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IoT enable flexible and smart seized asset management

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Abstract: The vigorous development of IoT applications has penetrated various industries, including intelligent manufacturing, smart agriculture, ecological environment protection, smart transportation, smart homes, *etc.*, greatly changing the traditional operation mode of the industry. This article proposes a method of applying the Internet of Things in seized assets management, which greatly facilitates the way how the judicial and other organizations manage assets based on the relevant data of the asset, which make it more flexible for the management and make most potential value of the asset for the stakeholders and control the operational risk through IoT technology. This article first discusses the background and advantages of the Internet of Things in seized asset management applications, and then presents several typical application cases and analysis from different industries. Provide the main technical framework of IoT system, the technologies including sensing, communication, and data processing and analysis for the application of the Internet of Things in seized asset management, as well as typical IoT devices, operational platforms, and application software used in the application. Finally, the potential values of the Internet of Things in the future market of seized asset management, as well as the challenges it faces and constructive suggestions for the future of scalable IoT applications for this domain are proposed.

Keywords: internet of things (IoT); seized asset management; technical framework; IoT devices; service platform; application

1. Background

1.1. IoT applications

1.1.1. IoT techniques and applications background

The Internet of Things [1] is widely used in healthcare, environmental, commercial, industrial, smart cities *etc.*, with the concept, technical development [2] and deeply uses of sensing, communication, network architecture [3], data processing, and intelligent computing [4]. The digital business model [5], data exchange mechanism [6] and semantic [7] interoperability is important for IoT applied in the application market, which identifies the main five challenges of the semantics in IoT including scalability and flexibility, standardization [8] and reusability, high level processing, data quality, data confidentiality

and privacy, interpretation and synthesis. The security [9], trustworthiness [10] and forensics [11] play an essential role in the challenges of the large-scale IoT promotion and industrialization.

1.1.2. Other sensing devices

The other sensing devices are the devices used in the seized asset management but not listed before. The other sensing devices collect real time information of the quantity of raw materials or products in the manufacturing enterprises, the real time data of on-site vehicle flow and personnel flow, capture and control the opening and closing status of the gate for the monitoring area. collects information, and other location sensor, camera, alarms, *etc*. Through multiple-terminal coordination, edge computing and modelling, IoT system periodically generates the digital production and operation analysis for the enterprise. These sensing devices can be used in multiple sealing scenarios such as factories and workshops.

1.1.3. IoT for seized asset management

The concept of seized asset management involves overseeing assets that are under a sealing state. It includes variety of properties such as houses, apartments, vehicles, and enterprise equipment with raw material, machinery, products, and transportation vehicles. Seized asset management is vital for asset holders and supervisor responsible for asset oversight. Traditionally, seized asset management has relied on paper seals or manual supervision for enforcement, which often results in seized assets are not being effectively regulated, utilized, or disposed of in real time. The Internet of Things provides a valuable solution for real-time sealing management and asset disposition. The application of seized asset management [12] is used to monitor the asset which is seized by supervisors, or government agencies or organizers to restrict the use, access and disposition. Seized asset management is used in these kinds of scenarios, including but not limited to administrative management by superior organization, enterprise management including auditing and internal control, production management, security control and confidentiality, quality control and product recycling.

1.1.4. Commencement sensing device

Commencement sensing device senses the position and move status of the asset, support start-up detection and automatic analysis of equipment start-up status, automatically monitor movement of the device, identify the destruction, dismantling and other behaviors, record on-site evidence, and send alert information. The commencement sensing devices are used for the seized property supervised by supervisor to ensure that the seized property is within a controllable range. The objects of seized property include but not limited to residence, factories, warehouses, workshops, equipment, *etc.*

1.2. Solutions with IoT for seized asset management

Traditional asset storage management often relies on manual supervision and recording, which presents the following problems and challenges:

- Uncertainty: Manual supervision may not provide accurate and real-time information, and there may be insufficient understanding of the status and conditions of asset storage;

- Security risk: The security monitoring of facilities and equipment related to storage may be limited and easily bypassed or damaged;
- Resource cost: The sealing process generally requires a large amount of human resources and time. In addition, supervision, recording, and reporting work also increase labor costs;
- Poor asset flexibility: After the assets of the enterprise are sealed, the enterprise cannot produce and operate, and raw materials, equipment, resources, *etc.* cannot be used.

The Internet of Things can solve the above problems with its characteristics:

- Real time monitoring: IoT sensors can monitor and record the status and facilities of enterprises in real time, providing accurate data for supervision and implementation of sealing measures;
- Data analysis: IoT platforms can analyze collected data, provide valuable information and insights, and assist regulatory authorities in making more informed decisions;
- Automated alarm: IoT devices can automatically detect abnormal situations and promptly notify relevant personnel through alarms, strengthening security monitoring of sealed enterprises;
- Asset active storage: Under the monitoring of the Internet of Things, enterprises can continue production and operation, and raw materials, equipment, resources, *etc.* can be used normally.

In summary, IoT technology provides a more efficient, accurate, and secure solution for asset storage management, thereby deal with the issues that exist through the traditional methods.

Weight sensing device

Weight sensing device measures the weight relevant data of the seized object on the crane scale and to evaluate the value of seized object such as steel. Weight sensing devices on the crane scale measure the weight, acceleration, swing and other data of the objective asset, and automatically identify illegal disassembly and trigger alarm. IoT gateway integrates these data from the weight sensing devices and records the history data, accumulates all the data, and generate the highly coupled data with the context. The IoT weighing software records the weight information for the object asset and computes the real value with the real price for the asset. The IoT weight sensing devices are installed on lifting equipment such as crane scale. Weight sensing devices are used in multiple scenarios require to weigh and evaluate the raw material, and so as for material recycle and disposal.

1.3. Advantages of IoT application for seized asset management

The advantages of IoT-based seized asset management are numerous. Firstly, an IoT system collects real-time data on seized assets. The information such as video and figure surround the asset or about the characteristics of the asset is sensed and sent to the platform periodically. The operation data for the seized enterprises are collected, including the number of material counts, energy consumption, daily output of products, et which combines with the operation model of factory to figure out the real production for enterprise. Secondly, the asset is more effectively monitored, checked, and managed according with real-time data. IoT system sends alarms to the users and helps to make assistant decisions when the abnormal conditions are detected. For example, if the asset is destroyed or the asset count decreases, the supervisor responsible for monitoring the asset receives an alert through the IoT system and can take appropriate action. Lastly, IoT-based seized asset management is more precise and does

not interfere with the original operating processes. Enterprises with sealed asset can continue production, and sealed real estate can be used by legitimate users through technical insurances.

In essence, assets are actively sealed using IoT technologies. Seized assets remain accessible and seized enterprises continue to be productive, while the disposal of assets becomes more flexible. On one hand, this enhances the value of the asset and improves the efficiency of its evaluation and disposal. On the other hand, real-time IoT monitoring for seized asset management advances the application of digitalization and intelligence in this field. More and more countries are adopting IoT technologies to monitor and manage their seized assets.

This paper proposes the use of IoT for seized asset management to enable flexible and smart asset management in the application, facilitating data share and cooperation among stakeholders in the ecosystem. It expands the concept of industry innovation into more IoT application sectors to enhance transparency and efficiency in management, improve the value of asset and protect the rights of involved stakeholders.

1.4. Typical application cases

1.4.1. The status of IoT technology and industry for seized asset management in China

In recent years, the process of digital transformation has been continuously deepening, and courts, enterprises, and institutions have gradually recognized the potential of IoT technology in improving the efficiency of asset management and reducing costs, and have begun to actively explore and apply related technologies.

In 2020, the Smart Court Laboratory of the Supreme People's Court was completed and put into use, marking the deepening of the comprehensive construction of smart courts. This marks the basic completion of the smart court system centered on smart trial, execution, service, and management by the people's courts, and the beginning of truly paving the way for the smartness of Chinese characteristic courts. However, with the in-depth exploration of "Internet Plus" by courts, some problems in the implementation work have not been solved. The Internet of Things technology for seized asset management improves the efficiency and accuracy of administrative management, and better serves judicial and law enforcement affairs. As a leading city in the development of IoT technology in China, Wuxi has explored the application of IoT technology in the field of mandatory enforcement, playing a leading and exemplary role. On November 9, 2020, Jiangsu Provincial High Court held an on-site meeting in Wuxi to promote the work experience of "Internet of Things Plus Execution" throughout Jiangsu province; At present, all courts in Jiangsu Province are undergoing trial operation. Xiamen in Fujian province and Shantou in Guangdong province are also trying to promote application. On December 11, 2020, the work experience of "Internet of Things plus Execution" was published and recommended in the 72nd issue of "Execution Work Dynamics" by the Executive Bureau of the Supreme People's Court, and courts across the country were required to learn and draw on it. On December 18th, the front-page headline of the People's Court Daily reported on the application of "Internet of Things Enforcement" in Wuxi Court. During the inspection period in Jiangsu, the supervision group of the National Commission for the Rule of Law reported the judicial application of "Internet of Things Plus Enforcement" in Wuxi courts as three advanced and typical cases in Jiangsu province.

China Railway Rolling Stock Corporation (CRRC) has upgraded its asset sealing and management work using IoT technology and big data. They have developed a sealed information verification and management system that can be interconnected. Through this system, court staff can access asset information in real-time, and the system has been promoted and applied in dozens of cities across the country.

1.4.2. IoT technology and industry status for seized asset management in foreign countries

At present, courts and regulatory authorities in some countries and regions are exploring the use of IoT technology to supervise and enforce the sealing measures of enterprises. In some countries or regions, IoT sensors may be used to monitor whether the doors and windows of sealed enterprises are opened or closed, record real-time usage of electricity, water flow, and monitor for illegal intrusion. These pieces of information can help the court ensure the effective implementation of sealing measures and provide more accurate data basis.

In India, courts use IoT sensors and mobile applications to monitor in real-time whether the doors and windows of sealed enterprises are open, and can authorize staff to enter the sealed enterprises through mobile applications. Indian electric motorcycle company Ather Energy uses IoT technology to improve response speed and accuracy for law enforcement agencies. The regulatory authority can remotely monitor the driving routes and behaviors of company employees at any time to maintain fairness and on-site operations in critical situations.

In addition, there have been many discussions on the research and development of IoT technology in asset storage management in various regions. For example, the American Journal of IoT Engineering has published an article on using IoT technology to improve court sealing procedures. Israeli technology company Axonize also provides an IoT platform aimed at helping regulatory authorities monitor asset sequestration status in real-time. ViewSonic, an American intelligent projection technology company, has provided law enforcement agencies with an intelligent surveillance camera through IoT technology. The product's fictional visual intelligent AI system converts the video signals of the surveillance camera into images and innovates in intelligent gestures, speech recognition, and other aspects.

From the current pilot demonstration applications in these industries, there is already a certain level of technological maturity. With the support of IoT technology, a large amount of operational data can be collected and analyzed from asset storage sites and machines. The data can be used to assist managers in verifying and ensuring real-time tracking and accurate recording of sealing actions. At the same time, through intelligent monitoring of asset storage sites, they can receive real-time alerts at any time, improve the response speed and accuracy of staff, significantly shorten the response time of tracking equipment, improve the positioning accuracy of equipment, enhance the safety of on-site operations, and accurately obtain asset storage information.

In summary, the construction and application of IoT systems for seized asset management have reached a certain scale.

2. IoT Techniques of Internet of Things for seized asset management

2.1. Technical framework of IoT system

The system of the IoT-based seized asset management is composed of components including data sensing, edge computing, management platform, and applications for client as shown in Fig. 1.

Data sensing collects on-site data through various IoT devices and report it to the management platform for comprehensive analysis and processing. It includes IoT electronic seal, projection seal, weight sensing devices, sensing cards for the device commencement status, and other sensing device which is the collection of the data sensing device for the asset except the IoT device type already listed. The sensing data types for IoT devices include position, weight, ranging, vibration, audio, videos, demolition status, *etc.* Usually, the IoT devices are capable of alarming and being remotely controlled by the clients, such as playing sound and light alarms, opening, and closing the gate for entrance, *etc.*

Edge computing realizes edge storage and edge analysis for asset data near the edge to ensure real-time data processing and data analysis, including real-time asset data analysis and alarm, asset weighing and evaluation, production and operation process data collaborative supervision and early warning.

Management platform is a web-based management platform. It collects and analyses the data reported by data sensing. After integrating sensing data with business information, the platform reflects the fusing business data in alarm events or flow events according to business regulatory rules. The platform also displays asset data to users with the format of event information, images, audio, and video.

Applications for client is divided into three types of API for each type of client, including API for applicant, API for supervisor, and API for maintainer. It mainly serves as the human-machine interface for performing daily operations for different clients such as sealing or unsealing, weighing, operation and maintenance. The API for supervisor and for applicant may be lightweight mini-programs, which are compatible for operating systems and don't need to be downloaded. In addition, the alert information of the seized object can be informed to the official account of the supervisor or the mobile device for the clients in short messages. The API for maintainer manages the status, daily operation and processing the alarm as an APP in the smart device.

The entities of data sensing are used to collect and integrate data for the asset and receive data from seized asset management platform. The entities of data sensing consist various kinds of sensors or measurement devices, or IoT gateways for some network conditions. Sensing devices acquire information about single or multiple status (e.g., position, movement, vibration) of entities of the asset. The data sensing can generate alarms and control command to control the operation of status of the asset. IoT gateways are devices which connect data sensing with the upper platform, and they can also connect one entity to another entity in the data sensing. The IoT gateways provide functions such as protocol conversion, address mapping, data processing for the sensing data, information fusion, device management, and edge computing. The IoT gateway can also perform security functions for constrained IoT devices for access authority.

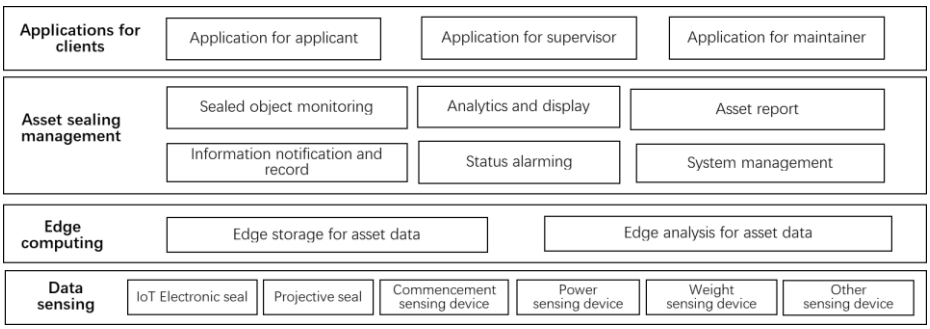

Figure 1. System overview of IoT-based seized asset management.

Edge computing devices on one hand store asset data related to IoT seized asset, and multiple types of databases are accessible, support the addition, deletion, retrieval, and modification of stored data, flexibly configurate, strategically adjust and optimize of multi-source data related to seized asset management. On another hand, analyse asset data processes the time sensitive data collected or generated by IoT devices, collect and statistics analyse localized, real-time, and short-term data, and make intelligent planning, decision optimization, predictive analysis of asset data, *etc.*

The entities of management platform are to deliver the core functions and services of IoT-based seized asset management to the clients including the applicant, supervisor, and maintainers. The entities of management platform continuously monitor the asset and checks figure and video info associated with abnormal events, it sends reminders for abnormal events by text messages or official social account. When the objective asset is unsealed, the authorized accesses for the corresponding users are automatically cancelled.

The entities of applications for clients provide on-line management and interactive applications for users. The clients include applicants, who usually are the individuals or enterprises to apply for their legitimate rights of the seized asset, and supervisors who execute the task of asset monitoring and maintainers who provide supportive services for the device installation and maintenance. The clients can use applications with software deployed in the devices (i.e., smart phone) with network interfaces to access and interact with the whole system. Depending on the client's role, different aspects of the system will be presented for observation and control.

2.2. Typical IoT devices

Power sensing device

Power sensing device senses the digital data of the power consumption meter for the production and operation. There are two types of sensing technology including visible type and infrared type. Power sensing devices are installed in the electrical box for the workshop or manufactures. The power sensing device are used in multiple seized scenarios which require to supervise the periodical power consumption such as factories, workshops, and equipment.

2.3. Application

The application for client is accessed through apps or integrated mini-program in smart terminals of clients. The applications are provided for three kinds of clients including the applicant who claims for legal rights for the asset, supervisor who monitors and checks on behalf of supervisor, and the maintainer who provides technical and supporting services. The applicants use the APP to manage the seized object, display the map for the seized object, confirm the alarm management when the alarms happen. The supervisors use the APP to manage the seized object with more functions, upload the weighing report for the object, display and upload the information of seized object in the map, execute the sealing and unsealing operation based on command, confirm the audio and video information, alarm management when the alarms happen. Maintainers use the APP not only to manage the seized object, display and upload the information of seized object in the map, execute the sealing and unsealing operation based

on command and confirm the alarm, but also manage the IoT device, information for all the clients, and provide functions of operation and maintenance for the whole system.

3. Potentials, Challenges and Suggestions

3.1. Potentials

The potential value of the Internet of Things in the future market of seized asset management is marvelous. Through the Internet of Things, dynamic perception and evaluation supervision of the entire asset management process can be achieved, and stakeholders such as managers, applicants, and asset disposers can be promoted to share and cooperate in the ecosystem of asset management. This improves the interoperability of IoT devices and platforms in the IoT system, helps enterprises to operate while some of their assets are seized, and promotes seized asset management and efficient processing. This applies IoT innovation to digital supervision to improve the transparency of asset management in execution and promote the concept of good faith law enforcement. The IoT system for seized asset management helps to achieve interconnectivity between IoT and seized asset management systems, improve the application level for smartness and digitalization of active sealing in enterprises, reduce resources and costs, achieve intelligent management of sealed assets, lay the foundation for enhancing the circulation value of enterprise assets, and promote the conception of kind law enforcement.

3.2. Challenges

There are types of challenges when applied IoT in the seized asset management domain. From technical perspective, the application of the Internet of Things still relies on the acquisition of various sensing data and the installation and deployment of sensing devices timely, and effective data analysis and control, reliable flexible and low-power network communication technology to achieve reliable data transmission to support the availability and reliability of application. From security perspective, it is necessary to access trustworthy devices, prevent network data transmission from being tampered with, and ensure privacy protection, and data integrity during application processes. From standard issue, industry applications cannot develop rapidly without standard guidance and direction. The lack of standards creates obstacles to interconnectivity, increases the cost of system operation and maintenance, and cannot effectively guarantee the overall performance of the system. In the future, it is highly necessary to pay more attention to the role of application standards for the industrial development.

3.2.1. Projective seal

It senses the video information surrounding the asset, monitor the on-site conditions in real-time and make intrusion analysis based on video and image information, and generates projective alert information. The projective seals are deployed near the entrance of the manufacturing factory and real estate to monitor the seized asset. The projective seals are used for seized asset and production monitoring.

3.2.2. IoT electronic seal

IoT electronic seal which utilizes audio, video, vibrating and other sensor technology, perceives of external events such as demolition, relocation and abnormal status change of the attached object or its

surroundings of the asset, generates on-site warning voice, photograph and video evidence, and transmits to the software platform and the mobile terminal of users. IoT electronic seal is different from the electronic seal for freight container. the latter is based on read-only RFID for seal ID and status automatic identification, and the former is an integrated sensor node to detect the status change of the attached objects and the surroundings of the asset and to generate on-site warning, take photos and set up video connection in real-time. The IoT electronic seal are used for seized asset monitoring and production sealing monitoring. IoT electronic seals are installed for the sealed objects with flat surface such as flat doors or windows. For seized asset monitoring, in this case the IoT electronic seal is attached on the door and IoT system is deployed, the permitted monitors will alarm when the abnormal is detected, such as the long-time touch, demolition of the seal. It will send voice reminder, take proactive figure and turn on video inspection for the clients to check.

3.3. Suggestions

For the future scalable development of IoT applications for seized asset management domain, the suggestions are proposed as follows regarding to the challenges. From the technical point view, it is of importance to seek more comprehensive sensing and reliable communication technologies for preliminary considerations. From the secure point view, in addition to local laws and regulations, the management policy and security techniques should comply with the requirements of relevant laws and regulations on data security, network security, privacy protection, *etc.*, especially to cover device access, device authorization, the encryption of data acquisition and transmission to avoid temptation, and fuzzy processing of application data to refrain from fraud. From the standardization point view, the special standards for unified architecture and interfaces, functional and performance requirements for IoT system are proposed and promote interconnectivity for peer devices, management platforms, and application software, *etc.*

3.4. Service platform

The Service platform realizes the core management for the seized asset from seized object management, assert report, and system management, *etc.*

Seized object management oversees the sealing and unsealing record, the platform can query and download all the history asset record for sealing and unsealing operations based on the IoT system, supervise the asset through IoT multiple devices at the site, jointly to ensure that the seized property is within a controllable status, dynamically monitor the quantity of raw materials and products, and generate daily production and operation situation of enterprises for manufacturing enterprises, supervise the asset from multiple dimensions including instant data and history data from different perspectives, generate the weighing record which is viewed and confirmed by the authorized third party such as notarial office, generate alarms and display them if the abnormal conditions happen.

Asset report is generated and exported through the seized asset management platform. Information notification is informed and pushed to relevant users through API such as official social account notification, SMS notification or other means.

System management covers role management, user management, log management, and operation management. Role management preset corresponding permission for different roles in the beginning

including supervisor, applicant, and maintainer. User management for the seized asset management platform manage the user account, Log management enable the operators to view and export the operation logs. Operation management record and export device fault records, record and query the equipment maintenance records, manage the event generation, analyses and compute to generate the prescriptive events or alarming with context for clients such as periodical production report or abnormal production, analyses the history and statistical monitoring data and display the data in the visualized mode for unified management and scheduling.

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Authors' contribution

Conceptualization, Mingjuan Wu and Haitao Liu; methodology, Haitao Liu; software, Mingjuan Wu; validation, Mingjuan Wu; formal analysis, Haitao Liu; investigation, Mingjuan Wu; resources, Haitao Liu; data curation, Haitao Liu; writing—original draft preparation, Mingjuan Wu; writing—review and editing, Haitao Liu; visualization, Mingjuan Wu; supervision, Haitao Liu; project administration, Mingjuan Wu; funding acquisition, Haitao Liu. All authors have read and agreed to the published version of the manuscript.

Conflicts of interests

The authors declare no conflicts of interest.

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