

Security Best Practices

for an i-Vu® Pro v10.0 system





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

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Security best practices

Carrier takes the security of our systems very seriously and you play the biggest part in this by installing and configuring systems in a secure manner. We encourage you to establish security policies for your own company networks and all the systems you install and service.

Follow the best practices in this document when deploying i-Vu® Pro building automation systems.

Use the Security Checklist in Appendix B to track important security steps when designing, installing and commissioning i-Vu® Pro systems.

Physical network security

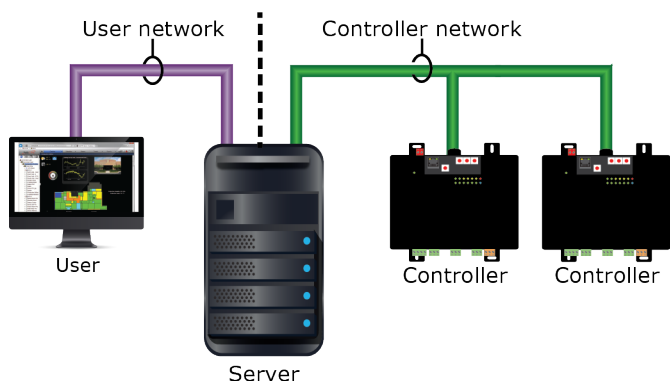
Physical network security protects network hardware and infrastructure (for example, servers, routers, switches, and cables) from damage, interference, and unauthorized access.

Ensure your physical network security plan includes the following:

- **Access control:** Restrict entry to data centers, server rooms, and access to networking equipment by using security measures like passcards, biometric identification, and surveillance.
- **Cable management:** Prevent tampering or unauthorized connections by restricting physical access to network cables and ports.
- **Device security:** Use locks and physical barriers to secure critical hardware.
- **Environmental protection:** Verify proper cooling, fire suppression, and disaster recovery plans. Physical network security measures should also address risks outside of deliberate or malicious attacks.
- **Multi-layer approach:** Combine digital network security and physical network security for a more robust security plan.
- **Surveillance and monitoring:** Install security cameras and motion sensors to detect unauthorized activity.

Network separation

Standard BACnet is an intentionally open system that makes it easy to discover and control any device on its network. Because of this, you should design your system to segregate users from the controller network by having two separate networks. For example, if the users are on a company's enterprise LAN, you would not want controllers on the LAN so that they are easy targets for misuse by anyone with access. Some of the biggest risks come from insiders such as the curious tinkerer, a student on an education system's network, or a disgruntled employee.



You can physically separate the user network and the BACnet network without any IP routing between them, or you can logically separate them at a switch using a Virtual Local Area Network (VLAN).

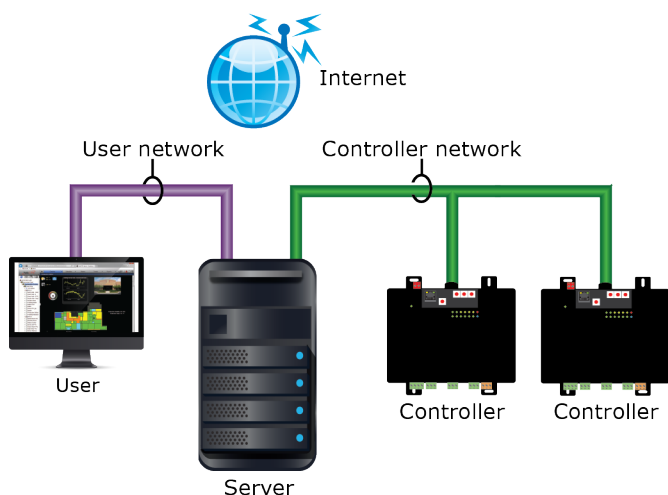
If you have dual NICs (Network Interface Cards), the server must have a different IP address for each network.

- User network - Configure this IP address and subnet mask in SiteBuilder on the **Configure > Preferences > Web Server** tab.
- BACnet network - Configure this IP address and subnet mask in the interface on the **Driver Properties > Connections page > Configure** tab.

Internet connectivity scenarios

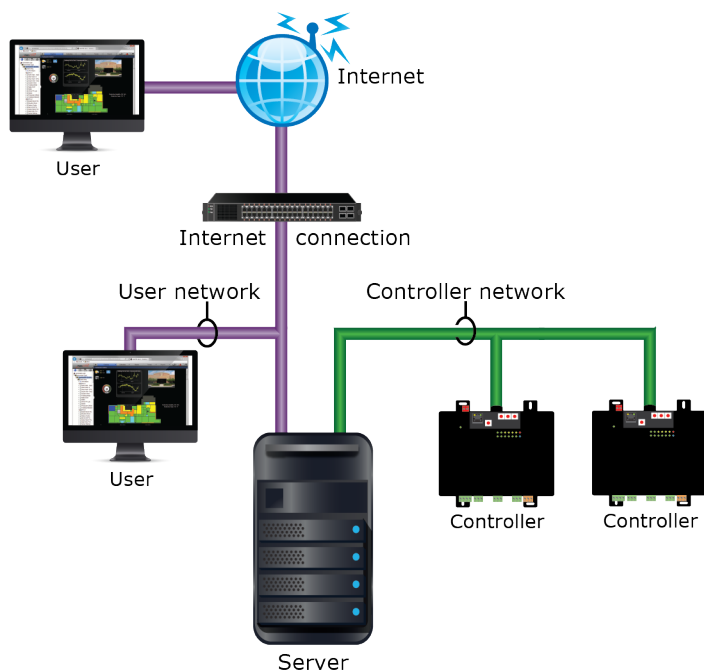
The i-Vu® Pro system's connection to the Internet may vary greatly based on the client's needs and IT capabilities. The following possible network scenarios are listed in order of DECREASING security.

Scenario A: Isolated Network - Low risk



Do not permanently expose the i-Vu® Pro server or the BACnet network to the Internet. You can, however, allow users to access the i-Vu® Pro server through a secure VPN connection. If a NAT router or firewall is present on the LAN for other purposes, it should not have any ports forwarded to the i-Vu® Pro server or any controllers.

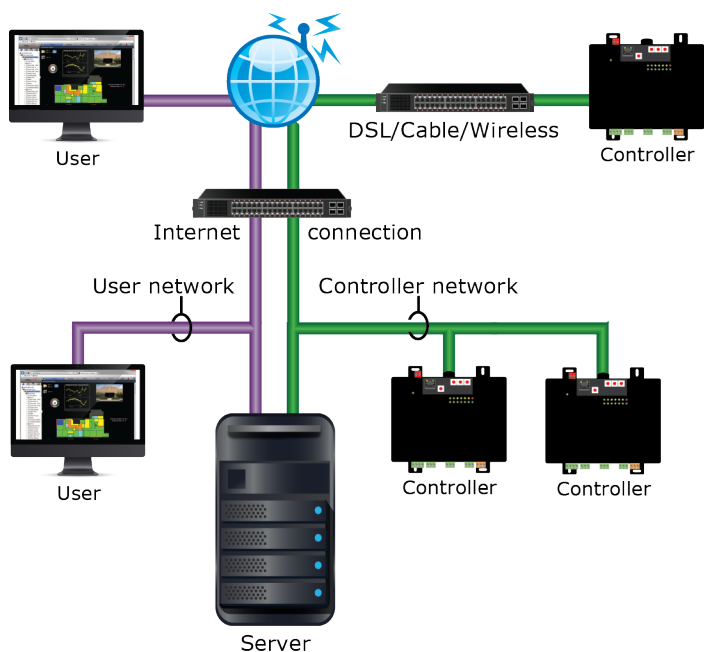
Scenario B: Public Users - Medium risk



It is acceptable to permanently expose the i-Vu® Pro server on the Internet as long as:

- The BACnet network is not exposed.
- The NAT/Firewall device exposing the i-Vu® Pro system exposes only TCP ports 80 and 443 on the i-Vu® Pro server.
- BACnet traffic on UDP port 47808 is not exposed.

Scenario C: Public Users with Distributed BACnet - High risk



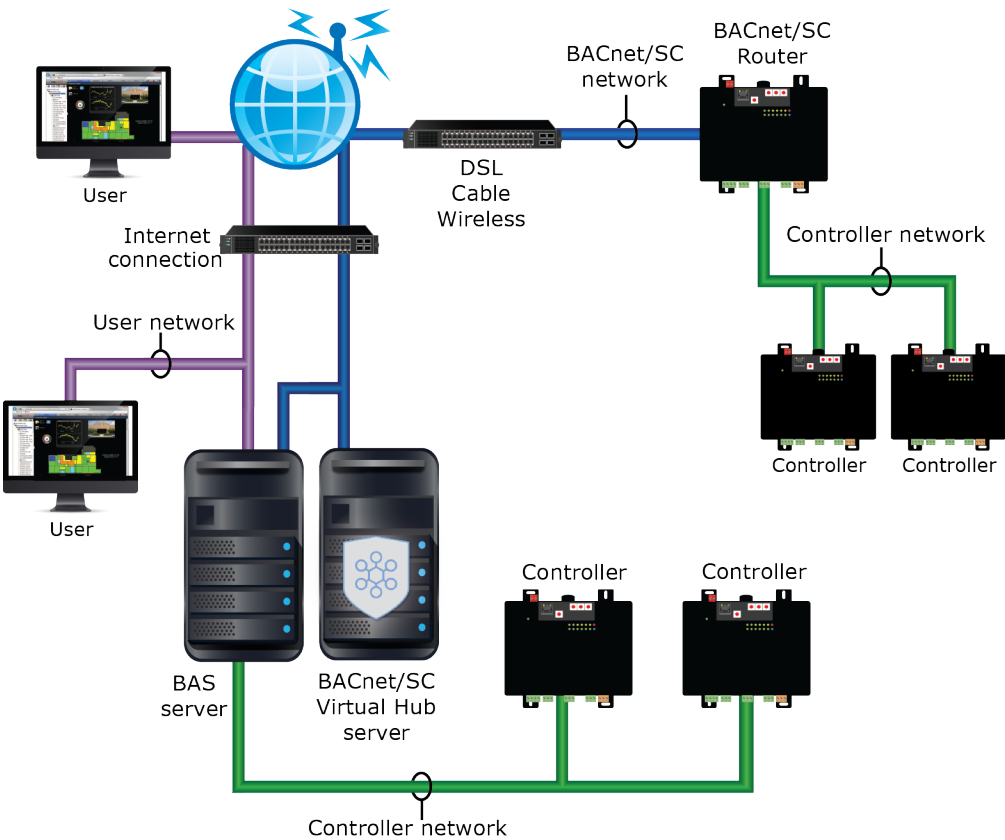
In this configuration, both users and BACnet controllers use a public network/Internet. Carefully plan this configuration to maximize security.

If the i-Vu® Pro server must connect to multiple sites over the Internet, connect them using a VPN to form a Wide Area Network that is secure (changing this to Scenario A).

If this is not possible, use the BACnet Firewall feature in Ethernet-capable controllers, or protect controllers with a whitelist that your IT department can configure in each Internet connection device where the network connects to the Internet. The whitelist allows communication with your i-Vu® Pro system only from devices whose public IP addresses are in the list. Often, the only address controllers need to talk to is the i-Vu® Pro server. The i-Vu® Pro server firewall's whitelist will have to include the public address of all remote IP controllers.

DO NOT connect BACnet controllers to the Internet without at least whitelist protection! If you do, they could easily be discovered and modified by anyone on the Internet. If a BACnet router is connected to the Internet without protection, then the entire network connected to it is accessible.

Scenario D: Public Users with Distributed BACnet/SC - Low risk



BACnet Secure Connect, or BACnet/SC, is an industry standard way of securing BACnet communications over the internet without the need for VPNs. A BACnet/SC network consists of multiple nodes connecting through a central hub. This hub can be located on premises or hosted on the Internet. The figure above depicts the BACnet/SC Hub installed on premises.

Network firewall

Limit the ports opened through any firewall or NAT port forwarding to the minimum ports required. The i-Vu® Pro system uses the following ports:

Port	Transfer	Protocol/User	Use
80 (default)	TCP	HTTP (Web server)	Client/Server
443 (default)	TCP	HTTPS (Web server)	Client/Server

Port	Transfer	Protocol/User	Use
443 (default)	TCP	WSS (secure WebSocket for BACnet/SC)	Client
47806 (default)	TCP	Alarm Notification Client	Client/Server
47808	UDP	BACnet/IP	Server/i-Vu router
47808	TCP	Diagnostic Telnet *	Client/Server
47812	UDP	CCN/IP	i-Vu CCN router/ Server
50005 50007 50008	UDP	CCN/IP	Server/i-Vu CCN router
50005 - 50008	UDP	Firmware CCN/IP	CCN router to CCN router

* This functionality is off by default. You can start it using the `telnetd` console command.

Scenarios B or C in the previous section require TCP ports 80 and 443 to be exposed to the Internet for user access.

Scenario C also requires UDP port 47808 to be exposed for both the server and the controller's firewall. If you do this, you **MUST** use a whitelist to limit connectivity.

Scenario D may require configuration of an outgoing port for BACnet/SC traffic and/or an incoming port protecting a BACnet/SC Hub.

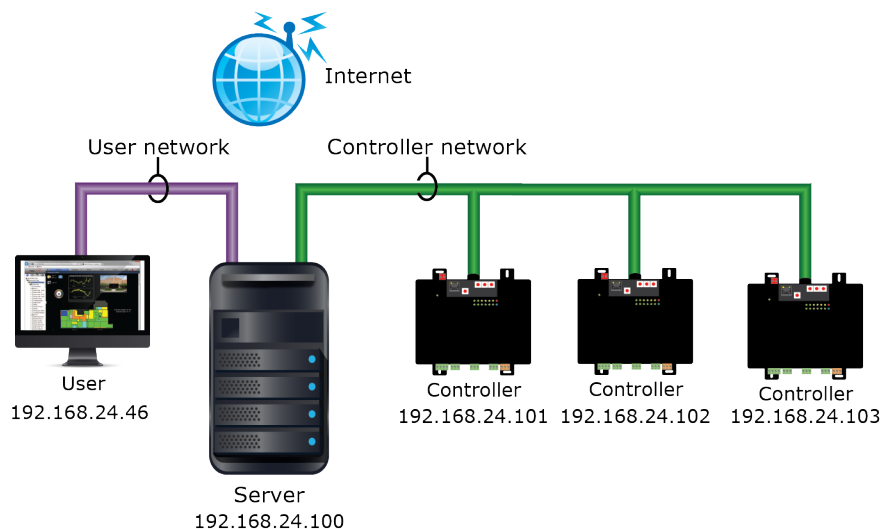
BACnet firewall

The `drv_fwex` and `drv_gen5` drivers for XT and TruVu controllers, and the v6-02 or later drivers for Carrier controllers with Ethernet capability, have a BACnet firewall feature that allows you to restrict BACnet/IP communication with the controller to all private IP addresses and/or to a whitelist of IP addresses that you define. This feature provides another layer of security for your system.

The following are examples of use cases for the BACnet firewall and instructions for setting it up.

Case 1: Isolated network

While an isolated network is secure from threats on the Internet, other users or devices on the local network can potentially interfere with controllers.

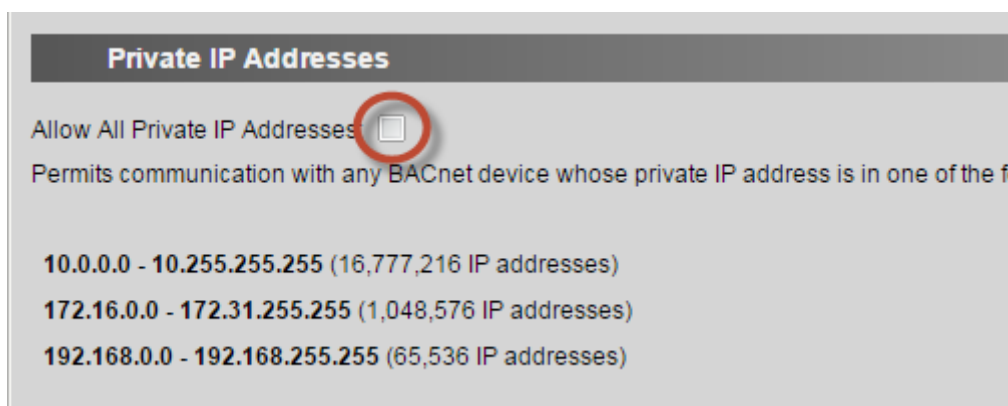


In this example, each controller's BACnet firewall should allow BACnet communication from the i-Vu® Pro server's IP address and the controller's IP addresses. The user at 192.168.24.46 should not be allowed BACnet communication with the controllers.

The server and controllers addresses fall within the private IP address range of 192.168.0.0 to 192.168.255.255, but restricting BACnet communication to all private IP addresses is not sufficient since that would allow communication from the user. So a whitelist must be created in the BACnet firewall.

To set up the BACnet firewall:

1. In the i-Vu® Pro interface, right-click each controller and select **Driver Properties**.
2. Select **BACnet Firewall > Properties** tab.
3. Check **Enable BACnet firewall**.
4. Uncheck **Allow All Private IP Addresses**.



5. Check **Enable Whitelist**.

6. On the first row, check **Enable**, check **Use IP Range**, and then enter the address range 192.168.24.100 through 192.168.24.103.

Whitelist

Enable Whitelist ☒

Permits communication only with BACnet devices that you specify in the whitelist table below

For each single IP address entry, select **Enable**, and then enter the address in the **First IP Address** then enter the last address in the range in the **Last IP Address** column.

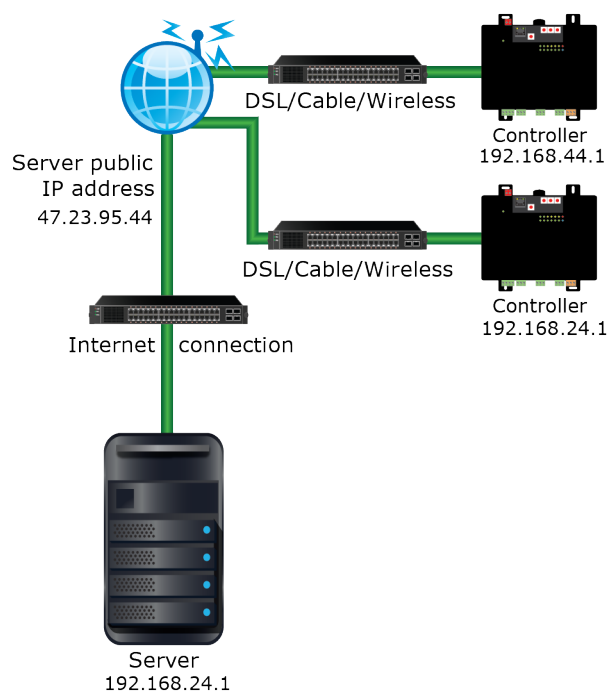
Index	Enable	First IP Address	Use IP Range	Last IP Address
1	<input checked="" type="checkbox"/>	192.168.24.100	<input checked="" type="checkbox"/>	192.168.24.103
2	<input type="checkbox"/>	0.0.0.0	<input type="checkbox"/>	

7. Click **Accept**.
8. Wait for the page to update, and then check **Confirm firewall settings**.

NOTE In this example, the server and controllers IP addresses are sequential so the whitelist could have an address range. If you anticipate future controller expansion, reserve extra sequential addresses so that you can simply expand the range in the BACnet firewall settings. If the IP addresses are not sequential, you must enter each IP address on a separate line and check **Enable**.

Case 2: Individual controllers exposed to the Internet

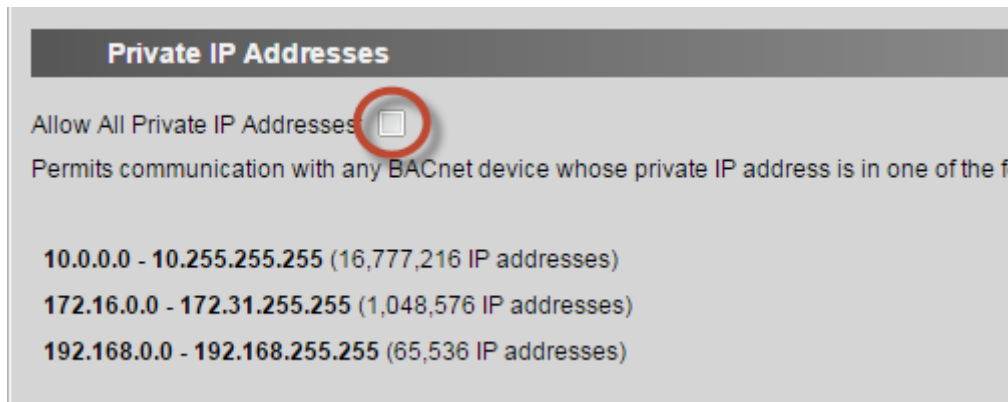
Controllers that are accessible on the Internet (for example, behind a DSL, cable, or wireless device) may not be protected by a network firewall or whitelist. This may be due to the network firewall's lack of capability or difficulty in setting it up.



In this example, each controller needs to communicate with only the i-Vu® Pro server so their BACnet firewall's whitelist should have only the server's public IP address. The controllers do not need to communicate with each other.

To set up the BACnet firewall:

1. In the i-Vu® Pro interface, right-click each controller and select **Driver Properties**.
2. Select **BACnet Firewall > Properties** tab.
3. Check **Enable BACnet firewall**.
4. Uncheck **Allow All Private IP Addresses**.



Private IP Addresses

Allow All Private IP Addresses ☐

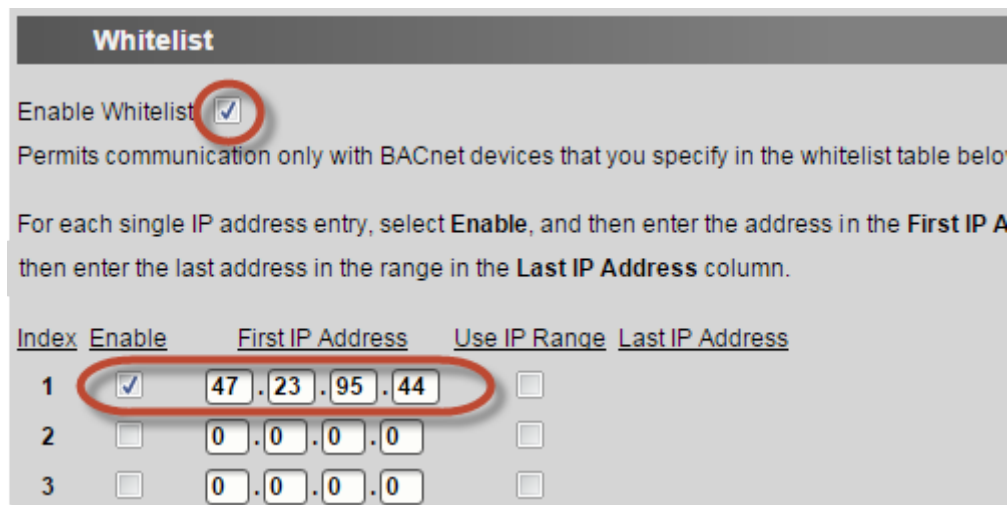
Permits communication with any BACnet device whose private IP address is in one of the following ranges:

10.0.0.0 - 10.255.255.255 (16,777,216 IP addresses)

172.16.0.0 - 172.31.255.255 (1,048,576 IP addresses)

192.168.0.0 - 192.168.255.255 (65,536 IP addresses)

5. Check **Enable Whitelist**.
6. On the first row, check **Enable**, and then enter the address 47.23.95.44.



Whitelist

Enable Whitelist ☒

Permits communication only with BACnet devices that you specify in the whitelist table below.

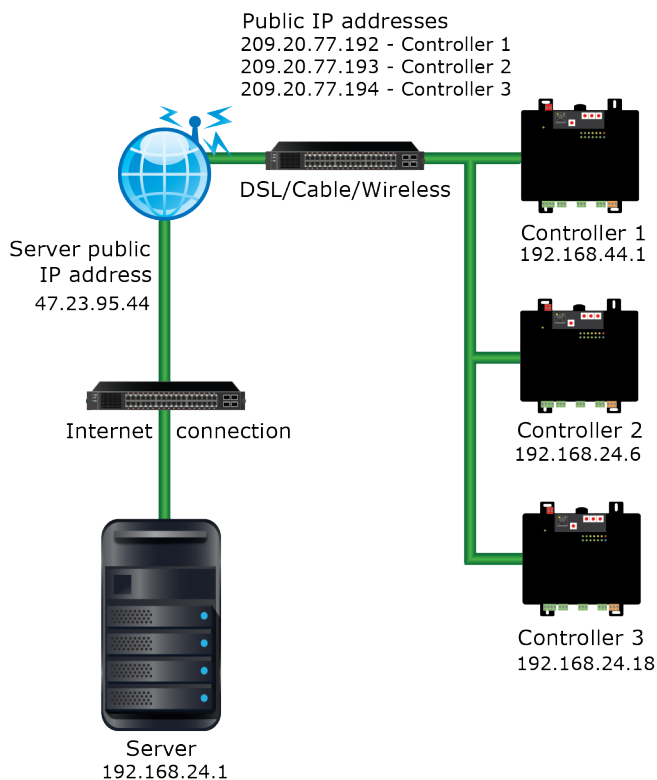
For each single IP address entry, select **Enable**, and then enter the address in the **First IP Address** column. If you want to specify a range of IP addresses, select **Use IP Range**, then enter the last address in the range in the **Last IP Address** column.

Index	Enable	First IP Address	Use IP Range	Last IP Address
1	<input checked="" type="checkbox"/>	47 . 23 . 95 . 44	<input type="checkbox"/>	
2	<input type="checkbox"/>	0 . 0 . 0 . 0	<input type="checkbox"/>	
3	<input type="checkbox"/>	0 . 0 . 0 . 0	<input type="checkbox"/>	

7. Click **Accept**.
8. Wait for the page to update, and then check **Confirm firewall settings**.

Case 3: Multiple controllers exposed to the Internet at one site

Multiple controllers that are accessible on the Internet (for example, behind a DSL, cable, or wireless device) may not be protected by a network firewall or whitelist. The controllers have private IP addresses, but it is their public IP addresses that are exposed to the Internet.

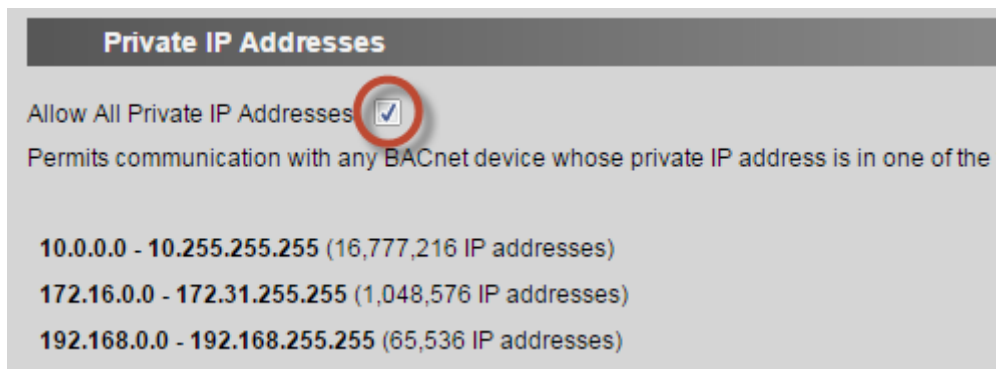


In this example, the controllers need to communicate with the i-Vu® Pro server and each other. The controllers are the only devices on the site's private network, or other devices present are benign.

Each controller's BACnet firewall should allow BACnet communication with the i-Vu® Pro server's public IP address and with all private IP addresses so that the controllers can communicate with each other. The BACnet firewall prevents BACnet communication to the controller's public addresses.

To set up the BACnet firewall:

1. In the i-Vu® Pro interface, right-click each controller and select **Driver Properties**.
2. Select **BACnet Firewall > Properties** tab.
3. Check **Enable BACnet firewall**.
4. Check **Allow All Private IP Addresses**.



5. Check **Enable Whitelist**.

6. On the first row, check **Enable**, and then enter the address 47.23.95.44.

Whitelist

Enable Whitelist ☒

Permits communication only with BACnet devices that you specify in the whitelist table below.

For each single IP address entry, select **Enable**, and then enter the address in the **First IP Address** column. Then enter the last address in the range in the **Last IP Address** column.

Index	Enable	First IP Address	Use IP Range	Last IP Address
1	<input checked="" type="checkbox"/>	47 . 23 . 95 . 44	<input type="checkbox"/>	
2	<input type="checkbox"/>	0 . 0 . 0 . 0	<input type="checkbox"/>	
3	<input type="checkbox"/>	0 . 0 . 0 . 0	<input type="checkbox"/>	

7. Click **Accept**.
8. Wait for the page to update, and then check **Confirm firewall settings**.

Users

Follow the guidelines below to limit unauthorized user access.

- **Policy exemptions**—Run the **Security > Operator Information** report to determine if any existing users are exempt from Automatic Logoff or the system's Password Policy, and remove those exemptions. All users, including administrator users, should be compliant with security policies.
- **Advanced password policy**—Enable the advanced password policy and require a minimum password length of at least 8 characters. This will disallow blank passwords.
- **No shared accounts**—Create a different account for each user. DO NOT create role-based accounts where multiple users log in with the same login name and password.
- **Delete old accounts** - Manage accounts when people no longer need access to the i-Vu® Pro system. Delete their account or change their password.
NOTE Run the **Security > Operator Information** report to check the following statuses.
 - Operators never logged in: ###
 - Operators last login > 180 days: ###
- **Auto Logoff** - Verify that **Log off operators after __ (HH:MM) of inactivity** is checked on the **System Settings > Security** tab.
NOTE You can disable this for an individual user (for example, an account for a monitoring center).
- **Policy exemptions** - Run the **Security > Operator Information** report to determine if any existing users are exempt from **Automatic Logoff** or the system's **Password Policy**, and remove those exemptions.
- **Lock out users**—Verify that **Lock out operators for __ minutes after __ failed login attempts** is checked.
- **Location-dependent security**—Consider using the optional location-dependent security policy. For large systems with many users, you can restrict users to only the locations they should have access to.

i-Vu Pro server

Follow the guidelines below to protect the i-Vu Pro server.

- **Patches**—Keep the i-Vu Pro system and the operating system up-to-date with the latest patches.

- **Anti-virus protection**—Keep the i-Vu Pro server's anti-virus software and definitions up-to-date.
- **Single-use server**—i-Vu Pro software should be the only application running on the server. DO NOT put other applications on the same server.
- **HTTPS**—Use https:// with a certificate signed by a standard certificate authority, when possible. If using a self-signed certificate, install the server certificate on the client computers so users do not develop the bad habit of ignoring the "unsafe certificate" error.
- **Remote access**—After commissioning, uncheck **Allow remote file management** on the **System Settings > Security** tab.
- **Device Password**—This password is only available on systems with one or more controllers with the Gen_5 driver. Setting the **Device Password** as described in the *i-Vu® Pro v8.0 Help* provides an additional level of security.
- **Installed Applications**—**Installed Applications** includes the full set of applications. There are no options to exclude certain applications during installation. Any applications that should not be available on the i-Vu® Pro server can be deleted from the installation folder.
- **File permissions**—The default file permissions of a product installation may not be the most secure setting depending on the installation needs. It is recommended that file permissions be examined after installation and configured to ensure that only authorized users and service accounts can access and modify files to the installation and data directories.

Database server

Follow the database server vendor's best practices for a secure installation. This should include steps such as changing default accounts and passwords.

Configure the database server to accept connections only from the i-Vu® Pro system. Most database servers have a whitelist mechanism to facilitate this.

Device-specific security

Devices with a drv_gen5 driver support the following device-specific security options.

- Configure the security settings on all service ports, as described in the *Adjusting driver properties and controller setup through the Service Port* section of your devices technical instructions.
- Network Time Protocol (NTP) - NTP provides a more secure means of keeping a device's clock in sync.

Appendix A: Glossary

BAS—A Building Automation System is a collection of BACnet and/or CCN devices, the i-Vu Pro server, and the network(s) they reside on.

LAN—A Local Area Network is a computer network that interconnects computers/devices within a limited area such as an office building.

Firewall—A device that restricts network traffic. Firewall functionality is often combined with IP Router functionality in a single device. A firewall is configured with rules to define what kind of traffic is allowed or blocked. Personal computers and servers have firewall functionality built into them.

IP router—An IP (Internet Protocol) device that connects two or more IP networks. Typically an IP router connects a local network to the larger enterprise/Internet network.

NAT router—An IP router that remaps IP addresses from one network to one or more IP addresses on another network. A NAT router is commonly used to connect devices on a private network to the Internet or enterprise network, and it often has firewall and port forwarding capabilities.

Port—A port is a 16 bit (0-65535) number associated with an IP address that defines an endpoint of a computer network connection. There are two types of ports, TCP and UDP. BACnet uses a UDP port. HTTP, HTTPS and Alarm Notification Client use TCP ports. To manage access to a port in a firewall, you must know its number and type.

Private IP address—An IP address in one of the following ranges:

10.0.0.0 – 10.255.255.255

172.16.0.0 – 172.31.255.255

192.168.0.0 – 192.168.255.255

VLAN—A Virtual Local Area Network is partitioned and isolated by the IP network switch (or router). It is typically as effective as physically separating the network.

VPN—A Virtual Private Network is a method for extending a private network across a public network, such as the Internet. A VPN enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network, and they benefit from the functionality, security and management policies of the private network.

Whitelist—A list of IP addresses that are the only ones allowed through a firewall. Advanced firewall devices can have different whitelists for a given port or protocol.

Appendix B: Security checklist

Physical network security

- ☐ Ensure proper measures are in place to protect and restrict access to the network hardware. See [Physical network security](#) (page 5).

Designing and Planning

- ☐ Separate user and BACnet networks either physically or with a VLAN.
- ☐ Determine the appropriate Internet connection scenario. See Internet connectivity scenarios.
- ☐ Use BACnet/SC when possible. BACnet/SC encrypts BACnet communications over the network to prevent information disclosure and supports device authentication to prevent spoofing.

Installing

If you have dual NICs:

- ☐ Enter the i-Vu Pro user network IP address and subnet mask in SiteBuilder on the **Configure > Preferences > Web Server** tab .
- ☐ Enter the i-Vu Pro BACnet network IP address and subnet mask in the i-Vu Pro interface on the **Connections** page > **Configure** tab.

If using Internet connectivity scenario A:

- ☐ Verify that IP addresses for the i-Vu Pro server and controllers are in one of the private IP address ranges.

If using Internet connectivity scenario B:

- ☐ Verify that controller IP addresses are in one of the private IP address ranges.
- ☐ Verify that the NAT router or firewall exposing the i-Vu Pro server only exposes TCP ports 80 and/or 443.

If using Internet connectivity scenario C:

Appendix B: Security checklist

- ☐ Verify that the NAT router or firewall exposing the i-Vu Pro server only exposes TCP ports 80 and/or 443, and UDP port 47808.
- ☐ Verify that each NAT router or firewall used (for both the server and each controller) has been configured with an appropriate whitelist of allowed IP addresses in your Internet connection device, or each controller is protected by its internal BACnet firewall feature.
- ☐ Test the whitelist protection from the Internet. Use a separate i-Vu Pro server on a public network by using a modstat like "modstat mac:0,b:1.2.3.4". Confirm you cannot access any of the system's controllers.
- ☐ Change the Administrator login name and add a password.
- ☐ If you are running a pre-v6.5 system, remove the Anonymous user account.
- ☐ Verify that the i-Vu Pro server's anti-virus software is up-to-date and is set to update automatically.
- ☐ Configure the database server to accept connections only from the i-Vu Pro application using a whitelist.

After Commissioning

- ☐ Enable the Advanced password policy and set the minimum password length to at least 8 characters.

On the **System Options > System Settings > Security** tab, verify that:

- ☐ **Allow remote file management** is not checked
- ☐ **Log off operators after __ (HH:MM) of inactivity** is checked
- ☐ **Lock out operators for __ minutes after __ failed login attempts** is checked

On SiteBuilder's **Configure > Preferences > Web Server** tab, verify that the following are not checked:

- ☐ Any **TLS Level** below "TLS 1.3"
- ☐ **Allow SOAP applications over HTTP**
- ☐ **Allow unsigned add-ons**
- ☐ Disable access to device service ports (drv_gen5 devices only). See the Configuration Access section of the device's security driver page.
- ☐ Use NTP (drv_gen5 devices only) rather than BACnet timesync to keep the device's clock in sync.

System Maintenance

- ☐ Install the latest software updates to keep the system current with the most recent security enhancements.

To quickly check security measures in place

In the i-Vu® Pro interface, use the *Security Review Report* to view your system's critical security compliance. These settings are described in more detail in the document above.

The *Security Review Report* displays the following:

Web Server	Possible responses	Recommendation for the most secure system
SSL Mode	HTTP, HTTPS, or HTTP & HTTPS	HTTPS
TLS in use	yes or no	yes (when SSL Mode is on or both)
TLS protocol	Version number	TLS 1.3
TLS Redirect HTTP to HTTPS	yes or no	yes (when SSL Mode is both)
Allow unsigned add-ons	yes or no	no
Allow SOAP over HTTP	yes or no	no
Reads X-Forwarded-For Header	yes or no	no
Certificate	Possible responses	Recommendation for the most secure system
Self-signed certificate in use	yes or no	no
Certificate issued by	Distinguished Name of the certificate signer	certificate information, not a setting
Certificate expired	yes or no	certificate information, not a setting
Certificate not yet valid	yes or no	certificate information, not a setting
Certificate expires	date and time the certificate becomes invalid	certificate information, not a setting
Possible responses		Recommendation for the most secure system
Email		
Secure SMTP enabled on email server	yes or no	yes
Passwords		
Operators never logged in:	number	0
Operators last login > 180 days	number	0
Password policy enforced	yes or no	yes
Exempt from password policy	number	0
Updates		
Latest cumulative update applied:	none or date	Keep the i-Vu® Pro system and the operating system up-to-date with the latest patches.

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*
		No updates yet	

* For internal use only



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