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NB-IOT Technology for the Improvement of Agriculture

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ABSTRACT : *In the field of IoT (Internet of Things), NB-IoT (Narrow Band Internet of Things) is a new technology that is based on cellular networks and appropriate for large-scale low-power IoT application scenarios. It is more frequently utilized in the agriculture industry than LTE and has the advantages of low power consumption, large area coverage, and inexpensive cost. In the planting business, NB-IoT may assist manage and control crop growth, prevent pests and diseases, and use water in a scientific manner. It can be used in animal husbandry to accurately raise and assess the health of the animals. In the aquaculture industry, environmental factors can be accurately measured to realize online remote monitoring. Nevertheless, there are still a lot of issues with NB-IoT that need to be resolved, including issues with power usage, network coverage, profitability in the marketplace, information security, and marketing.*
KEYWORDS *Animal husbandry, application, aquaculture industry, NB-IoT, planting.*

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I. INTRODUCTION

1.1 Characteristics of the NB-IoT technology

The full name of NB-IoT is Narrow Band Internet of Things. This is a new cellular network-based Internet of things technology. It allows low-power devices to connect to WANs via cellular data. It is appropriate for large-scale low-power IoT application scenarios, which is why it is also known as low-power WAN [1]. It is highly suited for scattered and low output value agricultural data collection because it possesses the three qualities of low power consumption, wide area coverage, and low cost [2]. This will enable farmers to realize intelligent management, increase production efficiency, and advance the advancement of modern agriculture.

In order to achieve industrial upgrading, agriculture is also continuously undergoing digital transformation due to changes in market demand and consumption trends. The agricultural industry may greatly benefit from the deployment of Internet of Things technology, which can help farmers implement intelligent management and advance the advancement of contemporary agriculture. Through NB-IoT technology, agricultural systems can realize functions such as remote monitoring, intelligent control and data analysis. For instance, by installing sensors and actuators, it is possible to achieve fully automated irrigation, fertilization, and ventilation by monitoring environmental parameters like soil humidity, temperature, and light intensity in real time and adjusting them automatically based on the needs of crop growth.

The ability of NB-IoT communication stability, a significant Internet of Things communication technology, to function regularly in the hilly regions of agricultural development is critical. (Deng Kaifeng et al., 2024) test the transmission reliability of NB-IT in the tea planting base of Changchun District, Chongqing with hilly regional attributes[3]. The SIM card is a China Complete NB-IoT card, the communication module uses the BC95-B5 signal intensity test, and multiple detection is used to confirm the packet loss rate of data transmitted relentlessly. Data gathering and transmission were carried out once every 30 minutes for numerous trials, with multiple test sites set at random to conduct the packet loss rate test in accordance with the actual conditions of the trial site. Analysis shows that NB-IoT has an average packet loss rate of 0.37% and robust, dependable communication, suggesting that the technology is feasible in mountainous areas [2].The NB-IoT network's coverage has progressively increased from urban to rural areas in recent years, signal transmission reliability has been further enhanced, and NB-IT technology has been applied in agriculture in a wider range of ways.

1.2 Differences between NB-IT and LTE

There are significant distinctions between NB-IoT and the conventional LTE mobile broadband Internet of Things (Table 1).

There are differences in positioning: NB-IoT positioning is for human usage, whereas LTE positioning is utilized by humans. Things and people have distinct requirements. When people travel, they need to view videos or move swiftly, thus LTE must maintain mobility and be online all the time. NB-IoT does not have this requirement.

Different speed: NB-IoT only supports low rate, and the network rate is often less than 200 Kbps, which is a huge difference with LTE. Traditional LTE provides high speed, hundreds of megabits or greater.

NB-IoT terminals are different, with agricultural collection points dispersed. In reality, people's network terminals are our mobile phones; there are no particular requirements for the battery's working life, as data indicates that it is currently two or three years. Mobile phones are everywhere we look, neither in fixed positions nor in areas with poor network coverage. It will take a lot of labor and material resources to replace a battery, which is why the design calls for a 10-year battery life [4]. To accomplish power and energy savings and extend the battery's useful life, terminal and network side cooperation are needed.

Difference in capacity: The number of supported connections is referred to as capacity. While NB-IoT enables 50,000 connections per cell, traditional LTE only supports a few hundred. NB-IoT can be referred to as "supporting mass connections" in contrast to LTE.

Mobility: NB-IoT terminals are mostly fixed, like water meters, so the requirements for mobility are not too high. As a result, NB-IoT only supports low speed movement and does not support network switching. However, different traditional LTE networks support high speed movement, supporting hundreds of kilometers per hour, as well as 5G, 4G to 2G, or 3G switch.

Data characteristics differ: while NB-IoT is little data packets, like copying an electricity meter, the number of bytes is very small. Traditional LTE networks are massive data packages, like people's everyday video and sound belong to the traffic of big data.

The cost of a terminal varies: whereas NB-IoT terminals consist of a few sensors and have a price target of $5 per module, standard LTE terminals, which include PCs, tablets, and smartphones, start at hundreds of yuan.

Table 1: Differences between LTE and NB-IT

	LTE mobile broadband Internet of Things	NB-IoT
Orientate	People network	Net
Velocity	High speed (hundreds of Mbps or higher)	Low speed (<200 kbps)
Battery life	No requirement (average 2~3 years to change the phone)	10 years (requiring terminal power saving and energy saving)
Volume	Hundreds of connections per cell	50,000 connections per cell (mass)
Mobility	Meet high mobility, support for LTE and IRAT type switching	Low mobility, no switching support
Characteristics of data	Big data packets (video, sound, etc.)	Small data packets (reading electricity meter data, etc.)
Terminal price	Thousands of yuan	5 yuan per module

II. APPLICATION OF NB-IOT IN CROP INDUSTRY

Crops growing in soil will experience problems with nutrient absorption, growth and development, and photosynthesis if the soil's temperature, moisture content, EC value, and pH value are not within the proper range to suit their needs. The environment in the shed is actively adjusted to the different growth and development stages of the crops in order to provide the ideal circumstances for their growth and development. Simultaneously, we employ inexpensive, dynamic, and instantaneous sensing technologies to gather and analyze crop growth and environmental data in order to recommend the necessary nutrient detection prescription for various crop cultivation management strategies. In order to guarantee crop quality and yield growth, timely management and adjustment in accordance with the prescription can provide an ideal growing environment for the crop, increase its economic worth, and enhance its overall benefits.

In agricultural production, it is possible to introduce diseases and pests and can lead to their frequent occurrence if the temperature or humidity at which plants and animals develop is unsuitable. Diseases and insect pests will cause an overuse of pesticides and antibiotics, which will compromise the safety and quality of agricultural products. In order to identify whether there are pests, what kind of pests there are, where they are found, and how to get rid of them, NB-IoT technology uses deep learning to evaluate and comprehend photos of illnesses and pests as well as the state in which agricultural products are ripening. Environmental regulation can lessen or completely prevent the appearance of diseases and insect pests if the latter can be foreseen through reliable and real-time temperature and humidity data collection.

2.1 Use cases of NB-IoT in crop farming

Agricultural irrigation accounts for almost 65% of China's overall water consumption, making it the industry with the largest water usage even though the country's northern area has a severe water shortage. The nation is now implementing the rural water pricing reform in an effort to save water and enhance the scientific and technological water use for rural irrigation. Accurately measuring the amount of tap water utilized is the key goal of this reform.

Water supply and information transmission will be inconvenient due to the requirement that the water meter outlet and sensor facilities for measuring water be installed at the field's motor wells or water channels. Furthermore, the manual reading process at the site requires a large number of workers, and the data collecting process is slow, making it impossible to implement the scientific recommendations for irrigation water. Some researchers are using NB-IoT technology to achieve intelligent water resource management as a solution to this issue.

They developed a model for predicting the water content of soil and uploaded pertinent data to the cloud-based automated irrigation management system via the NB-IoT data network. To achieve accurate irrigation, the management system modifies the irrigation plan based on the prediction model and monitoring data. It then uses NB-IoT to transmit a control signal to the irrigation equipment. This method guarantees the healthy growth of crops while also saving farmers money on labor and water resources [2].

Irrigation makes it convenient and NB-IoT technology makes it possible to accurately and thoroughly understand rural water supply information, which aids in the precise adjustment of water supply and scientific water supply of farmland. The benefits of crop irrigation will be significantly enhanced by the digitization and scientization of water consumption, resulting in the realization of the gain associated with water-saving agriculture.

III. APPLICATION OF NB-IOT IN ANIMAL HUSBANDRY

3.1 Application technology of NB-IoT in animal husbandry

In the animal husbandry sector, it is challenging to quickly ascertain the health of pigs, cattle, and sheep; collecting production data in an objective manner is challenging; breeding technology is very subjective; and businesses lack the capacity to organize and analyze large amounts of data. In addition to being challenging to identify and diagnose in a timely manner once pigs, cattle, or sheep become sick, the disease is also easily transmissible to other pigs, cattle, or sheep, posing serious dangers.

NB-IoT technology, however, has made it possible to create intelligent collars that will precisely capture location, activity, and vital sign data for sheep and cattle. Furthermore, calf pressure, fighting, coughing, sneezing, and calls related to stress disorders can all be observed via vocal monitoring in animals. Simultaneously, video surveillance can be utilized to identify weak and unwell animals. Disease monitoring, medication supply management, risk assessment, and production management assessment can all be completed more precisely and successfully when combined with sound and picture monitoring techniques. The gathering and use of these data can facilitate the tracking of sheep, cattle, and pigs as well as the prevention of losses and the early detection of illnesses. In the meanwhile, it can monitor the estrus of female animals, increase milk yield, and lower breeding risks in order to support careful breeding management.

Precise feeding management is also achievable using NB-IoT technology. In order to control the feeding system, achieve precise animal feeding, control the feeding, water, tank mixing, etc., to improve the meat material ratio, etc., video intelligent monitoring is used to gather and establish animal files (growth cycle, body weight, feeding information, etc.) and tower sensor data. These files are then uploaded to the data platform for analysis. Simultaneously, it can enhance productivity via testing, determine ovulation prediction, body condition score, animal health, inventory, and additional models, and fortify the conventional management of female production and pregnancy process, thereby averting the loss of empty pregnancy resulting from inaccurate mating time and female ovulation prediction.

To encourage the growth of rural insurance and agricultural credit, smart collar data on pigs, cattle, and sheep can also be supplied to commercial banks and insurance organizations. To raise the value of animal commodities, such information can also be posted on e-commerce platforms for pre-sale and booking.

3.2 Use cases of NB-IoT in animal husbandry

3.2.1 Livestock health was monitored all day in large farms using NB-IoT technology

Two sizable farms in the province of Henan currently employ the sound goods based on NB-IoT technology, which span the entire cycle of conservation and fattening. After a year of operation, they have kept an eye on the well-being of 200,000 pigs all day long. The monitoring system keeps track of the pigs' coughs and the locations of their coughs. It then directs the administrators to act promptly and assesses the effectiveness of medication in order to minimize manual entry, identify irregularities beforehand, lower the expense of medication administration, and raise breeding standards. Furthermore, intelligent inspection robot products—

which fully realize basic functions including pig weight estimate, sow weight measurement, cough monitoring, asset inventory, temperature monitoring, and monitoring of weak pigs—have also been implemented in the breeding base in Luoyang.

There is a lot of information to gather and share in the modern agriculture sector, but NB-IoT is only one data transmission technique that isn't appropriate in every situation. Information should be acquired using various forms of information acquisition and transmission dependent on the application and various real-world scenarios. NB-IoT's primary purpose is to leverage the IOT network to improve the efficiency and convenience of data acquisition.

3.2.2 Monitoring of broiler breeding environment

Broiler breeding environment monitoring system, which is based on NB-IoT technology, is an important trend in the development of modern animal husbandry. It applies the characteristics of NB-IoT to the production of modern animal husbandry through intelligent perception of information about livestock and poultry breeding environments, safe and reliable transmission and intelligent processing, real-time online monitoring, and intelligent control [5][6].

Professionals use NB-IoT technology and sensor technology combined to create an NB-IoT broiler breeding environment monitoring system. This system is used for monitoring and controlling the breeding environment of broilers through the use of climate, gas sensors, and infrared cameras to collect farm temperature and humidity, harmful gas, and individual broiler dynamic data information. The data parameters of the breeding environment are also utilized, allowing managers to effectively control the situation by responding promptly to early warning parameters. Managers can also monitor the breeding environment's parameter information in real time using a PC terminal or a mobile terminal, and adjust equipment based on specific value. The transmission layer of the system is made up of NB-IoT and the Internet. The NB-IoT module uses the corresponding network to send the collected data to the Internet, where it is received by the background server. The end user can then access these parameters over the network.

The system uses narrow band IoT technology as a wireless transmission component of the broiler breeding environmental monitoring system. It can be directly deployed in the 5G network, which can effectively reduce broiler meat decline, disease, and death. It can also effectively increase breeding income and improve the accuracy and timeliness of environmental measurements related to broiler breeding. This is because NB-IoT does not require the design of base stations or intermediate data processing platforms; instead, it can connect through the operators of the IoT platform to guarantee the stability and security of the data.

IV. APPLICATION OF NB-IOT IN THE AQUACULTURE INDUSTRY

4.1 Application technology of NB-IoT in the aquaculture industry

Water quality parameters like temperature, pH, and dissolved oxygen (DO) have grown in significance as a result of the aquaculture industry's explosive growth in many nations (Li and Yang, 2018) [10]. They are essential to aquatic animals' existence and have a major impact on the quality of the water. As a result, prompt water quality monitoring is crucial for aquaculture's high productivity, wellbeing, and security. Because of its rapid adoption in aquaculture and other industries, NB-IoT is highly accurate and efficient.

However, a number of issues, including inadequate network coverage, excessive terminal power consumption, a high total cost, and a large number of terminal equipment, prevent the aquaculture business from making significant progress. Farmers might select NB-IoT for cellular network-based aquaculture pond monitoring in order to address the aforementioned significant issues. This means that the aquaculture area's environmental monitoring system is directly linked to the cellular network, significantly simplifying the network's architecture and making deployment and maintenance easier. Through the NB-IoT connection, the inexpensive and low-power mobile terminals are dispersed throughout different breeding bases, offering a significant guarantee and priceless real-world experience for the advancement of aquaculture production and even NB-IoT research.

The aquaculture pond water quality monitoring system designed by Juan Huan et al. (2020) is composed of four layers: the application layer, the transmission layer (for hardware terminal user surface orientation and transmission business data), the platform layer (which gathers access network data for cloud platform and forwards various perception data types to the monitoring application system for specific processing), and the perception layer (which is in charge of aquaculture pond data acquisition and aeration control)**Error! Reference source not found.**. The system enables the distributed monitoring and centralized management of water quality parameters in the aquaculture environment. Its features include data collecting, remote transmission, storage management, intelligent control, and so forth. The system was applied to the fishery breeding base in Changzhou, Jiangsu Province.

4.2 Use cases of the NB-IoT in the aquaculture industry

The pond breeding mode is used at the fishery breeding base in Changzhou, Jiangsu province. The base is 0.1 square kilometers in size. For data monitoring, the researchers chose various breeding ponds and meteorological conditions (cloudy, sunny, rainy). In aquaculture ponds, a variety of aquatic species are positioned at varying depths, serving as excellent representatives of aquaculture habitats. In order to deploy the network structure and finish data collecting and coding, the monitoring system uses sensor nodes to collect water quality metrics including temperature, pH, and DO. It also leverages NB-IoT technology for this purpose. The application layer monitoring system calls the query interface in real time to accomplish the online remote monitoring of the aquaculture pond. The data is reported to the cloud platform through the NB module via the core network.

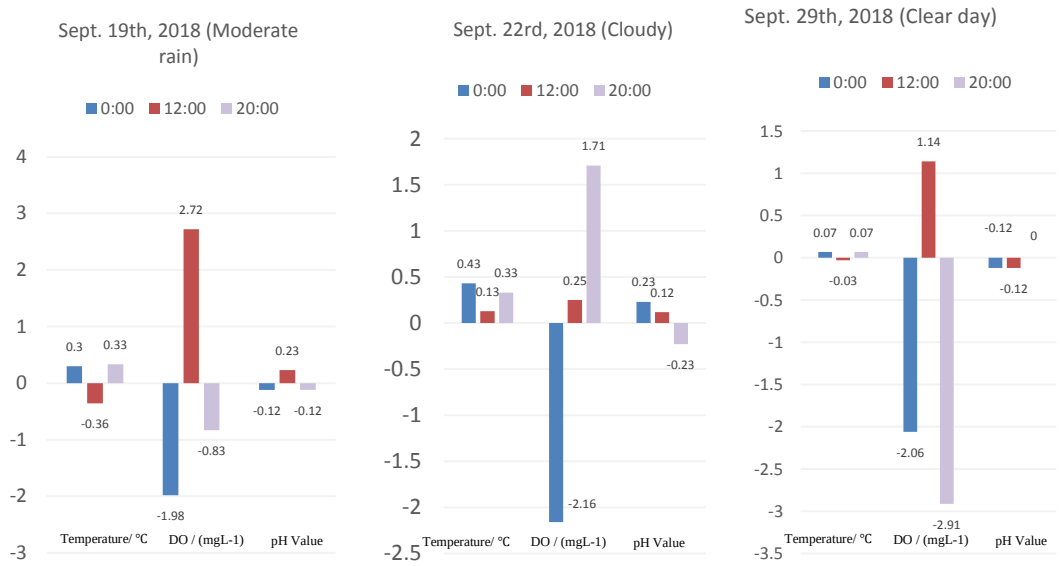

Fig.1 The relative error between the measured values and the true values received by the cloud platform of a breeding pond selected by the researchers

The stability and reliability of NB-IoT technology, the ease of data acquisition, and the promptness of instruction response, when combined with the actual circumstances of the aquaculture pool and as indicated by the above data analysis, allow for the technology to be used in a wider range of areas, such as agricultural monitoring to provide technical support and reference, as well as in the water quality environment prediction to provide broader technical support and reference.

V. CONCLUSION

It is evident that NB-IoT technology's application in agriculture is a reflection of its benefits over LET, including its wider coverage area, lower cost, and higher power consumption. The NB-IoT technology also offers higher efficiency, timeliness, and accuracy in the data processing process.

The primary advantage of this research is that it describes how NB-IoT technology differs from LET technology and examines its specific applications in aquaculture, animal husbandry, and planting. Second, in this research, we can explain the general transmission model of NB-IoT technology in agriculture applying parallel examples: perception (data acquisition), transmission (transmission data), processing (analysis data), and application (device response data).

We selected and examined the extensive use of NB-IoT technology in agriculture, but we did not go into great detail on how it is applied in other domains. But in reality, this technology has a very wide range of applications and is also heavily utilized in other domains including industrial production, communication, and environmental protection. NB-IoT technology development will, however, not be without difficulties.

Based on the findings published by GSMA, the worldwide cellular Internet of things in 2022 will mostly use 2G, 3G, 4G, and 5G networks. Approximately 14.3 billion connections will be made globally, with less than 20 percent of those connections being NB-IoT. It is evident that NB-IoT now has a tiny market share; the following are most likely the causes:

①Power consumption problem

The NB-IoT's low power consumption is one of its key benefits. While existing low-power Internet of Things solutions often use more 2G modules, NB-IoT has a little better power consumption than 2G. The

medium frequency band and high frequency applications do not differ significantly, and the NB-IoT deep standby (PSM mode) power consumption is similar to the 2G power loss condition. Many new technologies are impractical because of the NB-IoT module's present efficiency, which limits its standby time to less than ten years.

②Network coverage problem

However, in comparison to 2G, 3G, 4G, and 5G networks, the NB-IoT network's coverage and quality are still quite restricted, and there are still issues, which further contributes to the lack of faith in it.

③Commercial profit problem

The annual NB-IoT tariff will increase to 35 to 40 yuan if the operators are granted access to the high-frequency service capability. This will raise the ARPU value (average revenue per user) of the Internet of Things services, but it will still only provide a very small direct revenue contribution to the operators. The NB-IoT tariff revenue is still not noteworthy when compared to the three major operators' yearly revenue amount.

④Information security risks

Our lives will be more attractive and convenient thanks to the Internet of Things, but only if personal data is protected. The application becomes more intelligent as NB-IoT develops, but there are hazards to information security as well. From the application layer to the Internet of Things end point, we need to be mindful of how the security system is set up. Each component of the ecosystem must be addressed and built through network equipment, terminal information gathering modules, data transmission, and other system modules in order to build the NB-IoT information and security system. It will take time and experience to accumulate the necessary technical conditions for the construction of an NB-IoT information and security system.

⑤Promotion Issues

Regarding non-technology, which is the primary driver behind the adoption of NB-IoT technology in the Chinese market, operators' contributions to project implementation and marketing as well as market operation are insufficient. Additionally, in the process of encouraging the adoption of NB-IoT products, the pertinent units of the industry are more impulsive and mindful of formalism.

Exaggerated performance indicators, inadequate network coverage, issues with the business model, a hasty judgment, and other issues are, in short, the primary causes of the NB-IoT market's delayed expansion.

REFERENCES

[1] Li Pengfei. Research on the key technical points of narrowband Internet of Things [J]. Communication World, 2017, (05): 60-61.
[2] Li Zhaoxiong, Zhang Chaoyang, Liu Hui, et al. Application of NB-IoT technology in smart tea plantations [J]. Chinese Tea, 2023,45 (12): 14-20.
[3] Peng Weifeng, Luo Jing, Zhang Zhouya, et al. Research on tea pest control control system based on narrowband Internet of Things [J]. Agricultural mechanization research, 2024,46 (1): 84-89.
[4] Yu Lei. Study and implementation of the synchronous detection of the NB-IoT system [D]. Beijing University of Posts and Telecommunications, 2018.
[5] Qian Ping. Design of remote water quality monitoring system based on narrowband Internet of Things breeding [J]. Wireless Interconnection Technology, 2020,17 (07): 42-44.
[6] Chen Chuangye, Chen Rui, Hu Tianren, et al. Laying hens feeding environment monitoring system based on the Internet of Things technology [J]. Foreign Animal Husbandry Science (Pig and poultry), 2021,41 (04): 100-102.
[7] Xue Wei, Meng Fanli, Tan Pei, Li Ya, Ye Min. Research and application of cellular Internet of Things site planning platform based on cavity analysis algorithm [J]. Telecommunication Science, 2018,34 (S1): 134-139.
[8] Huang Jianqing, Wang Weixing, Jiang Sheng, Sun Daozong, Ou Guocheng, Lu Kangju. Development and experiment of aquaculture water quality monitoring system based on wireless sensor network [J]. Journal of Agricultural Engineering, 2013,29 (04): 183-190.
[9] Li Wenfeng, Li Long. Design of environmental monitoring system for broiler breeding based on narrowband Internet of Things technology [J]. Electronic Technology and Software Engineering, 2022 (10): 207-210.
[10] Liyang, Liu, P., Li, B. (2018). Water and Fertilizer.
[11] Juan Huan, Hui Li, Fan Wu, Weijian Cao, Design of water quality monitoring system for aquaculture ponds based on NB-IoT, Aquacultural Engineering, Volume 90, 2020,102088, ISSN 0144-8609.