

S4 Open: BACnet-N2 Router

Installation and Operations Guide



Enabling the transition from Metasys® to BACnet

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Please note that the terms S4 Open: BACnet-N2 Router and S4 Open Appliance, and their variations, are used interchangeably throughout this document.

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OVERVIEW

Overview

This document orients the new user to the user interface, concepts of operation, and administration of all S4 Open Appliances. The functionality of each product is determined by factory installed licensing certificates and can be easily upgraded in the field at any time. The S4 Open: Management Console is used for the administration, configuration and diagnostic evaluation of all members of the S4 Open product line.

This guide provides information on the installation, configuration, and application of the S4 Open: BACnet-N2 Router.

PRODUCT OVERVIEW

The S4 Open: BACnet-N2 router offers flexibility and cost savings when integrating legacy Metasys® N2 networks into BACnet environments. Avoid the heavy upfront costs of replacement or re-engineering existing devices by offering building owners a transition strategy.

FEATURES & BENEFITS

Features	Benefits
Support for all N2 variations	The N2 Router supports any N2 device that you will find on an N2 bus including N2 Open, VMA, Vendor Devices, Metasys Integrator, and Centaurus Integrator. Direct Read, Write, Override, and Release transactions for any point limited only by the programming in the N2 device.
Automatic N2 device discovery	The Configure Wizard automatically discovers N2 devices and applies the appropriate Device Type Template, drastically cutting down on the man hours required for this type of job
S4 Open Management Console	Appliance discovery, setup, commissioning, maintenance, and management are all performed from one convenient interface. Multiple copies of the Management Console can be installed to manage a facility in the way that works most effectively
Upstream Interface	Co-exist with the legacy head end: minimize downtime for building occupants, retain programming in the legacy head end, transition when you're ready
Gateway to BACnet IP, publish each N2 device as its own BACnet device in a virtual BACnet network.	Cost effective way to add value and extend the life of legacy systems in the short term, facilitates the migration away from Metasys® in the longer term.
"supervisory controller as a BACnet client"	The N2 Router can force the N2 data stream from legacy Metasys® supervisory controllers to participate in the BACnet priority array mechanism, giving the integrator complete control over which head end is commanding each point. No other product has this capability.

Concepts

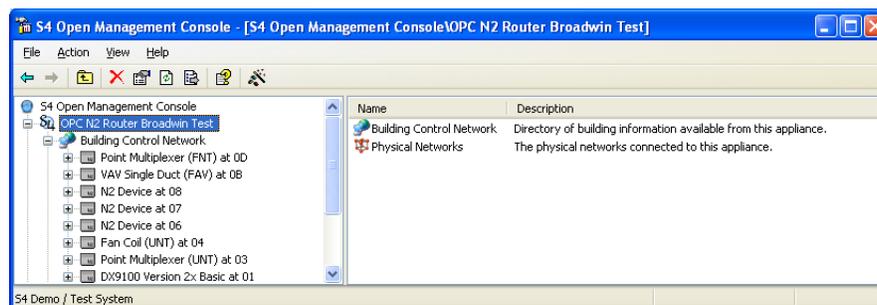
S4 OPEN: MANAGEMENT CONSOLE

All user interaction with the system is done through the S4 Open: Management Console. The console enables you to manage all S4 Open Appliances in your enterprise. Launch the console from the Windows Start menu. The S4 Open: Management Console is compatible with all versions of Microsoft Windows from XP on. The console may be installed on as many machines as you need at no additional charge.

IMPORTANT NOTE: You may need to manually uninstall any previous versions of the console prior to installation through the Add/Remove Programs utility in Windows Control Panel.

S4 Open Appliances are implemented using advanced object oriented technology. This gives our developers the power to perform the tasks necessary to deliver the services you need. More importantly, all of the proprietary details of physical devices are managed behind the scenes, presenting a consistent and predictable view of your building automation environment to you.

- Objects will dynamically be added or removed from the left hand navigation pane (as folders or detail objects) as needed to represent your building automation environment. You can expand or minimize the amount of detail that is presented in the navigation pane.
- Details about each object in the navigation pane are presented in the right hand pane.
- Properties pages are available as right click options from many objects. Wizards and drill down links provide more details about the objects and allow you to adjust user settable parameters.
- Real Time performance statistics are available from the properties page of many objects.
- Color coded icons are included in many places to give you quick look status information about the objects that they represent.
- Most operations are intuitive but help is available any time you need it. You can use the main Help menu item, right click on any object and select Help in the drop down menu, or press F1 on your keyboard at any time.
- Configuration changes can be made on an operational system and will automatically be reflected in the data provided on all interfaces.



S4 OPEN APPLIANCE

All system level commands are issued from the S4 Open Appliance object folder or set through associated Properties pages. In the previous screenshot, the specific product is the S4 Open: OPC-N2 Router, the default name displayed for the appliance object. This name may be customized for your installation on the appliance Properties page.

N2 Device Type Templates

Point mappings are provided as N2 Device Type Templates. A unique Device Type Template is provided for each combination of Metasys[®] hardware platform and application loaded into the Unitary or Application Specific Controller. Vendor provided N2 Compatible devices also have Device Type Templates. Device Type Templates are automatically assigned to each device object by the Configure Wizard. You have the option to override the assigned Device Type Template with your own variation for custom applications.

A default set of N2 Device Type Templates comes pre-loaded in the S4 Open Appliance. Additional Device Type Templates may be loaded via a library provided with the S4 Open: Management Console from a Properties page in the S4 Open Appliance main folder, or you may develop your own for unique requirements. Refer to other documentation for details on creating and maintaining Device Type Templates.

Configure Wizard

The primary system level configuration wizard is initiated as a right click command option on the S4 Open Appliance folder. In most cases, initiating this command is all you need to do to fully configure and commission an S4 Open Appliance. Do this after loading the appropriate set of N2 Device Type Templates into the appliance, if needed.

System Configuration File

The internal system file that contains all user-selectable options, the device type template catalog, and N2 device configurations.

BUILDING CONTROL NETWORK

The virtual objects in the Building Control Network (BCN) provide a unified view of your building automation environment. All devices and their points found on the downstream physical networks are represented as objects under this folder. Most of your interaction with the system will be with objects contained in this folder.

N2 address translation is automatically performed as multiple legacy downstream N2 networks are merged into the BCN during the Auto Configure process, ensuring that each N2 address published to the Upstream N2 network is unique. This allows you to merge multiple legacy N2 networks into one virtual N2 network without having to physically touch any of the N2 devices to adjust addresses. The Properties page for a device object shows the N2 address that it will publish on the Upstream N2 network. This is a user configurable value. You can also see the physical network and physical N2 address where the device was found on a legacy N2 network.

IMPORTANT NOTE: There is no data routing between the upstream interfaces and the physical N2 networks until after the Auto Configure process is completed. Points that exist on the devices on the physical N2 networks are not accessible via any upstream interface until this process is completed.

The Configure Wizard:

- Scans all physical networks
- Creates all of the virtual objects in the BCN
- Assigns N2 Device Type Templates to device objects
- Creates the appropriate routing algorithms for all published objects, and
- Publishes the point objects to the default upstream interfaces.

The virtual devices and points contained in the BCN folder can be published to any licensed upstream interface. You have the option of overriding the default publishing configuration on the Properties page of any point object.

By default:

- All current S4 Open Appliances publish all point and device objects to the Upstream N2 interface.
- The S4 Open: OPC-N2 Router, in addition, publishes all device and point objects to the industry standard open OPC interface with the addition of “Release” points, which OPC does not natively support.
- The S4 Open: BACnet-N2 Router, in addition, publishes all device and point objects to the industry standard open BACnet/IP interface.

You can manually create purely virtual device objects and point objects in the BCN. That is, objects that have no linkage to a physical device. These objects are used by our optional controller packages to store the results of calculations or publish global variables.

The “online” status of a N2 device is denoted by the color of the associated device object icon. Green indicates the device has seen recent activity, grey indicates that it has not. If access to a device fails, the N2 router will try multiple times to re-initialize the N2 device and try the N2 command again. Please note: This is completely independent from the online / offline status of a device in a Metasys[®] supervisory controller, Operator Workstation, or M-Series Workstation.

NETWORK CONNECTIONS

Metasys N2 & Ethernet Interfaces

Folders and objects within the container represent communications interfaces to the S4 Open Appliance. The following options are available within the Properties page for each network object:

- Associate a physical COM port with the network
- Associate an Ethernet Serial Server with the network
- Monitor real time performance of the network

- Examine the properties of devices found on the legacy N2 network
- Search for Field Devices on the network
- Enable or Disable the network

Most of your interaction with objects within the Physical Networks folder will be during initial setup of the S4 Open Appliance or when using the S4 Open Appliance as a diagnostic tool for your legacy N2 networks.

Upstream Network

The upstream N2 interface used to publish device and point objects is displayed as a network object under the Physical Networks folder. By default, this is configured for COM4.

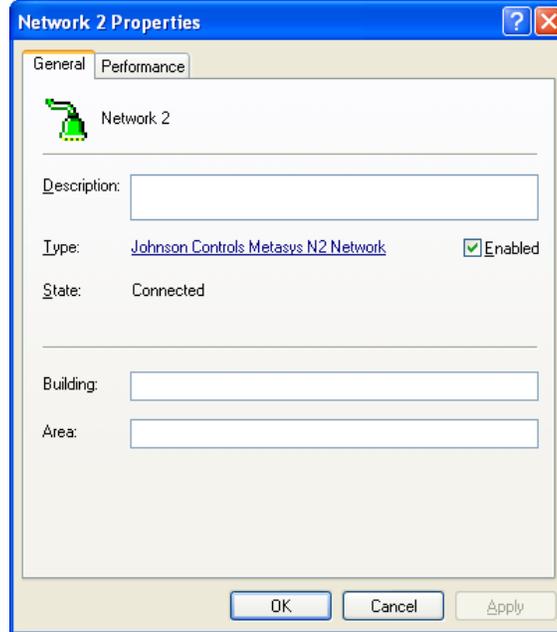
Connecting a Metasys[®] supervisory controller to the Upstream N2 port is completely optional (except when using the S4 Open: N2 Switch). If no Metasys[®] supervisory controller is attached, the S4 Open Appliance will automatically assume the role of the N2 Master. To shut off communications to the Metasys[®] supervisory controller, you can disable the Upstream N2 network from its Properties page, available as a right click option in the navigation pane.

IMPORTANT NOTE: We always caution customers about the risks of keeping both the legacy Metasys[®] supervisory controller and the new head end in the configuration. Doing this is technically viable, but the two head end systems may try to control the value of a point on a N2 device at the same time. You need to understand the control algorithms and programming implemented in both head end systems and make certain there are no conflicting control actions being generated.

Open Upstream Interfaces

Depending on the model of your S4 Open Appliance, it will support one or more of the following open protocols / interfaces as a target for publishing Device and Point objects to. OPC, BACnet / IP, XML, and SNMP utilize the system's Ethernet port; therefore, these options will **not** have a network object in the Physical Networks folder. Others, like BACnet MS/TP require a physical interface. In these cases, you will see additional network objects in the form of additional folders under the Physical Networks folder.

Network 1, Network 2 ... Network n



Network n is a view of what the S4 Open Appliance has found on each of the Downstream legacy BAS networks or field buses. “N” refers to the network number. The network type is found in the Properties page for the network. In this case, you can see we are working with Metasys® N2 networks.

IMPORTANT NOTE: The “Search Field Devices” command, available from a right click on the Network device object folder, should be used only when manually configuring the system or using the console as an N2 network diagnostic tool. Search Field Devices creates device objects in the corresponding Network n folder-- but it does not fully configure the system. Under normal circumstances, the Configure Wizard at the router node level will handle the entire process of setting up the system.

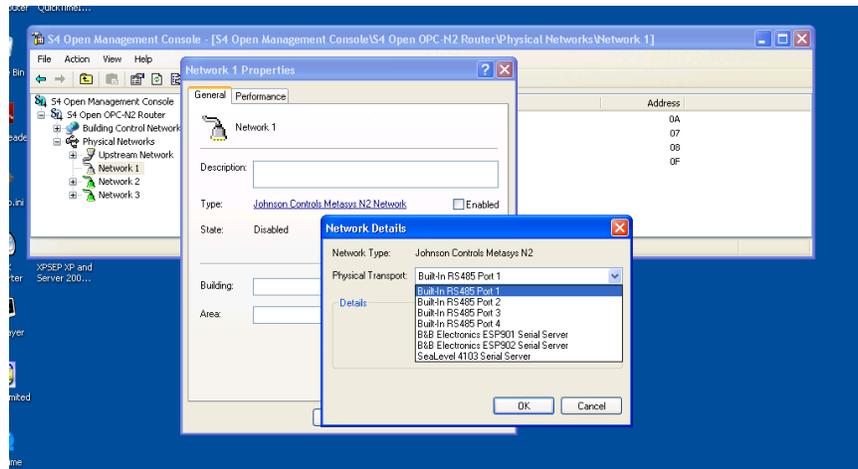
Network Extended N2 Connections

If you need more Downstream N2 interfaces than are physically provided by the COM ports on the appliance, or you need to extend N2 connections over your Ethernet infrastructure, commercially available Ethernet Serial Servers may be utilized.

The serial server is fully integrated with the network object interface. You will select a serial server type and its IP address via the Properties page for the Downstream or Upstream interface. Utilizing this technology, you can add as many Downstream networks as you need to license for an installation (within reason). This feature is not available for Upstream N2 Networks. Contact your reseller if you need to purchase licenses for additional interfaces.

OVERVIEW

S4 Open Appliances currently support Advantech, B&B and Sealevel Systems Ethernet serial servers. Check the S4 Group web site for an updated list of tested and supported devices.



IMPORTANT NOTE: S4 Open Appliances provide a lot of flexibility when integrating legacy N2 networks, but please be aware that you must still follow address space limitations and honor the Metasys® reserved N2 addresses when publishing to the Upstream N2 network. Typically, this means that you can assign N2 addresses 1 through 253. Addresses 0, 254, and 255 are reserved for Metasys®.

SPECIFICATIONS

S4 Open Appliances are hosted on an Advantech UNO-2059GL industrial PC

- *Power supply voltage:* 10-30 VDC, reversed wiring protection
- *Power Consumption:* 0.6A max under +24V power input or 1.2A max. under +12V power input
- *Power Requirement:* 1A typical under +24 V power input or 1.5 A typical under +12 V power input
- *Operating temperature:* -10 ~ 55°C (14 ~ 131°F)
- *Chassis size:* 164.8 mm (W) x 106.5 mm (L) x 35.5 mm (H) (6.5" x 4.2" x1.4")
- *Weight:* 0.8 kg

OPTIONS & ORDERING

How many devices?

The number of N2 devices determines the size of the router you will need. Choose from 16, 32, 64, 128, or 253 (256, with 3 addresses reserved by Metasys®).

How many Downstream interfaces?

Every S4 Open appliance comes with one downstream interface enabled by default. The Downstream Adapter provides an easy way to connect legacy Metasys® N2 buses to S4 Open appliances, without any wiring changes to either system. Simply disconnect the legacy bus from the controller, plug it into the S4 Open Appliance and rapidly begin the integration process. You may choose to enable one or two additional downstream ports, depending on your needs.

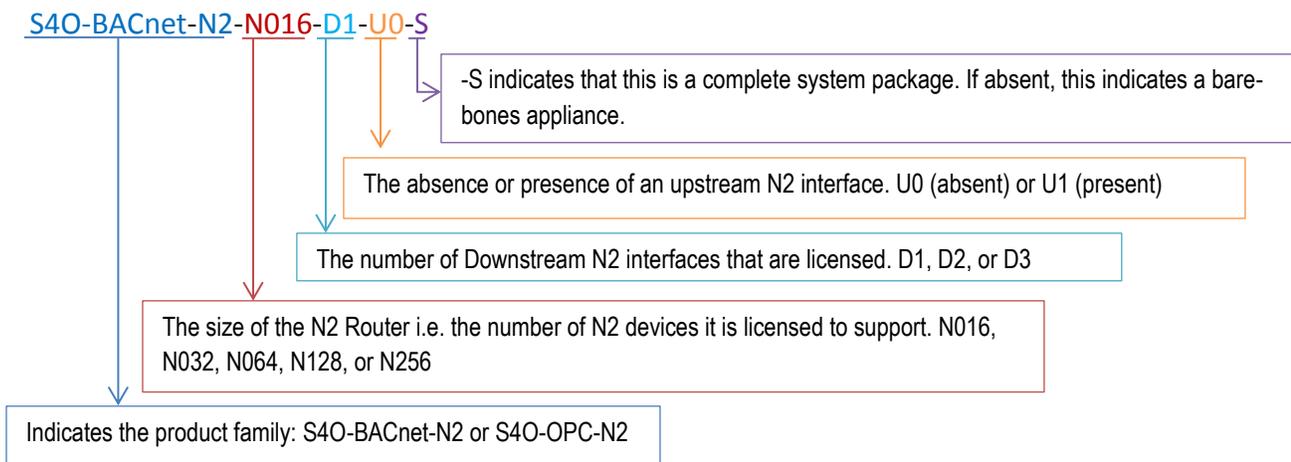
Upstream connectivity?

Upstream capability is available as an option on all S4 Open appliances, and comes with the full-size (256) router by default. Upstream connectivity provides an easy way to connect a legacy Metasys® supervisory controller to an S4 Open appliance. The installer simply disconnects the legacy bus from the supervisory controller, plugs the Upstream Cable into the supervisory controller, and continues on with the integration process.

System Bundles

S4 Open appliances are sold as system bundles, which means they come complete with power supply and all necessary cables and adapters, as well as the support CD and Quick Start guide.

All of the information above is represented in our product numbering system. See how it all comes together:



Successful Site Considerations

MATERIALS AND TOOLS FOR INSTALLATION

Johnson Controls ComBus Quick Tester	Available from The S4 Group;
S2USB from S Squared Innovations	Available from The S4 Group; you will need a laptop with you for the S2 device
Digital volt meter	(if not using one of the above tools)
M-Tools package	Contact S4 for a list of distributors
CAS BACnet Explorer	A demo is provided on the support CD that comes with the S4 Open appliance. The full version is available from Chipkin Automation Systems

MINIMUM REQUIRED TRAINING & SKILLS

Minimum S4 Training requirements:

- Attend a live demo or web training session

- Review manual and installation guides

- Ideal: attend an “integration bootcamp” course, or be trained by someone who has

Basic JCI skills required:

- Ability to use HVAC Pro, GX9100, find/export .DMO and .PRN files

- Know the sequence of operations for all N2 devices

- Get into the NCM (or other supervisory controller) to interpret custom code

- OR- hire a consultant with Metasys® expertise. The S4 Group maintains a list of Metasys® experts.

METASYS N2 INTEGRATION PLANNING GUIDE

A step-by-step guide to a successful Metasys® N2 integration project.

Remember to investigate before you integrate!

Integration Planning Guide

Investigate the Legacy N2 Bus

Before attempting to install an S4 Open Appliance, it is strongly recommended that the integrity of the N2 Bus be verified. A standard digital volt meter may be used to accomplish this, but we recommend using the ComBus Quick Tester or S2USB device.

- You will need any or all of the following tools. The more tools you have at your disposal the greater the accuracy of your information:
 - The ComBus Quick Tester – available from The S4 Group
 - Johnson Controls Utilities – Often, these utilities are located on the Operator Workstation located at the site.
 - HVACPRO
 - GX-9100
 - A digital volt meter
 - Site Plans / Metasys® Network Schematics
- Refer to the accompanying *Checking the Electrical Status of the N2 Bus* for information on verifying the physical integrity of a legacy Metasys® N2 installation.
- Complete the accompanying *N2 Bus Worksheet* for each physical N2 bus you plan to integrate.
 - Please fill out this worksheet as completely and accurately as possible.

Locate and Copy N2 Configuration Files

- You will need the following tools:
 - Access to the legacy Metasys® Operator Workstation.
 - A USB Thumb Drive or Other Storage Medium
- The files can usually be found in the following directories:
 - C:/WINPRO/ - Default directory of HVAC PRO for Windows
 - C:/HVACPRO/ - Default directory of HVAC PRO for Dos
 - C:/WGX9100/ - Default directory of GX-9100 for Windows
 - C:/GX9100/ - Default directory of GX-9100 for Dos
 - You can also search the local drives for files using Microsoft Windows search
- The files have the following extensions: (Files marked with a * contain the most relevant information)

System 9100 Devices (DX-9100, devices on the DX-9100 “XT” Bus) – Found in the GX-9100 directory

devicename.DXS	Configuration file generated by GX-9100, binary – can be read by GX-9100 and used to generate any of the other files
devicename.DMO*	The model file generated by GX-9100, this is the most useful file for integration purposes, text
devicename.DNC	Defines AI, BI, AO, BO points only, text
devicename.TAG	Defines custom user names for DX-9100 points, does not contain very much information but can be useful, text

INTEGRATION PLANNING GUIDE

LCP / DR-9100 Devices – Found in the HVACPRO directory (created by LCPCFG.EXE)

devicename.GPS*	The main configuration file, text
------------------------	-----------------------------------

Most other N2 Open Devices – Found in the HVACPRO Directory

.CFG – This file can be used to generate all other files	The binary configuration file. HVAC PRO creates this file when the configuration is saved.
---	--

.DAT	The graphing file. HVAC PRO creates this file while monitoring control loops or data points.
-------------	--

.DDL	The optional DDL incremental source file for the Control System (CS) Model.
-------------	---

.ERR	The error file. HVAC PRO creates this file if there are errors when saving a configuration.
-------------	---

.PRN*	The optional print file. HVAC PRO creates this file after saving a configuration.
--------------	---

ASC – “Application Specific Controller”

.ASC	The downloadable object file for an ASC.
-------------	--

TC – “TC-9100”

.TCD	The TC-9100 download file created during the File>Save/Save As process for a TC-9100 configuration, Metasys Release 9.01 or later.
-------------	--

VMA – “Variable Air Modular Assembly”

.MAB	The Metasys Application Basic file created by HVAC PRO. This file defines the VMA 1400 Series application that results from a Question/Answer Session.
-------------	--

.MAO	The Metasys Application Object file created during the File Save/Save As process. This file is downloaded into the VMA device.
-------------	--

.MAU	The Metasys Application User Information file used during download process. This file contains user information that enables a later upload.
-------------	--

- Copy the files that are relevant to your project to the storage device.
- These files will serve the basis for generating N2 Device Type Templates that will be used in the N2 Router to provide appropriate point mapping.

Investigate Legacy Supervisory Controllers, Operator Workstations and Application Data Servers

Plan and Budget the Project

- You will need the following resources:
 - Completed worksheets from the previous sections
 - An understanding of the goals for your project
- Complete the accompanying *Planning and Budgeting Worksheet*

Discuss Results with the Facility Owner

- Take all the information that has been gathered and present the facility owner with a comprehensive overview of:
 - The current situation – what’s working and what’s not from the customer standpoint
 - Existing facility conditions
 - The work that needs to be done to meet the project requirements
 - An accurate estimate of the total time and cost to complete the project
 - Transition strategy options and timeline- highest priority items can be tackled first, the rest of the work can be completed over X number of years, or as opportunities arise (during a remodel, for example)

Implement Solution

OTHER NOTES

Pre-Metasys[®] (JC8500) devices are not N2, and are therefore not supported by the S4 Open: BACnet-N2 router.

Approach the NCU, NEU, and Point Multiplexer devices with caution- be aware that you may require outside expertise

ASBESTOS ABATEMENT CONSIDERATIONS

Identifying Asbestos, and any other hazardous materials, in a facility along with the associated abatement approach is a standard part of the site survey and project planning process. An accepted attitude with asbestos contamination is that as long as it is left undisturbed, it does not pose a health threat. The S4 Open: BACnet-N2 Router facilitates this strategy by integrating to the legacy Metasys[®] N2 field bus and connected devices at the head end of the system. This avoids the costly and disruptive necessity of opening up contaminated access spaces thereby putting into effect an approach that avoids disturbing asbestos contaminated areas.

See case study: Jackson Federal Building, Seattle WA

INSTALLATION

Physical Installation

LOCATION CONSIDERATIONS

Consider the following when choosing a location for the Appliance:

This product is intended for indoor use only.

The required operating temperature range is from -10°C (14°F) to 55°C (131°F).

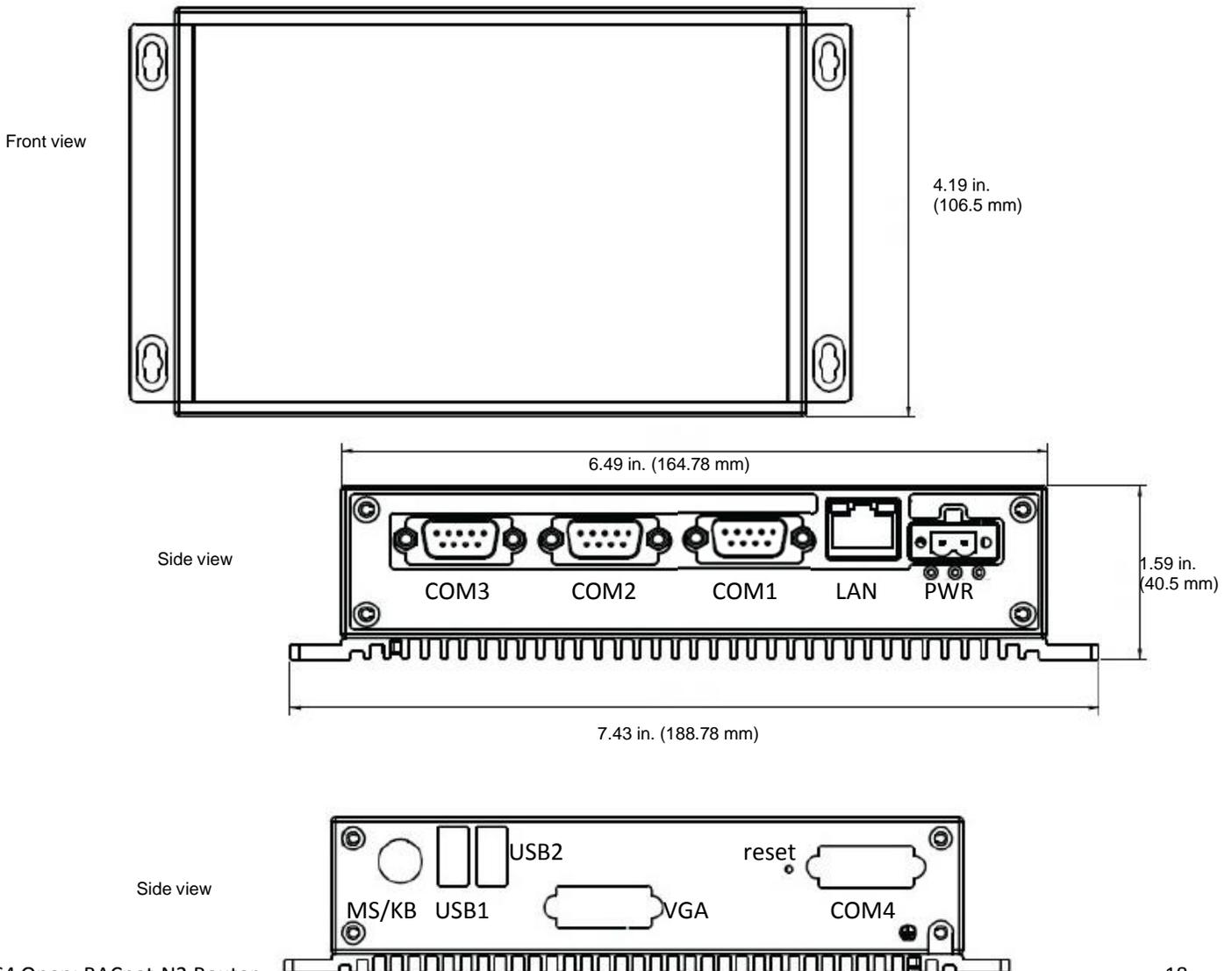
The maximum relative humidity is 95% at 40°C non-condensing.

Do not mount the unit in an area:

- Where excessive moisture, corrosive fumes, or explosive vapors are present.
- Where vibration or shock is likely to occur.
- Subjected to electrical noise, including the proximity of large electrical contractors, electrical machinery, welding equipment, spark igniters, and variable frequency drives.

Choose a location that allows enough clearance for wiring, servicing, and removal.

DIMENSIONS



COM PORT ASSIGNMENTS

The physical COM ports are labeled on the N2 Router. The default assignments are:

- COM1 – downstream N2 Network 1
- COM2 – downstream N2 Network 2
- COM3 – downstream N2 Network 3
- COM4 – upstream N2 Network

MOUNTING THE ROUTER

The N2 Router can be installed either by using the included DIN rail stands, or by mounting the router directly to a hard surface.

DIN Rail Mounting

1. Locate the DIN Rail stand labeled L and slide it onto the left side of the router, with the flat side of the stand facing up. Repeat for the right side of the router.
2. Position the router on the DIN rail, tilting the router to hook the DIN rail tabs over the top edge of the rail.
3. On both sides of the router, push the locking button up to secure the router to the rail.

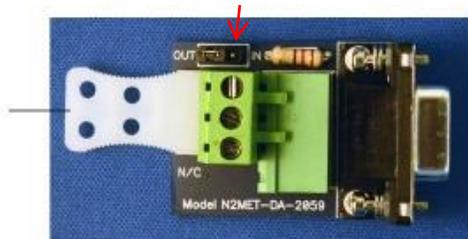
Wall Mounting

Insert screws through the holes on each side of the router; screw into pre-drilled holes in the wall.

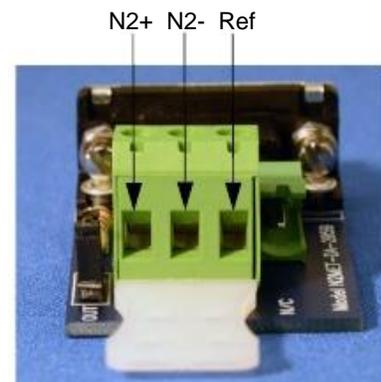
WIRING THE ROUTER

Make wiring connections to the N2 Router in the following order:

1. Wire the power supply.
 - a. On the green power supply, attach one lead to the +V and one lead to the -V inputs.
 - b. Connect the power supply to the Router.
2. Connect the existing N2 link(s) to the N2 Router.
 - a. On the downstream port adapter, thread the N2 link wires through the holes on the strain relief.
 - b. Connect the N2+, N2-, and Ref wires to the port adapter.



Downstream port adapter: top view



Downstream port adapter: wiring

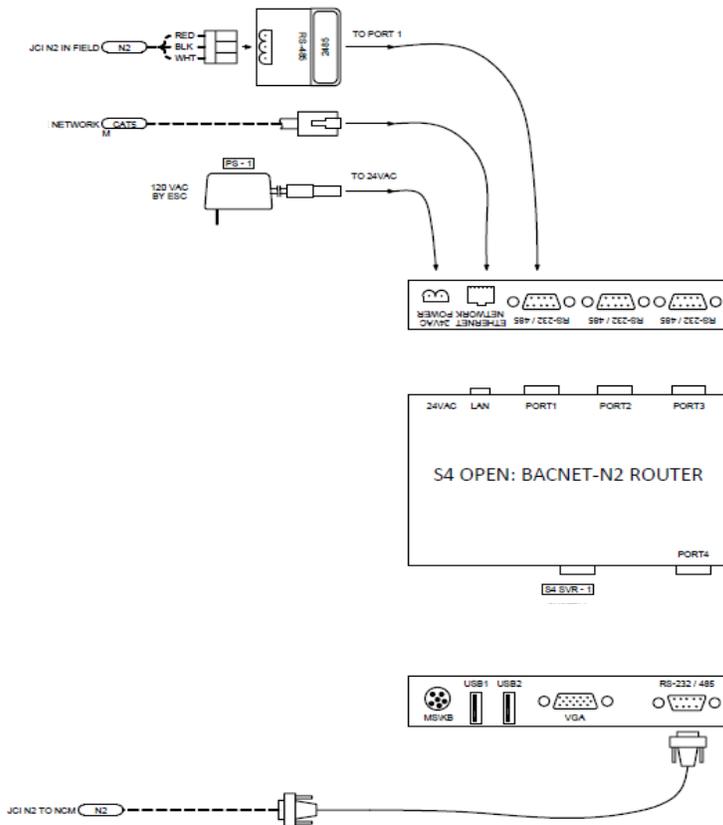
Note: This is the same style connector and pin arrangement used by the existing N2 link. You may be able to unplug the existing 3-wire connector from the JCI system controller and plug it into the downstream adapter port.

INSTALLATION

- c. Plug the adapter into the appropriate COM port. Connect the first N2 link to the COM1 port.
- d. Screw tighten the downstream adapter to the Appliance.
- e. Repeat the process with additional N2 links, if applicable, using COM2 then COM3 ports.

NOTE: Inspect the EOL settings on the Metasys® supervisory controller to determine if termination should be applied. If EOL is 'on' termination is applied and the jumper should be set to IN (see red arrow in top view image); conversely, if EOL is set to 'off' the jumper should be set to OUT.

- 3. Connect the N2 Router to the JCI Supervisory Controller (if the upstream feature is enabled)
 - a. Plug the 9-pin end of the upstream cable into the Router's upstream port (COM4). Tighten the connection.
 - b. Plug the green end of the upstream cable into the JCI Supervisory Controller.
- 4. Plug the Ethernet cable into the LAN port.



S4 Open Appliance Configuration

S4 Open Appliances are configured using the S4 Open Management Console.

SOFTWARE INSTALLATION

The Management Console can be installed on any PC running Microsoft® Windows version XP or later. The software may be installed on as many PCs as needed at no additional charge.

To install the program:

1. Insert the provided Support CD into the computer's CD drive
2. Navigate to My Computer and open the CD
3. Open the "S4 Open Management Console" folder
4. Double click "S4 Open Management Console.msi"

This will launch the Setup Wizard:



CONFIGURATION

5. Follow the prompts to complete installation.
6. Click “Finish” and reboot the PC

Windows Firewall Configuration
 After rebooting the PC, open the Open Management Console software. A Windows Security Alert may display a warning you that Windows Firewall has blocked some features of this program. If you receive this error:

1. Check Allow Microsoft Management Console to communicate on these networks: Private networks and Public networks.
2. Click Allow Access.

CONNECTING TO THE N2 ROUTER

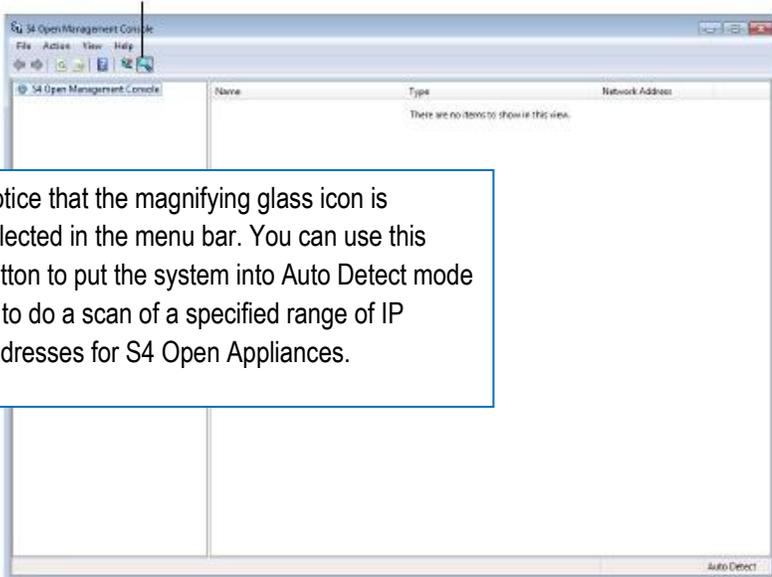
The router must be connected to the PC running the S4 Open Management Software. There are three ways to do this:

- Auto discovery: used when the PC and N2 Router are on the same IP subnet.
- Range discovery: used when the Router is not on the same subnet as the PC, and you do not know the exact IP address of the N2 Router.
- Direct link: used when you know the IP address of the N2 Router.

For initial configuration, it is recommended that you directly connect the N2 router to the PC and set your PC to dynamic addressing.

Auto Discovery

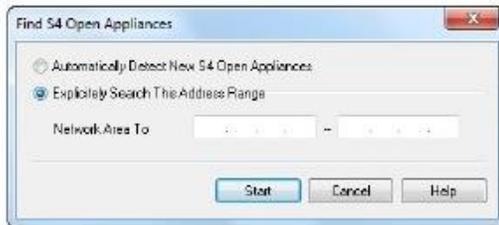
The S4 Open: Management Console starts in Auto Detect mode by default. Any S4 Open Appliance in the same local network segment will automatically identify itself to the console. An identified S4 Open Appliance object will be represented by a new folder in the console navigation pane. The status of the Auto Detect service is indicated in the lower right hand corner of the window any time that the “Console” node is selected in the left hand pane.



Notice that the magnifying glass icon is selected in the menu bar. You can use this button to put the system into Auto Detect mode or to do a scan of a specified range of IP addresses for S4 Open Appliances.

IMPORTANT NOTE: In the S4 Open: Management Console, you can see a periodic snapshot of status information from the S4 Open Appliances. You may need to use the F5 key (Refresh Screen) to get the most recent status of an appliance or object configured in an appliance. Please try this before assuming that the information you see is incorrect.

You can narrow the search area by entering a range of network addresses:

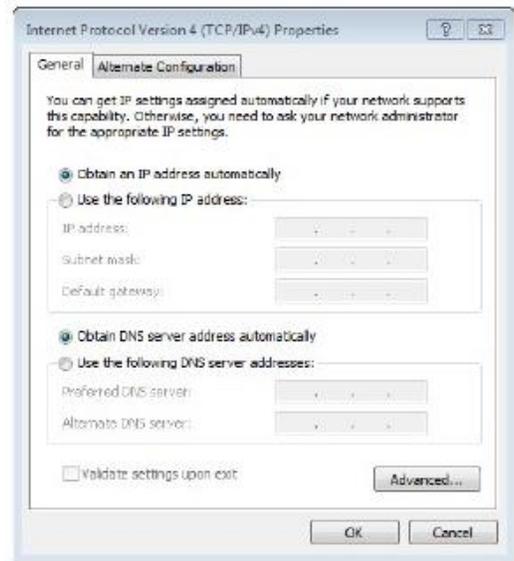


Manually Linking to S4 Open Appliances

To manually add appliances, right click on S4 Open: Management Console and select New -> Link to S4 Appliance. Add the appliance to the console by IP address. Refer to Help for detailed instructions on the Auto Detection Service for your S4 Open Appliance.

Alternatively, you can click on the S4* icon on the menu bar to manually set up a link to a S4 Open Appliance.

The process is completed by entering the IP address of the desired S4 Open Appliance in the following window.



CONFIGURATION WIZARD

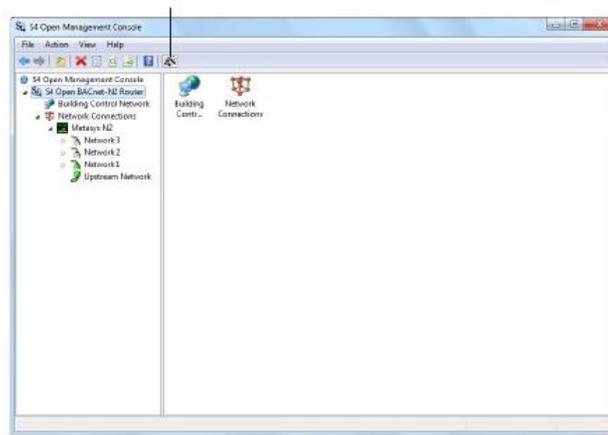
Scans the physical networks connected to the router and displays the results in the Management Console.

Best Practice: Before running the Configure Wizard, check the Building Control Network and the Physical Networks to make sure they do not contain any objects. Delete any objects in the networks before moving on to the next steps.

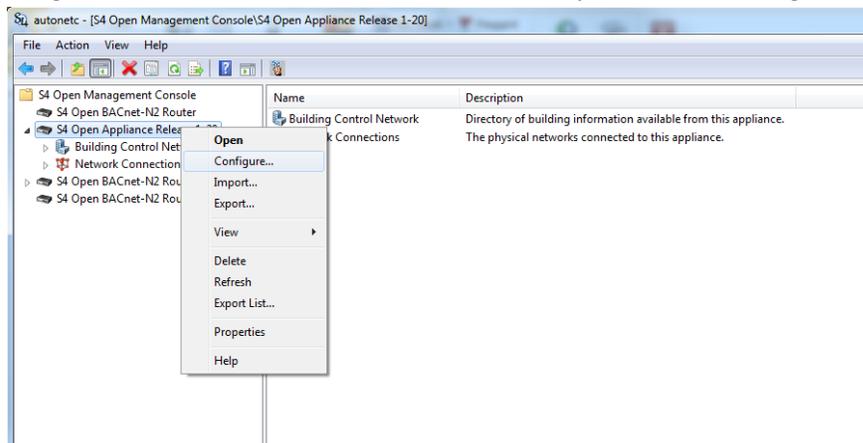
CONFIGURATION

To run the Wizard:

1. Click the configure button,



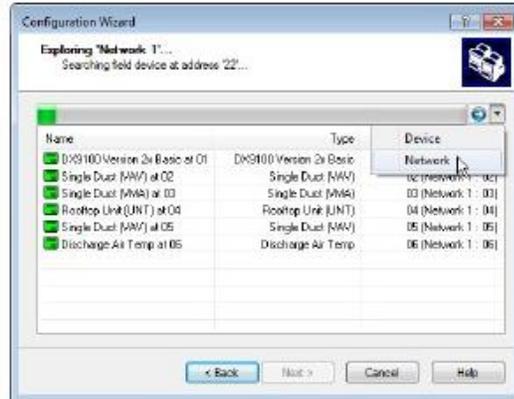
or right click on the router node in the left-hand pane of the Management Console. Select “Configure...”



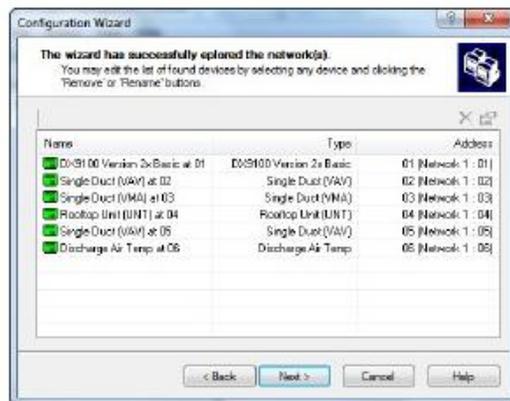
2. The Configure Wizard displays. Click Next:



- The Wizard will begin discovering devices on the first N2 network. When it has discovered all the devices on the first network, click the down button and click Network to skip to the next downstream port:



- Repeat Step 3 for all the networks (up to three)
- When all devices have been discovered, click Next.



CONFIGURATION

- Set the first BACnet device number. The Wizard will assign a BACnet device ID for each virtual BACnet device. The BACnet device ID will be the number you specify plus the N2 address.



- Click Next



- Click Finish

- A list of all devices discovered and created by the Configuration Wizard displays. Click Close to close the Wizard.



At this point, you may modify your configuration by removing any devices that have been detected but are not of interest, or prune points within devices as needed.

Best Practice: Export your configuration and keep it in a safe place!

System Administration and Operation

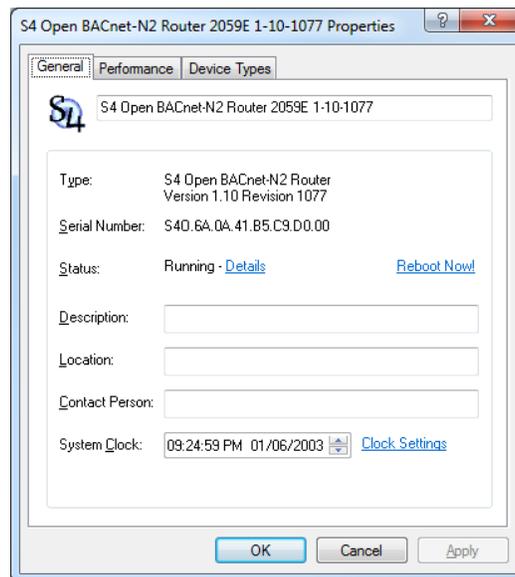
This section provides a sample of the most used features and services provided by S4 Open Appliances. It is intended as a general overview to continue your orientation to the system and not as a complete user's manual. The system has many more features and capabilities than described here. Refer to the on-board Help menu for complete details.

AUTOMATIC WINDOWS SECURITY AND PORT CONFIGURATION

Upon startup the S4 Open: Management Console automatically verifies that the host it is running on has its ports and firewall configured properly for communications with any S4 Open Appliance. It will prompt you for permission to change any settings that need to be adjusted for proper operation. The S4 Open: Management Console will also make any adjustments necessary for 3rd party client programs running on the same host to successfully communicate with the S4 Open Appliance.

SETTING SYSTEM OPTIONS

The Date, Time, and Time Zone can be configured from the General tab on the Appliance Properties page. To get to the Properties page, right click on the S4 Open Appliance folder in the navigation pane and select Properties.



SYSTEM STATUS

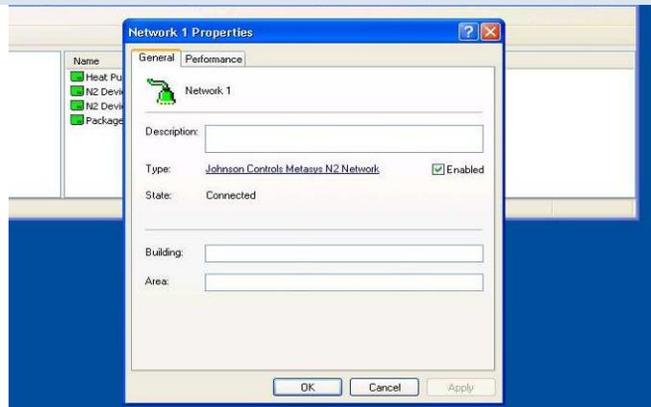
The S4 Open Appliance is normally in “Running” mode when the Properties/General tab is viewed. If the system is in “Service,” or any mode other than “Running,” this typically indicates either a licensing problem or incorrect software installation on the S4 Open Appliance. In this case, contact your reseller for assistance.

ADMINISTRATION

REMOTE SYSTEM REBOOT

If it ever becomes necessary to reboot your S4 Open Appliance, this can be done remotely by using the Reboot button on the General tab of the Properties page. You will see a change in the system status, hear a short beep from the appliance itself, and the system will be restarted.

ENABLING OR DISABLING PHYSICAL NETWORKS



You can disable unneeded physical networks by checking or unchecking the “Enabled” box on the Network Properties page. When a network is disabled, it will be ignored during the “Configure” process. No communications will occur with disabled networks at run time. You will see the network device object icon go grey for disabled networks. For instance, here you can see the Upstream Network is enabled.

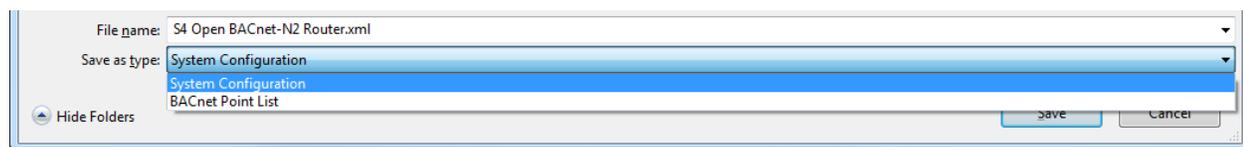
CONFIGURE WIZARD

To run the Configure Wizard, right click the top level folder of the S4 Open Appliance and select Configure.

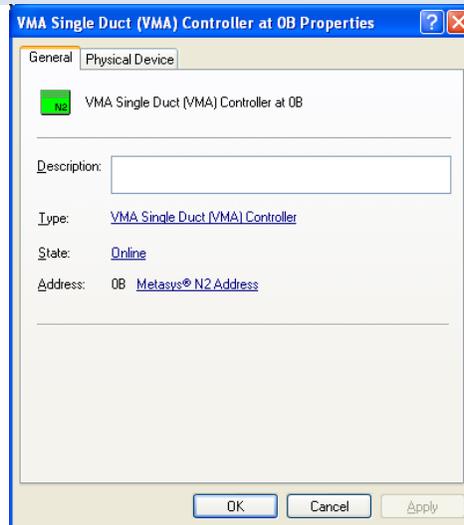
IMPORTANT NOTE: You can skip forward in the process by using the “GoTo Next” control when the system is exploring or searching downstream networks- just select the down arrow icon to the right of the progress bar. This feature can significantly decrease the amount of time that it takes to commission an S4 Open Appliance. Do this only if you are sure of the number of N2 devices on each legacy N2 network and the highest address where a device will be found.

BACKUP YOUR SYSTEM

To create a system backup, right click on the router node, select “Export.” Make sure the file type is set to “System Configuration.”



N2 DEVICE PROPERTIES



Each device object configured by the system has a Properties page where you can investigate details about the device.

- The N2 device hardware type
- The loaded Metasys® application
- The N2 Device Type Template assigned. You can click on the name of the assigned type to open the Type Details window.
- The device's actual N2 address on the physical network
- The virtual N2 address assigned to the device
- The Metasys® firmware version running in the device
- The HVAC Pro version
- The device creation date

N2 POINT ASSIGNMENTS

Device Types are defined based on the hardware family and loaded application. The point mappings come from information available in vendor documentation and are provided based on the information available. Before relying on these mappings for mission critical activities, we advise you to take a few preliminary steps:

- Prune any unneeded points from the device to minimize the volume of traffic generated.
- Look at the comments for each point and adjust the source string to reflect the actual configuration of the device. **Note:** In some cases, point addresses are dynamically assigned to the next available I/O when the application is generated by HVAC Pro.
- If your devices include any manually configured single side loop point definitions, etc. these will need to be manually added to the S4 Open Appliance Device Type definition.

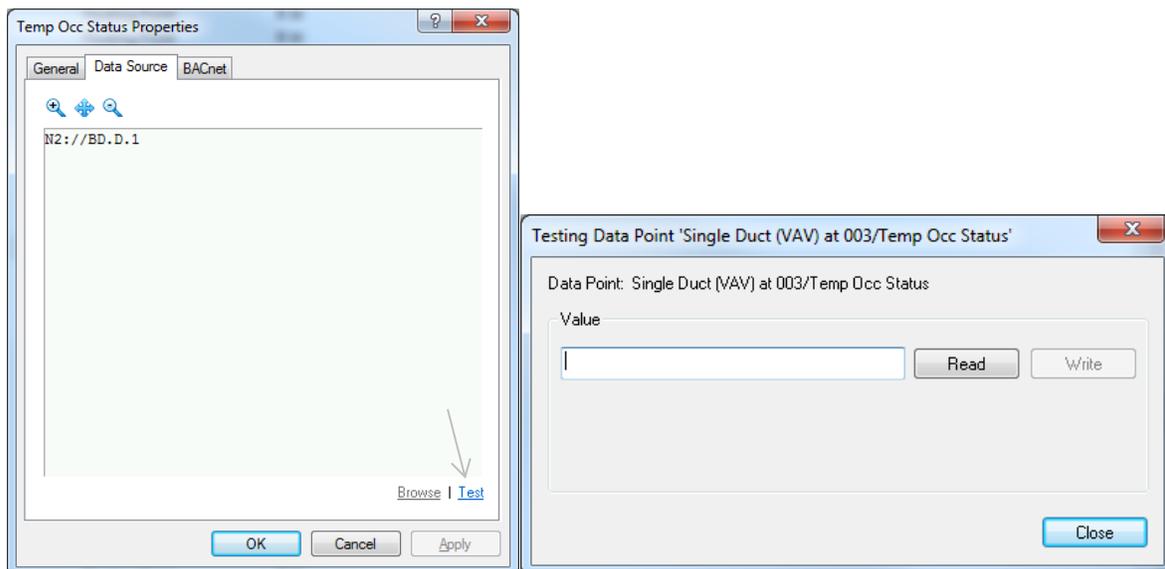
ADMINISTRATION

- In some cases the application generation process uses points for different purposes, depending on your responses to the Q&A session while the device is being defined and loaded. In these cases, multiple alias names for the point have been provided. We advise you to remove those that are unnecessary from the Device Type definition.

Device Type definitions may be modified in several ways. You can always edit the point definitions from the S4 Open Management Console; these changes will take effect immediately. Alternatively, you can edit the N2 Device Type Template for the device. This is a comma separated value (.CSV) file delivered with the system or obtained by exporting a Device Type Template from the Management Console. After editing the N2 Device Type Template to reflect your requirements, you will need to import it back into the Device Type Template library.

TESTING POINTS

- Select a point associated with a device object in the right hand pane of the Building Control Network object in the S4 Open: Management Console.
- Right click on the point and select Properties.
- Use the Test button (link) on the Source tab to start the point test process.
- Select the appropriate button to confirm that the point can be read or written.



Before writing a value to a point, be sure that the point is configured as writable in the S4 Open Appliance and that the BAS field device will allow the point to be written. Values entered into the write dialog box must be of the proper data type and within the size range of the data point being tested or an error will be displayed.

UPDATING AN S4 OPEN APPLIANCE

The S4 Appliances can be easily updated with a USB thumb drive. All of the files and folders that are part of the update package, (these will include a “startup” folder, an “automation_net” folder, and control files) should go in the root directory of the USB drive. The system recognizes the following commands in the form of control files (note that these files are empty, the system maintenance process just looks for their existence in the root directory):

FILE NAME – ACTION

NOS4APPLIANCE - Will start up the UNO 2059 without initiating the S4 Open applications. If this file exists on the USB thumb drive, the appliance application will not start up.

UPDATES4APPLIANCE - saves the certificate and automation.net.xml files from the current configuration. Then updates the build and startup.bat file on the appliance. After the action is completed, the file is renamed to prevent accidental multiple updates.

INITS4APPLIANCE - saves the automation.net.xml file from the current configuration onto your USB thumb drive. This replaces the automation.net.xml on the appliance with a default configuration file. After the action is completed, the file is renamed to prevent accidental initialization of the system configuration.

UPDATEDNA - saves the automation.net.xml file from the current configuration. Then replaces the file on the appliance with the one located in the \usb hard disk\dna folder. After the action is completed, the file is renamed to prevent accidental multiple updates.

UPDATECERT - saves the automation.cert.xml file from the current configuration. Then replaces the file on the appliance with the one located in the \usb hard disk\cert folder. After the action is completed, the file is renamed to prevent accidental multiple updates.

You can request several maintenance actions simultaneously by creating the appropriate files in the root of the USB thumb drive.

To initiate the process, simply insert the USB thumb drive into the appliance and reboot the system via the Management Console; this ensures that all configuration information is saved before the reboot. Note: You must use a USB 1.0 compatible thumb drive.

The update and initialize process may take several minutes to complete. While the update is in process you will not be able to access the appliance through the Management Console. You will hear a beep from the appliance when the reboot is initiated and another beep as the N2 Router application starts its initialization process. A log file is created in the Startup folder on the USB thumb drive indicating the results of the update process. Verify that all file copies were successful in this log file. When the application is fully operational, you will regain access to it through the S4 Open: Management Console. As a final step, verify the version information through the Management Console- found on the Properties page for the appliance.

ADMINISTRATION

UPDATING THE MANAGEMENT CONSOLE

S4 Open: Management Console updates are applied separately on your Windows PC using the provided .msi file.

IT Security and Network Administration Considerations

Under normal circumstances you will not need to use the information in this section. It provides information about system installation, how the system utilizes your IT environment, and security considerations. It is provided here to assist your IT staff in supporting the S4 Open Appliances.

S4 OPEN: MANAGEMENT CONSOLE INSTALLATION

The S4 Open: Management Console is installed from a Microsoft installation package. Typically, this is named “S4 Open Management Console.msi”. Simply copy this file to each PC upon which you want to install the software and double click on the file name. The installation process will automatically start and a wizard will guide you through the process.

AUTOMATED ERROR REPORTING

All S4 Open Appliances and the S4 Open: Management Console are capable of automatically sending error reports to the development team. In order to enable this capability, you must ensure that an SMTP path exists through any routers or firewalls from the device to the Internet.

TCP / IP PORT REQUIREMENTS AND FIREWALL SETTINGS

The following ports must be open to enable full functionality of your S4 Open Appliances. The S4 Open: Management Console properly configures these resources for the host system it is running on but there may be occasions where your IT support staff or network administrator needs to know these details.

- UDP Port 135 – DCOM / OPC Support
- TCP Port 25 – Outbound SMTP support
- UDP Port 61134 – Auto Detect S4 Open Devices
- UDP Port 68 – BOOTP Support for the S4 Open: Management Console
- UDP Port 68 – DHCP support for the S4 Open: Management Console

WINDOWS CE REMOTE MANAGEMENT TOOL

The Windows CE Remote Management Tool is available on all UNO-2059GL systems and later. The Remote Management Tool can be accessed using a web-browser pointed to the IP Address of the S4 Open Appliance. The default user name is Admin and the password is S4Appliance. Please note that the S4 Appliance must be power-cycled in order for configuration changes made using the remote management tool to take effect.

IP ADDRESS CONFIGURATION

A new system installation defaults to automatic IP assignment. If the customer network contains either a BOOTP or DHCP server it will use the MAC address of the appliance to assign either a fixed IP address or a dynamic IP address to the S4 Open Appliance. We highly recommend that your IT department configures your BOOTP or DHCP server to assign a fixed IP address to the S4 Open Appliance.

Configuring a static IP address without a DHCP or BOOTP server

By default, the S4 Open Appliance will attempt to retrieve an IP address from a DHCP or BOOTP server. If one is not available on the network where the S4 Open Appliance is being installed, the Appliance can be configured to use a static IP address. Microsoft Windows includes a DHCP failover mechanism known as APIPA. With APIPA, DHCP clients can obtain IP addresses when DHCP servers are nonfunctional or absent. APIPA exists in all popular versions of Windows except Windows NT. To complete this procedure, it is important to follow the next steps **EXACTLY** as prescribed:

1. Start with the S4 Open Appliance powered off.
2. Install the S4 Open Management Console on a Windows PC.
3. Set your PC Ethernet adapter to automatically obtain an IP address. (Refer to Windows help for additional information on this procedure.)
4. Connect a **CROSSOVER** Ethernet cable between the S4 Open Appliance and the PC.
5. Power on the S4 Open Appliance.
6. The S4 Open Appliance will go through its normal initialization process.
7. The PC and the S4 Open Appliance will negotiate addresses, with Windows automatically assigning IP addresses in the range of 169.254.x.x.

THE FOLLOWING TWO STEPS MAY TAKE SEVERAL MINUTES, PLEASE BE PATIENT.

When the initialization process is complete and the addresses are negotiated, the S4 Open Appliance will be auto-detected by the Management Console and its folder will show up in the navigation pane. At this point you will have normal communication between the Management Console and the appliance. Now, you will be able to go to the S4 Open Appliance's Properties page, select Communications Protocols, and change the IP address to a fixed IP address and subnet mask of your choice; the other fields can be left blank. Once this is done, hit the Apply button. The S4 Open Appliance will need to be rebooted for the changes to take effect; use the Reboot button on the General Properties tab to initiate the reboot sequence. The S4 Open Appliance will re-initialize itself with the address and subnet mask that was assigned to it.

To maintain communication between the Management Console and the S4 Open Appliance it is necessary to change the IP address of the PC running the Management Console to a fixed IP address in the same subnet as the S4 Open Appliance.

ADMINISTRATION

WINDOWS DOMAIN OR WORKGROUP MEMBERSHIP

The UNO 2059GL chosen for the production release of the S4 Open Appliances runs a release of Windows CE.NET that cannot fully participate as a host in a Windows domain or Workgroup environment. Any OPC client with a built in OPC browser that is Windows aware can search for and attach to remote S4 Open: OPC-N2 Routers.

Appendix A: An Overview of Metasys®

The Johnson Controls Metasys® building automation system is divided into two sections. The system level network, known as the N1 Bus, connects the various supervisory controllers (i.e. NAEs, NCMs, N30s, etc.) to one another and to operator workstations. The other half of this architecture is the N2 Bus, or field level network, which provides communication to and from the supervisory controllers and the various controllers, thermostats, and other devices in the field.

PHYSICAL SPECIFICATIONS OF THE N2 BUS

The N2 Bus communications interface is RS-485, 2-wire plus reference, half-duplex at 9600 baud. The format for transmission is 8 data bits with one start and one stop bit, no parity is used.

OPERATING SPECIFICATIONS

In order to complete a successful integration the N2 Bus must meet the following electrical standards. The ComBus Quick Tester can automate validating that the N2 Bus is within operating specifications, although a standard volt meter can be used for this same purpose.

- + to Ref VDC 2.45 – 3.00
- - to Ref VDC 1.90 – 2.54
- + to - VDC 0.38 – 0.92

N2 PROTOCOL INFORMATION

The N2 protocol itself comes in three different variants: N2Open, N2B and System91. N2Open was the first developed and has the largest number of examples in the field. This is also the protocol used by 3rd party vendor devices. N2B is essentially an early generic of BACnet wrapped in an N2 envelope and is only used by VMA devices. The System91 standard is used by the DX-9100 (which can be used as a standalone controller) and other System-91 devices. The S4 Open family of products supports all of these variants.

BENEFITS OF BACNET-N2 INTEGRATION

Johnson Controls has a large installed base, field devices were rock solid and can be expected to be serviceable for the short to intermediate term, field devices are ASCs that can run stand-alone if the N2 bus gets interrupted or the head end fails.

Integrating to a JCI system should be looked at as a short term success in taking over the account and gaining control of the user experience through replacing the head end. Long term it should be considered an annuity through which eventually all of the N2 devices will be replaced with SE devices.

APPENDIX A: METASYS®

Figure 1. JCI Metasys architecture

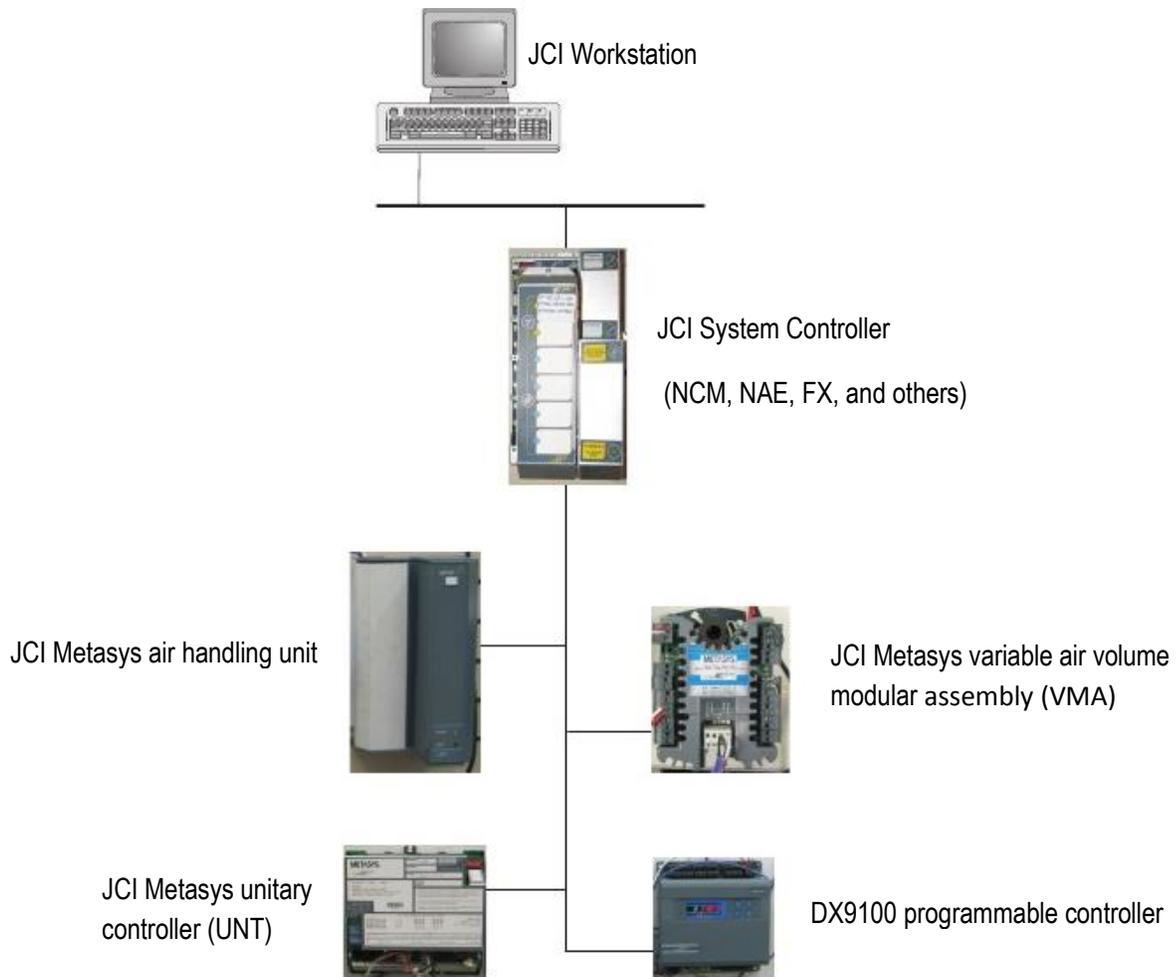
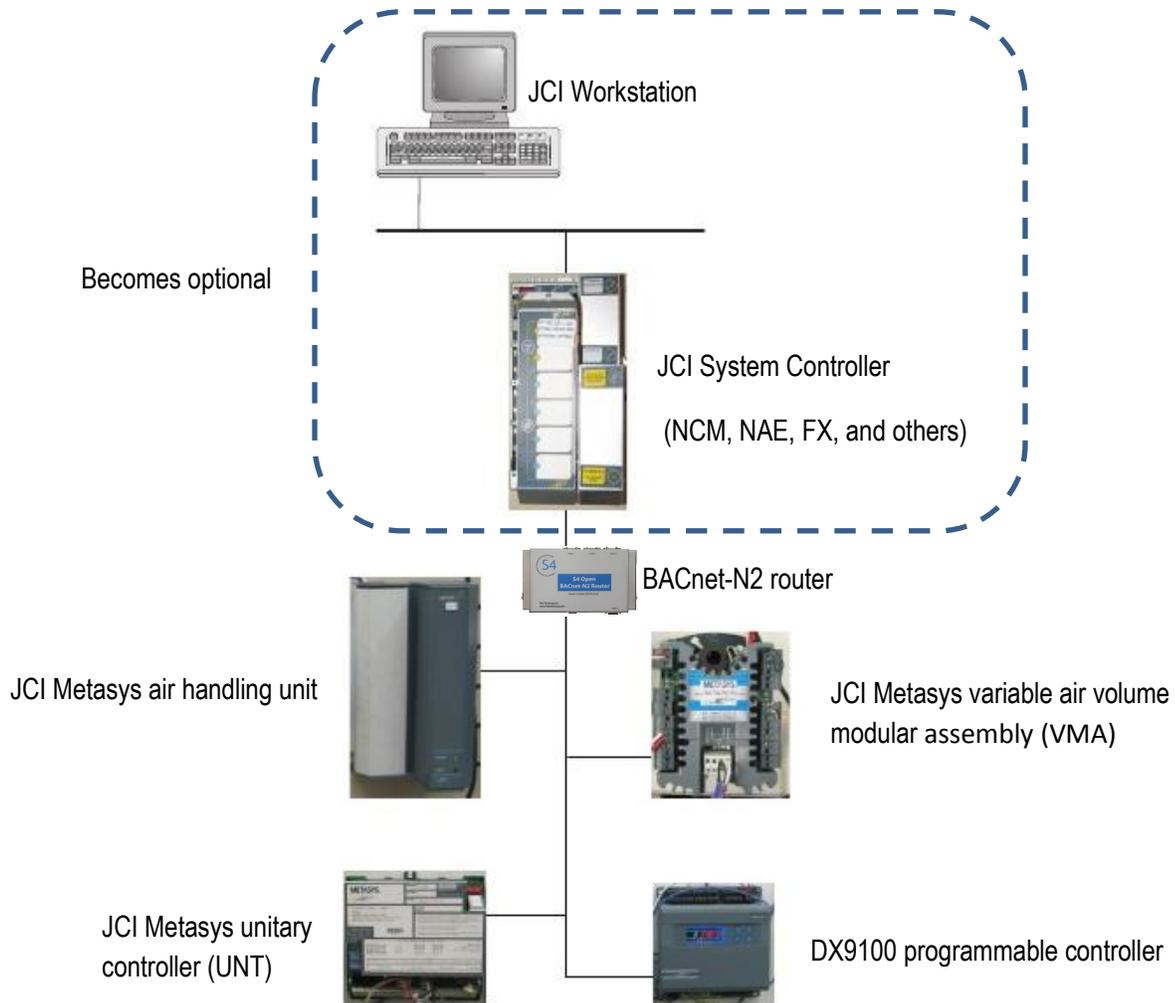


Figure 2. Metasys integration



Appendix B: Case Study

THE JACKSON FEDERAL BUILDING IN SEATTLE, WASHINGTON

Federal Office Building Integration

Legacy BAS Upgraded Without a Single Hour of Downtime

Partner: ATS Automation

Technology: Alerton Envision for BACtalk, S4 Open: BACnet-N2 Router

Customer: Government Services Administration

Facility Background

The U.S. Government General Services Administration (GSA) operates the Jackson Federal Building in downtown Seattle, Washington; it houses 35 agencies with 2,300 government employees and contractors within its 37 stories-- making it the largest Federal building in the Pacific Northwest region of the United States. Construction of the building was completed in 1974 with pneumatic controls. It subsequently went through several upgrades to introduce direct digital control technology. The existing system consisted of an aging JCI system with several generations of controllers, many of which were obsolete, and much of the as-built information was missing, unreadable, or inaccurate. At one point, a previous retrofit project added a smoke control system that interfaced heavily with the HVAC controllers, further complicating the integration and NCM phase out process.

Customer Requirements

The controls upgrade was performed as part of an all-around energy efficiency upgrade of the building. All of the aging mechanical equipment in the building was replaced. Every window was replaced with energy efficient glazing; lighting controls were added as a part of this project. The building was to remain occupied during the upgrade. GSA mandated zero interruptions to tenants' activities. There was no access to VAV boxes and most of the N2 bus wiring, as they were installed above ceilings that were heavily contaminated with asbestos. Zero downtime of mechanical systems and controls was allowed during normal business hours. The requirement was to achieve a completely seamless integration. ATS Automation was called in on the project because of their excellent history of complex integrations and well managed projects.

Solution

The ATS team spent a lot of time gathering information about the existing project and building. Coordination with other contractors and the creation of a master plan for the project was, in itself, a major undertaking. The first step was to mount new Alerton BCM building level controllers and pre-wire as much as possible. Then, an S4 Open: BACnet-N2 Router was installed with each existing NCM to allow the new Alerton head end to co-exist with the Metasys® NCMs and Operator Workstation during the planned transition period. After these preparatory steps, ATS continued with the integration using the following procedures.

- 1) They ran the Configure Wizard for each S4 Open: BACnet-N2 Router as it was installed. The wizard automatically discovered the N2 devices on the bus, provided BACnet point mappings, and activated the co-existence capability of the N2 Router-- giving both the NCM and the Alerton BACnet head end equal access to the devices on the N2 bus.
- 2) ATS began testing by reading and writing the data from Envision graphics, but without truly taking control of anything.
- 3) ATS wrote their software in the Alerton BCM global controller to control and optimize the JCI VAV boxes, and overnight or on weekends they would install it and test their sequences through the S4 Open: BACnet-N2 Router. Until they were comfortable that everything was perfect, ATS would remove their code and let the NCM run the system during the day. The Downstream Adapters and Upstream Cable provided with the N2 Router facilitated easy changes in configurations as required.
- 4) After processes were in place and fully tested, the NCM's were removed and a fully functional system remained, with Alerton BCM global controllers running JCI VAV boxes.

The project required 17 of the large (4 port) S4 routers. The ATS team was aware that the JCI N2 trunks were very heavily loaded, so they used the ability to split trunks in several locations where the wiring could support it, thereby improving trunk loading. This move was proactive on the part of ATS. The N2 trunk runs at 9600 baud and would be passing a lot more data than the previous system ever did. ATS also wanted to avoid the risk of coming up short on capacity if unexpected equipment were to be discovered on the network. The hardware gave ATS maximum flexibility. Built-in performance metrics were instrumental in determining where N2 trunks were overloaded and provided a confirmation of improved performance.

Unique Project Challenges

ATS planned on following the S4 Group's recommendation of co-existing with the Metasys® head end during a transition period. As a final step, the plan was to phase out the NCMs one at a time. After all of the Alerton BCM controllers were in place and programmed, it was learned that removing any one NCM triggered the smoke control system. The S4 Group provided a major enhancement to the S4 Open: BACnet-N2 Router to force N2 transactions coming from the NCM to utilize the BACnet Priority Array mechanism. This created the ability to move away from dependence on the NCMs one point at a time and smoothly complete the phase out process while maintaining the integrity of the smoke control system. This Supervisory Controller as a BACnet Client feature is now a standard part of all BACnet-N2 Routers.

Another unique challenge encountered involved a conflict between the field devices and Envision. Envision for BACtalk appropriately assumed that when it puts an entry into the highest active priority of the BACnet Priority Array, the Present Value would assume that value. However, the N2 field devices, knowing nothing about BACnet, were modifying the Present Value independently of Envision. To handle this conflict, The S4 Group provided an enhancement to optionally disable the BACnet Priority Array. Without a Priority Array in play, both Envision and the N2 device directly accessed the Present Value of the point and stayed in sync. This is now a standard point-level option in the N2 Router.

The ATS team made extensive use of the ComBus Quick Tester to validate the N2 buses before starting the integration process. In some cases, changes were detected in the status of the N2 bus during the project. Since asbestos abatement made repairs prohibitively expensive, the alternative solution was to install a RS-485 repeater immediately in front of the N2 Router to boost the power on outbound transmissions and clean up the signal on

CASE STUDY: Jackson Federal Building

inbound transmissions. This didn't fix out-of-spec N2 buses, but in all but one case it compensated for the problems and provided reliable communications. The one exception was due to incorrect N2 bus wiring. This required a small amount of asbestos remediation in order to repair the bus wiring. After the repair this bus also worked fine.

Other Approaches Considered

ATS considered Tridium and FieldServer, but neither can co-exist on the N2 Trunk with an NCM. Additionally, these options would have required a significant amount of system outage to complete the transition which was unacceptable.

CASE STUDY: Jackson Federal Building

The Building Today

The new system is completely operated by an Alerton BACnet front end. All new Alerton controllers were installed on large built up AHU's, chiller plant, steam heat exchangers, existing boilers, but ATS was able to make use of the existing JCI VAV controllers on 1200 Dual Duct boxes, a half dozen or so computer room units, and one NCM with a dozen JCI controllers downstream providing smoke control functionality. Alerton BCM global controllers bring in energy data from dozens of electrical steam and water meters. S4 Open: BACnet-N2 routers are installed on every N2 trunk.

Success

The end user is quite happy with the new system – a state of the art Alerton BACTalk control system that is much easier to operate, allows for E-mailing of alarms, energy reporting, secure web access, all while saving several million dollars on asbestos abatement/control issues that would have been required to replace all of the VAV box controllers. Federal agencies are looking at this as a model retrofit / upgrade project.

Appendix C: Integration Worksheets

N2 BUS WORKSHEET

N2 Bus # _____ of _____

Total Number of N2 Devices: _____

Electrical Status of the N2 Bus

	Observed	Recommended	Pass?
Voltage DC +		(2.45 – 3.00V)	Yes / No
Voltage DC -		(1.90 – 2.54V)	Yes / No
Bias		(+0.38 – +0.92)	Yes / No

Devices found on the Bus

Device Code	Protocol	Device/Controller Type	Number Found
???	N2	N2 Open Device not listed	
AHU	N2	Air Handling Unit Controller	
BAD	N2	N2 Device with invalid errors	
DC	Sys91	DC-9100 – Plant Controller	
DCM	N2	DCM-Digital Control Module	
DO	Sys91	DO-9100 – Digital Optimizer	
DR	Sys91	DR-9100 Room Controller	
DX	Sys91	DX-9100-Digital Controller	
IAC	N2	Access Controller	
IFC	N2	Fire Controller	
ILC	N2	ILC – Intelligent Lighting Control	
LCP	Sys91	LCP – Lab & Central Plant Controller	
LDT	N2	LDT - User Display	
MIG	N2	MIG - Metasys Integrator	
NDM	N2	N2 Dialer	
PHX	N2	Phoenix Fume Hood	
TC	Sys91	TC-9100 – Temperature Controller	
UNT	N2	Unitary Controller	
VAV	N2	VAV - Variable Air Volume Controller	
VMA	N2	VAM – Variable Air Volume Modular	
VND	N2	VND – Vendor Device (also FX)	
XBN	N2	XM – Baseframe Extension Module	
XRE	N2	XM – Baseframe Extension Module	
XRL	N2	XM – Baseframe Extension Module	
XRM	N2	XM – Baseframe Extension Module	
XT	Sys91	XT-9100 Extension Module	
XTM	Sys91	XTM-101 Extension Module	
WRX	N2	Wireless Receiver	

Do the number and type of N2 devices found match what was expected?

Yes / No

PLANNING AND BUDGETING WORKSHEET

Repair Work Is Needed on the N2 Bus Before Integration Can Proceed:	Yes / No
---	----------

- N2 Devices Need to be Reprogrammed or Recommissioned: Yes / No
- This Work Will Be Done By: Integrator / Building Owner / Third Party Selected by Integrator
- Estimated Cost for this Work: \$ _____

Time and Budget Must be Allocated for Replacement Custom Logic:	Yes / No
---	----------

- Number of Devices that Require Replacement Logic: _____
- Total Estimated Time to Complete this Process: _____
- Rate per Hour for this Service: \$ _____
- Cost of Hardware to Provide Replacement Logic \$ _____
- Total Cost to Replace Custom Logic: \$ _____

Number of N2 Routers to be used on this Project:	_____
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- Total Cost of N2 Routers: \$ _____
- Estimated time to Install N2 Routers: _____
- Cost per Hour for This Service: \$ _____
- Total Cost to Install N2 Routers: \$ _____

New Equipment Will be Installed for this Project:	Yes / No
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- New Field or Supervisory Controllers will be Installed: Yes / No
 - Cost of New Hardware: \$ _____
 - Estimated Labor Time to Install New Hardware: _____
 - Estimated Labor Time to Configure New Hardware: _____
 - Cost per Hour for This Service: \$ _____
 - Total Cost For this Service: \$ _____
- New Software will be Installed: Yes / No
 - Cost of New Software: \$ _____
 - Cost of Server / PC Software will Run On: \$ _____
 - Estimated Labor Time to Install New Software: _____
 - Estimated Labor Time to Configure New Software: _____
 - Cost per Hour for this Service: \$ _____
 - Total Cost for this Service: \$ _____
- Cost of New, Supporting, IT Network Infrastructure: \$ _____

Total Estimated Time for this Project:	_____
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Total Estimated Cost for this Project:	\$ _____
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