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The application of mobile edge computing in agricultural water monitoring system

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The application of mobile edge computing in agricultural water monitoring system

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Abstract. The intelligent construction and development of traditional agricultural water production process has become an important pillar industry in China's coastal areas. With the application of IoT technology, the agricultural water monitoring process can manage the data collected by the sensor system in real time. In this paper, a data link management solution is proposed in combination with advanced Mobile Edge Computing (MEC) technology, which effectively realizes the sinking of business anchor points and greatly reduces the business response time. The practical application shows that the scheme realizes the network and intelligence of agricultural water monitoring system management, and has broad market prospect.

1. Introduction

The development of intelligent agriculture has great significance to speed up rural and agricultural infrastructure, promote agricultural scientific and technological innovation, and develop a variety of intelligent agricultural control systems [1]. "Internet + agriculture" will integrate the agriculture with new generation of information network technology, which is represented by cloud computing, big data and Internet of things [2]. It will play an important role in the optimization of production factors in agriculture, support the intelligent development of agriculture, promote the upgrading of agricultural quality and efficiency, and revolutionize the way of agricultural production and operation [3].

In recent years, agricultural water monitoring mainly combines GPS positioning technology with sensor technology to realize the location and acquisition of agricultural resource information. At the same time, the wireless sensor network and mobile communication technology are used to realize the transmission of agricultural water resource information and the planning and management of agricultural resources. However, the traditional working process still has a lack of perfect information standard system and unified planning management, low level of agricultural intelligence, and low information processing timeliness, which limits the popularization of intelligent agriculture. This paper is based on the technology of the MEC, taking the advantage of the IoT, to make an intelligent modification of the traditional agricultural water monitoring system, which implements the management system design of intelligent agricultural monitoring data chain [4].

2. Mobile edge computing

Mobile Edge Computing (MEC) was originally proposed by Nokia and IBM in 2013 and was officially confirmed by the European telecommunications standards association in 2014. The MEC was born in the 4G era, because it can provide high speed and low latency network support, and can meet the development of innovative businesses such as AUV control, smart city, high efficiency Internet of things, etc., which is highly concerned by operators. The MEC allows the traditional wireless connection to be able to make a local and close-range deployment, and can upgrade the traditional wireless station to an intelligent base station [5].

The MEC has three advantages:

- Lower delay: the content of the business cache is very close to the user terminal device, which greatly reduces the business connection and response time delay, thus achieving fast feedback to the actual state of the network to improve the user experience, while reducing the congestion of other parts of the network.
- Location awareness: the MEC server can use a low-level message from the wireless network to determine the location of each of the connections, which will provide a good basis for subsequent service, analysis, and other business applications.
- Network information content: MEC server to obtain real-time network data interface (such as air condition, network parameters, etc.) can be used as power open to applications and services, so that it can be based on the content of perception differentiation of mobile broadband experience, thus for the development of new applications for network capacity information (through the ability to develop the API) to help mobile users based on the location of the point of interest, business information and social events provides the technical feasibility.

The traditional agricultural water monitoring system has a great delay in the speed of network response, especially for the damage caused by sudden water pollution and the failure to establish a rapid response mechanism. The application of MEC technology allows the time from sensor collecting information to committing emergency operations to be compressed to the second level. At the same time, with the traditional IoT technology, the high efficiency of agricultural water monitoring can be realized.

Agricultural water monitoring system structure as shown in figure 1, including sensing unit, the data transmission unit (DTU), MEC structure (including: edge services unit (ESU), routing unit (RU), the open ability unit (OAU), platform management unit (PMU), etc.), the core network server (CNS), etc.

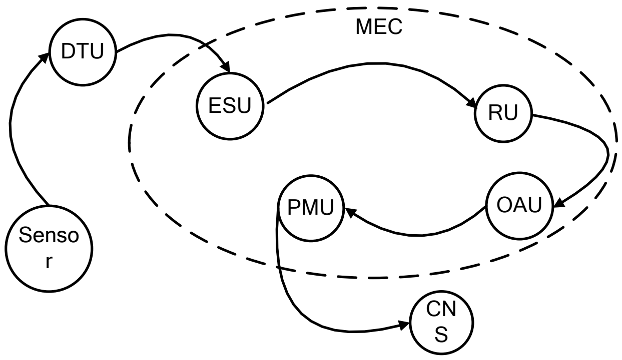

Figure 1. Agricultural monitoring system structure.

3. Agricultural monitoring data routing protocol design

The MEC environment is different from the cloud computing environment. The edge server is located in the wireless access network, avoiding the delay of the echo link. Therefore, the task of MEC should consider the random channel condition of the wireless access network and the occupancy rate of the server, such as channel, mission arrival and resource occupancy rate. In particular, due to the changing characteristics of the wireless channel, the computing task is randomly arriving on the mobile device, and the resource occupancy rate in the edge server system is also changing with time due to the multi-user competition. The above random environment affects the efficiency of task unloading.

However, in the research of traditional mobile cloud computing, the task uninstalling decision does not consider the above random characteristics due to the delay of transmission link delay and computation delay. Therefore, the high-reliability task unloading strategy or prediction method of adaptive MEC stochastic environment becomes the key task to satisfy the high reliability demand of 5G.

With the application and development of ioT technology, a data link management design agreement is proposed in the field of agricultural water monitoring system application. The basic feature of this agreement is to provide low delay and high reliable edge computing services in response to the random environment of MEC. The protocol is to model the environment in the MEC to a random disturbance, and to design an adaptive online task unloading algorithm based on model predictive control theory. Due to the existence of random perturbation, the user needs to perceive the real-time random disturbance of the environment and decide the length of the decision window. The proposed adaptive rolling time domain unloading mechanism determines the environment disturbance by monitoring the execution of the task, and adjusts the discount factor and the decision window length according to the disturbance frequency [6]. The time domain unloading mechanism is shown in figure 2:

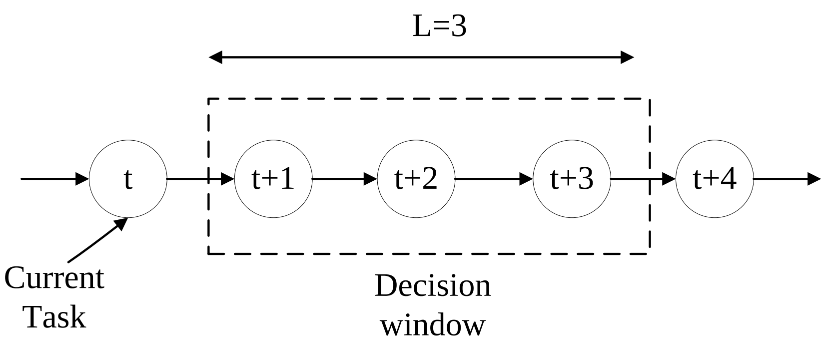

Figure 2. The length of window is 3 schematic.

The system data link management protocol message structure design, combining with the characteristics of industrial CAN bus and carry on the improvement of the customization, packet length less than 8 bytes, and for the first three bytes function division, to ensure that the intelligent agricultural water management system data transmission efficiency and reliability [7]. The packet structure is shown in table 1.

Table 1. The packet structure.

Function Frame Byte	ID23	ID22	ID21	ID20	ID19	ID18	ID17	ID16	ID15	ID14	ID13	ID12
	00		SrcMACID				00		DestMACID			
	ID11	ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
	FuncID				00		SourceID					
Data Frame Byte	Byte0 (SegFlag)											
	Byte1 (Err, Length)											
	Byte2											
	Byte3											
	Byte4											

4. Communication link programmable logic design

The hardware of the communication link is based On Altera's FPGA (Filed Gate Array device) for the design of the SOC (System on Chip) [8]. The data processing control IP core uses the AVALON bus and the function logic on chip to commit read and write access transformations. Because of the main module Nios Ⅱ belong to high-speed equipment and functional logic belongs to slow-speed, so the Nios Ⅱ required sequence transformation during the read and write access. Figure 3 shows the schematic diagram of the IP (intellectual property) core.

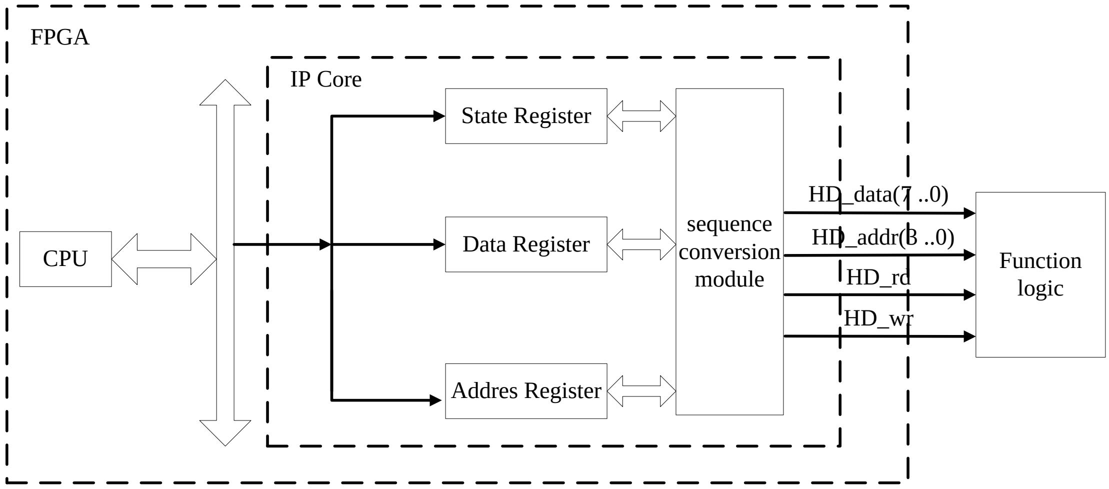

Figure 3. Data processing IP core block diagram.

4.1. AVALON slave port

The IP core provides a slave port, it can communicate with the main port on same AVALON bus (such as Nios Ⅱ processor). To ensure normal data communication, we set the following register from the port side. The data processing IP core reading register setting is shown in table 2.

Table 2. Data processing IP core reading register setting.

Name	Offset	State	Function
Read data register	0x01	Read	The current communication data reads the register
Read State register	0x02	Read	Current state register, high for busy, low for idle
Write data register	0x01	Write	Write the operation data register
Write address register	0x02	Write	Write the operation address register
Enable register	0x04	Write	Peripherals can read and write operations to make, high effective, low invalid

Register operations are configured according to the standard AVALON bus timing. For the logical operation of the slices, the corresponding data is output separately from the data bus, and the data processing operation is dependent on the energy level trigger.

4.2. Data processing control interface

The interface is connected with the data modulation and demodulation logic, and the time sequence is converted to read and write access to the chip of the functional logic through the interface. Among them, setting the data bus format is:

- HD_data (7… 0) is the eight-bit data bus;
- HD_addr (3… 0) is the four-bit address bus;
- HD_rd is the read operation enable signal;
- HD_wr is the written operation enable signal.

The simulation of data processing IP core is shown as Figure 4.

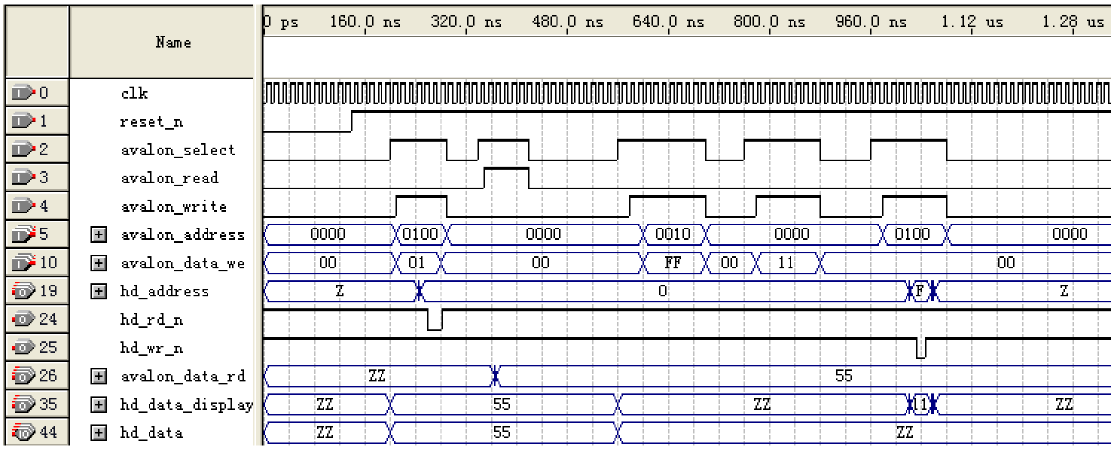

Figure 4. Data processing IP core simulation waveform.

5. Experiment and conclusion

In order to verify the reliability and practicability of this system, the project team conducted experiments on the field of agricultural experiment area in Qingdao economic and technological development zone. The project is divided into three test areas, with a range of 5 km, including 10 sensor nodes in each monitoring area. Monitoring sensors include: Pt100 temperature sensor, PH sensor, WQ401 dissolved oxygen sensor, etc. From the real-time monitoring platform, the system normally works. It shows that the interface is free to switch, and it can do the independent monitoring of each node. Water PH ranges from 6.8 to 7.4 and temperature ranges from 8.4 to 11.6 ℃, which is consistent with the manual measurement. At the same time, the system can complete the normal alarm of artificial activities, indicating that the system has reliable performance in unmanned monitoring.

The main innovative points of the data link management method based on WEC include the following:

- The agricultural water monitoring system includes all the functional terminal equipment and uses the solution based on SOC technology. The design is based on the new technology of Internet of things, GPRS and ZigBee wireless ad-hoc network technology, which is combined with DTU technology to realize data transmission. At the same time, the two-way transmission of state data and equipment information is guaranteed by full duplex communication, which greatly improves the area of monitoring area and the efficiency of the system.
- Agricultural water monitoring system PC uses .net platform as a software development environment, which has better man-machine interaction experience. And it also take advantage of the enterprise cloud servers to achieve 24 months system monitoring data storage, and provides the corresponding data analysis and statistics.
- The production practice proves that the system has been able to complete the industrial upgrading of traditional agricultural monitoring, and is an efficient and reliable mature management system. The system can be applied to different agricultural production environments in the aspects of sensor network management and data interaction.

Acknowledgments

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