NC-SI Overview and Performance

Understanding the DMTF Standard Manageability Interface

Intel® Networking Division

Revision 1.1

March 2013

Legal

Revisions

Date	Revision	Description
March 2013	1.1	Revised section 11.2.2.
February 2013	1.0	Initial Release

Contents

1 Introduction

This document provides a brief introduction to the DMTF (www.dmtf.org) Network Controller Sideband Interface (NC-SI) management interface. The primary reason for the overview is to provide background information for the main purpose of this document—discussion of the interface's performance and some important considerations a Management Controller designer can use to achieve the best performance over this interface.

The primary components discussed in this paper are:

- *DMTF Defined Network Component Sideband Interface (NC-SI)*

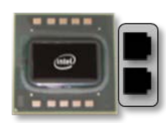
  The physical connection and protocol layer used to allow connectivity between a Management Controller (MC) and a Network Controller (NC)

- *Management Controller (MC)*

  A specialized microcontroller embedded on the motherboard of a computer that monitors and manages the system. Another name is Baseboard Management Controller (BMC). MC and BMC are used interchangeability throughout this document.

- *Network Controller (NC)*

  The Ethernet Controller utilizing the NC-SI interface to provided network connectivity to the MC.



- *Remote Management Console*

  A computer running software designed to communicate with a MC over a network interface.

2 Network Controller Sideband Interface

A Management Controller (MC) or Baseboard Management Controller (BMC) usually requires Ethernet connectivity for remote management. Initially, MC's had a dedicated Ethernet port to achieve this connectivity.

Later, Ethernet manufacturers started using proprietary sideband interfaces to provide a mechanism by which the MC could share an Ethernet port with the Operating System. This interface was generally based upon the I2C/SMBus interface, but had a proprietary protocol.

The DMTF set out to create an industry standard sideband interface that would operate at a much greater speed than SMBus and alleviate some of the burden on BMC engineers who, for years, had been writing different Ethernet code based on which manufacturers' Ethernet device was used as the LOM (LAN on Motherboard) for the server board.

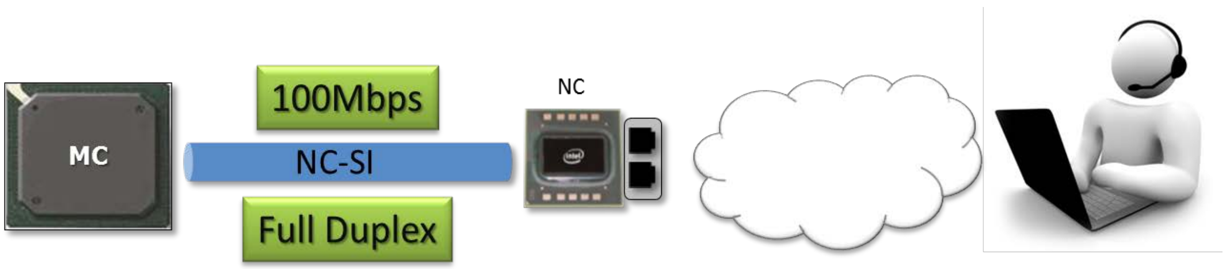


Figure 1 Sideband Interface

The result is the Network Controller Sideband Interface (NC-SI)—DMTF document DSP0222, released in 2009 as 1.0.0. Since that time, NC-SI has become the management interface of choice for the MC.

NC-SI is designed to provide a robust filtering mechanism allowing the MC to specify exactly the kind of Ethernet traffic it will accept. NC-SI also operates at speeds up to 100Mbps full-duplex.

3 NC-SI Usage

3.1 Request/Response Traffic Pattern

Typical traffic used in managing a server is a request/response based model. A management console sends a request and the MC replies with a response. This type of request/response model is very common when using management protocols such as IPMI (Intelligent Platform Management Interface) and has become ubiquitous on nearly all modern servers. Gathering information such as temperatures, voltages, fan RPM, thresholds etc., are usually done using a request/response mechanism.

This request/response type of traffic does not utilize much bandwidth. Using a utility called ipmiping that repeatedly sends a request to a MC, awaits a response and sends another request as fast as possible, tests show that this type of request/response traffic pattern results in about 0.06Mbps.

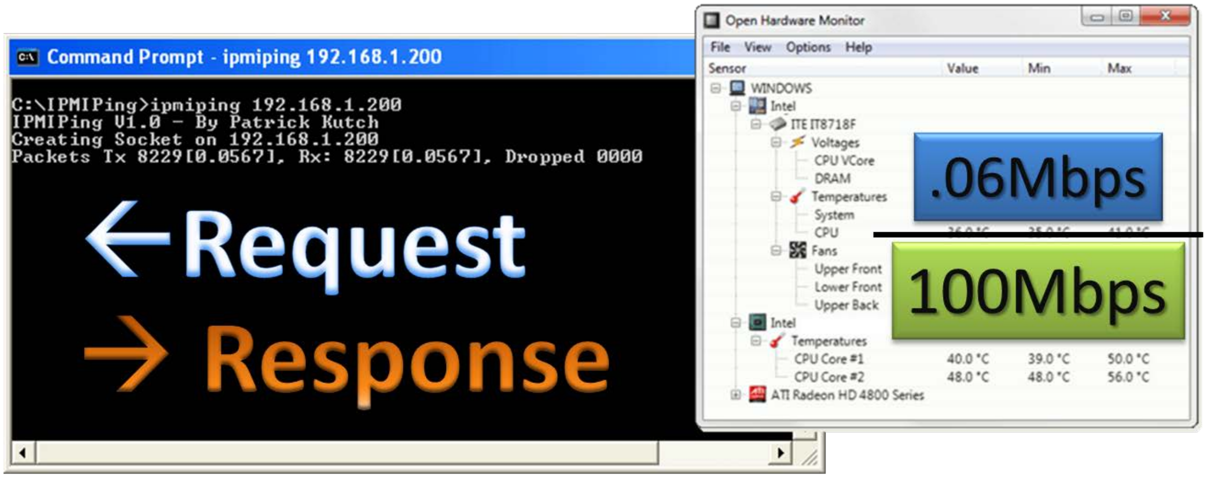


Figure 2 Request/Response Traffic

More 'normal' types of management traffic don't come even close to using any significant amount of the potential 100Mbps bandwidth available with NC-SI.

3.2 Streaming MC to Console Traffic Pattern

Another management traffic pattern is that in which the majority of the traffic is generated by the MC and sent to the network. In test results, this is referred to asBMC2Net (MC to Network) traffic. Examples of this pattern include the Keyboard Video & Mouse (KVM) redirection provided by many MC's and the Serial Over LAN traffic that is part of the IPMI 2.0 specification in which text screens (such as BIOS setup) are redirected to a serial port which, in turn, is captured by the MC and sent inside Serial Over LAN IPMI 2.0 packets to the remote management console.

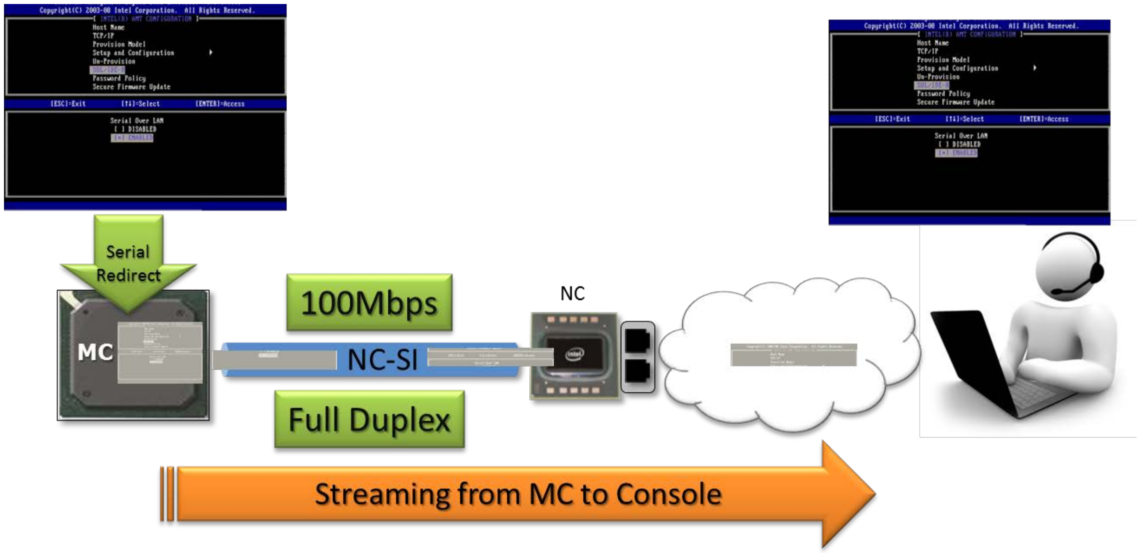


Figure 3 BMC2Net Example, Serial Over LAN

Use-cases or conditions where the BMC2Net traffic flow utilizes more than a few Mbps of throughput are rare, if not non-existent. Although there is 100Mbps bandwidth available, the types of management traffic coming from the MC to the Network simply do not require a great deal of bandwidth at this time. While Serial over LAN and KVM certainly benefit in performance with NC-SI over the legacy 100 MHz SMBus sideband interface, measurements show this traffic is much less than 10Mbps at any given time.

3.3 Streaming Console to MC traffic Pattern

One type of management traffic that makes good use of the NC-SI bandwidth, and is gaining in popularity, is that of remote media connections.

A growing number of MC's allow a management console to mount a local CD/DVD or ISO image which, over the network, appears as a local CD/DVD to the server Operating System. When the "virtual" media's data is accessed, the information is streamed from the remote console to the BMC, which then provides the data to the local Operating System. Of note is that this kind of traffic is a stream, rather than request/response in nature.

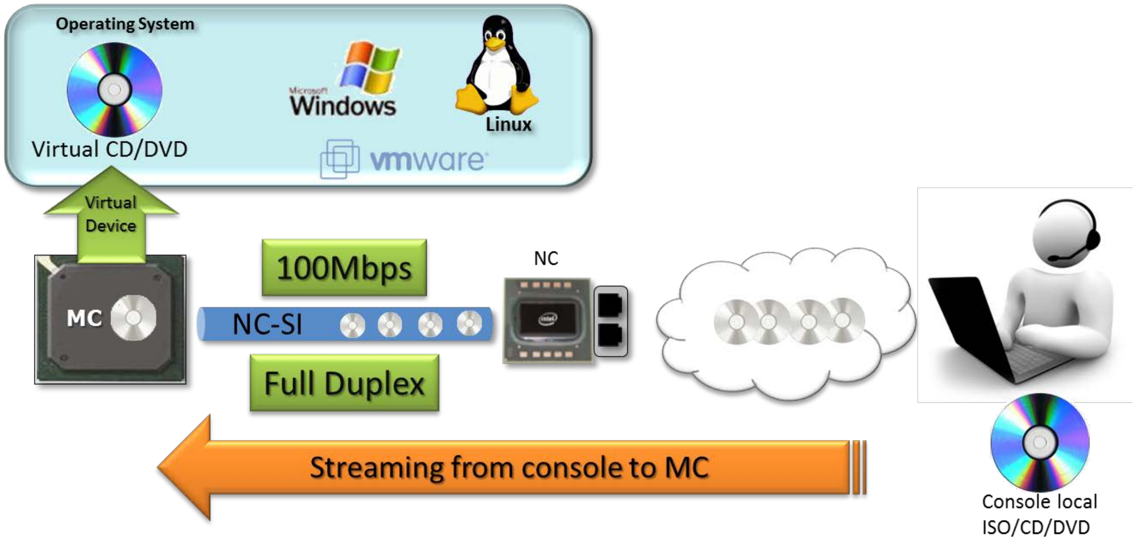


Figure 4 Remote Media – Net2BMC Streaming

Usage models for this kind of system include remote install of an Operating System as well as Application installation and patching. Good performance is key for a positive user experience.

Reports from customers that the performance with this kind of traffic have been disappointing led to some investigation, the results of which are the impetus for writing this paper.

While performance varies between MC's, servers and consoles, in general this kind of Net2BMC traffic is surprisingly poor, averaging less than 10Mbps. Performance has proven to be fairly constant whether the tests were performed on a 1Gbps device (for example, the Intel® I350©) or a 10Gbps device (such as the Intel® X520©).

4 NC-SI Performance

At Intel® lots of tests on the NC-SI interface are run to ensure it works as expected with respect to both the electrical connectivity and the protocol. It also seems quite certain that other Ethernet vendors providing NC-SI functionality do the same.

The Networking Division of Intel® makes a component of a server, just a small piece of the whole server. It neither makes nor, for the most part, has access to BMC's. Testing is done synthetically. Performance testing of NC-SI using Iperf and NTTTCP is usually done with an Intel® Xeon© powered Microsoft Windows Operating System on each side of the NC-SI interface with one representing a remote client, the other a MC.

Tests result in near line-rate performance with, in this case, line rate being the speed of the NC-SI interface; 100Mbps.

The big question the is why does synthetic testing show nearly 100Mbps sustained throughput, yet real-world evaluation using a MC has less than 10% of that throughput?

5 Investigation

It is baffling. How could customers be experiencing such very poor performance when the NC-SI interface on the Intel® NC's can handle sustained 100Mbps without any issues?

I began my investigation both on my own and working with customers. We found that if we set the external link speed of the NC to be 100Mbps, the resulting performance of the Net2MC streaming was extremely good (basically limit of MC performance).

A series of synthetic testing began using NTTTCP and different external link speeds. NTTTCP has an interesting feature in that it can report how many packets were retried. It was found that if the external link speed was 100Mbps, no packets were dropped, however, if the link speed was 1Gbps up to 5% of the packets were being retransmitted.

When doing performance testing, retransmits are a bad thing because a packet is only retransmitted after a timeout occurs, during which there is no acknowledgement to the packet that was sent. Understanding that the performance issue had to do with timeouts and retries, more testing was in order and the decision to use Iperf was made because it is available for both Linux and Microsoft Windows Operating Systems.

Results are shown in Figure 5. The data for Figure 5 is from Section 11.1 and was obtained using Iperf as described in Section 8.

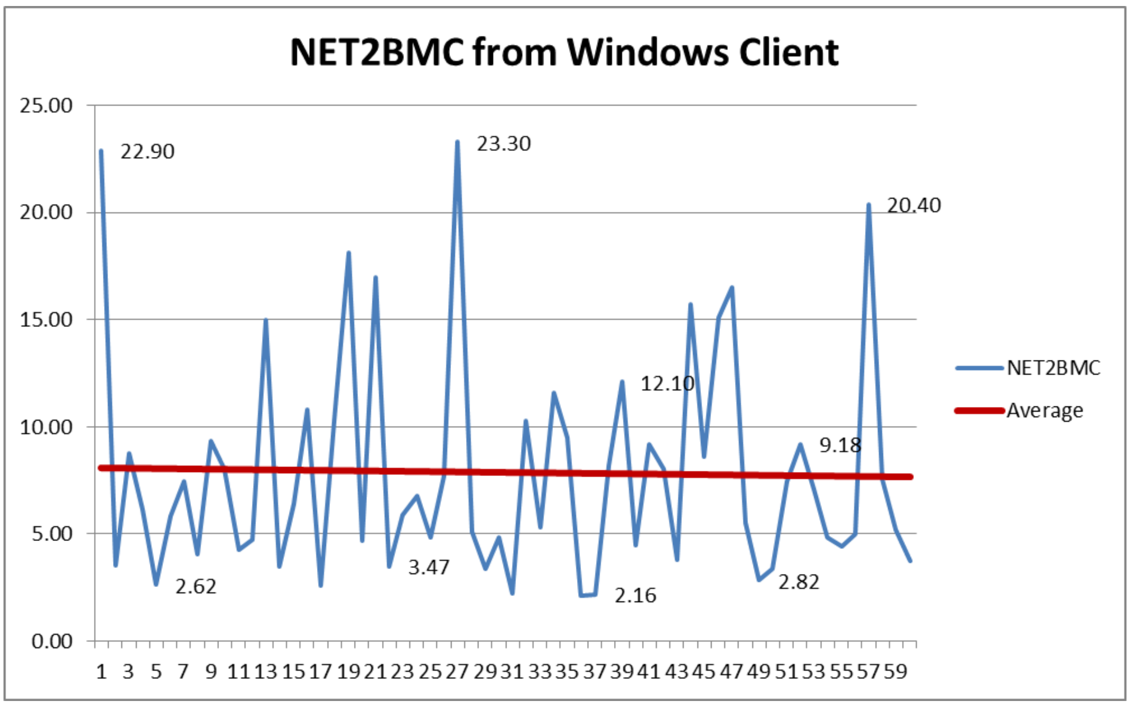


Figure 5 Results showing erratic performance

Shown above is that a bunch of data is sent from the remote console (running on Microsoft Windows Server 2008 R2) in a burst. Performance drops greatly and, after a while, a series of timeouts occur and data is sent in another burst. This test was performed with an external link speed of 1Gbps.

The same test was performed again, but with RHEL 6.3 rather than Microsoft Windows as the remote console OS.

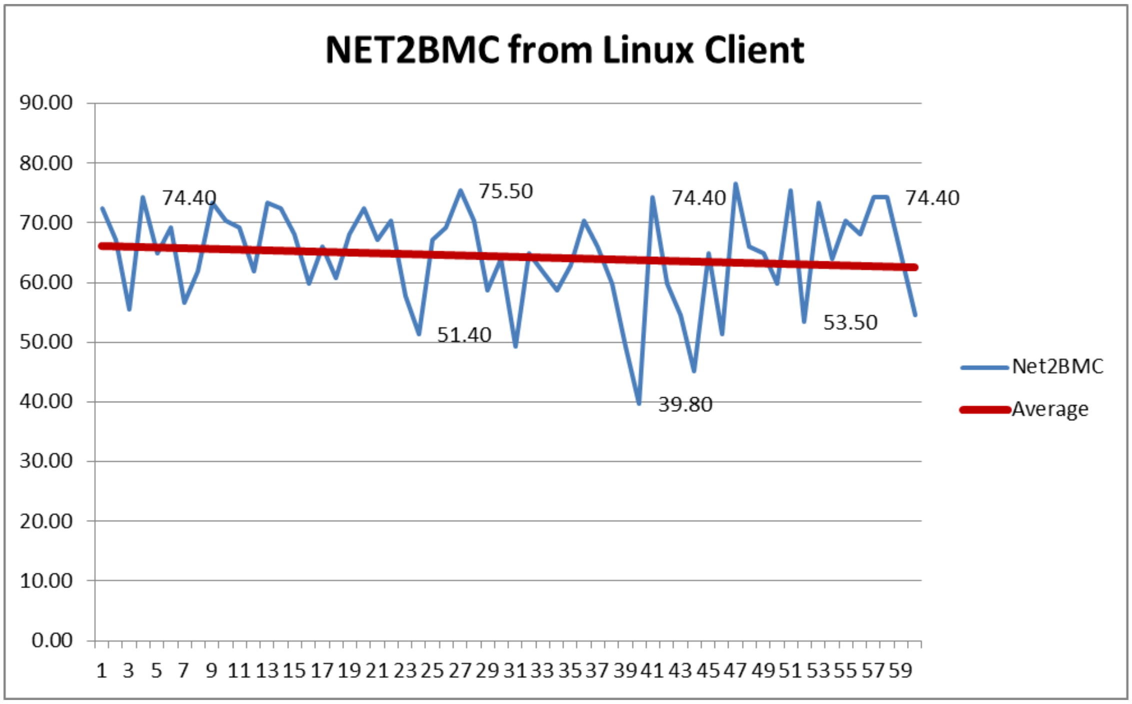


Figure 6 Iperf results for Linux Console

Note that the results from the Linux based client to the MC are significantly better than that of the Microsoft® Windows client. The average result, when using the Microsoft® Windows client, was 7.88Mbpsand 63.98Mbps with the Linux console.

5.1 BMC2NET Traffic

The MC to Network (BMC2NET) traffic flow using Iperf was next investigated, where the Iperf client ran on the MC and communicated with an Iperf server running on a Microsoft® Windows based OS, or a Linux OS.

Figure 7 and Figure 8 below show the results of the testing.

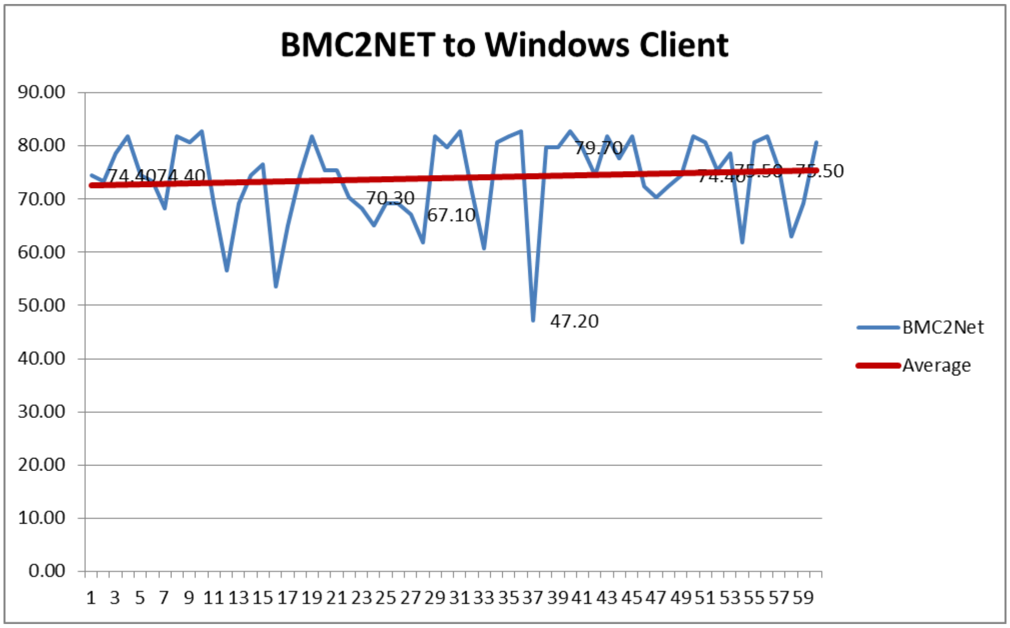


Figure 7 BMC2 NET, Windows Client

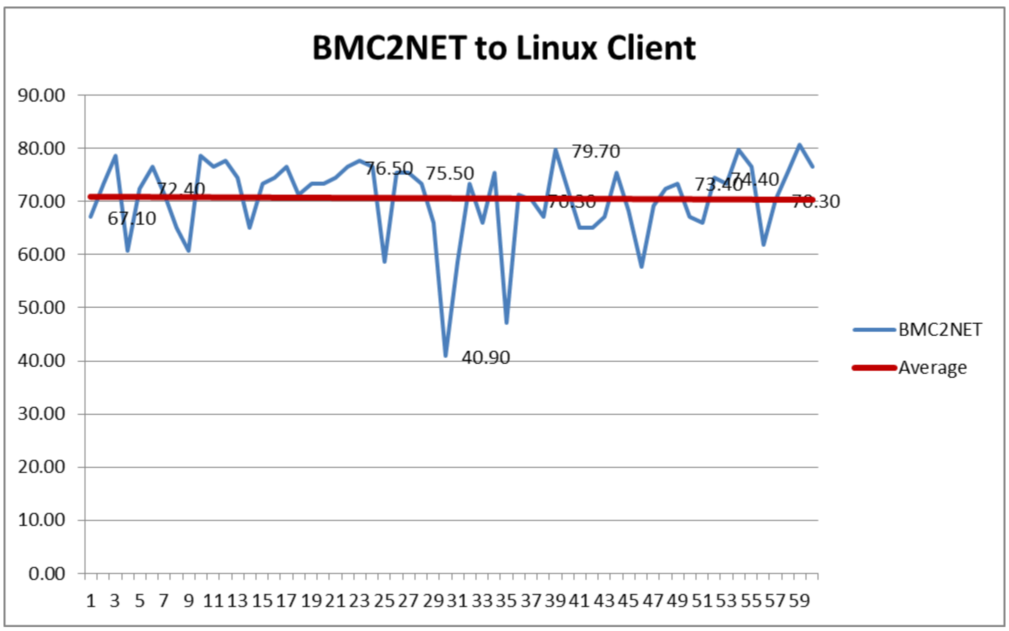


Figure 8 BMC2 NET, Linux Client

Clearly, transmitting from the MC to a remote client had little in the way of performance issues.

Synthetic tests (without using a MC) show line rate (100Mbps) performance is easily sustained. It seems the only reason the MC transmit rate is not any better is simply because the MC is a relatively small, discrete processor not designed, nor optimized, for network performance.

5.2 Bidirectional Performance

Next, performed was bidirectional testing where the MC ran both the Iperf server to receive traffic from a remote console and the Iperf client to transmit data to that same remote client.

Note that the charts and numbers used in this section represent an average between the two controllers and test BMC's used. The raw data is available in Section 11.

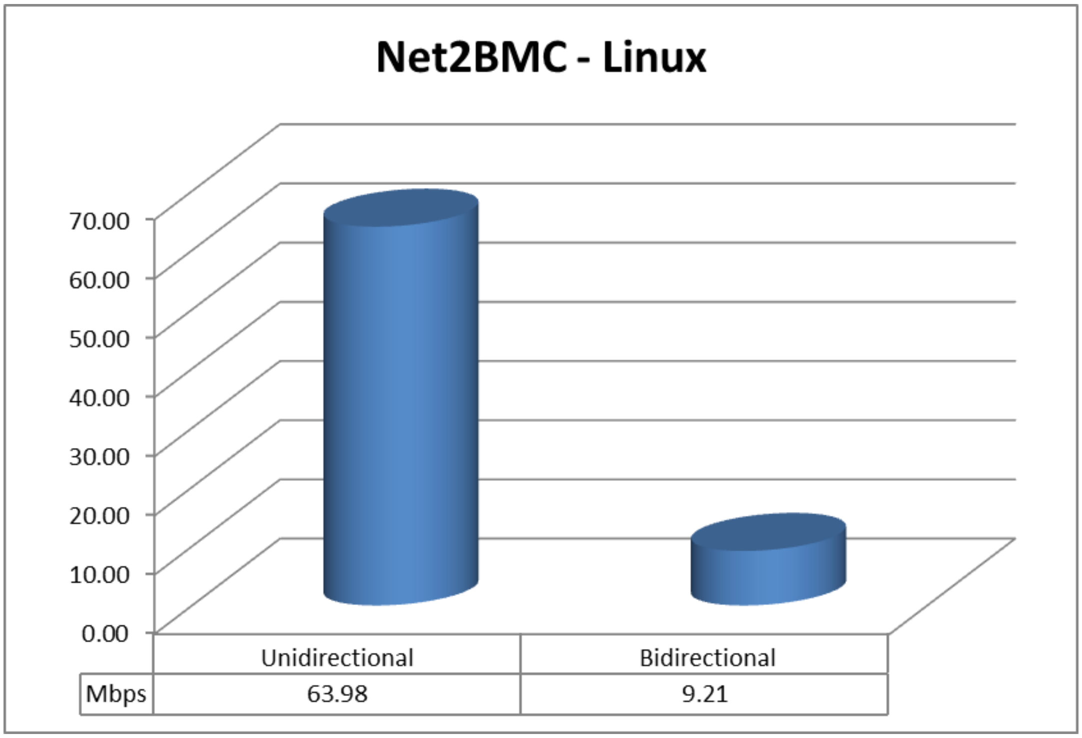


Figure 9 Unidirectional vs. Bidirectional Data Rates - Linux

Figure 9 shows the data rate of unidirectional (only transmitting from remote console to MC—Net2BMC) compared to bidirectional (where the MC was performing BMC2Net) traffic with a Linux remote console. Obviously, performance dropped significantly when bidirectional traffic began—from nearly 64Mbps to nearly 9Mbps.

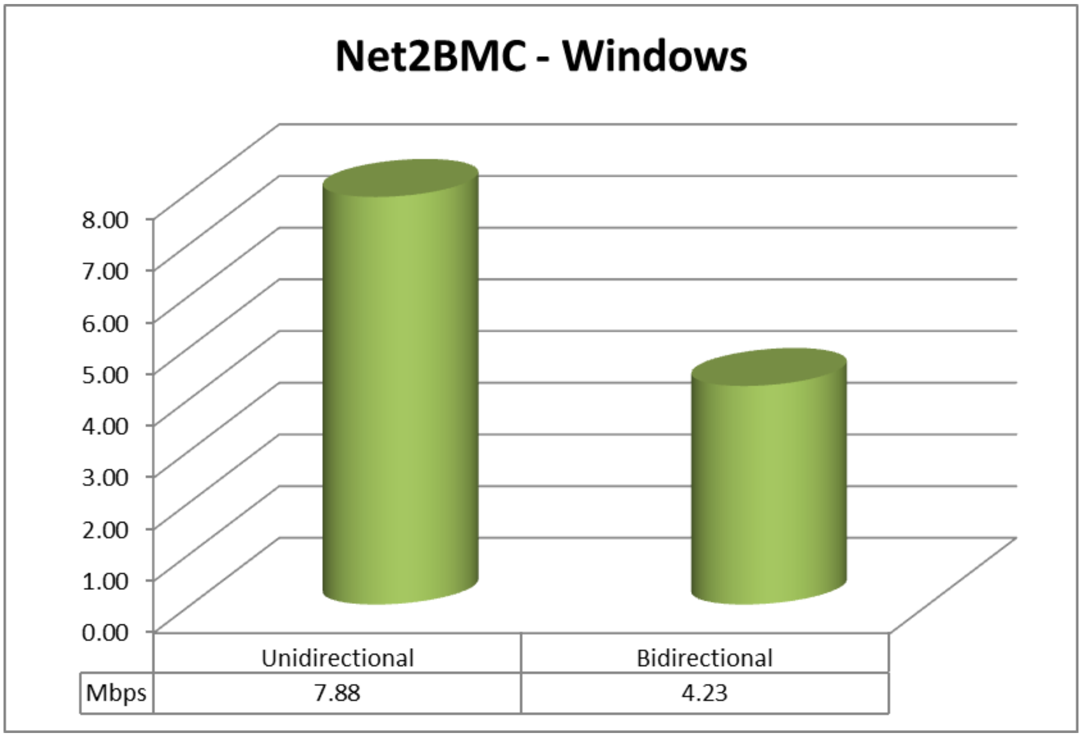


Figure 10 Unidirectional vs. Bidirectional Data Rates - Windows

The testing for bidirectional traffic when connected to a Microsoft® Windows based console also resulted in a drop in throughput performance in the Net2BMC traffic; from just under 8Mbps to nearly 4Mbps.

As Figure 11 shows, the different in BMC2Net throughput (when the MC is streaming data to a remote client) does not seem to differ much and is relatively consistent regardless of unidirectional vs. bidirectional traffic. The OS on the remote console seems to matter little as well.

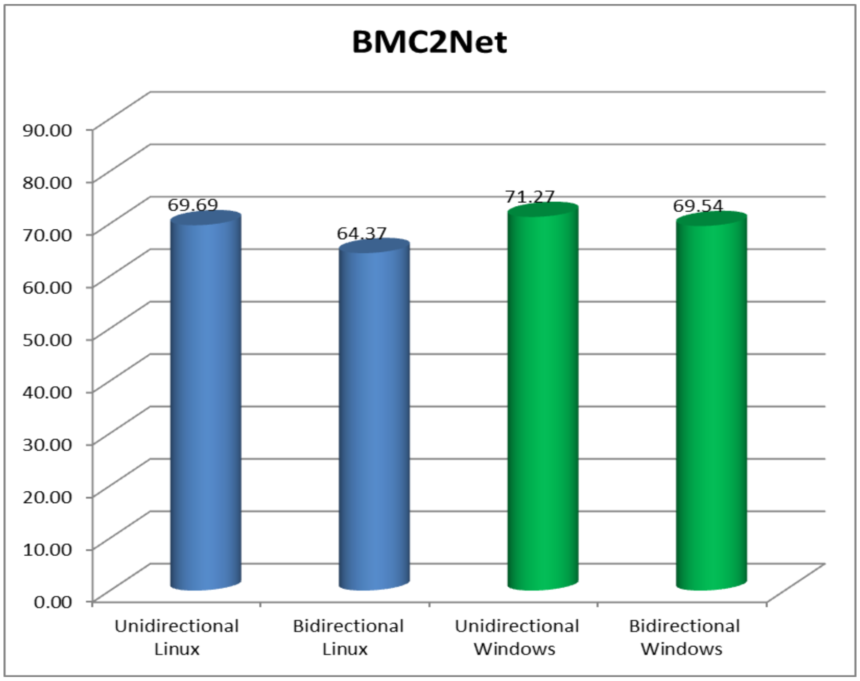


Figure 11 BMC2Net Performance

5.3 Testing Summary

To recap: the MC transmits data at a very respectable average rate of around 70Mbps, regardless of which remote Operating System it transmits to.

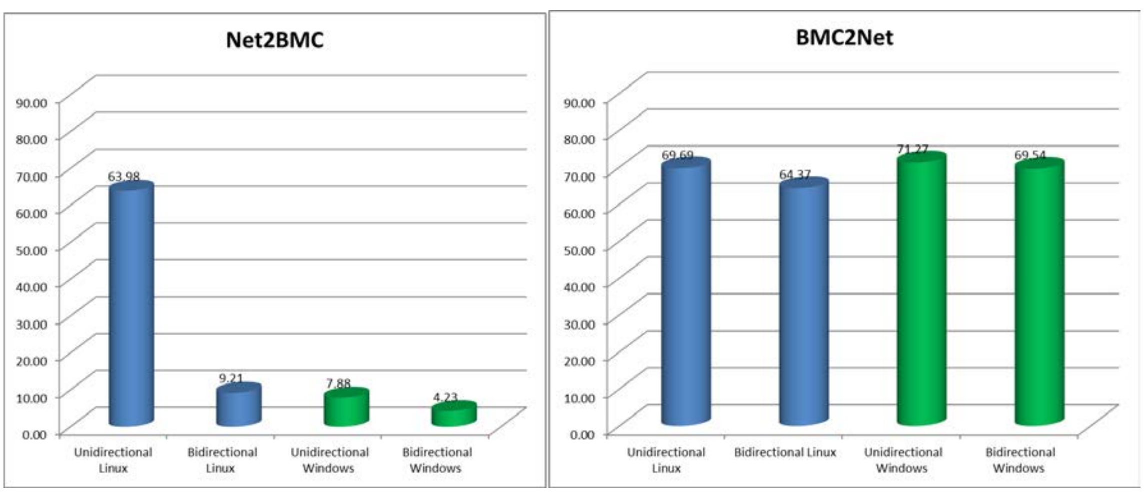


Figure 12 Performance Comparisons

There is, however, a big difference between streaming data from a Microsoft® Windows operating system (less than 8Mbps) and a Linux Operating system (~70Mbps) to the MC (Net2BMC).

For some reason, in most cases the Net2BMC streaming traffic gives significantly less performance throughput than what the NC-SI interface should be able to provide.

6 Conclusion

In the initial phase of research, it came to light that the problem was, in fact, that the remote console tries to stream data at a physical link speed rate (1Gbps or 10Gbps) over an NC-SI interface capable of only 100Mbps—akin to trying to drink water from a fire hose.

Figure 13 Overwhelmed

The data is simply being transferred at a rate faster than NC-SI can handle it, resulting in dropped packets and poor performance. 1Gbps or 10Gbps of data doesn't fit into a 100Mbps NC-SI connection!

However, more research showed that if the remote console ran, Linux the Net2BMC performance was, in fact, pretty decent.

6.1 TCP Window Size

With TCP Window Size, every time a TCP packet is sent, the sender indicates how much buffer space it has available to receive data as part of that packet.

For example, a client connects to a server and sends a request for some data. Part of the standard TCP header for that request is an indicator of how much data the client can receive before it runs out of buffer space. The server then can start streaming data to the client and can send as much data as the client indicated was available. When the client sends more requests or TCP Acks, those packets indicate how much buffer space is left which the server, in turn, again uses.

In this way, the network traffic is managed to accommodate currently available space on the receiving end.

Modern operating systems try and slide this TCP Window around for optimal performance, while also taking into account average latency of packets, link speed and a host of other variables.

Much information is available by searching on TCP Window size. The key point is that the network stack in the Operating System is responsible for sending the window size back and forth between the network connection points.

6.2 Fire Hose Theory Revisited

Since the network stack in the MC is responsible for indicating to the console streaming the data (Net2BMC) to the MC, contact was made with a major server manufacturer to obtain a special build of the BMC firmware for their server that allows shell access to the embedded Linux within the BMC. Investigation revealed the default receive buffer sizes used. For example in embedded Linux running on the BMC tested, it is 85Kb and the maximum is 798Kb.

The MC initially advertises that it can receive up to 85Kb of data at a time before its buffers overflow. The remote console receives this and, believing and tries to send up to 85Kb of data.

Since the NC-SI interface for the two NC's under test had only 8K (this value can be determined via the NC-SI Get Capabilities Command) of buffer space, and the remote console is sending data at more than 10 times the size than the NC-SI interface can buffer, the result is terribly poor performance and packet loss.

Even worse, analysis of the WireShark traces revealed that the embedded Linux network stack on the MC perceives the performance as so slow, it increases the TCP Window size in its responses and requests to the remote console to 798Kb—nearly 100 times more data than the NC-SI interface can handle.

So in the end, the drinking from the fire hose analogy is pretty accurate.

6.3 Not All Network Stacks Are Created Equal

Although the fire-hose theory seems to fit when using Microsoft® Windows as a client streaming large amounts of data to the MC, when the remote console is Linux, the performance is a respectable 60+Mbps. Why is that?

To a layman, one theory might be that Linux and Microsoft® Windows Operating systems both have some algorithms for adjusting TCP Window size dynamically to achieve the best results.

Also, the algorithms may differ between Linux and Microsoft® Windows. A shocking theory, perhaps, but one based upon testing that a Linux console communicating with a MC running Linux employs the same algorithm and, therefore, is able to adjust the TCP Window size in a way that makes for good performance. However, if the Microsoft® Windows network stack uses a different algorithm, the two network stacks don't ever sync up nicely.

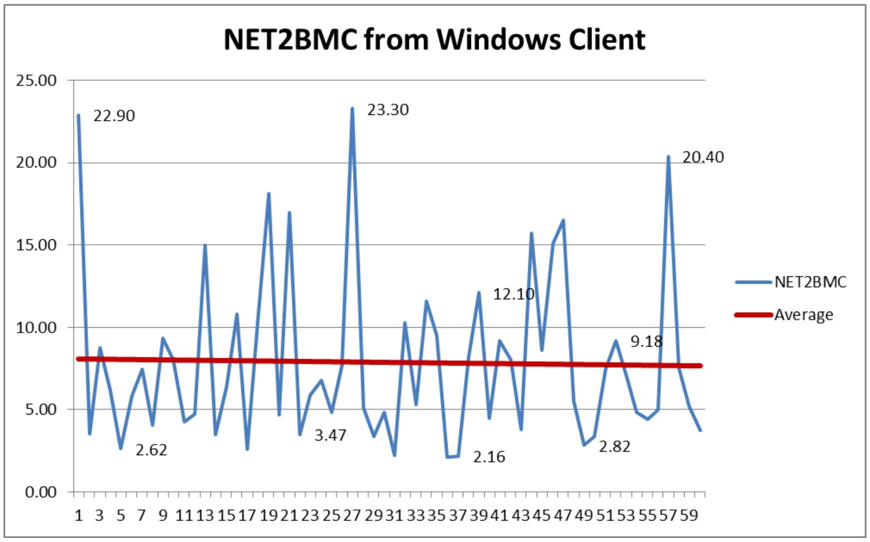


Figure 14 Erratic Performance

7 My Solution

Without an understanding of the complicated algorithm that the embedded Linux Operating System employs to determine initial and maximum TCP Window sizes, it was possible to figure out how to manually configure them in an attempt to find a reasonable set of values for improved performance.

Note that the following settings were gathered using a strictly brute-force method—make a change, perform a bunch of tests, record the results, then make a change and start over again.

To improve performance, two things were needed: override what the Linux OS in the MC would advertise for TCP Window size and how to keep the MC from transmitting more data than the NC-SI interface could handle (the cause of the poor BMC2Net performance with bidirectional traffic).

The following settings accomplished just that.

```
sysctl -w net.ipv4.tcp_rmem='4096 12288 12288'
sysctl -w net.ipv4.tcp_wmem='4096 16384 16384'
sysctl -w net.ipv4.route.flush=1
```

The code simply sets the TCP receive window to 12Kb and the transmit buffer to 16Kb.

A good source of information on these settings is located at http://www.performancewiki.com/linux-tuning.html.

7.1 Improved Performance

After changing the MC's maximum receive window size to 12Kb and changing the maximum transmit buffer size to 16Kb, the test results improved dramatically:

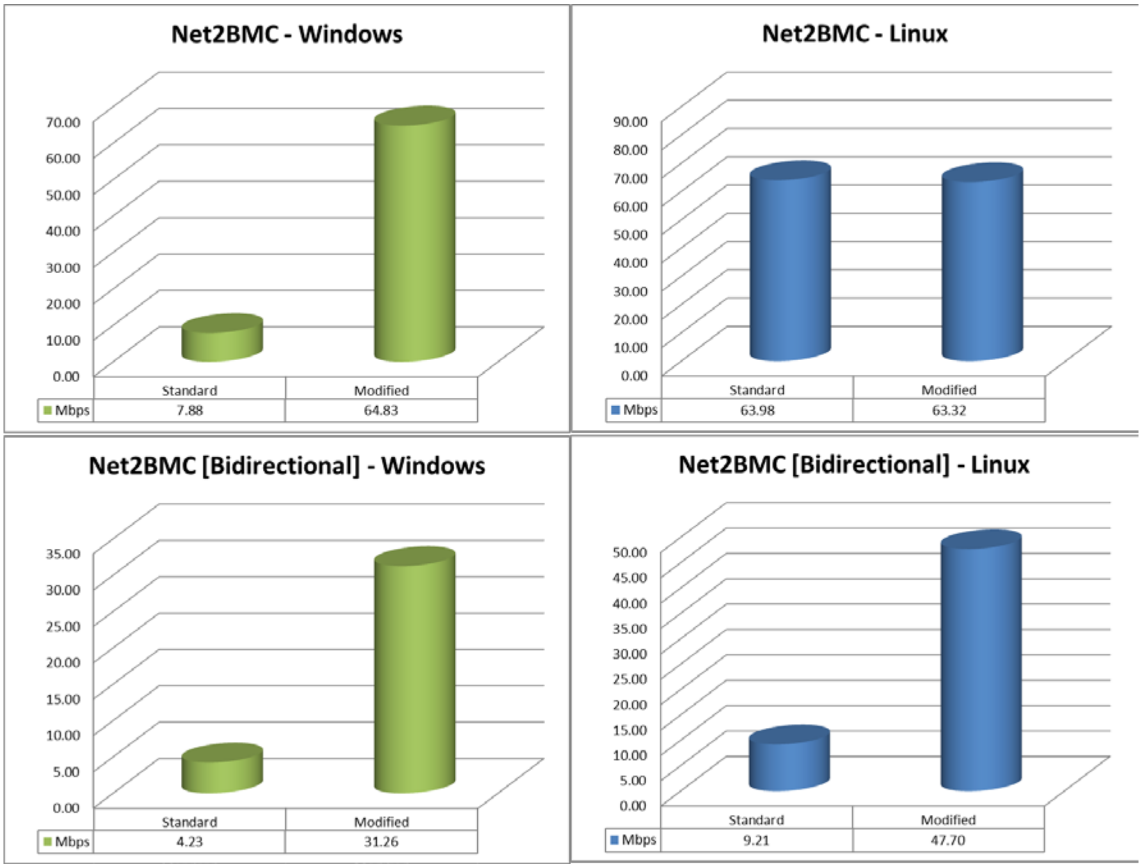


Figure 15 Testing Results

Figure 15 shows the Net2BMC throughput from a Windows client improved significantly; from less than 8Mbps to nearly 65Mbps for unidirectional traffic and from nearly 4bmps up to over 30Mbps with bidirectional traffic.

While the unidirectional Net2BMC traffic, when connected to a remote console running a Linux OS, didn't change with the new settings, the bidirectional Net2BMC traffic went from less than 10Mbps to nearly 50Mbps.

The data used for these represents the average from testing done using two different NC's; one from Intel® and another from an Intel® Ethernet competitor. That data is available in Section 11.

8 Testing Methodology

With performance testing, it is always important to document what is done so that it can be repeated.

All instances of Iperf testing were done as follows:

Server parameters:

```
iperf -s
```

Client parameters

```
iperf –c iperf_server_ip –i 1 –t 60
```

Where:

–i indicates the frequency at which to display the current throughput

-t indicates how many seconds to run the test.

All recorded results were run for 60 seconds and displayed in 1 second intervals.

The same parameters were used when performing NET2BMC and BMC2NET tests.

With the bidirectional testing, an instance of both the client and the server ran in both the BMC and the remote console.

To ensure accurate readings, only one side of the bidirectional testing was recorded at a time. For example, to test Net2BMC for bidirectional traffic, the BMC2Net test was started on the BMC, but the "–t" parameter was changed to 600 to ensure a long test period. After the test was running for a few seconds, the Net2BMC test was started, with the time set to 60 seconds. The output was recorded and is available later in this document.

8.1 Set Setup

Testing involved to new servers (released in 2012) that were identical in every way except for the Network Controllers (NC) installed. One particular server manufacturer designed the server with a specialized form factor NC add-in card supporting NC-SI.

One of the servers used an Intel® I350 based add-in card while the other used a competitor's add-in card to show that the performance challenges reported were not specific to a vendor or NC but rather, the NC-SI interface itself.

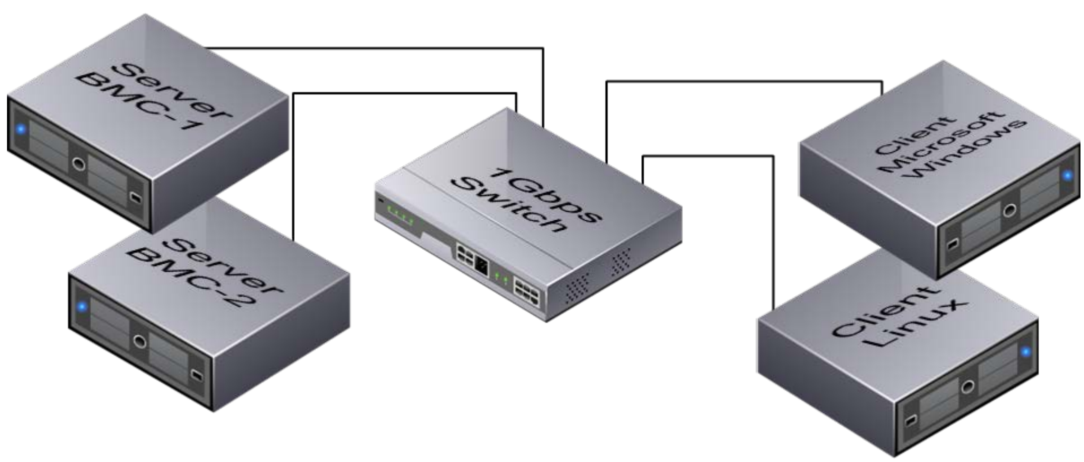


Figure 16 Test setup

Additionally, two other servers, one running Microsoft® Windows Server 2008 R2 for the Microsoft Windows® remote client and the other running RHEL 6.3 as the Linux based operating client. Both client systems were connected to a 1Gbps Ethernet switch using Intel® I350 Ethernet NICs. The test servers were connected to the same 1Gbps Ethernet switch.

Testing was done on a production network with lots of other traffic so there were variances in testing. From one test run to the next, with exactly the same test, the results varied as much as 5Mbps.

9 Conclusion

The NC-SI interface was designed by the DMTF to be a robust, easy to use, fast manageability interface. The NC-SI interface is capable of 100Mbps full-duplex sustained traffic.

As has been shown in this paper however, the NC-SI performance is only one piece of the puzzle. The BMC must properly configure the network stack parameters such as advertised receive buffer sizes to achieve optimal network performance. Simply using the defaults may not give the desired performance.

A BMC can determine how much NC-SI buffer space is available in a NC by using the NC-SI Get Capabilities Command. Using this information, the BMC can properly tune the network stack in order to get the best performance possible.

It is my sincere hope that you have found this information of use.

10 About the Author

Intel Manageability Technologist Patrick Kutch is a Technical Marketing Engineer (TME) for Intel Manageability technologies in then Intel Networking Division. As an Intel Technologist he works with customers and industry leaders, providing both educational materials and answering questions ranging from technical to architectural. He has worked in nearly every facet of Server Manageability, from contributing to the IPMI specification to writing management software over a span of 14 years at Intel. Patrick participates in various DMTF workgroups, including the one responsible for NC-SI. Patrick blogs about manageability and virtualization technologies at http://communities.intel.com/community/wired.

11 Testing Results

This section contains actual test results from IPerf testing. Actual data is provided to support the conclusions and charts presented.

11.1 Iperf—Default BMC Network Settings

11.1.1 RHEL 6.3 Console

	[BMC-1]				[BMC-2]			
	Unidirectional		Bidirectional		Unidirectional		Bidirectional	
time	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET
1	71.30	67.10	12.60	44.00	72.40	37.70	34.60	57.70
2	75.50	73.40	13.60	68.20	67.10	68.20	27.30	66.10
3	66.10	78.60	7.34	66.10	55.60	67.10	17.80	57.70
4	66.10	60.80	11.50	48.20	74.40	59.80	16.80	67.10
5	67.10	72.40	36.70	70.30	65.00	68.20	8.39	69.20
6	75.50	76.50	8.39	71.30	69.20	73.40	18.90	48.20
7	55.60	71.30	5.24	77.60	56.60	74.40	17.80	51.40
8	64.00	65.00	9.44	56.60	61.90	67.10	11.50	72.40
9	61.90	60.80	14.70	65.00	73.40	72.40	4.19	78.60
10	47.20	78.60	12.60	67.10	70.30	59.80	21.00	74.40
11	70.30	76.50	7.34	72.40	69.20	57.70	19.90	64.00
12	75.50	77.60	6.29	73.40	61.90	67.10	11.50	78.60
13	62.90	74.40	11.50	60.80	73.40	72.40	7.34	73.40
14	66.10	65.00	12.60	48.20	72.40	57.70	6.29	61.90
15	69.20	73.40	11.50	68.20	68.20	71.30	9.44	71.30
16	74.40	74.40	10.50	76.50	59.80	71.30	4.19	43.00
17	74.40	76.50	6.29	54.50	66.10	73.40	7.34	72.40
18	57.70	71.30	8.39	73.40	60.80	61.90	6.29	70.30
19	58.70	73.40	5.24	46.10	68.20	75.50	1.05	75.50
20	70.30	73.40	8.39	66.10	72.40	74.40	5.24	65.00
21	68.20	74.40	35.70	56.60	67.10	74.40	3.15	72.40
22	74.40	76.50	9.44	35.70	70.30	74.40	7.34	75.50
23	71.30	77.60	10.50	68.20	57.70	74.40	8.39	72.40
24	53.50	76.50	13.60	56.60	51.40	67.10	1.05	75.50
25	57.70	58.70	6.29	40.90	67.10	70.30	5.24	54.50
26	62.90	75.50	21.00	59.80	69.20	76.50	1.05	78.60
27	73.40	75.50	8.39	70.30	75.50	76.50	1.05	77.60
28	53.50	73.40	9.44	68.20	70.30	73.40	4.19	75.50
29	45.10	66.10	9.44	59.80	58.70	77.60	1.05	69.20
30	51.40	40.90	17.80	40.90	64.00	76.50	3.15	67.10
31	62.90	58.70	10.50	66.10	49.30	71.30	1.05	71.30
32	66.10	73.40	6.29	52.40	65.00	67.10	11.50	75.50
33	69.20	66.10	12.60	60.80	61.90	72.40	1.05	76.50
34	51.40	75.50	9.44	64.00	58.70	57.70	1.05	71.30
35	53.50	47.20	12.60	53.50	62.90	48.20	1.05	59.80
36	56.60	71.30	16.80	56.60	70.30	77.60	1.05	64.00

37	61.90	70.30	11.50	64.00	66.10	76.50	5.24	43.00
38	59.80	67.10	11.50	69.20	59.80	73.40	5.24	69.20
39	52.40	79.70	8.39	71.30	49.30	53.50	1.05	72.40
40	62.90	72.40	10.50	48.20	39.80	79.70	1.05	56.60
41	62.90	65.00	5.24	55.60	74.40	73.40	1.05	71.30
42	67.10	65.00	11.50	64.00	59.80	74.40	1.05	64.00
43	73.40	67.10	9.44	50.30	54.50	75.50	8.39	67.10
44	60.80	75.50	8.39	68.20	45.10	76.50	1.05	73.40
45	50.30	68.20	10.50	69.20	65.00	66.10	4.19	57.70
46	72.40	57.70	10.50	66.10	51.40	70.30	1.05	41.90
47	75.50	69.20	25.20	65.00	76.50	75.50	1.05	73.40
48	56.60	72.40	10.50	73.40	66.10	72.40	1.05	70.30
49	45.10	73.40	9.44	70.30	65.00	59.80	3.15	65.00
50	62.90	67.10	7.34	71.30	59.80	72.40	3.15	55.60
51	65.00	66.10	21.00	52.40	75.50	71.30	1.05	57.70
52	73.40	74.40	30.40	61.90	53.50	66.10	6.29	67.10
53	74.40	73.40	9.44	72.40	73.40	56.60	2.10	70.30
54	64.00	79.70	12.60	75.50	64.00	66.10	7.34	64.00
55	59.80	76.50	8.39	64.00	70.30	73.40	5.24	62.90
56	48.20	61.90	7.34	66.10	68.20	43.00	14.70	68.20
57	74.40	70.30	8.39	67.10	74.40	65.00	1.05	36.70
58	71.30	75.50	10.50	74.40	74.40	75.50	1.05	51.40
59	55.60	80.70	13.60	75.50	65.00	73.40	2.10	71.30
60	62.90	76.50	7.34	64.00	54.50	74.40	8.39	75.50
Average	63.57	70.55	11.82	62.73	64.39	68.84	6.61	66.02

11.1.2 Microsoft Windows Server 2008 Console

	[BMC-1]				[BMC-2]			
	Unidirectional		Bidirectional		Unidirectional		Bidirectional	
time	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2 NET
1	22.90	70.30	1.05	75.50	9.70	74.40	4.59	70.30
2	3.54	68.20	14.90	64.00	5.77	73.40	2.62	72.40
3	8.78	75.50	3.60	53.50	2.42	78.60	3.60	71.30
4	6.16	70.30	2.88	67.10	4.46	81.80	1.51	76.50
5	2.62	65.00	5.57	47.20	7.41	74.40	1.97	75.50
6	5.83	70.30	5.11	65.00	6.23	73.40	2.49	72.40
7	7.47	71.30	7.41	76.50	14.00	68.20	4.46	61.90
8	4.06	48.20	5.31	72.40	6.49	81.80	3.74	81.80
9	9.31	64.00	1.90	70.30	4.33	80.70	1.84	71.30

10	8.00	61.90	2.95	70.30	7.73	82.80	5.77	68.20
11	4.26	57.70	7.08	76.50	2.42	69.20	4.72	68.20
12	4.72	58.70	5.18	74.40	7.14	56.60	1.70	76.50
13	15.00	67.10	7.80	76.50	3.67	69.20	5.37	80.70
14	3.47	43.00	4.39	70.30	17.30	74.40	1.84	67.10
15	6.42	67.10	2.95	58.70	7.41	76.50	0.79	82.80
16	10.80	64.00	3.60	75.50	8.39	53.50	2.16	77.60
17	2.56	71.30	5.90	67.10	9.76	65.00	3.93	81.80
18	10.30	77.60	3.41	76.50	12.00	74.40	2.03	69.20
19	18.10	67.10	5.31	54.50	8.78	81.80	2.75	73.40
20	4.65	73.40	6.03	65.00	5.18	75.50	3.28	84.90
21	17.00	67.10	5.70	76.50	4.59	75.50	1.18	76.50
22	3.47	78.60	4.59	75.50	12.00	70.30	1.57	80.70
23	5.90	77.60	1.97	62.90	8.59	68.20	2.75	82.80
24	6.75	71.30	6.62	71.30	4.39	65.00	1.44	76.50
25	4.85	68.20	5.57	73.40	7.54	69.20	1.64	80.70
26	7.73	79.70	3.67	68.20	3.74	69.20	4.13	74.40
27	23.30	76.50	2.56	65.00	13.80	67.10	2.42	60.80
28	5.11	76.50	3.74	76.50	7.34	61.90	1.38	70.30
29	3.34	73.40	3.67	75.50	3.28	81.80	5.83	68.20
30	4.85	71.30	6.42	44.00	6.03	79.70	1.77	81.80
31	2.23	64.00	3.54	59.80	19.00	82.80	4.52	72.40
32	10.30	76.50	7.21	75.50	11.10	71.30	2.42	77.60
33	5.31	77.60	5.37	57.70	7.01	60.80	0.98	86.00
34	11.60	67.10	3.87	66.10	4.26	80.70	6.62	65.00
35	9.50	57.70	4.98	56.60	13.20	81.80	2.10	72.40
36	2.10	76.50	5.44	57.70	4.85	82.80	3.41	75.50
37	2.16	77.60	6.03	61.90	8.72	47.20	1.77	72.40
38	8.19	77.60	6.23	72.40	7.41	79.70	4.13	73.40
39	12.10	34.60	4.13	64.00	7.80	79.70	5.31	55.60
40	4.46	76.50	5.24	52.40	4.46	82.80	4.33	67.10
41	9.18	74.40	3.80	56.60	6.42	79.70	4.85	57.70
42	8.00	69.20	5.77	68.20	6.82	74.40	5.96	71.30
43	3.80	66.10	6.36	62.90	8.32	81.80	1.77	75.50
44	15.70	74.40	7.54	22.00	7.08	77.60	1.44	71.30
45	8.59	76.50	6.29	57.70	9.70	81.80	2.36	61.90
46	15.10	70.30	5.51	76.50	8.39	72.40	2.49	79.70
47	16.50	77.60	6.68	71.30	8.06	70.30	1.51	69.20
48	5.51	70.30	3.60	60.80	16.90	72.40	4.33	64.00
49	2.82	70.30	5.83	71.30	4.19	74.40	4.39	50.30
50	3.34	65.00	6.68	72.40	7.34	81.80	3.15	64.00

51	7.47	66.10	5.57	76.50	9.04	80.70	1.57	79.70
52	9.18	59.80	9.76	68.20	9.70	75.50	4.00	75.50
53	7.08	76.50	5.11	75.50	6.62	78.60	1.11	78.60
54	4.85	70.30	5.37	72.40	6.55	61.90	1.77	82.80
55	4.39	64.00	7.60	67.10	2.49	80.70	4.46	66.10
56	4.98	54.50	5.90	74.40	8.78	81.80	3.87	81.80
57	20.40	73.40	4.06	76.50	7.41	75.50	2.36	81.80
58	7.54	65.00	5.83	62.90	6.09	62.90	1.97	76.50
59	5.18	77.60	8.85	59.80	10.50	69.20	3.21	79.70
60	3.74	55.60	3.67	47.20	13.40	80.70	11.20	53.50
Average	7.88	68.58	5.31	66.17	7.89	73.95	3.14	72.91

11.2 Iperf—Modified BMC Network Settings

The following results were gathered after setting the BMC's network settings to those described in Section 7.

11.2.1 RHEL 6.3 Console

	[BMC-1]				[BMC-2]			
	Unidirectional		Bidirectional		Unidirectional		Bidirectional	
time	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET
1	71.30	68.20	34.60	29.40	60.80	72.40	52.40	72.40
2	71.30	51.40	28.30	29.40	70.30	65.00	68.20	68.20
3	68.20	69.20	27.30	37.70	70.30	64.00	74.40	44.00
4	60.80	65.00	31.50	28.30	67.10	54.50	76.50	68.20
5	69.20	59.80	15.70	33.60	58.70	61.90	69.20	69.20
6	73.40	70.30	15.70	25.20	62.90	70.30	69.20	65.00
7	71.30	65.00	24.10	47.20	44.00	45.10	67.10	58.70
8	65.00	52.40	29.40	35.70	67.10	54.50	74.40	59.80
9	46.10	60.80	27.30	37.70	61.90	54.50	60.80	50.30
10	73.40	51.40	18.90	40.90	55.60	57.70	66.10	52.40
11	73.40	70.30	27.30	9.44	60.80	47.20	65.00	53.50
12	69.20	52.40	36.70	38.80	54.50	64.00	60.80	61.90
13	68.20	71.30	23.10	35.70	59.80	60.80	67.10	64.00
14	55.60	68.20	31.50	31.50	73.40	49.30	64.00	60.80
15	70.30	54.50	30.40	27.30	55.60	72.40	60.80	51.40
16	73.40	57.70	32.50	21.00	62.90	59.80	59.80	56.60
17	71.30	38.80	29.40	36.70	34.60	67.10	62.90	44.00

18	40.90	64.00	40.90	32.50	64.00	60.80	64.00	61.90
19	50.30	57.70	31.50	29.40	72.40	64.00	62.90	60.80
20	72.40	56.60	24.10	34.60	69.20	72.40	38.80	47.20
21	73.40	66.10	32.50	33.60	72.40	68.20	44.00	60.80
22	54.50	52.40	31.50	34.60	62.90	70.30	47.20	68.20
23	56.60	60.80	36.70	35.70	71.30	73.40	55.60	62.90
24	59.80	49.30	33.60	48.20	72.40	67.10	60.80	67.10
25	47.20	50.30	30.40	46.10	68.20	67.10	60.80	64.00
26	61.90	70.30	28.30	28.30	65.00	66.10	59.80	70.30
27	62.90	60.80	32.50	33.60	72.40	62.90	70.30	67.10
28	57.70	47.20	37.70	36.70	48.20	39.80	71.30	65.00
29	59.80	48.20	45.10	36.70	77.60	61.90	76.50	66.10
30	49.30	58.70	25.20	44.00	69.20	73.40	51.40	46.10
31	65.00	66.10	19.90	33.60	65.00	67.10	67.10	56.60
32	56.60	58.70	36.70	22.00	67.10	73.40	72.40	67.10
33	57.70	64.00	45.10	47.20	77.60	73.40	69.20	61.90
34	64.00	60.80	33.60	37.70	74.40	68.20	74.40	62.90
35	56.60	68.20	35.70	32.50	75.50	69.20	66.10	64.00
36	62.90	71.30	29.40	29.40	60.80	61.90	69.20	72.40
37	58.70	74.40	35.70	37.70	66.10	70.30	74.40	68.20
38	49.30	64.00	33.60	37.70	37.70	59.80	66.10	64.00
39	62.90	60.80	34.60	39.80	75.50	60.80	76.50	61.90
40	54.50	52.40	24.10	34.60	74.40	54.50	56.60	64.00
41	72.40	71.30	25.20	34.60	62.90	62.90	62.90	55.60
42	70.30	71.30	38.80	40.90	65.00	72.40	54.50	69.20
43	60.80	55.60	28.30	39.80	70.30	74.40	69.20	64.00
44	67.10	67.10	33.60	36.70	74.40	62.90	73.40	61.90
45	58.70	64.00	31.50	39.80	75.50	73.40	45.10	69.20
46	66.10	64.00	41.90	39.80	65.00	64.00	61.90	61.90
47	66.10	62.90	33.60	40.90	64.00	73.40	68.20	59.80
48	67.10	46.10	24.10	34.60	59.80	45.10	69.20	61.90
49	62.90	48.20	32.50	37.70	67.10	49.30	73.40	49.30
50	54.50	66.10	29.40	35.70	65.00	66.10	68.20	69.20
51	68.20	72.40	30.40	34.60	55.60	65.00	40.90	43.00
52	60.80	69.20	23.10	31.50	56.60	59.80	72.40	53.50
53	64.00	55.60	38.80	21.00	66.10	65.00	66.10	57.70
54	64.00	67.10	34.60	43.00	67.10	59.80	77.60	64.00
55	61.90	65.00	28.30	35.70	71.30	46.10	66.10	64.00
56	70.30	66.10	32.50	36.70	53.50	68.20	65.00	58.70
57	71.30	59.80	32.50	43.00	61.90	48.20	74.40	61.90
58	61.90	67.10	31.50	21.00	32.50	58.70	60.80	60.80

59	56.60	62.90	33.60	33.60	39.80	52.40	64.00	59.80
60	70.30	56.60	29.40	29.40	64.00	56.60	60.80	64.00
Average	63.03	61.14	30.93	34.70	63.62	62.50	64.47	61.01

11.2.2 Microsoft Windows Server 2008 Console

	[BMC-1]				[BMC-2]			
	Unidirectional		Bidirectional		Unidirectional		Bidirectional	
time	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET	NET2BMC	BMC2NET
1	73.30	53.50	28.10	29.40	75.70	60.80	34.60	36.70
2	71.00	70.30	21.40	37.70	65.00	68.20	25.40	38.80
3	73.90	57.70	28.70	37.70	35.30	73.40	24.60	28.30
4	67.60	53.50	31.20	47.20	72.90	62.90	39.90	25.20
5	54.20	54.50	28.80	43.00	60.00	49.30	34.90	37.70
6	66.00	50.30	26.50	26.20	76.90	61.90	24.50	39.80
7	69.90	67.10	17.40	39.80	74.80	48.20	36.80	30.40
8	70.90	54.50	24.30	38.80	70.00	73.40	42.10	45.10
9	69.80	67.10	31.40	39.80	52.40	58.70	39.80	27.30
10	43.50	61.90	39.30	32.50	76.80	70.30	35.60	14.70
11	69.40	35.70	22.90	30.40	69.20	65.00	34.90	29.40
12	72.80	50.30	33.00	25.20	77.20	59.80	30.00	30.40
13	74.30	62.90	23.20	41.90	57.30	69.20	27.50	32.50
14	44.00	67.10	27.40	46.10	66.30	68.20	35.10	26.20
15	69.10	56.60	32.30	35.70	71.80	72.40	38.90	32.50
16	56.90	71.30	41.70	35.70	62.10	60.80	15.10	38.80
17	73.90	70.30	37.10	35.70	75.40	66.10	27.70	22.00
18	74.90	51.40	36.60	38.80	72.00	73.40	30.30	36.70
19	68.60	59.80	30.70	39.80	71.00	58.70	37.30	28.30
20	44.20	66.10	35.90	36.70	76.70	73.40	42.70	30.40
21	67.80	70.30	27.30	11.50	67.10	60.80	35.80	40.90
22	73.60	70.30	34.60	45.10	76.90	65.00	28.00	46.10
23	72.90	66.10	24.20	36.70	48.70	72.40	34.90	36.70
24	70.10	61.90	0.00	40.90	47.30	73.40	43.20	31.50
25	63.00	59.80	0.00	32.50	70.20	47.20	41.20	38.80
26	60.90	70.30	0.00	37.70	63.30	54.50	40.70	43.00
27	73.90	72.40	0.00	34.60	66.50	29.40	33.80	45.10
28	74.40	69.20	3.47	30.40	61.90	58.70	38.50	38.80
29	68.80	49.30	41.90	29.40	60.80	50.30	38.90	32.50
30	65.00	61.90	17.70	36.70	69.10	67.10	42.90	23.10
31	30.20	49.30	35.70	34.60	60.40	48.20	39.20	36.70
32	61.80	57.70	15.30	12.60	71.90	67.10	29.20	38.80

33	72.00	60.80	36.70	39.80	51.10	57.70	39.30	37.70
34	65.40	64.00	42.70	47.20	58.50	61.90	37.70	33.60
35	46.60	61.90	45.90	39.80	47.30	36.70	28.40	41.90
36	39.30	65.00	36.80	40.90	54.40	53.50	41.00	40.90
37	61.10	65.00	36.50	41.90	71.80	50.30	35.60	28.30
38	66.50	59.80	39.60	46.10	68.80	59.80	24.10	32.50
39	69.90	35.70	33.20	48.20	60.30	61.90	43.50	30.40
40	62.40	62.90	38.80	32.50	67.00	59.80	42.50	39.80
41	34.10	52.40	35.80	40.90	69.90	64.00	39.20	27.30
42	60.10	69.20	31.40	34.60	75.60	69.20	28.60	37.70
43	62.20	60.80	9.90	28.30	46.30	65.00	35.70	40.90
44	64.90	48.20	26.30	31.50	24.20	73.40	37.00	26.20
45	45.10	64.00	36.30	27.30	61.30	72.40	34.90	33.60
46	65.50	67.10	32.60	43.00	73.20	65.00	39.50	36.70
47	69.10	59.80	38.30	34.60	71.60	65.00	28.60	39.80
48	74.60	69.20	28.00	33.60	73.30	49.30	38.20	43.00
49	69.80	41.90	38.00	38.80	71.60	73.40	36.00	35.70
50	63.30	36.70	43.20	32.50	67.20	57.70	26.00	27.30
51	64.90	65.00	30.30	41.90	75.80	66.10	29.40	27.30
52	60.60	61.90	29.00	31.50	69.70	61.90	24.80	34.60
53	75.20	55.60	13.90	26.20	73.10	68.20	31.80	37.70
54	61.50	66.10	31.10	31.50	54.90	73.40	34.50	19.90
55	71.00	51.40	39.80	24.10	72.20	74.40	27.70	33.60
56	65.90	71.30	33.80	39.80	73.70	64.00	27.00	33.60
57	52.60	69.20	35.80	38.80	70.60	68.20	22.40	44.00
58	72.50	71.30	28.00	43.00	68.60	64.00	14.50	24.10
59	71.30	65.00	27.70	39.80	74.80	73.40	33.00	27.30
60	62.20	39.80	35.60	36.70	69.90	57.70	33.00	38.80
Average	64.00	60.02	28.88	35.93	65.66	62.59	33.63	33.96