ADDENDA

ANSI/ASHRAE Addendum aj to
ANSI/ASHRAE Standard 135-2012

BACnet™ Data Communication Protocol for Building Automation and Control Networks

Approved by ASHRAE on February 29, 2016, and by the American National Standards Institute on March 1, 2016.

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[This foreword and the "rationales" on the following pages are not part of this standard. They are merely informative and do not contain requirements necessary for conformance to the standard.]

FOREWORD

The purpose of this addendum is to present a proposed change for public review. These modifications are the result of change proposals made pursuant to the ASHRAE continuous maintenance procedures and of deliberations within Standing Standard Project Committee 135. The proposed changes are summarized below.

135-2012*aj*-1 Add support for IPv6, p. 2
135-2012*aj*-2 Add an additional method for VMAC determination, p. 26

In the following document, language to be added to existing clauses of ANSI/ASHRAE 135-2012 and Addenda is indicated through the use of *italics*, while deletions are indicated by ~~strikethrough~~. Where entirely new subclauses are proposed to be added, plain type is used throughout. Only this new and deleted text is open to comment as this time. All other material in this addendum is provided for context only and is not open for public review comment except as it relates to the proposed changes.

135-2012*aj*-1 Add Support for IPv6

Rationale

Adding support for IPv6 to BACnet had several challenges:

1. BACnet devices that cannot handle 18-octet MAC addresses will probably not be able to communicate with BACnet/IPv6 devices unless a network address translation mechanism is used.

2. The long address length used by IPv6 prevents BACnet from using certain BACnet/IP (Annex J) BVLL messages without modification because those messages contain fixed-length fields for 6-octet BACnet/IP addresses. New BVLL messages will have to be designed for IPv6.

3. BACnet was designed with the assumption that the NL header has a maximum length of 21 octets. This is evident from comparing the maximum APDU lengths in Clause 20.1.2.5 and the maximum NPDU lengths in Table 6-1. Messages routed to/from IPv6 devices would require that the NL header length exceeds 21 octets. Restrictions on the maximum APDU length would need to be added in order to avoid exceeding the maximum NPDU length. For example, on BACnet/Ethernet LANs, if the NL header is 24 octets in length, then the APDU must not exceed 1473 octets in length.

This addendum describes a mechanism by which IPv6 can be added to BACnet and remain backwards compatible with existing devices.

[Add New ANNEX U, p. 1027]

ANNEX U – BACnet/IPv6 (NORMATIVE)

(This annex is part of the standard and required for its use.)

U.1 General

This normative annex specifies the use of BACnet messaging utilizing Internet Protocol version six (IPv6) packets. The Request For Comments (RFC) documents that define IPv6 are maintained by the Internet Engineering Task Force. IPv6 is specified by RFC 2460, and the requirements of IPv6 nodes are defined in RFC 4294.

U.1.1 Addressing within BACnet/IPv6 Networks

U.1.1.1 IPv6 Addressing

IPv6 addresses consist of 128-bits. Addresses are classified as unicast, multicast, or anycast addresses. These classifications are identified by associating values within the 128-bit address with these special addresses.

In IPv4, link addresses are determined by using the combination of the IPv4 address and the subnet mask. This type of "on link" calculation is nonexistent in IPv6, which instead uses prefix notation as specified in RFC 4291.

A prefix is a bit string that consists of some number of initial bits of an address.

```
|          n bits               |           128-n bits            |
+-------------------------------+---------------------------------+
|       (sub-)network prefix    |           interface ID          |
+-------------------------------+---------------------------------+
```

The subnet prefix is further broken down into the global routing prefix and the subnet ID.

```
|         n bits         |   64-n bits  |         64 bits           |
+------------------------+--------------+---------------------------+
| global routing prefix  |   subnet ID  |       interface ID        |
+------------------------+--------------+---------------------------+
```

Global routing prefixes are broken down into groups accordingly. The subnet ID identifies a link within a site, and a link can be assigned multiple subnet IDs. Assignment of the subnet ID is performed by a local administrator.

The interface ID identifies the interface on a link and must be unique to the 64-bit prefix of the IPv6 address. Assignment of the interface ID can be one of the following: 1) a value derived from the Extended Unique Identifier (EUI)-64 address (RFC 2373), 2) a randomly generated interface identifier (RFC 3041), 3) manually configured, or 4) assigned during stateful address auto-configuration.

U.1.1.1.1 IPv6 Address Notation

The 128-bits of an IPv6 address are represented in 8 groups of 16 bits each. Each group is written as 4 hexadecimal digits and colons separate the groups. For example, the address 2001:0DB8:0000:0000:0000:0000:0000:0001 shows this full notation.

For convenience, an IPv6 address may be abbreviated to shorter notations by 1) removing one or more leading zeroes from any group of hexadecimal digits, and 2) replacing consecutive groups of zeroes with a double colon. See RFC 5952. Applying these rules to the example address results in the following "compressed" address: 2001:DB8::1.

In the case of documenting an IPv6 address combined with a port, the IPv6 address is delimited using square brackets. For example: [2001:DB8:1111:2222::CB0]:47808. See RFC 5952.

U.1.1.2 BACnet/IPv6 Addressing

Data link layer addressing between B/IPv6 nodes consists of a 128-bit IPv6 address followed by a two-octet UDP port number (both of which shall be transmitted with the most significant octet first). This address shall be referred to as a B/IPv6 address.

B/IPv6 nodes shall support configurable IPv6 addresses and shall be able to be set to any valid unicast IPv6 address. The default UDP port for all messages shall be 47808 (X'BAC0'); however, B/IPv6 nodes shall also support a configurable UDP port number and shall support, at a minimum, values in the range 47808 – 47832 and 49152 – 65535. For B/IPv6 nodes that support multiple B/IPv6 network ports, the UDP number for each B/IPv6 network port shall be settable across the noted valid range.

BACnet broadcasts between B/IPv6 nodes shall be delivered by IPv6 multicasts. An IPv6 multicast address consists of a 16-bit prefix followed by a 112-bit group ID. This address shall be referred to as a B/IPv6 multicast address. A B/IPv6 multicast domain consists of all nodes that can communicate with each other using a particular IPv6 multicast address and UDP port. The size of a B/IPv6 multicast domain is limited by the multicast scope and its associated administrative limits.

U.1.2 BACnet/IPv6 (B/IPv6) Network Definition

A BACnet/IPv6 network is a set of one or more B/IPv6 multicast domains and zero or more foreign devices assigned to a single BACnet network. A BACnet internetwork consists of two or more BACnet networks. These networks may be BACnet/IPv6 networks or use the technologies specified in Clauses 7, 8, 9, 11, Annex J, Annex H.2, and Annex O.

U.1.3 Remote Addressing of Devices on BACnet/IPv6 Networks

Devices on B/IPv6 networks are addressed using Virtual MAC Addressing (Annex H.7) in network and application layer services. The BACnet device instance is used as the VMAC address for the node as described in Annex H.7.2.

U.1.4 BACnet/IPv6 Concept

A B/IPv6 network shall function in concept identically to the BACnet/IP network type (Annex J) with respect to the inclusion of the BACnet Virtual Link Layer (BVLL) described in Annex J.2. BACnet broadcasts are transmitted using the appropriately scoped IPv6 multicast. B/IPv6 BBMDs are needed only to distribute BACnet broadcasts between nodes on different multicast domains which are otherwise unreachable using IPv6 multicast. A B/IPv6 BBMD also provides foreign devices access to B/IPv6 networks on different IPv6 links.

U.2 BACnet/IPv6 BACnet Virtual Link Layer

The BVLL provides the interface between the BACnet Network Layer (Clause 6) and the underlying capabilities of a particular communication subsystem. This annex specifies the BACnet Virtual Link Control (BVLC) functions

required to support B/IPv6 directed and broadcast messages. The purpose and format of each message is described in the following subclauses.

Note that each BVLL message has at least three fields. The 1-octet BVLC Type field indicates which underlying communication subsystem or microprotocol is in use. In this case, a BVLC Type of X'82' indicates the use of BACnet/IPv6 as defined in this annex. The 1-octet BVLC Function field identifies the specific function to be carried out in support of the indicated communication subsystem or microprotocol type. The 2-octet BVLC Length field is the length, in octets, of the entire BVLL message, including the two octets of the length field itself, most significant octet first.

Table U-1 B/IPv6 BVLL Messages

BVLC Function	B/IPv6 Length
X'00' BVLC-Result	9 octets
X'01' Original-Unicast-NPDU	10 octets + BACnet NPDU
X'02' Original-Broadcast-NPDU	7 octets + BACnet NPDU
X'03' Address-Resolution	10 octets
X'04' Forwarded-Address-Resolution	28 octets
X'05' Address-Resolution-ACK	10 octets
X'06' Virtual-Address-Resolution	7 octets
X'07' Virtual-Address-Resolution-ACK	10 octets
X'08' Forwarded-NPDU	25 octets + BACnet NPDU
X'09' Register-Foreign-Device	9 octets
X'0A' Delete-Foreign-Device-Table-Entry	25 octets
X'0B' Secure-BVLL	4 octets + Security Wrapper
X'0C' Distribute-Broadcast-To-Network	7 octets + BACnet NPDU

U.2.1 BVLC-Result: Purpose

This message provides a mechanism to acknowledge the result of those BVLL service requests that require an acknowledgment, whether successful (ACK) or unsuccessful (NAK).

U.2.1.1 BVLC-Result: Format

The BVLC-Result message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'00'	BVLC-Result
BVLC Length:	2-octets	X'0009'	Length, in octets, of the BVLL message
Source-Virtual-Address:	3-octets		
Result Code:	2-octets	X'0000'	Successful completion
		X'0030'	Address-Resolution NAK
		X'0060'	Virtual-Address-Resolution NAK
		X'0090'	Register-Foreign-Device NAK
		X'00A0'	Delete-Foreign-Device-Table-Entry NAK
		X'00C0'	Distribute-Broadcast-To-Network NAK

U.2.2 Original-Unicast-NPDU: Purpose

This message is used to send directed NPDUs to another B/IPv6 node or router.

U.2.2.1 Original-Unicast-NPDU: Format

The Original-Unicast-NPDU message consists of six fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'01'	Original-Unicast-NPDU
BVLC Length:	2-octets	L	Length L, in octets, of the BVLL message
Source-Virtual-Address:	3-octets		
Destination-Virtual-Address:	3-octets		
BACnet NPDU	Variable length		

U.2.3 Original-Broadcast-NPDU: Purpose

This message is used by B/IPv6 nodes which are not foreign devices to broadcast NPDUs on a B/IPv6 network.

U.2.3.1 Original-Broadcast-NPDU: Format

The Original-Broadcast-NPDU message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'02'	Original-Broadcast-NPDU
BVLC Length:	2-octets	L	Length L, in octets, of the BVLL message
Source-Virtual-Address	3-octets		
BACnet NPDU	Variable length		

U.2.4 Address-Resolution: Purpose

This message is broadcast by B/IPv6 nodes in order to determine the B/IPv6 address of a known virtual MAC address.

U.2.4.1 Address-Resolution: Format

The Address-Resolution message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'03'	Address-Resolution
BVLC Length:	2-octets	X'000A'	Length, in octets, of the BVLL message
Source-Virtual-Address	3-octets		
Target-Virtual-Address	3-octets		

U.2.5 Forwarded-Address-Resolution: Purpose

This message is unicast by B/IPv6 BBMDs to determine the B/IPv6 address of a known virtual address belonging to a different multicast domain.

U.2.5.1 Forwarded-Address-Resolution: Format

The Forwarded-Address-Resolution message consists of six fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'04'	Forwarded-Address-Resolution
BVLC Length:	2-octets	X'001C'	Length, in octets, of the BVLL message
Original-Source-Virtual-Address	3-octets		
Target-Virtual-Address	3-octets		
Original-Source-B/IPv6-Address	18-octets		

The Forwarded-Address-Resolution message is unicast to each address in the broadcast distribution and foreign device tables.

U.2.6 Address-Resolution-ACK: Purpose

This message is the reply to either the Address-Resolution or the Forwarded-Address-Resolution messages.

U.2.6.1 Address-Resolution-ACK: Format

The Address-Resolution-ACK message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'05'	Address-Resolution-ACK
BVLC Length:	2-octets	X'000A'	Length, in octets, of the BVLL message
Source-Virtual-Address	3-octets		
Destination-Virtual-Address	3-octets		

The Address-Resolution-ACK message is unicast to the B/IPv6 node that originally initiated the Address-Resolution message.

U.2.7 Virtual-Address-Resolution: Purpose

This message is unicast by B/IPv6 nodes to determine the virtual address of a device with a known B/IPv6 address.

U.2.7.1 Virtual-Address-Resolution: Format

The Virtual-Address-Resolution message consists of four fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'06'	Virtual-Address-Resolution
BVLC Length:	2-octets	X'0007'	Length, in octets, of the BVLL message
Source-Virtual-Address	3-octets		

The Virtual-Address-Resolution message is unicast to the destination B/IPv6 node.

U.2.8 Virtual-Address-Resolution-ACK: Purpose

This message is the reply to the Virtual-Address-Resolution message.

U.2.8.1 Virtual-Address-Resolution-ACK: Format

The Virtual-Address-Resolution-ACK message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'07'	Virtual-Address-Resolution-ACK
BVLC Length:	2-octets	X'000A'	Length, in octets, of the BVLL message
Source-Virtual-Address	3-octets		
Destination-Virtual-Address	3-octets		

The Virtual-Address-Resolution-ACK message is unicast to the B/IPv6 node that initiated the Virtual-Address-Resolution message.

U.2.9 Forwarded-NPDU: Purpose

This BVLL message is used in multicast messages from a BBMD as well as in messages forwarded to registered foreign devices. It contains the source address of the original node as well as the original BACnet NPDU.

U.2.9.1 Forwarded-NPDU: Format

The Forwarded-NPDU message consists of six fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'08'	Forwarded-NPDU
BVLC Length:	2-octets	L	Length L, in octets, of the BVLL message
Original-Source-Virtual-Address:	3-octets		
Original-Source-B/IPv6-Address:	18-octets		
BACnet NPDU from Originating Device	Variable length		

U.2.10 Register-Foreign-Device: Purpose

This message allows a foreign device, as defined in U.4.5.1, to register with a BBMD for the purpose of receiving broadcast messages.

U.2.10.1 Register-Foreign-Device: Format

The Register-Foreign-Device message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'09'	Register-Foreign-Device
BVLC Length:	2-octets	X'0009'	Length, in octets, of the BVLL message
Source-Virtual-Address:	3-octets		
Time-to-Live :	2-octets	T	Time-to-Live T, in seconds

The Time-to-Live value is the number of seconds within which a foreign device must re-register with a BBMD or risk having its entry purged from the BBMD's FDT. This value will be sent most significant octet first.

U.2.11 Delete-Foreign-Device-Table-Entry: Purpose

This message is used to delete an entry from the Foreign-Device-Table.

U.2.11.1 Delete-Foreign-Device-Table-Entry: Format

The Delete-Foreign-Device-Table-Entry message consists of four fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'0A'	Delete-Foreign-Device-Table-Entry
BVLC Length:	2-octets	X'0019'	Length, in octets, of the BVLL message
Source-Virtual-Address:	3-octets		
FDT Entry:	18-octets		

The FDT entry is the B/IPv6 address of the foreign device to be deleted.

U.2.12 Secure-BVLL: Purpose

This message is used to secure BVLL messages that do not contain NPDUs. Its use is described in Clause 24.

U.2.12.1 Secure-BVLL: Format

The Secure-BVLL message consists of four fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'0B'	Secure-BVLL
BVLC Length:	2-octets	L	Length L, in octets, of the BVLL message
Security Wrapper:	Variable length		

The BVLL to be secured is placed into the Service Data field of the Security Wrapper. For more details on securing BACnet messages see Clause 24.

U.2.13 Distribute-Broadcast-To-Network: Purpose

This message provides a mechanism whereby a foreign device shall cause a BBMD to distribute a Forwarded-NPDU BVLC to the local multicast domain, to all BBMD's configured in the BBMD's BDT, and to all foreign devices in the BBMD's FDT except the originating node.

U.2.13.1 Distribute-Broadcast-To-Network: Format

The Distribute-Broadcast-To-Network message consists of five fields:

BVLC Type:	1-octet	X'82'	BVLL for BACnet/IPv6
BVLC Function:	1-octet	X'0C'	Distribute-Broadcast-To-Network
BVLC Length:	2-octets	L	Length L, in octets, of the BVLL message
Original-Source-Virtual-Address:	3-octets		
BACnet NPDU from Originating Device:	Variable length		

U.3 BACnet/IPv6 Directed Messages

B/IPv6 nodes shall communicate directly with each other by using the B/IPv6 unicast address of the recipient. Where Internet access is not required, devices may use link-local (RFC 4291) unicast addresses when the network is contained on one link, or unique local unicast addresses (RFC 4193) when the network spans multiple links. Where Internet access is required, devices shall use global unicast addressing. Each NPDU shall be transmitted in a BVLL Original-Unicast-NPDU.

The Destination-Virtual-Address field of BVLC messages which are unicast conveys the intended recipient of the NPDU. Nodes which receive a message containing this parameter with a value which is not itself shall discard the message.

U.4 BACnet/IPv6 Broadcast Messages

BACnet broadcast messages shall be delivered by IPv6 multicasts as opposed to using IP broadcasting. Broadcasting in IPv6 is subsumed by multicasting to the all-nodes link group FF02::1. However, the use of the all-nodes group is not recommended, and BACnet/IPv6 uses an IANA permanently assigned multicast group identifier to avoid disturbing every interface in the network.

The IANA assigned BACnet/IPv6 variable scope multicast address is FF0X:0:0:0:0:0:0:BAC0 (FF0X::BAC0) which indicates the multicast group identifier X'BAC0'. The following multicast scopes are defined for B/IPv6.

B/IPv6 Multicast Address	Scope	Purpose
FF00::BAC0	Reserved	Do not use.
FF01::BAC0	Interface-local/Node-local	Packets with this destination address may not be sent over any network link, but must remain within the current node; this is the multicast equivalent of the unicast loopback address.
FF02::BAC0	Link-local	Used to reach all B/IPv6 devices on the directly attached link. This scope is not routable by IPv6 routers.
FF03::BAC0	Reserved	Do not use.
FF04::BAC0	Admin-local	The smallest scope that must be administratively configured.
FF05::BAC0	Site-local	Restricted to the local physical network. Used to reach all B/IPv6 devices at the same site.
FF08::BAC0	Organization-local	Intended to span multiple sites belonging to a single organization.
FF0E::BAC0	Global	Intended to be routed over the public internet.

All B/IPv6 devices shall, at a minimum, support the use of the link-local scoped multicast address. In addition, B/IPv6 devices shall be able to be configured to use the multicast address indicated in the BACnet_IPv6_Multicast_Address property of a B/IPv6 Network Port object. The value of the BACnet_IPv6_Multicast_Address property shall consist of any valid prefix, scope, and group ID.

BACnet broadcast messages shall be transmitted in a BVLL Original-Broadcast-NPDU. Broadcast messages to devices outside the multicast domain, or to devices which are otherwise unreachable by IPv6 multicast, shall be distributed by BBMDs in BVLL Forwarded-NPDUs.

U.4.1 BACnet/IPv6 Multicast Examples

In the B/IPv6 network shown in Figure U-1, which is composed of a single subnet (2001:DB8:1111:2222::/64), a link-local multicast from Device A will reach all nodes which are members of the [FF02::BAC0]:47808 multicast domain.

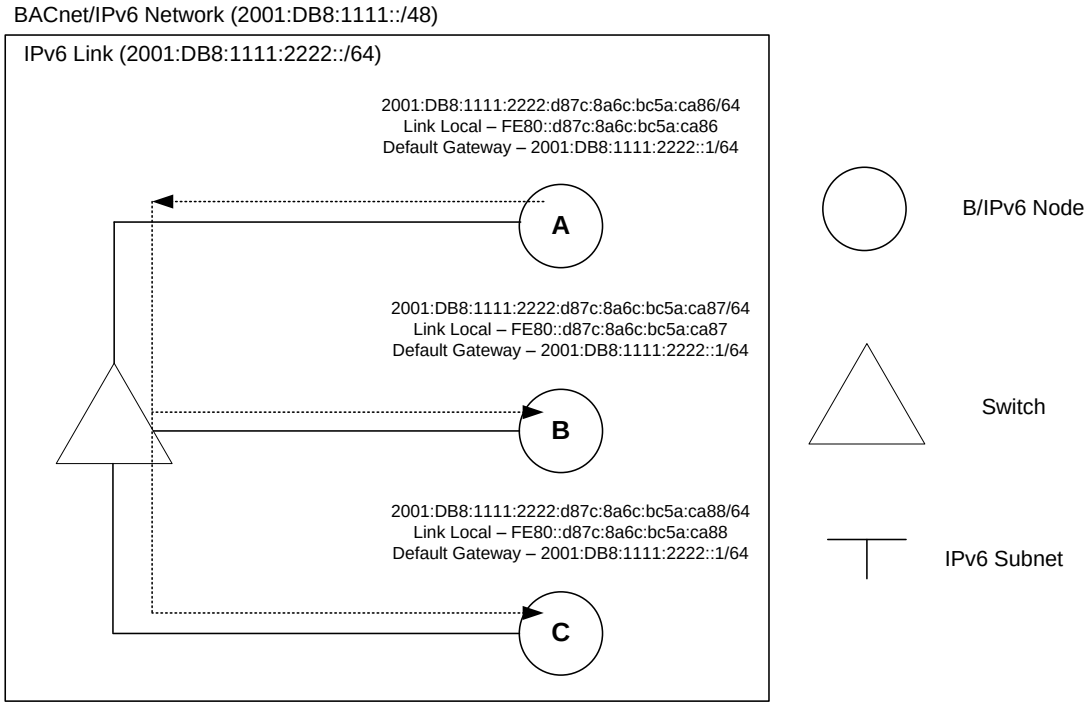


Figure U-1. Use of link-local multicasts on a single IPv6 link

In the B/IPv6 network shown in Figure U-2, which is composed of multiple subnets, the IPv6 router is configured such that IPv6 Link 1, IPv6 Link 2, and IPv6 Link 3 are included in a single organization. An organization scope multicast from Device A will reach all nodes which are members of the [FF08::BAC0]:47808 multicast domain.

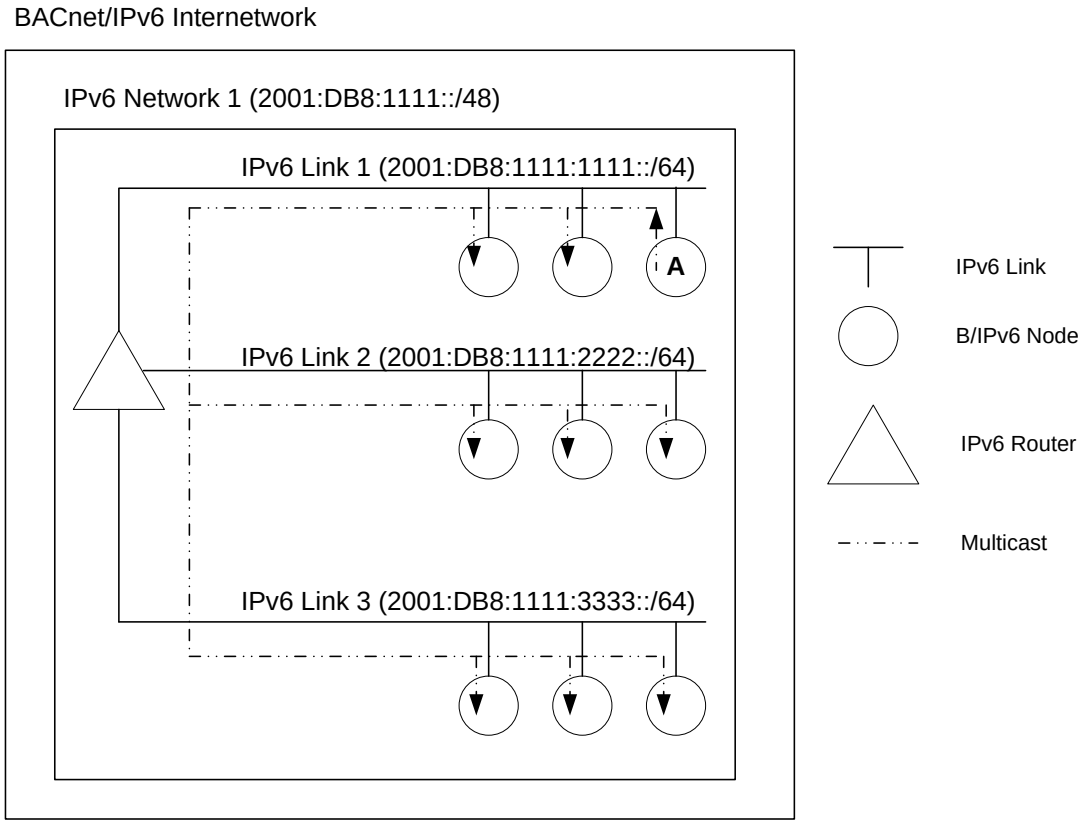


Figure U-2. Use of organization scope multicasts on multiple IPv6 links

U.4.2 BACnet/IPv6 BBMD Concept

If a B/IPv6 multicast domain is part of a B/IPv6 network comprised of two or more B/IPv6 multicast domains, and if the multicast domain contains a B/IPv6 device or devices that do not register as foreign devices, then the multicast domain shall have at least one BBMD. Only "two-hop" distribution shall be used. Each B/IPv6 BBMD shall possess a table called a Broadcast Distribution Table (BDT). The BDT determines which remote B/IPv6 BBMDs receive forwarded BACnet broadcasts. To reduce BACnet broadcast traffic, it is possible to configure the BDT to forward BACnet broadcasts only to BBMDs where they are required.

A B/IPv6 BBMD shall also possess a Foreign Device Table as described in U.4.5.2.

A device that will operate on a B/IPv6 network and cannot be configured as a BBMD shall be capable of registering as a foreign device with a BBMD.

U.4.2.1 BACnet/IPv6 BBMD Example

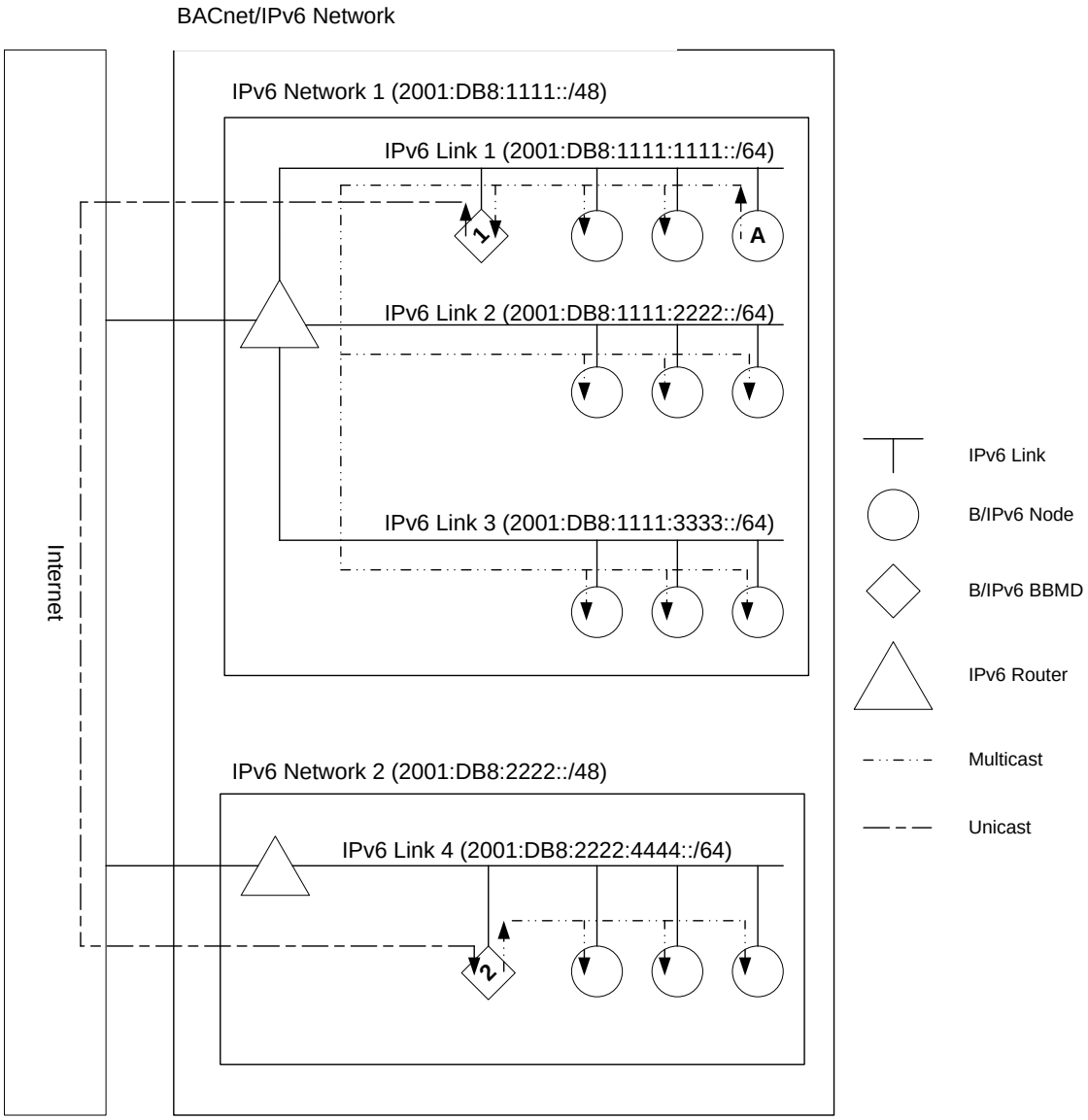


Figure U-3. Broadcast distribution using B/IPv6 BBMDs

The B/IPv6 network shown in Figure U-3 is composed of two or more IPv6 networks, each of which is composed of one or more links and is connected to the Internet. A site-local scope multicast (FF05::BAC0) from Device-A will reach all devices on IPv6 Network 1 which are members of the [FF05::BAC0]:47808 multicast domain, but requires forwarding by BBMD 1 to BBMD 2 (path 2), and BBMD 2 to multicast it on its local link (path 3) in order to reach devices on network 2. All links in IPv6 network 1 are assumed to belong to the same site-local multicast scope and that the IPv6 router for network 1 is configured to include all links within network 1.

U.4.2.2 BACnet /IPv6 Broadcast Distribution Table Format

The BDT shall consist of either the eighteen-octet B/IPv6 address of the peer BBMD or the combination of the fully qualified domain name service (DNS) entry and UDP port that resolves to the B/IPv6 address of the peer BBMD. The Broadcast Distribution Table shall not contain an entry for the BBMD in which the BDT resides.

U.4.3 BACnet/IPv6 BBMD Configuration

The configuration of the BACnet-related capability of a BBMD shall consist of supplying it with a BDT. The table may be supplied by writing to the B/IPv6 Network Port Object which represents this network port.

U.4.4 BACnet/IPv6 BBMD Operation - Broadcast Distribution

Upon receipt of a BVLL Original-Broadcast-NPDU message from the local multicast domain, a BBMD shall construct a BVLL Forwarded-NPDU message and unicast it to each entry in its BDT. In addition, the constructed BVLL Forwarded-NPDU message shall be unicast to each foreign device currently in the BBMD's FDT.

Upon receipt of a BVLL Forwarded-NPDU message from a BBMD which is in the receiving BBMD's BDT, a BBMD shall construct a BVLL Forwarded-NPDU and transmit it via multicast to B/IPv6 devices in the local multicast domain. In addition, the constructed BVLL Forwarded-NPDU message shall be unicast to each foreign device in the BBMD's FDT. If the BBMD is unable to transmit the Forwarded-NPDU, or the message was not received from a BBMD which is in the receiving BBMD’s BDT, no BVLC-Result shall be returned and the message shall be discarded.

Upon receipt of a BVLL Distribute-Broadcast-To-Network message from a registered foreign device, the receiving BBMD shall construct a BVLL Forwarded-NPDU and multicast it to B/IPv6 devices in the local multicast domain. In addition, the constructed BVLL Forwarded-NPDU message shall be sent to each entry in its BDT as described above in the case of the receipt of a BVLL Original-Broadcast-NPDU as well as directly to each foreign device currently in the BBMD's FDT except the originating node. If the BBMD is unable to perform the forwarding function, or the message was not received from a registered foreign device, then it shall return a BVLC-Result message to the foreign device with a result code of 'Distribute-Broadcast-To-Network NAK' indicating that the forwarding attempt was unsuccessful.

Upon receipt of a BVLL Distribute-Broadcast-To-Network message, a BACnet/IPv6 device that is not configured as a BBMD shall return a BVLC-Result message containing a result code of 'Distribute-Broadcast-To-Network NAK' indicating that the forwarding attempt was unsuccessful.

Upon receipt of a BVLL Address-Resolution message from the local multicast domain whose destination virtual address is not itself, the receiving BBMD shall construct and transmit a BVLL Forwarded-Address-Resolution via unicast to each entry in its BDT as well as to each foreign device in the BBMD's FDT.

Upon receipt of a BVLL Address-Resolution message from a registered foreign device whose target virtual address is not itself, the receiving BBMD shall transmit a BVLL Forwarded-Address-Resolution via unicast to each entry in its BDT as well as to each foreign device in the BBMD's FDT except the originating node. The receiving BBMD shall also transmit a BVLL Forwarded-Address-Resolution via multicast to the local multicast domain. If the BBMD is unable to transmit the Forwarded-Address-Resolution message, or the message was not received from a registered foreign device, then the receiving BBMD shall return a BVLC-Result message with a result code of 'Address-Resolution NAK' to the initiating node indicating that the forwarding attempt was unsuccessful.

Upon receipt of a unicast BVLL Forwarded-Address-Resolution message from a BBMD who is listed in the receiving BBMD's BDT and whose target virtual address is not itself, the BBMD shall transmit a BVLL Forwarded-Address-Resolution via unicast to each foreign device in the BBMD's FDT. The receiving BBMD shall also transmit a BVLL Forwarded-Address-Resolution message via multicast to the local multicast domain. If the BBMD is unable to transmit the Forwarded-Address-Resolution message, or the message was not received from a BBMD which is in the receiving BBMD’s BDT, no BVLC-Result shall be returned and the message shall be discarded.

U.4.5 Addition of Foreign B/IPv6 Devices to an Existing BACnet/IPv6 Network

U.4.5.1 Foreign Device Definition

A "foreign" device is a BACnet/IPv6 node that is unable to communicate directly in a BACnet/IPv6 multicast domain of the BACnet/IPv6 network.

U.4.5.1.1 BBMD Operation - Foreign Devices

In order for a foreign device to fully participate in the activities of a BACnet/IPv6 network, the device must register itself with a BACnet/IPv6 BBMD serving one of the BACnet/IPv6 multicast domains of that network. "Full participation" implies the ability to send and receive both unicast and broadcast messages. Registration consists of sending, via unicast, a BVLL Register-Foreign-Device message to an appropriate BBMD and receiving a BVLC-Result message containing a result code of 'Successful completion' indicating the successful completion of the registration.

U.4.5.2 BACnet /IPv6 Foreign Device Table

The FDT shall consist of zero or more FDT entries. Each entry shall contain the B/IPv6 address and the TTL of the registered foreign device.

U.4.5.3 Use of the BVLL Register-Foreign-Device Message

Upon receipt of a BVLL Register-Foreign-Device message, a BBMD that has foreign device registration enabled and having available table entries, shall add an entry to its FDT as described in U.4.5.2 and reply with a BVLC-Result message containing a result code of 'Successful completion' indicating the successful completion of the registration. A BBMD incapable of providing foreign device support shall return a BVLC-Result message containing a result code of 'Register-Foreign-Device NAK' indicating that the registration has failed.

Upon receipt of a BVLL Register-Foreign-Device message, a BACnet/IPv6 device that is not configured as a BBMD shall return a BVLC-Result message containing a result code of 'Register-Foreign-Device NAK' indicating that the registration has failed.

U.4.5.4 Use of the BVLL Delete-Foreign-Device-Table-Entry Message

Upon receipt of a BVLL Delete-Foreign-Device-Table-Entry message, a BBMD shall search its foreign device table for an entry corresponding to the B/IPv6 address supplied in the message. If an entry is found, it shall be deleted and the BBMD shall return a BVLC-Result message to the originating device with a result code of 'Successful completion'. Otherwise, the BBMD shall return a BVLC-Result message to the originating device with a result code of 'Delete-Foreign-Device-Table-Entry NAK' indicating that the deletion attempt has failed.

Upon receipt of a BVLL Delete-Foreign-Device-Table-Entry message, a BACnet/IPv6 device that is not configured as a BBMD shall return a BVLC-Result message containing a result message containing a result code of 'Delete-Foreign-Device-Table-Entry NAK' indicating that the deletion attempt has failed.

U.4.5.5 Foreign Device Table Timer Operation

Upon receipt of a BVLL Register-Foreign-Device message, a BBMD shall start a timer with a value equal to the Time-to-Live parameter supplied plus a fixed grace period of 30 seconds. If, within the period during which the timer is active, another BVLL Register-Foreign-Device message from the same device is received, the timer shall be reset and restarted. If the time expires without the receipt of another BVLL Register-Foreign-Device message from the same foreign device, the FDT entry for this device shall be cleared.

U.5 BACnet /IPv6 VMAC Table Management

The Virtual MAC address table shall be updated using the respective parameter values of the incoming messages. For outgoing messages to a VMAC address that is not in the table, the device shall transmit an Address-Resolution message. The Virtual MAC Address table shall be updated with the values conveyed in the Address-Resolution-ACK message.

To learn the VMAC address of a remote BACnet device with a known B/IPv6 address, a B/IPv6 node may send a Virtual-Address-Resolution message to that device and use the information of the Virtual-Address-Resolution-ACK message to update the VMAC table.

Upon receipt of a Virtual-Address-Resolution message, the receiving node shall construct a Virtual-Address-Resolution-ACK message whose Source-Virtual-Address contains its virtual address and transmit it via unicast to the B/IPv6 node that originally initiated the Virtual-Address-Resolution message.

Upon receipt of an Address-Resolution or Forwarded-Address-Resolution message whose target virtual address is itself, a B/IPv6 node shall construct an Address-Resolution-ACK message and send it via unicast to the B/IPv6 node that originally initiated the Address-Resolution message.

In addition to forwarding NPDU's to other BBMDs and foreign devices, a B/IPv6 BBMD is used in determining the VMAC address of a B/IPv6 node that is not reachable by multicasts or is registered as a foreign device. See Clause U.4.4.

[Change **Clause 3.2**, p. 2]

…

link: *a communication facility or medium over which nodes can communicate at the IP link layer.…*

multicast domain*: A group of B/IPv6 nodes that can communicate with each other using a particular IPv6 multicast address and UDP port combination.*

…

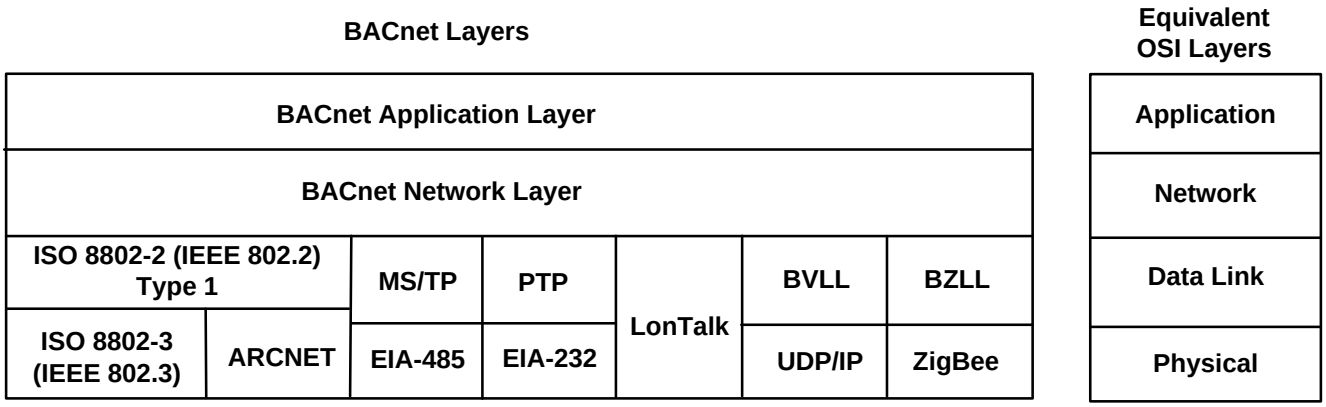
[Change **Clause 3.3**, p 7]

…

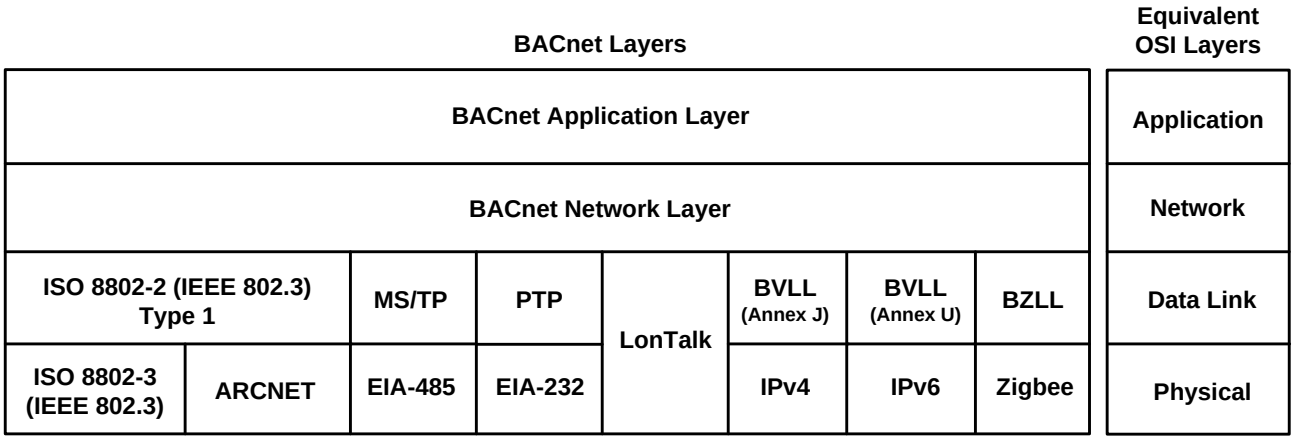
B/IP	BACnet/IP
B/IP-M	BACnet/IP multicast
B/IPv6	*BACnet/IPv6*
…	
FDT	foreign device table
IANA	*The Internet Assigned Numbers Authority*
ICI	interface control information
…	
IP	Internet Protocol - RFC 791
IPv4	*Internet Protocol version 4 - RFC 791*
IPv6	*Internet Protocol version 6 - RFC 2460*
ISO	International Organization for Standardization
…	
SLAAC	*IPv6 Stateless Auto Address Configuration, RFC 4862*
...	

[Change **Figure 4-2**, p. 9]

[current figure]



[new figure]



[Change **Table 6-1**, p. 47]

Table 6-1. Maximum NPDU Lengths When Routing Through Different BACnet Data Link Layers

Data Link Technology	Maximum NPDU Length
ISO 8802-3 ("Ethernet"), as defined in Clause 7	1497 octets
ARCNET, as defined in Clause 8	501 octets
MS/TP, as defined in Clause 9	501 octets
Point-To-Point, as defined in Clause 10	501 octets
LonTalk, as defined in Clause 11	228 octets
BACnet/IP, as defined in Annex J	1497 octets
ZigBee, as defined in Annex O	501 octets
BACnet/IPv6, as defined in Annex U	*1497 octets*

[Change **Table 6-2**, p. 51]

Table 6-2. BACnet DADR and SADR encoding rules based upon data link layer technology

BACnet Data Link Layer	DLEN	SLEN	Encoding Rules
ISO 8802-3 ("Ethernet"), as defined in Clause 7	6	6	Encoded as in their MAC layer representations
ARCNET, as defined in Clause 8	1	1	Encoded as in their MAC layer representations
MS/TP, as defined in Clause 9	1	1	Encoded as in their MAC layer representations
LonTalk domain wide broadcast	2	2	The encoding for the SADR is shown in Figure 6-3
LonTalk multicast	2	2	
LonTalk unicast	2	2	The encoding for the DADR is shown in Figure 6-4
LonTalk, unique Neuron ID	7	2	
BACnet/IP, as defined in Annex J	6	6	Encoded as specified in J.1.2
ZigBee, as defined in Annex O	3	3	~~A VMAC Address encoded as a device instance as shown in Annex H.7 Virtual MAC Addressing~~ *Encoded as specified in Annex H.7.2*
BACnet/IPv6, as defined in Annex U	*3*	*3*	*Encoded as specified in Annex H.7.2*

[Change **Clause 24.2.10**, p. 727]

24.2.10 Authentication Mechanism

…

APDU PDU Types: Confirmed-Request, Unconfirmed-Request

NPDU PDU Types: Initialize-Routing-Table, Establish-Connection-To-Network, Disconnect-Connection-To-Network

B/IP BVLL Types: Write-Broadcast-Distribution-Table, Read-Broadcast-Distribution-Table, Register-Foreign-Device, Read-Foreign-Device-Table, Delete-Foreign-Device-Table-Entry

B/IPv6 BVLL Types: Address-Resolution, Forwarded-Address-Resolution, Virtual-Address-Resolution, Register-Foreign-Device, Delete-Foreign-Device-Table-Entry

…

[Change **Clause 24.6**, p 745]

24.6 ~~Securing a BVLL~~ *Securing BVLL Messages*

24.6.1 Securing B/IP BVLL Messages

…

[Add **Clause 24.6.2**, p. 747]

24.6.2 Securing B/IPv6 BVLL Messages

B/IPv6 BVLLs are divided into 2 groups: those that contain an NPDU, such as Original-Broadcast-NPDU or Distribute-Broadcast-To-Network, and those that do not, such as Register-Foreign-Device or BVLL-Result.

To secure a B/IPv6 BVLL message that does not contain an NPDU, the original BVLL shall be placed in the Service Data field of a Security Wrapper, and that Security Wrapper shall be used as the service data for a Secure-BVLL (BVLC Function X'0B') message, as shown in Figure 24-X.

The ability to generate and consume Security Wrappers requires that the sender and receiver of secured BVLL messages are full BACnet devices with all the requirements thereof.

The Secure-BVLL message consists of the following fields:

Table 24-x. Secure-BVLL Message Fields

Field	Size	Description
BVLC Type	1-octet	BVLL for BACnet/IPv6 (value = X'82')
BVLC Function	1-octet	Secure-BVLL (value = X'0B')
BVLC Length	2-octets	Length L, in octets, of the Secure-BVLL message and its contents up to and including the Signature. It includes the padding if the Secure-BVLL is encrypted.
Security Wrapper	variable	As described in the Security Wrapper clause.

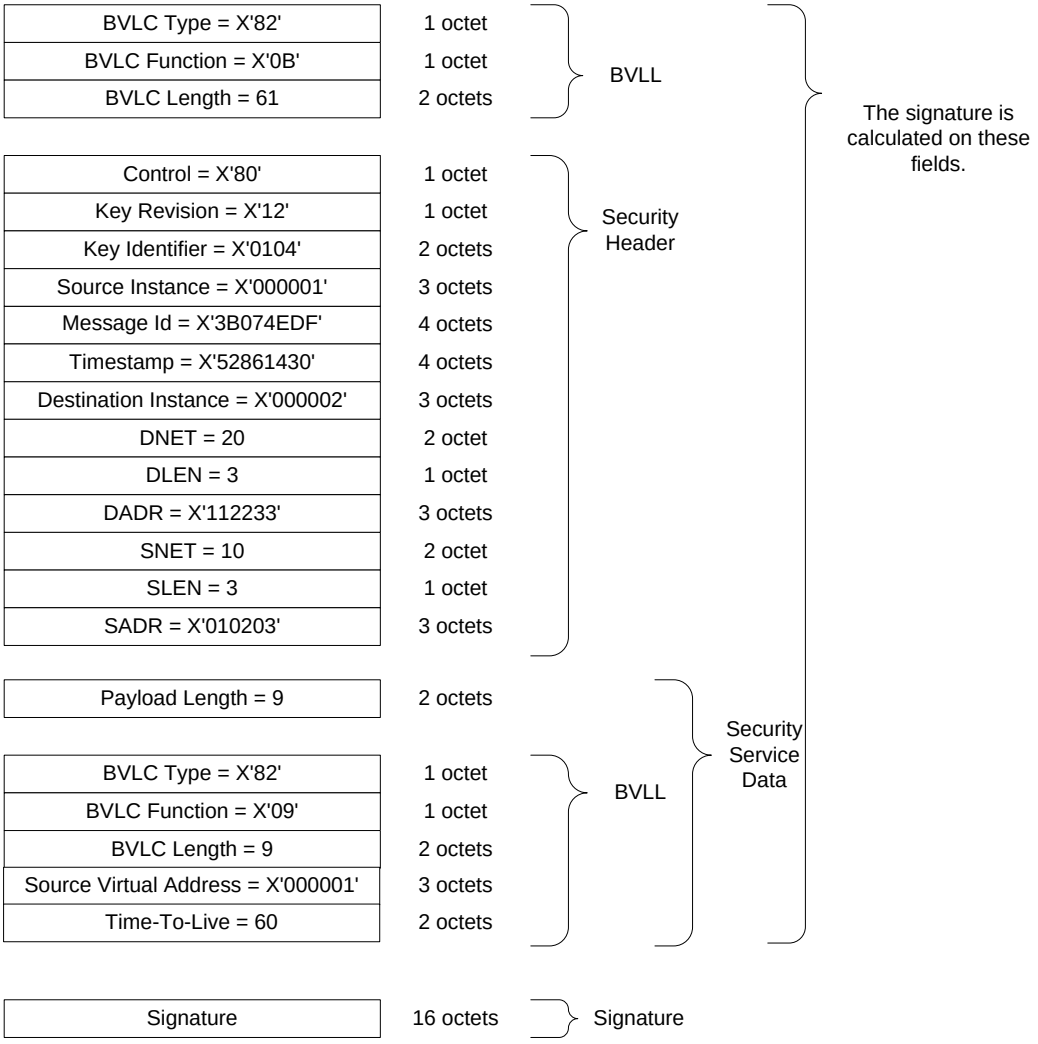


Figure 24-X. An example secured B/IPv6 BVLL (Register-Foreign-Device)

B/IPv6 BVLL messages that contain an NPDU are transmitted without modification as specified in Annex U. However, there is no loss of security capability because those NPDUs may be secure NPDUs, containing their own Security Wrappers, based on the security policies of the network and sending device. If plain (non-secured) NPDUs are not desired in B/IPv6 BVLL messages, then the network security policy of the BACnet/IPv6 network should not be plain.

B/IPv6 BBMDs do not perform wrapping/unwrapping functions on forwarded NPDUs the way routers do. The Network Security Policy that guides such operations in routers applies to an entire BACnet network, and B/IPv6 BBMDs only serve to facilitate broadcasts between distant parts of a single network, which is governed by a single network security policy.

The possible error codes returned in response to a Secure-BVLL message are the same as for the Security-Payload message and are listed in Table 24-5. The 'Ignorable' column indicates whether the device is allowed to silently fail the request and not report the error condition to the requestor. For more information on selecting an error code to return, see Clause 24.16.2.

An example of a B/IPv6 BVLL message containing a secure NPDU is shown in Figure 24-Y.

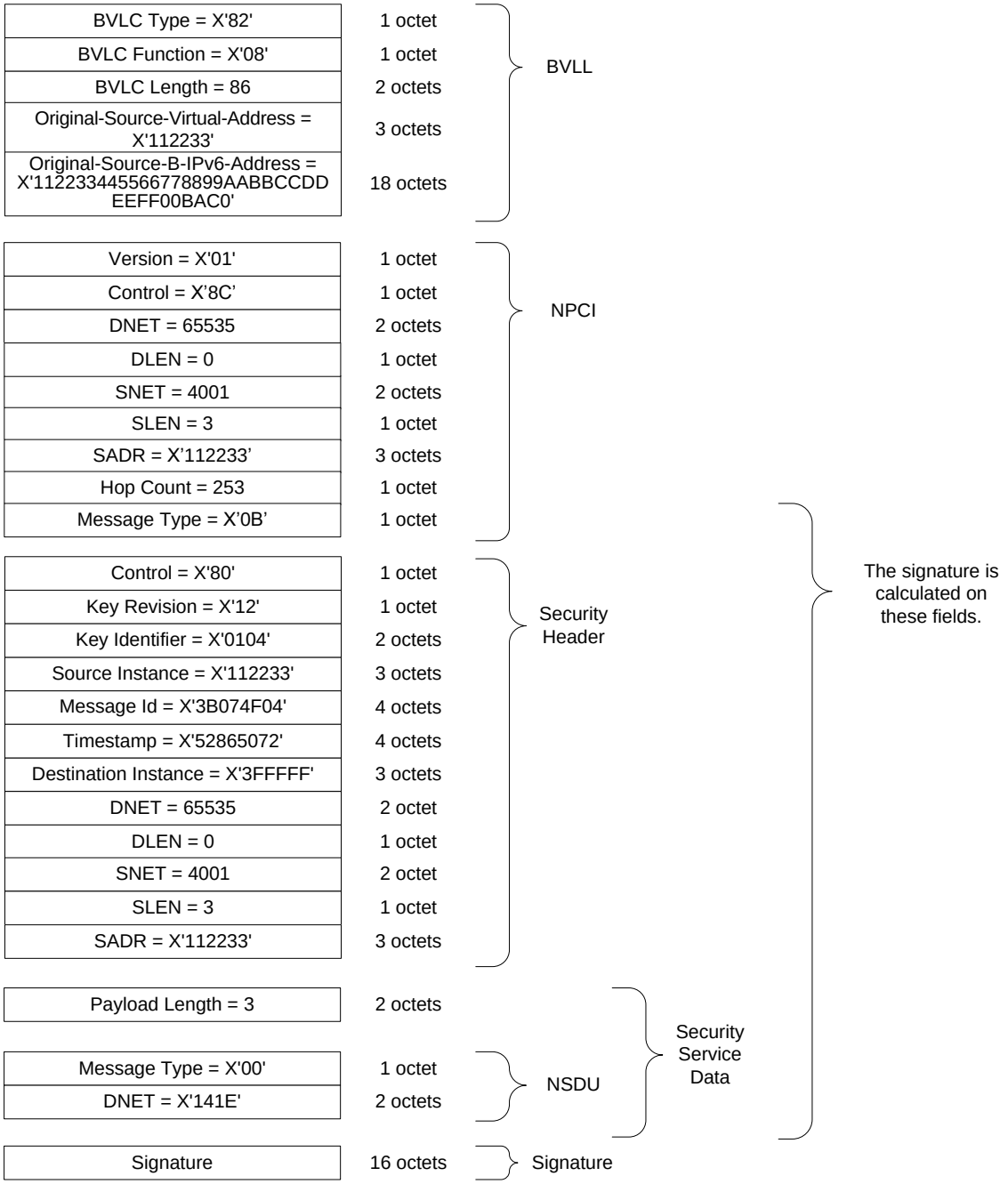


Figure 24-Y. An example B/IPv6 BVLL containing a Secured NPDU (Who-Is-Router-To-Network).

[Change **Table 12-X** in **Addendum 135-2012*ai***, p. 3]

Property Identifier	Property Datatype	Conformance Code
…		
BBMD_Broadcast_Distribution_Table	BACnetLIST of BACnetBDTEntry	O[11]
BBMD_Accept_FD_Registrations	BOOLEAN	O[11]
BBMD_Foreign_Device_Table	BACnetLIST of BACnetFDTEntry	O[12]
FD_BBMD_Address	BACnetHostNPort	O[13]
FD_Subscription_Lifetime	Unsigned16	O[13]
...		
BACnet_IPv6_Mode	*BACnetIPMode*	*O[X]*
IPv6_Address	*OCTET STRING*	*O[X+1]*
IPv6_Prefix_Length	*Unsigned8*	*O[X+1]*
BACnet_IPv6_UDP_Port	*Unsigned16*	*O[X]*
IPv6_Default_Gateway	*OCTET STRING*	*O[X+1]*
BACnet_IPv6_Multicast_Address	*OCTET STRING*	*O[X]*
IPv6_DNS_Server	*BACnetARRAY[N] of OCTET STRING*	*O[X+1]*
IPv6_Auto_Addressing_Enable	*BOOLEAN*	*O[X+2]*
IPv6_DHCP_Lease_Time	*Unsigned*	*O*
IPv6_DHCP_Lease_Time_Remaining	*Unsigned*	*O*
IPv6_DHCP_Server	*OCTET STRING*	*O*
IPv6_Zone_Index	*CharacterString*	*O[X+3]*
…		

...

[11] Required to be present if the port is a BACnet/IP *or BACnet/IPv6* port and the device is capable of functioning as a BBMD.

[12] Required if the port is a BACnet/IP *or BACnet/IPv6* port and the device is capable of functioning as a BBMD.

[13] Required to be present if the port is a BACnet/IP *or BACnet/IPv6* port and BACnet_IP_Mode *or BACnet_IPv6_Mode respectively* is set to FOREIGN.

...

[X] Required to be present if the port is a BACnet/IPv6 port.

[X+1] Required to be present if the port is a BACnet/IPv6 port. Read-only if the value is configured by automatic address assignment.

[X+2] Required to be present if the port is a BACnet/IPv6 port and supports automatic IPv6 address assignment.

[X+3] Required to be present if the port is a BACnet/IPv6 port and the node supports multiple IPv6 link local addresses.

[Change Table **12-Y** in **Addendum 135-2012*ai***, p. 5]

If the value of Network_Type is…	… then these are the additional properties required of the corresponding Network Port Object.
…	
BACNET_IPV6 (BACNET_IPv6_Mode is NORMAL)	*MAC_Address* *BACnet_IPv6_Mode* *IPv6_Prefix_Length* *IPv6_Address* *BACnet_IPv6_UDP_Port* *BACnet_IPv6_Multicast_Address* *IPv6_Default_Gateway* *IPv6_DNS_Server* *IPv6_Auto_Addressing_Enable* *IPv6_Zone_Index*
BACNET_IPV6 (BACNET_IPv6_Mode is FOREIGN)	*MAC_Address* *BACnet_IPv6_Mode* *IPv6_Prefix_Length* *IPv6_Address* *BACnet_IPv6_UDP_Port* *BACnet_IPv6_Multicast_Address* *IPv6_Default_Gateway* *IPv6_DNS_Server*

	IPv6_Auto_Addressing_Enable *IPv6_Zone_Index* *FD_BBMD_Address* *FD_Subscription_Lifetime*
BACNET_IPV6 *(BACNET_IPv6_Mode is BBMD)*	*MAC_Address* *BACnet_IPv6_Mode* *IPv6_Prefix_Length* *IPv6_Address* *BACnet_IPv6_UDP_Port* *BACnet_IPv6_Multicast_Address* *IPv6_Default_Gateway* *IPv6_DNS_Server* *IPv6_Auto_Addressing_Enable* *IPv6_Zone_Index* *BBMD_Broadcast_Distribution_Table* *BBMD_Accept_FD_Registrations* *BBMD_Foreign_Device_Table*

[Change Clause **12.X.12 Command Property** in **Addendum 135-2012*ai***, p. 8]

12.X.12 Command

...

Any of the following commands may be written to this property:

...

RENEW_FD_REGISTRATION — This port shall attempt to renew its foreign device registration with the BBMD indicated in FD_BBMD_Address.

If the value of Network_Type is not BACNET_IPV4 *and not BACNET_IPV6*, or if the *IP mode* ~~value of BACnet_IP_Mode~~ is not FOREIGN, writing this value shall result in the return of a Result(-) with an 'Error Class' of PROPERTY and an 'Error Code' of VALUE_OUT_OF_RANGE.

...

...

RENEW_DHCP — If DHCP is supported, then this device shall attempt to renew the DHCP lease for this port.

If the port cannot be made to renew the DHCP lease *or otherwise determine the address automatically in IPv6*, writing this value shall result in the return of a Result(-) with an 'Error Class' of PROPERTY and an 'Error Code' of OPTIONAL_FUNCTIONALITY_NOT_SUPPORTED.

If the value of Network_Type is BACNET_IPV4 *or BACNET_IPV6* and the BACnet_IP_DHCP_Enable *or the IPv6_Auto_Addressing_Enable* property *respectively* is not present, writing this value shall result in the return of a Result(-) with an 'Error Class' of PROPERTY and an 'Error Code' of OPTIONAL_FUNCTIONALITY_NOT_SUPPORTED.

If the value of Network_Type is not BACNET_IPV4 or *BACNET_IPV6*, writing this value shall result in the return of a Result(-) with an 'Error Class' of PROPERTY and an 'Error Code' of VALUE_OUT_OF_RANGE.

…

[Add new **Clauses 12.X.Y?** in **Addendum 135-2012*ai***, p. 18]

12.X.Y1 BACnet_IPv6_Mode

This property, of type BACnetIPMode, indicates the BACnet/IPv6 mode of this network port.

This property shall have one of the following values:

NORMAL The device is operating as neither a foreign device nor a BBMD over this network port.

FOREIGN The device is operating as a foreign device over this network port.

BBMD The device is operating as a BBMD for this network port.

Writing to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y2 IPv6_Address

This property, of type OCTET_STRING, indicates the IPv6 address of this network port. This property shall be conveyed most significant octet first. If the IPv6 address is obtained automatically, this property shall be read-only, and the value of this property shall contain the address with the highest precedence. See RFC 6724.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y3 IPv6_Prefix_Length

This property, of type Unsigned8, indicates the length in bits of the subnet prefix of the IPv6 address of this network port. The value of this property shall be in the range 1 to 128. If the IPv6 address is obtained automatically, this property shall be read-only.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y4 BACnet_IPv6_UDP_Port

This property, of type Unsigned16, indicates the BACnet/IPv6 UDP port number of this network port.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when a value of ACTIVATE is written to the Command property.

12.X.Y5 IPv6_Default_Gateway

This property, of type OCTET STRING, indicates the IPv6 address of the default gateway for this network. This property shall be conveyed with the most significant octet first. If the IPv6 address is obtained automatically, this property shall be read-only.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y6 BACnet_IPv6_Multicast_Address

This property, of type OCTET STRING, contains the IPv6 multicast address and UDP port to be used for the distribution of BACnet broadcast messages in the local multicast domain. See Clause U.4. The value of this property shall be comprised of the IPv6 multicast address followed by the UDP port, both of which shall be conveyed with the most significant octet first.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y7 IPv6_DNS_Server

This property, of type BACnetARRAY[N] of OCTET STRING containing at least one entry, indicates the IPv6 address of the DNS server used by this network port for Internet host name resolution. The values of this property shall be conveyed with the most significant octet first. If the DNS server addresses are obtained automatically, this property shall be read-only.

A value of X'00000000000000000000000000000000' in an array entry indicates that the DNS server address is not available or is not configured.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y8 IPv6_Auto_Addressing_Enable

This property, of type BOOLEAN, indicates whether or not this network is configured for automatic address assignment via DHCPv6, Stateless Auto Address Configuration (SLAAC, RFC 4862), or neighbor discovery. A value of TRUE indicates that automatic address assignment is enabled, FALSE indicates it is not.

This property is required if any form of IPv6 automatic address configuration is supported by this network port.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

12.X.Y9 IPv6_DHCP_Lease_Time

This read-only property, of type Unsigned, indicates the lease time in seconds of the last DHCPv6 lease obtained for the port. If IPv6_Auto_Addressing_Enable is FALSE, or DHCPv6 is not in use, or no lease has been acquired, or the value is unknown, this property shall be 0.

12.X.Y10 IPv6_DHCP_Lease_Time_Remaining

This read-only property, of type Unsigned, indicates the lease time in seconds remaining of the last DHCPv6 lease obtained for the port. If IPv6_Auto_Addressing_Enable is FALSE, or DHCPv6 is not in use, or no lease has been acquired, or the value is unknown, this property shall be 0.

12.X.Y11 IPv6_DHCP_Server

This read-only property, of type OCTET STRING, indicates the address of the DHCPv6 server from which the last DHCPv6 lease was obtained for the port. If the address of the DHCPv6 server cannot be determined, or DHCPv6 is not in use, the value of this property shall be X'00000000000000000000000000000000'.

12.X.Y12 IPv6_Zone_Index

This property, of type CharacterString, contains the zone index for the B/IPv6 link local address when the node supports multiple IPv6 link local addresses.

According to RFC 4007, because all link-local addresses in a host have a common prefix, normal routing procedures cannot be used to choose the outgoing interface when sending packets to a link-local destination. A special identifier, known as a zone index, is needed to provide the additional routing information.

If this property is writable, then a successful write to this property shall set the Changes_Pending property to TRUE. A value written to this property shall become effective when the device receives a ReinitializeDevice service request with a 'Reinitialized State of Device' of ACTIVATE_CHANGES or WARMSTART.

[Change **Clause 12.X.8** in **Addendum 135-2012*ai***, p. 6]

12.X.8 Network_Type

This property, of type BACnetNetworkType, represents the type of network this Network Port object is representing.

This property shall have one of the following values:

ETHERNET	ISO 8802-3 (“Ethernet”), as defined in Clause 7
…	
BACNET_IPV6	*BACnet/IPv6, as defined in Annex U*
<Proprietary Enum Values>	A vendor may use other proprietary enumeration values to indicate that this port represents the use of message structures, procedures, and medium access control techniques other than those contained in this standard. For proprietary extensions of this enumeration, see Clause 23.1 of this standard.

[Change **Clause 21** additions in **Addendum 135-2012*ai***, p. 21]

BACnetNetworkType ::= ENUMERATED {
ethernet (0),
arcnet (1),
mstp (2),
ptp (3),
lontalk (4),
bacnet-ipv4 (5),
zigbee (6),
virtual (7),
non-bacnet (8),
bacnet-ipv6 (9),
...
}
-- Enumerated values 0-63 are reserved for definition by ASHRAE. Enumerated values
-- 64-255 may be used by others subject to the procedures and constraints described in Clause 23.

BACnetBDTEntry ::= SEQUENCE {
bbmd-address [0] BACnetHostNPort,
broadcast-mask [1] OCTET STRING *OPTIONAL* -- *shall be present if BACnet/IP, and absent for BACnet/IPv6*
}

BACnetFDTEntry ::= SEQUENCE {
bacnetip-address [0] OCTET STRING, -- the 6-octet B/IP *or 18-octet B/IPv6* address of the registrant
time-to-live [1] Unsigned16, -- time to live in seconds at the time of registration
remaining-time-to-live [2] Unsigned16 -- remaining time to live in seconds, incl. grace period
}
...

BACnetHostAddress ::= CHOICE {
none [0] NULL,
ip-address [1] OCTET STRING, -- 4 octets *for B/IP or 16 octets for B/IPv6*
name [2] CharacterString -- Internet host name (see RFC 1123)
}

[Change **Clause 21**, starting p. 661]

BACnetPropertyIdentifier ::= ENUMERATED { -- see below for numerical order

```
        ...
        backup-preparation-time                 (339),
        bacnet-ipv6-mode                        (435),
        bacnet-ipv6-udp-port                    (438),
        bacnet-ipv6-multicast-address           (440),
        base-device-security-policy             (327),
        ...
        interval-offset                         (195),
        ipv6-address                            (436),
        ipv6-auto-addressing-enable             (442),
        ipv6-default-gateway                    (439),
        ipv6-dhcp-lease-time                    (443),
        ipv6-dhcp-lease-time-remaining          (444),
        ipv6-dhcp-server                        (445),
        ipv6-dns-server                         (441),
        ipv6-prefix-length                      (437),
        ipv6-zone-index                         (446),
        is-utc                                  (344),
        ...
-- -numerical order reference
        ...
        -- see egress-active                    (386)
        -- see bacnet-ipv6-mode                 (435),
        -- see ipv6-address                     (436),
        -- see ipv6-prefix-length               (437),
        -- see bacnet-ipv6-udp-port             (438),
        -- see ipv6-default-gateway             (439),
        -- see bacnet-ipv6-multicast-address    (440),
        -- see ipv6-dns-server                  (441),
        -- see ipv6-auto-addressing-enable      (442),
        -- see ipv6-dhcp-lease-time             (443),
        -- see ipv6-dhcp-lease-time-remaining   (444),
        -- see ipv6-dhcp-server                 (445),
        -- see ipv6-zone-index                  (446),
        ...
        }
-- The special property identifiers all, optional, and required are reserved for use in the
...
```

[Add new entries to **Clause 25**, p. 772]
[Note that these lines are added exactly as shown, including both normal and italicized text]

25 REFERENCES

...
IETF RFC 2373, *IP Version 6 Addressing Architecture*, Internet Engineering Task Force

IETF RFC 2460, *Internet Protocol, Version 6 (IPv6) Specification*, Internet Engineering Task Force

IETF RFC 3041, *Privacy Extensions for Stateless Address Autoconfiguration in IPv6*, Internet Engineering Task Force

IETF RFC 4007, *IPv6 Scoped Address Architecture*, Internet Engineering Task Force

IETF RFC 4193, *Unique Local IPv6 Unicast Addresses*, Internet Engineering Task Force

IETF RFC 4291, *IP Version 6 Addressing Architecture*, Internet Engineering Task Force

IETF RFC 4294, *IPv6 Node Requirements*, Internet Engineering Task Force

IETF RFC 4862, *IPv6 Stateless Address Autoconfiguration*

IETF RFC 5952, *A Recommendation for IPv6 Address Text Representation*, Internet Engineering Task Force

IETF RFC 6724, *Default Address Selection for Internet Protocol Version 6 (IPv6)*, Internet Engineering Task Force

...

[Change **ANNEX A**, p. 775]

ANNEX A - PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (NORMATIVE)

...
Data Link Layer Options:

☐ BACnet IP, (Annex J)
~~☐ BACnet IP, (Annex J), Foreign Device~~
☐ *BACnet IP, (Annex J), BACnet Broadcast Management Device (BBMD)*
☐ *BACnet IP, (Annex J), Network Address Translation (NAT Traversal)*
☐ *BACnet IPv6, (Annex U)*
☐ *BACnet IPv6, (Annex U), BACnet Broadcast Management Device (BBMD)*
☐ ISO 8802-3, Ethernet (Clause 7)
...
☐ Other: _____

...

Networking Options:
...
~~☐ BACnet/IP Broadcast Management Device (BBMD)~~
~~Does the BBMD support registrations by Foreign Devices? ☐ Yes ☐ No~~
~~Does the BBMD support network address translation? ☐ Yes ☐ No~~

135-2012*aj-2* Add an additional method of VMAC determination

Rationale

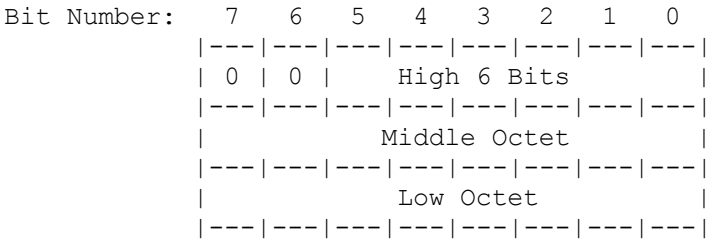
In device deployment scenarios where a device is physically installed on a network without having an application loaded, and loading the application shall be performed via the BACnet network, the device is required to have a VMAC address before a Device object exists in the device.

Random instance VMAC addresses are introduced so that a device without having a Device object configured can select a VMAC address that does not conflict with VMAC addresses built from configured Device object instances.

[Change **Clause H.7.2**, p. 856]

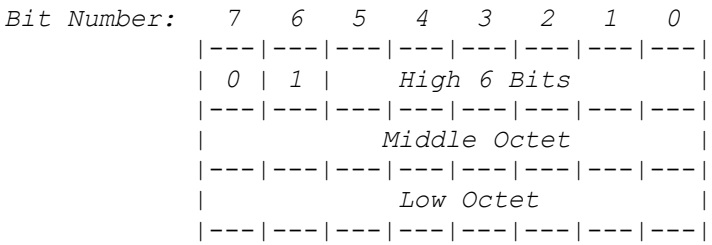
H.7.2 Using Device Instance as a VMAC Address

When a particular data link layer specifies that each node's BACnet device instance is to be used as the VMAC address for the node, then the device instance as a VMAC address shall be transmitted as 3 octets, with the high order octet first, and formatted as follows:



Nodes that do not have a BACnet device instance configured shall generate and use a random instance VMAC address. The generation and use of a random instance VMAC address does not affect the BACnet device instance which remains not configured. To ensure that the random instance VMAC is not used by another node, the node shall attempt to resolve the generated VMAC in the network. If the node detects that another node is already using the random instance VMAC it has generated, it shall generate another random instance VMAC address. Once a node obtains a BACnet device instance, the node shall cease using the random VMAC and shall start using the regular device instance VMAC as described above.

*The random portion of a random instance VMAC address is a number in the range 0 to 4194303. The resulting random instance VMAC address is in the range 4194304 to 8388607 (*X'*100000*' to X'*7FFFFF *'). The generation of a random instance VMAC shall yield any number in the entire range with equal probability. A random instance VMAC is formatted as follows:*



[Add a new entry to **History of Revisions**, p. 1027]

(This History of Revisions is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard.)

HISTORY OF REVISIONS

…	…	**…**
1	18	**Addendum aj to ANSI/ASHRAE 135-2012** Approved by ASHRAE on February 29, 2016, and by the American National Standards Institute March 1, 2016. 1. Add support for IPv6 2. Add an additional method for VMAC determination

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