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Internet of Things and Big Data Analytic: A State of the Art Review

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Abstract

The Connectivity plays a vital role in today's world when it comes to a device or things connection. The Internet of Things (IoT) plays a fundamental role in understanding real-world objects virtually and generating massive amounts of data from and for them. The exponential rise in data consumption and the exploding number of IoT-connected devices are only two indicators of how the expansion of Big-Data (BD) exactly parallels that of the IoT. Concerns of data collecting efficiency, data processing, analytics, and security are not trivial when it comes to managing big data in a constantly growing network. Researchers have looked at the difficulties of implementing the Internet of Things to find solutions to these issues. Despite the abundance of research on big data, analytics, and the Internet of Things, the intersection of these fields opens several prospects for developing big data and analytics in IoT settings. This paper focuses on feasible and ideal solutions for the effective integration of IoT with BD. The challenges of combining IoT and BD were also illustrated by presenting an analysis of this issue to a community of readers.

Keywords: *Big Data, RFID, IoT Architecture, IoT, Big Data-IoT.*

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I. INTRODUCTION

Communication today has become at the core of human life until yesterday. The Internet was the pinnacle of communication between people today. The Internet has become from the past, and the Internet has appeared [1]. The efficiency, performance, and communication of things in the Internet of Things depend on the amount of data (Big Data) produced from things, processing, and storage [2].

The Internet of Things (IoT) is the network of physical objects—instructors, tools, cars, buildings, and other objects embedded within a network that allows these objects to gather and share data through electronics, circuits, applications, sensors, and network connectivism [3]. To make objects more specifically embedded into computerized networks and increase performance and precision, the Internet of things allows remotely to be sensed and controlled within the current network infrastructure [4]. The idea of the intelligent device network was questioned in 1982 when a revamped coke machine was the first Internet-linked devise to announce its inventory and whether newly-laden beverages were cold—the concept of a network of intelligent devices [5]. Technology pioneer is known for the word 'Internet of Thing' to describe a structure in which the Internet through ubiquitous sensors is linked to the physical world.

Big data remains a mature and evolving subject [6]. Large datasets and files have extended beyond commercial information management systems capabilities and capabilities. For effective data storage and retrieval, organized representations become bottlenecks. Gartner has recognized four key problems (four Vs): increased data volume, increased speed (e.g., data entry and exchange), an expanded range of data forms and systems, and an increase in data uncertainty [7].

Safety and privacy problems can be resolved or reduced by using big data and resources (BD) research techniques [8]. Big data is a standard modern concept used to explain surprisingly quickly organized and unstructured data volume changes. Considerable data precision can lead to trust in decisions, and better decisions can lead to improved organizational success, cost savings, and reduced risks [9].

BD typically uses a base technology, cloud computing (CC), to run [10]. CC may also be used as the basis for another networking technology related to IoT [11]. IoT's fundamental concept is the dispersed existence of a multitude of devices or things that are used by individuals such as RF tags, cameras, cell phones, and actuators [12]. These things communicate with one another and collaborate with others to accomplish shared goals through particular approaches [13]. The IoT can be characterized as the network for the collection and exchange of information about the bibliography of physical objects, computers, cars, buildings, and other things embedded in electronics, software, sensors, and network connections [14]. Examples include volume constraints, contact capacities, energy, and IoT devices' processing [15].

These inefficiencies encourage one to merge CC and IoT technology features [16]. ACCEPTED MANUSCRIPT IoT safety focuses on the health of IoT-linked devices and networks [17]. IoT entails increasing the superiority of objects and individuals, with special identificatory and the ability to transfer data automatically over a network [18]. Mobile networking, lower costs for PCs, and an absolute number of networked computers in the IoT drive the transition into cloud computing [19, 20]. In particular, CC is associated with data processing capacity in a fog network rather than keeping the processing power in a cloud or a central data warehouse [21].

In this paper, fundamental work steps of Internet-of-Things and Bigdata are discussed, the architecture of the Internet of Things is illustrated. The paper has outlined very efficient technologies in the IoT. Moreover, the IoT features were pointed, the challenges and issues in implementing the Internet of Things were discussed. Finally, the need for integration between the IoT and BD was discussed.

The rest of this work is organized as the following The fundamental work step of IoT in section II. In section III, The fundamental work step of IoT. In section IV, the Architecture of IoT is illustrated In section V, KEY Issues in implementing IoT are discussed In section VI. Bigdata concepts The need for integration between IoT and big data. In section VII, Literature review. In section VIII, All mentioned and reviewed researches are compared and discussed. Finally, in section IX, the Conclusion of this work is presented.

II. THE FUNDAMENTAL WORK STEP OF IOT

A. *Review Stage*

Object sensing, Detecting, and connecting device data: Depending on the various types of sensors, data can include sensed information, including acceleration, Moisture, heat, motion, and chemical nature of the environment. Various types of sensors may be used [22].

B. *Triggering of an action*

data that are received are Attributed, then it handled in the intelligent device's processing unit. An action that is to be invoked is calculated according to the processed information [22, 23].

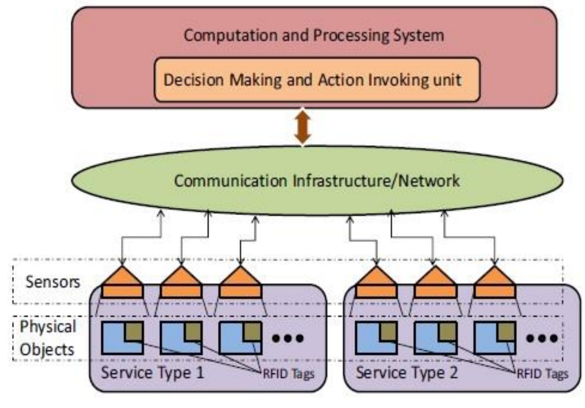

Fig. 1. The basic IoT network

C. *The system or intelligent computer*

Offers a rich range of resources and provides a framework for providing the administrator with input on the current system's state. Therefore, the results are submitted to the supervisor of the acts that were invoked [23].

III. ARCHITECTURE OF IOT

IoT Architecture is a structure of various elements that make up an IoT networking system, such as sensors, actuators, protocols, cloud servers, and layers. It typically consists of distinct layers that allow administrators to analyze, monitor, and preserve the system's integrity. It also needs a roadmap for alignment with the company's current infrastructure and processes, as with any system architecture proposal [8, 24]. The IoT Architecture consists of the following layers [25]:

1) Perception Layer: It becomes the physical substrate that has environmental information identification and collection sensors. It senses those spatial parameters in the environment or distinguishes such intelligent objects.

2) Network Layer: Network Layer's primary function is to relay data obtained from the sensor of those devices safely to the system processing unit. The medium for transmitting this data may be wireless or wired. Depending on the sensor systems, the technologies used could be infrared, WiFi, 3G, Bluetooth, etc. Thus, the data is transferred to the middleware layer from the perception layer through the network layer, which is its function.

3) Middleware Layer: It has some advanced features such as storage, computing, processing, and action-taking capability. This layer stores all information and gives appropriate information to that gadget based on the gadget address and title. It may moreover take choices based on dataset estimations determined from sensors.

4) Application Layer: application processes are handled based on data gathered from the middleware-layer. This application includes sending emails, warning activation, protection system activation, computer flipping on or off, smart-watch, smart farming.

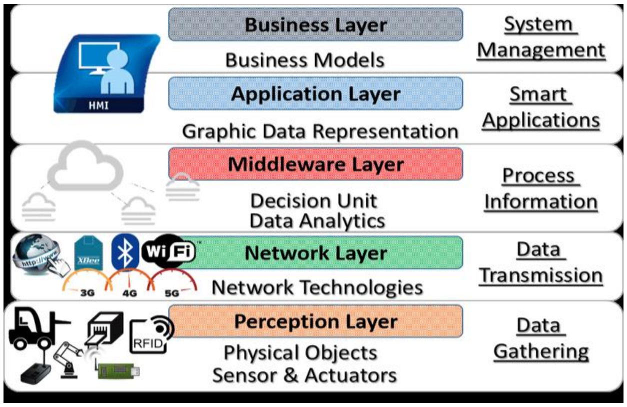

Fig. 2. The IoT Architecture

5) Business Layer: Any device's performance relies not only on the technology used in it but also on how it is distributed to its customers. The business layer does these functions for the system. It includes developing flowcharts, diagrams, outcome analysis, and how to develop the device.

IV. KEY ISSUES IN IMPLEMENTING IOT

Internet of Things offers a massive variety of advantages these days and its implementations in almost every region. On the other hand, before and after its introduction, it often goes through several problems and difficulties. Some of these issues are briefly explained here:

1) (RFID) Radio Frequency Identification: It is a technique that uses certain radio waves to move the identity of the target or an individual through a serial number. In the IoT, RFID is essential to address problems relevant to object recognition financially. Based on tags' power supply strategy, RFID tags are divided into three distinct groups (Passive, Semi-Passive, Active). RFID primarily consists of a get-to controller, a computer program, a radio wire, and a server. RFIDs can be utilized in quiet checking, conveyance, and military applications [26, 27].

2) Wireless Sensor Networks (WSN): Comprises independent and autonomous gadgets that are spatially disseminated. WSN employs specific sensors to arrange to screen and analyze natural and physical conditions like sound, vibration, weight, temperature, movement, and various toxins, displaying at shifting areas. The WSN is formed by thousands of hubs that can connect and communicate information. The WSN in IoT is gently ubiquitous in many ways, including safety, manufacturing, and surgery exploration. The fire of the trees [28, 29].

3) Actuators: Turn the energy into action. In the form of electric current or hydraulic liquid, they suck up some supply of electricity. They can also produce rotational motion, oscillatory movement, or linear movement. it works within small zones, generally up to 30 feet, transmitting data at less than one Mbps. In general, actuators are used in engineering and automotive applications [30].

4) (NFC)Near Filed Communication: Wireless technology with limited ranges of service. It resides on the 13.56 MHz range, requiring a separation of up to four centimeters. It is easy and helps customers worldwide share digital documents, make easy purchases, and use a button, link to electronic devices. NFC can also work efficiently in dusty conditions, it does not require line of sight contact, and it is thus a convenient and simple form of interaction [31].

5) ZigBee: The technology has been developed to boost the functioning of (WSN). The ZigBee-Alliance founded it. It was established. A system that works for small transmission scopes is efficient and flexible and has low costs. Its data transfer speeds are lower, and the architecture of its protocol is very versatile. They were primarily used for home control, medical tracking, remote cultivation [32].

6) Bluetooth: It is a technology that works for short areas wirelessly. The alternative to other wireless technology is an economical one. Bluetooth eliminates the need for physical cabling of cable systems such as PDAs, notebooks, printers, tablets, etc. It runs in the Tens of meters range and transmits at a rate below 1Mbps. You may also use Bluetooth can be used as Personal Area Networks [33].

7) WIFI: Wireless connection that allows different devices to create contact throws a signal. Vic Hayes has established wireless Fidelity. It is used these days because it is a high-speed connection. It is (Wireless LAN) to connect public areas, such as hospitals, cafes, airports, organizations, and homes. Also, mobile devices, smartphones, notebooks, and many devices come with embedded WiFi (CE) [34].

8) Barcode: It is a machine-readable representation of numerals and characters composed of bars and spaces. Currently, as seen below, stripes are ubiquitous on packets of items sold at supermarkets, grocery stores, and other stores [35].

9) Internet Protocol (IP): A primary critical network protocol used on the Internet is the Internet Protocol. The IP is responsible for transferring datagrams around the borders of the network. IP has two variants currently in operation: IPv4 and IPv6. IPv4, however, is only primarily used over the Internet. Internet users can use iPv4 for everyday use. The capacity to appeal to many IP addresses is IPv6 [36].

10) Artificial Intelligence: Artificial Intelligence is sometimes referred to as a technology composed of electronic and interactive worlds sensitive to the world and individuals in turn. In an intelligent environment, through the use of knowledge or intelligence fed into the network's linked devices, the devices function in the direction of allowing users to conduct their routine life tasks simply and regularly [37].

V. BIG DATA CONCEPTS

Big data (Bigdata) is characterized as a massive volume of data that needs modern computational technology and techniques to retrieve helpful data collection knowledge [38].

1) Volume: the amount of knowledge provided by several sources. That being considers when working with Big Data.

2) Variety: Different channels, such as sensors, social media, and smartphones, produce homogeneous and heterogeneous outputs. Such information contains audio, video, email, making this information is heterogeneous data.

3) Velocity: mean how to speed data are created in real-time. In a broader sense, the change rate, the connecting of approaching information sets at various speeds, and action bursts are included.

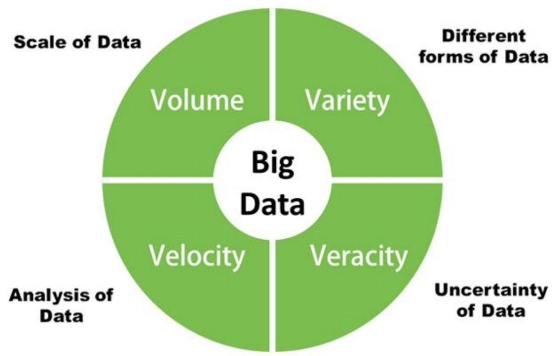

Fig. 3. Concept of Big Data

4) Veracity: refers to data biases, noise, and data irregularities. After analysis, the corporation must have helpful knowledge so that the organization can make informed decisions.

VI. NEED OF INTEGRATION BETWEEN IOT AND BIG DATA

The IoT function of Big-Data is to process and archive vast volumes of data on a real-time basis using various storage technologies [38]. Extensive data analysis is evolving as a key to understanding IoT devices' data that helps to take the initiative to enhance decision-making. IoT and BD-generated data are connected. Big data alone is not adequate to require any form of analytics to enhance IoT devices' different processes. Big data and IoT integration will improve operations through numerous industries such as the modern education system, intelligent transportation, climate protection, agriculture, and much more [39].

There are different technologies available that help communicates with the vast quantity of IoT data and other sources. Column-focused databases[x], HadoopSQL, Hive, Wibidata[x], PLATFORA, the Sky Tree, the Schema-less, or the NoSQL databases, etc. Large data insight streaming, Large Data Lambda Architecture, Map elimination, PIG [40].

VII. LITERATURE REVIEW

The authors of [41] presented the topic of handling data on the Internet of Things appropriately. For this aim, the researcher will inform the measured approach to the IoT data collection and query and the pivot tables' capacity to index and scan for this type of data. In addition to implementing two real universes, a large-scale IoT data collection from the COMPOSITION and MONSOON European Union initiatives (under grants No. 723145 and 723650), the researcher has demonstrated that the metric method enables efficient access to the Internet of Things data.

A research work performed in-depth research on approaches and technology for IoT enormous information clustering examination and created and executed a data collection preparing and model framework based on the calculation for clustering analysis. This show is seen as an encouraging expansion to the current Lager Comfort framework at the research facility. This made up for the first system's deficiencies in gathering and analyzing energetic occasions. It also updated the initial Hadoop stage utilized within the research facility and utilized form 2.6.0 connected by the current venture, which advance moved forward the test's productivity. In particular, this subject recommends a system for clustering complex occasion design interaction investigation. In clustering methods, this method of research draws on similar algorithms. Relate endotestae was carried out on the algorithm to check the validity of the algorithm. Big data modeling Hadoop techniques are used for processing in the experiment. The study is inspired that there is a certain degree of coherence in this form of clustering analysis [42].

In research [43], authors suggest strategies to compress graphs, a concept-driven by Huffman Coding, identified unique patterns and substituted them with varying sizes of identifiers. Remarkably, given a graph in = (Vz, Ez), when V is the set of vertices and E is the set of edges, /|V|/ = n, authors suggest methods to minimize the storage capacity of the graph by compressing the mathematical attribute function of the same. Compared to the adjacent matrix, the proposed methods show that the space required to save the graphs is reduced by up to 80%. Extend methods even to other incarnations. In the case of the limited asset Web of things, the suggested protocols help resolve problems relating to the organizational sharing of information.

Fakhrazeev et al. demonstrated new planning methods, collecting, and manipulating data in initiatives focused on the Internet of Things idea. The best arrangements are considered, including network management mechanisms and tactics, modern computer structure practices in programs, ways to display and interpret data for better customer observation and realization, and other technological technologies theoretically applicable to innovations focused on the Internet of Things definition. The procurement and incorporation of solutions into a single coordinated data collection and processing arrangement are being carried out. The scope of use is being explored, and the intended structure is being implemented. Consequences of the evaluation of experiment findings dependent on the experimental facilities of National Instruments are presented [44].

A group work demonstrates the feasibility of IoT implementation in high-intense big-size information and time-restricted incidents for noise level measurement. A test solution was developed and implemented in an iterative process in a real-time, privacy compliant IoT sensor device below strict budget and production time restrictions. The sensor system helps festival management quickly monitor record and further, provide fact-full insights created for decision-making to settle commotion disruptions by applying real-time Big data analytics to the collected data. This whole process was demonstrated by using the IoT's lightweight architecture to demonstrate how network implementations for IoT big data analytics in technology stacks can be used [45].

Research [46] extended the Internet of Things for home modules in the latest electronic product to construct an IoT network infrastructure in conjunction with the ZigBee module and database. Authors are using TCP/IP and ASP.NET in the experiment to create a tracking device that can track and analyze Bigdata. The electronic devices are given unique code to guide and track the operation to recognize, classify, and either handle or advise it through a ZigBee that combines with a user-friendly web interface. As a result, people will track and get information about their homes even though they go outside.

A group of scholars focus on combining all three technology or areas, such as Blockchain, Analytic of Bigdata, and Internet of Things. The author believed that those three technologies would play a critical role in overcoming each other's shortcomings. It will aid in future job studies based on our review and case studies [47].

Lwin et al. described the development of a City Geospatial Dashboard that can capture, distribute and simulate geospatial information obtained from satellites, IoT computers, and other Bigdata. Compared to the adjacent matrix, the proposed methods show that the space required to save the graphs is reduced by up to 80%. Extend methods even to other incarnations. In the case of the limited asset Web of things, the suggested protocols help resolve problems relating to the organizational sharing of information [48].

Niu et al. in their research incorporates cloud computing, big data, Zig-bee, Author Chat public number, and other technology in this paper to develop and deploy a tracking system based on the IoT for agriculture [49]. The sensing layer unit gathers the sensing information, processes the network layer, and transmits it to the cloud platform. To carry out real-time surveillance of agricultural production and automated operation of facilities, the cloud platform carries out real-time analysis and decisions after data collection.

Pavlovskiy in [50] discussed the issue of standardization in storing and distributing Bigdata in the IoT implementation in the article. The author highlights big data's fundamental concerns, analyzing the science, technical and economic obstacles to considerable data growth. The author provides recommendations for viewpoint analysis in the area of establishing data representation criteria.

Song and Zhu introduced the Android-based application's development environment and contact with the server [51]. It analyzes and integrates an intelligent farmer's real-time data track, environmental data query, energy usage data analysis, and remote control. The free Android framework helps the app provide a decent space for expansion and view data easily, efficiently, and flexibly. Farmers can identify problems in photovoltaic systems, batteries, etc., promptly and minimize safety risks. However, Android-based client applications can have a certain degree of blocking connections to remote servers due to mobile phones' low signal limitations in some remote regions. The communications network will continue to develop as the country spends extensively on telecom networks. Client applications designed for mobile phones based on the Android platform are expected to be widely available.

Researchers of [52] provided an immersive simulation technique for IoT, Big Data, and Cybersecurity issues for media discussions. Hacker Nets seek to showcase the rivalry between topics and their overtime. The author's comprehensive user network fluctuation displays the social media dataset apps, demonstrating that Hacker Nets will easily highlight new topics and allow users to discover the relationships between individuals. For more than twelve years, cybersecurity has been the dominant issue for debate, while IoT and Big Data are the new fields of the present Industry 4.0 and will continue to be the subjects of concern.

Bao et al. recommended a joint-cloud computing adaptive erasure code for ACIoT-named IoT Big Data to keep NRC data repair at a minimum. In specific, the author first presents an idea of a weighted average (AWL) erasure-coded data strip that is proportional to the NRC average in Joint Cloud storage systems. The author then proposes an active parallel trial and error algorithm to calculate the optimal generator matrix and data positioning method for achieving the lowest AWL within different network environments and encoding parameters. With the optimal generator matrix and data spot, ACIoT can achieve the lowest NRC by encoding and positioning each bunch of data. Tests demonstrate that, as against other state-of-the-art erasure codes, ACIoT cuts NRC by 26.4%-44.7% [53].

Fireteanu presented the benefits of combining Tableau Desktop with data from projects on the Internet of Things. Tableau Desktop is a platform for data analysis that produces custom graphs and accurate acquired/execution information representations. To get a better description of the selected IoT project, this tool's key functionalities may be used. It is easier to track the entire project and reliably classify the focus areas for various action points within the project by reviewing more comprehensive data representations. The presence of both obtained and implementation data accumulated from multiple contexts represents another benefit. Some IoT projects rely on this form of usability because they manage enormous data quantities that require continuous and live monitoring. Tableau is known for its ability to track vast volumes of data and produce valuable maps, tables, geographic measurements of dashboards, and partitioning data [54].

Authors of [55] provided a general overview of the security vulnerabilities in the Internet of things and suggested some mitigation and protection steps in light of actual network situations. An enhanced shell ranking optimization algorithm in data management in centralized Information Infrastructure Logistics is proposed based on the study of data processing of IoT technology and logistics unified information system. According to the features of the Internet of things technology and unified information.

Authors of [56] analyze the heterogeneous multi-source data collection paradigm, suggests device architecture system for data collection based on the industrial Internet of things gateway and addresses. The core issue of heterogeneous multi-source data acquisition in the industrial sector is that the authors realize the real-time collection in the industrial field of heterogeneous multi-source data and generate high-value data for the whole manufacturing chain the use of extensive production data.

Wang and Ma introduced a novel structural risk supervision approach based on Big Data technology for Internet finance in China [57]. The strategy is based on Big Data technologies, combines IT with Stuff Internet technology, can monitor Chinese Internet funding processes in real-time, and offers information to related staff with ease. The results reveal that this solution will effectively improve Chinese Internet financial systemic risk regulation and reduce damages caused by China's Internet financial systemic risk.

VIII. DISCUSSION

From the previous section, it can be seen that researchers have employed different types of techniques in Bigdata with the IoT field. Scientists have issued a list of their recommendations upon studying theirs. Table I of the paper explains the explanations explained in the paper. The article should include a comparison of the success and commonalities in the methodology of Bigdata with IoT. The researcher used the objective and aim, and the Research Used Tools and Techniques and the results.

It is evident from the table that the scientific area of Bigdata Scheduling tools and technic, two real universes, a large scale IoT data collection, Big data modeling Hadoop technique, Huffman Coding, GPS, geo-analysis, BlockChain and IoT, parallel trial-and-error algorithm, shell ranking optimization algorithm. By using this methodology and techniques, both researchers have strong structures, frames, and functions.

TABLE I: BIGDATA AND IOT TECHNIC AND RESULT

Ref.	Objective and Aim	Tools/Technique	Results
[41]	presented the topic of handling data on the Internet of Things in an appropriate manner	two real universes, a large scale IoT data collection	demonstrated that the metric method enables efficient access to the Internet of Things data.
[42]	It prepared and model framework that's based on the calculation for clustering analysis.	Big data modeling Hadoop technique.	A certain degree of coherence in this form of clustering analysis.
[43]	identified unique patterns and substituting them with identifiers that are of varying size.	Huffman Coding	offer assistance unravels the issues related to exchanging information over the organization in the restricted asset Web of Things.
[44]	demonstrated new planning methods, collecting, and manipulating data in initiatives focused on the Internet of Things idea.	network management mechanisms and tactics	A single coordinated data collection and distribution arrangement is carried out to procure and incorporated solutions.
[45]	demonstrates the feasibility of IoT implementation in high-intense big-size information and time-restricted incidents for noise level measurement	applying real-time Big data analytics to the collected data	In an iterative model applied in real-time under tight budgetary and development time constraints, a privacy-compliant IoT sensory interface.
[46]	extended the use of the IoT for home modules in the latest electronic product to construct an IoT network infrastructure	ZigBee, TCP/IP, and ASP.NET track and analyze Bigdata	even though they go outside, people will track and get information about their homes.
[58]	focus on combining all three technology or areas, such as BlockChain, Analytic of Bigdata, and IoT.	Blockchain and IoT.	play a critical role in overcoming each other's shortcomings
[48]	described the development of a City Geospatial Dashboard	GPS, geo-analysis	capture, distribute and simulate geospatial information obtained from satellites, IoT computers, and other Bigdata
[49]	developed and deploy a tracking system based on the IoT for agriculture	ZigBee	carry out real-time surveillance of agricultural production and automated operation of facilities
[50]	discussed the issue of standardization in the area of storing and distribution of Bigdata in the IoT implementation	-------------	Viewpoint analysis in the area of establishing data representation criteria.
[51]	introduced the Android-based application's development environment and contact with the server.	Intelligent farmer's real-time data track	develops as the country spends extensively on telecom networks.
[52]	provided an immersive simulation technique for IoT, Big Data, and Cybersecurity issues for media discussions.	---------	Allow users to discover the relationships between individuals.
[53]	suggested an adaptive erasure code for Joint-Cloud storage of IoT Big Data named ACIoT to minimize the NRC of data repair.	Parallel trial-and-error algorithm.	obtain the lowest NRC by encoding and positioning each bunch of data with the optimum generator matrix and data location scheme
[54]	presented the benefits of combining Tableau Desktop with data from projects on the Internet of Things	------------	Ability to track vast volumes of data and produce valuable maps, tables, geographic measurements of dashboards, and partitioning of data.
[55]	provided a general overview of the security vulnerabilities in the Internet of things	shell ranking optimization algorithm	data processing of IoT technology and logistics unified information system
[56]	analyzes the heterogeneous multi-source data collection paradigm	heterogeneous multi-source data acquisition	manufacturing chain for the use of extensive production data.
[57]	introduced a novel structural risk supervision approach based on Big Data technology for Internet finance in China.	----------------	Financial systemic risk and reduce the damage incurred by the systemic financial risk of China's Internet.

IX. CONCLUSION

In this paper, various research papers were reviewed about the Internet of Things, its infrastructure, Bigdata analytics systems, and data processing methods. It was noted that there is an urgent need for the integration of the IoT and Bigdata, as there is an urgent need to store and process Bigdata for the Internet of Things to work with high efficiency, technologies which are very important for IoT devices connection are explained in this paper.

This paper addressed essential methods to manage Bigdata with IoT. The literature review indicated that various active mechanisms contribute to Bigdata achievement. Nowadays, researchers are working more toward Bigdata with IoT fields. Therefore, efficient Bigdata with IoT frames or systems have been developed, such as introduced the Android-based application's development environment and contact with the server, provided a general overview of the security vulnerabilities in the Internet of things, extended the use of the IoT for home modules in the latest electronic product to construct an IoT network infrastructure, Prepared and model framework that's based on the calculation for clustering analysis.

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