BASrouters — BACnet Routing Examples

The BACnet 135 standard defines a network layer that allows multiple BACnet networks to send and receive messages over a single BACnet internetwork without concern for different data links. Interconnecting two BACnet networks requires a BACnet router, and Contemporary Controls offers four models — the BASrouter, Portable BASrouter, BASrouterLX, and BASrouterSX. Information about each model, such as functionality and capability, can be found on individual data sheets. This application guide provides examples of common BACnet routing applications and how each of these routers can be used to solve a particular need.

Because some of these applications involve connections to the Internet and the subnetting of IP networks, Contemporary Controls' Skorpion IP Routers are used in some of the examples. Please search document for double spacing between sentences and change all to single spaced. To aid in understanding the required configuration of the equipment, web page configuration screens are shown with the proper settings. Eleven application examples are provided. For convenience, reference material on the four BACnet routers can be found at the back of the application guide.

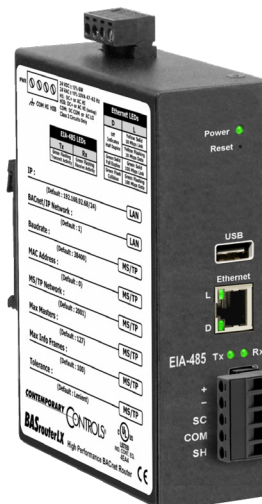**Contemporary Controls' BACnet routers are versatile because they can route between…**

- BACnet/IP and BACnet MS/TP
- BACnet Ethernet and BACnet MS/TP
- BACnet/IP and BACnet Ethernet
- BACnet/IP and BACnet Ethernet and BACnet MS/TP
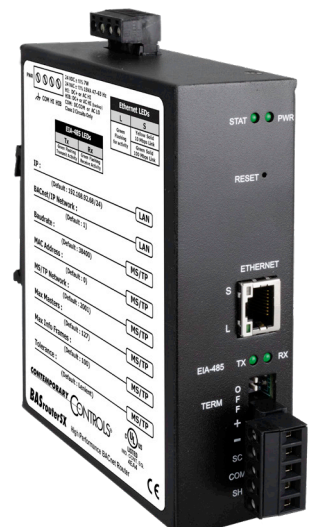- Two BACnet/IP networks (between two UDP ports)

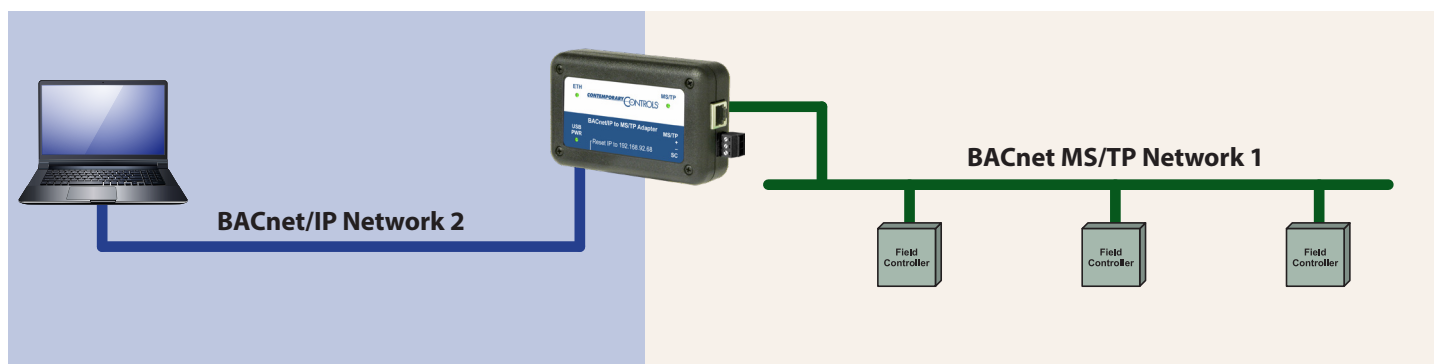**Portable BASrouter**   **BASrouter**   **BASrouterLX**   **BASrouterSX**

Application #1 — Commissioning BACnet MS/TP using a Laptop Computer

Some BAS commissioning software was developed for a BACnet/IP environment but can only be used to commission BACnet MS/TP devices if the proper connection is made. The BAS Portable Router is a perfect fit for this application. The BACnet/IP port on the portable router connects to the laptop's Ethernet port using CAT5 cable while the MS/TP port connects to the target BACnet MS/TP network. Power for the portable router is derived from one of the laptop's USB ports using a USB cable. However, no communication occurs over the USB port.

Using the portable router's web page, the baud rate of the MS/TP port is set to correspond to the baud rate of the MS/TP network. There is no auto-bauding option with the portable router. The target MS/TP must be assigned a unique BACnet network address from that of the BACnet/IP network created with the laptop connection. There is nothing to preclude the use of multiple BASrouters on the same MS/TP network as long as unique BACnet network assignments are made to each created network.

BACnet/IP Network 2

BACnet MS/TP Network 1

Field Controller   Field Controller   Field Controller

PC Configuration

Internet Protocol (TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 192 . 168 . 92 . 69
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 92 . 1

○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: .   .
Alternate DNS server: .   .

Advanced...

OK   Cancel

Router Configuration

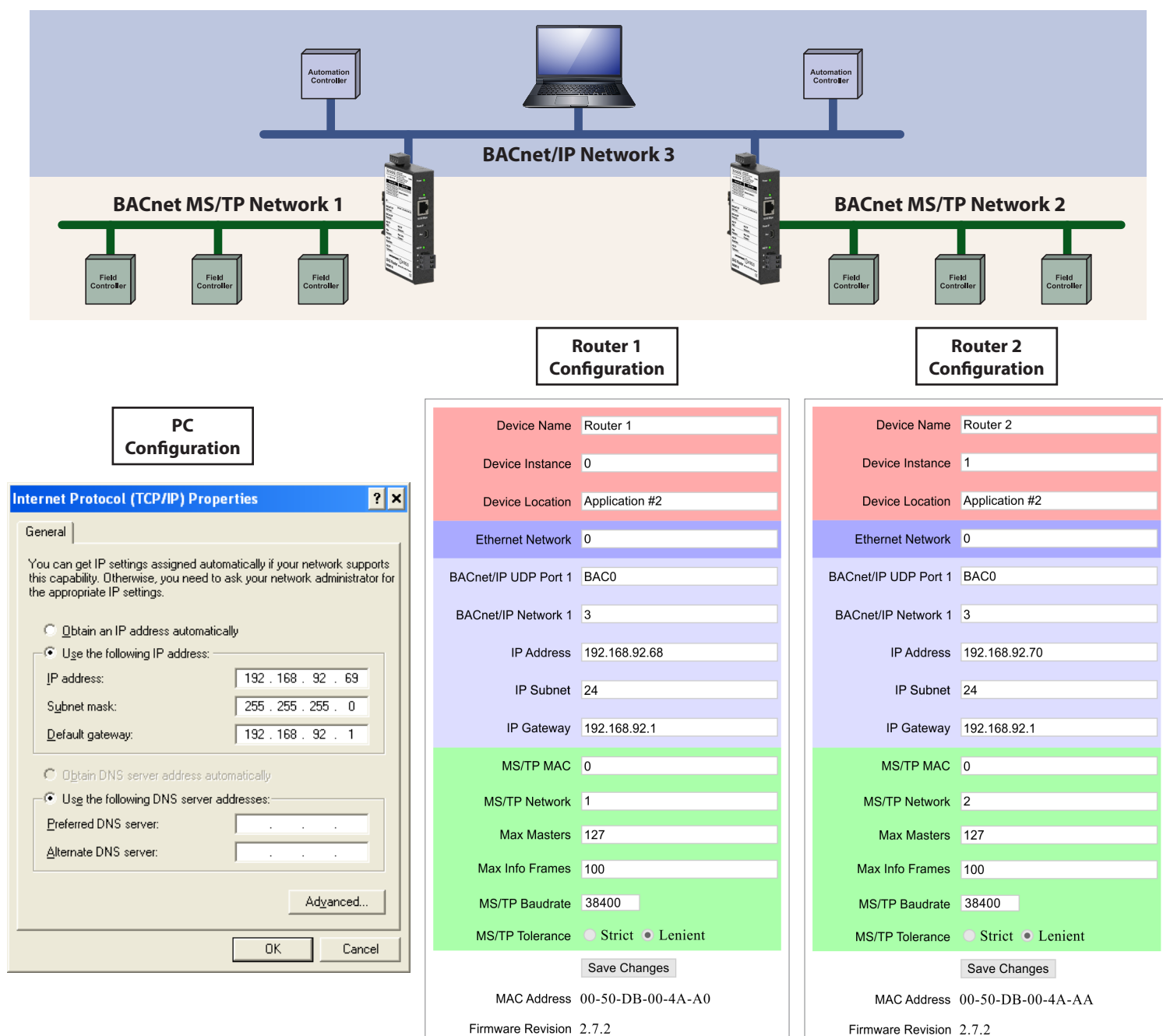|	
Device Name	BASRTP-B
Device Instance	0
Device Location	Application #1
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	2
IP Address	192.168.92.68
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	1
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-5C-E2

Firmware Revision 2.7.2

Application #2 — Connecting Together BACnet's Automation and Field Levels

One advantage of BACnet is that the same protocol can operate at both the automation level, and the field level where the field controllers are operating. The automation devices are BACnet/IP compatible operator workstations (B-OWS) and building controllers (B-BC) while the field devices are application specific controllers (B-ASCs). In order to interconnect these two levels, a BASrouter is needed. On the BACnet/IP side, the BASrouter can operate up to 100 Mbps while supporting both auto-negotiation and Auto-MDIX. On the MS/TP side, baud rates up to 76.8

kbps are supported — 115.2 kbps on the BASrouterLX and BASrouterSX. Notice that multiple BASrouters can reside within the same BACnet internetwork. A cluster of MS/TP devices located at distant parts of a building can be connected to the same BACnet/IP network but at different locations using separate BASrouters. This could be a more convenient solution than using EIA-485 repeaters to extend MS/TP networks especially if the MS/TP devices cannot all operate at the same baud rate. Using repeaters with auto-bauding MS/TP devices can also be tricky.

BACnet/IP Network 3

BACnet MS/TP Network 1

BACnet MS/TP Network 2

Router 1 Configuration

Device Name	Router 1
Device Instance	0
Device Location	Application #2
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	3
IP Address	192.168.92.68
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	1
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient
	Save Changes
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.7.2

Router 2 Configuration

Device Name	Router 2
Device Instance	1
Device Location	Application #2
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	3
IP Address	192.168.92.70
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient
	Save Changes
MAC Address	00-50-DB-00-4A-AA
Firmware Revision	2.7.2

PC Configuration

Internet Protocol (TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 192 . 168 . 92 . 69
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 92 . 1

○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: .   .   .
Alternate DNS server: .   .   .

Advanced...

OK   Cancel

Application #3 — Tunnelling over BACnet/IP

In a tunnelling application, a lower speed technology uses a high speed technology to pass data between two lower speed segments without any change in the end-to-end protocol. With this approach, minimal understanding of the high speed protocol is required. In this example, two BACnet MS/TP networks located in separate buildings need to be connected together but no fieldbus wiring exists between the two buildings. Instead, it is desired to utilize the buildings' existing Ethernet cabling. This can be accomplished with the use of two BASrouters. The result is three cable segments each requiring a unique BACnet network number. This solution is not limited to just two MS/TP segments. Additional segments each with

a BASrouter can be added together through the use of an Ethernet switch. Once the data is tunnelled onto Ethernet, advantage can be taken of all the Ethernet connectivity products that are available. For example, the cabling between buildings could be fibre optics thereby providing the ultimate in electrical isolation.

Using a high-speed BACnet/IP tunnel for two low-speed networks is acceptable but the inverse of using two high speed networks using a low speed MS/TP tunnel is not. With a low-speed tunnel like MS/TP, the maximum message size is still too short for the longer sized messages of BACnet/IP. This should be avoided.

BACnet/IP Network 3

Router 1 **Router 2**

BACnet MS/TP Network 1 **BACnet MS/TP Network 2**
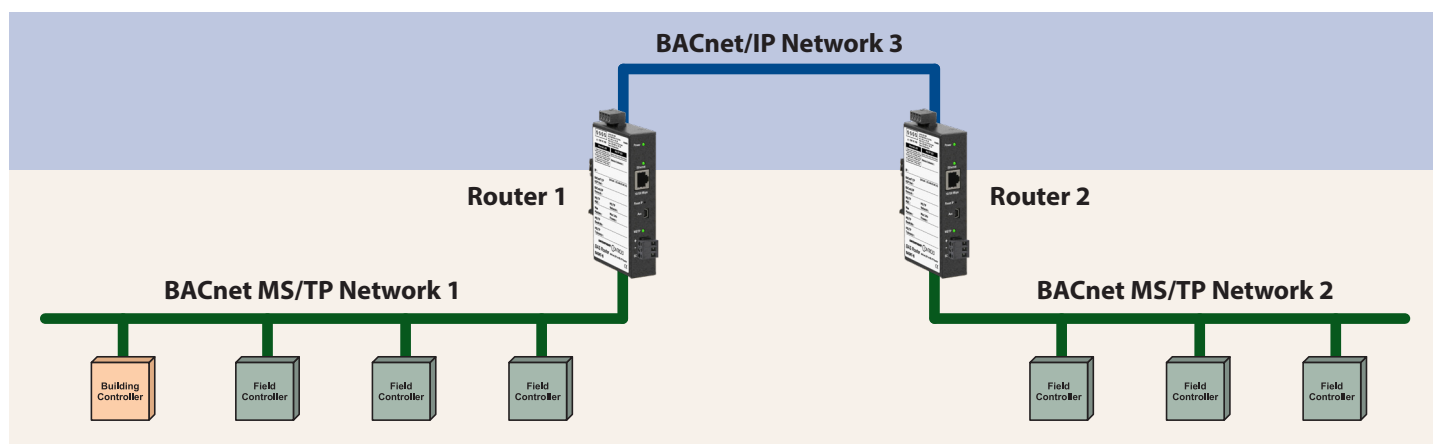
	Router 1 Configuration		Router 2 Configuration	
Device Name	Router 1		Device Name	Router 2
Device Instance	0		Device Instance	1
Device Location	Application #3		Device Location	Application #3
Ethernet Network	0		Ethernet Network	0
BACnet/IP UDP Port 1	BAC0		BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	3		BACnet/IP Network 1	3
IP Address	192.168.92.68		IP Address	192.168.92.70
IP Subnet	24		IP Subnet	24
IP Gateway	192.168.92.1		IP Gateway	192.168.92.1
MS/TP MAC	0		MS/TP MAC	0
MS/TP Network	1		MS/TP Network	2
Max Masters	127		Max Masters	127
Max Info Frames	100		Max Info Frames	100
MS/TP Baudrate	38400		MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient		MS/TP Tolerance	○ Strict ● Lenient
	Save Changes			Save Changes
MAC Address	00-50-DB-00-4A-A0		MAC Address	00-50-DB-00-4A-AA
Firmware Revision	2.7.2		Firmware Revision	2.7.2

Application #4 — Adding BACnet/IP Automation Equipment to an MS/TP Network

Usually when you think of adding a router, you think of BACnet/IP at the automation level and BACnet MS/TP at the field level. However, it is quite possible to have an MS/TP network with both clients and servers functioning successfully at only the field level and learning that the new field equipment you are adding only has a BACnet/IP interface. The BASrouter will work in this application. Simply connect the BASrouter between the BACnet MS/TP network and the BACnet/IP device. This will not improve equipment speed to the overall internetwork, but the new equipment will be connected.

BACnet/IP Network 2

BACnet MS/TP Network 1

Automation Controller

BASRT-B BACnet Router

Field Controller

Field Controller

Field Controller

Field Controller

Building Controller
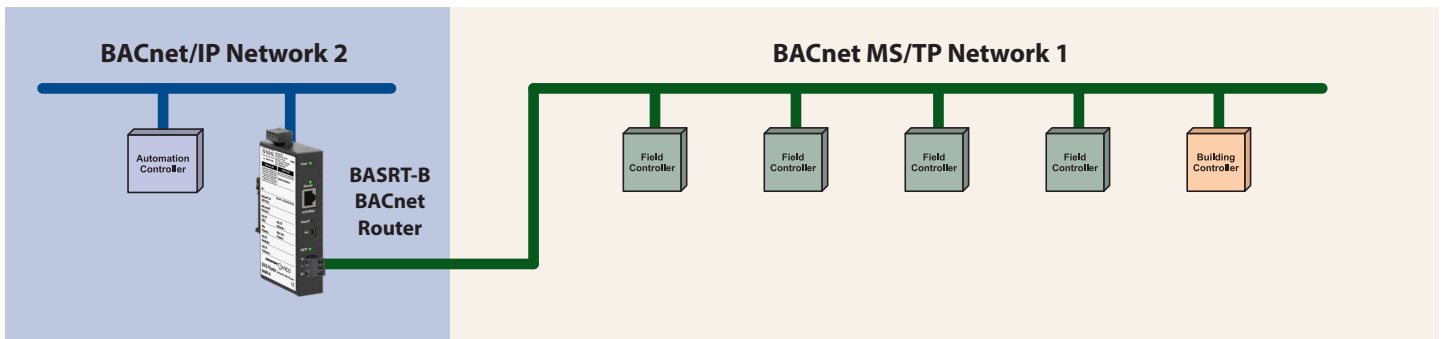
Router Configuration

Device Name	Router
Device Instance	0
Device Location	Application #4
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	2
IP Address	192.168.92.68
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	1
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	◯ Strict ⦿ Lenient
	Save Changes
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.7.2

Application #5 — One-armed Router Supporting BACnet Ethernet

BASrouters support BACnet/IP to BACnet MS/TP routing but BACnet Ethernet can be added to the mix which allows the BASrouter to simultaneously route between MS/TP, BACnet/IP, and BACnet Ethernet. Do not confuse BACnet Ethernet and BACnet/IP. BACnet Ethernet uses Ethernet as its data link technology and MAC addresses for station addressing. BACnet/IP does not need to use Ethernet at all. However, if Ethernet is being used with a BACnet/IP device, the device must be accessed by its IP address and not just its MAC address. BACnet/IP to BACnet Ethernet routing is possible with all of our BASrouter products. In such a case, there is no connection to the MS/TP port on the BASrouter. There is only the one connection to the Ethernet port on the BASrouter. This is called "one-armed routing" since there is only one connection. If routing to MS/TP is still desired, a connection can be made accordingly to achieve three-way routing.
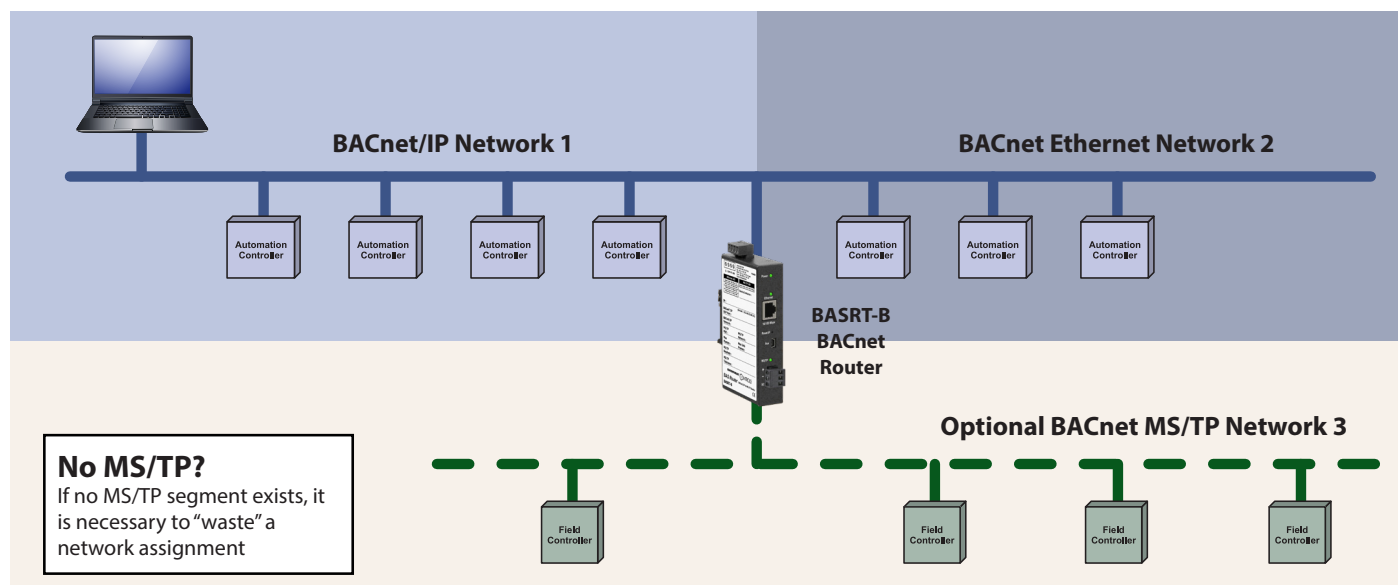
BACnet/IP Network 1

BACnet Ethernet Network 2

Automation Controller

Automation Controller

Automation Controller

Automation Controller

BASRT-B BACnet Router

Automation Controller

Automation Controller

Automation Controller

Optional BACnet MS/TP Network 3

No MS/TP?
If no MS/TP segment exists, it is necessary to "waste" a network assignment

Field Controller

Field Controller

Field Controller

Field Controller

Internet Protocol (TCP/IP) Properties

PC Configuration

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 192 . 168 . 92 . 69
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 92 . 1

○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

Advanced...

OK   Cancel

Router Configuration

BACnet Ethernet to BACnet MS/TP

Before BACnet/IP became popular, BACnet Ethernet was used at both the automation and field levels. It is still used today — so routing between BACnet Ethernet and BACnet MS/TP is required. All BASrouters route between BACnet Ethernet and BACnet MS/TP. To enable BACnet Ethernet routing, you must configure the BASrouter web page such that a unique nonzero network number is assigned to the Network parameter for BACnet Ethernet. The same applies to the Network parameter for BACnet MS/TP.

Device Name	Router
Device Instance	0
Device Location	Application #5
Ethernet Network	2
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.92.68
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	3
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.7.2

Application #6 — BBMD Server without Firewall

When attaching BACnet devices to IP networks, it is possible that the IP network has been subnetted through the use of IP routers, such as our Skorpion IP routers. Most IP routers will not pass broadcast messages which are crucial to BACnet's operation. The solution is to incorporate BACnet/IP Broadcast Management Device (BBMD) functionality within the BACnet internetwork.

The BBMD concept requires that a broadcast message originating on one subnet be encapsulated into a directed message and sent to all remote subnets since these directed messages will pass through IP routers. Once the encapsulated messages are received on the remote subnets, a BBMD device will decode the message and resend it on its local subnet as a broadcast message. Therefore it appears that a BBMD device must be present on each subnet in order to provide this encoding and decoding function. However, this is not the case if all the BACnet/IP devices support Foreign Device Registration (FDR). At a minimum, one BBMD device is required on one of the subnets, with FDR devices registering to this one BBMD. This is what is shown in the following example, with a BASrouter providing BBMD functionality while allowing foreign device registration. Notice that connecting to a BACnet MS/TP network is an option.

Before the BASrouter can function as a BBMD, it must be configured. A BBMD setup page is accessed by clicking the Advanced button on the BASrouter's main web page. On the Advanced screen, BBMD is enabled by checking a box. There are two choices for the BBMD UDP port. Normally, the primary BACnet/IP UDP is used, but an alternate port can be chosen. An Accept FDR box (checked by default) allows foreign devices to register with the BBMD. But if BBMD is not enabled, FDR is ignored. You will need to set the FDR device address to 192.168.2.2 in your PC application and on the controllers on the 192.168.1.0 subnet. The application controllers on the 192.168.2.0 subnet need not register because the BBMD is on the same subnet.

Another button accesses the Broadcast Distribution Table (BDT). On this table, the locations of up to five BBMDs can be entered by specifying their IP addresses and subnet masks. Note that all BBMDs must all be on the same BACnet/IP internetwork as the BASrouter.

Finally, another button gives access to the Foreign Device Table (FDT) which displays all the foreign devices that have registered with the BBMD.

Not all IP Routers allow for their firewalls to be disabled but this is a feature with the Skorpion EIPR routers.

Although the BACnet/IP network is subnetted, all subnets are assigned the same network number — in this example Network 1.
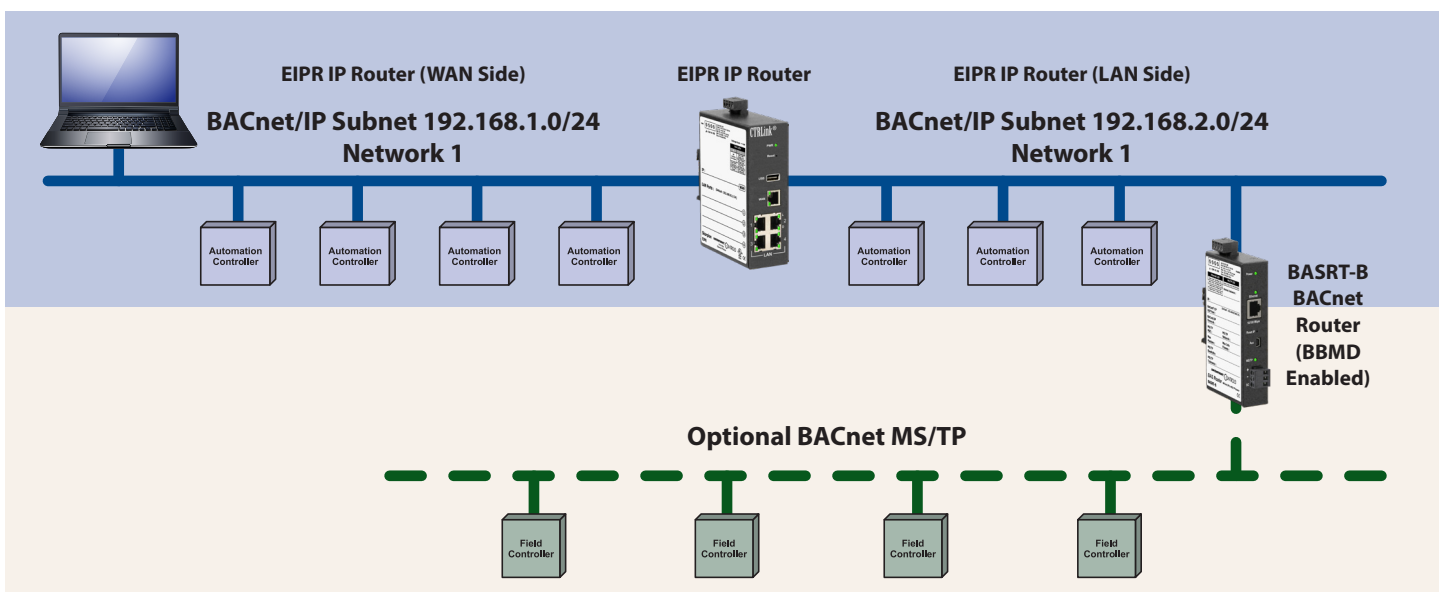
Application #6 — BBMD Server without Firewall

Main Screen

Device Name	Router (BBMD Enabled)
Device Instance	0
Device Location	Application #6
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.2.2
IP Subnet	24
IP Gateway	192.168.2.1
MS/TP MAC	0
MS/TP Network	3
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-A0

Firmware Revision 2.7.2

PC Configuration

(TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:

IP address: 192 . 168 . 1 . 2
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 1 . 1

○ Obtain DNS server address automatically
● Use the following DNS server addresses:

Preferred DNS server: . . .
Alternate DNS server: . . .

Advanced...

OK   Cancel

Advanced Screen

BBMD Enable	☑
BBMD UDP Port	Primary
Accept FDR	☑

Broadcast Distribution Table

Foreign Device Table

Secondary BACnet/IP UDP Port	0000
Secondary BACnet/IP Network	0
Public IP Address	0.0.0.0

Save Changes

IP Router Setup

WAN Setup

Connection Type: Static IP
IP Address: 192 . 168 . 1 . 1
Subnet Mask: 255.255.255.0
Default Gateway: 192 . 168 . 1 . 254
Static DNS 1: 0 . 0 . 0 . 0
Static DNS 2: 0 . 0 . 0 . 0
Static DNS 3: 0 . 0 . 0 . 0

Optional Settings (required by some ISPs)
Host Name:
Domain Name:
MTU: ○ Enable ● Disable Size: 1500

LAN Setup

Router IP
Local IP Address: 192 . 168 . 2 . 1
Subnet Mask: 255.255.255.0

Network Address Server Settings (DHCP)
Local DHCP Server: ● Enable ○ Disable
Start IP Address: 192 . 168 . 2 . 100
Number of Addresses: 10 (1 to 50)
Client Lease Time: 0 minutes (0 means one day)

Save Cancel

Disable the IP Router Firewall

Firewall

Firewall Status: ○ Enable ● Disable

Save Cancel

Application #7 — Connecting Field Devices on Multiple Floors

In a typical HVAC installation, many Fan Coil Units (FCU) or Variable-Air-Volume (VAV) terminal units will be installed in the ceiling on each floor of a multistory office building. Frequently, these units contain BACnet MS/TP controllers all sharing one EIA-485 bus. Depending on the rating of the EIA-485 transceivers, 32, 64 or 128 devices are allowed on the same bus. Having a large number of devices on the same bus over several floors with concealed wiring makes troubleshooting much more difficult. Adding EIA-485 repeaters compounds the problem.

A better approach has all the terminal control units on each floor bused together with one end connected to the MS/TP port on the BASrouter and the far-end terminated with a 120 ohm resistor. The BASrouter is shipped with EIA-485 bias and termination applied so there is no need for an external terminator on the near side. The BASrouter Ethernet port is then tied to a 10/100 Mbps Ethernet Switch, and then a cable connection is brought up through risers to the centrally-located building or automation controllers that operate over BACnet/IP. Installed on each floor is a BASrouter dedicated to the field devices on that floor. If the building supports structured wiring, the BASrouter Ethernet wiring can share this system. With this approach, there is no need to carry EIA-485 wiring between floors. By having a fewer number of field devices on one MS/TP segment, network traffic on that segment is reduced.

Many MS/TP field controllers support auto-bauding so it is only necessary to set the baud rate on the BASrouter to the desired setting, and all the field controllers will follow suit. The maximum number of MS/TP devices on each segment is often arbitrary. Assuming that half-load EIA-485 transceivers exist on the field controllers, a reasonable limit would be about 40. Each MS/TP segment is treated as a separate BACnet network so each segment must be assigned a unique network number including the BACnet/IP network.
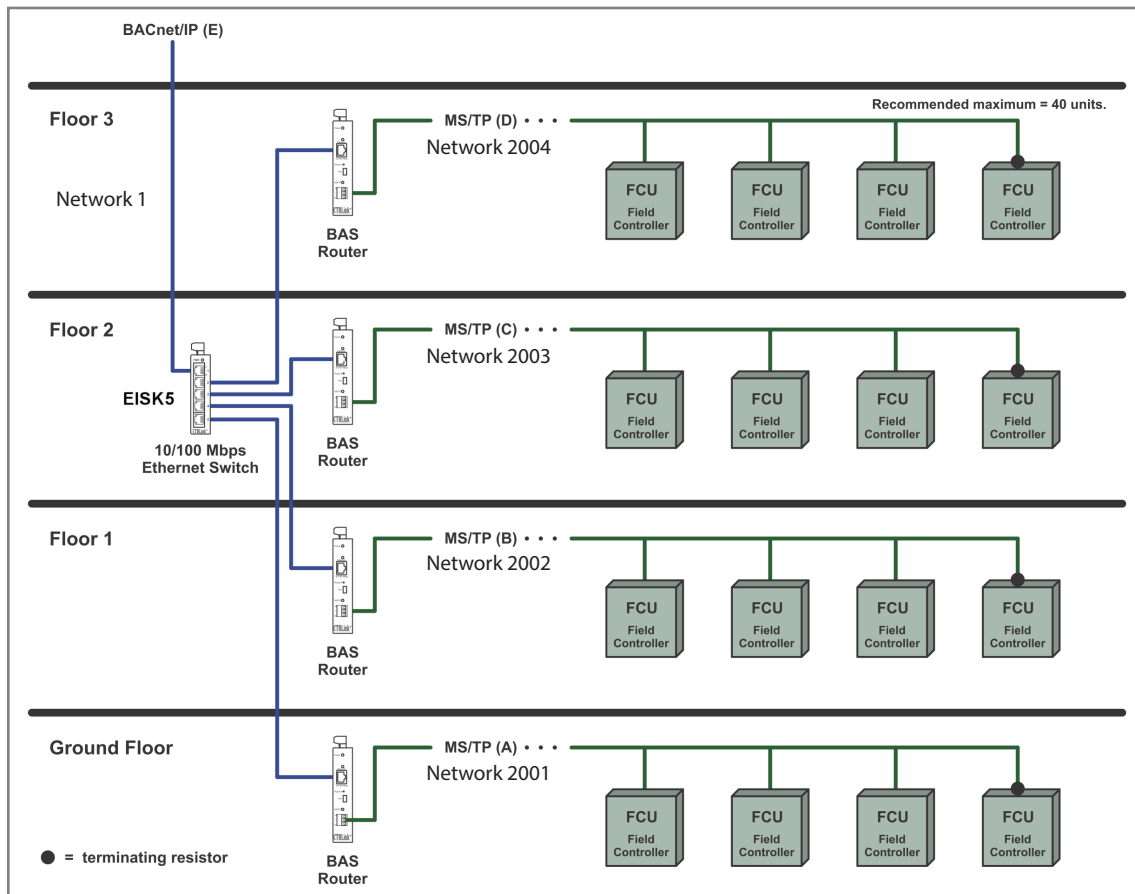
Application #7 — Configuring the BASrouters

Router 3 Configuration

Device Name	Router 3
Device Instance	3
Device Location	Application #7
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.92.71
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2004
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-AA
Firmware Revision 2.7.2

Router 2 Configuration

Device Name	Router 2
Device Instance	2
Device Location	Application #7
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.92.70
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2003
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-A4
Firmware Revision 2.7.2

Router 1 Configuration

Device Name	Router 1
Device Instance	1
Device Location	Application #7
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.92.69
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2002
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-A0
Firmware Revision 2.7.2

Router G Configuration

Device Name	Router G
Device Instance	0
Device Location	Application #7
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.92.68
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2001
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-AB
Firmware Revision 2.7.2

Application #8 — BBMD Server with Firewall but No Local IP Devices

This application is very similar to Application #6 but this time the EIPR IP Router firewall is enabled. A firewall requires that message initiation begin on the LAN-side of the IP router and not from the WAN-side. Therefore it would be impossible for a request initiated on the WAN-side to reach the BASrouter located on the LAN-side unless a "port is opened" in the IP Router. This action is called Port Forwarding and the port that must be opened is the UDP port 47808 which is the registered BACnet port (BAC0). Using the IP Router Port Forwarding screen, both the 47808 UDP and TCP ports are enabled to IP LAN-side address 192.168.2.2 which is the address of the BASrouter and the BBMD Server. On the Firewall screen, the Firewall is shown as enabled. On the Advanced screen of the BASrouter, both BBMD and Accept FDR must be checked.

The IP Router address on the WAN-side is 192.168.1.1. Although this happens to be a private IP address, it still must be entered on the Advanced screen of the BASrouter as the Public IP Address. Because of the firewall, BACnet clients located on the WAN-side must be informed that to reach BACnet devices on the LAN-side they must use this Public IP Address 192.168.1.1.
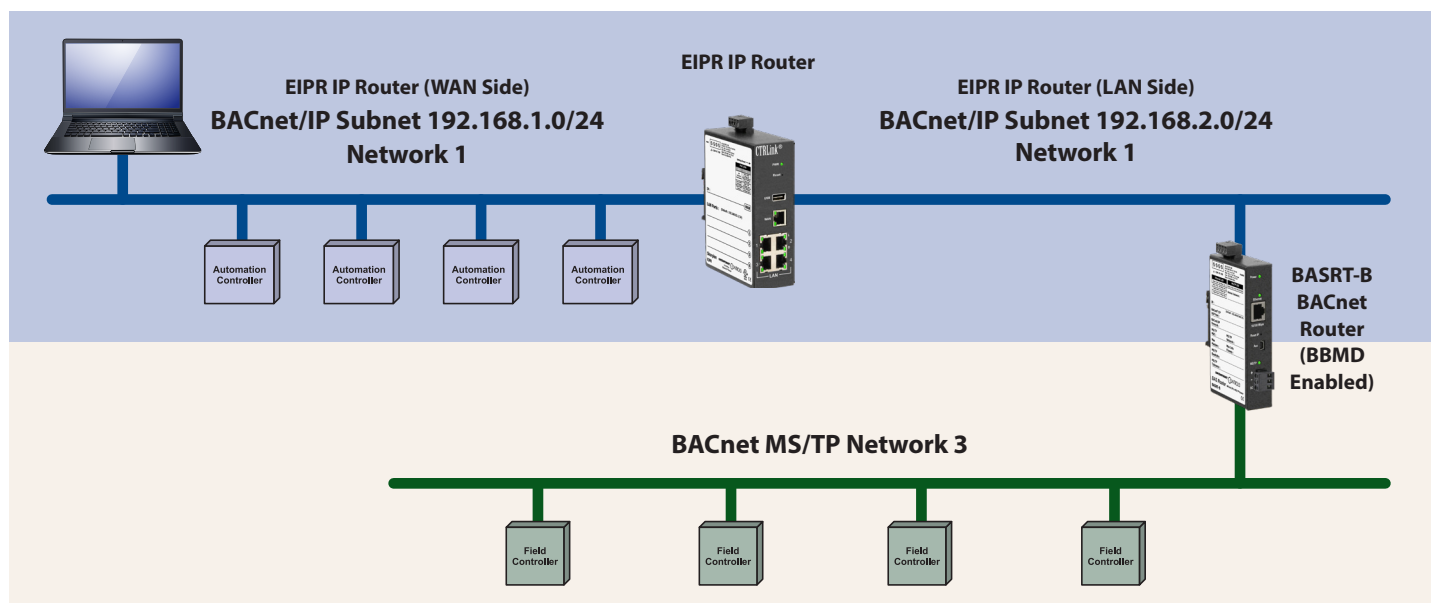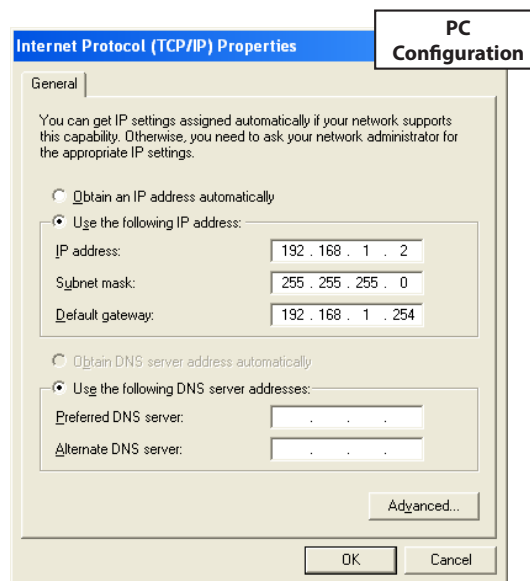
A BACnet/IP controller on the 192.168.1.0 subnet must have its Foreign Device Registration configured for a BBMD address of 192.168.1.1 and not the actual BBMD address of 192.168.2.2. However, because of the Port Forwarding entry made to the IP Router, a BACnet message sent to 192.68.1.1 will be forwarded to 192.68.2.2.

The PC in this example is running a BACnet client application so it must be configured for Foreign Device Registration just like the BACnet/IP controllers. If a BBMD

resided on the 192.168.1.0 subnet, FDR would not need to be configured for any devices on this subnet.

There are some settings on the IP Router that should be explained. For the LAN Setup, DHCP Server Settings are shown to be enabled. This allows DHCP client devices on the attached subnet to receive an IP address if requested. However, the BASrouter does not have DHCP client capability so its IP address must be manually set to 192.168.2.2. The Local IP Address is the LAN-side address of the IP Router.

On the WAN Setup there is a Default Gateway Address of 192.168.1.254 which represents the IP address of an upstream IP Router that is not shown. This setting has no relevance to this application.

PC Configuration

EIPR IP Router

EIPR IP Router (WAN Side)
BACnet/IP Subnet 192.168.1.0/24
Network 1

EIPR IP Router (LAN Side)
BACnet/IP Subnet 192.168.2.0/24
Network 1

Automation Controller

Automation Controller

Automation Controller

Automation Controller

BASRT-B BACnet Router (BBMD Enabled)

BACnet MS/TP Network 3

Field Controller

Field Controller

Field Controller

Field Controller

Application #8 — BBMD Server with Firewall but No Local IP Devices

Main Screen

Device Name	Router (BBMD Enabled)
Device Instance	0
Device Location	Application #8
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	1
IP Address	192.168.2.2
IP Subnet	24
IP Gateway	192.168.2.1
MS/TP MAC	0
MS/TP Network	3
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-4A-A0

Firmware Revision 2.7.2

IP Router Port Forwarding

Port Forwarding

WAN IP Port	TCP/UDP		LAN IP Address				LAN IP Port	Enabled
47808	Both ▼	TO	192	168	2	2	47808	☑
	Both ▼	TO						☐
	Both ▼	TO						☐
	Both ▼	TO						☐

Save   Cancel

Firewall Setting

Firewall

Firewall Status: ● Enable ○ Disable

Save   Cancel

Advanced Screen

BBMD Enable ☑

BBMD UDP Port Primary ▼

Accept FDR ☑

Broadcast Distribution Table

Foreign Device Table

Secondary BACnet/IP UDP Port	0000
Secondary BACnet/IP Network	0
Public IP Address	192.168.1.1

Save Changes

IP Router Setup

WAN Setup

Connection Type   Static IP ▼

IP Address: 192 . 168 . 1 . 1

Subnet Mask: 255.255.255.0 ▼

Default Gateway: 192 . 168 . 1 . 254

Static DNS 1: 0 . 0 . 0 . 0

Static DNS 2: 0 . 0 . 0 . 0

Static DNS 3: 0 . 0 . 0 . 0

Optional Settings
(required by some ISPs)

Host Name:

Domain Name:

MTU: ○ Enable ● Disable Size: 1500

LAN Setup

Router IP
Local IP Address: 192 . 168 . 2 . 1

Subnet Mask: 255.255.255.0 ▼

Network Address
Server Settings (DHCP)

Local DHCP Server: ● Enable ○ Disable

Start IP Address: 192 . 168 . 2 . 100

Number of Addresses: 10 (1 to 50)

Client Lease Time: 0 minutes (0 means one day)

Save   Cancel

Application #9 — Remote Access to an Existing BACnet/IP Internetwork

This application is a variant of Application #8 except that the PC is located remotely but attached to the Internet as is the IP router. Both the PC and the WAN-side of the IP Router have public IP addresses (1.2.3.4 and 2.3.4.5 for example). On the LAN-side of the IP Router is the building's automation system consisting of BACnet MS/TP and BACnet/IP devices. This is a common request — how do I access an existing BACnet system via the Internet?

In this example, there are four BACnet/IP devices on the LAN-side of the EIPR IP Router — three BACnet/IP controllers and one BASrouter serving an MS/TP segment. Because of the enabled firewall in the IP Router, it is necessary to use Port Forwarding as was done in application #8 in order to penetrate the firewall but the problem is that Port Forwarding can only address one device when four devices need to be addressed. Therefore we need the BASrouter's ability not only to route between BACnet/IP and BACnet MS/TP but to another BACnet/IP network as well. This is how it is done.

The BASrouter IP address is 192.168.2.2 and the LAN-side IP address of the IP Router is 192.168.2.1. The Port Forwarding screen on the IP Router is configured similar to that of Application #8 but this time a different UDP port — 47809 — is used. This is an alternate BACnet port (BAC1) so it is necessary to verify that it is available. Two UDP ports are required in this application because we need

to route between an incoming BACnet/IP network (network 1000) carrying requests from the Internet and an outgoing BACnet/IP network (network 1) where three BACnet/IP controllers are attached. Although physically these two BACnet networks are on the same IP subnet, they are treated differently in terms of BACnet. Since the existing BACnet system is probably using port BAC0, it is more convenient not to change this port setting on all the installed devices. Instead, we will configure the BASrouter Main Screen for BACnet/IP UDP Port 1 as BAC1 the BACnet/IP Network 1 as 1000. On the Advanced screen we will configure the Secondary BACnet/IP Network as 1 and the Secondary BACnet/IP UDP Port as BAC0. The Public IP Address becomes 2.3.4.5. This will allow for BACnet/IP to BACnet/IP routing using a technique called NAT Traversal.

BBMD must be enabled on the Advance screen but it is unnecessary to have the BACnet/IP controllers be set for FDR because they reside on the same IP subnet as the BASrouter. However, the PC's FDR settings must include a BBMD address of 2.3.4.5 in order to reach the WAN-side of the IP Router that will forward the requests through port forwarding.

In this example, public addresses 1.2.3.4 and 2.3.4.5 are used as an example. In reality the PC TCP/IP configuration screen and the WAN Setup screen will be dictated by the Internet Service Providers (ISP) involved.

AG-BASRTB00-AE3
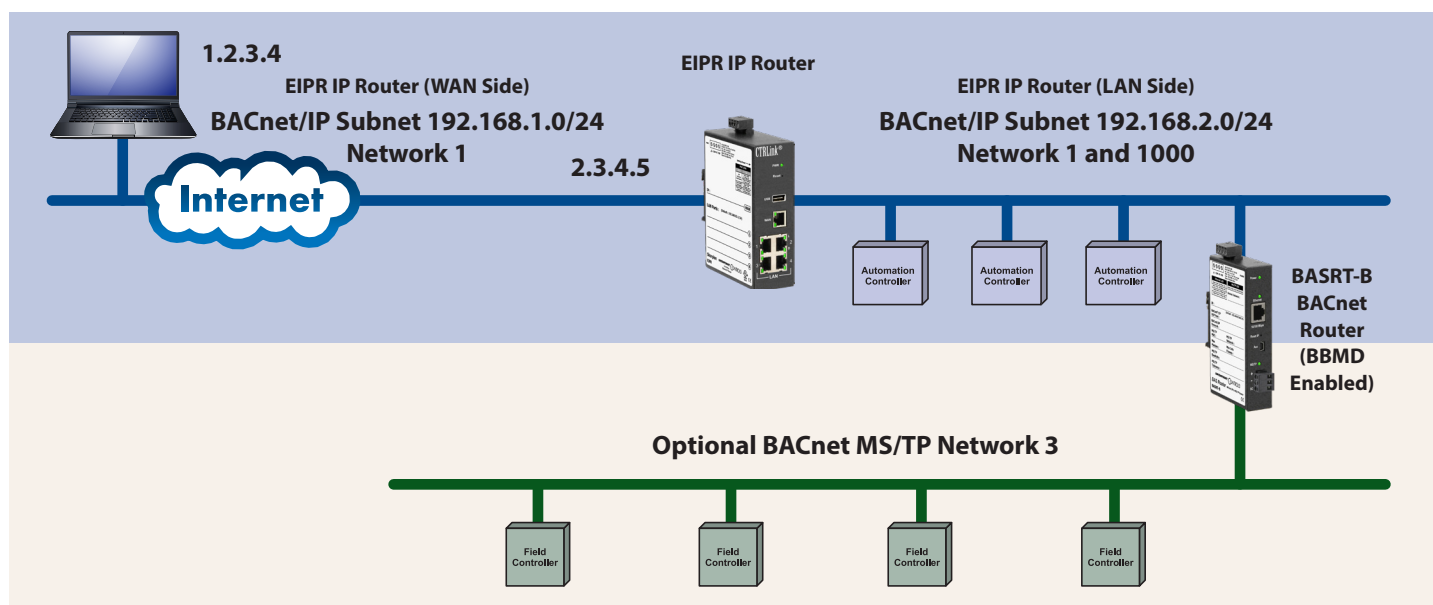
Application #9 — Configuring the BASrouter and IP Router

Main Screen

Device Name	Router(BBMD Enabled)
Device Instance	0
Device Location	Application #9
Ethernet Network	0
BACnet/IP UDP Port 1	BAC1
BACnet/IP Network 1	1000
IP Address	192.168.2.2
IP Subnet	24
IP Gateway	192.168.2.1
MS/TP MAC	0
MS/TP Network	3
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	○ Strict ● Lenient

Save Changes

MAC Address 00-50-DB-00-D8-E7
Firmware Revision 2.7.2

IP Router Port Forwarding

Port Forwarding

WAN IP Port	TCP/UDP		LAN IP Address	LAN IP Port	Enabled
47809	Both	TO	192 . 168 . 2 . 2	47809	✓
	Both	TO	. . .		☐
	Both	TO	. . .		☐
			. . .		☐

Save   Cancel

Advanced Screen

BBMD Enable ✓
BBMD UDP Port Primary
Accept FDR ✓

Broadcast Distribution Table
Foreign Device Table

Secondary BACnet/IP UDP Port BAC0
Secondary BACnet/IP Network 1
Public IP Address 2.3.4.5

Save Changes

IP Router Setup

WAN Setup

Connection Type Static IP
IP Address: 2 . 3 . 4 . 5
Subnet Mask: 255.0.0.0
Default Gateway: 10 . 0 . 0 . 1
Static DNS 1: 0 . 0 . 0 . 0
Static DNS 2: 0 . 0 . 0 . 0
Static DNS 3: 0 . 0 . 0 . 0

Optional Settings (required by some ISPs)
Host Name:
Domain Name:
MTU: ○ Enable ● Disable Size: 1500

LAN Setup

Router IP
Local IP Address: 192 . 168 . 2 . 1
Subnet Mask: 255.255.255.0

Network Address Server Settings (DHCP)
Local DHCP Server: ● Enable ○ Disable
Start IP Address: 192 . 168 . 2 . 100
Number of Addresses: 10 (1 to 50)
Client Lease Time: 0 minutes (0 means one day)

PC Configuration

Internet Protocol (TCP/IP) Properties

General

You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.

○ Obtain an IP address automatically
● Use the following IP address:
IP address: 192 . 168 . 1 . 2
Subnet mask: 255 . 255 . 255 . 0
Default gateway: 192 . 168 . 1 . 1

○ Obtain DNS server address automatically
● Use the following DNS server addresses:
Preferred DNS server: . .
Alternate DNS server: . .

Advanced...

OK   Cancel

Application #10 — Capturing MS/TP Traffic

The BASrouterLX and BASrouterSX are high-performance routers with diagnostic capabilities. They have a faster processor and more memory than the BASrouter or Portable BASrouter. The BASrouterSX is available as a GSA-compliant model for added security which has been tested and approved for use in U.S. government buildings. It can perfrom all the previous 9 applications. One feature that the BASrouterLX and BASrouterSX have over the BASrouter or Portable BASrouter is the ability to capture MS/TP traffic and present that traffic to a PC connected on the BACnet/IP side of the BASrouterLX/BASrouterSX. Installed on the same PC that is used for browsing is the Wireshark® protocol analyser. It can be downloaded for free from Wireshark.org. Intended for analysing packets sent over Ethernet, Wireshark can also decode packets sent over a serial bus like MS/TP thanks to its built-in BACnet decoder.

Capturing serial data remotely is a handy feature when verifying proper MS/TP network activity without the requirement of installing specialized interfacing hardware

to the MS/TP bus. The BASrouterLX continuously records the last 3900 messages sent over MS/TP including both data and token passes. The BASrouterSX continuously records, approximately, the last 32,000 messages sent over MS/TP, including both data and token passes. By selecting the **Generate MS/TP Wireshark File**, those last messages are converted to a "pcap" format file for viewing by a Wireshark. Once the conversion is made, click the **View MS/TP Traffic** button to send the captured file to the attached PC for Wireshark viewing. BACnet protocol decoding is built into this free but powerful protocol analyser so the system integrator can study the traffic for any anomalies while verifying that all serial devices are participating in the token pass. No special configuration is involved. Any properly installed BASrouterLX and BASrouterSX are ready to transfer captured MS/TP at anytime. **NOTE:** You must have Wireshark on installed on your PC to view the .pcap file.
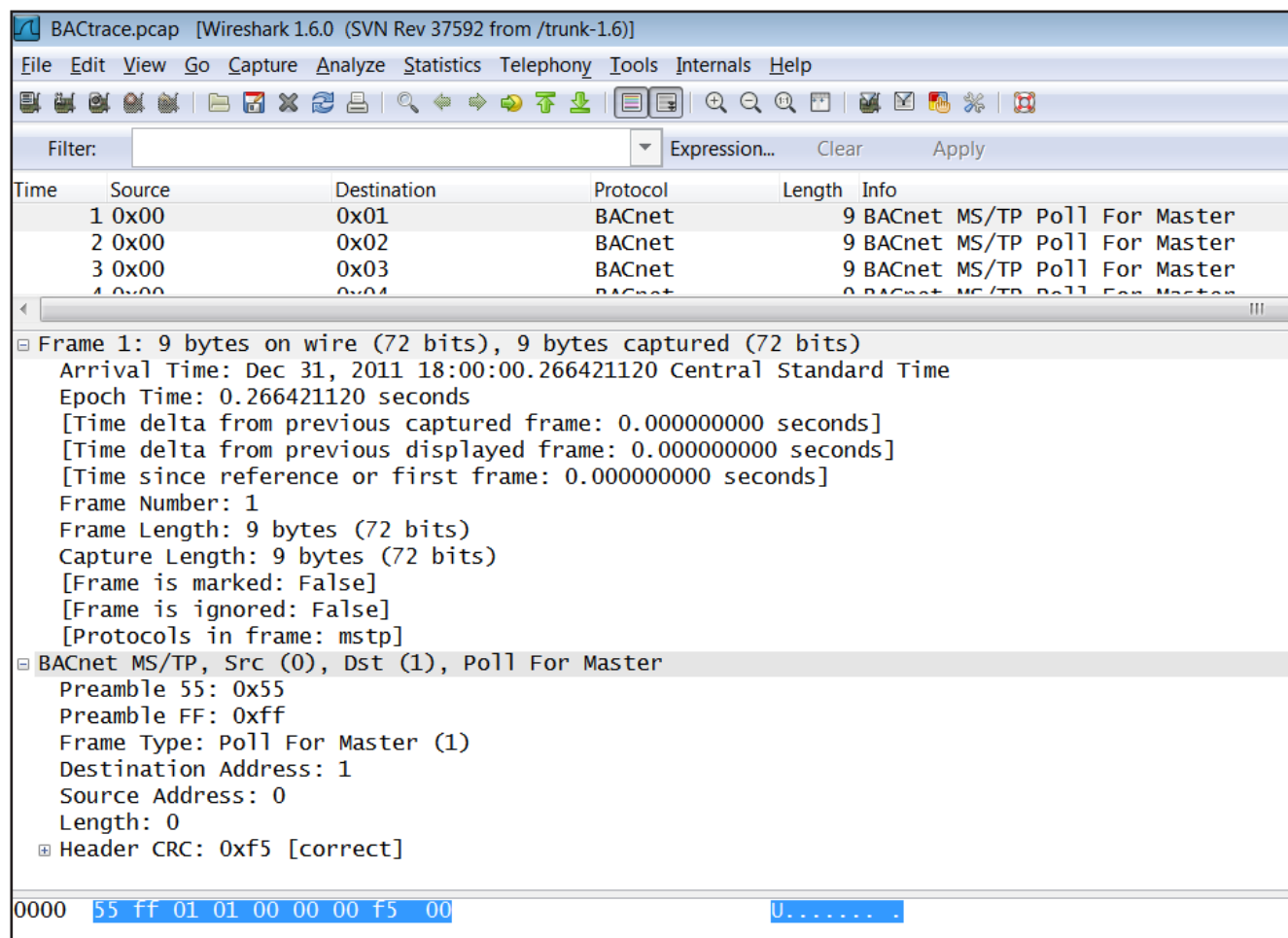
Application #11 — Proxy Support for MS/TP Slave Devices

BACnet MS/TP is short for BACnet over a master/slave token-passing network. Stations that support the token-passing protocol are called masters while stations that do not support the token-passing protocol are called slaves. This is oftentimes confusing. The master with the token has momentary control over the network. This station can basically send a message or pass the token to its logical neighbour — the station with the next highest address. Master addressing begins at zero and can go up to 128. Once the token reaches the master with the highest address, that master passes the token to the station with the lowest address. So if a slave device does not participate in the token passing process, how can it be reached? The answer is a slave proxy which the BASrouterLX and BASrouterSX support.
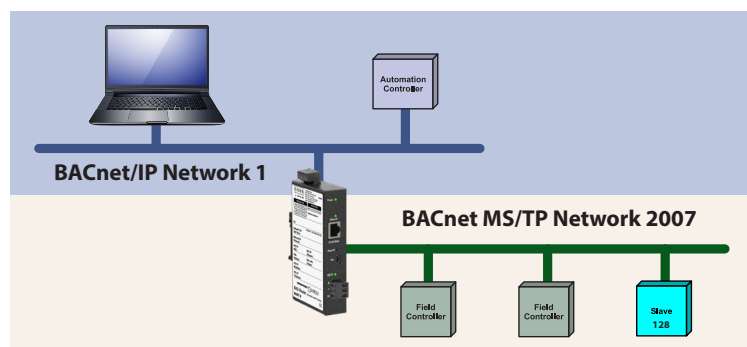
Slave devices need to be assigned to a slave proxy and there are two ways of doing this — manual and auto discovery. If you know the particulars of the slave device you can enter the data manually by checking the **Slave Proxy Enable** on the Advanced — Slave Proxy screen and then clicking **Apply**. Next enter the data for each slave device. You will need to know its MAC Address, Device Instance, Vendor ID and Max APDU. Unlike master devices, slave addresses can range from 0 to 254. These values must have been set in the slave device previously. This information is simply transferred to the slave proxy. Once the entries are made the **Apply** button is clicked. This data will appear in the **Slave Proxy Table** as an entry. Individual entries can be deleted by entry number.

The second approach to registering a slave device is auto discovery. Check the **Auto Slave Enable** box and then click Apply. The **View Auto Slaves** button will then become active. Clicking on this button begins the automatic discovery process which can be lengthy. The results of the discovery process will appear in the **Slave Proxy Table** as above. Individual entries can be deleted by entry number.

Once a slave device is registered with the slave proxy, communication to the slave is possible.

BACnet/IP Network 1

BACnet MS/TP Network 2007

Basic Parameters for All BASrouters

Device Parameter	Default Value	Description
Device Name	[varies]	The user can specify a name in this field. The default is the model name followed by the last 6 digits of the device's Ethernet MAC address.
Device Instance	0	This 22-bit decimal value (0–4,194,302) must be unique .
Device Location	[varies]	The user can specify a location in this field.

BACnet Ethernet Parameter	Default Value	Description
BACnet Ethernet Network	0	16-bit decimal value (1–65534). Each BACnet network, regardless of technology, must have a unique network number. By retaining the default value of 0, BACnet Ethernet routing is disabled.

BACnet/IP Parameters	Default Value	Description
BACnet/IP UDP Port	BAC0	16-bit hex value (0–FFFF) is set to BAC0 as the default value and should be used. All BACnet/IP devices on the same BACnet network must have the same UDP port assignment. For other assignments choose ports in the range from BAC1 to BACF while verifying that these ports are available.
BACnet/IP Network	1	16-bit decimal value (1–65534). Each BACnet network, regardless of technology, must have a unique network number. It is recommended that all subnets of the same BACnet/IP network be given the same BACnet network number as well.
IP Address	192.168.92.68	IP address in dotted decimal format. Select a valid address in the range from 0.0.0.1 through 255.255.255.254.
IP Subnet	24	Decimal value (0–30) in the "slash" notation is the number of bits with a "1" in the mask. The default value of 24 corresponds to 255.255.255.0 in the dotted decimal format. All devices on the same subnet which communicate via BACnet/IP should use the same subnet mask.
IP Gateway	192.168.92.1	IP Gateway address in dotted decimal format. Select a valid address in the range from 0.0.0.1 through 255.255.255.254.

MS/TP Parameters	Default Value	Description
MS/TP MAC Address	0	Decimal value (0–127) represents the MAC address of the router's MS/TP port. Lower MAC address numbers are preferred.
MS/TP Network	2001	16-bit decimal value (1–65534). Each BACnet network, regardless of technology, must have a unique network number.
Max Masters	127	This 8-bit decimal value (1–127) represents the highest master MAC address in the MS/TP network. If the highest value MAC address is unknown or if additional devices are to be added in the future above the current highest MAC address, use the default setting of 127.
Max Info Frames	100	This is the maximum number of messages (1–100) that can be routed onto the MS/TP network by the router per token pass. Values above 20 are typical.
MS/TP Baud Rate	38400	The baud rate of the MS/TP network can be 9600, 19200, 38400 or 76800 bps. All MS/TP devices on the same MS/TP network must use the same baud rate. Auto-bauding devices will set their baud rates to that of the BASrouter.
MS/TP Tolerance	Lenient	Affects the degree to which interoperability with devices is successful. Lenient option causes less efficient traffic but optimises interoperability.

Advanced Parameters for the BASrouter

BBMD Parameters	Default Value	Description
BBMD Enable	Unchecked	Check this if your BACnet communications will pass through multiple subnets. **Warning:** If this is enabled when unneeded, the BASrouter will search for nonexisting BBMDs — and so traffic efficiency will suffer.
BBMD UDP Port	Primary	Leave this unchanged, unless your BACnet communications involve two BACnet/IP networks.
Accept FDR	Unchecked	Check this if the BAsrouter must communicate with BACnet devices in other subnets where no BBMD is present — and if those devices are capable of Foreign Device Registration.
Broadcast Distribution Table	Hidden	Click this button to define or display the table of up to 5 BBMDs that will communicate with the BASrouter.
BBMD IP Address	0.0.0.0	Enter the IP Address of each BBMD that will communicate with the BASrouter.
Broadcast Distribution Mask	255.255.255.255	For each listed BBMD, leave this subnet mask at its default value — except in the **very rare circumstance** in which the intervening IP router is able to forward broadcasts.
Foreign Device Table	Hidden	Click this button to display the table of up to 5 Foreign Devices that have registered with the BASrouter. The table also displays (in seconds) the set value of the TTL (Time-To-Live) parameter — as well as the Remaining Time unless re-registration occurs. This parameter is read-only.

NAT Parameters	Default Value	Description
Secondary BACnet UDP Port	0000	If the BASrouter routes between two BACnet/IP networks, each network must use a different UDP Port. Enter the **remote** port number here.
Secondary BACnet Network	0	If the BASrouter routes between two BACnet/IP networks, each network must use a different network number. Enter the **remote** network number here.
Public IP Address	0.0.0.0	If the BASrouter has a non-routable local IP address (e.g., 192.168.92.68) **and** communicates with BACnet devices across a **firewall**, enter the public IP address of the NAT router. This will be the IP address of the remote side of the NAT router which must be configured so that remote traffic — specified by the Secondary BACnet/IP Network setting — is port-forwarded to the BASrouter. This value is used in the Forwarded-NPDU IP Address field.

Special Parameters for the BASrouterLX and BASrouterSX

Setup Tab Parameters

System	Default Value	Description
Device Description	Blank	Up to 80 characters chosen by the user.

Time	Default Value	Description
Set Date (YYYY, MM, DD)	1970,1,1	Wireshark captures especially use this value.
Set Time (hh, mm, ss)	0,0,0	Wireshark captures especially use this value.

Username/Password	Default Value	Description
Username	admin	Up to 80 characters chosen by the user.
Password	admin	Up to 80 characters chosen by the user.

Config Upload/Download	Default Value	Description
Select Configuration File ...	Blank	**Browse...** to a device configuration file, then click **Upload.**
Save Configuration File to PC	n/a	Click **Save** to save the current BASrouterLX configuration to a PC.

Firmware Upload	Default Value	Description
Select Firmware File ...	Blank	**Browse...** to a device firmware file, then click **Upload.**

Advanced Tab Parameters

BBMD	Default Value	Description
BBMD Enable	Unchecked	Check this if your BACnet communications will pass through multiple subnets. **Warning:** If this is enabled when unneeded, the BASrouter will search for nonexisting BBMDs — and so traffic efficiency will suffer.
BBMD UDP Port	Primary	Leave this unchanged, unless your BACnet communications involve two BACnet/IP networks.
Accept FDR	Unchecked	Check this if the device must communicate with BACnet devices in other subnets where no BBMD is present — and if those devices are capable of Foreign Device Registration.

NAT	Default Value	Description
Secondary BACnet/IP UDP Port	0000	If routing between two BACnet/IP networks, each network must use a different UDP Port. Enter the remote port number here.
Secondary BACnet/IP Network	0	If the device routes between two BACnet/IP networks, each network must use a different network number. Enter the remote network number here.
Public IP Address	0.0.0.0	If the device has a non-routable local IP address (e.g., 192.168.92.68) and communicates with BACnet devices across a firewall, enter the public IP address of the NAT router. This will be the IP address of the remote side of the NAT router which must be configured so that remote traffic — specified by the Secondary BACnet/IP Network setting — is port-forwarded to the device. This value is used in the Forwarded-NPDU IP Address field.

Slave Proxy	Default Value	Description
Slave Proxy Enable	Unchecked	Check this to allow the device to proxy MS/TP slave devices.
Auto Proxy Enable	Unchecked	Check this to discover slaves automatically then click **View Auto Slaves**.
Manual Slave Proxy Entry	Unchecked	Click the **Apply** button to add your entry to the **Slave Proxy Table**.

Broadcast Distribution Table	Default Value	Description
BBMD IP Address	Blank	The IP Address of the BBMD that will communicate with the device.
Broadcast Distribution Mask	255.255.255.255	The BBMD subnet mask — at its default value except in the **rare cases** in which the intervening IP router is able to forward broadcasts.
Delete Entry No:	Blank	To remove an entry from the table, enter its number then click this button.