Review

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Internet of Things and Distributed Computer Systems in Business Models

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Review

Internet of Things and Distributed Computer Systems in Business Models

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Abstract: The integration of the Internet of Things (IoT) and Distributed Computer Systems (DCS) is transforming business models across industries. IoT devices enable real-time monitoring of equipment and processes, reducing downtime and enhancing efficiency. In the case, manufacturing companies use IoT sensors to monitor machinery, predict failures, and schedule maintenance. Also, automation via IoT, reduces manual intervention, resulting in boosted productivity in smart factories and automated supply chains. IoT devices generate thus vast amounts of data, which businesses analyze to gain insights into customer behavior, operational inefficiencies, and market trends. In turn, distributed computer systems process this data, providing actionable insights and enabling advanced analytics and machine learning for future trend predictions. While, IoT facilitates personalized products and services by collecting data on customer preferences and usage patterns, enhancing satisfaction and loyalty, IoT devices support new customer interactions, like wearable health devices, and enable subscription-based and pay-per-use models in transportation and utilities. Conversely, real-time monitoring enhances security, as distributed systems quickly respond to threats, ensuring operational safety. It also aids regulatory compliance by providing accurate operational data. In this way, this study, through a Bibliometric Literature Review (LRSB) of 91 screened pieces of literature, aims at ascertaining to what extent the aforementioned capacities enhance business models. The study concludes that those systems leverage businesses, promoting competitive edge, continuous innovation, and adaptability to market dynamics. A review of 91 academic documents from the Scopus database highlights these impacts.

Keywords: internet of thing; distributed computer systems; business

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1. Introduction

The advent of the Internet of Things (IoT) and distributed computer systems has ushered in a transformative era in business models across various industries. These innovations have redefined the technological environment and fundamentally altered how businesses operate, compete, and deliver customer value [1]. The convergence of IoT and distributed computing systems catalyzes a shift from traditional, centralized business frameworks to more agile, decentralized, and data-driven models. This transformation is driven by the need for enhanced efficiency, real-time decision-making, and a greater emphasis on customer-centric approaches. Dijkman et al. [2] define IoT as the interconnected network of physical devices embedded with sensors, software, and other technologies. This innovation enables these devices to collect and exchange data. In addition, the vast network of connected devices generates an unprecedented volume of data, providing businesses with valuable insights into consumer behavior, operational efficiency, and market trends. The ability to monitor, analyze, and act upon real-time data has become a crucial part of modern business strategies. It enables companies to optimize processes, reduce costs, and enhance the customer experience.

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Simultaneously, distributed computer systems have further revolutionized business operations. According to Ageed et al. [3], these innovations encompass a range of technologies, including cloud computing, edge computing, and blockchain. These systems distribute computing resources across multiple locations rather than relying on a single centralized server [4]. This decentralization enhances system resilience, reduces latency, and facilitates more efficient resource utilization. Cloud computing; in particular, has democratized access to powerful computing resources, enabling businesses of all sizes to leverage advanced technologies without significant upfront investments.

The integration of IoT and distributed computer systems has significantly impacted business models. Traditional businesses, which often relied on hierarchical and linear processes, are now evolving into more dynamic and interconnected entities. The ability to leverage real-time data through IoT devices allows businesses to monitor operations continuously, making adjustments on the fly to optimize performance [5]. Predictive analytics, powered by data from IoT sensors, enable companies to anticipate issues before they occur, reducing downtime and increasing efficiency. Moreover, distributed computer systems facilitate greater flexibility and scalability in business operations. Alamouti et al. [4] explain that decentralized computing resources ensure companies to quickly adapt to changing demands and scale their operations efficiently. Blockchain technology enhances security and transparency, fostering trust and enabling new collaboration and transactions without traditional intermediaries [6]. These technological advancements also support the creation of personalized customer experiences. Analyzing data from various perspectives allows businesses to gain deeper insights into customer preferences and behavior, allowing for more targeted marketing and tailored product offerings. This customer-centric approach enhances satisfaction, builds loyalty, and drives growth. To what extent internet of things and other distributed computer systems enhance business models? This research question guides this piece of literature over the intended literature review.

2. Materials and Methods

This research employs the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework to conduct a systematic bibliometric literature review (LRSB) on the impact of the Internet of Things (IoT) and distributed computer systems on business models. The PRISMA framework is a widely recognized methodology that ensures transparency, thoroughness, and reproducibility in systematic reviews [7,8]. The researcher utilized the LRSB methodology to identify relevant sources and synthesize findings, contrasting with conventional literature review methods. LRSB employs a replicable, scientific, and transparent approach designed to minimize bias by thoroughly exploring both published and unpublished literature pertinent to the study topic [9–11]. Additionally, the researcher provides an audit trail, allowing readers to assess the quality of the studies integrated into the research, along with their methodologies and findings.

LRSB involves a systematic screening and selection of information sources to ensure the credibility and accuracy of the presented data. This process encompasses three phases and six steps [9–11] (Table 1).

Table 1. Process of systematic LRSB.

Fase	Step	Description
	Step 2	searching for appropriate literature
	Step 3	critical appraisal of the selected studies
	Step 4	data synthesis from individual sources
Interpretation	Step 5	reporting findings and recommendations
Communication	Step 6	Presentation of the LRSB report

Source: Adapted from Rosário and Dias [9,11].

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The researchers utilized the Scopus database to identify and select reputable sources recognized within the scientific and academic communities. However, it is important to acknowledge a limitation of this study: its exclusive reliance on the Scopus database, which may exclude other valuable scientific and academic databases. To ensure comprehensive coverage, the literature search should include peer-reviewed scientific and academic publications up to August 2024.

The search process began by identifying the database, in this case, Scopus. For the initial search (Table 2), the review process was conducted using the Scopus database, known for its comprehensive coverage of peer-reviewed literature. The screening and selection process involved several stages. First, a broad search identified 206,901 documents based on the keywords "internet of thing." This was refined by including the exact keyword "distributed computer systems," which reduced the results to 2,926 documents. Finally, limiting the search to the subject area "Business" narrowed the results to 91 documents. The titles and abstracts of these 91 documents were reviewed for relevance to the research topic.

Table 2. Screening methodology.

Scopus Database	Screening	Publications
Initial Query	Keywords: internet of thing	206,901
First Screening	Keywords: internet of thing Add the exact keyword: distributed computer systems	2,926
Eligibility criteria	Keywords: internet of thing Add the exact keyword: distributed computer systems Limited: Business	91
Final screening	Keywords: internet of thing Add the exact keyword: distributed computer systems Limited: Business Published until August 2024	

Source: Adapted from Rosário and Dias [9,11].

The full-text articles were retrieved and evaluated based on the inclusion and exclusion criteria. The inclusion criteria required articles to address the impact of IoT and distributed computer systems on business models, be peer-reviewed, and be published in the subject area "Business." Articles not written in English, inaccessible through the Scopus database, or identified as duplicates were excluded from the review. This thorough screening process resulted in a final selection of 91 documents that met all criteria and were included in the systematic review (N=91).

Thematic analysis was used to analyze and organize the study findings. Rosário and Dias define thematic analysis as a research technique for extracting meaning and concepts from data by identifying, analyzing, and recording common patterns or themes from identified studies. Similarly, Rosário et al. [11] describe a theme-centric review as an approach that explains how previous publications contribute to a study topic by identifying key themes, concepts, and phenomena of interest. This method allowed the researcher to organize the results based on common patterns or themes, illustrating how businesses use predictive analytics to anticipate customer behaviors and plan accordingly.

We utilized content and thematic analysis methods to identify, examine, and present the diverse documents, as suggested by Rosário and Dias [9,10]. The 91 scientific and academic documents indexed in Scopus were then analyzed both through narrative and bibliometrically to deepen the content and derive common themes that directly address the research question (Figure 1).

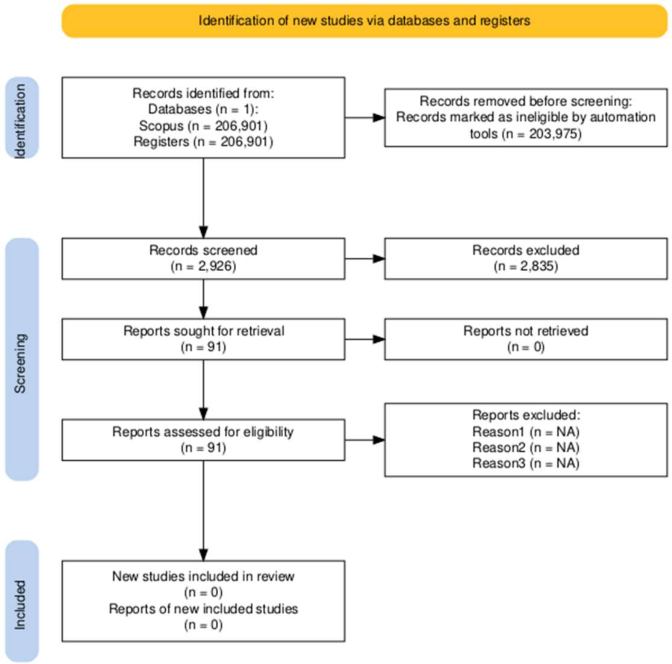

Figure 1. PRISMA 2020 flow diagram of the literature search and screening process [7,8].

A set of standards aimed at improving the transparency and quality of systematic reviews is provided by the PRISMA 2020 guidelines. These guidelines offer a detailed checklist and a flow diagram to assist researchers in reporting their systematic reviews clearly and comprehensively. This effort is essential to ensure that scientific evidence is robust and reliable, thereby facilitating informed decision-making in clinical practice and scientific research [7,8].

For data analysis, we utilized content and thematic analysis methods to categorize and discuss the diverse documents, as recommended by Rosário and Dias [9,11].

The 91 documents indexed in Scopus were analyzed both through narrative and bibliometric means to deepen our understanding of the content and to identify common themes that directly address the research question [9–11]. Among the selected documents, 53 are Conference papers; 34 are articles; 2 are books; and 2 are book chapters.

3. Publication Distribution

Internet of Things and Distributed Computer Systems in Business Models were addressed up to August 2024. The year 2018 had the highest number of peer-reviewed publications, reaching 24. Figure 2 summarizes the peer-reviewed literature published up to August 2024.

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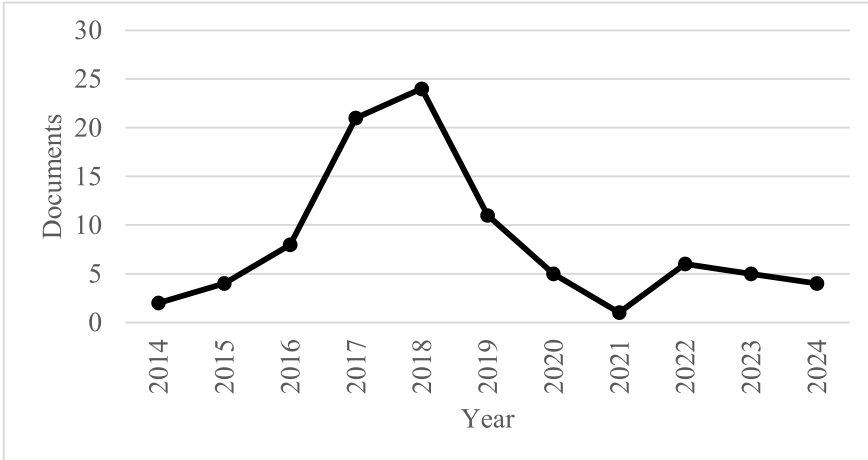

Figure 2. Documents by year.

The publications were sorted out as follows: Proceedings 19th IEEE International Conference On Computational Science And Engineering 14th IEEE International Conference On Embedded And Ubiquitous Computing And 15th International Symposium On Distributed Computing And Applications To Business Engineering And Science Cse Euc Dcabes 2016 8 (6); Lecture Notes In Business Information Processing (5); IEEE Transactions On Engineering Management (4); with 2 (Proceedings 2018 IEEE 27th International Conference On Enabling Technologies Infrastructure For Collaborative Enterprises Wetice 2018; Proceedings 2017 5th International Conference On Enterprise Systems Industrial Digitalization By Enterprise Systems Es 2017; Proceedings 14th International Symposium On Distributed Computing And Applications For Business Engineering And Science Dcabes 2015; Knowledge Based Systems; Journal Of Network And Systems Management; Journal Of Cleaner Production; International Journal Of Production Research; International Journal Of Information Management; IEEE Potentials; IEEE International Conference On Industrial Engineering And Engineering Management; Benchcouncil Transactions On Benchmarks Standards And Evaluations); and the remaining publications with 1 document.

Similarly, Figure 3 illustrates the regions with the most significant literature contributions on the topic. China, the USA, India, and Germany stand out with the highest levels of scientific output in related fields, among other countries publishing on the subject.

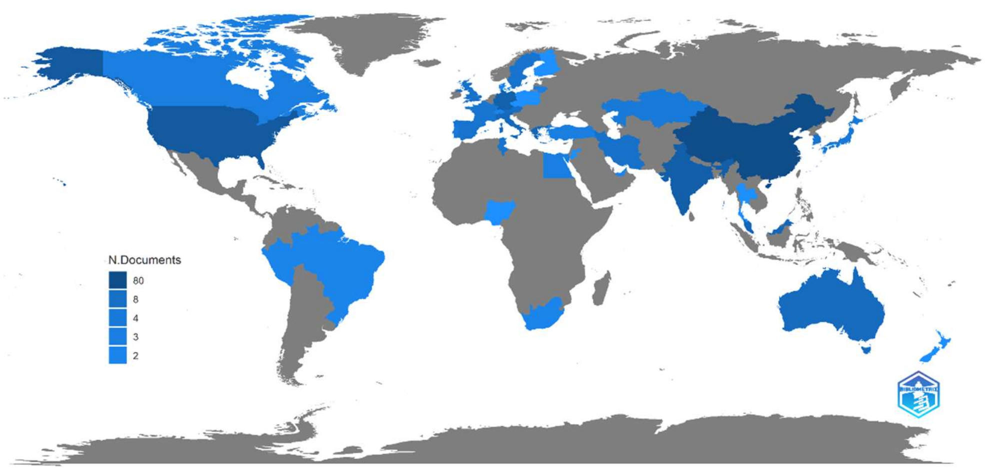

Figure 3. Documents by Geographical Area.

Table 3, along with Figure 3, visually illustrates the top 10 nations making notable scientific contributions in the examined domains. The objective of this investigation is to identify countries that prioritize harnessing cutting-edge technology in the realm of smart tourism Internet of Things.

Table 3. Top 10 countries by number of publications.

Country	Number of Publications
CHINA	80
USA	35
INDIA	24
GERMANY	22
GREECE	15
MALAYSIA	14
ITALY	12
AUSTRALIA	10
AUSTRIA	8
IRAN	7

Source: own elaboration.

In Table 4 we analyze the Scimago Journal & Country Rank (SJR), the best quartile, and the H index by Technological Forecasting and Social Change with 5,780 (SJR), Q1, and H index 177. There are a total of 13 publications in Q1, 7 publications in Q2, 1 publication Q3, and 3 publications in Q4. Publications from best quartile Q1 represent 19% of the 68 publications titles; best quartile Q2 represents 10%, best Q3 represents 1% and best Q4 represents 4% of each of the titles of 68 publications. Finally, 44 publications without indexing data represent 65% of publications.

Table 4. Process of systematic LRSB.

Title	**SJR**	**Best Quartile**	**H Index**
International Journal Of Information Management	5,780	Q1	177
IEEE Communications Standards Magazine	2,740	Q1	36
International Journal Of Production Research	2,670	Q1	186
Knowledge Based Systems	2,220	Q1	169
Transportation Research Part A Policy And Practice	2,180	Q1	167
Journal Of Cleaner Production	2,060	Q1	309
Electronic Commerce Research And Applications	1,340	Q1	101
Industrial Management And Data Systems	1,210	Q1	125
IEEE Transactions On Engineering Management	1,200	Q1	112
Journal Of Network And Systems Management	1,040	Q1	40
TQM Journal	0,940	Q1	79
Engineering Construction And Architectural Management	0,900	Q1	73
Big Data And Cognitive Computing	0,820	Q2	33
Journal Of High Technology Management Research	0,720	Q2	55
Electricity Journal	0,710	Q1	58
Service Oriented Computing And Applications	0,560	Q2	31

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Journal Of Organizational And End User Computing	0,490	Q2	46
International Journal Of Crowd Science	0,380	Q2	15
Engineering Management In Production And Services	0,380	Q2	21
ZWF Zeitschrift Fuer Wirtschaftlichen Fabrikbetrieb	0,350	Q2	18
Lecture Notes In Business Information Processing	0,340	Q3	63
IEEE Potentials	0,170	Q4	39
International Journal Of Product Development	0,120	Q4	30
Paper Asia	0,110	Q4	6
Proceedings 19th IEEE International Conference On Computational Science And Engineering 14th IEEE International Conference On Embedded And Ubiquitous Computing And 15th International Symposium On Distributed Computing And Applications To Business Engineering And Science Cse Euc Dcabes 2016	0	-*	11
Proceedings 2018 IEEE 27th International Conference On Enabling Technologies Infrastructure For Collaborative Enterprises Wetice 2018	0	-*	6
Proceedings 2017 5th International Conference On Enterprise Systems Industrial Digitalization By Enterprise Systems Es 2017	0	-*	8
Proceedings 14th International Symposium On Distributed Computing And Applications For Business Engineering And Science Dcabes 2015	0	-*	8
IEEE International Conference On Industrial Engineering And Engineering Management	0	-*	27
Wit Transactions On Information And Communication Technologies	0	-*	14
Rtsi 2017 IEEE 3rd International Forum On Research And Technologies For Society And Industry Conference Proceedings	0	-*	13
Proceedings Of The European Conference On E Government Eceg	0	-*	16
Proceedings Of The 2016 IEEE 20th International Conference On Computer Supported Cooperative Work In Design Cscwd 2016	0	-*	12
Proceedings Of The 2015 IEEE 19th International Enterprise Distributed Object Computing Conference Workshops And Demonstrations Edocw 2015	0	-*	8
Proceedings 2021 International Conference On Management Science And Software Engineering Icmsse 2021	0	-*	6

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Proceedings 2019 IEEE International Conference On Services Computing Scc 2019 Part Of The 2019 IEEE World Congress On Services	0	-*	16
Proceedings 2019 4th International Conference On Internet Of Things Smart Innovation And Usages Iot Siu 2019	0	-*	13
Proceedings 2018 Crypto Valley Conference On Blockchain Technology Cvcbt 2018	0	-*	13
Proceedings 2018 17th International Symposium On Distributed Computing And Applications For Business Engineering And Science Dcabes 2018	0	-*	6
Proceedings 2017 IEEE 19th Conference On Business Informatics CBI 2017	0	-*	17
Proceedings 2017 2nd International Workshop On Science Of Smart City Operations And Platforms Engineering In Partnership With Global City Teams Challenge Scope 2017	0	-*	7
Proceedings 2016 IEEE 9th International Conference On Service Oriented Computing And Applications Soca 2016	0	-*	5
Picmet 2019 Portland International Conference On Management Of Engineering And Technology Technology Management In The World Of Intelligent Systems Proceedings	0	-*	12
International Conference On Logistics Engineering Management And Computer Science Lemcs 2014	0	-*	5
Ictc 2019 10th International Conference On ICT Convergence ICT Convergence Leading The Autonomous Future	0	-*	12
Conference Proceedings Of The 6th International Symposium On Project Management Ispm 2018	0	-*	2
Annual Conference On Innovation And Technology In Computer Science Education Iticse	0	-*	37
2018 IEEE International Conference On Engineering Technology And Innovation ICE Itmc 2018 Proceedings	0	-*	16
2017 IEEE Technology And Engineering Management Society Conference Temscon 2017	0	-*	9
2017 26th International Conference On Computer Communications And Networks ICCCN 2017	0	-*	22
2016 Management And Innovation Technology International Conference Miticon 2016	0	-*	6
10th IEEE Int Conf On Service Operations And Logistics And Informatics Soli 2015 In Conjunction With Ict4all 2015	0	-*	7
Benchcouncil Transactions On Benchmarks Standards And Evaluations	-*	-*	-*

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Proceedings Of The 32nd International Business Information Management Association Conference Ibima 2018 Vision 2020 Sustainable Economic Development And Application Of Innovation Management From Regional Expansion To Global Growth	-*	-*	-*
Proceedings Of The 2020 IEEE International Conference Quality Management Transport And Information Security Information Technologies IT And Qm And Is 2020	-*	-*	-*
Proceedings 2020 2nd International Conference On Applied Machine Learning Icaml 2020	-*	-*	-*
Proceedings 2017 IEEE 3rd International Conference On Collaboration And Internet Computing Cic 2017	-*	-*	-*
Joint 13th Ctte And 10th Cmi Conference On Internet Of Things Business Models Users And Networks	-*	-*	-*
Fog Computing Concepts Frameworks And Technologies	-*	-*	-*
Crowdsourcing Of Sensor Cloud Services	-*	-*	-*
6g Connectivity Systems Technologies And Applications Digitalization Of New Technologies 6g And Evolution	-*	-*	-*
2024 2nd International Conference On Disruptive Technologies Icdt 2024	-*	-*	-*
2023 9th International Conference On Web Research Icwr 2023	-*	-*	-*
2022 International Conference On Data Analytics For Business And Industry Icdabi 2022	-*	-*	-*
2020 International Conference On Technology And Entrepreneurship Virtual Icte V 2020	-*	-*	-*
2018 7th International Conference On Industrial Technology And Management Icitm 2018	-*	-*	-*
18th Asia Pacific Network Operations And Management Symposium Apnoms 2016 Management Of Softwarized Infrastructure Proceedings	-*	-*	-*
Proceedings Of The 11th International Conference On Strategic Management And Its Support By Information Systems 2015 Smsis 2015	-*	-*	-*

*data not available. Source: own elaboration.

As shown in Table 4, the significant majority of publications do have quartile Q1.

The subject areas covered by the 91 scientific and/or academic documents were: Business, Management and Accounting (91); Computer Science (65); Engineering (46); Decision Sciences (39); Mathematics (17); Social Sciences (12); Environmental Science (4); Energy (4); Economics, Econometrics and Finance (4); Physics and Astronomy (2); Medicine (1); and Materials Science (1).

The most cited article was "Smart manufacturing", with 883 published Smart manufacturing 2,670 (SJR), the best quartile (Q1) and with H index (186), in this paper is to examine the concepts of

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cyber-physical systems spearheaded by the internet of things, cloud computing, service-oriented computing, artificial intelligence, and data science. In Figure 4 we can analyze citation changes for documents published until August 2024. The period 2014-2024 shows a positive net growth in citations with an R2 of 66%, reaching 5,249 citations in August 2024.

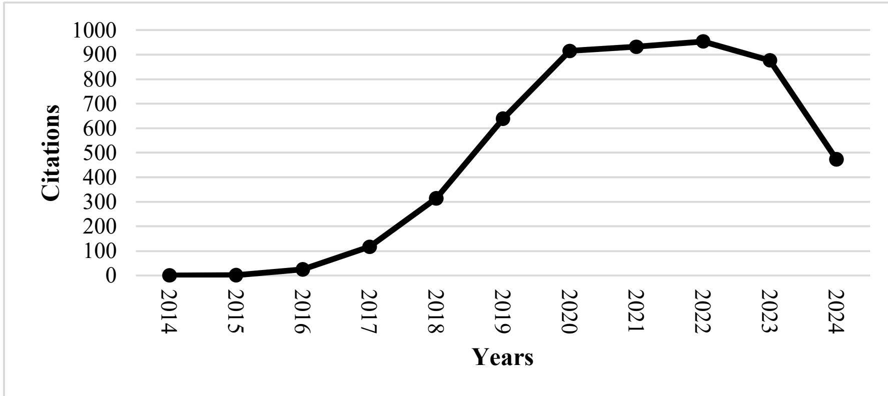

Figure 4. The evolution of citations between 2014 and 2024.

The h-index is used to determine the productivity and impact of a published work based on the maximum number of included articles with at least the same number of citations. Of the documents considered for h-index, 28 were cited at least 28 times.

Citations of all scientific and/or academic documents from the period ≤2014 to until August 2024, with a total of 5,249 citations, of the 91 documents 15 were not cited. The self-citation of documents in the period ≤2014 to May 2024 was self-cited 276 times.

The bibliometric analysis aimed to identify metrics that reveal patterns and developments in scientific or academic content within documents, with a focus on principal keywords (Figure 5).

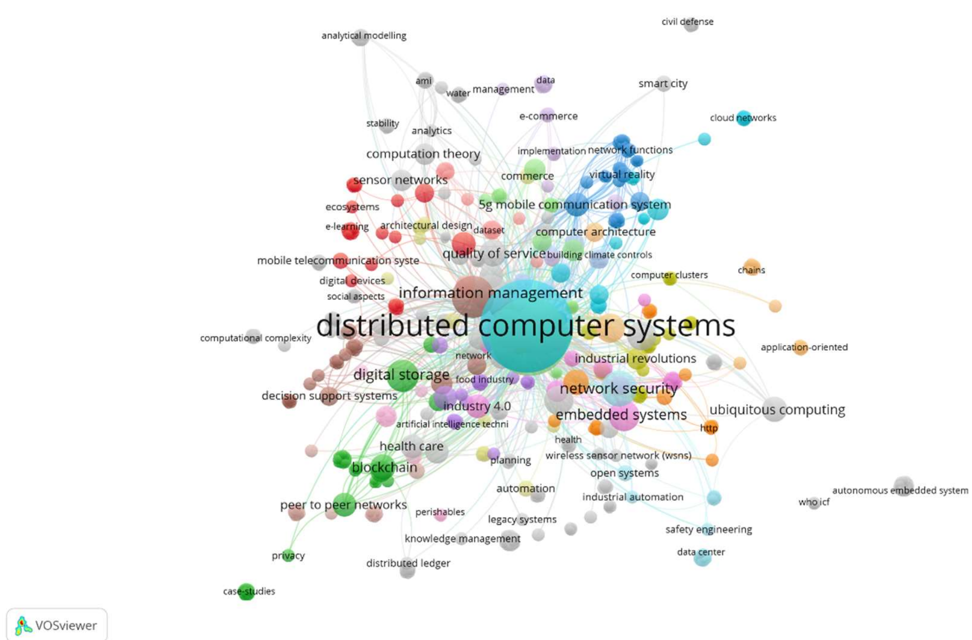

Figure 5. A network of all keywords.

This visualization highlights most network nodes, where the size of each node corresponds to the frequency of the associated keyword, indicating how often it appears. Additionally, the connections between nodes represent keyword co-occurrences, showing which keywords appear together. The thickness of these links illustrates the frequency of these co-occurrences, effectively demonstrating how often the keywords are found together.

In these diagrams, the size of each node reflects the frequency of its associated keyword, while the thickness of the links between nodes indicates the frequency of keyword co-occurrence. Different colors represent various thematic clusters. Nodes illustrate the range of topics within a theme, and the links demonstrate the relationships among these topics within the same thematic group.

The results were obtained using VOSviewer, scientific software designed to analyze key search terms like “Internet of Things and Distributed Computer Systems in Business Models.” The study focused on scientific and academic documents related to these topics. Figure 6 showcases the connected keywords, illustrating the network of co-occurring keywords in each scientific article. This analysis helps identify the subjects researchers have investigated and highlights emerging trends for future research groups.

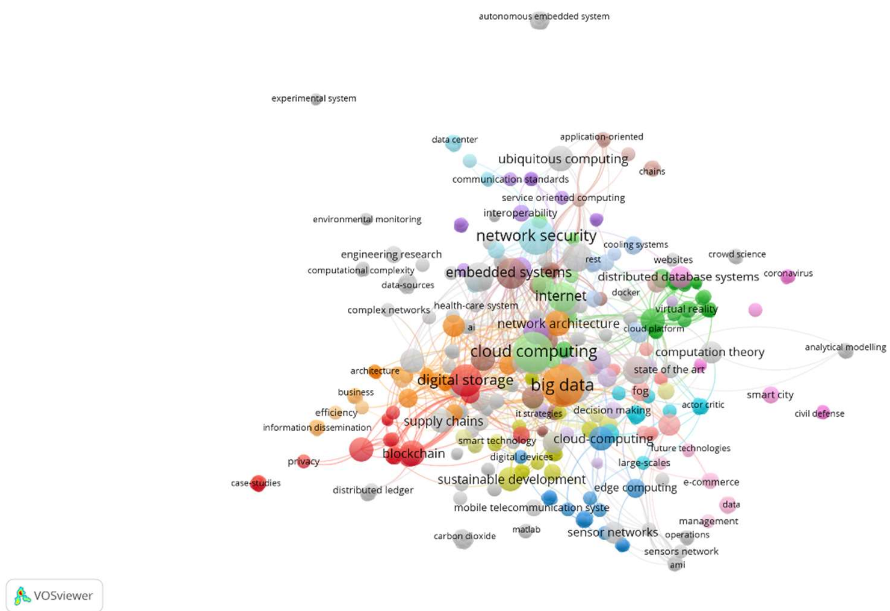

Figure 6. A network of Linked Keywords.

Lastly, Figure 7 presents an extensive bibliographic coupling based on document analysis, allowing for interactive exploration of the co-citation network. This feature enables users to navigate the network and uncover patterns within “Internet of Things and Distributed Computer Systems in Business Models” across various studies.

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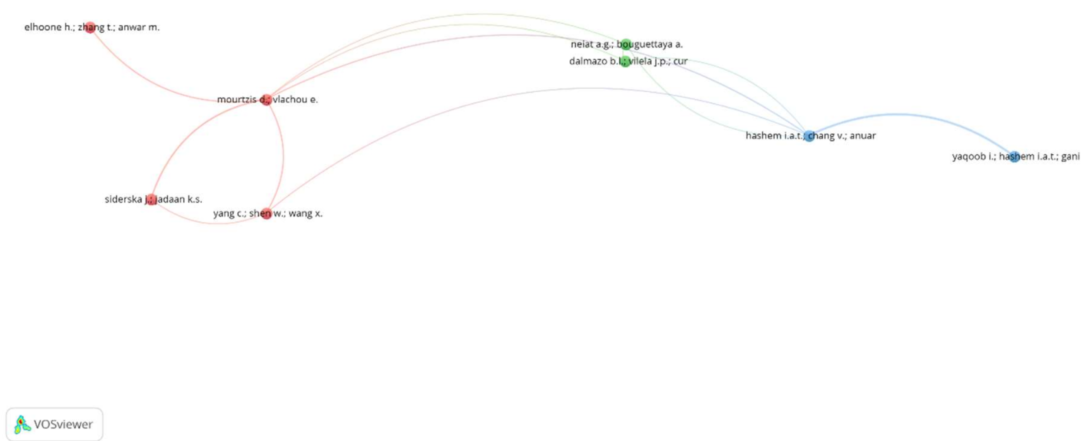

Figure 7. A network of co-citation.

In summary, the chosen methodology ensured precision and provided comprehensive data for future researchers to build upon this review. By addressing key issues, it enhanced coherence and improved the overall validity and reliability of the findings. Adhering to established guidelines for systematic reviews and meta-analyses, we achieved a high methodological standard. These aspects will be discussed in further detail below.

4. Theoretical Perspectives

The integration of the IoT and distributed computing systems has catalyzed significant changes in contemporary business models. These technological advancements have introduced new levels of connectivity, efficiency, and data-driven decision-making capabilities [12]. IoT enables real-time data collection and analysis, while distributed computing systems enhance flexibility, scalability, and security. Together, these innovations facilitate the development of dynamic and customer-centric business strategies, transforming traditional operational frameworks and opening up new avenues for competitive advantage [13]. This literature review examines the intersection of IoT and distributed computing within business models.

4.1. Internet of Thingss

IoT refers to a network of interconnected physical devices that communicate and exchange data with each other over the internet or other communication networks. The history of this innovation dates back to 1999 when Kevin Ashton proposed the concept of IoT. He defined it as “uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology” [14] (p.243). However, this definition has continued to change as researchers and scientists strive to understand the concept and the innovations involved. For example, Rose et al. [15] (p.7) define it as a term used to describe “scenarios in which Internet connectivity and computing capability extend to a variety of objects, devices, sensors, and everyday items.” Li et al. [14] (p.243-244) found that it is also defined as a “dynamic global network infrastructure with self-configuring capabilities based on standards and interoperable communication protocols; physical and virtual ‘things’ in an IoT have identities and attributes and are capable of using intelligent interfaces and being integrated as an information network.” Despite the different wording, these definitions all converge on the core idea

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that IoT encompasses a vast network of interconnected devices that communicate and interact with each other and the environment, driven by advanced technologies and protocols to enhance automation, efficiency, and data exchange. Figure 8 shows the significant evolution of IoT and enabling technologies.

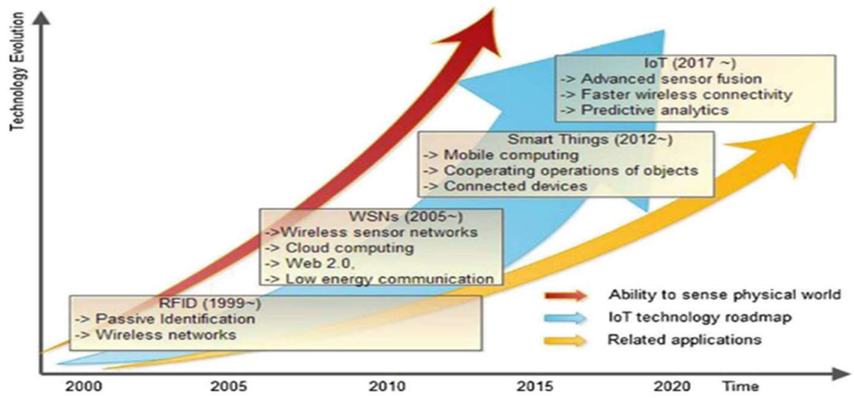

Figure 8. IoT evolution since 1999 [14].

IoT devices are often embedded with sensors, software, and other technologies, which help collect and transmit data to central systems or other devices. The primary objective of IoT is to enable seamless connectivity and data exchange between objects, creating a smart environment where devices can autonomously make decisions or provide insights based on the data collected [16,17]. IoT encompasses a wide range of applications and devices, from everyday consumer products like smart thermostats and wearable fitness trackers to complex industrial systems such as smart manufacturing equipment and automated supply chains [18]. Each IoT device typically includes sensors that monitor environmental conditions or user interactions, processors that handle data processing, and communication modules that enable data transmission. The data collected by these devices can include information on temperature, humidity, location, motion, and other variables relevant to their function.

The core of IoT lies in its ability to create a connected ecosystem where devices can work together to enhance functionality and efficiency. For example, IoT devices such as smart lighting systems, thermostats, and security cameras can be interconnected in a smart home environment to provide a cohesive user experience [19]. These devices can be programmed to operate based on user preferences or environmental conditions, such as adjusting the thermostat when a user leaves the house or turning on lights as dusk approaches. In industrial settings, IoT enables advanced monitoring and automation by integrating sensors and devices within machinery and infrastructure [20,21]. This can significantly improve operational efficiency, predictive maintenance, and real-time analytics. For instance, sensors embedded in manufacturing equipment can monitor performance metrics and detect anomalies, allowing for timely maintenance and reducing the risk of equipment failures [22]. This wide application of IoT innovations in multiple settings is projected to contribute significantly to global economic growth. For instance, Rose et al. [15] indicate that the global economic impact of IoT will reach US $11 trillion by 2025, with more than 100 billion connected IoT gadgets. This shows the innovation's massive potential and continued growth.

4.2. Distributed Computer Systems

Distributed computer systems are a computing architecture where multiple interconnected computers, or nodes, work together to perform tasks and process data as a unified system. Unlike centralized computing systems, where a single server or mainframe handles all processing, distributed systems distribute computational workload across multiple machines, often spread over different geographical locations [23]. This architecture leverages the power of multiple processors or computers to achieve greater performance, reliability, and scalability. In a distributed computer system, nodes communicate and coordinate with each other through a network, which can range from local area networks (LANs) to wide area networks (WANs) or even the internet [24,25]. Each node in the system can be an individual computer, server, or device contributing to the overall computational power. The nodes collaborate to achieve common objectives, such as processing large volumes of data, running complex algorithms, or hosting applications and services.

One of the primary advantages of distributed computer systems is their ability to scale horizontally. As the demand for computational resources increases, additional nodes can be added to the network to handle the increased load, thus providing scalability and flexibility [26]. This approach contrasts with vertical scaling, where increasing the capacity of a single machine is often limited by hardware constraints. Distributed systems can also enhance fault tolerance and reliability by replicating data and functions across multiple nodes [27,28]. If one node fails, others can continue to operate, minimizing the impact on the overall system and ensuring continuous service availability. Distributed systems also facilitate resource sharing and load balancing [29]. Resources such as storage, processing power, and network bandwidth are distributed across the nodes, optimizing their utilization and balancing the workload to prevent bottlenecks [30]. This distributed approach allows for efficient management of resources and improved performance, as tasks can be allocated dynamically based on current system demands and node capabilities.

Distributed computer systems can support various types of distributed architectures and models, including client-server, peer-to-peer (P2P), and cloud computing models. In a client-server model, clients request services or resources from a central server, which processes the requests and provides the necessary responses [31,32]. In contrast, P2P networks involve a decentralized approach where each node, or peer, can act as both a client and a server, sharing resources and data directly with other peers. Cloud computing is a prominent example of a distributed system [33]. It provides on-demand access to a shared pool of computing resources, such as servers, storage, and applications, over the internet [34]. Cloud service providers manage and operate distributed infrastructure, offering to user scalability, flexibility, and cost-efficiency. This model allows businesses and individuals to leverage powerful computational resources without investing in and maintaining their hardware.

4.3. Business Models

A business model defines how a company creates, delivers, and captures value in the market. It is a comprehensive framework that outlines the key components of a business's operations and strategy, detailing how it generates revenue, provides products or services, and maintains competitive advantage [5,35]. In addition, business models are often used as tools for initiating organizational changes to enhance performance and productivity. They guide a company's strategic direction, making it an essential element for achieving long-term success and sustainability [36]. A business model consists of nine major building blocks, as shown in Figure 9.

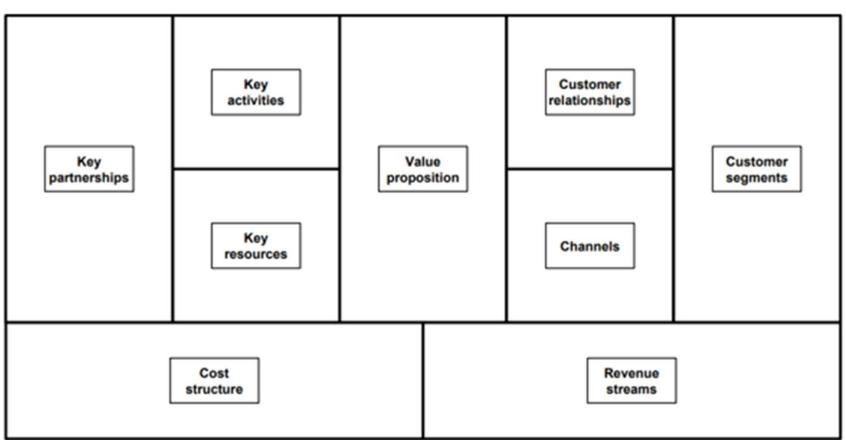

Figure 9. Business model canvas [5].

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4.3.1. Value Proposition

The value proposition is the fundamental component of any business model. It articulates the unique benefits and value that a company offers to its customers. This could include solving specific problems, fulfilling unmet needs, or delivering superior products or services [5]. For example, a company offering a revolutionary technology that enhances productivity or a service that simplifies a complex process can attract customers by demonstrating clear value.

4.3.2. Revenue Streams

Revenue streams refer to the various ways a company generates income from its customers. These can include direct sales of products or services, subscription fees, licensing fees, advertising revenue, or transaction-based charges. Different business models may utilize multiple revenue streams to diversify income sources and mitigate financial risks.

4.3.3. Customer Segments

Customer segments identify the distinct groups of people or organizations a business aims to serve. Each segment may have specific needs, preferences, and behaviours, influencing how the company tailors its products or services. Understanding customer segments helps businesses to design targeted marketing strategies and develop solutions that resonate with different audiences.

4.3.4. Channels

Channels describe the various methods and pathways a company uses to reach and communicate with its customers. According to Kiel et al. [5], this can include physical stores, online platforms, direct sales teams, or third-party distributors. Effective channel strategies ensure that products or services are accessible to customers in the most convenient and efficient manner.

4.3.5. Customer Relationships

Customer relationships encompass the types of interactions and engagements a company maintains with its customers. This includes customer service, support, loyalty programs, and personalized experiences [37]. Building strong customer relationships is essential for retaining customers and encouraging repeat business. Companies may adopt various strategies, such as offering exceptional customer service, creating loyalty rewards, or implementing personalized marketing.

4.3.6. Key Concepts

Key activities are the essential actions and processes that a company must perform to deliver its value proposition and operate effectively. These activities range from product development to marketing and sales, supply chain management, and customer support. Identifying and optimizing key activities helps businesses streamline operations and enhance overall efficiency [37].

4.3.7. Key Resources

Key resources are the assets and capabilities required to support the company's operations and achieve its objectives. These resources can be physical, intellectual, human, or financial. For example, a technology company may rely on its intellectual property (patents, software), skilled engineers, and funding to develop and market innovative products [37].

4.3.8. Key Partnerships

Key partnerships involve collaborating with other businesses or organizations to achieve mutual benefits. Partnerships can include strategic alliances, joint ventures, supplier relationships, and distribution agreements. Leveraging the strengths and resources of partners allows companies to expand their reach, access new markets, and enhance their offerings [37].

4.3.9. Cost Structure

The cost structure outlines the expenses and financial commitments associated with running the business. This includes fixed costs, such as salaries and rent, and variable costs, including production and marketing expenses. Analyzing the cost structure helps businesses manage their budget, optimize spending, and ensure profitability [37].

The use of IoT and distributed computer systems results in businesses adjusting their processes and operations to accommodate the innovations. As a result, these changes have resulted in various impacts on business models. This section synthesizes data to show how IoT and distributed computer systems influence the adopted business models.

4.3.10. Improved Data and Workflow Management

Integrating IoT and distributed computer systems significantly enhances business data and workflow management. IoT devices are equipped with various sensors and connectivity capabilities, continuously collecting vast amounts of data from different aspects of operations [38]. This real-time data collection allows businesses to monitor processes, track performance, and identify inefficiencies that might go unnoticed. For example, in a manufacturing setting, IoT sensors can monitor the status of machinery, track production output, and detect deviations from standard operating conditions [39]. This immediate visibility into operations enables proactive maintenance, reducing downtime and improving overall productivity. Distributed computer systems further improve data and workflow management by providing the necessary infrastructure to process and analyze the large volumes of data generated by IoT devices [40,41]. The decentralized approach minimizes latency and ensures that data can be processed close to its source, which is crucial for real-time analytics and decision-making. Businesses can thus leverage distributed systems to handle complex data sets, perform advanced analytics, and derive actionable insights quickly.

Moreover, the synergy between IoT and distributed systems facilitates seamless integration and coordination across different departments and processes within an organization. Workflow management systems powered by these technologies can automate routine tasks, such as data entry, reporting, and scheduling, allowing employees to focus on more strategic activities [42,43]. For instance, IoT devices can automatically update inventory levels in a warehouse management system, triggering reorders when stock runs low [44]. Distributed systems ensure this information is immediately available across the supply chain, enabling timely and efficient responses. In addition, integrating IoT and distributed systems support advanced data management strategies, such as edge computing and real-time data streaming [45]. Edge computing processes data at or near the source of data generation, reducing the need for data to travel to a centralized data center. This approach is particularly beneficial in scenarios where real-time processing is critical, such as in autonomous vehicles or industrial automation [46]. Real-time data streaming, facilitated by distributed systems, allows businesses to analyze data as it arrives, providing up-to-the-minute insights and enabling rapid responses to changing conditions.

4.3.11. Automation and Task Scheduling

IoT and distributed computer systems facilitate automation and task scheduling in business operations, driving efficiency, reducing manual effort, and enhancing productivity. IoT devices are equipped with sensors and connectivity, enabling businesses to automate routine and repetitive tasks traditionally performed manually [47]. This capability is particularly impactful in sectors like manufacturing, logistics, and healthcare, where precision and timely execution of tasks is crucial. For instance, manufacturing plants use IoT-enabled sensors to monitor machinery performance, detect anomalies, and automatically adjust settings to optimize production processes [48,49]. These sensors can trigger automated maintenance schedules based on real-time data, preventing equipment failures and reducing downtime. Hossain et al. [50] explain that the ability to collect and respond to data in real time ensures that machines operate at peak efficiency, minimizing waste and maximizing output. Distributed computer systems play a crucial role in this automation by processing the vast amounts of data generated by IoT devices, running complex algorithms to predict maintenance needs, and scheduling tasks accordingly.

IoT and distributed systems allow businesses to implement advanced task scheduling algorithms considering multiple variables, such as resource availability, task priority, and real-time data inputs. According to Pham and Huh [51], these algorithms can dynamically allocate tasks to the most appropriate resources, ensuring optimal use of personnel, equipment, and time. For example, in a smart factory, IoT devices can monitor the status of different production lines and automatically assign tasks to the lines that are best equipped to handle them [52]. It helps balance workloads and prevents bottlenecks. Furthermore, automating administrative and back-office tasks through IoT and distributed systems frees employees to focus on more strategic and value-added activities [53,54]. Routine tasks like data entry, report generation, and inventory management can be automated, reducing the risk of human error and increasing overall productivity. Distributed computing ensures that these automated systems are robust, scalable, and capable of handling the demands of a growing business.

4.3.12. Enhanced Operational Efficiency

IoT and distributed computer systems enhance operational efficiency across various business functions. For instance, businesses utilize IoT devices to continuously monitor and report on various operational parameters [55]. This provides them unprecedented visibility into their processes. In addition, Xiong et al. [56] indicate that this real-time monitoring allows organizations to identify and address inefficiencies promptly, ensuring smoother operations and reducing wastage. Distributed computer systems complement IoT by providing the computational power necessary to process and analyze the vast amounts of data generated by IoT devices [57,58]. These systems can distribute the computational load across multiple nodes, ensuring efficient data processing without bottlenecks. For instance, a large manufacturing plant can use distributed systems to aggregate data from hundreds of IoT sensors, analyze it to identify patterns and trends and provide actionable insights to operators and decision-makers [59]. This decentralized approach to data processing ensures that insights are derived quickly, enabling timely decision-making and rapid responses to operational issues.

4.3.13. Improved Decision-Making

IoT and distributed computer systems transform business decision-making processes from reactive to proactive data-driven approaches. IoT devices continuously generate vast amounts of real-time data from various sources, such as sensors, machinery, and user interactions [60]. This data provides a comprehensive view of business operations, customer behaviour, and market trends, forming the basis for informed and timely decisions. Distributed computer systems facilitate the processing and analysis of the massive volumes of data generated by IoT devices [61]. These systems distribute the computational load across multiple nodes, allowing efficient and scalable data processing. This decentralized approach ensures data can be analyzed close to its source, reducing latency and enabling real-time analytics [62]. For instance, IoT sensors can monitor traffic patterns, air quality, and energy usage in a smart city. Distributed systems can process this data in real time to optimize traffic flow, reduce pollution, and manage energy distribution, supporting quick and effective decision-making by city planners and administrators.

The combination of IoT and distributed systems facilitates the use of advanced analytics and machine learning algorithms. These technologies can uncover hidden patterns, predict future trends, and provide actionable insights [63]. In the financial sector, IoT devices can monitor market conditions, track asset performance, and gather economic indicators. Distributed systems can analyze this data using predictive analytics to forecast market trends, assess risks, and develop investment strategies [64,65]. This level of predictive capability enables financial institutions to make proactive decisions, mitigate risks, and capitalize on emerging opportunities. Furthermore, IoT and distributed computing systems provide a holistic view of the organization's operations and market environment [66]. These technologies enable executives to make data-driven decisions aligned with business

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objectives. For example, real-time data on production efficiency, customer feedback, and market trends can inform strategic initiatives such as product development, market expansion, and operational improvements [67,68]. Distributed systems ensure that decision-makers have access to up-to-date and accurate information, enabling them to respond swiftly to changes in the business landscape.

4.3.14. New Revenue Streams

IoT and distributed computer systems enable innovative business models and services that generate additional income. Granados et al. [69] found that IoT devices can transform traditional products into smart, connected products that offer additional value to customers. For example, a manufacturer of home appliances can integrate IoT sensors into their products, allowing customers to monitor and control them remotely through a mobile app [70]. This can lead to the introduction of subscription-based services for remote monitoring and maintenance, generating recurring revenue [71,72]. Distributed systems facilitate these new business models by providing the infrastructure to support large-scale IoT deployments and data processing [73]. They enable businesses to offer services such as predictive maintenance, where customers pay for monitoring and maintenance services based on real-time data from their equipment. In addition, the data collected by IoT devices can be monetized through data analytics services, where businesses analyze and sell insights derived from the data to other companies or stakeholders.

4.3.15. Enhanced Customer Experiences

IoT and distributed computer systems enable personalized and responsive interactions, thereby enhancing customer experiences. IoT devices can collect detailed data on customer preferences, behaviors, and usage patterns, allowing businesses to tailor their products and services to meet individual needs [74]. Distributed systems support these personalized experiences by processing and analyzing the data collected by IoT devices. They enable real-time personalization, where services and recommendations are dynamically adjusted based on current data [75]. For example, a retail store can leverage IoT sensors to track customer movements and preferences within a store. At the same time, distributed systems can analyze this data to provide personalized offers and product recommendations [76]. This level of personalization enhances customer satisfaction and loyalty by making interactions more relevant and engaging.

4.3.16. Supply Chain Optimization

Businesses use IoT and distributed computer systems to optimize supply chain operations. IoT devices provide real-time visibility into various aspects of the supply chain, such as inventory levels, shipment status, and environmental conditions. This visibility allows businesses to monitor and manage their supply chains more effectively, reducing delays and improving efficiency [77,78]. Distributed systems enable predictive analytics, where historical data and current trends are analyzed to forecast demand, optimize inventory levels, and identify potential disruptions. For example, IoT sensors in a warehouse can track inventory movements and send real-time data to a distributed system, which analyzes the data to predict stock outs and automatically reorder supplies [79]. This proactive approach minimizes inventory shortages and excesses, ensuring a smooth and efficient supply chain.

4.3.17. Enhanced Security and Compliance

IoT and distributed computer systems enhance security and compliance by providing real-time monitoring and automated response capabilities. IoT devices can detect and report security threats, such as unauthorized access or anomalies in operational data, enabling businesses to respond promptly to potential risks [52]. For instance, IoT sensors in a data centre can monitor for unusual temperature fluctuations or unauthorized entry, triggering alerts and initiating corrective actions. Distributed systems support the implementation of advanced security protocols, such as encryption

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and access control, to protect sensitive data [80,81]. In addition, distributed systems can ensure compliance with regulatory requirements by providing accurate and timely data on various aspects of operations. For example, in the pharmaceutical industry [82], IoT devices can monitor and record the conditions under which drugs are stored and transported, while distributed systems analyze this data to ensure compliance with regulations and standards.

4.3.18. Cost Reduction

The integration of IoT and distributed computer systems can lead to significant cost reductions across various business operations. IoT devices enable real-time monitoring and management of assets, reducing the need for manual inspections and maintenance [46]. For example, IoT sensors can detect equipment malfunctions and trigger automated maintenance processes, minimizing downtime and reducing repair costs [83]. Distributed systems contribute to cost reduction by optimizing resource allocation and improving operational efficiency. They enable businesses to analyze data and identify areas where costs can be reduced, such as energy consumption, inventory management, and labor [84,85]. For instance, distributed systems can analyze energy usage data from IoT sensors and identify patterns that lead to energy waste, allowing businesses to implement energy-saving measures. Additionally, the automation and task scheduling capabilities of distributed systems reduce the need for manual intervention and labour costs, further contributing to overall cost savings.

4.4. Challenges

Despite the multiple positive impacts of IoT and distributed computer systems, there are several challenges to watch out for. For instance, the increased connectivity results in complex systems that can be hard to manage and subject to higher security threats. Such situations can undermine customer trust and confidence in the organization's capacity to manage their data, thereby affecting customer relationships, loyalty, and overall sales [86]. Therefore, businesses should implement appropriate strategies to address potential challenges associated with adopting and implementing IoT and distributed computer systems.

4.4.1. Data Security and Privacy

The rapid expansion of IoT and distributed computer systems introduces significant data security and privacy challenges. For instance, IoT devices are interconnected and continuously collecting data, increasing the potential entry points for cyber-attacks [44]. These devices often handle sensitive information, such as personal health data, financial transactions, or proprietary business information. The sheer volume and variety of data generated by IoT devices make it challenging to ensure robust security measures across all network points [87]. In a distributed computer system, data is processed and stored across multiple nodes, further complicating security management. Ensuring that data is protected in transit between nodes, as well as while stored at various locations, requires sophisticated encryption methods and consistent security protocols [25,88]. The decentralized nature of these systems means that vulnerabilities in any single node can potentially compromise the entire network, making it difficult to implement a unified security strategy. Privacy concerns are also heightened with the extensive data collection capabilities of IoT devices [89]. The constant monitoring and collection of personal data can lead to unauthorized access or misuse if not properly managed. The risk of data breaches or leaks can undermine consumer trust and result in significant legal and financial repercussions.

4.4.2. Complexity and Management

The integration of IoT and distributed computer systems introduces substantial complexity in terms of system management and coordination. IoT networks consist of numerous interconnected devices, each generating vast amounts of data that must be managed, processed, and analyzed [90]. Managing such a large-scale, heterogeneous network requires advanced infrastructure and

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sophisticated software to ensure seamless operation and interoperability. Distributed computer systems, which operate by dividing computational tasks across multiple nodes, add another layer of complexity. The complexity of these innovations is evidenced in Gao et al. [91] research, which indicates that a simple IoT application consisting of 95% status reporting queries and 5% user queries, serving 10 billion devices, requires 1000 to 100,000 nodes functioning at a 50ms response rate. Coordinating these nodes, managing their interactions, and ensuring data consistency across the network can be challenging.

4.4.3. Requires Extensive Resources

Implementing and maintaining IoT and distributed computer systems often requires extensive resources, both in terms of financial investment and technical expertise. The deployment of IoT devices involves significant upfront costs for purchasing and installing sensors, communication modules, and other hardware [92]. Additionally, the infrastructure needed to support data collection, storage, and processing, including servers, networking equipment, and cloud services, represents a substantial financial commitment. The operational costs associated with these technologies also add to the resource requirements [93]. Managing, maintaining, and updating IoT devices and distributed systems involves ongoing expenses for system administration, cyber security measures, and technical support. As these systems generate large volumes of data, businesses need to invest in scalable data storage solutions and high-performance computing resources to handle data processing and analytics effectively.

4.4.4. Software Quality Issues

The development and deployment of software for IoT and distributed computer systems are fraught with challenges related to software quality. The complexity of these systems requires that software solutions be robust, reliable, and capable of handling diverse and dynamic conditions [33]. However, ensuring high software quality can be difficult due to the numerous interactions and dependencies involved. IoT devices and distributed systems often operate with real-time data and require high levels of accuracy and reliability [94,95]. Software bugs or performance issues in any component of the system can lead to cascading failures, impacting the overall functionality and reliability of the system [96,97]. Ensuring that software can handle edge cases, unforeseen scenarios, and varying operational conditions adds to the complexity of development and testing.

4.4.5. Data Consistency and Synchronization

Maintaining data consistency and synchronization across IoT and distributed computer systems presents a significant challenge. In distributed systems, data is often spread across multiple nodes, each of which may process and update data independently [98]. Ensuring all nodes have a consistent view of the data and that changes are accurately reflected across the entire system is complex. For IoT networks, where devices generate data continuously and in real-time, achieving data consistency becomes even more challenging [99,100]. Data collected from various IoT devices must be integrated and synchronized to provide a unified view. Discrepancies or delays in data synchronization can lead to inconsistent or outdated information, affecting decision-making and operational efficiency [101,102]. The challenge is further compounded by issues such as network latency, device failures, and data transmission errors.

4. Conclusions

IoT and distributed computer systems are significantly transforming business models by enabling real-time data collection, advanced analytics, and automated processes. IoT devices encompass sensors, wearables, and smart appliances. They provide real-time monitoring of operations, predictive maintenance, and automation, enhancing efficiency and reducing costs. On the other hand, distributed computer systems distribute data processing tasks across multiple nodes, providing the necessary computational power and scalability to handle the vast amounts of data

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generated by IoT devices. IoT and distributed systems facilitate improved decision-making by providing timely, data-driven insights, which help businesses optimize operations, personalize customer experiences, and create new revenue streams. Furthermore, these technologies enable supply chain optimization by offering real-time tracking and data analysis, ensuring smoother operations, reducing costs, and enhancing overall efficiency. The combined impact of these innovations is driving businesses toward more efficient, innovative, and competitive operations.

However, the integration of IoT and distributed systems also presents significant challenges that businesses must address to fully realize their benefits. Data security and privacy are paramount concerns since interconnected systems increase the risk of cyber-attacks and data breaches. Managing extensive IoT networks and distributed systems require substantial resources and specialized expertise, adding to the complexity of implementation and maintenance. Software quality issues, data consistency, and synchronization further complicate the deployment and operation of these systems. To ensure that data remains consistent and synchronized across all nodes of a distributed system, is crucial for maintaining the integrity and reliability of business processes. Businesses must address these challenges to ensure the reliability, security, and efficiency of their IoT and distributed systems implementations. By tackling these issues proactively, organizations can better leverage these technologies to drive innovation, improve operational efficiency, and maintain a competitive edge in their respective industries. Addressing these challenges is crucial for operational success and maintaining customer trust and compliance with regulatory standards, thereby safeguarding the long-term sustainability and growth of the business.

Theories related to the IoT and Distributed Computer Systems have significantly impacted business models across various industries. These contributions can be categorized into several key areas:

(i) Internet of Things; a) Data-Driven Decision Making (IoT devices generate vast amounts of data, enabling businesses to make more informed decisions. This data can be analyzed to optimize operations, improve customer experiences, and predict future trends (e.g., In retail, IoT sensors track inventory levels in real time, allowing for efficient stock management and reduced wastage); b) Operational Efficiency (IoT technologies automate and streamline processes, leading to enhanced efficiency and reduced operational costs (e.g., Smart factories use IoT devices to monitor equipment health, predict maintenance needs, and minimize downtime); c) New Revenue Streams (IoT enables the creation of new business models, such as subscription-based services and pay-per-use models, by providing continuous connectivity and real-time monitoring (e.g., Companies like Rolls-Royce offer "Power by the Hour" programs for their aircraft engines, charging airlines based on usage rather than ownership); d) Enhanced Customer Experience; a) IoT devices facilitate personalized and immersive customer experiences by collecting and analyzing user data (eg., Smart home devices, like thermostats and lighting systems, adjust settings based on user preferences and behaviors); e) Improved Supply Chain Management (IoT enhances visibility and traceability in supply chains, leading to better inventory management and logistics optimization (e.g., IoT-enabled logistics platforms provide real-time tracking of goods, ensuring timely deliveries and reducing losses);

(ii) Distributed Computer Systems; a) Scalability and Flexibility (Distributed systems allow businesses to scale their operations seamlessly by distributing workloads across multiple machines (e.g., Cloud computing services like AWS and Azure provide scalable infrastructure, enabling businesses to adjust their computing resources based on demand); b) Cost Reduction (By utilizing distributed systems, companies can reduce costs associated with maintaining and upgrading physical infrastructure (e.g., Netflix uses distributed computing to stream content to millions of users worldwide, reducing the need for expensive on-premises data centers; c) Enhanced Reliability and Redundancy (Distributed systems improve reliability by distributing tasks across multiple nodes, reducing the risk of system failures (e.g., Google's search engine infrastructure uses distributed computing to ensure continuous availability and quick recovery from failures); d) Improved Performance (Distributed computing allows for parallel processing, significantly improving the performance of data-intensive tasks (e.g., Financial institutions use distributed systems to perform complex risk calculations and trading algorithms in real-time); e) Global Reach and Accessibility

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(Distributed systems enable global access to services and applications, supporting businesses in reaching a wider audience (e.g., Social media platforms like Facebook and Twitter use distributed computing to handle the vast amounts of data generated by users worldwide).

(iii) Integration of IoT and Distributed Systems in Business Models; a) Smart Infrastructure (Combining IoT with distributed systems enables the creation of smart cities and infrastructure, enhancing urban living and efficiency (e.g., Smart grids use IoT sensors and distributed computing to manage energy distribution and consumption more effectively; b)Edge Computing (Integrating IoT with edge computing, a form of distributed computing, allows data processing closer to the data source, reducing latency and bandwidth usage (e.g., Autonomous vehicles use edge computing to process data from sensors in real-time, enabling faster decision-making); c) Predictive Analytics and Maintenance (IoT data combined with distributed computing powers predictive analytics, helping businesses anticipate issues before they arise (e.g., Manufacturing companies use predictive maintenance to foresee equipment failures, reducing downtime and repair costs); d) Personalized Services (The integration of IoT and distributed systems supports the delivery of personalized services at scale (e.g., E-commerce platforms use data from IoT devices and distributed systems to offer personalized recommendations to users); e) Enhanced Security (Distributed systems enhance the security of IoT networks by providing decentralized data storage and processing, reducing the risk of centralized attacks (e.g., Blockchain technology, a form of distributed ledger, can secure IoT transactions and data exchanges).

These contributions illustrate how IoT and distributed computer systems are reshaping business models, driving innovation, and creating new opportunities across industries.

Exploring future lines of investigation in IoT and Distributed Computer Systems within business models involves examining emerging trends, challenges, and opportunities that these technologies bring. (i) advanced Data Analytics and AI Integration (investigate the integration of advanced analytics and artificial intelligence to extract deeper insights from IoT data, enabling predictive and prescriptive analytics. Focus Area: Developing AI models that can autonomously interpret IoT data for real-time decision-making and automated responses; (ii) distributed Computer Systems (Investigate the evolution of decentralized architectures, such as blockchain and distributed ledgers, in enhancing trust and transparency in business models.

Focus Area: Applying decentralized systems in supply chain management, finance, and digital identity verification; and integration of IoT and Distributed Systems in Business models to explore the creation of fully autonomous systems that leverage IoT data and distributed computing to operate without human intervention. Focus Area: Developing autonomous logistics, industrial automation, and smart infrastructure management solutions.

By exploring these future lines of investigation, businesses can better understand the potential of IoT and distributed computer systems to innovate, optimize, and transform their operations and strategies.

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Appendix A

Table A1. Overview of document citations period ≤2014 to 2024.

Documents		≤2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Strengthening Supply Chain Visibility with Blockchain: A PRISMA-Based Review	2024	-	-	-	-	-	-	-	-	-	4	5	9
An Integrated Pricing, QoS-Aware Sensor Location Model for Security Protection in Society 5.0	2023	-	-	-	-	-	-	-	-	-	1	-	1
Blockchain for the Management of Internet of Things Devices in the Medical Industry	2023	-	-	-	-	-	-	-	1	3	6	7	18
Understanding competency requirements in the context of AEC industry informatization: policy insights from China	2023	-	-	-	-	-	-	-	-	-	1	1	2
Distributed agent-based deep reinforcement learning for large scale traffic signal control	2022	-	-	-	-	-	-	-	-	6	18	12	36
5G Security Threats	2022	-	-	-	-	-	-	-	-	-	1	-	1
Blockchain-Based Sensitive Document Storage to Mitigate Corruptions	2022	-	-	-	-	-	-	-	-	-	3	-	3
Information interaction in distributed systems	2020	-	-	-	-	-	-	-	-	-	2	-	2
Cyber-based design for additive manufacturing using artificial neural networks for Industry 4.0	2020	-	-	-	-	-	-	2	13	23	22	13	73
Modeling for malicious traffic detection in 6G next generation networks	2020	-	-	-	-	-	-	3	1	4	4	1	13
Probabilistic data structures for big data analytics: A comprehensive review	2020	-	-	-	-	-	-	6	7	6	11	5	35
Research and Design on Key Technologies of Spatial-Temporal Cloud Platform Construction	2019	-	-	-	-	-	-	-	-	-	-	3	3
Fog Radio Access Networks in Internet of Battlefield Things (IoBT) and Load Balancing Technology	2019	-	-	-	-	-	-	1	-	1	3	-	5

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Distributed healthcare and medicine: Technological feasibility and future scope for redirecting the current centralized model to benefit remote areas	2019	-	-	-	-	-	-	-	1	-	-	-	1
Engineering resilient collaborative edge-enabled IoT	2019	-	-	-	-	-	-	4	6	4	2	-	16
Distributed intelligence: A critical piece of the microgrid puzzle	2019	-	-	-	-	-	-	2	1	1	1	-	5
A survey on internet of things based smart, digital green and intelligent campus	2019	-	-	-	-	-	-	4	6	9	5	7	31
Analytical modelling and QoS evaluation of IoT applications in E-government	2019	-	-	-	-	-	-	-	-	-	1	-	1
Linguistic Abstractions for Interoperability of IoT Platforms	2019	-	-	-	-	-	-	-	1	1	-	-	2
Enhancing teamwork behavior of services	2019	-	-	-	-	-	-	-	1	-	-	-	1
Retrofitting of Workflow Management Systems with Self-X Capabilities for Internet of Things	2019	-	-	-	-	-	-	-	1	1	-	-	2
S-CHIRP: Securing communications in lightweight peer-to-peer networks in the IoT	2019	-	-	-	-	-	-	-	-	2	-	-	2
Research on the Fusion Model Reference Architecture of Sensed Information of Human Body for Medical and Healthcare IoT	2018	-	-	-	-	-	-	2	2	2	-	-	6
Selective blockchain transaction pruning and state derivability	2018	-	-	-	-	-	1	3	7	11	12	6	40
Integration of big-data ERP and business analytics (BA)	2018	-	-	-	-	-	1	4	9	8	5	6	33
Secured distributed IoT based supply chain architecture	2018	-	-	-	-	-	2	1	2	2	-	-	7
READ: Reliable event and anomaly detection system in wireless sensor networks	2018	-	-	-	-	-	1	3	3	-	-	1	8
The governance of smart mobility	2018	-	-	-	-	9	45	74	66	51	55	34	334

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Efficient Management of Perishable Inventory by Utilizing IoT	2018	-	-	-	-	-	1	2	2	-	1	-	6
Inclusion of blockchain in course of distributed systems at the school of computer science	2018	-	-	-	-	-	-	1	-	-	1	-	2
Crowdsourcing of Sensor Cloud Services	2018	-	-	-	-	3	2	1	-	-	1	-	7
Adaptive security architecture for protecting RESTful web services in enterprise computing environment	2018	-	-	-	-	-	1	3	4	6	4	-	18
Minimizing the trade-off between sustainability and cost effective performance by using autonomous vehicles	2018	-	-	-	-	-	4	16	16	27	23	16	102
Research on the innovation of liaoning public safety and security emergency management system from the perspective of smart city	2018	-	-	-	-	-	-	1	-	-	-	1	2
Optimized Hexagon-Based Deployment for Large-Scale Ubiquitous Sensor Networks	2018	-	-	-	1	3	9	3	-	3	-	1	20
Overview of 5G Security Challenges and Solutions	2018	-	-	-	-	6	26	59	69	62	54	33	309
CE-GMS: A cloud IoT-enabled grocery management system	2018	-	-	-	-	1	1	5	1	8	1	2	19
Smart cities: Under-gridding the sustainability of city-districts as energy efficient-low carbon zones	2018	-	-	-	-	7	12	9	19	14	12	6	79
Smart manufacturing	2018	-	-	-	-	19	76	157	152	197	180	102	883
Fog computing: Concepts, frameworks and technologies	2018	-	-	-	-	1	4	8	9	12	5	2	41
Modern trends in digitalization of tourism industry	2018	-	-	-	-	-	1	1	1	1	2	4	10
Cloud manufacturing: A service-oriented manufacturing paradigm. A review paper	2018	-	-	-	-	5	13	15	19	19	13	6	90
IoT platform for real-time multichannel ECG monitoring and	2018	-	-	-	-	-	1	2	5	4	1	-	13

classification with neural networks													
An Elliptic Curve Cryptography Based Encryption Scheme for Securing the Cloud against Eavesdropping Attacks	2017	-	-	-	-	-	1	1	4	1	1	1	9
Internet-of-Things and Cloud Computing for Smart Industry: A Systematic Mapping Study	2017	-	-	-	-	2	3	3	3	2	-	2	15
From Intelligent Manufacturing to Smart Manufacturing for Industry 4.0 Driven by Next Generation Artificial Intelligence and Further on	2017	-	-	-	-	2	16	22	24	27	23	21	135
An industrial IoT framework to simplify connection process using system-generated connector	2017	-	-	-	-	-	1	-	-	-	-	-	1
IoT based agriculture as a cloud and big data service: The beginning of digital India	2017	-	-	-	-	4	15	16	19	18	19	9	100
Concatenating unprotected internet of things network event-driven data to obtain end-user information	2017	-	-	-	-	-	1	-	-	-	-	-	1
Cloud storage hub: Data management for IoT and industry 4.0 applications: Towards a consistent enterprise information management system	2017	-	-	-	-	2	1	1	6	3	1	1	15
Algorithms for big data delivery over the internet of things	2017	-	-	-	-	-	4	1	1	1	1	-	8
Blockchain technology innovations	2017	-	-	-	0	13	48	72	62	102	99	40	436
Troubleshooting Wireless Coexistence Problems in the Industrial Internet of Things	2017	-	-	-	-	4	2	6	7	2	4	-	25
DockerCap: A Software-Level Power Capping Orchestrator for Docker Containers	2017	-	-	-	-	4	4	8	2	1	2	-	21
Development of a Hybrid Defensive Embedded	2017	-	-	-	-	-	-	1	1	1	-	-	3

System with Face Recognition													
FFWD: Latency-Aware Event Stream Processing via Domain-Specific Load-Shedding Policies	2017	-	-	-	-	1	1	-	-	-	-	-	2
TSTP MAC: A Foundation for the Trustful Space-Time Protocol	2017	-	-	2	1	2	1	-	-	1	-	-	7
Business and market perspectives in 5G networks	2017	-	-	-	-	-	4	3	5	2	2	-	16
Array of things: A scientific research instrument in the public way	2017	-	-	-	1	4	17	18	14	9	13	6	82
Performance Analysis of Network Traffic Predictors in the Cloud	2017	-	-	-	1	1	4	5	4	4	3	-	22
Crowd science and engineering: concept and research framework	2017	-	-	-	-	5	11	9	10	6	8	2	51
E-commerce logistics in supply chain management Implementations and future perspective in furniture industry	2017	-	-	-	-	4	10	11	19	18	28	15	105
Multi-perspective digitization architecture for the internet of things	2017	-	-	-	-	1	-	2	-	-	-	-	3
Resource provisioning for IoT services in the fog	2016	-	-	-	8	14	34	32	31	22	14	4	159
Big data: From beginning to future	2016	-	-	-	20	31	41	55	42	55	41	20	305
Towards task scheduling in a cloud-fog computing system	2016	-	-	-	8	18	33	40	41	25	25	12	202
The role of big data in smart city	2016	-	-	6	34	86	122	155	150	112	78	51	794
Applications of Internet of Things in manufacturing	2016	-	-	-	9	19	12	6	11	15	8	4	84
Cloud-based cyber-physical systems and quality of services	2016	-	-	3	8	16	10	13	4	6	11	3	74
Study on the IOT architecture and gateway technology	2016	-	-	1	5	6	11	14	13	12	19	3	84
Software quality issues and challenges of internet of things	2016	-	-	-	3	1	7	3	7	3	2	2	28

Cloud operating system for industrial application	2015	-	-	2	2	3	2	2	2	2	1	-	16
Digital enterprise architecture-transformation for the internet of things	2015	-	1	8	10	13	20	14	19	11	9	1	106
Short description and benefits of system lifecycle management in context of industrial internet including industry 4.0 and internet of thinks and services	2015	-	-	2	2	1	1	1	2	-	-	-	9
Internet of things: Big challenge for enterprises	2015	-	-	1	3	-	-	-	-	-	-	-	4
The design and development of intelligent warehouse management system: Based on.NET and internet of things	2014	-	1	-	1	1	-	-	-	2	-	-	5
	Total	-	2	25	117	314	639	915	932	954	877	473	5,249

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