

application GUIDE



BAS Routers — BACnet Routing Examples

The BACnet 135 standard defines a network layer allowing 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 provides three models of BACnet routers — the BASrouter, Portable BASrouter and the BASrouterLX. 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 sub-netting of IP networks, Contemporary Controls' EIPR-E IP Router is used in some of the examples. 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 three 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



Portable **BASrouter**



BASrouter



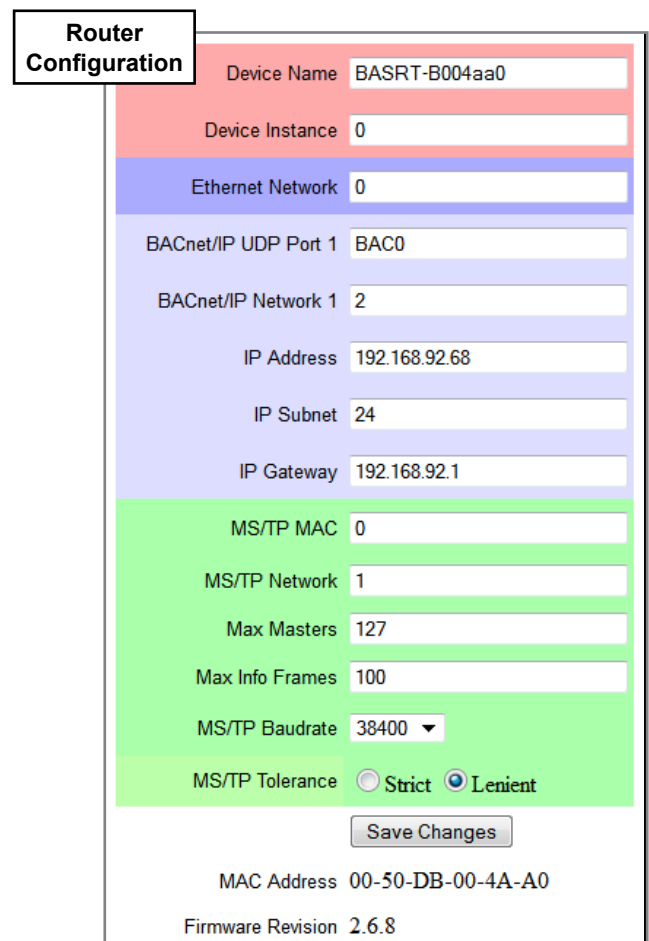
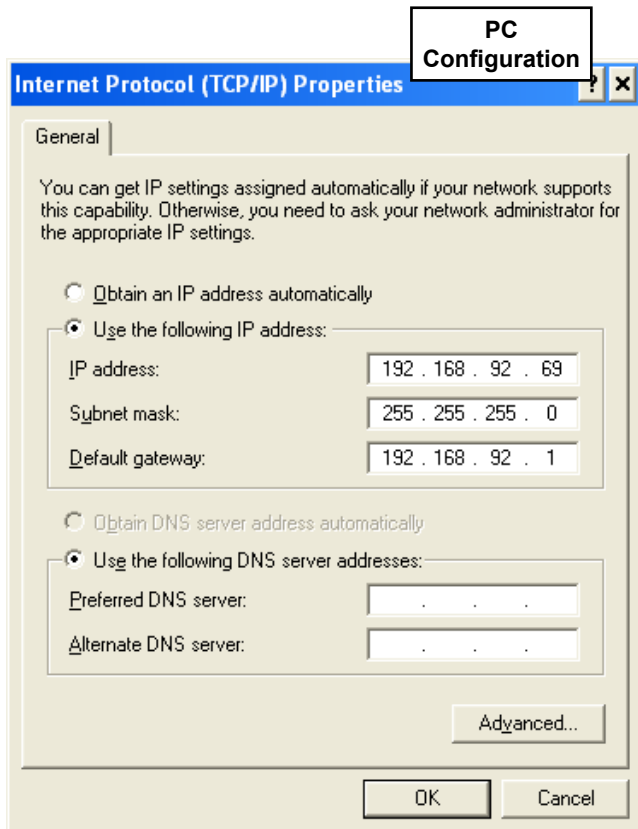
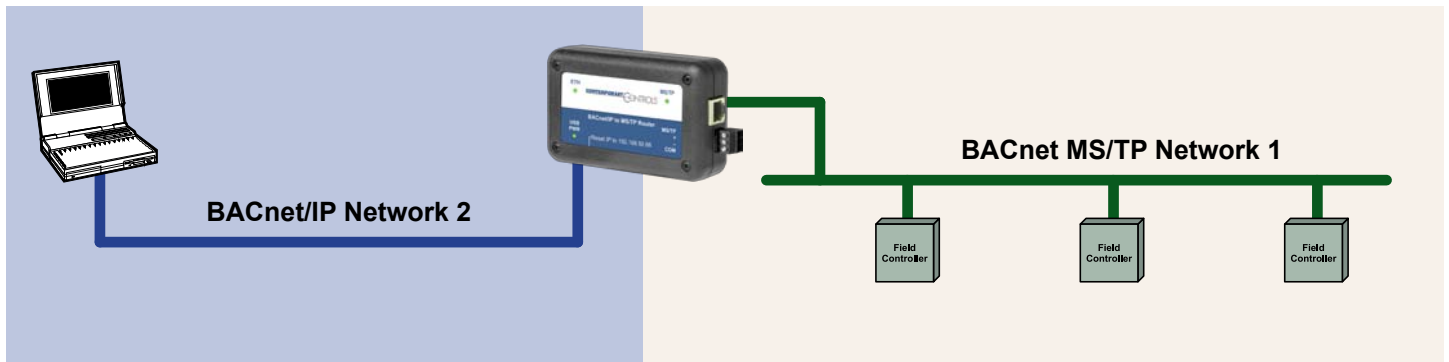
BASrouterLX

BASautomation®

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

Some BAS commissioning software was developed for a BACnet/IP environment but could 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

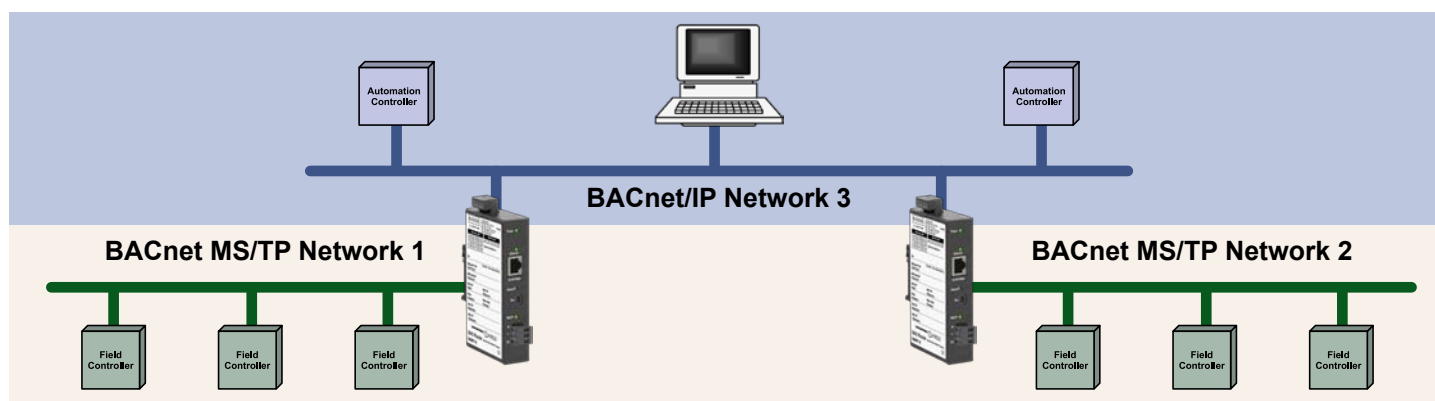
occurs over the USB port. Using the portable router's web page, the baud rate of the MS/TP port is set to correspond to the baud rate of the MS/TP network. There is no auto-bauding option with the portable router. The target MS/TP must be assigned a unique BACnet network address from that of the BACnet/IP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



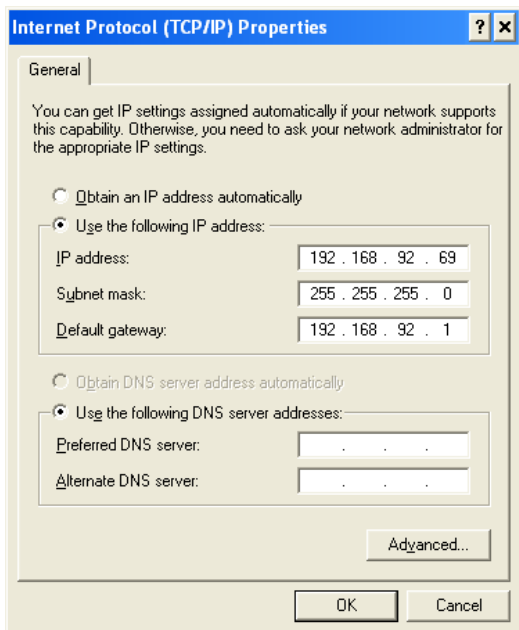
Application #2 — Connecting Together BACnet's Automation and Field Levels

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 BAS Router is needed. On the BACnet/IP side, the BAS Router 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. Notice that multiple BAS Routers 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 BAS Routers. 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.



PC Configuration



Router 1 Configuration

Device Name	BASRT-B004aa0
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient

Save Changes

MAC Address 00-50-DB-00-4A-A0
Firmware Revision 2.6.8

Router 2 Configuration

Device Name	BASRT-B004aaa
Device Instance	1
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient

Save Changes

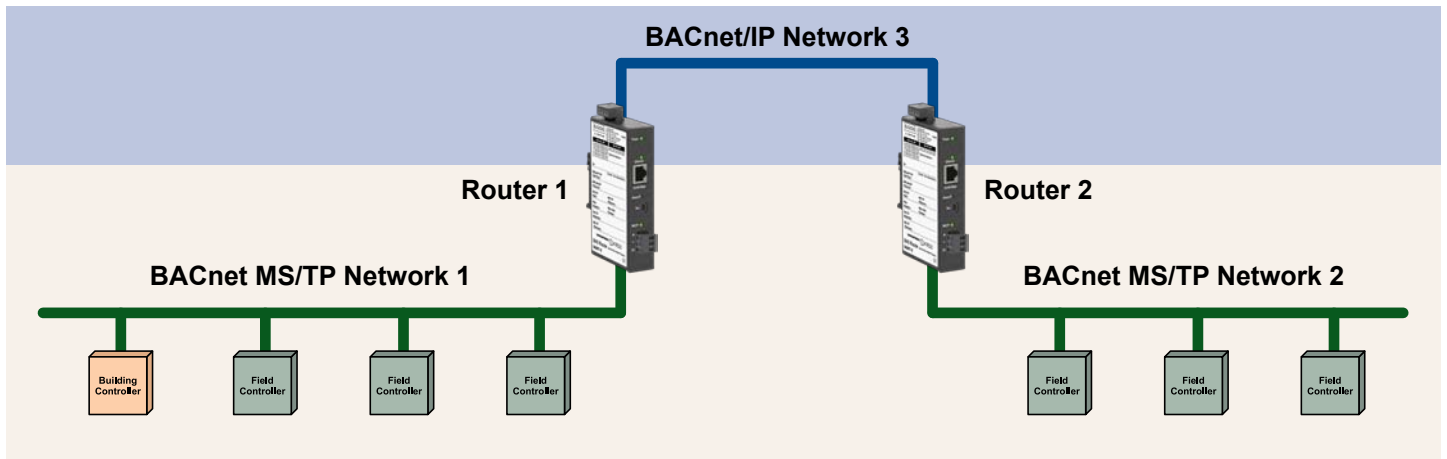
MAC Address 00-50-DB-00-4A-AA
Firmware Revision 2.6.8

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 BAS Routers. 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 BAS Router

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.



Device Name	BASRT-B004aa0
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.6.8

Router 1 Configuration

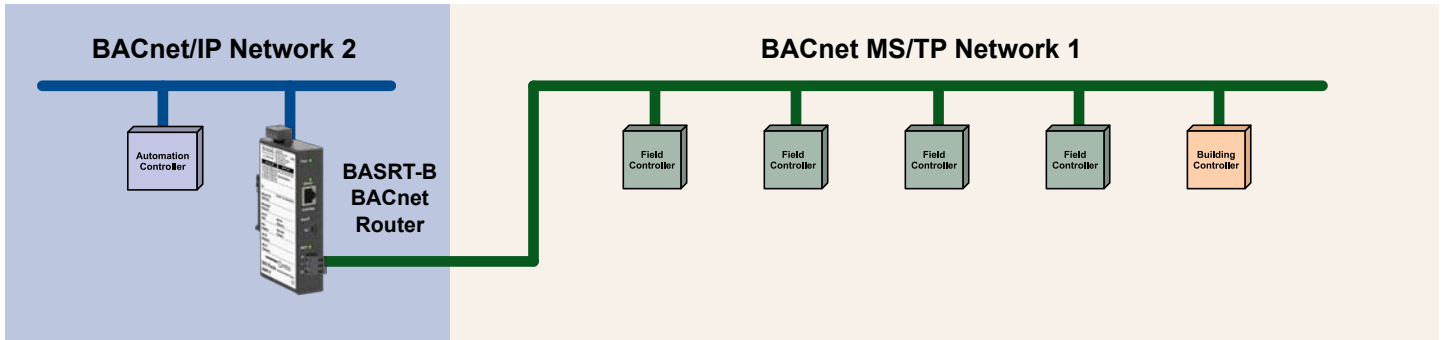
Device Name	BASRT-B004aaa
Device Instance	1
Ethernet Network	0
BACnet/IP UDP Port 1	BAC0
BACnet/IP Network 1	3
IP Address	192.168.92.70
IP Subnet	24
IP Gateway	192.168.92.1
MS/TP MAC	0
MS/TP Network	2
Max Masters	127
Max Info Frames	100
MS/TP Baudrate	38400
MS/TP Tolerance	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-AA
Firmware Revision	2.6.8

Router 2 Configuration

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 finding out that the field equipment that needs to be

added has only a BACnet/IP interface. The BAS Router will work fine in this application as well. Simply connect the BAS Router between the BACnet MS/TP network and the BACnet/IP device. There will be no speed improvement to the overall internetwork, but the new equipment will be connected.



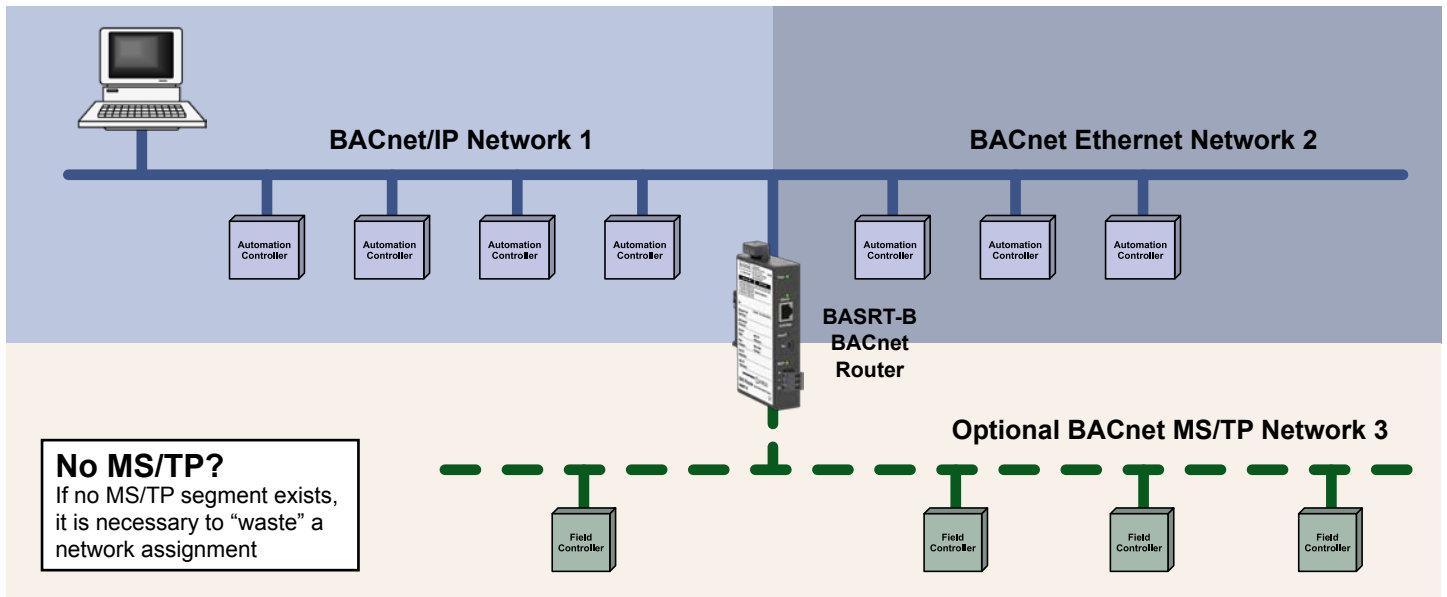
Router Configuration

Device Name	BASRT-B004aa0
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.6.8

Application #5 — One-armed Router Supporting BACnet Ethernet

Not only do all BAS Routers support BACnet/IP to BACnet MS/TP routing, BACnet Ethernet can be added to the mix in support of three-way routing. Do not confuse BACnet/IP and BACnet Ethernet. 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 either of the

BAS Router products. In such a case, there would be no connection to the MS/TP port on the BAS Router. There would only be the one connection to the Ethernet port on the BAS Router. This is called “one-armed routing” since there is only one connection. If routing to MS/TP is still desired, a connection could be made accordingly to achieve three-way routing. The BAS Router can simultaneously route between MS/TP, BACnet/IP, and BACnet Ethernet.



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:

Subnet mask:

Default gateway:

Obtain DNS server address automatically

Use the following DNS server addresses:

Preferred DNS server:

Alternate DNS server:

Advanced...

OK Cancel

PC 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 BAS Routers route between BACnet Ethernet and BACnet MS/TP. To enable BACnet Ethernet routing, you must configure the BAS Router web page such that a unique non-zero network number is assigned to the Network parameter for BACnet Ethernet. The same applies to the Network parameter for BACnet MS/TP.

Router Configuration

Device Name	BASRT-B004aa0
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
Save Changes	
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.6.8

Application #6 — BBMD server without Firewall

When attaching BACnet devices to IP networks it is possible that the IP network has been sub-netted through the use of IP routers such as the EIPR-E. 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 would appear 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 to be located on one of the subnets with FDR devices registering to this one BBMD. This is what is shown in the example with a BAS Router providing BBMD functionality while allowing for foreign device registration. Notice that connecting to a BACnet MS/TP network is an option.

Before the BAS Router can function as a BBMD it must be configured. A BBMD setup page is accessed by clicking the

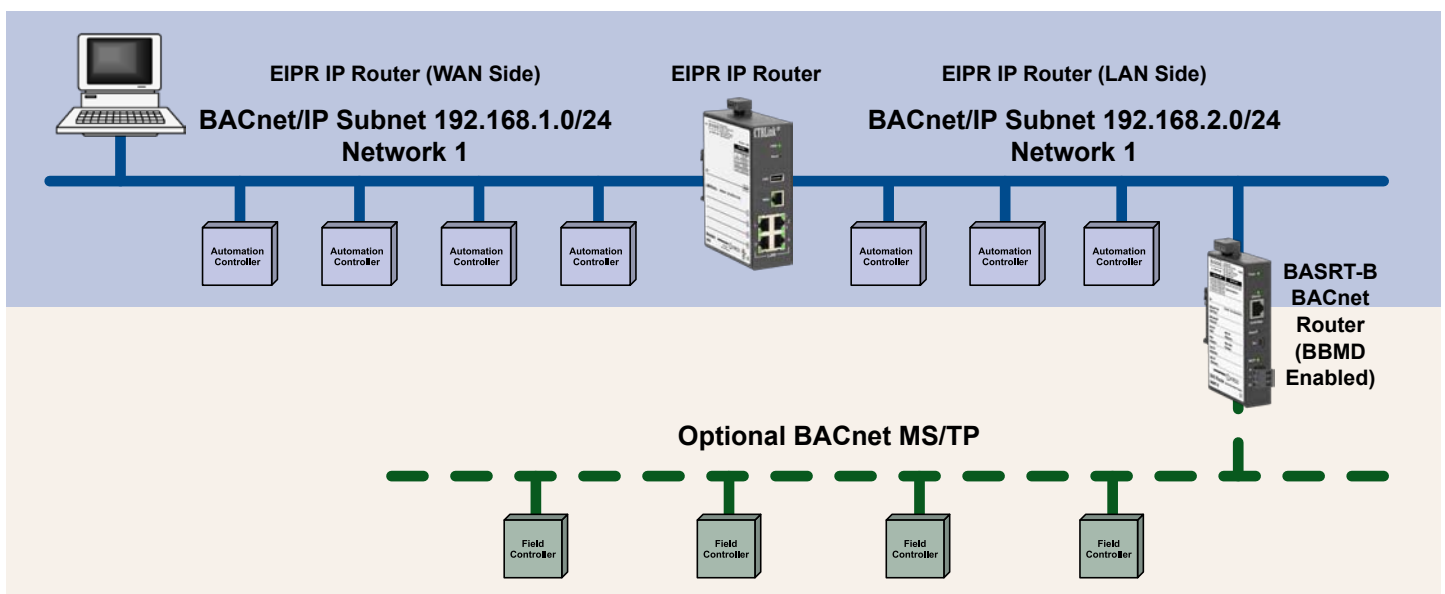
Advanced button on the BAS Router's main web page. On the Advanced screen, BBMD is enabled by checking a box. There are two choices for the BBMD UDP port. Normally, the primary BACnet/IP UDP is used, but an alternate port can be chosen. An Accept FDR box (checked by default) allows foreign devices to 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 BAS Router.

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 EIPR IP Router.

Although the BACnet/IP network is sub-netted, all subnets are assigned the same network number — in this example Network 1.



Application #6 — BBMD Server without Firewall

Main Screen

Device Name: BASRT-B004aa0

Device Instance: 0

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: 192.168.1.1

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: 2.6.8

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

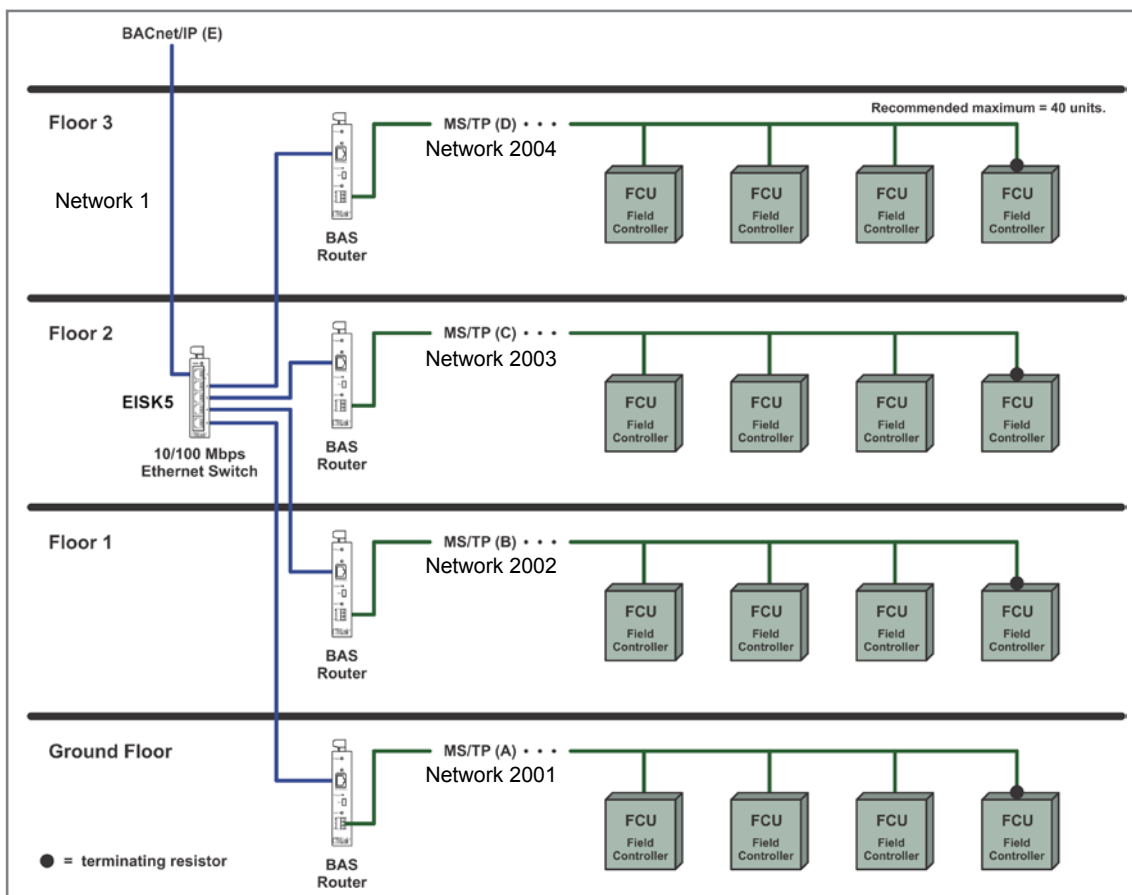
Application #7 — Connecting Field Devices on Multiple Floors

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 multi-storey 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 BAS Router and the far-end terminated with a 120 ohm resistor. The BAS Router is shipped with EIA-485 bias and termination applied so there is no need for an external terminator on the near side. The BAS Router 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. On each floor will be installed a BAS Router dedicated to the field devices on that floor. If the building supports structured wiring, the BAS Router 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 BAS Router 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 BAS Routers

Router 3 Configuration

Device Name	BASRT-3
Device Instance	3
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-AA
Firmware Revision	2.6.8

Router 2 Configuration

Device Name	BASRT-2
Device Instance	2
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-A4
Firmware Revision	2.6.8

Router 1 Configuration

Device Name	BASRT-1
Device Instance	1
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.6.8

Router G Configuration

Device Name	BASRT-G
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-AB
Firmware Revision	2.6.8

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 BAS Router 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 BAS Router and the BBMD Server. On the Firewall screen, the Firewall is shown as enabled. On the Advanced screen of the BAS Router, 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 BAS Router 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.

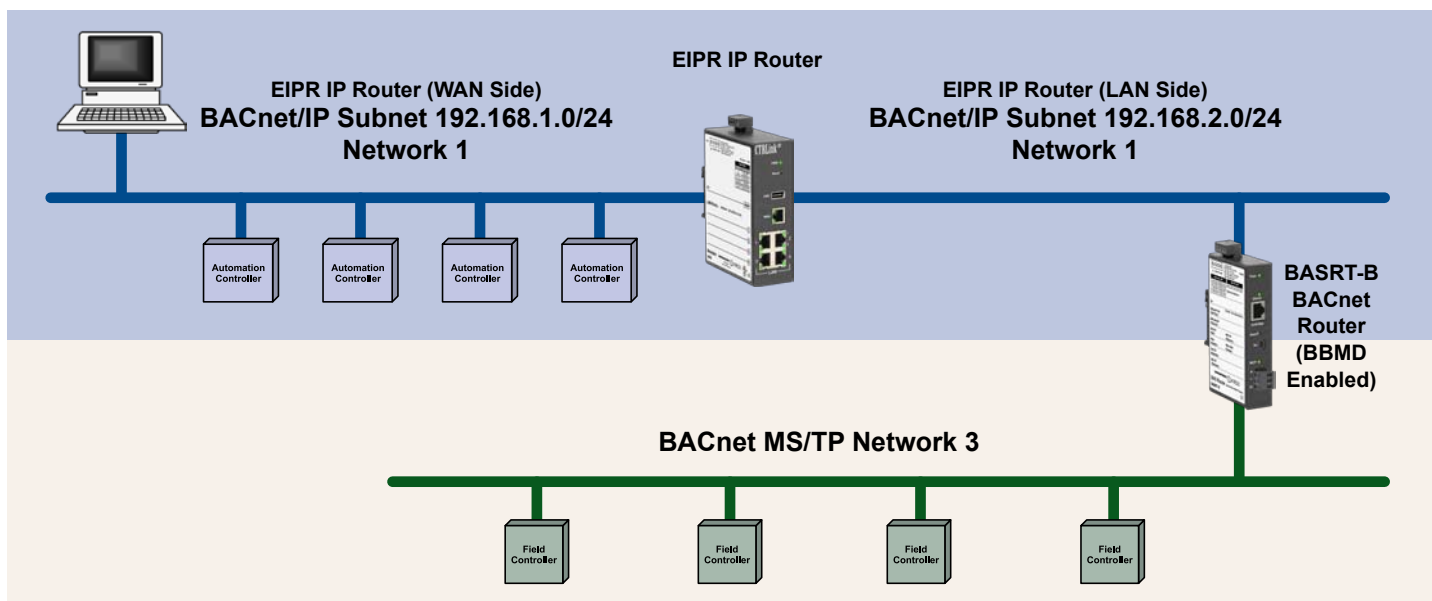
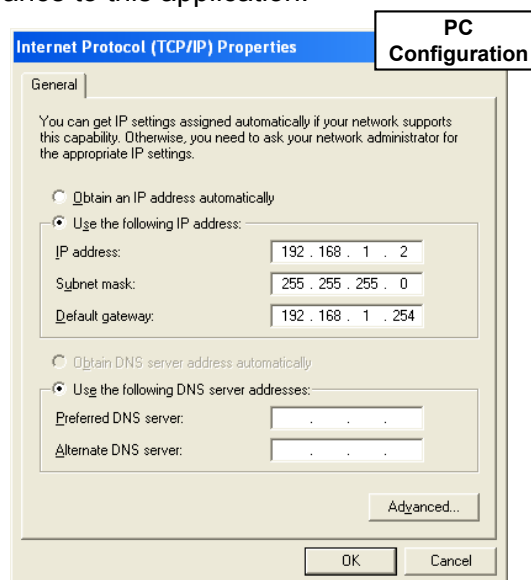
A BACnet/IP controller on the 192.168.1.0 subnet must have its Foreign Device Registration configured for a BBMD address of 192.168.1.1 and not the actual BBMD address of 192.168.2.2. However, because of the Port Forwarding entry made to the IP Router, a BACnet message sent to 192.68.1.1 will be forwarded 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 BAS Router 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.



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

Main Screen

Device Name	BASRT-B004aa0
Device Instance	0
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	<input type="radio"/> Strict <input checked="" type="radio"/> Lenient
<input type="button" value="Save Changes"/>	
MAC Address	00-50-DB-00-4A-A0
Firmware Revision	2.6.8

IP Router Port Forwarding

WAN IP Port	TCP/UDP	TO	LAN IP Address	LAN IP Port	Enabled
47808	Both	TO	192 . 168 . 2 . 2	47808	<input checked="" type="checkbox"/>
	Both	TO			<input type="checkbox"/>
	Both	TO			<input type="checkbox"/>
	Both	TO			<input type="checkbox"/>

Firewall Setting

Firewall

Firewall Status: Enable Disable

Advanced Screen

BBMD Enable	<input checked="" type="checkbox"/>
BBMD UDP Port	Primary
Accept FDR	<input checked="" type="checkbox"/>
<input type="button" value="Broadcast Distribution Table"/>	
<input type="button" value="Foreign Device Table"/>	
Secondary BACnet/IP UDP Port	0000
Secondary BACnet/IP Network	0
Public IP Address	192.168.1.1
<input type="button" value="Save Changes"/>	

IP Router Setup

WAN Setup

Connection Type:

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)

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?

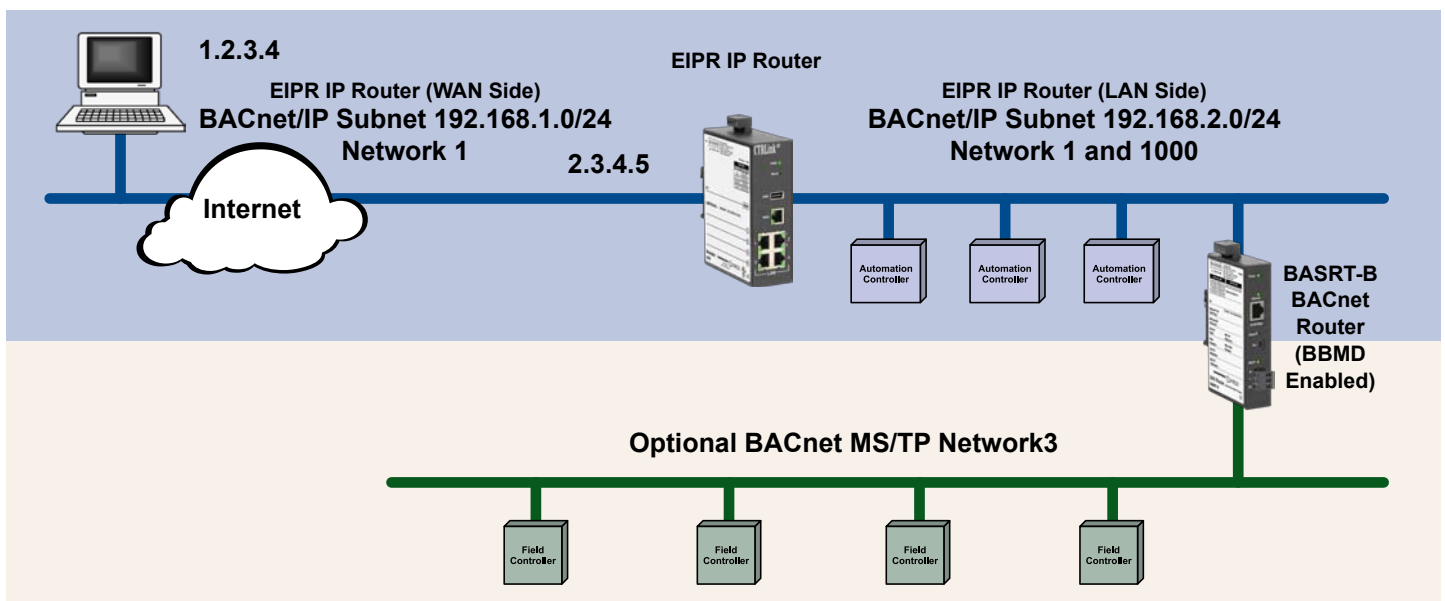
In this example, there are four BACnet/IP devices on the LAN-side of the EIPR IP Router — three BACnet/IP controllers and one BAS Router serving an MS/TP segment. Because of the enabled firewall in the IP Router, it is necessary to use Port Forwarding as was done in application #8 in order to penetrate 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 BAS router'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 BAS Router 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 BAS Router 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 BAS Router. 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.



Application #9 — Configuring the BAS Router and IP Router

Main Screen

Device Name: BASRT-B004aa0

Device Instance: 0

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-00-4A-A0

Firmware Revision: 2.6.8

IP Router Port Forwarding

WAN IP Port	TCP/UDP	TO	LAN IP Address	LAN IP Port	Enabled
47809	Both	TO	192 . 168 . 2 . 2	47809	<input checked="" type="checkbox"/>
	Both	TO			<input type="checkbox"/>
	Both	TO			<input type="checkbox"/>
	Both	TO			<input type="checkbox"/>

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...

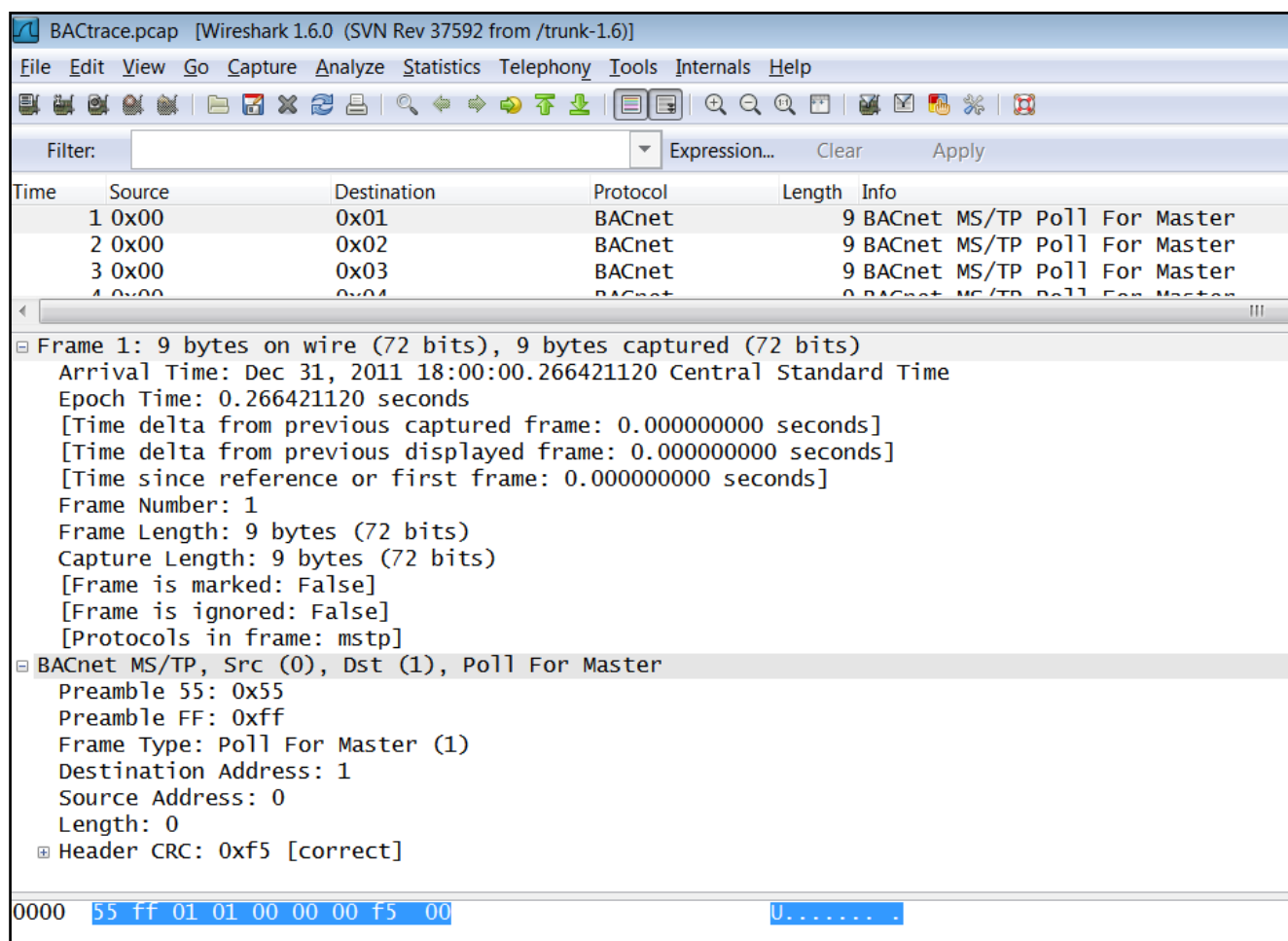
OK Cancel

Application #10 — Capturing MS/TP Traffic

The BASrouterLX is a high-performance router with diagnostic capabilities. It has a faster processor and more memory than the BASrouter or Portable BASrouter. It can do all the previous 9 applications. One feature that the BASrouterLX has 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. Installed on the same PC that is used for browsing is the Wireshark protocol analyzer. It can be downloaded for free from Wireshark.org. Intended for analyzing 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. As a background task, the BASrouterLX continuously records the last 3900 messages sent over MS/TP including both data and token passes. By depressing the **Generate MS/TP Wireshark File**, those last 3900 messages are converted to a “pcap” format file for viewing by a Wireshark. Once the conversion is made, depressing the **View MS/TP Traffic** button sends the captured file to the attached PC for Wireshark viewing. BACnet protocol decoding is built into this free but powerful protocol analyzer 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 is ready to transfer captured MS/TP at anytime.



Application #11 — Proxy Support for MS/TP Slave Devices

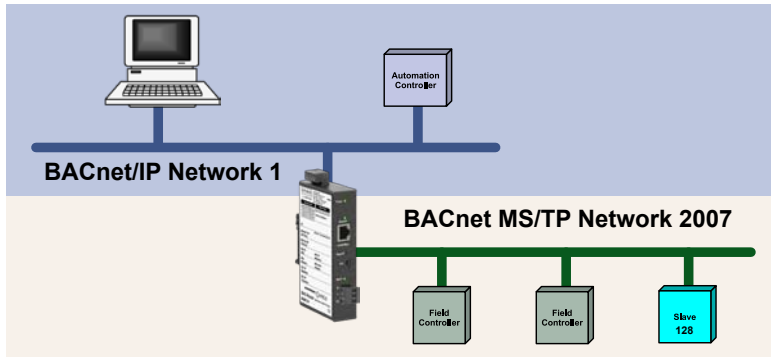
BACnet MS/TP is short for BACnet over a master/slave token-passing network. Stations that support the token-passing protocol are called masters while stations that do not support the token-passing protocol are called slaves. This is oftentimes confusing. The master with the token has momentary control over the network. This station can basically send a message or pass the token to its logical neighbor — the station with the next highest address. Master addressing begins at zero and can go up to 127. 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 supports.

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 had to 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.



Slave Proxy Enable: View Discovered Slaves

Auto Slave Enable:

Slave Proxy Logging Enable:

Manual Slave Proxy Entry

MAC Address: Device Instance:

Slave Proxy Table

Entry No.	MAC Address	Device Instance

Device Name:

Device Instance: (0 - 4194302)

Device Description:

Device Location:

Ethernet Network: (0 - 65534)

BACnet/IP UDP Port 1: (Hexadecimal value e.g. BAC0)

BACnet/IP Network 1: (1 - 65534)

IP Address:

IP Subnet: ▼

IP Gateway:

MS/TP MAC: (0 - 127)

MS/TP Network: (1 - 65534)

Max Masters: (0 - 127)

Max Info Frames:

MS/TP Baudrate: ▼

MS/TP Tolerance: Strict Lenient

Basic Parameters for All BAS Routers

<i>Device Parameter</i>	<i>Default Value</i>	<i>Description</i>
Device Instance	0	The router device instance is a 22-bit decimal value (0–4,194,302). Each BACnet device has a unique device instance.
<i>BACnet Ethernet Parameter</i>		
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.
<i>BACnet/IP Parameters</i>		
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.
<i>MS/TP Parameters</i>		
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 BAS Router.
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

<i>BBMD Parameters</i>	<i>Default Value</i>	<i>Description</i>
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 non-existing 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.
<i>NAT Parameters</i>	<i>Default Value</i>	<i>Description</i>
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

Setup Tab Parameters

<i>System</i>	<i>Default Value</i>	<i>Description</i>
Device Description	Blank	Up to 80 characters chosen by the user.
Device Location	Blank	Up to 80 characters chosen by the user.
<i>Time</i>	<i>Default Value</i>	<i>Description</i>
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.
<i>Username/Password</i>	<i>Default Value</i>	<i>Description</i>
Username	admin	Up to 80 characters chosen by the user.
Password	admin	Up to 80 characters chosen by the user.
<i>Config Upload/Download</i>	<i>Default Value</i>	<i>Description</i>
Select Configuration File ...	Blank	Browse... to a BASrouterLX configuration file, then click Upload .
Save Configuration File to PC	n/a	Click Save to save the current BASrouterLX configuration to a PC.
<i>Firmware Upload</i>	<i>Default Value</i>	<i>Description</i>
Select Firmware File ...	Blank	Browse... to a BASrouterLX firmware file, then click Upload .

Advanced Tab Parameters

<i>BBMD</i>	<i>Default Value</i>	<i>Description</i>
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 non-existing 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 BASrouterLX must communicate with BACnet devices in other subnets where no BBMD is present — and if those devices are capable of Foreign Device Registration.
<i>NAT</i>	<i>Default Value</i>	<i>Description</i>
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 BASrouterLX 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 BASrouterLX 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 BASrouterLX. This value is used in the Forwarded-NPDU IP Address field.
<i>Slave Proxy</i>	<i>Default Value</i>	<i>Description</i>
Slave Proxy Enable	Unchecked	Check this to allow the BASrouterLX 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 .
<i>Broadcast Distribution Table</i>	<i>Default Value</i>	<i>Description</i>
BBMD IP Address	Blank	The IP Address of the BBMD that will communicate with the BASrouterLX.
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.

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