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Review

A Systematic Mapping: Exploring Internet of Everything Technologies and Innovations

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Abstract: The Internet of Everything (IoE) represents a paradigm shift in the world of connectivity. While the Internet of Things (IoT) initiated the era of interconnected devices, the IoE takes this concept to new heights by interlinking objects, individuals, data, and processes. Symmetry in IoE innovation and technology is essential for creating a harmonious and efficient ecosystem to ensure that the benefits are accessible to a broad spectrum of society while minimizing potential drawbacks. This comprehensive review paper explores the multifaceted landscape of the IoE, delving into its core concepts, enabling technologies, real-world applications, and the intricate web of challenges it presents. A focal point of this review is the diverse array of real-world applications spanning healthcare, smart cities, industry 4.0, agriculture, and sustainability. Previous works and examples illustrate how the IoE reshapes these domains, leading to greater efficiency, sustainability, and improved decision making. However, the transformative power of the IoE is accompanied by a host of challenges, including security and privacy concerns, interoperability issues, and the ethical implications of ubiquitous connectivity. These challenges are dissected in order to comprehensively understand the obstacles and potential solutions in the IoE landscape. As we stand on the cusp of an IoE-driven future, this review paper serves as a valuable resource for researchers, policy makers, and industry professionals seeking to navigate the complexities of this emerging paradigm. By illuminating the intricacies of the IoE, this review fosters a deeper appreciation for the transformative potential and the multifaceted challenges that lie ahead in the Internet of Everything era.

Keywords: Internet of Everything; Internet of Things; cloud computing; security; privacy; smart systems

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1. Introduction

The digital transformation of the 21st century has ushered in a new era of connectivity, where everyday objects, devices, and systems are becoming increasingly interconnected, intelligent, and data-driven. As a result of the exponential emergence of the Internet in interconnected networks, most technology must adhere to more rigorous standards. This transformative phenomenon is commonly referred to as the Internet of Things (IoT) [1,2]. However, beyond the IoT lies a more comprehensive and expansive concept known as the Internet of Everything (IoE), which expands the boundaries of network connectivity with intelligent devices and is forecasted to see even more rapid advancement in the future [3]. The IoE is an ecosystem where devices and things are connected to the Internet, and where people, processes, and data are seamlessly integrated, creating a web of interconnectedness that transcends traditional boundaries [4]. The Internet of Everything (IoE), as delineated by Cisco Systems Inc., encompasses an intricate network of interconnections involving individuals, processes, data, and IoT devices. According to Cisco's estimations, the forthcoming 15 years are poised to yield substantial advantages from IoE implementation in the global public sector, amounting to an impressive USD 4.6 trillion. Simultaneously, the private sector is expected to generate a remarkable USD 14.4 trillion in economic value during this period [5].

In this digital realm, objects can communicate with each other, make autonomous decisions, and interact with humans in ways that were once the stuff of science fiction. The IoE concept not only encompasses smart devices and sensors but also leverages data analytics, artificial intelligence, cloud computing, and advanced networking technologies to create a symbiotic relationship between the digital and physical worlds. It promises to revolutionize industries, enhance the quality of life, and address some of the most pressing global challenges, from healthcare and transportation to energy efficiency and sustainability. This introduction sets the stage for a deeper exploration of the IoE ecosystem, its key components and challenges, and the transformative impact it is poised to have on various domains of human activity. In the following sections, we will delve into the fundamental concepts, technologies, applications, and emerging trends of the Internet of Everything.

In this paper, we have divided the structure into sections and subsections. In the introduction part, we introduced the concept of the Internet of Everything (IoE) and its transformative potential, setting the stage for our journey. In the section on related works, we examine existing research and innovation efforts, highlighting the progress made thus far. The materials and methods section delves into the critical components of the IoE, emphasizing the convergence of the IoE that underpins this revolutionary concept. Our discussion of the results underscores the dynamic and multifaceted nature of IoE innovation. Ultima, the promise of IoE technologies and innovation is substantial, offering boundless opportunities for a brighter and more connected future.

The motivation to explore IoE technologies is driven by its capacity to solve complex challenges. The IoE has the potential to address global issues such as the integration of physical and digital realms, creating a landscape where devices, systems, and individuals converge, interoperate, and share data in real time. In conclusion, this exploration of IoE technologies and innovation sets the stage for a compelling journey into the interconnected world of the future. By understanding and leveraging IoE, we can pave the way for a more efficient, sustainable, and connected society that unlocks opportunities for growth and transformation across all sectors.

2. Related Works

The evolution of the Internet of Everything (IoE) has been a subject of profound interest and investigation in recent years. Researchers and scholars alike have delved into various facets of the IoE, seeking to unravel its intricate web of connections between people, processes, data, and objects. A significant body of related works has emerged, shedding light on the transformative potential of the IoE in diverse domains, including industry IoT (IIoT) and cognitive IoT (CIoT), as shown in Figure 1. These studies have elucidated the critical role of the IoE in enhancing efficiency, enabling data-driven decision making, and ushering in the new era of connectivity.

The IoE plays a pivotal role in enabling the creation of innovative services, based on the Internet of Things (IoT), fog, and cloud computing paradigms. IoT-based sensors are poised to enhance data transmission for analysis, thus contributing to improved decision making and an overall increase in the quality of citizens' lives [6]. The IoE is anticipated to receive significant amounts of attention in the coming years, especially with the emergence of new, exciting technologies in the sectors of networking, software, hardware, and luxury-oriented services for humans [5]. Several researchers have made significant contributions, with diverse objectives that collectively enhance the capabilities of the IoE. Antonios et al. conducted a systematic literature review on semantic technologies in smart cities, with objectives centered on identifying trends and challenges in adopting semantic interoperability solutions for sustainable, green, and resilient urban environments [7].

Figure 1. The Internet of Everything (IoE).

In the context of the Internet of Everything (IoE) environment, the incorporation of infrared communication into the smart home system emerges as a noteworthy development. Researchers [8] have effectively addressed the longstanding challenge wherein a significant portion of infrared-communication-based household appliances faced limitations in their integration into the smart home network. This innovative effort not only resolves this problem but also helps to lower the implementation costs of such a smart home system, making it more affordable and useful in the everyday lives of the general population.

Another study attempted to replicate a multitude of pragmatic Internet of Everything (IoE) scenarios, mirroring real-world applications. In this pursuit, this paper adeptly harnesses the capabilities of the Cisco Packet Tracer, an instrumental tool employed in the experimental setup [9]. This comprehensive exploration necessitates the interconnection of a substantial array of sensors and devices, effectively emulating the complexities that are inherent to IoE ecosystems. Moreover, this investigative work encompasses the deployment of a diverse range of network components, including routers, switches, and servers, with IoT devices thus culminating in the establishment of a fully operational network infrastructure, like the contributions such as [10].

Numerous researchers are eagerly contributing to holistic performance enhancement by adopting heuristic and metaheuristic algorithms that are used extensively for time–cost optimization in cloud computing [11]. Equally, in [12], the study focuses on elevating various performance aspects of quality management (QM) and bolstering consumer confidence within the Internet of Everything (IoE) framework. The study introduces a QM platform designed to prioritize swift responses and minimize latency in acquiring sensor data, while also ensuring authentication, data consistency, and transparency in the context of cold supply chain logistics. Additionally, an innovative adaptive data smoothing and compression (ADSC) mechanism is proposed to efficiently reduce the size of IoE data. This facilitates storage within edge gateways, even when they have limited computational and storage capacities. This research contributes significantly to optimizing cold supply chain logistics by harnessing IoE and blockchain technologies to enhance quality management and transparency in supply chain operations.

3. Materials and Methods

Systematic mapping or scoping studies aim to offer a comprehensive perspective on a specific research field by categorizing and organizing existing research. These studies primarily delve into the body of available research to assess the breadth of various subjects, publication frequency, emerging research patterns, and the sources where relevant studies have been disseminated. In this particular study, the systematic mapping process adheres to the recommendations outlined by Petersen et al. [13]. In accordance with the systematic mapping study guidelines, the key procedural stages encompass defining research inquiries, scouring for pertinent academic papers, screening these papers, annotating abstracts with relevant keywords, extracting data, and creating a visual representation, as illustrated in Figure 2. Each of these steps yields specific outcomes, and the ultimate product of this entire undertaking is a systematic map, which is further elucidated in [13,14].

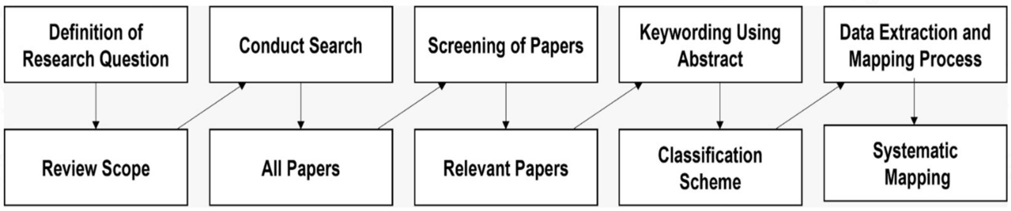

Figure 2. Systematic mapping [13].

Definition of Research Questions (Research Scope)—The principal objective of a systematic mapping study is to establish a comprehensive view of a specific research domain, determining the extent and nature of the research and findings available in that domain.

Conducting the Search for Primary Studies (All Papers)—The identification of primary studies was accomplished by employing search terms within scientific databases or by manually perusing relevant conference proceedings and journal publications.

Screening of Papers for Inclusion and Exclusion (Relevant Papers)—Inclusion and exclusion criteria were applied to sift through studies that were pertinent to addressing the research inquiries, discarding those that did not meet the criteria.

Keywording of Abstracts (Classification Scheme)—Keywording served as a method to expedite the development of the classification scheme and ensure that it took into account existing studies, thereby reducing the time required.

Data Extraction and Mapping of Studies (Systematic Map)—Once the classification scheme had been established, the relevant articles were organized within it, signifying the practical phase of data extraction.

3.1. Research Questions

The primary research question (RQ) of this systematic mapping study was: "What innovations are derived from IoE technology?" This primary question was divided into seven RQs. Table 1 lists the formulated RQs along with the rationale behind each RQ.

Table 1. Research questions.

RQ No.	Research Question	Motivation
RQ1	To which domains has the IoE been heavily applied?	To identify the domains in which IoE has been heavily applied.
RQ2	What types of problems exist in IoE innovations?	To identify the types of problems in IoE innovation.
RQ3	What is the contribution of the IoE to each innovation?	To synthesize research efforts, highlighting common themes in research contributions.
RQ4	What are the most frequently used evaluation metrics?	To highlight the most frequently used evaluation metrics, based on the IoE innovation.
RQ5	What are the limitations of each IoE innovation?	To highlight the limitations in research works based on innovation.
RQ6	What are the trends and directions of the IoE in each innovation?	To recognize common themes and provide a comprehensive roadmap for IoE's continued growth and evolution.
RQ7	What are the demographics of the primary studies?	To highlight the distribution of primary studies based on the type, year, and venue of publication.

3.2. Data Sources

We examined twelve electronic databases as our main sources for potentially relevant studies. Google Scholar was omitted from the selection due to its lower precision in delivering results and the significant overlap with results from other data sources. The electronic databases utilized during the search process are detailed in Table 2.

Table 2. Electronic databases.

Database Name	Link
MDPI	https://www.mdpi.com (accessed on 15 September 2023)
IEEE Xplore	https://ieeexplore.ieee.org/Xplore/home.jsp (accessed on 18 September 2023)
Science Direct	https://www.sciencedirect.com (accessed on 15 September 2023)
Springer Link	https://link.springer.com (accessed on 18 September 2023)
ACM	https://dl.acm.org/ (accessed on 15 September 2023)
Wiley	https://onlinelibrary.wiley.com (accessed on 20 September 2023)
Emerald	https://www.emerald.com/insight/ (accessed on 15 September 2023)
AIS	https://aisel.aisnet.org/ (accessed on 19 September 2023)
AIMS	https://www.aimspress.com/ (accessed on 19 September 2023)
ZTE	https://www.zte.com.cn/global/about/magazine/ (accessed on 19 September 2023)
BEIESP	https://www.blueeyesintelligence.org/ (accessed on 20 September 2023)
IOP	https://ioppublishing.org/ (accessed on 19 September 2023)

3.3. Search Terms

To ensure a thorough search of pertinent studies, it is crucial to identify the appropriate search terms. Kitchenham et al. [15] introduced the population, intervention, comparison, and outcome (PICO) perspective as a valuable framework for this purpose. This perspective has been widely adopted in numerous systematic literature reviews (SLRs). Below, the relevant PICO terms are listed:

- Population: primary studies on the Internet of Things;
- Intervention: IoE innovations;

- Comparison: problems, innovation, advantages, limitation performance metrics, and future directions;
- Outcome: innovation, advantages, and limitations of IoE technology.

("Internet of Things" OR "Internet of Everything" OR "Internet of Everything Technologies" OR "Internet of Everything Trends" OR "Internet of Everything Limitation" OR "Internet of Everything Innovations") AND ("Artificial Intelligence" OR "Smart Environment" OR "Smart Systems" OR "Cloud Computing" OR "Security Privacy" OR "Network Technologies")

3.4. Inclusion and Exclusion Criteria

In this systematic mapping study, inclusion and exclusion criteria were used to select and excludestudies from the data sources to answer the RQs. These criteria were applied to all studies retrieved during the different phases of the study selection procedure (see Table 3). Early cited articles were also included, provided the full text was available.

Table 3. Inclusion and exclusion criteria.

	Inclusion Criteria
IC1	Articles that are peer-reviewed
IC2	Articles providing the IoE and domain used
IC3	Inclusion of the most recent article in the case of multiple studies on the same theme
IC4	Articles published from 2014 to 2023
	Exclusion Criteria
EC1	Articles that do not meet the inclusion criteria
EC2	Articles that are only available in the form of an abstract or presentation
EC3	Studies in languages other than English
EC4	Studies with no validation of the proposed techniques or validation solely through expert opinion
EC5	Articles providing unclear results or findings

4. Results and Discussion

In this section, all the RQs are answered by analyzing the results extracted from the collection of primary studies. In the course of our discussions, each primary study is referenced using a unique Paper Identification (PID), and these PIDs correspond to the research works summarized in Appendix A.

4.1. RQ1: To Which Domains Has the IoE Been Heavily Applied?

This research question aims to provide a comprehensive overview of the collective endeavors of researchers who have dedicated their studies to similar domains, thereby fostering a broader understanding and development of IoE applications. The following domains and their respective researchers have demonstrated shared objectives within their distinct domains.

The Healthcare Domain: Researchers [16–18] have contributed 6% of the total noteworthy contributions to IoE-driven innovations, and their studies all fall within the healthcare domain compared with other domains. These shared objectives underscore the unwavering commitment of these researchers to enhancing healthcare services, promoting seamless information integration, and ultimately benefitting patients, healthcare providers, and various stakeholders.

Smart Cities and Urban Environments: In the domain of smart cities and urban environments, complementary efforts from [7,19–22] have contributed 13% of IoE applications, with influential contributions to this domain. Their shared goals revolve around optimizing urban resource allocation, reducing latency, and nurturing sustainable, green, and resilient urban environments through the integration of IoE technologies. Researchers [8,23] have focused on advancing IoE applications within smart homes. Their research initiatives collectively contribute to the convenience and energy efficiency of smart home environments.

Cloud Computing, Fog, and Edge Collaboration: Several researchers, including [20,24–28], have made significant contributions to advancing IoE integration in the field of cloud computing and collaboration. These initiatives collectively highlight the crucial role that cloud computing plays in the Internet of Everything (IoE) and its potential to offer useful services to end users. IoE skills in fog and cloud situations have been improved by researchers, including [19,29–31]. Researchers are working together to maximize the potential of cloud and fog technologies to enhance Internet of Everything (IoE) applications. In IoE research, refs. [31–34] have all advanced the field of edge computing. By emphasizing effective job scheduling and resource allocation, together, these research projects tap into the potential of edge computing in Internet of Everything applications. In the domain of cloud computing, fog, and edge collaboration, approximately 25% of the researchers included in this study have dedicated their efforts, marking it as the most prominent domain for IoE application within existing research endeavors.

The Security Domain: Researchers [35–41], have made significant contributions to the field of IoE security, with 13% of IoE research applied to this domain. Their joint research efforts address the most important issues around security and privacy in the IoE ecosystem.

Distributed Systems: The domain of distributed systems within IoE research has been contributed to by 4% of the contributions of researchers [42,43]. Their shared objective revolves around various advancement schemes for trustworthy data collection in large-scale sensor-distributed systems.

Advancements in AI and AI-Related Domains: Researchers [23,44] have made significant strides in leveraging artificial intelligence and related domains, contributing 4% to the broader IoE research landscape. Their domain-specific focus involves enhancing industrial robotics and manufacturing through innovative sensor devices.

Optimization of Network Technologies: Various researchers [3,24,45,46] have made 8% contributions to IoE research in the domain of network technology optimization. Through the connection of terrestrial IoT networks and the resolution of associated problems, their research aims to improve networking performance.

Business Strategies: Researchers [47–51] have extended IoE research into the realm of business strategies. Together these, research initiatives explore the transformative potential of the IoE in various business contexts. The business domain makes a substantial contribution, accounting for approximately 9% of the overall IoE applications compared with other domains.

The Education Domain: In the field of education, 6% of IoE research is applied to this domain. Researchers [52–54] are focused on unlocking the revolutionary possibilities offered by the Internet of Everything (IoE). These research initiatives, taken together, aim to improve educational experiences and reinforce security by incorporating IoE platforms.

The Smart Systems Domain: Within the domain of smart systems, researchers [37,44,55,56] share common objectives in IoE research contributing significantly to the research landscape, with an 8% contribution among other domains. These researchers have successfully enhanced relevant strategies within the smart systems domain.

The Agriculture Domain: In the domain of agriculture, researchers [27,57] have made significant contributions, with IoE technologies representing 8% of their collective efforts to enhance agricultural best practices.

In summary, a total of 11 diverse domains within the Internet of Everything (IoE) landscape have benefited from the collaborative efforts of researchers who share common objectives, which are described in this study. As depicted in Figure 3, the cloud computing, fog, and edge collaboration domain represents 25%, signifying its substantial prevalence in the IoE landscape compared with other domains. This prominence can be attributed to its central role in enabling IoE services, minimizing latency, and streamlining data processing and analysis. This domain effectively caters to the fundamental infrastructure and connectivity demands of IoE, rendering it a primary focal point for researchers and practitioners in this field.

Collectively, these researchers have contributed to the advancement of similar domains, addressing critical challenges and fostering innovation through their IoE expertise. Therefore, there are also interconnections between researchers' work in various domains. This interdisciplinary collaboration leads to innovations that leverage IoT technologies to address complex challenges across diverse domains. Table 4 offers a structured summary of the number of studies within the IoE field, illustrating the interconnections among studies in different domains and their contributions to diverse IoT applications. Furthermore, as addressed in RQ1 discussions, Figure 3 presents the percentages of research undertaken in various domains, enhancing the comprehensibility of the analysis.

Table 4. Number of studies and interconnections in IoT applications.

Domain	Primary Studies	Interconnections in IoT Applications	Number of Papers
Healthcare	PS1, PS3, PS21	Remote patient monitoring systems: IoT-enabled healthcare.	3
Smart Cities	PS2, PS5, PS8, PS9, PS22, PS48, PS50	Smart traffic management systems: real-time IoT monitoring for urban mobility and resource allocation.	7
Smart Systems	PS4, PS35, PS49, PS46	Innovations in industrial robotics and sensor devices: IoT applications in manufacturing and automation.	4
Cloud, Fog and Edge	PS6, PS29, PS39, PS40, PS52, PS7, PS12, PS41, PS43, PS11, PS23, PS26, PS30	Edge computing for real-time data processing: reducing IoT latency and enhancing efficiency.	13
Security	PS13, PS24, PS25, PS27, PS33, PS36, PS37, PS47	Multifactor authentication solutions: strengthening IoT security across various domains.	7
Distributed Systems	PS10, PS54	Trustworthy data collection methods: enhancing data quality in IoT applications.	2
AI	PS18, PS19	Innovations in AI: IoT applications in industrial automation.	2
Networks	PS17, PS20, PS51, PS53	Optimal network solutions: strengthening IoT across various network domains.	4
Business	PS14, PS28, PS32, PS38, PS42	Innovative business models: leveraging IoT for supply chain optimization and operational efficiency.	5
Education	PS34, PS44, PS45	Interactive learning environments: using IoT for enhanced educational experiences and security.	3
Agriculture	PS16, PS31	Precision agriculture solutions: real-time IoT monitoring for sustainable farming.	2

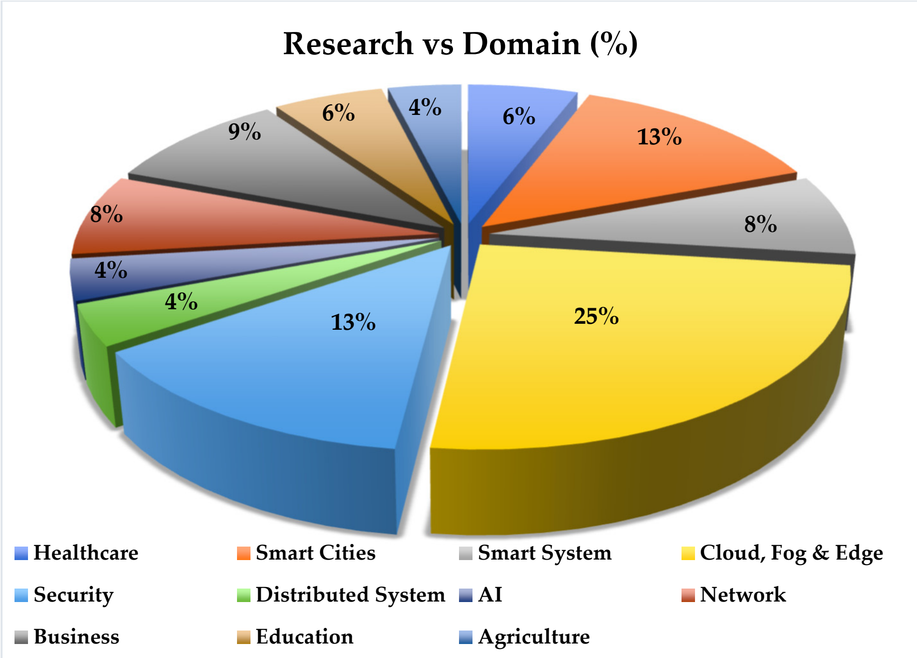

Figure 3. IoE technology in various domains.

4.2. RQ2: What Types of Problems Exist in IoE Innovations?

The Internet of Everything (IoE) encompasses a wide range of innovations and technologies that aim to connect not onlydevices and people, but also data, processes, and things in a more comprehensive and integrated manner. As a result, IoE innovations can address a diverse set of problems and challenges across various domains. Based on the analysis of this study, we identify the current problems in IoE innovations. Below are some common types of problems in IoE innovation.

4.2.1. Healthcare

As healthcare becomes more patient-centric, it needs a multilayer architecture to manage the enormous amount of data generated by the system, such as to control COVID epidemics/pandemics while maintaining privacy and addressing protection issues in healthcare [16,17]. The proliferation of the e-commerce market has posed challenges to staff safety, product quality, and operational efficiency, especially for cold-chain logistics (CCL). Recently, the logistics of vaccine supply under the worldwide COVID-19 pandemic has re-aroused public attention and led to calls for innovative solutions to tackle the challenges remaining in CCL [18].

4.2.2. Smart Environments

Due to the unprecedented increase in the use of IoE technology and the volume of data it generates, there is a need to develop a state-of-the-art architecture to support a wide range of applications to manage smart city resources efficiently and intelligently [19,47]. The main challenge in realizing the smart city vision is providing seamless interoperability between the IoE entities [7]. This is due to most of the systems nowadays working in a silo-based manner and not being able to be connected or communicate with other systems [8,20,23]. Security has become a hot subject of particular concern, with issues of complicated technology and a massive volume of data [37]. The IoE also poses considerable challenges to firms, including the development of interoperability between systems, coping with entrenched industry partners that do not collaborate with the new developments, path-dependent legacy processes and transactions, contractual and liability issues, security challenges, loss of control, as well as privacy concerns related to the explosion of data collected and used by businesses and their smart things [41,44,48,58].

4.2.3. Power Systems, Virtualization, Distributed Systems, and Automation

The IoT evolves into the IoE by incorporating the concept of things. A further step towards a Tactile Internet requires significantly reduced latency [3]. The coordination and management of the IoE in different equipment is challenging, and the energy consumption efficiency could be much higher, which is the bottleneck of battery-operated IoT equipment [46]. To meet the growing demands for IoE devices, the current power supply system needs improvement in both system and unit-level energy storage and management [55]. Challenging environments include environments where the medium is inhomogeneous, or the signal propagation is subject to high scattering and multipath effects. In addition, peer-to-peer networking of small devices and smart sensors will attract even more attention, with increased integration of participator sensing within the Internet of Things [29]. The disaster area is a constantly changing environment, making it challenging to distribute supplies effectively. The lack of credibility of IoE devices' data operations, trust evaluation, and accurate information about the required goods and potential bottlenecks in the distribution process can be detrimental [42,43]. The IoE is expected to reinvent the business and the automation wheel altogether. From operational models to business and manufacturing frameworks, everything is likely to change with the change in data available and the smart connectivity between people and machines for critical decision making [59]. For several IoT applications, a long range, low cost, and low power consumption are the main connectivity constraints to meet, making many network technologies impractical [60].

4.2.4. Cloud, Fog, and Edge

Sensory infrastructure deployment and sensing technique development across different domains may share common challenges and specificities, which should be considered when designing an architecture. That is, sensors or sensory infrastructures belonging to one domain should be transmitted to and used by another domain when needed [24,26]. One main challenge is moving these data from the underlying IoT to the cloud; architecture must support resource sharing across other domains [26,28]. Malicious attack detection and mitigation are essential issues for the Internet of Everything (IoE) [29]. Massive devices will lead to explosive traffic growth, which in turn will cause a significant burden for data transmission and content delivery [25,33]. The distributed environment used for the IoE's generation of big data (BD) has the potential to lead to data storage and processing problems. Inherent problems are the reason for the inefficient working of the applications in the cloud environment [21,22,34]. Several challenges include the significant fluctuation of user devices' requests at the edge side, the lack of collaboration among edge nodes, service delays, resource exploitation in multidevice fog-cloud architecture, and problems associated with time-sensitive applications [19,30–32].

4.2.5. Digital Marketing and Blockchain

Ongoing challenges persist in maintaining security within this context, while also adapting to evolving legal privacy requirements, many of which demand further technical clarification [60]. In the age of the Internet of Everything (IoE), intricate patterns of connectivity emerge among individuals, processes, data, and devices. When evaluating the assessment of companies operating within the IoE industry, the predominant issue revolves around substantial uncertainty [51]. Critical concerns in the IoE domain include user consent and data security, encompassing mobile devices and diverse service providers [27,58]. In the IoE ecosystem, the majority of "things" consist of low-power, low-performance devices. Several device attributes, such as security, privacy, power consumption, and computational capabilities, pose challenges when integrating a blockchain environment into the IoE [35].

4.2.6. Data Security and Deep Learning

With the increasing ubiquity and sophistication of facial recognition technology, a potential security and privacy concern regarding the exposure of facial data linked to sensitive personal information within the expansive Internet of Everything application platform arises [40]. Across various domains, the Internet of Everything generates copious data, encompassing domains like healthcare systems, traffic management, smart city surveillance, educational platforms, social networks, and government entities, among others. Scouring through this extensive dataset and locating specific data or keys presents a formidable challenge [56]. To safeguard the integrity of data, multiple security protocols operate in tandem with confidential keys, aiming to furnish security services. The primary hurdle lies in securely exchanging or distributing keys between two parties operating over an inherently insecure network [39]. Most existing anomaly detection solutions within the Internet of Everything are characterized by time-consuming processes and exhibit suboptimal accuracy levels [61].

4.2.7. Agriculture

The combined forces of climate change and a swiftly growing global population have significantly burdened agriculture. This, in turn, has created a ripple effect on the Earth's water resources, a critical component of sustainable development. The imperative to transition away from fossil fuels for powering irrigation systems, prompted by climate change, necessitates striking a delicate balance [57]. Addressing the challenges within this sector is pivotal in order to reinvigorate it and propel it towards enhanced progress [27].

4.2.8. Education

Teaching has evolved beyond the mere transmission of content knowledge; it now emphasizes the development of the practical "how, when, and why" aspects of applying this knowledge in real-world contexts [53]. The complexity in designing and implementing IoE-based educational systems arises from the need to create multiple intelligent agents that infuse intelligence into every facet of the teaching–learning experience. The absence of intelligence within IoE-related systems can impede the management of the vast volume of information generated by individuals and devices within these systems [52]. To establish a smart campus, a range of systems is essential, including those for detection, monitoring, and analysis [54].

Based on the discussion, Table 5 has outlined the common challenges encountered in IoE innovation across diverse domains. Meanwhile, Figure 4 showcases the specific number of problems that researchers have focused on within their respective domains in the IoE landscape.

Table 5. Common problems in IoE innovation.

Primary Studies	**Common Problems in IoE Innovation**
PS1, PS3, PS21	Data Management, Privacy, COVID-19 tracking
PS2, PS5, PS8, PS9, PS22	Data Volume, Interoperability, Security, Resource Management
PS51, PS53, PS4	Low Latency, Energy Efficiency, Coordination, Disaster Management
PS6, PS39, PS52, PS15, PS40	Data Sharing, Security, Traffic Growth, Data Storage and Processing
PS30, PS42, PS40, PS35, PS13	Data Security, Privacy, Low-Power Devices, Connectivity Challenges
PS36, PS46, PS33, PS18	Facial Recognition Security, Data Search, Key Exchange
PS16, PS40	Climate Change, Energy Efficiency, Water Resources, Crop Quality
PS34, PS44, PS45	Educational Systems, Intelligence, Security
PS4, PS49, PS35, PS46	Power Supply, Tourism Management, Cognition, Data Searching

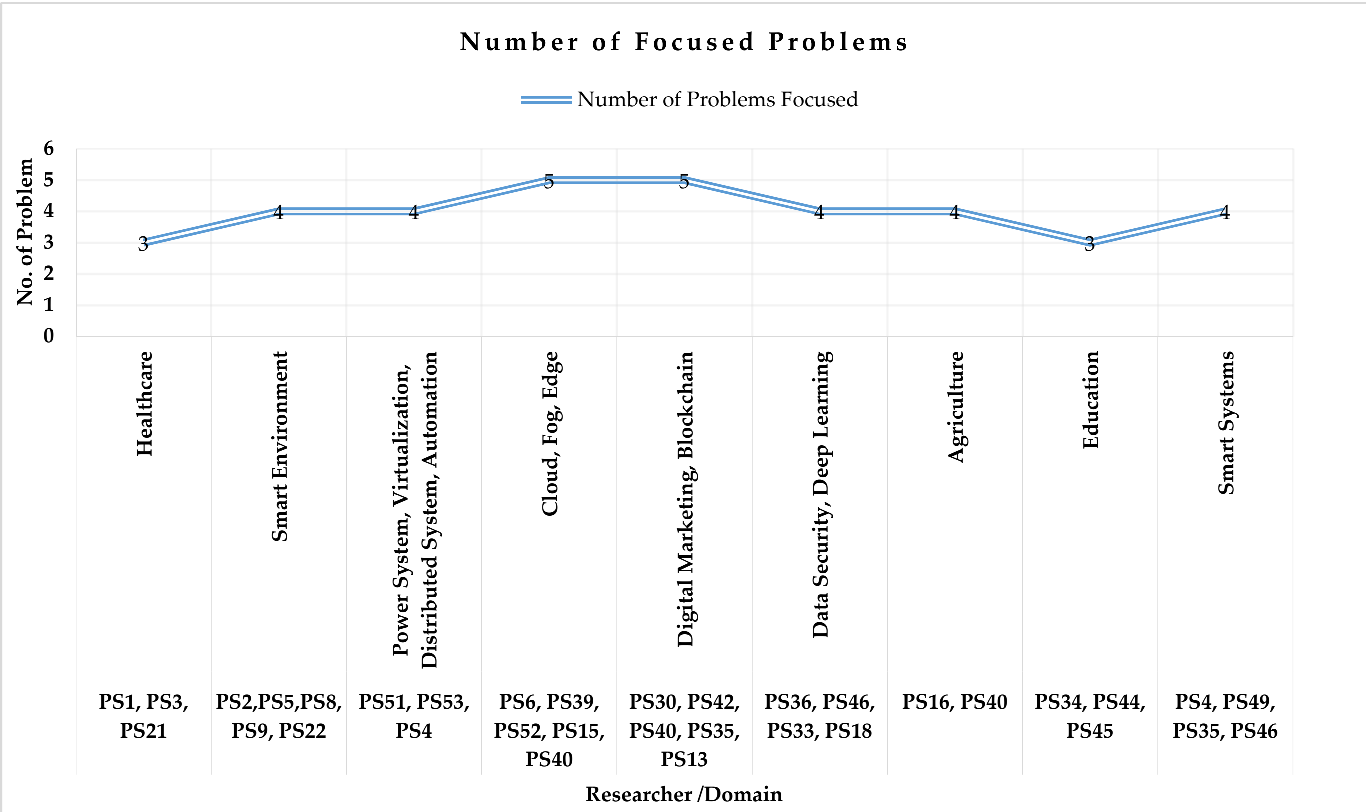

Figure 4. Number of IoE problems focused on.

4.3. RQ3: What Is the Contribution of the IoE to Each Innovation?

Researchers from different fields have strived to harness the IoE's potential for addressing domain-specific challenges. This subsection synthesizes their efforts, highlighting common themes in research contributions.

4.3.1. Healthcare

An exceptionally spectacular usage of the IoE was while the whole world suffered with the COVID-19 pandemic. The healthcare domain has witnessed significant IoE-driven improvements, and one of them is aimed at tracking and containing pandemics such as COVID-19 [16]. Leveraging accurate tracking technologies, cloud computing, and interoperable devices, researchers have focused on screening and identifying infected individuals during their daily routines. Other research endeavors [17,18] have proposed a multilayer architecture and a cyber-physical platform framework that applied the Internet of Everything (IoE) and digital twin (DT) technologies, respectively, to promote information integration and provide smart services for different stakeholders in the healthcare area.

4.3.2. Smart Cities and Urban Environments

Smart cities have been at the forefront of IoE research, with a focus on resource allocation and job offloading architectures using intelligence-enriched 6G architectures [19]. The concept of EdgeOSH [20] has been introduced, revolutionizing home automation through edge computing. Researchers [21,22] have adopted fog aims to enhance data processing through the blockchain–fog architecture network (BFAN) whereas others [22] have introduced fog nodes (FN) within fog computing (FC) to facilitate IoT applications in urban environments, satisfying mobility support, low latency, and geo-distribution requirements. As a part of smart cities, [8] specifically focused on smart homes through introducing convenience and energy efficiency to daily life within smart homes.

4.3.3. Cloud, Fog, and Edge Collaborations

Mutual objectives shared by several researchers [24–28] were achieved through adopting cloud, fog, and edge environments in IoE. Researchers have proposed a cloud-based architecture for resource sharing (CARS) and the energy-efficient cloud-based Internet of Everything (EECloudIoE) [25]. These architectures introduce geographically distributed platforms connecting sensors and various IoE components, providing valuable services to end-users. Dhaya and Khantavel contribute to this landscape by focusing on algorithmic efficiency within multi-data-center environments, further optimizing resource management in cloud-based IoE platforms [28]. Moreover, the paper [26] underscores the importance of integration by outlining a research agenda for the integration of IoT and cloud computing across various application fields. The peer-to-peer central-registry-biased Internet of Everything protocol (P2PRioEP) [27] formalizes provisions for hybrid peer-to-peer IoT networks, promoting efficient collaboration and data exchange within IoE ecosystems. Xu et al. introduce adaptive mechanisms for dynamically collaborative computing power and task scheduling (ADCS) [32]. This approach enhances the efficiency of edge computing by dynamically allocating resources and tasks, aligning to optimize edge computing in IoE scenarios. Yi et al. reimagine IoE as an end–edge–cloud collaborative system that promotes the development of digital twin-based methods within edge computing [33]. Jain et al. highlight the importance of cyber twins in network frameworks by introducing a metaheuristic with blockchain-based resource allocation techniques [34]. Sachdev navigates key security and privacy issues related to edge AI in IoT/IoE digital marketing environments [56]. Bera et al. focus on enhancing security by introducing an artificial-intelligence-based blockchain-envisioned access control framework. This framework addresses the critical need for robust security measures within fog and cloud environments [29]. Velasquez et al. identify key challenges in developing a fog orchestrator to support IoE, particularly its impact on fog service orchestration tasks [30]. This research objective aims to streamline the orchestration of services within fog environments, ensuring efficient and reliable IoE operations. The objective of [31] is to introduce a conceptual model for mixed reality (MR) applications within fog and cloud environments. By enhancing user experiences through IoT/IoE models, this research contributes to the evolving landscape of mixed reality applications, which is increasingly relevant in the context of IoE.

4.3.4. Advancements in AI

The authors of [59,61] both leveraged artificial intelligence in the IoE to enhance anomaly detection. The authors of [61] propose a novel deep learning framework that combines decomposition methods, deep neural networks, and evolutionary computation. Furthermore, innovations in force and tactile sensors, along with AR sensors, drive advancements in industrial robotics and manufacturing [59].

4.3.5. Security in the IoE

Security remains a paramount concern in IoE research. Innovations include novel blockchains such as "PUFChain" [35], which is designed for resource-constrained IoT environments. Various authentication schemes have been proposed for 6G IoE-based vehicular communication environments [36], emphasizing privacy preservation and security. Security and privacy challenges posed by personal smart devices used within enterprise settings were explored by [41]. Zhan et al., in their study, introduced the Internet of Everything smart logistic network (IoE-SLN) to improve smart logistics [37]. Various transportation system applications were integrated to enhance logistics parameters, supported by mathematical analysis. IoE research on distributed systems focuses on disaster management [42]. Researchers propose the integration of blockchain, the IoT, and the IoE to streamline disaster responses, reduce response times, and ensure the secure distribution of goods. Furthermore, content-based intelligent trust evaluation (CITE) schemes have been introduced for collecting trustworthy data in large-scale sensor-cloud systems [43].

4.3.6. Optimization of Network Technologies with IoE

The virtualization of networking services is explored, with a focus on customized and on-the-fly interconnectivity [29]. Other research emphasizes connecting terrestrial IoT network segments to satellite backends via satellite broadband [62]. Further, Iannacci aims to build an inclusive vision of the IoT, IoE, Tactile Internet, and 5G by leveraging MEMS technology, with a focus on energy harvesters (EH-MEMS) and radio frequency passives (RF-MEMS) [3]. A data manipulation method proposed by [46] aims to reduce energy consumption and network traffic in IoT networks, with an enhancement from software-defined networking (SDN).

4.3.7. Enhancing Business Strategies via the IoE

IoE research extends to the realm of business strategies. Researchers explore how the IoE impacts business models and value creation [48]. Additionally, studies evaluate the implications of the IoE on marketing analytics [49], new product development, and management [50]. Approaches for determining objective and subjective weights in decision making are also introduced [51]. Demirkan et al. explored the impact of emerging big data and smart analytics on transforming connected products into "smart service" businesses [47]. This described a paradigm shift in value chains towards continuous data flow through complex business systems.

4.3.8. The IoE in Education

Looking at an education perspective, the IoE has a transformative potential in improvising the field of learning. Ref. [52] focuses on developing system of systems (SoS) architectures to support educational contexts, fostering novel educational applications and dynamic interactions. Secure and agile architectures for IoE-based educational models and learning analytics systems (LAS) are proposed [53]. Furthermore, campus security management and notification systems are designed to enhance security and monitoring [54]. Researchers have similar objectives in terms of providing advancement in education services in the IoE environment.

4.3.9. IoE Research for Smart Systems

The authors of [44,55] are both engaged in the area of smart systems in IoE research. Specifically, their research underlines the significance of efficient power supply systems with a high-output performance and extended lifetime, placing a strong emphasis on self-power capability in order to guarantee the long-term viability and maintenance-free operation of IoE networks. Additionally, these researchers expand their focus to include the design of architectural models for managing tourism information effectively, introducing the concept of smart tourism [44]. Fan et al., in their paper, describe that their objectives revolve around enhancing power supply systems and architectural models for the IoE while incorporating tourism management strategies [55]. Next, in their research, Pedro et al. introduced a cognition module for gathering information from smart systems to create knowledge for intelligent services [58]. The goal was to develop a generic framework for various smart systems, enabling horizontal integration. Similarly, research by Vaya and Hadpawat aimed to provide efficient keys or data-searching mechanisms for clients to explore big data within a database [56]. The respective studies share common objectives in the realm of IoE in terms of contributing to various smart system enhancements. Adenugba et al. demonstrated how smart irrigation systems powered by renewable energy sources (RES) could substantially improve crop yield and agricultural profitability [57]. They emphasized control and monitoring using sensors and environmental data from the Internet of Everything (IoE). Kumar et al. aimed to attain a standard quality in crops, focusing on duration, measure, hygiene, and blooming stem. They proposed an advanced prototype to enable continuous tracking and informed decision making for farmers, using data mining principles [27]. Researchers have proposed smart operating systems to streamline IoE system management for practitioners [23].

Further, the emerging areas in Internet of Everything (IoE) research were examined, revealing several key domains where researchers have made notable contributions. Figure 5 illustrates this and includes smart cities (23.08%), marked by urban applications and resource allocation; smart systems (30.77%), focusing on efficient power supply and architectural models; cloud/fog/edge (15.38%), involving collaborations between the IoE and cloud technologies; disaster management (15.38%), integrating blockchain and the IoT for logistics and disaster response; network technologies (7.69%), emphasizing networking virtualization; and education (7.69%), aiming to enhance educational systems. Smart systems garnered the most attention from researchers, with smart cities being the second most explored domain. This analysis showcases the multifaceted nature of IoE research, spanning various domains and applications.

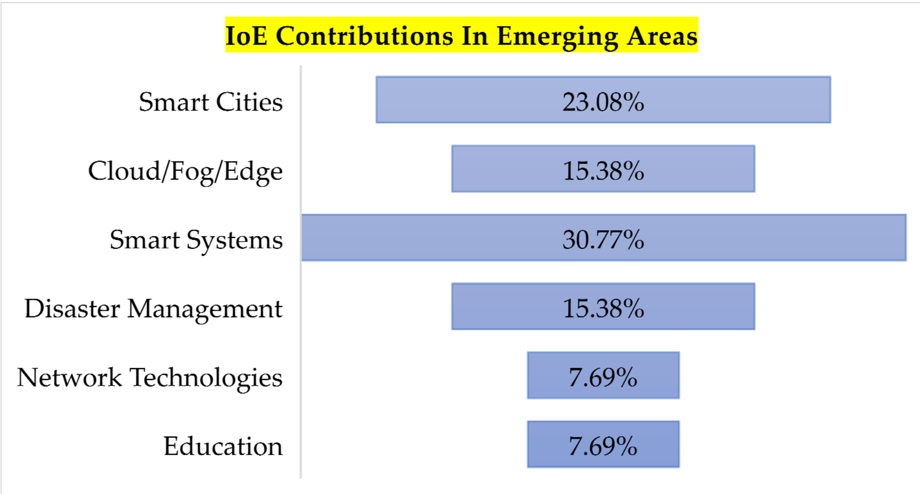

Figure 5. Contributions in Emerging Areas.

The research contributions summarized in this article emphasize the IoE's versatility and transformative potential. They highlight the diverse ways in which IoE technologies can address domain-specific challenges and inspire interdisciplinary collaboration. As the IoE continues to evolve, researchers from various domains are poised to contribute to its growth and maturity [63].

4.4. RQ4: What Are the Most Frequently Used Evaluation Metrics?

Evaluation metrics play a vital role in gauging the quality of the IoE. Various evaluation metrics are at our disposal for assessing IoE innovation, as illustrated in Figure 6. The lines and circles in Figure 6. represent the evaluation metrics and the total number of primary studies associated with the enhancement of each specific performance metrics. The employment of multiple evaluation metrics is of paramount importance, since an innovation may excel under one metric but underperform when assessed with another [64]. Therefore, selecting the right evaluation metrics is crucial for ensuring the proper and optimal development of IoE innovation. Quantitative evaluation, a methodology that relies on numerical indices derived primarily from objective data collection methods, systematic and controlled observation, and a well-defined research design, comes into play. Specifically, it is imperative to specify the evaluation metric. Within the realm of IoE innovations, the researchers in this study primarily considered accuracy, energy consumption, power consumption, completion time, and cost as the most significant dimensions for evaluation, as illustrated in Table 6.

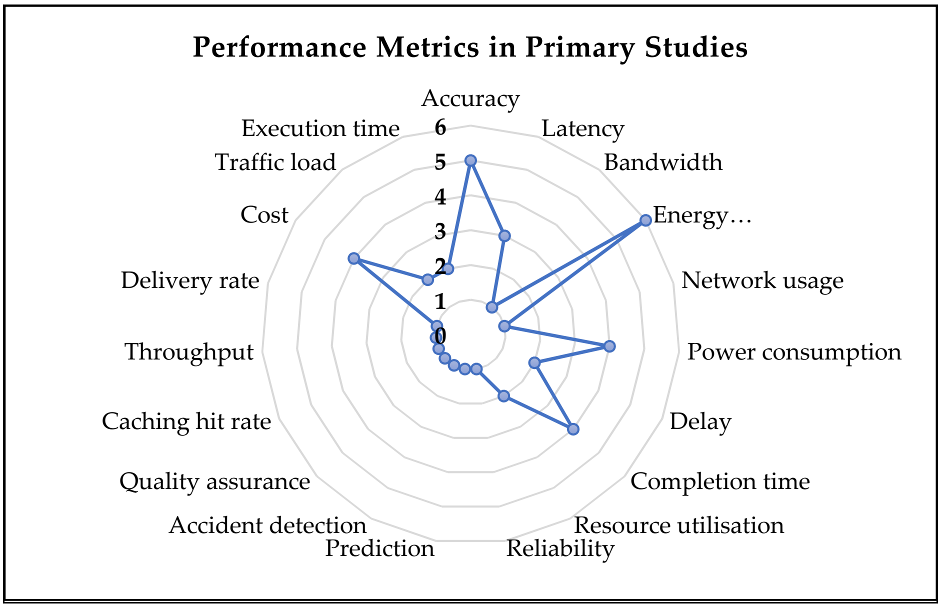

Figure 6. Visualization of performance metrics used in IoE.

Table 6. Performance metrics in primary studies.

Performance Metric	Primary Studies	Number of Papers
Accuracy	PS1, PS18, PS21, PS25, PS43	5
Latency	PS2, PS3, PS8	3
Bandwidth	PS2	1
Energy consumption	PS3, PS4, PS8, PS10, PS29, PS53	6
Network usage	PS3	1
Power consumption	PS4, PS9, PS26, PS43	4
Delay	PS10, PS12	2
Completion time	PS11, PS12, PS13, PS18	4
Resource utilization	PS11, PS26	2
Reliability	PS12	1
Prediction	PS16	1
Accident detection	PS21	1
Quality assurance	PS21	1
Caching hit rate	PS23	1
Throughput	PS23	1
Delivery rate	PS23	1
Cost	PS26, PS33, PS38, PS54	4
Traffic load	PS29, PS53	2
Execution time	PS33, PS43	2

4.5. RQ5: What Are the Limitations in Each IoE Innovation?

In the realm of Internet of Everything (IoE) research, several research works across various domains have made significant contributions, but they are not without their limitations. These limitations, when analyzed collectively, provide valuable insights into the challenges faced by researchers in harnessing the potential of the IoE. The limitations identified in most of the research works are summarized below.

4.5.1. Storage Challenges

Several research works, such as [16], highlight the challenge of high storage usage when collecting data in IoE applications. The sheer volume of data generated by IoE devices can lead to storage constraints, impacting the scalability and long-term feasibility of solutions. Limited storage capacity, as observed in [17], can result in extended data transfer times to the cloud. This limitation hampers the timely availability of critical information, potentially impacting decision making processes.

4.5.2. Computation Overhead

Computation-intensive tasks, driven by multiple scheduling algorithms, as can be seen in [19,33], can lead to a high computational overhead. This limit affects the efficiency and real-time performance of IoE systems, especially in resource-constrained environments. In IoE systems, especially those involving financial transactions, drawbacks related to latency, as identified in [42], can impact the overall user experience. Transaction processing delays may deter users from adopting IoE solutions.

4.5.3. Power Supply Assessment

The research work [55] emphasizes the need for a more comprehensive assessment of power supply systems in IoE. Neglecting to evaluate the continuity and quality of power supplies can lead to disruptions in IoE applications, particularly in scenarios where uninterrupted power is crucial.

4.5.4. Lack of Assessment

Some research, including [20], has limitations in terms of assessment. Failure to evaluate factors such as user experience, cost, and delay can result in incomplete insights into the overall performance and feasibility of IoE solutions.

4.5.5. Data Size Effect

The impact of the data size on performance [34], as mentioned in [37], can be a significant disadvantage. The researcher overlooked and underestimated the need for efficient data handling and processing techniques in IoE applications.

4.5.6. Cost-Intensive Technologies

High costs associated with infrastructure, such as core cloud connectivity via high-speed optical links pose a limitation in terms of the scalability and affordability of IoE deployments, as in [34]. Nevertheless, Ref. [29] used blockchain technology, known for its cost-intensive nature. Hence, implementing such technologies, as [29,34] do, can lead to high expenses, making scalability and cost-effectiveness challenging.

4.5.7. Technical Feasibility

The research work [48] focuses on business model management but may not be directly applicable at the technical infrastructure level. This constraint highlights the need for aligning business models with technical feasibility.

4.5.8. Response Time Oversights

Response time oversights, as noted in [19], can be resulted from extensive routing packets in networks. Equally, Ref. [27] focused on passing messages safely; however, the response time was not measured as well as in [39]. Failure to consider response times can impact the usability and efficiency of IoE environments.

4.5.9. Data Privacy, Accuracy, and Integration

Ensuring data accuracy and fostering inter-agency collaboration are essential for data-driven decision making in the IoE. Research works in [22] overlooked the limitations associated with data accuracy and integration between different government agencies. Elsewhere, accuracy discussions, as omitted in [53], are critical, especially in applications where precision is paramount. Data privacy in [31] needs to be addressed comprehensively to ensure the trustworthiness of IoE systems. This research is closely linked to security concerns, as discussed in [65], where data integrity emerges as a prominent issue in various cloud computing scenarios, necessitating the implementation of robust security strategies to tackle this challenge.

4.5.10. Extensive Network

Network elements, such as the case discussed in [39], disregarded the heavy utilization of the network, while the research work in [46] describes the omission of the packet loss adversely affected the network's heavy usage in their research contributions.

4.5.11. Adaptability

Dhaya and Kanthavel focused on the requirement for adaptive adaptability to a variety of platforms and contexts, neglecting the limitations of pre-defined approaches in multi-data-center systems [28].

4.5.12. Limited Data Ingestion

Conversely, studies conducted by [27,43,57] exhibit limitations related to restricted data acquisition, primarily centered on indoor data obtained from sensing devices. Broadening the scope of data sources has the potential to enrich the range of applications within the Internet of Everything (IoE) [66].

Below is a summary in Table 7, and Figure 7 presents limitations of individual research works. The lines and circles in Figure 7 illustrate the limitations of the IoE, along with the total number of primary studies that have identified similar research gaps in this area.

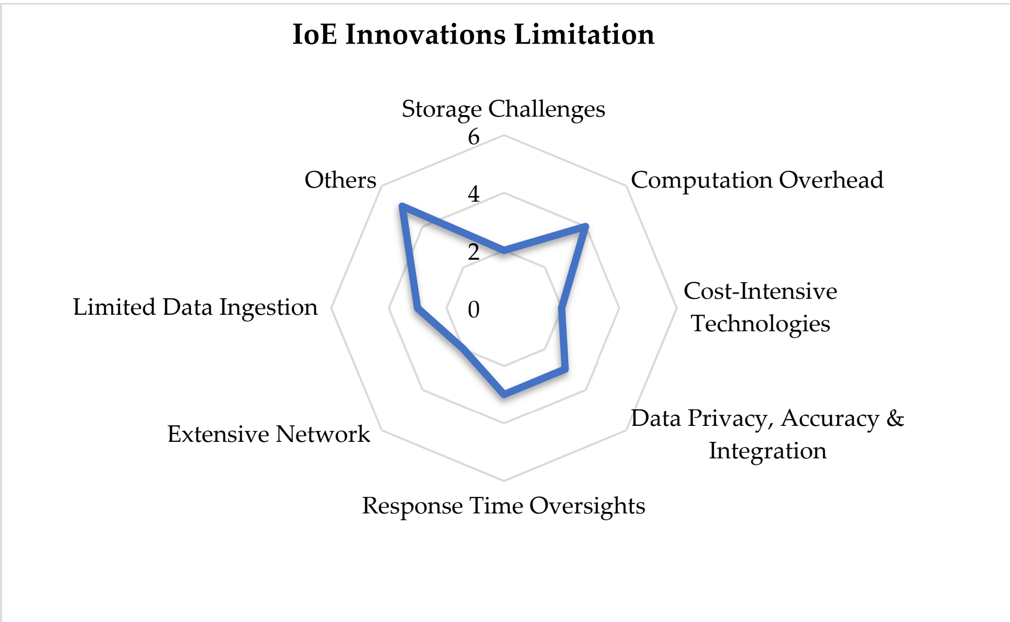

Figure 7. Limitation in IoE Innovations.

Table 7. Limitation of IoE innovation based on the primary studies.

Limitation	Primary Studies	Number of Papers
Storage Challenges	PS1, PS3	2
Computation Overhead	PS2, PS3, PS23, PS10	4
Cost-Intensive Technologies	PS7, PS26	2
Data Privacy, Accuracy, and Integration	PS9, PS44, PS43	3
Response Time Oversights	PS29, PS33, PS40	3
Extensive Network	PS33, PS53	2
Limited Data Ingestion	PS54, PS16, PS31	3
Others	PS52, PS38, PS39, PS28, PS5	5

4.6. RQ6: What Are the Trends and Directions of the IoE in Each Innovation?

In the dynamic domain of Internet of Everything (IoE) research, numerous researchers have made noteworthy contributions, each envisioning specific future avenues for advancing the field. These future research trends and directions, when clustered together based on common themes, provide a comprehensive roadmap for the IoE's continued growth and evolution.

- **Scalability and Adaptability:** Researchers, such as [16], have laid the foundation for transformative IoE applications. Future endeavors involve exploring the scalability and adaptability of these applications to accommodate evolving digital landscapes and ensure their sustained impact.
- **Component Performance:** A common thread among papers is the focus on component-level performance [19]. Researchers plan to design, evaluate, and optimize individual components within IoE systems, ensuring a deeper understanding of their roles and contributions to system efficiency.
- **Validation and Testing:** The study described in [17] emphasizes the need for rigorous validation and testing. Researchers intend to evaluate IoE systems using practical toolkits and real cloud environments, providing empirical insights and validating the practical applicability of their findings.
- **Integration and Efficiency:** Several papers, including [55], emphasize the integration of various systems within IoE networks. Future research aims to enhance the efficiency, reliability, and sustainability of these integrated systems, potentially expanding their applications.
- **Real-Time Data Analytics:** The challenge of real-time data analysis, acknowledged by researchers in [21], remains a focal point for future work. Innovations in data processing and analytics are essential to keep pace with the ever-expanding data volumes.
- **5G and IoT Management:** With the emergence of 5G, researchers, such as in [22], foresee extending their work to manage the influx of IoT devices and applications, including those requiring a low latency and high bandwidth.
- **Governance and Legal Considerations:** Studies such as [42] underscore the importance of governance and legal frameworks in the IoE, particularly in distributed ledger technology (DLT)-based systems. Future research aims include addressing governance aspects and ensuring robustness.
- **Microservices and Resource Allocation:** Xu et al. outline plans to introduce microservices and optimize computational power scheduling. This approach aligns with efforts to enhance resource allocation methods within the IoE [32].
- **Energy-Efficient Designs:** Research into ultralow power designs, as suggested by [35], will continue, focusing on achieving energy-efficient IoE systems and exploring alternative consensus algorithms.

- **Business Intelligence:** Several papers, such as [47], highlight the significance of business intelligence applications. Future work may delve into more comprehensive analytics, harnessing data-driven insights for strategic decision making.
- **Packet Routing:** Future research, as mentioned in [25], seeks to design context-based packet routing architectures. These architectures aim to optimize throughput and response times, enhancing IoE communication efficiency.
- **Renewable Energy Integration:** Researchers, exemplified by [57], envision expanding IoE systems to incorporate diverse renewable energy sources and hybrid grids. These expansions can enhance sustainability and grid independence, especially in remote regions.
- **Network Integration:** Researchers, such as in [45], emphasize the seamless integration of multiple networks. Future work explores advanced methods and mechanisms to achieve contextual and geographical integration, enriching IoE services.
- **Interdisciplinary Studies:** Researchers in the study [48] call for interdisciplinary research involving economics, computer science, psychology, law, and ethics. Collaborative efforts will provide holistic insights into the IoE's multifaceted aspects.
- **Privacy Protection:** Addressing privacy challenges in the IoE, as recognized by [40], remains crucial. Future research endeavors should focus on devising effective mechanisms and privacy management theories to safeguard user data.
- **Diverse Applications:** The versatility of IoE solutions, as seen in [53,54], prompts future work exploring applications across various domains, including healthcare and education. Gao et al. proposed a New Bee for mobile devices to find coordination from a Wi-Fi node to assist ZigBee nodes for neighbor discovery [67].
- **Semantic Interoperability:** Researchers, exemplified by [7], anticipate harnessing advanced technologies like AI and machine learning to enhance semantic interoperability solutions. These technologies can improve data analysis and collection.
- **Flexibility for Diverse Scenarios:** Future research, as indicated by [33], aims to enhance the flexibility of proposed methods to adapt to different network scenarios, ensuring versatility in IoE deployments.
- **Secure Communication:** Ensuring secure communication in the IoE, as highlighted in [36], remains paramount. To improve IoE services, future studies will put a priority on creating strong security measures.
- **Cost and Consumption Studies:** The research conducted in [34] emphasizes the need for comprehensive studies on power consumption and costs. These studies will contribute valuable insights into the cost-effectiveness of IoE solutions.
- **Common Challenges:** Addressing common challenges in IoE services was identified as a priority for future enhancement in [38]. Strategies to overcome these challenges will maximize IoE productivity and utility.
- **Edge AI Implementation:** The implementation of edge AI, as discussed in [60], poses a promising direction for future research. Scaling up edge AI applications in digital marketing settings will be a focus. In the similar AI advancement Hameed et al. devised an Internet of Things Auto (IOTA)-based mobile crowd-sensing technology utilizing machine learning to identify and prevent mobile users from participating in deceptive sensing activities [68].
- **Data Security and Privacy:** There should be more research on data security, information privacy, and personal information, according to a few papers, including [49]. The IoE's dependability will be improved through thorough security measures in future studies.
- **IoE Integration:** Future research will explore IoE integration with edge and fog computing environments, as envisioned by [26]. This exploration seeks to optimize the synergy between these paradigms.
- **Efficiency Enhancement:** Researchers, exemplified by [28], aim to leverage AI techniques to reduce energy consumption in multi-data-center cloud environments, aligning with sustainability goals.

- **Performance Metrics:** Researchers, as indicated by [46], propose additional performance metric evaluations. These evaluations will offer a comprehensive understanding of IoE systems' performance.
- **Data Acquisition Strategies:** Zheng et al. highlight the recruitment of a broader range of data collectors for enriched data acquisition strategies in future work. Expanding data sources can enhance the breadth and depth of IoE applications [43].

The future directions for Internet of Everything (IoE) research encompass a broad range of domains and applications. Researchers are focusing on scalability, component performance, validation and testing, integration and efficiency, real-time data analytics, 5G and IoT management, governance and legal considerations, microservices and resource allocation, energy-efficient designs, business intelligence, packet routing, renewable energy integration, network integration, interdisciplinary studies, privacy protection, diverse applications, semantic interoperability, flexibility for diverse scenarios, secure communication, cost and consumption studies, addressing common challenges, edge AI implementation, data security, IoE integration, efficiency enhancement, performance metrics, and data acquisition strategies. These diverse avenues collectively contribute to the development of a more interconnected and intelligent future in the realm of the IoE, addressing challenges and enhancing system efficiency across various sectors and applications. Table 8 presents the consolidated primary studies with similar areas of future work in the context of Internet of Everything (IoE) research.

Table 8. Future directions for IoE innovations.

Area of Future Work	Primary Studies	Number of Papers
Scalability, Adaptability, And Integration	PS1, PS4, PS18, PS21, PS39, PS40, PS44, PS45	8
Component Performance	PS2	1
Validation, Testing, And Secure Communication	PS3, PS24	2
Real-Time Data Analytics	PS8	1
5g And IoT Management	PS9	1
Governance, Legal Considerations, And Interdisciplinary Studies	PS10, PS28	2
Microservices, Resource Allocation, And Efficiency Enhancement	PS11, PS52	2
Energy-Efficient Designs and Cost Studies	PS13, PS26	2
Common Challenges and Performance Metrics	PS27, PS53	2
Packet Routing and Edge AI Implementation	PS15, PS29, PS30	3
Semantic Interoperability and Flexibility	PS22, PS23	2
Business Intelligence	PS14	1
Privacy Protection and Data Security	PS32, PS36	2
Cognitive Layer Refinement	PS35	1
Multicriteria Decision Making and Adaptability	PS42	1
Scientific Experiments and Data Acquisition Strategies	PS34, PS54	2

4.7. RQ7: What Are the Demographics of the Primary Studies?

To address this research question (RQ), an investigation into three key facets of the primary studies was conducted. These aspects encompassed the publication year, the type of publication, and the primary source that has disseminated the highest number of pertinent studies (including journals and conference proceedings).

4.7.1. Publication Year

Between the years 2014 and 2023, a total of 53 publications were culled from the literature, adhering to the methodology described in Section 3 This progression is depicted in Figure 8, illustrating the evolution of the literature within the IoE domain. The research activity within this domain is notably dynamic and vigorous.

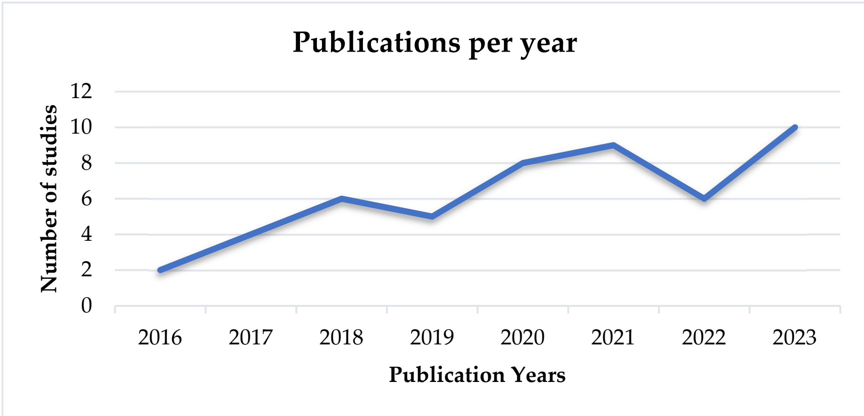

Figure 8. Number of publications per year.

During the period from 2014 to 2019, the research activity exhibited a relatively linear trend, with a limited number of publications. However, in 2023, there was a substantial upsurge in research activity centered on the IoE, resulting in 10 publications. This heightened interest can be attributed to the growing demand for the IoE. In 2022, a minor drop in publications was observable, totaling six papers. In general, despite the fluctuations in the annual number of publications concerning IoE research, the overall research activity exhibits a consistent upward trajectory, indicating sustained growth, especially over the past decade.

4.7.2. Publication Types

In the scope of this mapping study, the authors included content from a wide spectrum of sources, which included 30 distinct journals, 14 conference proceedings, 1 magazine, 1 symposium proceedings, and 1 book chapter. As illustrated in Figure 9, the majority of primary studies were derived from journal articles, totaling 35, followed by conference proceedings (14), magazines (2), symposium proceedings (1), and, finally, book chapters (1).

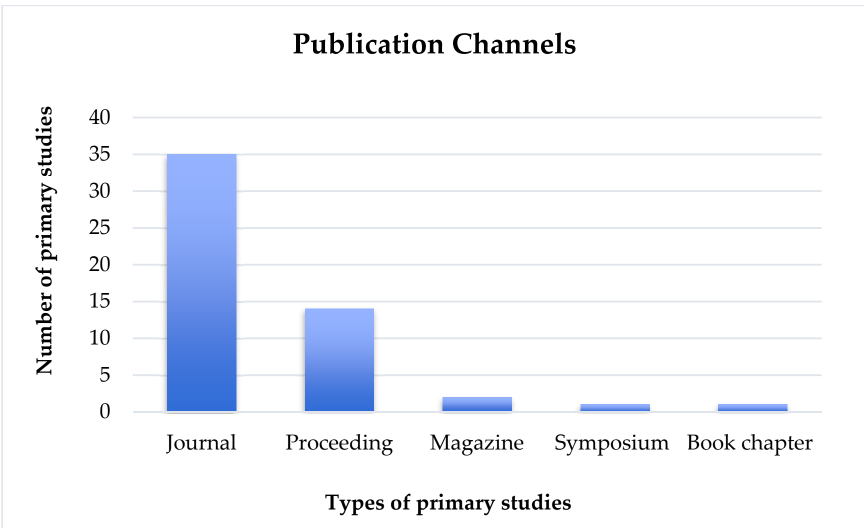

Figure 9. Publication channel.

4.7.3. Publications with Relevant Studies

Concerning the publication venues in which studies on the IoE were published, Table 9 depicts the ten most active journals. The *IEEE Internet of Things Journal* was the top contributor among all the journals, with three publications. Meanwhile, the *Internet of Things*, *Journal of Ambient Intelligence and Humanized Computing*, *Journal of Parallel and Distributed Computing*, and the *IEEE Consumer Electronics Magazine* each provided two articles. The other selected studies published one article in the following journals: *Future Internet*, *Journal of Innovation & Knowledge*, *IEEE Sensors Journal*, *IEEE Transactions on Industrial Informatics*, and *Journal of Internet Services and Applications*.

Table 9. Top 10 represented publications.

Title	Number of Papers
IEEE Internet of Things Journal	3
Internet of Things	2
Journal of Ambient Intelligence and Humanized Computing	2
Journal of Parallel and Distributed Computing	2
IEEE Consumer Electronics Magazine	2
Future Internet	1
Journal of Innovation & Knowledge	1
IEEE Sensors Journal	1
IEEE Transactions on Industrial Informatics	1
Journal of Internet Services and Applications	1

5. Conclusions

In conclusion, this study explores various facets of the Internet of Everything (IoE) technology and its innovations. The study began with a thorough review of related works in the IoE domain, highlighting key research areas and emerging trends. By defining clear research objectives, the study aimed to provide a comprehensive understanding of the IoE's vast landscape, emphasizing similarities and commonalities across diverse applications and domains.

The research has uncovered numerous advantages in harnessing IoE technology, particularly in healthcare, smart cities, cloud, fog, and edge collaborations, as well as advancements in AI-related domains, security, network technologies optimization, business strategies, education, and smart systems. These advantages emphasize IoE's transformative potential in enhancing various aspects of our lives, from healthcare management to urban living and business strategies. However, it is essential to acknowledge the limitations and challenges associated with IoE technology, including data security and privacy concerns, resource optimization, and scalability issues. Future works in the IoE domain should address these challenges, focusing on mitigating limitations and fostering innovation to unlock the full potential of IoE applications across diverse domains.

Author Contributions: Introduction and Conclusion, N.N.M.; Methodology, N.A.M.Y., E.A.S. and F.M.A.; formal analysis, N.N.M.; Resources, N.A.M.Y. and F.M.A.; Writing—Original Draft Preparation, F.M.A. and N.A.M.Y.; Writing—Review and Editing, M.M.D., E.A.S. and N.N.M.; Results and Discussions, F.M.A. and N.A.M.Y.; supervision, N.N.M. and M.M.D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

This section provides an overview of the research involving innovation in the IoE by briefly summarizing each study.

PS1: Sharma and Sigh provided progressed fitness services and enabled advanced clinical selections from a few different angles during the pandemic [16].

PS2: Jamil et al. employed intelligent task-offloading techniques with dynamic resource allocation [19].

PS3: Sasikumar and Vijayakumar presented a concept known as the fog-cloud, which is a healthcare monitoring model that uses the framework of the IoT to focus on the various challenges of healthcare [17].

PS4: Fan et al. argued that the IoE will be critically dependent on progress in the development of efficient power supply systems [55].

PS5: Cao et al. proposed EdgeOSH, which can be used as a guide for prototype practices on smart home systems [20].

PS6: Sherif et al. presented a four-layer architecture for CARS by describing the functionalities, responsibilities, and interlayer interactions of each layer [24].

PS7: Bera et al. proposed a blockchain-based framework. As a result, the AI/ML algorithms can work as per their expectation to make correct predictions with the authentic datasets stored in the blockchain [29].

PS8: Singh et al. proposed a BFAN architecture that includes an energy-efficient platform for a thing-aware wired/wireless TCP/IP connection, intra-primary communication in fog computing, and security with blockchain [21].

PS9: Naranjo et al. described that FOCAN can be classified as a computation- and communication-efficient structure and scalable routing algorithm that minimizes the average power consumption of FNs [22].

PS10: Javadpour et al. showed a significant enhancement in the performance, monitoring, and complexity management of the disaster aid network [42].

PS11: Chen et al. proposed a framework that separates the cloud and edge sides, which makes it possible to apply our algorithm in open-source platforms [32].

PS12: Manogaran and Rawal. introduced a resource allocation method in the fog-cloud architecture to minimize service delays and resource exploitation [63].

PS13: Mohanty et al. presented a new consensus algorithm, PoP, and a novel blockchain architecture, PUFchain [35].

PS14: Demirkan et al. investigated how a customer can outsource the management of their devices/networks by taking advantage of cloud computing and virtualization and demanding a guaranteed level of service agreement that includes automatic diagnostics, optimal performance, and high availability [47].

PS15: Swarna et al. developed a methodology for integrating the Internet of Everything (IoE) with the cloud to create the efficiently named energy-efficient cloud-based Internet of Everything (EECloudIoE) using wind-driven optimization and Firefly bio-inspired algorithms [25].

PS16: Adenugba et al. developed a system that demonstrated the viability of the IoE-based approach for solar-powered smart irrigation systems with the use of artificial intelligence [57]

PS17: Younis aimed to create a smart living environment where communication and services are seamlessly adapted to the context [45].

PS18: Djenouri et al. proposed a combination of decomposition, deep neural networks, and evolutionary computation to find anomalies in the dataset [61].

PS19: Jinan and Sabah proposed new forms of force and tactile sensors, along with AR sensors, that provide feedback based on the sense of sight as well as the latest innovations in industrial robotics and manufacturing [59].

PS20: Maria and Nicola describe how to enable the IoE with LPWAN (LoRaWAN in particular) and a GEO-based satellite segment [62].

PS21: Shen et al. introduced the real-time location and working status of humans, together with gateway layout and operating status, which are twined and visualized in a tracking map [18].

PS22: Antonios et al. provided research insights, including the introduction of a new evaluation framework that assesses semantic interoperability solutions at four maturity levels [7].

PS23: Yi et al. presented a method that shows stable and good performance and can adapt to large-scale networks easily [33].

PS24: Kohli et al. gave an overview of the advancement of 5G technology, which gave rise to numerous security and privacy threats; it is expected that all such security and privacy threats will be resolved with the introduction of 6G technology [36].

PS25: Dong and Hu argued that tracking and tracing will be significantly faster, and that stock-taking accuracy in warehouses with connected pallets will be much greater [37].

PS26: Jain et al. provided resource allocation techniques to monitor, manage, and share resources effectively [34].

PS27: Sajid et al. described the established security concerns around the IoE and provided a possible way out that can be utilized for advanced analysis/discussions by analysts and professionals [38].

PS28: Langley et al. suggested taxonomy and the theorizing of propositions to help researchers conduct case studies to more deeply examine the nature of smartness and validate its different levels, as exemplified in our taxonomy [48].

PS29: Narjes et al. proposed the novel nature-inspired SRS algorithm to evaluate its performance in solving a particular CCSC problem [11].

PS30: Sachdev discussed key security and privacy issues raised for edge AI in the IoT/IoE digital marketing context [60].

PS31: Kumar et al. developed an IoE technology that accomplished and recognized agricultural habitat data gatherings like soil moisture, humidity, light, and temperature [27].

PS32: Petrescu et al. reported the challenges and benefits of using the IoE in marketing policies, practice, and research as well as the opportunities provided for targeted services [49].

PS33: Ashraf et al. proposed a key exchange lightweight algorithm to secure users from attacks in the IoE [39].

PS34: Silva and Braga developed the SoS, which can be useful to increase the efficiency of the teaching–learning process by automating in-classroom daily tasks [52].

PS35: Pedro et al. propose a framework that is generic enough for any smart system in the domain of IoEs [58].

PS36: Wang et al. propose a risk sources identification process that can effectively help identify various risks of physiological data breaches, providing some reference for relevant parties to conduct privacy and data protection [40].

PS37: Majeed et al. presented an analytical model which would help organizations recognize the threat at hand and begin to construct systems and networks capable of being resilient to future IoE environments, where any "thing" may be an insider [64].

PS38: Golovatchev et al. presented the first findings that guide practitioners through the implementation of the industrial IoE and its impact on new product development and management [50].

PS39: Roy and Chowdhury reported on the integration of the IoT, and the cloud is very essential for providing computational and storage infrastructure and supporting the development of services and applications beyond the limits of the conventional IoT [26].

PS40: Kumar et al. proposed a method for the agroecological variables of humidity, light, and temperature, which instantly determine the standard enhancement of crops [27].

PS41: Velasquez et al. presented fog service orchestrator architectures and their relationships with the challenges of the fog.

PS42: Peng et al. developed the HFS-CoCoSo approach for disposing of the problem of IoE companies' evaluation [51].

PS43: Elawady et al. introduced a general domain model capable of dealing with the design of various applications based on the IoT, MR, and fog computing technologies and incorporating the benefits of each one [31].

PS44: Ahad et al. described that deep learning techniques are well suited for getting a student-centric learning ecosystem, wherein a student is given a customized learning strategy or approach as per their need and desire to achieve better understanding and longer retention [53].

PS45: Tsung and Wen recommend also paying more attention to anti-fraud operations involving human factors [54].

PS46: Ganesh and Verma proposed a system that can identify the best keys available in the entire body of data, which will act as connectivity points [56].

PS47: Heman and Kusum focused on the realization of connecting the various devices over the Internet in an intelligent way that envisions the IoE [41].

PS48: Cao et al. suggested that in general, whether it is in a smart home or a connected vehicle, the user experience is very critical to the success of IoE applications [23].

PS49: Bulti et al. enhance business-oriented intelligent digital marketing systems [44].

PS50: Ma proposed that by adding an intelligent gateway module into the smart home system, users can view the indoor environment information in real time through the Internet, and in case of an emergency, quickly receive alarm information to protect the safety of their property to the greatest extent [8].

PS51: Iannacci built the unique and crosslinked frame of reference around the IoT, IoE, and Tactile Internet, and correlated it with 5G [3].

PS52: Dhaya and Kanthavel showed that the algorithmic performance is improved as the number of variables increases [28].

PS53: Salehi et al. proposed the compression method in IoT networks to decrease the volume of data exchange across the network in order to reduce energy consumption in IoT devices [46].

PS54: Zheng et al. ensure the effectiveness of network data collection and the quality of applications constructed based on these data. This paper proposes an effective CITE security scheme for trust evaluation and MEVs' path planning [43].

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