



# CAS BACnet BBMD CAS-1000-06

Chipkin - Enabling Integration

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## BBMD Description

BACnet/IP networks use UDP to communicate. UDP is a connectionless protocol therefore when a message is broadcasted on one subnet, routers do not forward the message onto other subnets. This means that a BACnet Client will not be able to discover other BACnet servers on different subnets using a UDP broadcast Who-Is message.

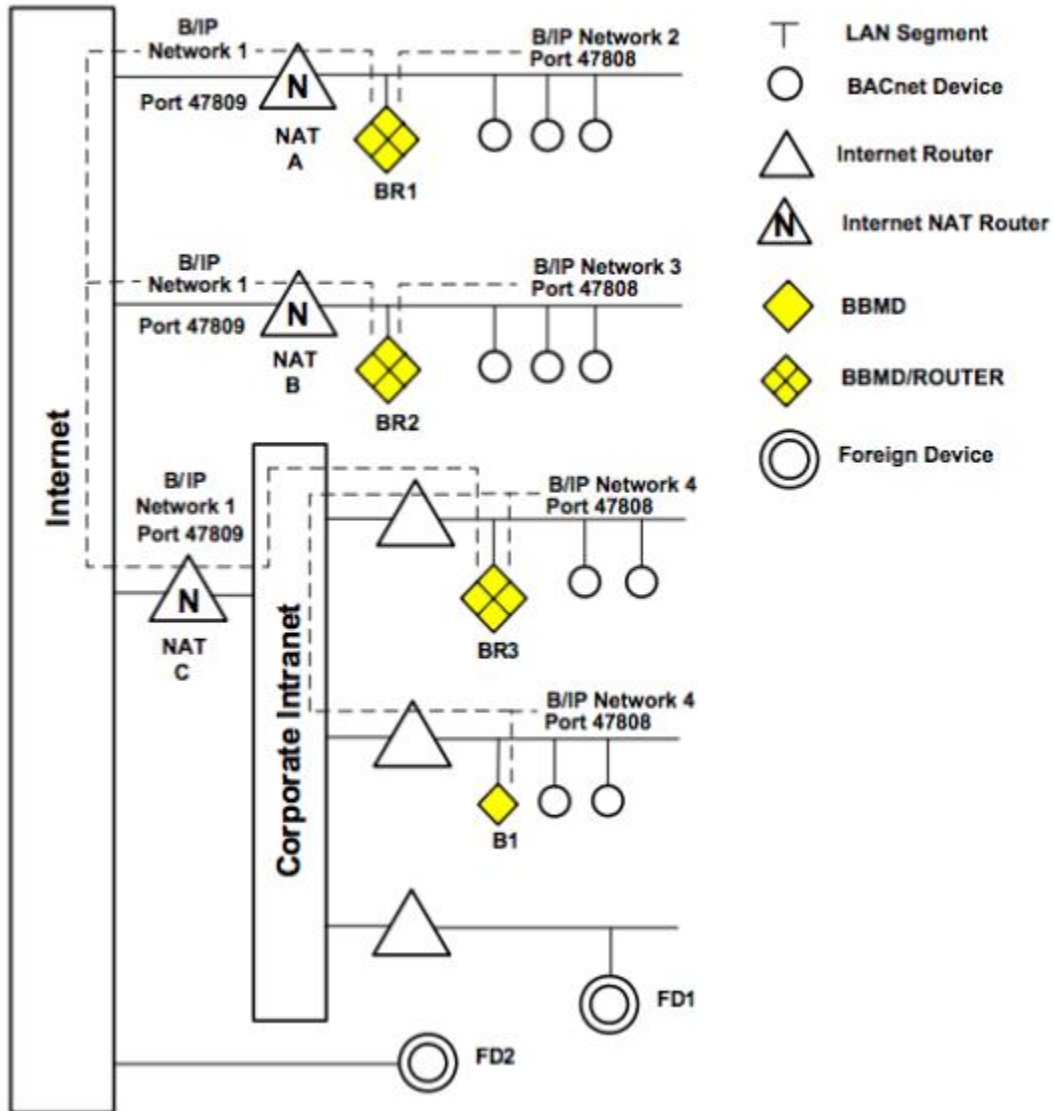
Generally, each subnet would need to have its own client configuration device to monitor and update BACnet devices comprising the network. Broadcast messages, such as network discovery, are not forwarded through routers and will only be transmitted to devices on the same subnet. This means that clients can only discover and configure BACnet devices that exist on the same subnet. This would make it difficult to configure a large BACnet network consisting of several subnets as you would need a client for each subnet.

A BACnet Broadcast Management Device (BBMD) offers a solution to this problem by forwarding broadcast messages across subnets. This allows BACnet devices to discover other devices on separate subnets and get the necessary information to communicate with them.

The CAS BACnet BBMD application provides a means for BACnet devices on different subnetworks to send and receive broadcast messages from each other through message forwarding. This allows for the creation of a large BACnet network comprising several different subnets which is useful for a facility that contains many subnets. With the introduction of a BBMD to each subnet, a single client can discover and configure BACnet devices and networks on other subnets.

# Connection Diagram

This block diagram lists a common configuration for multiple BACnet devices spread across different subnets.



## BBMD Configuration

To configure the BBMD application, run the executable file for the application to generate settings files.

### 1.1 Configure the BACnet Device

The CAS BACnet BBMD application has several user-configurable options for the device properties and log enabling. These settings are controlled in the settings.csv file and are loaded upon application startup. If a settings.csv file does not exist, the application will generate a default one.

The following settings can be configured in the Settings.csv file:

Column Title	Function	Legal Values
Device Instance	The instance of the device on the network	<b>389999</b> <sup>(1)</sup>
Device Name	The name of the BACnet device	<b>Chipkin BBMD</b>
Device Description	The description of the BACnet device	<b>Chipkin BACnet BBMD device</b>
BACnet UDP Port	The UDP port of the network the BACnet device will participate in	<b>47808</b> <sup>(2)</sup>
Logging Level	Changes how much information will be displayed to the output window	<b>DEBUG, INFO</b>

\* Bolded values are defaults

1. Must be unique on network
2. Can be any UDP port

Save the settings.csv file and launch the application in the same folder. If successful, the application will display the loaded configuration settings on start-up:

```
[10:47:01.077] INFO: Loading configuration from settings.csv file...
[10:47:01.078] INFO: Device instance: 389999
[10:47:01.078] INFO: Device name: Chipkin BBMD
[10:47:01.078] INFO: Device description: Chipkin BACnet BBMD device
[10:47:01.078] INFO: Device port: 47808
[10:47:01.079] INFO: Logging level: DEBUG
[10:47:01.079] INFO: OK
```

### 1.2 Configure the Broadcast Distribution Table

A typical broadcast distribution table (BDT) will be configured with the host BBMD address and a BBMD address for every subnet on the larger network. Also note that each subnet mask associated with each address will be the same for every BBMD's table. Refer to (TBD) for more information on the BDT. If the broadcastdistributiontable.csv file does not exist, the application will generate one.

Entries are stored in the broadcastdistributiontable.csv file as follows:

Column Title	Function	Legal Values
IP Address	The IP Address of a BBMD	IP Address including port in the format #.#.#.#:#
Broadcast Distribution Mask	The subnet mask of the BBMD	Subnet mask in the format #.#.#.#

Save the broadcastdistributiontable.csv file once it is configured with the proper table for your network. Launch the application to load the new table or press “R” during operation to reload the file. The BDT may be displayed at any time by pressing “B” in the application window.

```
[10:13:50.247] INFO: Broadcast Distribution Table:
[10:13:50.248] INFO: 0: IP Address: 192.168.1.12:47808, Mask: 255.255.255.255
[10:13:50.248] INFO: 1: IP Address: 192.168.4.229:47808, Mask: 255.255.255.255
```

### 1.3 Configure the Network Adapter

The application allows the user to select which network adapter on the device the application will operate on. The application will read the properties of the selected network adapter and configure the application accordingly. This includes identifying the local IP address and subnet mask for use with the BDT. If the adapters.csv file does not exist, a default one will be generated with a list of found network adapters on the local device.

Entries are stored in the adapters.csv file as follows:

Column Title	Function	Legal Values
Adapter	The MAC address of a network interface	MAC address in hex in the format x-x-x-x-x-x
Enabled	Selects the adapter to be used for the application	0 – Disabled 1 – Enabled

Save the adapters.csv file once it is configured with the network adapter you wish to use. Note that only one may be activated at a time. Activating more than one will default to using the first one on the list and produce an error.

### 1.4 Run the Application

Once the settings.csv, broadcastdistributiontable.csv, and adapters.csv files are configured correctly, you may run the BBMD application using the included executable. Both settings files should be in the same folder as the BBMD application executable.

If the BBMD is successfully set up, the following will be displayed:

```
[14:01:49.853] INFO: Setting up BBMD
[14:01:49.853] DEBUG: Loading entries from BroadcastDistributionTable.csv...
[14:01:49.853] DEBUG: OK
[14:01:49.854] DEBUG: Enabling BBMD Functionality...
[14:01:49.854] DEBUG: OK
[14:01:49.854] INFO: OK
```

The BACnet device is now operating as a BBMD and will forward broadcast messages to other BBMDs in its BDT. The BBMD also supports discovery and will respond to Who-Is messages on the network.

## 1.5 Application Operation

You may issue several commands to the application. If you press the H key and hit enter, the following menu will be displayed:

```
CAS BACnet Stack BBMD v0.0.1.0
Help:
- Q - Quit
- F - Display Foreign Device Table
- B - Display Broadcast Distribution Table
- R - Reload Broadcast Distribution Table from File
- L - Clear Foreign Device Table
```

These commands will display various properties pertaining to the BBMD's current operation. The BBMD may use a new BDT without stopping operation by reloading the new BDT from the file.

## 1.6 Registering Foreign Devices

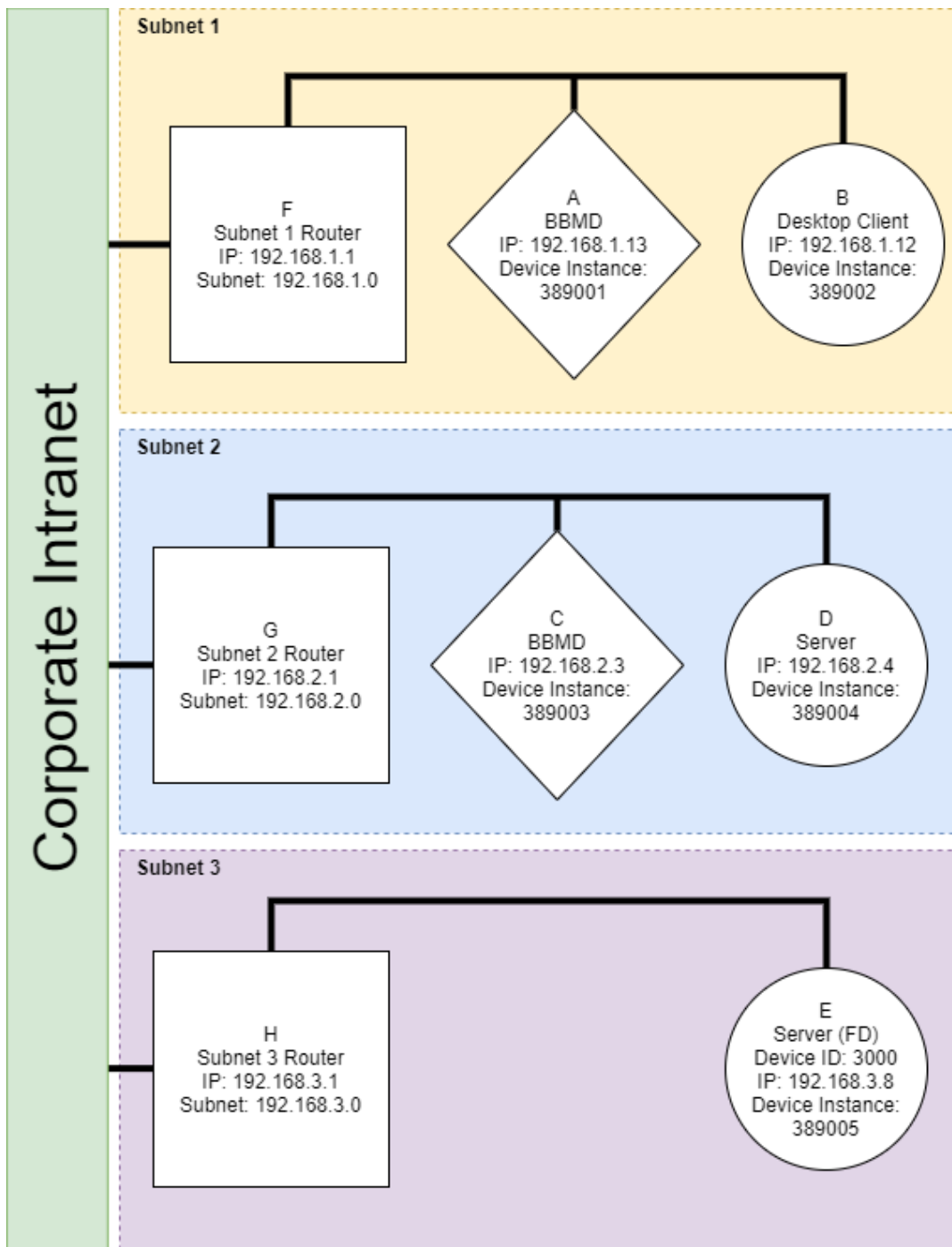
Once a foreign device registers with a BBMD, the BBMD's foreign device table (FDT) will be updated with an entry containing the foreign device's IP address, time to live, and time Remaining. BBMD will forward any received broadcast or forwarded messages to the foreign device as long as the entry exists in its FDT. The BBMD's FDT can be displayed in the application by typing "F" in the application window. For more information on the FDT and foreign devices, refer to the Foreign Device Table section of this manual.



## Quick Start Guide

This guide will describe the steps to setting up a basic BACnet network with three subnets. Each subnet will either have a BBMD and a BACnet server device or a foreign device to showcase the message forwarding functionality of the application. Routing between the subnetworks is outside the scope of this guide.

### 2.1 Device Setup



**IP Subnet 1:**

- BBMD running the BBMD application
- Server device
- Client device

**IP Subnet 2:**

- BBMD running the BBMD application
- Server device

**IP Subnet 3:**

- Server device capable of foreign device registration

Example server and client devices can be found on the Chipkin Automation Systems Github page at <https://github.com/chipkin>.

The server device on subnet 3 must be capable of sending foreign device registration requests or support the BIBB Network Management-Foreign Device Registration-A (NM-FDR-A).

## 2.2 Device Configuration

You may use the sample configurations in the Appendix B of the manual or run the application once to have sample files generated for you. Each device running the BBMD application will have a broadcastdistributiontable.csv that is configured as follows:

IP Address	Broadcast Distribution Table
192.168.1.1:47808	255.255.255.255
192.168.2.1:47808	255.255.255.255

The IP address of each device is in the format x.x.x:xx eg. 192.168.1.10:47808. The masks are configured so that each BBMD will forward messages as unicast messages, or one-hop distribution. More details on this configuration can be read in the Broadcast Distribution Table section of this guide.

The settings.csv file that is generated by default, or the example configuration in the configuration section of this guide, will need to be modified to change each device's instance. Their settings may be further changed if desired.

The adapters.csv file will need to be configured to use the network adapter the BBMD will operate on. A default adapters.csv file will be created by the application which will contain a list of the found network adapters on the device. An adapter will be selected by default, but this may not be the correct adapter for your device configuration.

## 2.3 Running the Application

When the `broadcastdistributiontable.csv` and `settings.csv` files have been configured properly, it is time to run the BBMD application. Startup the client, servers, and BBMDs in no specific order. The BACnet network is now operational and broadcast messages will be forwarded between subnet 1 and subnet 2. We will allow the foreign device to participate in this network in the following step.

If the application fails to start up, please refer to the troubleshooting section of this guide.

## 2.4 Registering the Foreign Device

For the foreign device to participate in the BACnet network, since there are no BBMDs or other BACnet devices on its subnet, it must register with a BBMD to be eligible to receive forwarded messages. This is done by sending a Register-Foreign-Device BVLL message to a BBMD. Because the BBMDs forward any broadcast messages between each other, the BBMD the foreign device registers with does not matter as it will receive any forwarded messages. For more information on foreign devices, please refer to the Foreign Device Table section of the manual.

## 2.5 Testing the Network

The network is now fully configured. To check or modify the contents of either devices' BDT or FDT, you may refer to the Usage section of the manual.

To test the ability to forward messages, broadcast a Who-Is message from the Client Device. Every server device and BBMD on the network should respond with an I-Am, allowing the client to detect any device on any subnetwork.

The foreign device may test functionality by issuing a distribute-broadcast-to-network BVLL message while it is configured as a registered foreign device. This message will be sent to the BBMD it is registered with, and the BBMD shall forward the message to its own subnet as well as the other BBMD's subnet.

You may refer to Appendix A of this guide for various testing tools you may use to verify or debug application functionality.

## BBMD Test tools

A list of BBMD testing tools that you can use to test the functionality of your system.

### CAS BACnet Explorer

The CAS BACnet Explorer is a tool for testing, debugging, and discovering BACnet networks and devices. This is useful for polling information from devices on the same BACnet network or from different subnetworks.

<https://store.chipkin.com/products/tools/cas-bacnet-explorer>

### Wireshark

Wireshark is a tool for viewing and monitoring network packets that pass through your local device's interface. This may be useful for verifying that packets are being routed properly.

<https://www.wireshark.org/>

## Tables

### Broadcast Distribution Table

The Broadcast Distribution Table (BDT) contains the address of BBMDs on other subnets comprising the BACnet network. Every BBMD in a BACnet network must be configured with the same BDT for proper operation.

Each entry in the BDT contains two properties: The IP address of a BBMD on another subnet and the BBMD's broadcast distribution mask. Proper BDT configuration requires an entry for the host BBMD device and entries containing the IP address and subnet mask of BBMDs on other subnets for messages to be forwarded to.

Different subnet mask configurations in the BDT can allow the BBMD to perform either in One-Hop or Two-Hop distribution mode.

#### One-Hop:

If the host portion of the subnet mask is configured with all 1's such that the mask is FF.FF.FF.FF, Forwarded-NPDUs will arrive from other BBMDs as a unicast message. This indicates that the BBMD must broadcast the Forwarded-NPDU to its own subnet as it has not been received by devices on the subnet.

#### Two-Hop:

If the host position of the subnet mask is not configured with all 1's such that the mask is FF.FF.FF.00, Forwarded-NPDUs will arrive from other BBMDs as a directed broadcast. This indicates that the message has already been received by devices on the same subnet, causing the BBMD to only forward the message to registered foreign devices.

### Foreign Device Table

The foreign device table (FDT) contains entries for foreign devices that have registered with the BBMD. Being registered allows the foreign device to send Distribute-Broadcast-To-Network messages to the BBMD and for the BBMD to forward broadcast messages to the foreign device. The only method of adding entries to the FDT is via a foreign device sending a Register-Foreign-Device BVLL message.

Each entry in the foreign device table consists of three properties: the IP address, time to live, and time remaining. The IP address is the destination the BBMD uses to forward messages. When a foreign device registers, it must supply a time-to-live which can be between 0-65,535 seconds (approximately 18 hours). This represents how long the foreign device can stay registered with the BBMD and will have its entry purged after the time expires. If reading the table, the time-remaining property represents how long the FDT entry will be maintained before it will be purged. Each foreign device is given a 30-second grace period before its entry will be purged from the table after time expiry.

A recommended value for a foreign device time-to-live may be 3600 seconds, or one hour. If a device re-registers as a foreign device with the BBMD, its entry will simply be updated in the FDT with a new time-to-live. A foreign device may periodically re-register with the BBMD to continue participation in the BACnet network. If a time of 3600 seconds is entered, the foreign device will have to re-register with the BBMD every hour.

The foreign device table is not persistent between reboots of the BBMD. If the BBMD is reset, all foreign devices will need to re-register with the BBMD to participate in the BACnet network.

## Logging

The CAS BACnet BBMD application offers two different methods of logging: INFO level and DEBUG level. Logging information will be displayed in the application window and logs will be outputted to a log.txt file in the application directory. The logging level can be selected in the settings.csv file and each level will display the following:

### INFO

The INFO level will only display minimal information about the application operation. This includes some information about creating the device, loading the settings, and displaying incoming and outgoing messages. You may want to use this mode for normal operation.

### DEBUG

The DEBUG level contains more information about the application operation. This includes all log data in INFO as well as detailed device startup information and rendered XML of any BACnet messages sent or received by the application. You may want to use this mode if you need to debug the application or would like to see detailed information on the messages exchanged by it.

### Wireshark Logs

The application will create Wireshark logs if the logging level is DEBUG. These logs contain messages sent and received by the BBMD and are outputted to the BBMD\_log.pcapng file in the application directory. If the BBMD\_log.pcapng file already exists, the application will append new messages to the existing log file. Please note that these logs do not capture all adapter traffic and should only be used for viewing/testing BBMD functionality. For example, if the BBMD receives a broadcast message, the log will report the destination address as the BBMD rather than the broadcast address.

## Appendix A – Troubleshooting

### Appendix A.1 - Debugging the BBMD Application

- The application is failing to start

#### Check the Adapters Configuration

You may need to verify that the application is using the correct network adapter on your device by checking the adapters.csv file. The configuration of the BDT relies on which adapter settings you use for correct operation. If you are unsure of the adapters on your device, the application will generate an adapters.csv file containing a list of found adapters if the configuration file does not already exist.

#### Check Broadcast Distribution Table Configuration

If the broadcast distribution table is not configured correctly, the application will fail to start. The table must be configured appropriately as outlined in the broadcast distribution table section of this manual. This requires that, at minimum, the table includes an entry containing the host device's IP address and subnet mask. The host device IP address and subnet mask are retrieved from the selected adapter in adapters.csv.

#### Verify proper read/write permissions

If any configuration files do not exist, the application will generate them. However, if the application does not have sufficient permissions to read/write to the disk, it will fail to start and these settings files will not be created. Please check the terminal output and/or the logs for any warnings pertaining to these.

#### Verify network permissions

Make sure the application has sufficient permissions on your device to set up a server on the network. You may need to allow the BBMD application through your firewall to communicate with the network.

#### Verify network configuration

Your computer's main network adapter must be configured correctly as its data is parsed by the application to configure the network port object of the device. If the application is using a different network adapter, it will not launch correctly.

- Messages are not being forwarded

#### Verify BDT configuration

Make sure each BBMD has the same BDT and each entry contains correct IP address and broadcast distribution mask information for each BBMD on the network.

If the BBMDs are configured in one-hop distribution, messages will be forwarded as unicast messages between BBMDs and, upon arrival, will be broadcasted by the BBMD on its local subnet. In two-hop, messages will be forwarded as directed subnet broadcasts.

#### Check network traffic through Wireshark

Verify that the BBMDs are sending forwarding messages properly by monitoring the adapter traffic through Wireshark or another tool. Make sure that the destination of the forwarded packets is accurate to your network configuration.

### Check network configuration

If network packets have the correct destination address, you may need to check your router configuration. Make sure the proper routes are setup between subnets so that the routers forward messages between them.

Not all routers support directed broadcasts. In the case that subnet router does not, you may have to use two-hop distribution mode for that BBMD's subnet. If you are unsure of how to access or find these network parameters, you may need to contact your local IP administrator to check the network permissions.

- **The Foreign Device is not Receiving Messages**

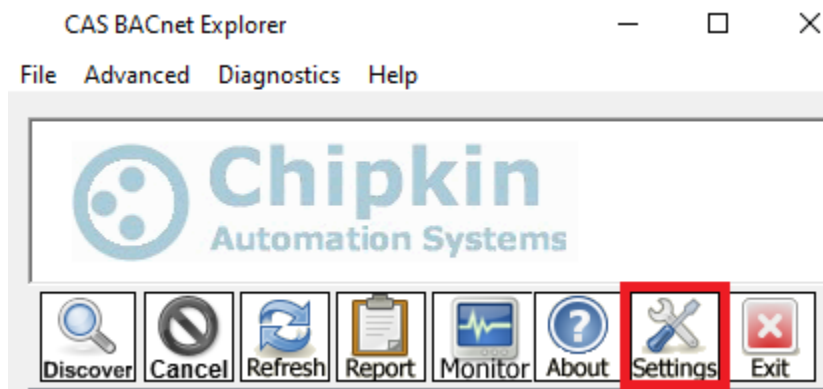
### Check the BBMD's FDT

If the foreign device is not receiving messages, it is possible that its time to live has expired and its entry has been purged from the BBMD's FDT. This can be checked in the application by reading the BBMD's FDT and verifying the entry exists. The foreign device table is not persistent between boots so the foreign device must re-register with the BBMD if the BBMD is reset.

## Appendix A.2 - Using CAS BACnet Explorer for Testing BBMD Forwarding

Follow the steps in this section to setup the CAS BACnet Explorer and parse data from the BBMD and other BACnet devices comprising the network. This application will need to be used on a computer that is not currently running the BBMD application.

1. Download and install the tool: <https://store.chipkin.com/products/tools/cas-bacnet-explorer>
2. In the tool, click on the Settings button:



3. In the Transmit dialog box, Set the settings as follows:

- Networks: BACnet IP
- BACnet IP: 47808 (or port of the other BACnet devices)



- Select a network device: Click on device connected to network

Network

Networks

BACnet IP

BACnet Ethernet

BACnet MSTP

BACnet IP

BACnet IP Port

\* BACnet MSTP MAC address must be unique on the MSTP network.

BACnet MSTP

Comm port

Baud rate

MAC Address \*

Select a network device

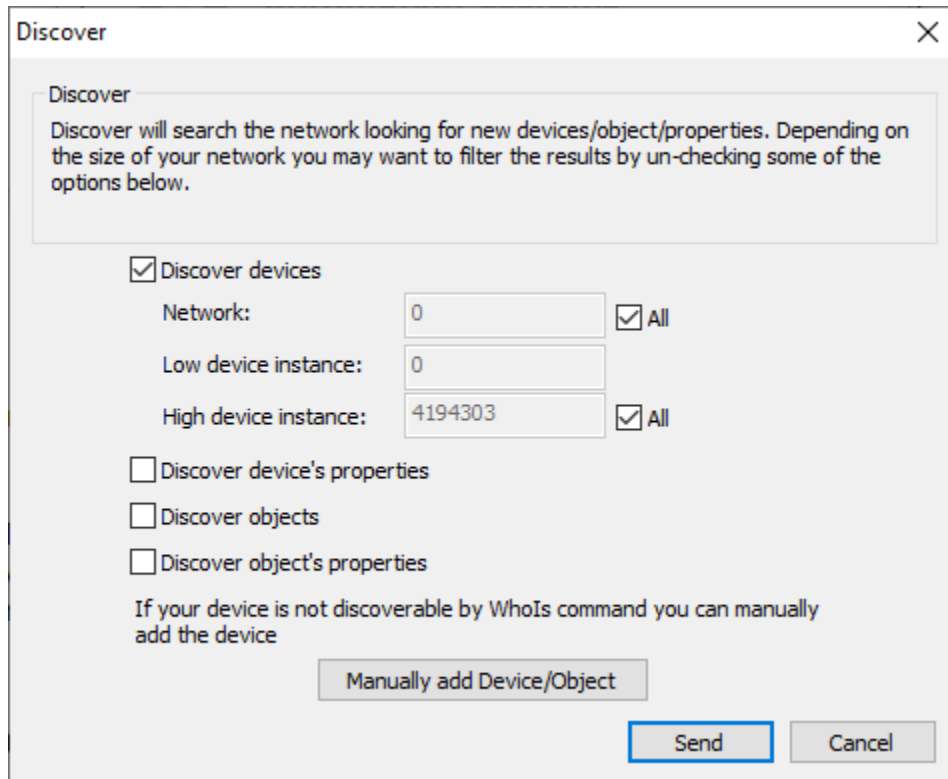
ID	IP address	Name
1	192.168.1.12	'Intel(R) Ethernet Connection I217-V' on local host
0	192.168.1.29	'Qualcomm Atheros Ar81xx series PCI-E Ethernet Controller' on local host

Click OK to proceed.

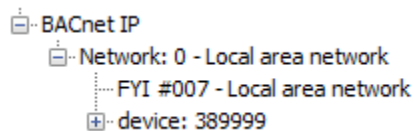
4. On the main page, click on the Discover button



5. In the discover menu, click on the box that says discover devices and click send



- The application will display a list of devices in the application window. This includes any BBMD and BACnet devices participating in the BACnet network. You can use this to verify that messages are being forwarded between networks by trying to discover BACnet devices on other subnets.

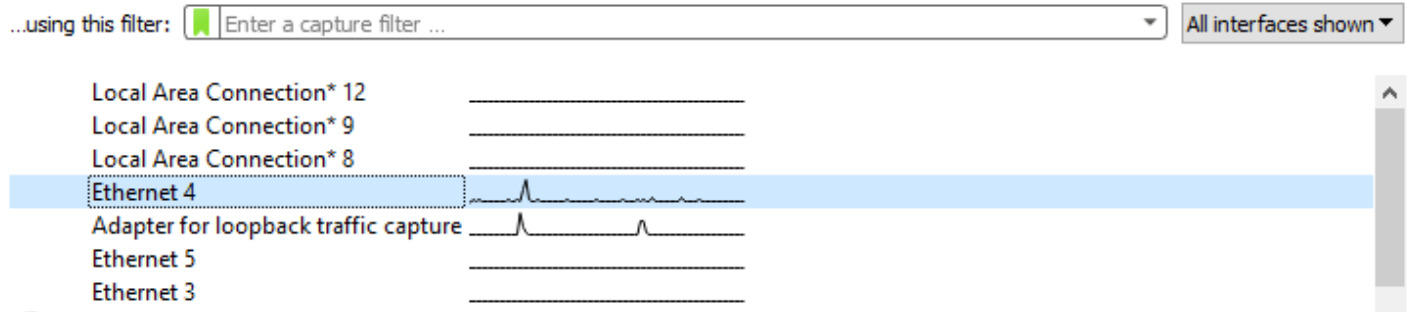


### Appendix A.3 - Using Wireshark to Check Network Traffic

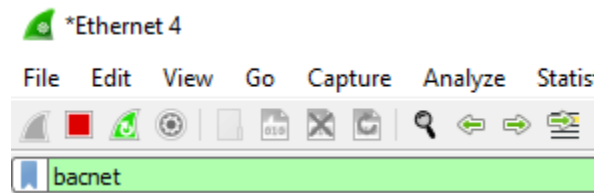
Follow the steps in this section to setup Wireshark to check the network traffic of a BACnet device on the network. This will allow you to monitor any incoming and outgoing BACnet packets sent to and from the computer.

- Download and install the tool: <https://www.wireshark.org/>
- In the tool, under the Capture menu, double click on your network interface:

## Capture



- In the filters box, type “bacnet” and hit enter:



- The application will now display any BACnet messages sent or received through that network adapter:

No.	Time	Source	Destination	Protocol	Length	Info
2893	117.342077	192.168.1.12	192.168.4.229	BACnet...	73	Unconfirmed-REQ i-Am device,389999
7524	206.590268	192.168.1.23	192.168.1.255	BACnet...	60	Unconfirmed-REQ who-Is
7635	221.523656	192.168.1.12	192.168.4.229	BACnet...	73	Unconfirmed-REQ i-Am device,389999
8088	230.313380	192.168.1.23	192.168.1.255	BACnet...	60	Unconfirmed-REQ who-Is
8089	230.316899	192.168.1.12	192.168.4.229	BACnet...	60	Unconfirmed-REQ who-Is
8090	230.329209	192.168.1.12	192.168.4.229	BACnet...	73	Unconfirmed-REQ i-Am device,389999

- Click on a packet to view more detailed information such as the packet contents:

- ▼ BACnet Virtual Link Control
  - Type: BACnet/IP (Annex J) (0x81)
  - Function: Forwarded-NPDU (0x04)
  - BVLC-Length: 10 of 31 bytes BACnet packet length
  - IP: 192.168.1.29
  - Port: 47808
- > Building Automation and Control Network NPDU
- ▼ Building Automation and Control Network APDU
  - 0001 .... = APDU Type: Unconfirmed-REQ (1)
  - Unconfirmed Service Choice: i-Am (0)
  - > ObjectIdentifier: device, 389999
  - > Maximum ADPU Length Accepted: (Unsigned) 1476
  - > Segmentation Supported: no-segmentation (3)
  - > Vendor ID: Chipkin Automation Systems (389)

You may verify that BACnet messages are being sent or received by the network by checking these packets. An example use case would be running Wireshark with the BBMD application.

## Appendix A.4 – Checking the BBMD Port

If the BBMD appears to be correctly operating but no messages appear on Wireshark, it is possible the port the application is trying to bind to is currently being used by another process. This can result in blockage of the BBMD's network traffic.

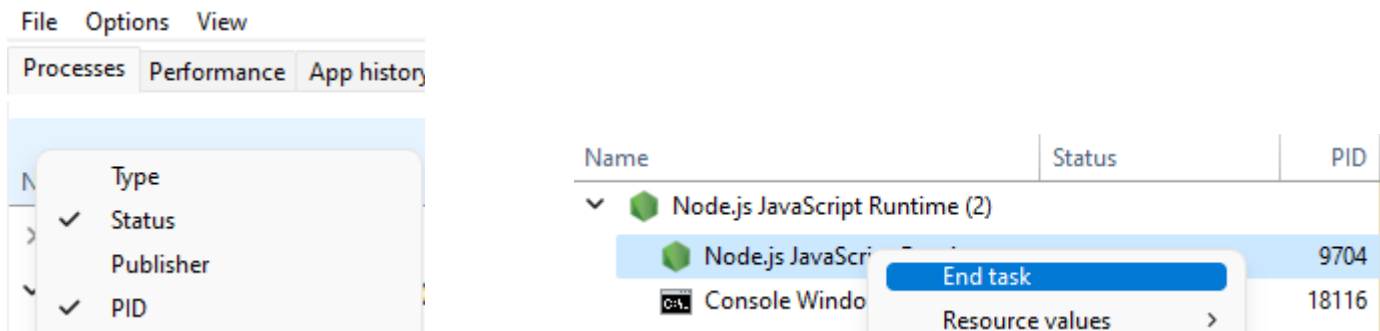
On a windows device, this can be checked by opening a command prompt and running the following command:

```
netstat -ano | findstr 47808
```

In this example, we are checking the BACnet port 47808. Running the command will print nothing if the port is not in use. However, if it is currently in use, it will display something like the following:

```
Z:\Chipkin>netstat -ano | findstr 47808
UDP    10.135.246.136:47808    *:*                9704
```

This shows that there is a process with a PID 9704 currently bound to the 47808 UDP socket. We can further investigate this issue by opening task manager, clicking more details, and searching for the PID. If the PID column does not appear on your computer, it can be made visible by right clicking the title row.



To fix this issue, we will stop the found process and verify the port is free by running netstat once again. If we get an empty return value from netstat, the port is now freed and the BBMD application should be re-tested.

```
Z:\Chipkin>netstat -ano | findstr 47808
Z:\Chipkin>
```

## Appendix B - Example Configurations

**broadcastdistributiontable.csv**

```
# Created by: CAS BACnet BBMD
# Created on: 2021-05-03
IP Address,Subnet Mask
# One-Hop examples:
# 192.168.1.12:47808,255.255.255.0
# 192.168.2.11:47808,255.255.255.0
# Two-Hop examples:
# 192.168.3.10:47808,255.255.255.255
# 192.168.4.9:47808,255.255.255.255
```

**settings.csv:**

```
# Created by: CAS BACnet BBMD
# Created on: 2021-05-03
Setting,Value
Device Instance,389999
Device Name,Chipkin BBMD
Device Description,Chipkin BACnet BBMD device
BACnet UDP Port,47808
# Logging levels supported: INFO or DEBUG
Logging Level,DEBUG
```

**adapters.csv:**

```
Adapter,Enabled
0-ff-f0-dc-a8-29,0
fc-aa-14-74-be-a2,1
fc-aa-14-74-be-a0,0
```

## Appendix C - BBMD

### Appendix C.1 – Case Study

A university has several buildings. Each building has several BACnet/IP sensors in them. A central control room that monitors all the buildings sensors using an HMI. The university has segmented the buildings into their own VLANs where each building has a different subnet. When the HMI tries to discover the BACnet/IP device across the university campus it sends out a IP/UDP broadcast. The IP/UDP broadcasts are not routed through the NAT routers and HMI can not discover any of the other BACnet/IP devices on the different VLANs or sub networks.

The solution is to install and configure a BBMD device on each VLAN and subnetwork. The BBMD device receives the IP/UDP broadcast message and relays it to the other BBMD devices on different VLANs or subnetworks networks through a directed IP/UDP message. When a BBMD receives a directed message from another BBMD it will broadcast the message on its local network VLAN/Subnet. The communication is bidirectional so devices on the VLANs and subnets can communicate to the HMI via the BBMDs as well.

This allows a central HMI to communicate with all the BACnet/IP devices in the different segregated building/VLANs/Subnets.

### Appendix C.2 - Keyword

BACnet Broadcast Management Device, BBMD, L.7.3 BACnet Broadcast Management Device (B-BBMD), ANSI L.7.3, Foreign Device, Foreign Device Table, FDT, Broadcast Distribution Table, BDT.

## Appendix D – License

On start up the CAS BACnet BBMD application will produce a prekey.txt into the root folder. This prekey.txt can be used to generate a license.txt file by Chipkin support.

### Directions

1. Start the CAS BACnet BBMD application on the installation computer.
2. Send the prekey.txt found in the running directory to Chipkin support [support@chipkin.com](mailto:support@chipkin.com). Include your job reference number FSE##### in the email.
3. Chipkin support will reply with a license.txt file. Put this file into the running directory of the CAS BACnet BBMD application.
4. Restart the application.

---

## Appendix E - Glossary of terms

- **BBMD** – BACnet Broadcast Management Device
- **BDT** – Broadcast Distribution Table
- **FDT** – Foreign Device Table
- **FD** – Foreign Device

## Revision History

This table summarizes the update history for this document. Please contact Chipkin for an updated version of this document if required.

Date	Agent	Revision	Comments
2020 DEC 01	JMC	1	Created initial document
2021 MAY 03	JMC	2	Added adapter selection information with examples
2021 MAY 11	JMC	3	Example adapter settings file reflects new formatting
2021 MAY 12	JMC	4	Added details regarding Wireshark logging in DEBUG mode
2024 JAN 18	JMC	5	Added Appendix A.4