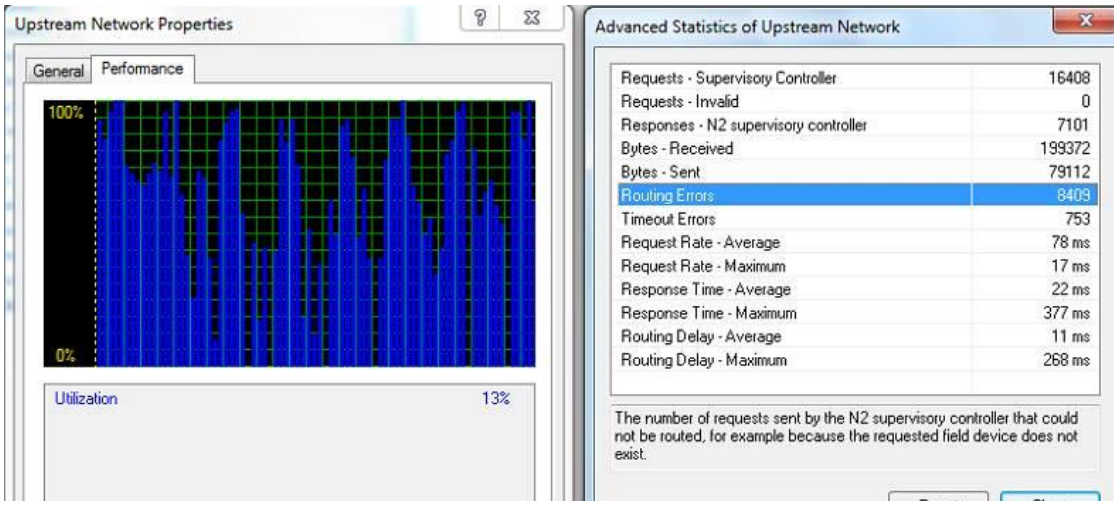
Case Study: Resolving N2 Bus (RS-485) Issues on an existing S4 Open: BACnet-N2 Router installation.

Recently, a large number of timeouts and routing errors on our Metasys *system have alerted us to a problem. The spare capacity on the upstream network shows that the Metasys controller is leaving the S4 router space to blend in messages on the trunk for the purposes of the BACnet interface.*



Challenge:

A system that has been operational for 2 years suddenly starts to cause devices to toggle between online/offline in the Metasys system. When the devices switch between on and offline every few minutes, they prevent us from recognizing a pattern. Consequently, due to the Metasys system going offline, it has become unreliable and many aspects of the building that need to be controlled must be operated manually.

Background:

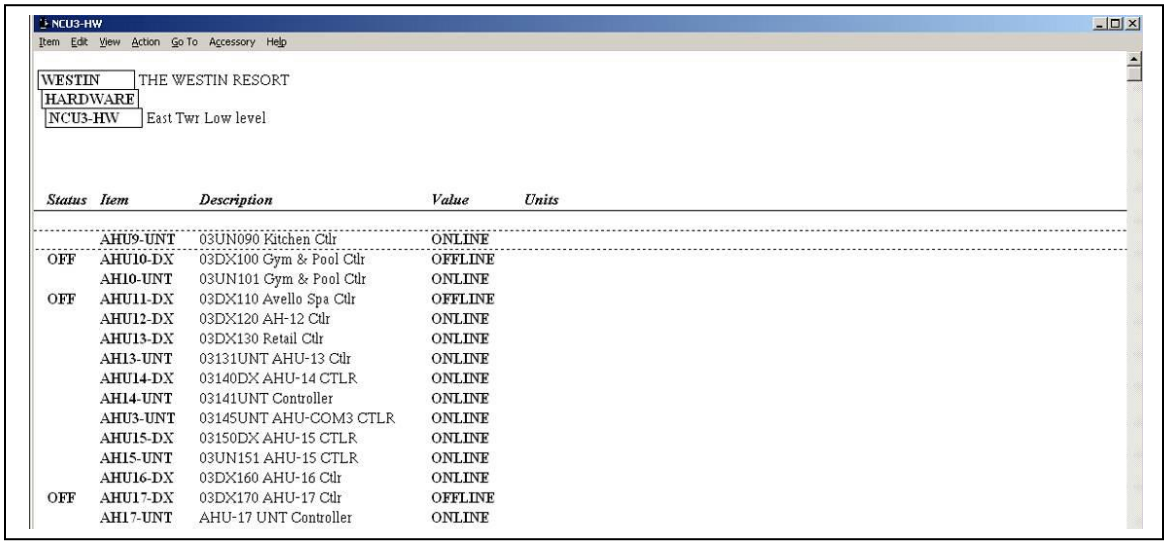
Four S4 Open: BACnet-N2 routers were deployed in 2012 for a ski resort hotel as part of an initiative to reduce very high energy costs. A requirement of this project was that the original Metasys® supervisory controllers continue to perform their normal operations through installation and moving forward. To this end, the Upstream N2 functions of the S4 routers were used. In this mode of operation, the S4 router acts as a middle man, servicing requests from the original Metasys controllers as well as servicing requests from the BACnet IP interface. During the initial phase of the project the routers were installed, configured and working properly. The goal of a reduction in the hotel energy costs was met and the customer was well satisfied.

Provided that the original loading of the N2 trunk has the spare bandwidth, this 'interlacing' of messages has proven to be very successful. It allows project team members to start working with the BACnet objects and to continue with the 'new' project while the site continues to operate as if nothing had changed. On some projects the upstream interface is retained and in other projects it is removed once the new programming and graphics have been implemented. A command contention system based on the BACnet Priority Array mechanism is provided so that the project can control which interface (original N2 or new BACnet) wins when it writes to a N2 object.

Symptoms

After a long period of perfect operations, the Ski Resort noticed the following issues:

1. On the four installed S4 systems, the status reported whether the N2 devices were online/offline by the toggling of the NAE. The devices would randomly go offline for up to 20 minutes before toggling back online. One could not predict which devices would be the next to toggle their state.
2. Moreover, when a device was offline, attempts by the NAE controller to send commands/schedules and set points failed.



Status	Item	Description	Value	Units
	AHU9-UNT	03UN090 Kitchen Ctlr	ONLINE	
OFF	AHU10-DX	03DX100 Gym & Pool Ctlr	OFFLINE	
	AH10-UNT	03UN101 Gym & Pool Ctlr	ONLINE	
OFF	AHU11-DX	03DX110 Avello Spa Ctlr	OFFLINE	
	AHU12-DX	03DX120 AH-12 Ctlr	ONLINE	
	AHU13-DX	03DX130 Retail Ctlr	ONLINE	
	AH13-UNT	03131UNT AHU-13 Ctlr	ONLINE	
	AHU14-DX	03140DX AHU-14 CTLR	ONLINE	
	AH14-UNT	03141UNT Controller	ONLINE	
	AHU3-UNT	03145UNT AHU-COM3 CTLR	ONLINE	
	AHU15-DX	03150DX AHU-15 CTLR	ONLINE	
	AH15-UNT	03UN151 AHU-15 CTLR	ONLINE	
	AHU16-DX	03DX160 AHU-16 Ctlr	ONLINE	
OFF	AHU17-DX	03DX170 AHU-17 Ctlr	OFFLINE	
	AH17-UNT	AHU-17 UNT Controller	ONLINE	

Steps to Solution

The statistics used to initially isolate the problem are built into the S4 Open: BACnet-N2 Router. Additional diagnostic tools provided the ability to capture a snapshot of the N2 bus activity for detailed analysis. These tools allowed us to move through a series of steps to pinpoint the problem.

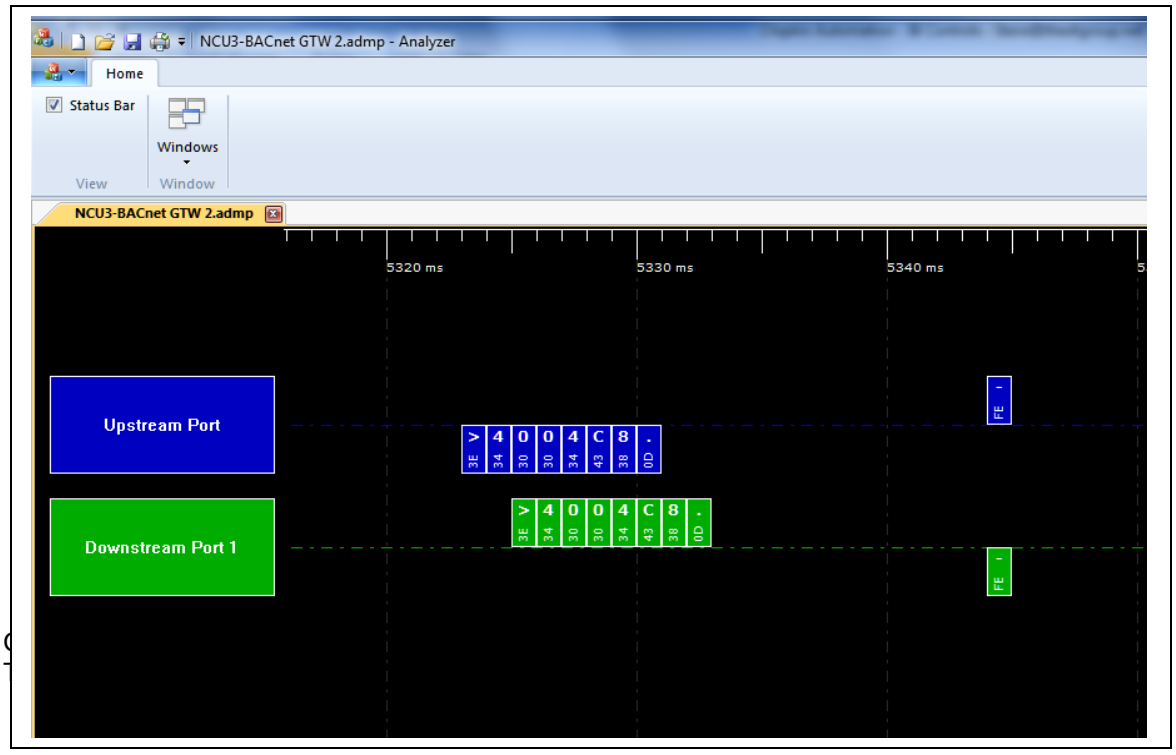
1. The first step in our solution was to evaluate the versions of firmware. We noticed that an older but stable version was installed at the site.

2. Next, was to evaluate the N2 performance using the S4 Router diagnostic reports/screens. This step detected a large number of timeouts and a large number of Routing Errors. A timeout is a message which is not responded to. A Routing error is a message to a device that doesn't exist (or which cannot be reached.) Typically, the error counts of these types are small.
3. To pinpoint the source of the problem, we evaluate the N2 loading. Questions we had to ask where how heavily is the existing controller loading the N2 traffic? Is there enough space in the bandwidth loading to add the message required by the BACnet function of the Router? We noticed that the loading was low.
4. For further analysis, we captured snapshots of the N2 Trunk traffic.
5. Finally, to get a complete picture of the situation, we question customers about their circumstances on site. Changes in the performance of a HVAC system are often associated with a change in season – a loop that has been tuned for one season doesn't work in another, flooding, ice melt, ground movement, overheating… These are all seasonal factors.

SnapShot / Serial Capture Analysis

On the first snapshot we saw attempts to initialize and bring device 08 and 2E back online. Both of these timed out without the devices responding. We also saw a request for a transaction against the device at 2E timing out. This was a point level transaction, so the device must have been online and was no longer reachable.

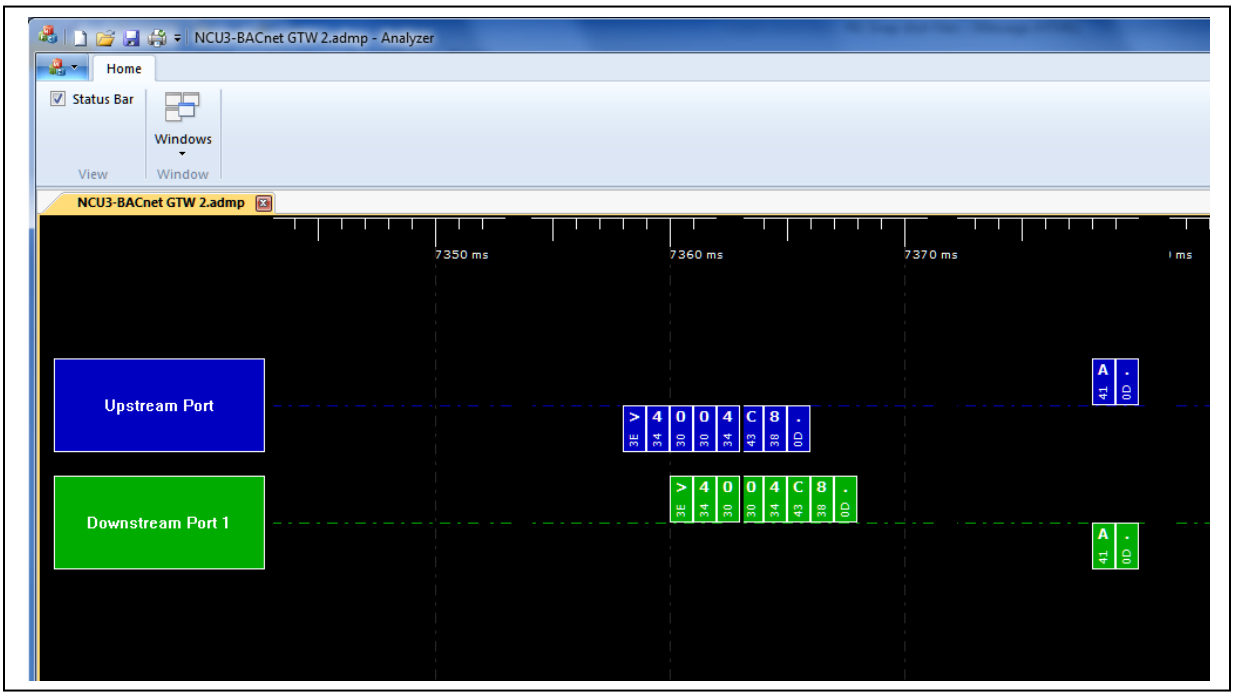
On the second snapshot we saw another attempt at bringing the device at 08 online. Again we were unsuccessful. Below you will see a test of one of the issues:



Looking at the image above of a COS poll request for the device at 0x40, we can see the N2 transaction starts with a >. The response that follows is invalid as it should start with either A (Ack) or N (Nak). A single character A is acceptable in this case; however, that is not what we are seeing. This could be garbling on the line, it could be an invalid response being generated from this address, it could be another device responding when it shouldn't and stepping on the A (simple one character Ack) response, or it could be a spurious response from another device.

Based on everything else that we saw, we think this started out as a valid response and became garbled due to N2 bus quality problems.

As we see, there is a long delay on the bus while the NCM is waiting for the proper response. In essence, it never happens. Then we see the NCM trying again and getting a valid response.



In general, what we are seeing is a completely normal operation of the N2 router, it is:

- Passing transactions from the NCM to the N2 bus and routing the responses back.
- Trying to bring offline devices back on line. There have been both successful and unsuccessful attempts at this.

- Most of the time we see successful point level transactions or COS polls at the device level. In a few cases we have observed timeouts where the N2 Router is waiting for an N2 device to respond which it never does.

We didn't see any completely **spurious communications** on the bus so we don't think that there was a **rogue device** responding when it shouldn't. Everything we saw in the snapshots reinforces what we saw when looking at the stats. You have a N2 bus that is not operating properly and the next step is to diagnose why.

```
00000010: 01259E00 46000100 01259E00 46010000
00000020: 02259E00 46000100 02259E00 30010000
00000030: 03259E00 30000100 03259E00 30010000
00000040: 04259E00 30000100 04259E00 34010000
00000050: 05259E00 34000100 05259E00 43010000
00000060: 06259E00 43000100 06259E00 0D010000
00000070: 07259E00 0D000100 07259E00 3E000000
00000080: 16259E00 30000000 17259E00 30000000
00000090: 19259E00 30000000 1A259E00 30000000
000000A0: 1B259E00 30000000 1C259E00 0D000000
000000B0: 1D259E00 3E000000 2A259E00 42000000
000000C0: 2B259E00 34000000 2C259E00 3E010100
000000D0: 2C259E00 38000000 2D259E00 42010100
000000E0: 2D259E00 30000000 2E259E00 34010100
000000F0: 2E259E00 30000000 2F259E00 38010100
00000100: 2F259E00 30000000 30259E00 30010100
00000110: 30259E00 41000000 31259E00 30010100
00000120: 31259E00 42000000 32259E00 30010100
00000130: 32259E00 31000000 33259E00 41010100
00000140: 33259E00 46000000 34259E00 42010100
00000150: 34259E00 33000000 35259E00 31010100
00000160: 35259E00 38000000 36259E00 46010100
00000170: 36259E00 0D000000 37259E00 33010100
00000180: 37259E00 38010100 37259E00 0D010100
```

Chunk of N2 message shown in Hex. It's easy to see a series of constant length messages – the most obvious clue that there is no rogue transmitter.

Possible Solutions:

1. The customer was advised to check the N2 trunk and to check the devices on the trunk.
2. The simplest way to do this is with the ComBus Quick Tester. This test device allows the customer to establish if the trunk meets JCI's standards. Moreover, using this device the customer can do an N2 device count. Doing this repeatedly would show if there is a faulty device, meaning that the N2 device count would keep changing.
3. Another test is to *segment* the trunk to try and find a device that is not operating reliably. Such a method usually begins by splitting the trunk in two and seeing which half works best. The process of dividing continues until faulty devices have been isolated.

4. Ensuring all components are operating as intended by researching all environmental and building related events. E.g. cable that runs underground/on the exterior is subject to mechanical and weather issues.

Our solution

For our client, the problem was resolved by isolating the section of trunk which contained the faulty device. It was noted that the section of trunk ran through a building area that had flooded as the seasons changed and that the flood had damaged the device: a faulty DX9100. Once we detected the faulty device, the recommended solution was two-fold depending on the customers' needs:

1) The interim solution: to power-down the DX9100. In this instance, removing the faulty device to temporarily run the system without it. This is a solution of sorts, but not a permanent solution.

2) The long term solution: replace it. By simply replacing the faulty device, the system would return working as intended.

The S4 Open: BACnet-N2 Router quickly demonstrated its value when the energy management project was originally implemented. Now, it has proven itself again when the power of the S4 Open monitoring and diagnostic tools allowed us to deliver ongoing support by quickly diagnosing the symptoms, then facilitating drilling down to the level of detail necessary to get to the root cause of the problem and get the customer back to normal operations in record time.