GTI Requirements and Typical Industry Applications of Passive IoT White Paper

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Version:	V0.1
Deliverable Type	□ **Procedural Document** □ **Working Document**
Confidential Level	□ **Open to GTI Operator Members** □ **Open to GTI Partners** □ **Open to Public**
Working Group	5G ENS
Task	Proximity network
Source members	CMCC
Support members	Huawei, ZTE, Comba
Editor	
Last Edit Date	25-10-2023
Approval Date	DD-MM-YYYY

Document History

Date	Meeting #	Version #	Revision Contents
DD-MM-YYYY		NA	
DD-MM-YYYY			
DD-MM-YYYY			
DD-MM-YYYY			
DD-MM-YYYY			

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1 Executive Summary

This article explores the extensive applications and potential benefits of Passive Internet of Things (IoT) technology in various sectors, including logistics, warehousing, manufacturing, electricity, healthcare, animal husbandry, and households. It delves into how Passive IoT technology enhances efficiency, reduces operational costs, and bolsters management and monitoring capabilities in these domains, facilitating their transition to more intelligent and efficient systems.

In logistics, Passive IoT technology improves operations, enhances efficiency, and reduces costs through end-to-end cargo tracking and management, enabling intelligent logistics. In warehousing, the efficient data collection and management with passive tags boost warehouse productivity, cut costs, and enable smart warehousing management. In manufacturing, Passive IoT technology, by implementing asset lifecycle management, accelerates the digitization and smartification of modern manufacturing processes. In the electricity sector, passive tags play a crucial role in equipment temperature monitoring and real-time surveillance, enhancing the security of power systems. In healthcare, Passive IoT technology supports the digital management of medical devices, improving asset management efficiency, while also aiding in patient tracking and health monitoring. In animal husbandry, passive tags monitor livestock numbers, health, and behavior, enhancing farmers' management efficiency and reducing their workload. In households, the cost-effective and flexible deployment of passive tags promotes the widespread adoption of smart home devices, offering a wider range of smart home services.

In summary, Passive IoT technology drives smart, digitized, and efficient operations across various sectors, meeting diverse modern demands, enhancing management and monitoring capabilities, and propelling industries toward increased intelligence and efficiency.

2 Abbreviations

3 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

4 Typical Industry Application

The significant advantages of passive IoT communication are battery-free, maintenance-free, and low cost, with the help of passive sensing, extremely low-power communication technology, and key technologies at all levels of data and intelligence. With extremely low hardware complexity, the new passive IoT tag can support the integrated ability of "sensing and communication", combined with a new system architecture. This technology can meet the application requirements of ultra-low power consumption, ultra-low cost, and extremely small size, expand and support a variety of industrial applications, and enable industrial applications such as warehousing, logistics, manufacturing, transportation, medical care, animal husbandry, and home furnishing.

4.1 Logistics

With the accelerated promotion and application of new technologies such as big data, cloud computing, artificial intelligence, and blockchain, building an efficient logistics system has become a basic requirement for the development of today's logistics industry. The smart logistics system is the only way for the development and transformation of my country's logistics industry, and the smart logistics marked by modern information technology is entering a stage of rapid development.

supply chain logistics management runs through the entire logistics process. Through the unified control of capital flow, logistics and information flow in the procurement process, the optimal match between the total cost and total efficiency of the procurement process can be achieved. Smart logistics can also provide suppliers, manufacturers, and consumers with comprehensive information services such as transportation, warehousing, packaging, and distribution, and reduce operational risks. Therefore, the whole process management of logistics and the traceability of the whole life cycle of goods have become urgent problems to be solved by smart logistics.

The logistics application scenario has the characteristics of a wide range of movement, frequent data reading, and a large amount of concurrent data. Generally, the indoor network communication distance is required to be greater than 30 meters, and the outdoor network communication distance is greater than 100 meters, and the tags are required to have sensing capabilities such as temperature and humidity sensing, pressure/vibration sensing, etc.

As a typical representative of automatic identification technology, the new passive Internet of Things technology has the characteristics of high identification accuracy, reliable performance, large amount of stored information, and resistance to oily and sewage washing. Moreover, the new passive tags are small in size, maintenance-free, and low in cost, and are suitable for the entire process management of assets, the entire life cycle management of products, and the refined management of logistics. The new passive tags are easy to combine with sensors. Passive tags with environmental sensors such as temperature, humidity, and acceleration can realize the whole-process status monitoring of cold and fresh items and the full-process traceability of high-value items to ensure the safety of items and the quality during transportation, significantly improve the efficiency of logistics transportation and management, and help the realization of smart logistics.

4.2 Storage

Warehousing runs through all aspects of logistics and is an integral part of logistics. As an important part of the whole process of logistics, warehousing puts forward higher requirements for the accuracy of information identification and the efficiency of information integration. In addition, with the increase of land use costs and labor costs, storage costs have also increased significantly, and storage costs have become a key factor in determining logistics prices. The contradiction between the increase in the total amount of logistics and the decrease in logistics costs will continue to promote the upgrading of industrial technology, and the cost reduction and efficiency increase of warehousing will become the core of the future development of my country's logistics industry.

Different from traditional warehousing, intelligent warehousing management uses 5G, Internet of Things, big data and other technologies to clearly and accurately record the types, quantities, production attributes, stacks and other information of goods in the warehouse. This not only facilitates managers to accurately grasp the product data and supply chain information of each link, reasonably maintain and control inventory, but also helps to reduce storage costs and improve operational efficiency. In warehouse management, lower cost and more efficient passive IoT technologies are required. Specifically, it is necessary to accurately track all links such as incoming goods into the warehouse, storage in the warehouse, circulation processing, and goods out of the warehouse, so as to realize automatic identification of goods information and visual management of supply chain information, thereby meeting the needs of warehousing automation, informatization, and intelligence.

The warehousing application scenario has the characteristics of huge data volume, frequent data reading operations, and cost sensitivity, and has high requirements for inventory efficiency and cost. In addition, in the warehousing scenario, the indoor communication distance is generally required to be greater than 30 meters, the network coverage has no dead ends, the anti-multipath interference ability is strong, and it is required to support stack-level positioning.

The new passive tags have extremely small size and extremely low cost, and are extremely competitive in scenarios with huge cargo throughput such as large warehouses. Thanks to the improvement of the performance of passive tags and readers, the new passive IoT will support automatic reading of large quantities of goods and have more efficient inventory efficiency. In addition, the new passive IoT system has the functions of large-scale networking and precise positioning, which is conducive to the realization of accurate search and rapid circulation of goods in large warehouses, and helps the realization of smart warehousing.

4.3 Manufacture

With the rise of a new round of scientific and technological revolution and industrial transformation, the green, digital, intelligent and customized trends in the development of modern manufacturing have become increasingly prominent, and the development of manufacturing has

shifted from scale expansion to enhanced digital and intelligent technology innovation and application. With the new generation of information technology as the core, intelligent manufacturing combined with 5G, artificial intelligence, wireless sensing and other technologies has become a new stage in the development of modern manufacturing.

Different from traditional production sites, there are a large number of sensor nodes in the environment of modern manufacturing factories, which are used for temperature, humidity, vibration monitoring, production line monitoring, dangerous event monitoring, etc. At the same time, in some applications, sensor nodes may be required to be deployed in harsh environments (such as: high/low temperature, high humidity, easy to leak environments, etc.), special location spaces (such as: dense magnetic field environment), or even extremely dangerous environments (such as: moving or rotating parts, high vibration conditions, etc.) to complete intelligent sensing of manufacturing process data. In addition, with the acceleration of supply chain circulation, modern manufacturing puts forward higher requirements for the connection and timely data sharing of upstream and downstream supply chains. Therefore, the manufacturing industry needs a smarter, more efficient and more compatible asset life cycle management method.

The manufacturing scene has the characteristics of special working environment and delay sensitivity. Generally, the network communication delay is required to be on the order of 10 milliseconds to 100 milliseconds. The tags can support multiple sensors, and have high/low temperature resistance and corrosion resistance.

Due to its power-free and maintenance-free features, the new passive tag can be deployed in the special environment of the above-mentioned manufacturing plants. At the same time, it is expected to realize self-supply of sensor terminals based on environmental energy harvesting technology. In addition, its extremely low-cost characteristics help to realize "one code to the end", open up all aspects of modern manufacturing from procurement, processing, circulation to scrapping, etc., realize seamless connection of business processes and data, and coordinate management of upstream and downstream departments. It is helpful for accurate control and timely sharing of asset inventory, avoiding problems such as "multiple collection and repeated collection", and accelerating production efficiency.

4.4 Electricity

Under the pressure of "dual carbon" goals, deep peak shaving and ultra-low emissions have become an inevitable development trend and long-term research hotspot in the energy industry. Major power plants urgently need to introduce new technologies to transform and upgrade to intelligence. Abnormal temperatures of various equipment in the power system will lead to safety accidents such as melting and burning. Smart and digital power grids based on wireless methods are an important direction for the future of power.

In the power system, there is a possibility of poor interface at the interface of primary equipment, which will lead to serious first-level accidents such as power grid business failure. Therefore, real-time temperature monitoring of equipment is required. At present, it mainly relies on infrared

equipment to monitor the power grid. However, the infrared thermodynamic map based on surface temperature measurement cannot directly locate the point, and the accuracy and timeliness are low. Moreover, the power scene covers a large area and has a lot of site data, and the ultra-high voltage equipment cannot be manually detected in the working state. Therefore, there is an urgent need for automated and maintenance-free equipment to empower smart power scenes.

Power scenarios have the characteristics of large coverage area, high real-time requirements, and strong electromagnetic interference. Generally, the network communication distance is required to be greater than 50 meters, and the ability to resist electromagnetic interference and temperature, humidity, and vibration sensing capabilities is required.

The new passive tag has the characteristics of flexible deployment, real-time efficiency, high security, and low maintenance cost. In the short term, it can cover scenarios in specific areas such as substations and power distribution rooms, replacing infrared or wired connections, and realizing data collection from micro sensors such as temperature and humidity. Facing medium and long-term evolution, the new passive Internet of Things technology can be applied to wide-area coverage scenarios such as transmission lines and outdoor cable trenches, and achieve a 0-1 breakthrough in the sensing capabilities of related scenarios.

4.5 Transportation

In recent years, with the rapid growth of the number of electric bicycles in our country, traffic accidents and fire accidents caused by electric bicycles continue to occur. The intelligent management of electric bicycles is an important and difficult point to be solved urgently.

On the one hand, there are a large number of electric bicycles, and road supervision is relatively difficult. Speeding, illegal carrying, and random lane changes are all high-frequency violations of electric bicycles, and accidents caused by them are not uncommon. On the other hand, some users do not have a high awareness of fire safety. Electric bicycles entering elevators, charging at home, blocking fire escapes, and charging piles are unstable often occur. The number of fires caused by electric bicycles and their battery failures remains high. Therefore, the transportation industry needs to apply a more efficient, reliable and convenient supervision method to manage the safety of electric bicycles.

The intelligent supervision of electric bicycles in the transportation industry can be divided into two sub-scenarios. One is the road supervision scene to conduct illegal supervision on electric bicycles in motion. Such scenarios usually have the characteristics of fast driving speed and wide range of movement. Generally, the outdoor communication distance of the network is required to be greater than 100 meters, the coverage has no blind spots, and low-latency data transmission and network switching are supported. The second is the parking supervision scene to conduct real-time supervision of violations such as electric bicycles entering corridors and elevators, as well as the health status of electric vehicle batteries. Such scenarios have the characteristics of severe multipath effects and object occlusion, and generally require the network to have strong anti-

multipath interference capabilities and support high-precision positioning.

The new passive tag has the characteristics of high accuracy, reliable performance, low cost, and easy deployment. On the one hand, it can be pasted on the license plate of an electric bicycle to assist the traffic department in monitoring the driving and parking status of the electric bicycle. On the other hand, with the help of environmental energy harvesting technology, the new passive tag can be combined with sensors such as temperature and humidity, and attached to the battery module of the electric bicycle to monitor its temperature and humidity status, reduce the risk of battery overheating and fire, and reduce fire hazards. In addition, the new passive Internet of Things system supports continuous networking and precise positioning, which can realize the tracking and management of electric bicycles in a wide area and strengthen the intelligent supervision of electric bicycles.

4.6 Medical

With the construction and development of modern medical care, the informatization, intelligent management and service level of hospitals are constantly improving, and the passive Internet of Things has very great application prospects in smart medical services.

On the one hand, large hospitals usually have a large number of medical assets, which have similar packaging but different uses. For the management of medical assets, the traditional method mainly relies on manual work. Therefore, the efficiency is low, the error rate is high, and it is easy to find the equipment that cannot be found quickly in an emergency. On the other hand, in large hospitals, medical staff usually need to monitor each inpatient's medical information, health signs and other data one by one. The management process is complicated and the manpower consumption is relatively large. In addition, with the miniaturization of medical devices, human implantable devices, such as cardiac pacemakers, insulin pumps, and interventional devices, are gradually used in operations. However, traditional implantable devices contain electronic components and usually need to be equipped with batteries to achieve data exchange and control. The device is difficult to implant and faces the problem of battery replacement.

Medical scenarios have the characteristics of complex working environment, diverse needs, and high reliability requirements. Generally, it is required to support a network coverage of more than 1 km in a relay state and a service reliability of more than 99%.

The new passive tag has excellent characteristics such as low cost, small size, battery-free, maintenance-free, water resistance and high temperature resistance. On the one hand, it can support the digital collection, storage and sharing of medical information within the hospital, realize efficient management of medical assets, improve the efficiency of drug management, and meet the management of special medical devices in high temperature, high pressure or high humidity environments. On the other hand, by attaching the new passive tag to the patient in the form of a small bracelet, the follow-up treatment and health monitoring of the patient can be realized, and the patient's activity track can also be reflected to prevent the patient from leaving without permission and simplify the hospital care process, also improve management level. In

addition, based on the characteristics of environmental energy communication, the new passive tags can realize the battery-free operation of medical implantable devices, greatly extend the working life of the devices, and can be miniaturized enough to further reduce the risk of human rejection.

4.7 Animal Husbandry

With the rapid development of the animal husbandry industry, the level of scale and specialization has been continuously improved. Transforming and upgrading traditional animal husbandry, developing and innovating modern intelligent animal husbandry, and accelerating the informationization of animal husbandry have become more and more important factors for the development of animal husbandry.

The intelligence level of modern animal husbandry is low, but with the improvement of the level of refinement of livestock management, modern animal husbandry puts forward higher requirements for the automatic identification of livestock and objects and the collection and monitoring of surrounding environmental information. The existing common management and monitoring method is that livestock wear heavy active sensors, the frequency, efficiency and accuracy of periodic temperature monitoring and inventory are low, and the equipment maintenance cost is high. At the same time, with the development of modern animal husbandry towards large-scale and intensive development, the distribution and range of activities of livestock will become very extensive, requiring new communication and sensing technologies with long communication range and fast return speed to meet the needs of remote operation.

The livestock scene has the characteristics of a large number of livestock, a wide range of distribution and activities, and strict size restrictions on the equipment worn by livestock. Generally, the outdoor communication distance is required to be greater than 100 meters, and the network coverage has no blind spots. At the same time, the tags support periodic sensing data collection and reporting.

The new passive tag has the characteristics of small size, light weight and low cost, and can be combined with a variety of biometric sensors. This kind of tag can be placed on the body of the livestock to monitor the number, physical condition and behavior track of the livestock, and give timely feedback to the farmers when necessary. Moreover, most animal husbandry scenes are outdoors, which can conveniently collect environmental energy such as solar energy to enable tags, and based on the capabilities of outdoor base stations, large-scale information collection and communication can be realized. Farmers do not need to count and inspect livestock one by one on the spot, but can remotely control the situation of livestock through mobile phones, which greatly improves work efficiency and convenience. The new passive Internet of Things technology can realize the identification, identification, tracking and query of various links from agricultural breeding, acquisition, processing, transportation and sales. At the same time, it also provides effective information for livestock disease prevention, related supervision and management, and helps the intelligent development of modern animal husbandry.

4.8 Household

In recent years, driven by intelligent and automated high-tech, the smart home industry has entered a period of rapid development. Especially under the impact of the epidemic, people's requirements and expectations for the home living environment are more urgent, which also prompts the smart home industry to usher in new development opportunities.

The smart home uses the residence as a platform and connects various devices in the home through the Internet of Things. Its initial development is mainly based on remote control of lighting, remote control of electrical appliances and electric curtain control. With the improvement of people's living standards, the Internet of Things technology represented by intelligent object finding is gradually applied in the smart home environment. People expect to use the Internet of Things technology with lower cost, extremely small device size, no need to charge and maintain for the management of household assets, to achieve fast household item search, item cycle inventory and other applications.

Home scenarios have the characteristics of complex deployment environments and diverse business requirements. Generally, indoor network communication distances are required to be greater than 10 meters, relays are supported, multi-path interference resistance is strong, and single-item-level positioning is supported.

The new passive tags can be flexibly deployed in the home due to their ultra-low cost, extremely small size, washable, and flexible/foldable form factor. For example, embedded in walls, ceilings, and furniture, or attached to keys, passports, and clothes, greatly increasing the types of interactive devices in smart homes, and providing services such as home environment sensing data collection, alarm information collection, and security protection.

5 Conclusion

This white paper emphasizes the extensive applications of passive IoT technology in various critical sectors, including logistics, warehousing, manufacturing, electricity, healthcare, livestock, households, transportation, and traffic. In logistics, it enhances efficiency, reduces costs, and has the potential to support autonomous driving in the future. In warehousing, it improves efficiency and lowers costs through smart warehousing management. In manufacturing, it boosts production efficiency and drives automation. In the electricity sector, it enhances system security. In healthcare, it enhances equipment management efficiency. In the livestock industry, it enhances production quality. In smart homes, it elevates the quality of life. By providing a comprehensive overview of passive IoT technology's current and future applications in these sectors, it delves into the significance and value of passive IoT communication technology within the context of 6G, and how it empowers the creation of a green, energy-efficient, intelligent, and highly efficient next-generation mobile communication network. In the future, China Mobile Research Institute will collaborate with various industry stakeholders, leveraging the support of China's National Natural Science Foundation, universities, and joint laboratories to drive technological innovation, product

development, and application expansion. Furthermore, it will establish a "Passive IoT Technology Joint Innovation Center," fostering consensus and forming a collaborative force to collectively propel the development of the passive IoT industry and establish innovative business models for the Internet of Things.