Hindawi
Security and Communication Networks
Volume 2023, Article ID 9785098, 1 page
https://doi.org/10.1155/2023/9785098

Retraction

Retracted: Secure Internet of Things Gateway Technology Based on Multicommunication Methods

Security and Communication Networks

Received 13 September 2023; Accepted 13 September 2023; Published 14 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Q. Zhang, "Secure Internet of Things Gateway Technology Based on Multicommunication Methods," *Security and Communication Networks*, vol. 2022, Article ID 8511809, 8 pages, 2022.

Hindawi
Security and Communication Networks
Volume 2022, Article ID 8511809, 8 pages
https://doi.org/10.1155/2022/8511809

Research Article

Secure Internet of Things Gateway Technology Based on Multicommunication Methods

Qiangshan Zhang

Xinyang Vocational and Technical College, Xinyang, Henan 464000, China

Correspondence should be addressed to Qiangshan Zhang; 201804210@stu.ncwu.edu.cn

Received 8 July 2022; Revised 27 August 2022; Accepted 4 September 2022; Published 21 September 2022

Academic Editor: C. Venkatesan

In order to explore how the Internet of Things implements a secure Internet of Things gateway technology, the author proposes a research on a secure Internet of Things gateway technology based on multicommunication methods. This method recommends key technical problems and solutions based on information represented by multiple communication methods and explores how the Internet of Things can realize the research of Internet of Things gateway technology. Research has shown that the security IoT gateway based on multiple communication methods is about 40% more efficient than the traditional method. By studying some exploratory guidance and suggestions for the development of the Internet of Things, it is found that there are still many problems to be solved before realizing the real Internet of Things environment.

1. Introduction

With the emergence of Internet of Things technology and the rapid development of computer technology, network communication technology, and embedded technology, a profound technological change is taking place in the field of industrial control [1]. Simple, independent local data monitoring systems are being integrated, they can be replaced by the remote data monitoring system that can realize cooperative work by self-organizing network, and the overall resource utilization and security performance of the system have been improved. As the core of this new monitoring system, the IoT gateway realizes the integration of the wireless sensor network and the traditional communication network, completes the protocol conversion between different types of networks, and provides a platform for remote management and monitoring of underlying devices.

Nowadays, IoT technology is widely used in the fields of smart grid, smart security, smart transportation, smart medical care, logistics management, and smart home, and there have been many successful industry application cases such as many data exchange platforms [2]. In particular, the application of the Internet of Things in some high-risk fields has extremely important scientific research and practical value, such as disaster early warning, emergency rescue and disaster relief, and environmental monitoring in dangerous areas, and the application in these fields can give early warning of hazards, avoid the occurrence of major accidents or the further expansion of hazards to a large extent, and effectively maintain the safety of people's lives and properties [3].

In today's information world, there are a large number of information interactions between people and things, and between things, which makes the field of information and communication technology gradually show a new model: connecting anyone from any time, any place to develop and connect any object, and the connection of everything forming the Internet of Things [4]. With the development and deepening of the Internet of Things, its ultimate purpose is to pass a variety of nodes composed of sensors and connect things in all corners of the world, so as to realize the exchange of information anytime and anywhere between people, people and things, and things. As far as the traditional network is concerned, the terminal device is limited to the corresponding data transceiver module embedded in the device, directly or indirectly connected to the network through technologies such as Ethernet/GPRS/3G, and accessed through PCs, mobile phones and other devices to obtain information. For the Internet of Things, in order to achieve the above-mentioned barrier-free information exchange, a large number of sensing nodes are often required to form a sensor network; these terminal sensor devices have a wide range of types and use different protocols; if you want to use the traditional mode to directly connect each node to the network, no matter what the wireless network technology connection capability is, the low power consumption requirements of most of the sensor nodes working in the battery-powered environment, or the overall cost of the system, are unrealistic; therefore, a new type of network element device is required to enable these terminal devices to be seamlessly connected to the network, and this device is the IoT gateway.

In the field of information perception of the Internet of Things, due to the special application scenarios of wireless sensor network technology, it is generally used in local areas, and the networks cannot communicate with each other, and it is not suitable for remote data transmission; this makes the sensor equipment nodes form information islands, which cannot achieve true comprehensive interconnection and collaborative perception. In addition, there are many types of sensing technologies in IoT applications, and different communication protocols are used, which cannot achieve interconnection at all [5, 6].

The Internet of Things is the integration of intelligent perception, radio frequency identification technology, ubiquitous computing, and ubiquitous applications. It is called the third wave of the development of the world's information industry after computers and the Internet. The main purpose of the Internet of Things is to enable new sensing devices with radio frequency technology, infrared sensing technology, or other sensing capabilities, and it can be seamlessly integrated into the Internet to achieve mutual information exchange, and further intelligent identification, monitoring, and management [7]. Figure 1 presents a three-dimensional conceptual model of the Internet of Things.

2. Literature Review

Jangirala et al. said that the concept of the Internet of Things first appeared in Bill Gates' book "The Road to the Future" published in 1995, and they proposed a prototype of the Internet of Things connected by "things-things" [8]. Dushku proposed the concept of "Internet of Things" called EPC system [9]. Then Shen first proposed the concept of "Internet of Things," which is mainly based on item coding, radio frequency identification, and the Internet. It is simply defined as a new technology in which various sensors and the existing Internet are connected to each other [10]. Luo et al. said that, in 2005, the International Telecommunication Union formally proposed the concept of "Internet of Things" in "ITU Internet Report 2005: Internet of Things," and since then, the research on the Internet of Things technology in various countries in the world has entered a new round of strategic development period [11]. Huang said that, in recent years, major developed countries and regions in the world have attached great importance to the research on the Internet of Things and successively put forward relevant informatization strategies [12]. Simadiputra and Surantha proposed the e-Korea strategy and then further launched the u-Home strategy, which is one of the eight innovative services of Korea's u-IT839 plan; smart home allows Koreans to remotely control home appliances through wired and wireless means and enjoy high-quality multimedia services with two-way interaction at home [13]. Martinezdelucena and Frohlich said that, in 2004, when the Japanese government completed the two E-Japan strategic goals ahead of schedule, the U-Japan plan, which aims to develop a ubiquitous network society, is put forward, and the sensor network is listed as one of its four key strategies, seamless connection to ubiquitous network environment, and finally, a society in which everyone can benefit from ICT [14].

Peng et al. believe that, now, major operators have initially built wired and wireless communication networks covering the world, in order to meet the user's high bandwidth, long-distance transmission requirements [15]. At present, in order to realize the long-distance interconnection of sensing nodes, many sensor networks rely on wired networks or cellular communication networks to varying degrees, combining it with sensor networks, RFID, and other sensing technologies, and the information of each node of the wireless sensor network in a small range is connected to the Internet through the aggregation node, this kind of network element device that realizes seamless network integration across wireless sensor networks and traditional communication networks; in fact, it is the prototype of the Internet of Things gateway.

IoT gateway, as a new term, will play an extremely important role in the future IoT era; it will become the link between wireless sensor network and traditional communication network, complete the protocol conversion between wireless sensor networks, traditional communication networks, and other different types of networks, and realize data interconnection between local and wide areas. In addition, the IoT gateway also needs to have the device management function, and through the IoT gateway device, the operator can manage the underlying sensing nodes, understand the relevant information of each node, and realize remote control. The IoT gateway first has the function of acquiring information such as the attributes and status of each node; that is, it can perceive the real-time status of each node. The second is to have functions such as remote control, wake-up, and diagnosis of nodes, that is, in order to realize automatic management of nodes. IoT gateway access must have cross-domain communication requirements; therefore, a perfect addressing technology is required to ensure that the information of all nodes can be located and queried accurately, efficiently, and safely. With the development of IoT applications, the number of node addresses will gradually increase, and its coding structure is different from the domain name structure in DNS; therefore, a set of addressing technologies different from the Internet is required to meet the needs. The gateway must realize the protocol conversion from the sensor network to the traditional communication network, uniformly encapsulate the standard format data transmitted on the protocol adaptation layer, unpack the

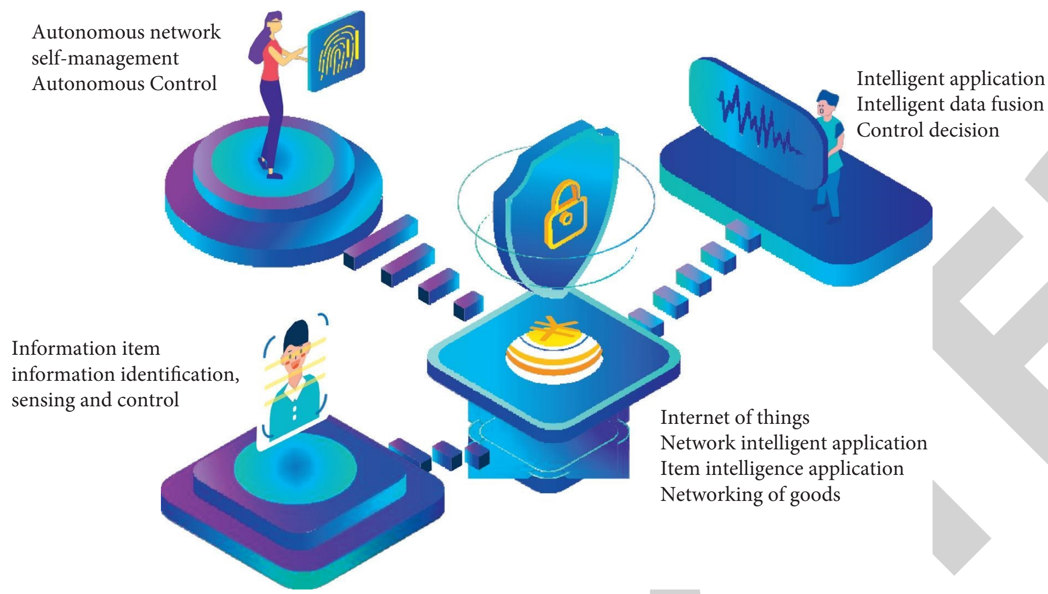

Figure 1: 3D conceptual model of IoT.

data sent by the wide area access layer into standard format data, and realize command parsing and then convert it into signals and control commands that can be recognized by the perception layer protocol.

3. Methods

3.1. Rough Set Theory. Rough set theory is a mathematical tool for dealing with ambiguity and uncertainty; the core idea of the theory is to quantify and represent knowledge certainty and ambiguity by means of object sets [16]. When rough set theory deals with finite element sets (domains of discourse), for any given set composed of objects in the domain of discourse, the characteristic data of the objects (the equivalence relationship obtained by the complete set or subset of individual attributes) for analysis, individual objects are divided into four sets: lower approximation sets, upper approximation sets, boundary fields, and negative fields. The lower approximate set represents, under the condition of existing conditional attribute knowledge, a collection of objects that can be unambiguously identified as belonging to that given collection of objects [17]. The upper approximate set represents, under the condition of existing conditional attribute knowledge, the set of objects that can be identified that may belong to this given set of objects. The boundary domain is defined as the dissimilar set of the upper approximation set and the lower approximation set and is the largest set that only contains the set of objects that may belong to the given set of objects and does not contain the objects that are definitely belonging to the set of given objects. A negative domain means, under the condition of existing conditional attribute knowledge, a clearly identified set of individual objects that do not belong to the set of the given object.

The general information system $S = (U, A)$, where U represents a nonempty finite set of individual objects, called the universe of discourse; A is a nonempty finite set, called an attribute set, and for any attribute a (a EA), there is an attribute value V, which corresponds to it, as shown as follows:

$$a\colon U \longrightarrow Va. \tag{1}$$

For a given information system $s = (U, A)$, the conditional attribute set is shown in (2), then IND(P) is called (3), and the equivalence relation is reflexive, symmetric, and transitive.

$$P \subseteq A, \tag{2}$$

$$IND(P) = \{(u, v) \in IND(P)\}. \tag{3}$$

Using condition P, the universe of discourse U is classified under the equivalence relation, as shown in

$$\frac{U}{IND(P)} = \{Ri(u) \mid u \in U\}. \tag{4}$$

For a given set of information system and condition attributes and objects, the following equations are shown:

$$S = (U, A), \tag{5}$$

$$P \subset A, \tag{6}$$

$$X \subseteq U. \tag{7}$$

Under the equivalence relation, the set X can be characterized by the lower approximation P(X) and the upper approximation P(X), as shown in the following equations:

$$\underline{P}(X) = \cup\left\{Y \in \frac{U}{IND(P)} \mid Y \subseteq X\right\}, \tag{8}$$

$$\underline{P}(X) = \cup\left\{Y \in \frac{U}{IND(P)} \mid Y \cap X \neq \varphi\right\}, \tag{9}$$

$$\underline{P}(X) = \left\{u \in U \mid R_p(u) \subseteq X\right\}. \tag{10}$$

3.2. Selection of System Hardware Platform. The whole intelligent gateway system platform based on the Internet of Things is realized based on the embedded system technology. In recent years, the upsurge of embedded system applications has been increasing, mainly due to two reasons: first, the development of chip technology makes a single chip have stronger processing power, and it has become possible to integrate multiple interfaces [18]. On the other hand, the reason is the need for application. Due to the improvement of product reliability, cost, and upgrading requirements, embedded systems gradually stand out from pure hardware implementation and applications implemented using general-purpose computers, becoming the focus of attention in recent years.

Embedded processors are mainly divided into four categories: embedded microprocessors, embedded microcontrollers, embedded DSP processors, and embedded systems on a chip [19]. The embedded microprocessor is evolved from the CPU in the general-purpose computer, but it only retains the functional hardware closely related to the embedded application, in order to reduce power consumption and resources and to achieve the special requirements of embedded applications. It generally has the characteristics of strong support for real-time multitasking, strong storage area protection, and low power consumption. The typical representative of embedded microcontroller is single chip, which is mainly used to realize simple system. Embedded DSP processor is specially used for signal processing applications, such as digital filtering, spectrum analysis, and other instruments. The embedded system-on-a-chip is an integrated device that pursues the most inclusive product system; its biggest feature is that it realizes the seamless combination of software and hardware and directly embeds the operating system code module in the processor chip, which is highly comprehensive, and a complex system can be realized by using hardware description languages such as VHDL inside the chip [20].

The embedded microcontroller has a simple structure and poor scalability, making it difficult to meet the complex functional requirements of an intelligent gateway system, and the embedded DSP processor is a dedicated chip for signal processing, which is also inapplicable; although the embedded SoC can be flexibly customized according to system requirements, there is no redundant resources and low power consumption, but its high cost and strong specificity are not conducive to expansion, taking into account that the embedded microprocessor not only can meet the system requirements, but also has good real-time performance, stability, and reliability and has low cost, which is the best choice. At present, the main embedded microprocessors include PowerPC, MIPS, and ARM series, which are different in performance parameters and application fields. Table 1 compares the characteristics of the three embedded microprocessors.

The above three embedded processors have a wide range of applications, and they are emphasized according to their respective characteristics [21]. PowerPC processors have strong floating-point performance and multimedia processing capabilities and are highly integrated; they are the first choice for high-end embedded applications, but their chips are more expensive and consume more power than ARM; therefore, mobile embedded devices such as mobile phones never use a PowerPC processor. The MIPS processor pursues perfect performance, the power consumption is slightly larger than that of the ARM chip, and the openness of its core platform is not good, resulting in insufficient support for development tools. ARM series processors occupy most of the market of low-end embedded applications due to their low power consumption, low cost, and easy development. In recent years, the newly launched ARM Cortex-M series is an optimized processor core specially designed for low-end control applications, and compared with traditional embedded microcontroller microcontrollers, its processing capability is stronger and more targeted, the price is very low, and it will gradually replace traditional 8/16 bit microcontrollers in the low-end microcontroller market. Obviously, the ARM microprocessor can better meet the needs of the intelligent gateway system, so it is finally chosen to build the hardware platform of the gateway system [22].

3.3. Overall Structure of Gateway Platform Hardware. The gateway platform is the core component of the intelligent gateway system, and its main body is divided into two parts: the core board and the peripheral board. The core board includes the microprocessor CPU, extended SDRAM, Nand Flash, and power management chips; these peripheral modules are mainly used to expand CPU resources to meet system requirements, and they have no direct data interaction with other peripheral modules, so they are integrated into a single board and only provide other interfaces of the CPU, which is conducive to reducing the interference caused by other peripheral circuits to this part; at the same time, the system flexibility is improved [23].

The peripheral board contains all other peripheral modules and their external interfaces, such as Ethernet, 3G, CAN, and Zigbee, and they are connected to the CPU through different interfaces or buses for data interaction and task processing; they are responsible for all the functions of the network management platform, and Table 2 describes their composition and overall structure.

The embedded microprocessor is the core of the system and is responsible for the operation and management of the entire system, but it cannot work independently and must be equipped with additional peripheral circuits to provide it with the necessary operating conditions, which is the minimum system structure [24]. First of all, in order to make the system work stably and reliably, the power supply circuit needs to provide all levels of power supply signals, the clock circuit provides the clock for the circuit to work, and the reset circuit provides the reset signal. In addition, if the embedded microprocessor has no on-chip program

Table 1: Comparison of embedded microprocessors.

	PowerPc	MIPS	ARM
Instruction length	32	16/32/64	16/32
Power consumption	High	Generally	Low
Cost	High	Low	Low
Development tool support	Less	Few	Many
Application field	Servers, military, industrial control, communications, consumer electronics and aerospace, etc.	Game consoles, routers, laser printers, digital TVs	Industrial control, consumer electronics, communication systems

Table 2: Gateway platform CPU and peripheral modules.

Module	Configure chips or parameters	Illustrate
CPU	Marvell PxA310	XScale cove 624 MHz
SDRAM	Mobile DDR	128 MB × 2.16 bit, 130 MHz
Flash	Nand flash	1 GB.sbit
PMIC	LP3972SQ-A514	Provides 6 system power supplies
Ethernet	DM9000 A	Support 10 M/10DM BASE-T

memory, or the on-chip capacity cannot meet the application requirements, it is necessary to expand the external memory. Finally, in order to carry out the system development and debugging, the JATG debugging interface is also required; generally, the internal microprocessors use the JATG interface; of course, this part is not necessary after the actual work of the system.

The role of the power supply in the whole system is crucial; it provides power to the whole system and is the basis for the normal and stable operation of the system. The gateway platform requires multiple voltage levels due to numerous peripheral modules and different working levels of each module. Table 3 describes this in detail.

Table 3: Summary of operating voltage of system peripheral modules.

Voltage level	Module name
5 V	PMIC
3.3 V	3G, RS-485, CAN, NET, Zibgce, RF, Nand flash
1.8 V	3G_USB2.O
Other	GPIO and reset circuit module name

3.4. Ethernet Network Module. To establish a connection with the LAN monitoring center, the gateway platform must be equipped with a network controller module, so that it can be connected to the host through a crossover cable or connected to the LAN where the host is located through a switch to form a simple LAN system. The network module of the platform uses the DM9000AEP chip produced by Lianjie International, which is a fully integrated and cost-effective single-chip high-speed Ethernet MAC controller chip, which follows the 802.3 Ethernet transmission protocol and has a 10/100 M adaptive physical layer interface; configuration can be done automatically to best fit its line bandwidth [25]. The description of other circuits in the minimum system of the gateway platform is shown in Table 4.

4. Results and Analysis

Today, the development of China's Internet of Things industry is showing a rapid growth trend, with an industry scale of 365.11 billion yuan, according to experts' predictions, and the Internet of Things industry will form a trillion-dollar communications industry. If the Internet of Things network is fully completed, its output value will be 30 times larger than that of the Internet [26]. In the next 10 years, the Internet of Things technology may be popularized on a large scale, and the Internet of Things industry in China will show a thriving development trend. The scale of China's IoT industry is shown in Figure 2.

In the gateway system, the database realizes data storage management through data interaction with the Java Web server program, and the connection between the server program and the database is realized through a set of standard database access APIs, namely, Java Data Base Connectivity (JDBC). JDBC consists of a set of classes and interfaces written in Java language; it is a Java API that executes SQL language, and using a unified API, users can write databases in pure Java language and send SQL statements to any relational database and, regardless of the type of RDBMS, do not need to consider platform issues when writing programs in Java [27].

When developing JDBC applications in the traditional way, a database connection is established for each request, and a database connection takes up a lot of system resources, and I/O overhead is large, and it is difficult to manage and close multiple connections at the same time; the exception causes a connection not to be closed normally, which leaks the memory of the database system and causes the database to crash. In order to solve this problem, we adopt database connection pooling technology [28]. Connection pooling technology allows an application to obtain a connection from the connection pool and use it continuously, instead of

Table 4: Other circuit descriptions of the minimum system of the gateway platform.

Circuit name	Illustrate
Clock circuit	The system has two clocks, one is for CPU and other circuits, using 13 M active oscillator, and the other is RTC dedicated timing clock, built with 32.768 K active clock.
NandFlash	As a system boot chip, it stores the bootloader of the Linux operating system, the kernel, and the file system. After the system is powered on or reset, the commands are obtained from the first address and executed sequentially. The system uses the NanclF flash model K9F1G0suoc-PCBO with a capacity of 1 GB.
Mobile DDR	SRAM is static RAM with extremely high read and write speed. It is used for variables, data and buffering in the system, and programs can also be copied to SRAM to run, in order to improve the system efficiency, but it is a volatile storage, the data will be lost when power off, so it cannot boot the program to run. This system expands two pieces of SRAM, the model is K4X1G163PE-FGC6, the capacity is l28 MB, and the frequency is 130 MHz.

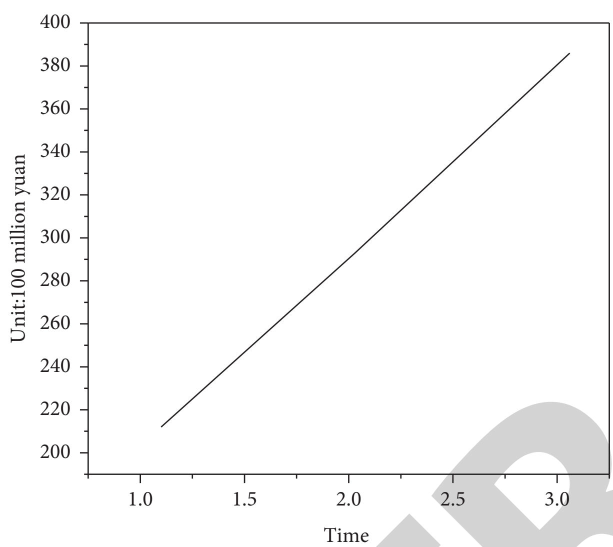

Figure 2: The scale of China's IoT industry.

having to reestablish the connection for every connection request. Once a new connection is created and placed in the connection pool, the application can reuse the connection without having to implement the entire database connection creation process. When an application requests a connection, the connection pool allocates a connection for it; after the connection is used up, the connection is returned to the connection pool without being released directly, and the creation and closing of the connection are managed by the connection pool, which greatly improves the efficiency of the program.

When developing Web programs, the Tomcat server itself supports database connection pool technology, which brings convenience to the realization of the system. When using it, you need to copy the JDBC driver (mysql-connector-java-5.1.6-bin.jar) of MySQL 5.6 to the Tomcat program installation directory, modify the context.xml and web.xml files, and add the JDBC driver support statement; finally, import the build path in the Web project; that is, the database connection can be made in the program. When using the database connection pool, first, import the database driver, then use lookup() to find the connection, use the getConnection() function to obtain a connection, and finally, call the close(function to put the connection back into the database connection pool.

The intelligent gateway system based on the Internet of Things is mainly used in the collection of various industrial data; that is, it collects the collected terminal data through the wireless sensor network, realizes the protocol conversion on the gateway platform, and finally transmits it to the monitoring center. The system provides a variety of data transmission methods; in the actual application process, one or more transmission methods are selected according to actual needs and field equipment. According to the different types of collected data and application fields, the distribution number and location of the collection points in the field are uncertain, and the transmission distance of the wireless sensor network will be restricted by factors such as the location of the collection terminal, the site environment, and the location of obstacles, and in order to ensure that all the collection point data can be received by the network management platform, it is necessary to install the gateway device according to the on-site environment. On the other hand, in a wide range of application scenarios, such as underground mines, farmland, buildings, and workshops, multiple gateway devices need to be installed to collect data of different types, locations, and methods. The emergence of the above two situations makes the number of gateway devices, placement locations, and transmission methods present various uncertainties; in this case, the gateway system will form a network, in which the gateway device and the monitoring server act as nodes in the network, and the communication link formed by each communication method acts as a network path. With the change of the number of nodes and the communication link, the network is also changing in real time.

In addition, with the popularization of the application of the gateway system, some users put forward new requirements for the system, that is, in order to formulate the best network transmission path according to different priority principles. The gateway system is applied in different occasions, and users have different requirements for the real-time monitoring data and monitoring cost. For example, it is used in the temperature monitoring of underground safety equipment, which requires strong real-time data and timely alarm when danger occurs; this requires that the selection of data transmission paths be based on the principle of time optimization. It is used for temperature monitoring in farmland or field environment, and it has a large number of collection points, a wide distribution range, unattended maintenance, and high equipment replacement costs;

however, the monitoring data changes slowly, the collection interval is large, and the real-time requirements are low, which requires data transmission paths. The selection is based on the principle of optimal energy consumption. When applied to data monitoring with multiple monitoring centers, and when some monitoring centers are far away, since long-distance transmission relies on 3 G networks, long-term data transmission with a large number of collection points will greatly increase the monitoring cost, which requires the data to be communicated over short distances first. The method is summarized to the local monitoring point and then transmitted to the remote monitoring point through a low-cost method such as a wired network, thereby saving the implementation cost; at this time, the selection of the transmission path is based on the principle of the lowest cost. In order to realize the path switching under different principles, it is necessary to formulate a special optimal path planning scheme for the system; on the one hand, it is necessary to know the transmission cost of each transmission path, such as transmission rate, cost/data amount, energy consumption/distance, and other parameters. These parameters constitute the path weight of the system network, and the path optimization algorithm calculates the current network to obtain the optimal path between the gateway device and the monitoring center.

5. Conclusion

Although the Internet of Things technology has achieved some phased results, it is still in the initial stage of exploration. The research on the Internet of Things environment only puts forward some new theories and methods for the fusion processing of Internet of Things information from the perspective of data information. In the future work, we may start from the heterogeneous data fusion algorithm for the next research work. The heterogeneity of data description refers to the use of different ontology description models during data abstraction, and the resulting data cannot be interoperable. Assuming that the IoT data is defined by the corresponding managers to describe the model, the natural existence of the heterogeneity of the description model is recognized. Under this condition, we research an efficient model matching method to quickly and accurately find out the similarities between the description models, guaranteeing its efficiency and accuracy.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

References

[1] H. Li, W. Dong, Y. Wang, Y. Gao, and C. Chen, "Enhancing the performance of 802.15.4-based wireless sensor networks with nb-iot," *IEEE Internet of Things Journal*, vol. 7, no. 4, pp. 3523–3534, 2020.

[2] M. E. Ouldkablia, B. Kechar, and S. Bouzefrane, "Iot-based smart home process management using a workflow approach," *International Journal of Information Technology and Web Engineering*, vol. 15, no. 2, pp. 50–76, 2020.

[3] J. A. Uqaili, chool of Electronic Engineering Beijing University of Posts & Telecommunications BeijingChina, H. M. Bilal, S. Dehraj, and M. Abbas, "Implementation of scalable and energy efficient wsn platform for iot applications," *Indian Journal of Science and Technology*, vol. 13, no. 36, pp. 3725–3737, 2020.

[4] E. Boonchieng, A. Saokaew, and O. Chieochan, "The prototype of the integration between low cost single private lora gateway and public ais nb-iot," *Journal of Internet Technology*, vol. 20, pp. 1317–1326, 2020.

[5] Y. Shi, Y. Xia, and Y. Ga, "Joint gateway selection and resource allocation for cross-tier communication in space-air-ground integrated iot networks," *IEEE Access*, vol. 9, p. 1, 2020.

[6] K. Jeba and J. J. Roopa, "434 mhz environmentally safe monitoring schema for vehicular network by ai-ml-iot technologies," *Journal of Cases on Information Technology*, vol. 23, no. 2, pp. 26–38, 2021.

[7] J. S. Park, S. Lee, and I. H. Suh, "The study of routing methods on the secure vehicle gateway system," *Transaction of the Korean Society of Automotive Engineers*, vol. 28, no. 12, pp. 851–858, 2020.

[8] S. Jangirala, A. K. Das, M. Wazid, and A. V. Vasilakos, "Designing secure user authentication protocol for big data collection in iot-based intelligent transportation system," *IEEE Internet of Things Journal*, vol. 8, p. 1, 2020.

[9] E. Dushku, M. M. Rabbani, M. Conti, L. V. Mancini, and S. Ranise, "Sara: secure asynchronous remote attestation for iot systems," *IEEE Transactions on Information Forensics and Security*, vol. 15, p. 1, 2020.

[10] M. Shen, H. Liu, L. Zhu et al., "Blockchain-assisted secure device authentication for cross-domain industrial iot," *IEEE Journal on Selected Areas in Communications*, vol. 38, pp. 942–954, 2020.

[11] H. Luo, C. Wang, H. Luo, F. Zhang, F. Lin, and G. Xu, "G2f: a secure user authentication for rapid smart home iot management," *IEEE Internet of Things Journal*, vol. 8, no. 13, Article ID 10884, 2021.

[12] K. Huang, "Secure efficient revocable large universe multi-authority attribute-based encryption for cloud-aided iot," *IEEE Access*, vol. 9, p. 1, 2021.

[13] V. Simadiputra and N. Surantha, "Rasefiberry: secure and efficient raspberry-pi based gateway for smarthome iot architecture," *Bulletin of Electrical Engineering and Informatics*, vol. 10, no. 2, pp. 1035–1045, 2021.

[14] M. Martinezdelucena and A. A. Frohlich, "Security and effectiveness analysis of the gateway integrity checking protocol," *IEEE Transactions on Dependable and Secure Computing*, vol. 19, p. 1, 2021.

[15] C. Peng, J. Chen, P. Vijayakumar, N. Kumar, and D. He, "Efficient distributed decryption scheme for iot gateway-based applications," *ACM Transactions on Internet Technology*, vol. 21, no. 1, pp. 1–23, 2021.

[16] S. Atiewi, A. Al-Rahayfeh, M. Almiani, S. Yussof, and Y. Jararweh, "Scalable and secure big data iot system based on multifactor authentication and lightweight cryptography," *IEEE Access*, vol. 8, p. 1, 2020.

[17] B. E. Sabir, M. Youssfi, O. Bouattane, and H. Allali, "Towards a new model to secure iot-based smart home mobile agents

using blockchain technology," *Engineering, Technology & Applied Science Research*, vol. 10, no. 2, pp. 5441–5447, 2020.

[18] L. Sung and D. H. Cho, "Multi-user hybrid beamforming system based on deep neural network in millimeter-wave communication," *IEEE Access*, vol. 8, p. 1, 2020.

[19] H. Nashaat, E. Ahmed, and R. Rizk, "Iot application placement algorithm based on multi-dimensional qoe prioritization model in fog computing environment," *IEEE Access*, vol. 8, p. 1, 2020.

[20] Y. Wang, Q. Lu, Y. Jin, and H. Zhang, "Communication modulation signal recognition based on the deep multi-hop neural network," *Journal of the Franklin Institute*, vol. 358, no. 12, pp. 6368–6384, 2021.

[21] S. Hong, S. Lee, J. Lee, and M. Je, "A multi-mode ulp receiver based on an injection-locked oscillator for iot applications," *IEEE Access*, vol. 8, p. 1, 2020.

[22] M. Saki, M. Abolhasan, J. Lipman, and A. Jamalipour, "A comprehensive access point placement for iot data transmission through train-wayside communications in multi-environment based rail networks," *IEEE Transactions on Vehicular Technology*, vol. 69, Article ID 11937, 2020.

[23] C. Wang and X. Di, "Research on integrity check method of cloud storage multi-copy data based on multi-agent," *IEEE Access*, vol. 8, p. 1, 2020.

[24] A. Sharma, R. Kumar, M. W. A. Talib, S. Srivastava, and R. Iqbal, "Network modelling and computation of quickest path for service-level agreements using bi-objective optimization," *International Journal of Distributed Sensor Networks*, vol. 15, no. 10, Article ID 155014771988111, 2019.

[25] M. S. Pradeep Raj, P. Manimegalai, P. Ajay, and J. Amose, "Lipid data acquisition for devices treatment of coronary diseases health stuff on the Internet of medical things," *Journal of Physics: Conference Series*, vol. 1937, no. 1, Article ID 012038, 2021.

[26] X. Zhao, X. Liu, J. Liu, J. Chen, S. Fu, and F. Zhong, "The effect of ionization energy and hydrogen weight fraction on the non-thermal plasma volatile organic compounds removal efficiency," *Journal of Physics D: Applied Physics*, vol. 52, no. 14, Article ID 145201, 2019.

[27] R. Huang, P. Yan, and X. Yang, "Knowledge map visualization of technology hotspots and development trends in China's textile manufacturing industry," *IET Collaborative Intelligent Manufacturing*, vol. 3, no. 3, pp. 243–251, 2021.

[28] X. Zhan, Z. H. Mu, R. Kumar, and M. Shabaz, "Research on speed sensor fusion of urban rail transit train speed ranging based on deep learning," *Nonlinear Engineering*, vol. 10, no. 1, pp. 363–373, 2021.