IPv6

Best Practices

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Important changes are listed in **Document revision history** at the end of this document.

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Introduction

Internet Protocol version 6 (IPv6) is the most recent IP, providing identification and location for computers on networks and routing traffic across the Internet. It was developed to deal with IPv4 32-bit address space exhaustion. IPv6 supports 128-bit address space and can potentially support 2^128 or 3.4 x 10^38 unique IP addresses. With this large address-space scheme, IPv6 can provide unique addresses to every device or node attached to the Internet.

Commonly used terms

Prefix: The network portion of an IPv6 address

Prefix length: This is the number of most-significant or leftmost bits that define the prefix. It is equivalent to the subnet mask in IPv4, and can /0 through /128.

Interface ID: Equivalent to the host portion of an IPv4 address

Node or device: Anything that can have an IPv6 address

Scope: The range to which routers can forward multicast packets

Background information

- An IPv6 address is composed of 2 parts, the prefix and the Interface ID. Addresses are grouped into 8 segments with a : (colon) as a separator.
- IPv6 uses hexadecimal numbers to represent addresses.
- IPV6 addresses have a shortened or normalized notation in which leading zeros within a segment are removed. Consecutive segments with all zeros will be shortened to :: (double colon)

  `2001:0012:0000:0000:0000::d850:02e0:09ff` becomes `2001:12::d850:2e0:9ff`

IPv6 Address modes supported

Mode	Purpose	Example
Default IP Address	The i-Vu® XT router automatically generates an IPv6 Address, Prefix Length, and Default Gateway. The address is based on the Address Rotary switch (FD01::192:168:168:address rotary). Prefix Length is 64, and the Default Gateway will be FD01::192:168:168:254. This addressing mode is typically only used for demonstration, development, or test purposes, and is not recommended for end use.	Address: fd01::192:168:168:11 Prefix length: 64 Default Gateway: fd01::192:168:168:254 Multicast address: ff05::bac0
Custom Static	The operator sets the IPv6 Address, Prefix Length, and Default Gateway. This mode is generally the best option if SLAAC is not available. Consult your IT group when using Custom Static IPv6 addressing.	Address: 2001:db8:1111:2222:d87c:8a6c:bc5a:ca88 Prefix length: 64 Default Gateway: 2001:db8:1111:2222::1 Multicast address: ff08::bac0

Mode	Purpose	Example
DHCP	In this mode, the i-Vu® XT router is assigned an IPv6 address, Prefix length, and Default Gateway based on information provided by a DHCPv6 server on the network.	Address (autogenerated): 2601:19c:8180:1b60::12% 3068773472 Prefix length: 128 Default Gateway (autogenerated): fe80::e222:2ff:fe4d:e51 Multicast address: ff08::bac0
Link-local	The i-Vu® XT router generates a network address that is only valid for communications within the network segment or the broadcast domain that the host is connected to. Link-local addresses are non-routable and start with FE80. This addressing mode is typically only used for demonstration, development, or test purposes, and is not recommended for end use.	Address: fe80::2e0:c9ff:fe23:ea8 Prefix length: 64 Default Gateway: fe80::1 Multicast address: ff02::bac0
StateLess Address Auto Configuration (SLAAC)	In this mode, the i-Vu® XT router automatically generates an IPv6 Address, Prefix Length, and is assigned a Default Gateway based on information received on its network. SLAAC is similar to DHCP on IPv4 and can be used to generate global IPv6 addresses. This mode is generally the best option. Consult your IT group when setting up SLAAC IPv6 addressing. **NOTE** If the i-Vu® XT router is configured for SLAAC on a network where SLAAC is not available, the i-Vu® XT router uses its Link-Local address, and networking will not function as expected.	Address (autogenerated): 2600:1700:8e50:d850:2e0 :c9ff:fe23:ea8 Prefix length: 64 Default Gateway (autogenerated): fe80::e222:2ff:fe4d:e51 Multicast address: ff08::bac0

IPV6 multicast

IPv6 uses multicast instead of broadcast for distribution of messages. The key difference between broadcast and multicast is that in the broadcast the packet is delivered to all the hosts connected to the network whereas, in multicast packet is delivered to intended recipients only (see https://techdifferences.com/difference-between-broadcast-and-multicast.html).

With BACnet/IPv4, it is necessary to use BBMD and FDT to overcome the limitations of broadcast.

- With BACnet/IPv6, it is possible to eliminate BBMD and FDT with the use of properly scoped IPv6 addresses and multicast addresses.

- If using globally scoped IPv6 and multicast addresses, BBMD and FDT may not be required. This depends on how your IT group configures the scope IPv6 Multicast Addresses in their IPv6 (internet) routers.

- If your company limits the scope of IPv6 Multicast Addresses, then BBMD and FDT is required.

- If using link-local IPv6 Address or Multicast address, BBMD and FDT do not function as expected; IPv6 (internet) routers do not forward the packets.

  IMPORTANT While IANA has assigned BACnet/IPv6 variable scope multicast addresses, each organization can configure multicast differently. The company IT group should be consulted when configuring BACnet/IPv6 multicast.

- When B/IPv6 network composed of a single subnet (2001:DB8:1111:2222::/64), a link-local multicast from a device reaches all nodes which are members of the [FF02::BAC0]:47808 multicast domain.

- When a B/IPv6 network 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 reaches all nodes which are members of the [FF08::BAC0]:47808 multicast domain.

- A B/IPv6 network can be 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 reaches all devices on IPv6 Network 1 which are members of the [FF05::BAC0]:47808 site-local multicast domain, but requires forwarding by BBMD 1 to BBMD 2, and BBMD 2 to multicast it on its local link in order to reach devices on IPv6 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 IPv6 Network 1 is configured to include all links within IPv6 Network 1.

To configure the i-Vu® XT router

Network Number: The network number used for the BACnet/IPv6 network port. The valid range of network numbers is 0 to 65534. 0 indicates the BACnet/IPv6 network port is disabled.

Address Mode: This dropdown allows selection of the type of IPv6 addressing to use for IPv6.

NOTE There is a known "loss of communication" defect after switching the Address Mode from one type to another. The workaround is to to power cycle the router.

- **Default IP Address**: In this mode, the i-Vu® XT router automatically generates an IPv6 Address, Prefix Length, and Default Gateway. The IPv6 Address is based on the Address Rotary switch (FD01::192:168:168:address rotary), the Prefix Length will be 64, and the Default Gateway will be FD01::192:168:168:254. This addressing mode is typically only used for demonstration, development, or test purposes, and is not recommended for end use.
- **Custom Static**: In this mode, the operator sets the IPv6 Address, Prefix Length, and Default Gateway. If SLAAC is not available, this is probably the mode an operator should use. When using Custom Static IPv6 addressing, the company IT group should be consulted.
- **DHCP**: In this mode, the i-Vu® XT router is assigned an IPv6 address, Prefix length, and Default Gateway based on information provided by a DHCPv6 server on the network. DHCPv6 is similar to DHCP on an IPv4 network.
- **Link-local**: In this mode, the i-Vu® XT router will generate a network address that is valid only for communications within the network segment or the broadcast domain that the host is connected to. By definition, Link-local addresses are non-routable. This addressing mode is typically only used for demonstration, development, or test purposes, and is not recommended for end use.
- **SLAAC**: (StateLess Address Auto Configuration). In this mode, the i-Vu® XT router will automatically generate an IPv6 Address, Prefix Length, and Default Gateway based on information received on the network. SLAAC is somewhat analogous to DHCP on IPv4 and can be used to generate global IPv6 addresses. If available, this is probably the mode an operator should use. When setting up SLAAC IPv6 addressing, the company IT group should be consulted.

  NOTE If the router is configured for SLAAC on a network where SLAAC is not available, it will fall back to using its Link-Local address and networking will not function as expected.

Prefix Length: The length, in bits, of the subnet prefix of the IPv6 address of the network port. The valid range of this value is 1 to 128. When using automatic IPv6 addressing modes, this value will be determined automatically. When manually configuring this value, the company IT group should be consulted.

Default Gateway: The IPv6 address of the default gateway for this network. When using automatic IPv6 addressing modes, this value will be determined automatically. When manually configuring this value, the company IT group should be consulted.

UDP Port: The UDP port number for BACnet/IPv6 of this network port.

Multicast Address: The IPv6 multicast address to be used for the distribution of BACnet broadcast messages in the local multicast domain. See IPv6 Multicast section above for a further discussion of IPv6 Multicast.

Multicast UDP Port: The UDP port to be used for the distribution of BACnet/IPv6 multicast messages.

DNS: The IPv6 address(es) of the DNS server(s) used by this network port for Internet host name resolution. When using SLAAC, these values will be obtained automatically. When manually configuring these values, the company IT group should be consulted. Note: DNS servers are only required if name resolution for BBMD, NTP, or BACnet/SC will be needed.

IPv6 Network Interfaces: This section displays the configured IPv6 addresses. It is typically used to verify the Address Mode selected is functioning properly.

1. Determine the appropriate addressing mode for the customer and set it via local access GigE port page.
2. Assert the i-Vu® XT router is communicating (eg: ping the router via the IPv6 address / browse to the router using the IPv6 address if you have enabled local access over the GigE port). Note that if you have an IPv6 network communication error with DHCPv6, SLACC, Custom, or Default addressing, the router will fall back to link-local.

To configure a BACnet/IPv6 network and connection

SiteBuilder

Add a BACnet Network

- Media Type: BACnet/IPv6

Add a BACnet Device Router

- Configure the Device Instance.
- You do not have to specify any other IPv6 addressing values.

NOTE The BACnet protocol uses a Virtual MAC Address (VMAC) for device addressing in IPv6, so you will mostly not see an actual IPv6 address in SiteBuilder and the i-Vu® application for a device, but the VMAC instead; the configured device instance number.

i-Vu® application

On the System Configuration tree / Connections page

- On the **Configure** tab, select **BACnet/IPv6 Connection**.
  - Configuration options for BACnet/IPv6 are described below. Because of the complexity in configuring IPv6 addressing and multicasting, the your IT group should be consulted to configure the IPv6 settings.
  - Set the IPv6 Multicast Address scope as necessary (see *IPv6 multicast* (page 4))

Server IPv6 Address: Type the server's IPv6 address. It is recommend to specify an address for this field since most machines have multiple IPv6 addresses available. This is especially true if you have multiple network interfaces enabled. The server's IP address can be determined by using the `ipconfig /all` (Windows) or `ifconfig` (Linux) commands.

Prefix Length: Value set between 10 and 127 to define the number of leftmost bits identifying the network portion of the address.

BACnet Port: Enter `47808` unless you need to communicate with a third-party device using a different port for BACnet communication, or your IT administrator specified a different port. Ensure your IPv6 ports are different than your IPv4 ports and that you assign the connection to the same IPv6 multicast group

IPv6 Multicast Address: Used for broadcasts on an IPv6 network using SLAAC, defined by the building network administrator

IPv6 Multicast Port: The port the controller uses for BACnet communication broadcasts, must be the same as the BACnet Port

Disable Field Alarms: Select if you do not want to retain incoming alarms on this connection. This box may be checked during start-up then cleared for normal operation.

Poll Interval: How often the i-Vu® application checks the communication status of the peer caching router. If it cannot communicate with the router, the application generates a Dead Module Timeout alarm.

Foreign Device: If the i-Vu® server is on an IPv6 network segment that does not have an Carrier® controller serving as a BBMD, select **Force Registration**.

Register with Device: If you selected **Force Registration** in the previous field, select the BBMD on a remote IPv6 network from which the i-Vu® server will receive BACnet/IPv6 broadcasts.

Primary BBMD: If you selected **Force Registration** in the previous field, select the primary BBMD.

Backup BBMD if primary fails: To have a backup in case the first BBMD fails, select another BBMD.

Network Node: Specify which network the i-Vu® server is physically connected to. This is used to specify which BACnet/IPv6 network the i-Vu® server is on if there are multiple BACnet/IPv6 network nodes with different network numbers in your system.

- Start the connection
- Assert that you can Modstat the i-Vu® XT router as well as a downstream module

To test IPv6 SLAAC addressing with an Enterprise router

A convenient way to test SLAAC IPv6 is to connect your PC, i-Vu® XT router, and ISP router all into a switch, for example, Linksys.

1. On the ISP router, ensure IPv6 LAN is enabled.
2. On the PC, run `ipconfig /all` (Windows) or `ifconfig` (Linux) and copy the IPv6 address for your Ethernet adapter and paste it into your IPv6 connection page in the i-Vu® interface.
3. Start the connection.
4. Access the i-Vu® XT router via local access and on the GIG-E configuration page, choose **SLAAC addressing** and restart.
5. Verify that you can Modstat the i-Vu® XT router and a downstream module.

IPv6 with an external IP router

Use a private network for testing.

- Turn off NAT routing
- The IPv6 firewall should be disabled

Enable router advertisement

Non-industrial routers, such as residential type routers, may not support multicast routing. To route across subnets, use BBMD. Ensure the format of your bbmd file / entries is correct (see the help documentation).

Tips and troubleshooting

Setup tips

- IPv6 SLAAC configuration probably requires input from your IT group.
- When pinging an IPv6 address, if "%" appears at the end of the address disregard any characters after the %. The link-local IPv6 address is always present regardless of address mode configured on the i-Vu® XT router.
- Use `ipconfig /all` (Windows), `ifconfig` (Linux) `/ ping / i-Vu® connection page / Modstat` to verify addressing.
- Modstat's "Current" address indicates the router's actual addresses. The "Assigned" addresses is used after the router restarts.
- When browsing to an IPv6 i-Vu® XT router over the GigE port, you can use either the IPv4 or IPv6 address. Note that the i-Vu® application only uses the protocol specified on the **Connections** page for that network.
- When browsing to an IPv6 address over the GigE port, some browsers require the address to be surrounded with brackets, for example "https://[fe80::2e0:c9ff:fe23:ea8]". Delete any characters after the %.
- The server's IPV6 address on the **Connections** page and the i-Vu® XT router's IPv6 address are different. Ensure the i-Vu® connection page is using the address for the computer's Ethernet adapter.
- The UDP port for the BACnet/IPv6 defaults to 47808.
- Ensure your network media type (set in SiteBuilder) and your Connection type (set in the i-Vu® interface) match.

Communication tips

- After making configuration changes, restart connections when the blue restart banner appears.

- Use same-scope IPv6 addresses for all devices, routers, and computers (i-Vu®) intended to communicate with each other. Do not mix link-local with global scope.

- It is possible to have both IPv6 and IPv4 network ports enabled on an i-Vu® XT router. To use IPv6 with i-Vu®, it must be set as the "Home" network. The GigE ports page and the Modstat detail the IPv4 and IPv6 addresses.

- Techniques to help verify addressing:
  - In the i-Vu® XT router Gig-E port configuration pages, define an IPv4 address in the Primary BACnet/IP in addition to the IPv6 addressing configuration information
  - In the i-Vu® interface, on the i-Vu® XT router's **Driver** > **Advanced** > **Security** page, setting **Allow Configuration** on the Gig-E port enables browsing to the i-Vu® XT router.
  - Browsing to the i-Vu® XT router with either IPv4 or IPv6 can be done to verify connectivity
  - Modstat the i-Vu® XT router as well as a downstream module
  - To restrict configuration page browsing over the Gig-E port after troubleshooting, deselect **Allow Configuration on the Gig-E port** in the i-Vu® interface.

Troubleshooting

There is a known "loss of communication" defect after switching the Address Mode from 1 type to another. A workaround is to to power cycle the i-Vu® XT router.

- ICMPv6 is required for IPv6 communications, and Windows 10 Firewall does not allow ICMPv6 by default. If a Windows machine is not responding to Neighbor Solicitations, add ICMPv6 to the incoming firewall rules. If the firewall is not the problem, `netsh int ipv6 show joins` can be used to verify that the machine has joined the multicast group.

- To verify a Windows computer is processing ICMPv6 messages, use Wireshark to show the ICMPv6 router solicitation and router advertisement messages: `icmpv6.type == 134 || icmpv6.type==133`.

- Changing between IPv4 and IPv6 may cause issues with Windows network adapters.

Document revision history

Important changes to this document are listed below. Minor changes such as typographical or formatting errors are not listed.

Date	Topic	Change description	Code*
4/17/24	Setup tips	Chanded UDP Port number for BACnet/IPv6	X-AE-SS-E
	i-Vu® application	No changes yet	

* For internal use only