

REALIZATION OF THE COMMUNICATION BETWEEN DEVICES OF BACNET/IP AND REAL-TIME DATABASE

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ABSTRACT

Aimed at interoperability and mutual communication limitations of building automation equipment for different manufacturers and systems, a device driver of DasRdb real-time database is designed and developed independently based on BACnet/IP technology after the BACnet/IP technology and real-time database was analyzed. The device driver adopts UDP communication mode to write and read operations respectively by driving the real-time database DasRdb. This can effectively realize the communication between BACnet devices and DasRdb real-time database, and make it possible for building automation equipment to interoperate. The field engineering application shows that the designed driver conforms to the requirements of the consistency of BACnet, and it has the characteristics of simple, efficient, high precision and good real-time.

Keywords: BACnet/IP, UDP, Real-time database, Device driver, Building automation equipment.

1. INTRODUCTION

With the further development of intelligent building and smart city, building automation system (BAS) is moving in the direction of network, intelligent and integrated [1]. It is inevitable to integrate the central air conditioning systems, power monitoring systems, intelligent lighting systems, elevator systems, fire and intrusion alarm systems and other subsystems to the same network platform.

Due to the interoperability of intelligent building communication devices to continuously strengthen and seamless integration of intelligent building rising, intelligent building storage capacity of status data is increasing, and the efficiency of stored data is decreasing, which has become the bottleneck to improve the performance of building automation system. The rise of real-time database technology and its wide application in ISCS (Integrated Supervisory Control System) provides a new way to solve this problem. Real-time database can be timely and accurately access to real-time data, suitable for processing continuous updated data and affairs with time constraints [2]. At present, real-time database has already been applied in IBMS (Intelligent Building Management System) .

2. THE REALIZATION OF THE BACNET/IP TECHNOLOGY

2.1 BACnet standard system

BACnet(A Data Communication Protocol for Building Automation and Control Network)[3] is a data

communication protocol special customized for intelligent building and control system network . It is funded by the American Society of Heating Refrigerating and Air Engineers (ASHRAE)[4], used to open field bus of building automation systems, and it has become an unique ISO standard (ISO16484-5) in the field of building automation system[4,5].

2.2 BACnet/IP architecture

Intelligent building control network is moving into the direction of integration of the Internet, entering the network era. BACnet/IP technology through two layers of micro protocol BACnet/IP (BIP) protocol and BACnet virtual link layer (BVLL) to shield the difference between BACnet and the bottom of the Internet, to realize the seamless interconnection based on IP protocol [6]. In BACne/IP network, you can send messages to any of the BACnet devices based on TCP/IP protocol through a unique IP address. At the other end of the transmission network, the data block encapsulated in the data segment will be taken out from the transmission network and restored to the original data packets [7]. BACnet/IP architecture is shown in Fig.1.

BACnet Application Layer				
BACnet Network Layer				
ISO 8802-2 (IEEE 802.2) Type I	MS/TP	PTP	LonTalk	BVLL
ISO 8802-3 (IEEE 802.3)	ARCNET	EIA-485 (RS485)		EIA-232 (RS232)
				IP

Figure 1. BACnet/IP architecture

3. DASRDB REAL-TIME DATABASE

Real-time database DasRdb is responsible for on-site data acquisition and conversion as well as storage of engineering values of historical data. Device drivers simply need to provide on-site acquisition value, and the mutual conversion between acquisition value and engineering value will be accomplished through the formula. Running real-time database need to read fast, be flexible access, be easy data sharing between modules. Device drivers are written by regular way of DLL, and real-time database DasRdb loads these DLL drivers dynamically when it starts. Each device DLL drivers also use standardized interface functions, and the driver achieve its specific functions by calling the standard interface functions. ECDINFO driver information structure is shown in Figure 2 (filled out by the driver, fixed length of 512 bytes), including specific information for each device manufacturer.

```

typedef struct tagECDINFO { // Driver information structure size=512
    unsigned long dwEcdVer; //Specification version, in hexadecimal notation
    char szVersion[28]; // The version number, such as V1.0.0
    char szCategory[96]; // Device driver classification
    char szProducer[32]; //Equipment manufacturers, such as "Omron"
    char szDriverName[32]; // Device driver name
    char szCommDesc[32]; //Communications description, such as
        "BACnet/IP"
    char szDriverFileName[32]; // Driver file names . such as "BACnet/IP"
}
    
```

Figure 2. Information structure of the device driver

4. REALIZATION OF THE COMMUNICATION BETWEEN REAL-TIME DATABASE AND COMMUNICATION EQUIPMENT

Real-time database DasRdb used in this article is developed by Shenzhen DAS Intellitech Co., LTD, which has independent intellectual property rights, and its real-time values of variables in the real-time database can be dynamically refreshed efficiently. Communications equipment adopted global controller of BCM-ETH and BCM-MS/TP, field controller such as VLC-853, VLC-1600, VLC-550 and VLC-660R, which is produced by the U.S. ALERTON company [8]. The bus connection of BCM-ETH, BCM-MS/TP, and each of BCM-MS/TP adopted the way of hand in hand, and BACnet/IP mode is used for communication. The equipment on the MS/TP bus is also using hand in hand with the bus connection and MS/TP mode is used for communication. The rate of MS/TP bus transfer can be up to 76.8Kbps [9], and the rate of transmission on the BACnet/IP bus can reach 10/100Mbps [9,10].

4.1 The network structure model of field engineering application system

In the field of engineering applications, a global controller connected three BCM-MS/TP via the way of hand in hand, and each global controller BCM-MS/TP used the same way of hanging 127 different field controllers, such as VLC-853, VLC1600, VLC550 and VLC660R. Real-time database DasRdb can read and write the real-time dynamic data when it is running on the PC and the PC terminal is connected to

the BCM-ETH through network cable. The network structure of field engineering application is shown in Figure 3.

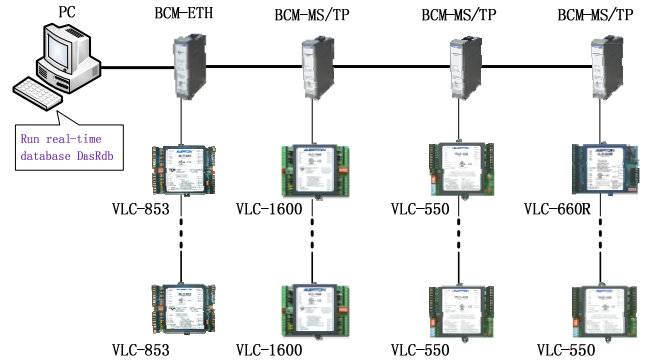


Figure 3. The network structure of field engineering application

4.2 Device driver process

The main process Run of the Device driver is shown in Figure4.

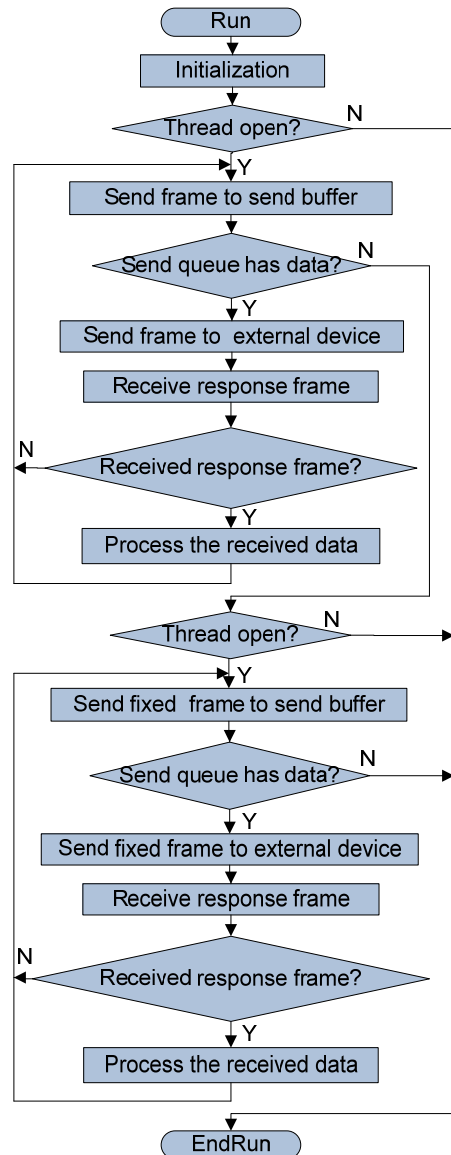


Figure 4. Drivers flowchart

The driver process can be described as follows:

(1) After entering the main process Run, the program first initializes, including open communication port, open threads, group command frame, etc., and then enters the main loop.

(2) Firstly, the real-time database DasRdb carries on write operation, judging whether the thread is open in the first nested loop of the main loop, if the thread is off, then exit; otherwise, it will immediately send frames to send buffer.

(3) To determine whether there is data in the data buffer, if there is no data, then enter the next read operation; if there is data, it will immediately send frames (i.e. write command frame) to the external devices, and receive response frame operation from the external devices.

(4) Determine whether the response frame is successfully received from the external devices, if not successfully received, return and immediately send frames to send buffer; Otherwise, the received data will be processed, and invoke the callback function to refresh real-time database DasRdb, and then enter the next step.

(5) The real-time database DasRdb carries on read operation, judging whether the thread is open in the second nested loop of the main loop, if the thread is off, then exit; otherwise, it will immediately send fixed transmission frame (i.e. read command frame) to send buffer.

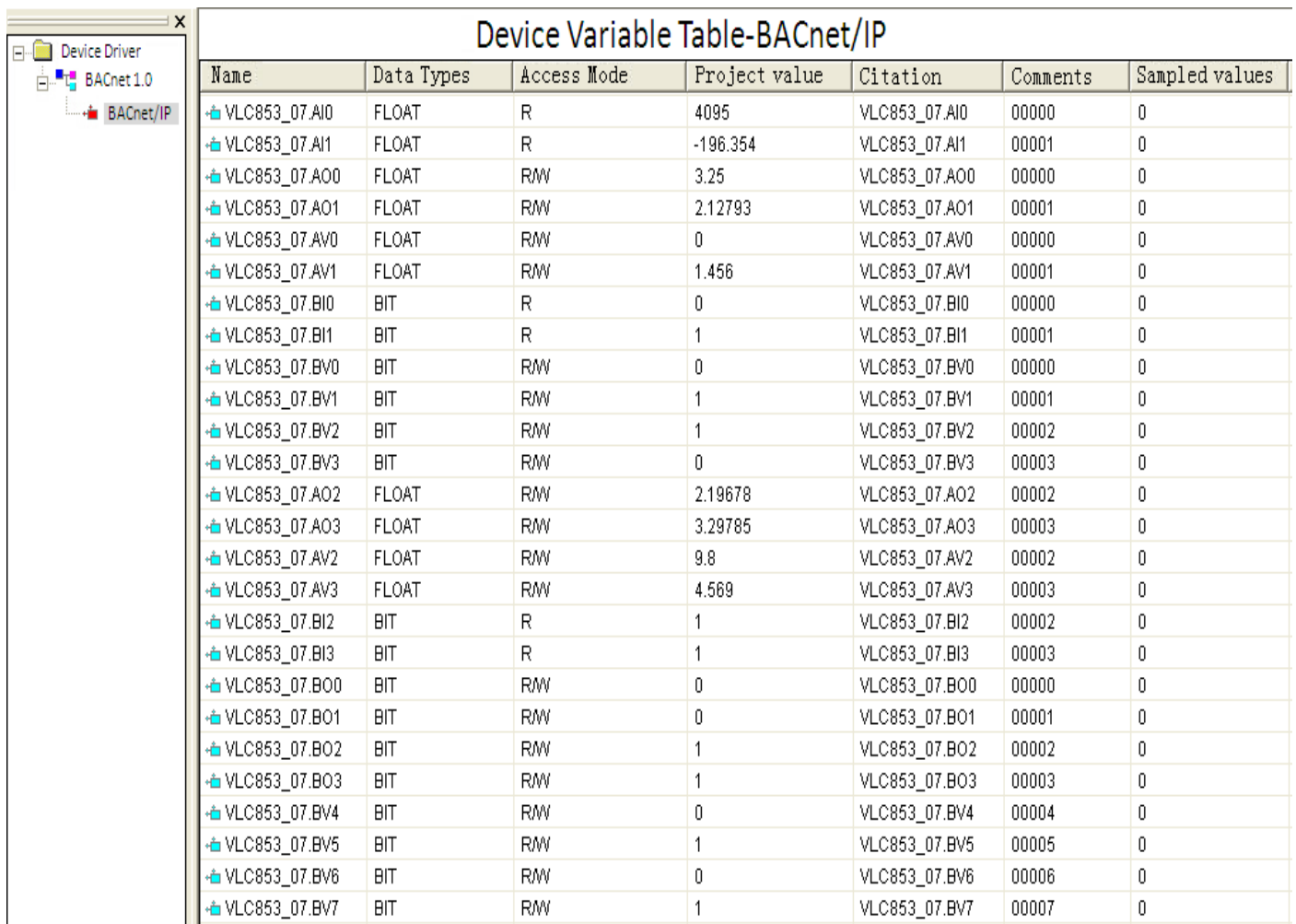
(6) To determine whether there is data in the data buffer, if there is no data, and then enter the next read operation; if there is data, it will immediately send fixed transmission frame to the external devices, and receive response frame operation from the external devices.

(7) Determine whether the response frame is successfully received from the external devices, if not successfully received, return and immediately send the fixed transmission frame to send buffer; Otherwise, the received data will be processed, and invoke the callback function to refresh real-time database DasRdb, and then enter the next loop.

5. TEST AND ANALYSIS OF EXPERIMENTS

5.1 Test results

According to the structure of the model shown in Figure 3, the BCM-ETH and a VLC-853 device access BACnet/IP network; the MAC address configuration of the VLC-853 device is 7, and the IP address of the BCM-ETH is set to 192.168.1.100, port 47808, as a test platform. The driver runs on the PC, which is used to read and write the object of the equipment, and to refresh and display the real-time database DasRdb. Run the driver, get real-time database running interface of the test as shown in Figure 5.



Name	Data Types	Access Mode	Project value	Citation	Comments	Sampled values
VLC853_07.AI0	FLOAT	R	4095	VLC853_07.AI0	00000	0
VLC853_07.AI1	FLOAT	R	-196.354	VLC853_07.AI1	00001	0
VLC853_07.AO0	FLOAT	RW	3.25	VLC853_07.AO0	00000	0
VLC853_07.AO1	FLOAT	RW	2.12793	VLC853_07.AO1	00001	0
VLC853_07.AV0	FLOAT	RW	0	VLC853_07.AV0	00000	0
VLC853_07.AV1	FLOAT	RW	1.456	VLC853_07.AV1	00001	0
VLC853_07.BI0	BIT	R	0	VLC853_07.BI0	00000	0
VLC853_07.BI1	BIT	R	1	VLC853_07.BI1	00001	0
VLC853_07.BV0	BIT	RW	0	VLC853_07.BV0	00000	0
VLC853_07.BV1	BIT	RW	1	VLC853_07.BV1	00001	0
VLC853_07.BV2	BIT	RW	1	VLC853_07.BV2	00002	0
VLC853_07.BV3	BIT	RW	0	VLC853_07.BV3	00003	0
VLC853_07.AO2	FLOAT	RW	2.19678	VLC853_07.AO2	00002	0
VLC853_07.AO3	FLOAT	RW	3.29785	VLC853_07.AO3	00003	0
VLC853_07.AV2	FLOAT	RW	9.8	VLC853_07.AV2	00002	0
VLC853_07.AV3	FLOAT	RW	4.569	VLC853_07.AV3	00003	0
VLC853_07.BI2	BIT	R	1	VLC853_07.BI2	00002	0
VLC853_07.BI3	BIT	R	1	VLC853_07.BI3	00003	0
VLC853_07.BO0	BIT	RW	0	VLC853_07.BO0	00000	0
VLC853_07.BO1	BIT	RW	0	VLC853_07.BO1	00001	0
VLC853_07.BO2	BIT	RW	1	VLC853_07.BO2	00002	0
VLC853_07.BO3	BIT	RW	1	VLC853_07.BO3	00003	0
VLC853_07.BV4	BIT	RW	0	VLC853_07.BV4	00004	0
VLC853_07.BV5	BIT	RW	1	VLC853_07.BV5	00005	0
VLC853_07.BV6	BIT	RW	0	VLC853_07.BV6	00006	0
VLC853_07.BV7	BIT	RW	1	VLC853_07.BV7	00007	0

Figure 5. Running interface of DasRdb of the test

5.2 Consistency Analysis

Use VTS (Visual Test Shell) software to access BACnet devices and to read the data. VTS sends ReadPropertyMultiple service primitives to specify BACnet

device, for example, the service primitives of A11 is "0C 00 00 00 01 1E 09 55 1F", and then BACnet devices run this procedure to reply. The following Figure 8 is the reply results after sending A11, A00, AV0, AV1, B10, B01, BV0 primitives.

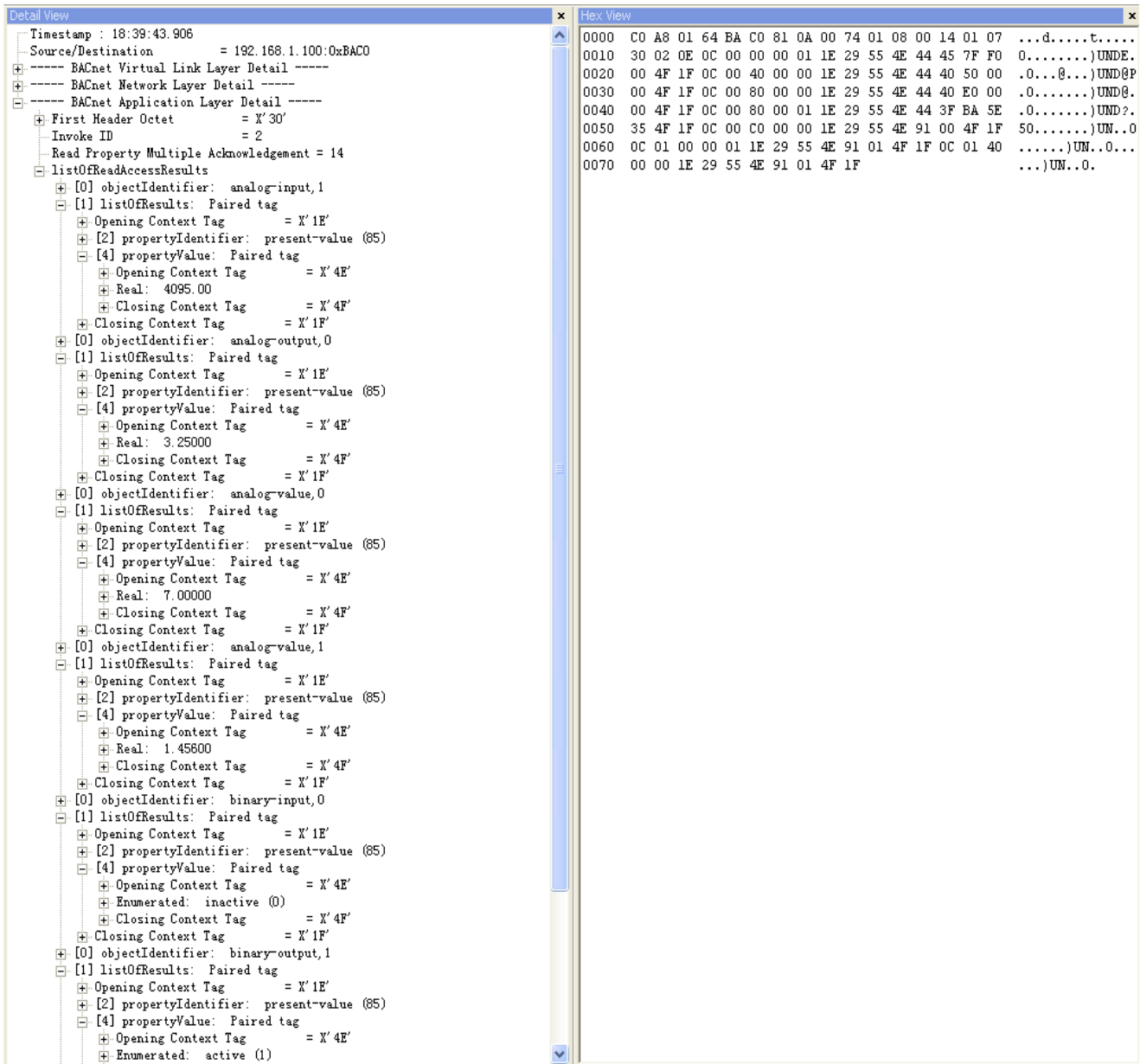


Figure 6. VTS experimental test results

From the VTS test results in Figure 6, it can be seen that A11, A00, AV0, AV1, B10, B01, BV0 of BACnet device returns the value of the Real respectively are 4095.00, 3.25000, 7.00000, 1.45600, 1, 0, 1. Comparing DasRdb results of experimental tests in Figure 7, we are pleasantly surprised to find that in addition to the different bits of data retention, numerical value completely consistent.

Test results show that data acquired in real-time database DasRdb and response data acquired using VTS software on a PC to send ReadPropertyMultiple instructions are exactly the same, in line with BACnet standard conformance specification. It can be seen that the proposed driver is feasible and efferent.

6. FIELD ENGINEERING APPLICATIONS

According to the network structure model of field engineering application shown in Figure 4, BCM-ETH, three BCM-MS/TP connects hand in hand in bus-type mode, each global controller BCM-MS/TP hang multiple field controllers such as VLC-853, VLC1600, VLC550 and VLC660R. Running the device drivers on a PC, the PC as a master node is connected to the BACnet/IP network, to read and write the object of the equipment, and to refresh and display the real-time database DasRdb. Run the driver, get real-time database running interface as shown in Figure 7.

Name	Data Types	Access Mode	Project value	Citation	Comments	Sampled values
VLC550_B1F_02_1.SFY_ST	BIT	R	1	VLC550-B1F-02-1.SFY-ST	00000	0
VLC550_B1F_02_1.SFY_ALM	BIT	R	0	VLC550-B1F-02-1.SFY-ALM	00001	0
VLC550_B1F_02_1.SFY_MA	BIT	R	1	VLC550-B1F-02-1.SFY-MA	00002	0
VLC550_B1F_02_1.1#PFY_C	BIT	R	1	VLC550-B1F-02-1.1#PFY-C	00003	0
VLC550_B1F_02_1.2#PFY_C	BIT	R	0	VLC550-B1F-02-1.2#PFY-C	00004	0
VLC550_B1F_02_1.1#XF_Air Supply Temperature1	FLOAT	R	19.0476	VLC550-B1F-02-1.1#XF-送风温度1	00005	0
VLC550_B1F_02_1.2#PFY_ST	BIT	R	0	VLC550-B1F-02-1.2#PFY-ST	00007	0
VLC550_B1F_02_1.2#PFY_ALM	BIT	R	0	VLC550-B1F-02-1.2#PFY-ALM	00008	0
VLC550_B1F_02_1.2#PFY_MA	BIT	R	0	VLC550-B1F-02-1.2#PFY-MA	00009	0
VLC550_B1F_02_1.2#PFY_Remote Control	BIT	R	0	VLC550-B1F-02-1.2#PFY-远程控制	00010	0
VLC550_B1F_02_1.1#XF_CO2 Feedback Value	FLOAT	R	774.603	VLC550-B1F-02-1.1#XF-CO2反馈值	00011	0
VLC550_B1F_02_1.1#XF_CO2 Set Value	FLOAT	R	800	VLC550-B1F-02-1.1#XF-CO2设定值	00012	0
VLC550_B1F_02_1.1#XF_Frequency Modulation Proportion	FLOAT	R	5	VLC550-B1F-02-1.1#XF-调频比例	00013	0
VLC550_B1F_02_1.1#XF_Frequency Modulation Integral	FLOAT	R	3	VLC550-B1F-02-1.1#XF-调频积分	00014	0
VLC550_B1F_02_1.1#XF_Frequency Modulation Differential	FLOAT	R	1	VLC550-B1F-02-1.1#XF-调频微分	00015	0
VLC550_B1F_02_1.1#XF_Return Air Temperature	FLOAT	R	24.2369	VLC550-B1F-02-1.1#XF-回风温度	00016	0
VLC853_B1F_01_1.2#Lighting Circuits_C_ST	BIT	R	1	VLC853-B1F-01-1.2#照明回路-C-ST	00000	0
VLC853_B1F_01_1.2#Lighting Circuits_O_ST	BIT	R	0	VLC853-B1F-01-1.2#照明回路-O-ST	00001	0
VLC853_B1F_01_1.1#XF_Indoor Humidity1	FLOAT	R	52.7228	VLC853-B1F-01-1.1#XF-室内湿度1	00002	0
VLC853_B1F_01_1.1#XF_Indoor Humidity2	FLOAT	R	62.5397	VLC853-B1F-01-1.1#XF-室内湿度2	00003	0
VLC853_B1F_01_1.1#XF_Indoor Temperature1	FLOAT	R	23.8462	VLC853-B1F-01-1.1#XF-室内温度1	00004	0
VLC853_B1F_01_1.1#XF_Indoor Temperature2	FLOAT	R	24.2369	VLC853-B1F-01-1.1#XF-室内温度2	00005	0
VLC853_B1F_01_1.1#XF_Blasting Humidity1	FLOAT	R	98.0464	VLC853-B1F-01-1.1#XF-送风湿度1	00006	0
VLC853_B1F_01_1.1#XF_Blasting Humidity2	FLOAT	R	98.0464	VLC853-B1F-01-1.1#XF-送风湿度2	00007	0
VLC853_B1F_01_1.1#SFY_C	BIT	R	1	VLC853-B1F-01-1.1#SFY-C	00008	0
VLC853_B1F_01_1.2#SFY_C	BIT	R	0	VLC853-B1F-01-1.2#SFY-C	00009	0
VLC1600_B1F_01_1.1#PFY_ST	BIT	R	1	VLC1600-B1F-01-1.1#PFY-ST	00000	0
VLC1600_B1F_01_1.1#PFY_ALM	BIT	R	0	VLC1600-B1F-01-1.1#PFY-ALM	00001	0
VLC1600_B1F_01_1.1#PFY_MA	BIT	R	1	VLC1600-B1F-01-1.1#PFY-MA	00002	0
VLC1600_B1F_01_1.2#PFY_Remote Control	BIT	R	1	VLC1600-B1F-01-1.2#PFY-远程控...	00003	0
VLC1600_B1F_01_1.2#XF_Fresh Air Humidity	FLOAT	R	65.9585	VLC1600-B1F-01-1.2#XF-新风湿度	00004	0
VLC1600_B1F_01_1.2#XF_Fresh Air Temperature	FLOAT	R	30.4762	VLC1600-B1F-01-1.2#XF-新风温度	00005	0
VLC1600_B1F_01_1.3#XF_Remote Control	BIT	R	1	VLC1600-B1F-01-1.3#XF-远程控制	00006	0
VLC1600_B1F_01_1.3#XF_Power Feedback	FLOAT	R	25	VLC1600-B1F-01-1.3#XF-功率反馈	00007	0
VLC1600_B1F_01_1.3#XF_Frequency Feedback	FLOAT	R	50	VLC1600-B1F-01-1.3#XF-频率反馈	00008	0
VLC1600_B1F_01_1.2#Lighting Circuits_C_ST	BIT	R	1	VLC1600-B1F-01-1.2#照明回-C-ST	00014	0
VLC1600_B1F_01_1.2#Lighting Circuits_O_ST	BIT	R	0	VLC1600-B1F-01-1.2#照明回-O-ST	00015	0

Figure 7. Running interface of DasRdb field engineering applications

In Figure 9, the VLC-550_B1F_02_1, LC-853_B1F_01_1 and VLC-1600_B1F_01_1 are the three device name, used to distinguish between different devices and device location; “SFY” represents air blower, “PFY” represents exhaust fan, “XF” represents air supply, “ST” represents a running state, “C-ST” represents the closed state, “O-ST” indicates the off-state, “ALM” indicates fault alarm, “MA” indicates auto mode. As can be seen from the diagram, the real-time database can read a variety of different BACnet standard objects.

The inevitable direction of automatic control and communication protocol is IP-based. Field application shows that, through independent research and development, device driver based on BACnet/IP protocol is capable of driving real-time database DasRdb efficiently to collect real-time data of BACnet/IP devices. It solves that the equipment of various manufacturers is not compatible and difficult integration in the building automation system, and provides a unified standard to realize the integration of different building control equipment. On the current situation of social technology, BACnet/IP protocol used in the field controller is feasible, due to the decreasing cost of Ethernet, using integrated wiring technology to establish a BACnet/IP communication network has great practical value, and has already started to get a wide range of application. In addition, the engineering application found that device driver using BACnet/IP protocol communication is the best choice, compared to Modbus, OPC and other protocols in terms of remote monitoring.

7. CONCLUSIONS

With the growing rise of intelligent building and the further promotion of BACnet protocol, BACnet/IP can enable the building automation equipment of different manufacturers, different systems to be mutual communication, coordination, which make it possible for building intelligent, network and integrated. Accordingly, ISCS throughout the building automation equipment is also more and more attention. Due to real time database timely and accurately to read and write the status of the building automation equipment, it can be used to design and integrate the ISCS of the whole intelligent building, which has a very broad application prospects, and it is significant of the intelligent building and smart city to facilitate each subsystem integration.

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