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The Connective Mechanism of BACnet and 6LoWPAN

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Abstract: This study presented a connective mechanism of BACnet and 6LoWPAN. Associate virtual address and physical address using VMAC Table in BZLL layer in order to achieve the expansion of BACnet to IPv6; Match the format of protocol of IPv6 with the IEEE 802.15.4 packets using 6LoWPAN adaptation layer, BACnet eventually can directly running on the 6LoWPAN networks. Compared with the BACnet and IEEE 802.15.4 which using gateway to connecting, not only save the complex and expensive gateway, but also effectively avoid the bottleneck caused by the gateway and extremely enhance the transmit speed of packets and the integration of system.

Key words: BACnet, 6LoWPAN, IEEE 802.15.4, IPv6, intelligent building

INTRODUCTION

According to existing works (Kastner *et al*., 2005), the Wireless Sensor Network (WSN) have been favored by the experts of building automation systems. Compared with the wired networks, WSN have low-power, low cost, self-organized and easy installation which has become the mainstream in the field of building automation (Yicka *et al*., 2008).

In this study, we proposed the connective mechanism of BACnet and 6LoWPAN. To achieve the building control network extensions, take the 6LoWPAN network as the underlying communication network of BACnet using the advantages of 6LoWPAN . We have known that 6LoWPAN can improve the interoperability between wireless devices (Ma and Luo, 2008), plus its low complexity and less resource requirements, it will making BACnet can meet future demands. And IPv6 technology can provide huge space of address, global unicast address and more security. This research is a hot spot in the field of intelligent building.

In this study, we realized exchange between BACnet and 6LoWPAN using embedded a VMAC in the BZLL. And take IEEE 802.15.4 as the underlying communication standard of BACnet through 6LoWPAN adaptation layer. Finally realized the IEEE 802.15.4-based intelligent building automation. Currently, ANSI/ASHRAE has established a working group (SSPC 135) specializing in intelligent building control network. With low rate, low power, low cost and characteristics of ad hoc networks, IEEE 802.15.4 became the first choice. For this reason, this study presented a application model of BACnet with IEEE 802.15.4 and confirmed its availability and flexibility. BACnet and 6LoWPAN internet not only achieve the applications of BACnet in 802.15.4 networks, but realize interconnection between multiple BACnet networks through IPv6 technology. Compared with use special gateway, our models not only saved the complex and expensive gateway, but also effectively avoid the bottlenecks and greatly enhance the data rate and system intetration.

BACNET AND 6LOWPAN TECHNOLOGY

BACnet technology: ASHRAE Standard BACnet-A Data Communication Protocol for Building Automation and Control Network (ASHRAE Standard, 2008) has become the only international standard (ISO 16484-5) and the EU(CEN) standards.

BACnet standard with its advanced technology, streamlined architecture and an open concept made more than 200 countries and a number of vendors to BACnet protocol extensive research, development and application. BACnet standard has the following advantages:

- Dedicated to the field of intelligent building automation construction and high performance
- Completely open, advanced technology
- Has good scalability
- Does not depend on the existing LAN or WAN technology, with good interconnection properties

Currently, the underlying communication protocol of BACnet is based on the main wired LAN standard, because the cable network restrictions, in many applications have revealed its deficiencies. With the low rate, low power, low cost and characteristics of ad hoc networks, the IEEE 802.15.4 standard has more and more

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applications. It used in building automation was follow the technological trends. Therefore, this study proposed a connective mechanism of BACnet and 6LoWPAN, it greatly enhanced the ability of BACnet application.

6LoWPAN technology: The IETF 6LoWPAN Working Group (Internet Engineering Task Force 6LoWPAN Working Group) defines how to use IEEE 802.15.4 link in support of IP-based communications, while ensuring compliance with open standards and interoperability with other IP devices, the technology is not depends on multiple gateways. Since IPv6 addresses and a great header, the data transmission may be too large and can not accommodate a very small 802.15.4 packet. 6LoWPAN Working Group developed an IP header compression method which only transfer the necessary contents. They adopted a pay-as-you-use in the header compression method, removed the IPv6 header of the redundant or unnecessary network-level information and received it from 802.15.4 packets header of the link level. 6LoWPAN is an open technology to support the development of its upper range of applications. It provide a feasible for building automation with 802.15.4 integration. Therefore, this study presented a model which BACnet application can be extended to IEEE 802.15.4 networks using 6LoWPAN technology and making all kinds of low-power wireless devices can be applied to intelligent building automation system.

THE CONNECTIVE MECHANISM OF BACNET AND 6LOWPAN

BACnet and 6LoWPAN are in accordance with OSI reference model. For realize the stack based on OSI router/data-link-layer, we integrate the BACnet devices into 6LoWPAN networks followed the approach of OSI protocol stack. In the existing BACnet system architecture, take 6LoWPAN network as Porter and expansion of existing wireless communication between the BACnet networks. Since the underlying protocol of BACnet is greatly simplified, in which the physical layer, data link layer and network layer is responsible only for communication and interoperability features from the application layer alone. In order to meet the real-time performance and increase communication efficiency, BACnet protocol physical layer, data link layer and network layer only provides connectionless type of communication service and connection-oriented applications to communications services delivered to the application layer processing (Park *et al*., 2007). According IEEE standard 802.15.4 (IEEE Standards, 2006), we can take 6LoWPAN network as the physical layer and data link layer of BACnet for transfer information (Osterlind *et al*., 2007). However, since IPv6 address and data header too bigger to accommodate the IEEE 802.15.4 packets, WSN technology can not run directly in the IPv6 network. Therefore, we introduce 6LoWPAN technology for solve this problem.

6LoWPAN adaptation layer: BACnet and 6LoWPAN interconnect structure shown in Fig 1; we have known that the role of 6LoWPAN adaptation layer is to Ipv6 packets into pieces and compression, decompression and restructuring. 6LoWPAN technology uses a pay-as-you-use approach, that communication carry necessary header (IETF, 2007). Removal of IPv6 header in the network-level redundancy and unnecessary information, IP header received these informations from the related field of IEEE 802.15.4 header. The entire 40-byte IPv6 header is reduced to a header compression byte (HC1)and 1 byte of remaining number of hops. Because the source and destination IP addresses can be generate by

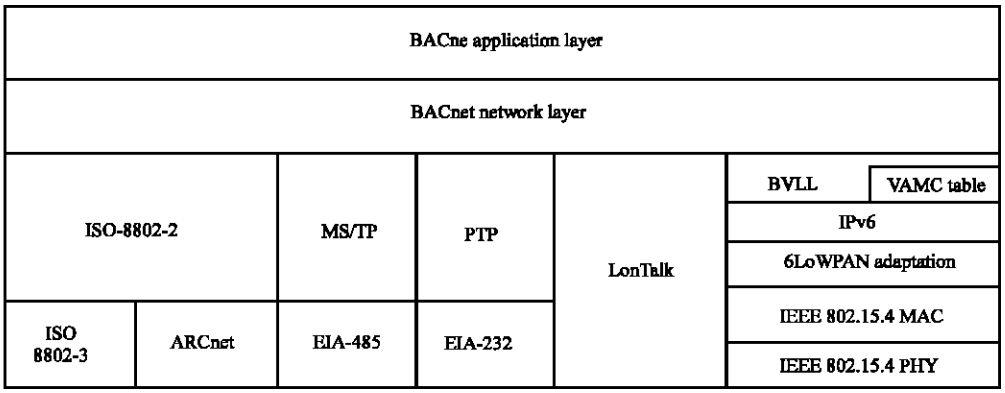

Fig. 1: The architecture of BACnet and 6LoWPAN interconnection

link-level 64-bit unique ID (EUID 64) or the 16-bit short address of IEEE 802.15.4. 8-byte User Datagram Protocol packet's header is compressed to 4 bytes. So the NPDU (BACnet network layer Data Units) can be transmitted through the IEEE 802.15.4.

BVLL layer: As shown in Fig. 1, to achieve the translation between virtral address and physical address, the BVLL layer associated the virtual address and physical address through bound VMAC table (ASHRAE Standard 2008). When the VMAC was received the DL-UNITDATA indication primitive from the link layer ,before uploading to the network layer, source address and destination address will be replaced by related virtual address in VMAC bound table. When the VMAC received the DL-UNITDATA. request the primitive from network layer, before it arrive to the link layer, the source address and destination address will be replaced by related physical address in VMAC bound table.

Every node in a BACnet/6LoWPAN network must have a BVLL layer. This BVLL layer provide data link services between the BACnet network layer and a single BACnet/6LoWPAN networks. Figure 2 shows a single BACnet/6LoWPAN node without routing which take endpoint x as BACnet terminal node.

BVLL can create a binding BACnet endpoint and Generic Tunnel clusters to the 6LoWPAN route map which use 6LoWPAN GroupID of BACnet and 6LoWPAN interconnection network. Each node will receive the Read Attribute order in response to a VMAC address to BVLL. When a response is received, the router will be create a VMAC entity for this responsed node. As a node starts, it will send a multicast advertisement Properties command to the all of nodes in BACnet network for display the attributes of protocol address(VMAC address). When a node's BVLL receive a new VMAC address, it will send a multicast advertisement Properties command to display the property of protocol address (the new VMAC address). In order to find a new network node, router's BVLL will periodically send a Read Attribute command requests attributes of protocol address from all network node. The router requires the cycles of all property of Protocol address are local events.

THE APPLICATION OF BACNET AND 6LOWPAN INTERCONNECTED NETWORK

This study proposed a concept of BACnet and 6LoWPAN interconnected network. The BACnet/ 6LoWPAN nodes in the physical network will seen as IEEE 802.15.4 network nodes. To achieve data transmission in the physical layer interconnected each BACnet/6LoWPAN node using the advantages of 802.15.4. For BACnet users, the data transmission is transparent. The operation on BACnet application layer still follow the implementation of BACnet standard.

Figure 3 shows an application of BACnet and 6LoWPAN interconnected network. Each sensor in the room through a wireless link to connect to the edge router and then connect to a local server and controller via a local link, you can also remote control through BACnet Router.

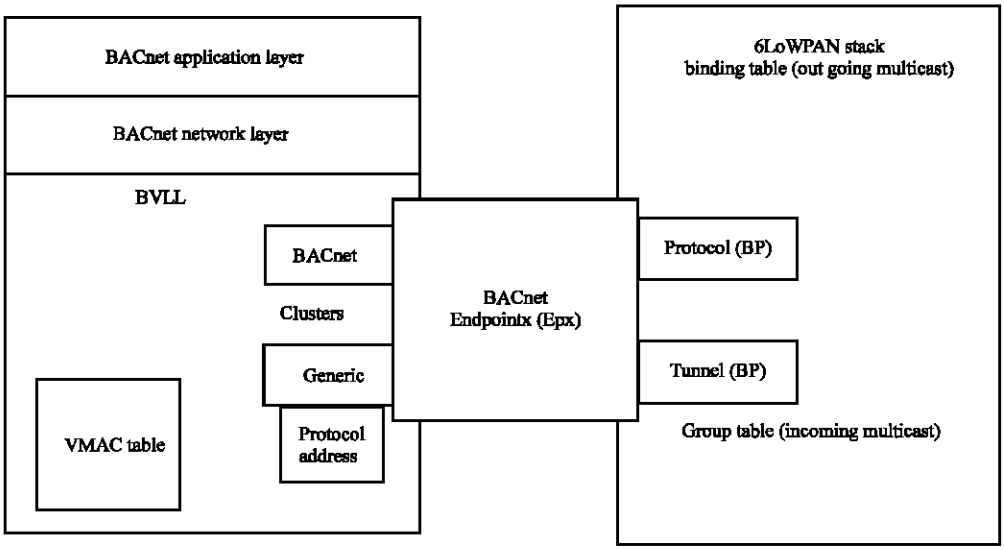

Fig. 2: The principle of BZLL in BACnet and 6LoWPAN interconnected network

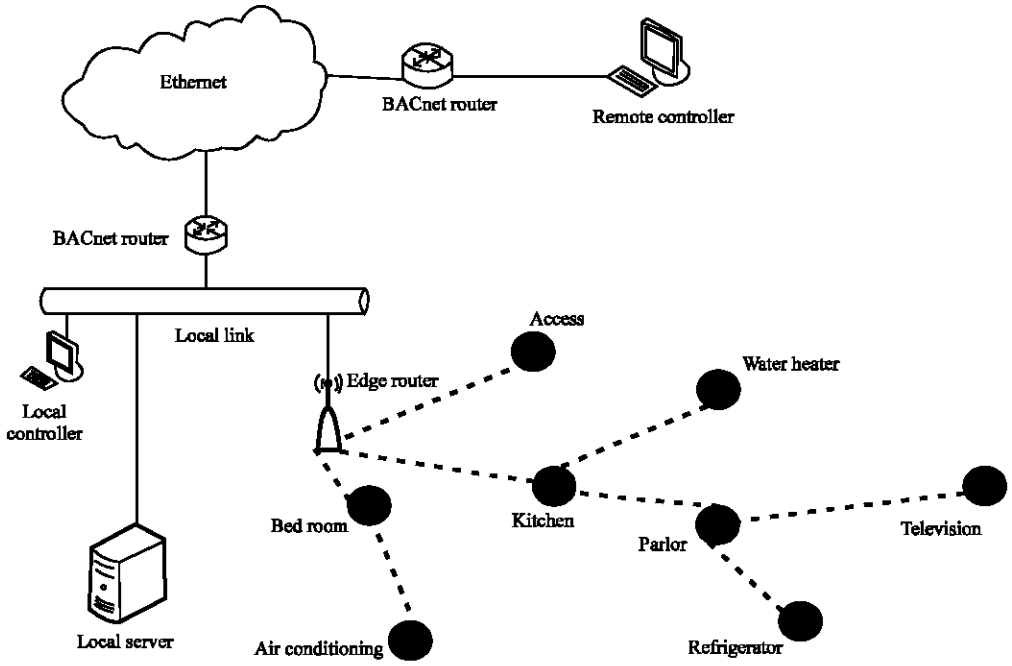

Fig. 3: The application of BACnet and 6LoWPAN interconnected network

CONCLUSIONS

This study proposed a connective mechanism of BACnet and 6LoWPAN, makes BACnet can run on IEEE 802.15.4 networks using 6LoWPAN technology. As the WSN achieve more and more widely used with short range, low speed, low power, low cost and characteristics of ad hoc networks. The interconnection of BACnet and WSN has become the major trends in the field of building automation. 6LoWPAN is standard of running IPv6 in IEEE 802.15.4, this connective mechanism is a practical application of BACnet and IEEE 802.15.4 interconnected.

As technology continues to evolve and the needs of practical applications, the future work will mainly around the connective mechanism of BACnet and 6LoWPAN and to perfect it. To further confirm the availability of this mechanism, we will simulate it using TinyOS2.1 simulation platform.

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