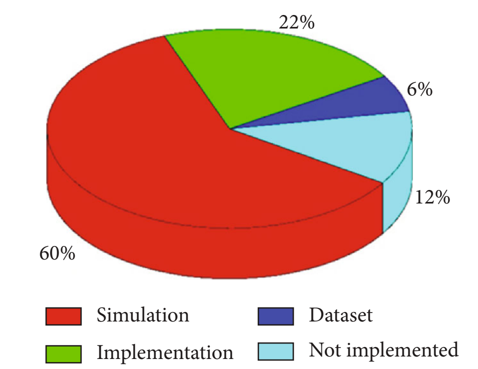

Figure 14: Evolution of the data in the literature.

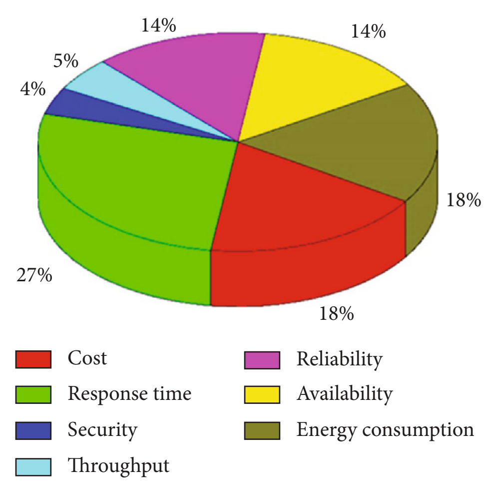

Figure 15: Evaluation criteria.

application techniques. Figure 12 represents a comparison of the percentage of IoT applications to date, based on the taxonomy provided in Section 4. We looked at environmental, healthcare, commercial, industrial, smart city, and general aspects of IoT applications. In the literature, the smart city method has the largest percentage of application domains, with 30% utilization. Healthcare applications account for 20% of all IoT utilization, followed by commercial applications (14%), environmental applications (12%), general applications (12%), and industrial applications (10%).

Figure 13 depicts the main contexts of IoT applications. With 21 investigations, we discovered that QoS-aware techniques are the most popular, followed by intelligent monitoring with 17 studies.

According to Figure 14, 24% of the research studies have adopted the recommended strategy for developing IoT applications. Furthermore, it has been found that 58% of the research publications used simulation tools to evaluate the IoT platform's case studies. In addition, 14% of the studies did not include any implementation. The evaluation criteria according to cost, response time, security, energy consumption, etc. are shown in Figure 15. It has been found that 4% of the present articles used datasets to analyze their case studies utilizing analytical methodologies such as prediction and testing.

The main concern of the IoT is security and privacy because the architecture of IoT changes with respect to the area of application. Reduced energy usage is one of the most crucial concerns in IoT. Green IoT is a major idea that guides the development of many technologies and concerns aimed at achieving a sustainable world with smart technologies in which the energy requirement of smart IoT items can be minimized. Green IoT is enabled by a number of factors, including green RF identification, green wireless sensor networks, green communication between machines, green data centers, and green cloud computing. Future efforts in these areas, such as green IoT design, understanding the characteristics of various IoT applications and service requirements for these applications, and presenting appropriate energy consumption models for various parts of IoT systems, will help to address the energy consumption challenge.

7. Conclusion

IoT is one of the fastest-growing technologies having almost applications in every field. This paper presented the latest research and their findings based on various applications in different sectors. Furthermore, applications, opportunities, and challenges in various sectors are also presented. It has been seen that the majority of the studies were in the prototype stage, with systems being used in laboratories and research centers to evaluate and analyze the contents and gadgets.

The major findings of this study are listed below:

(i) The goal of the IoT is to bring about a major change in the efficiency and quality of individuals life

(ii) Various researchers have developed their application-specific architecture for IoT to improve the security features and reduce the complexity of the system

(iii) The security and computation speed of IoT system are the main issues where more work has to be done in the future

(iv) IoT has the potential to create extensions and enhancements to basic services in logistics, security, transportation, energy, healthcare, education, and other fields

(v) A concerted effort is required to push the industry to maturity beyond the early stages of market growth, guided by a shared awareness of the potential's distinct existence in the fields of utilities and business

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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