

# The science behind the report: Optimize networking performance with the Dell PowerEdge R750 featuring a modern 100Gb Broadcom NIC

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [Optimize networking performance with the Dell PowerEdge R750 featuring a modern 100Gb Broadcom NIC](#).

We concluded our hands-on testing on September 21, 2022. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on August 15, 2022 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

## Our results

To learn more about how we have calculated the wins in this report, go to <http://facts.pt/calculating-and-highlighting-wins>. Unless we state otherwise, we have followed the rules and principles we outline in that document.

## Frames per second: Read summary

Table 1: Frametest read results, in frames per second, that the Broadcom 57508 solution achieved. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Instance number											
Run	1	2	3	4	5	6	7	8	9	10	11	12
1	25.2	50.4	75.5	100.7	125.8	150.9	175.6	200.4	224.8	233.3	234.0	235.4
2	25.2	50.4	75.6	100.6	125.7	150.7	175.5	200.5	225.4	234.6	234.7	234.8
3	25.2	50.4	75.5	100.7	125.7	150.7	175.5	200.6	225.1	233.9	234.0	234.7
4	25.2	50.4	75.6	100.7	125.8	150.9	175.7	200.5	225.1	235.1	234.4	234.8
5	25.2	50.4	75.6	100.7	125.7	150.8	175.4	200.6	225.2	234.2	233.9	234.3
6	25.2	50.3	75.5	100.7	125.8	150.7	175.8	200.3	225.1	233.6	235.5	235.9
7	25.2	50.4	75.6	100.6	125.8	150.8	175.6	200.4	225.3	233.0	233.8	233.2
8	25.2	50.4	75.6	100.7	125.8	150.8	175.7	200.5	225.2	234.4	234.2	236.1
9	25.2	50.4	75.6	100.6	125.6	150.8	175.5	200.5	225.4	231.6	233.9	233.4
10	25.2	50.3	75.5	100.7	125.6	150.7	175.2	200.6	225.1	234.1	235.5	235.0
11	25.2	50.4	75.6	100.6	125.8	150.8	175.6	200.6	225.1	234.5	233.9	236.4
12	25.2	50.4	75.6	100.7	125.8	150.8	175.6	200.0	224.8	234.0	234.7	234.8
13	25.2	50.5	75.6	100.7	125.7	150.7	175.7	200.6	225.2	233.4	234.5	233.8
14	25.2	50.4	75.5	100.6	125.7	150.7	175.5	200.5	225.0	234.7	234.9	233.2
15	25.2	50.4	75.6	100.7	125.7	150.8	175.7	200.7	224.9	233.3	235.3	234.4
<b>Average</b>	25.2	50.4	75.5	100.7	125.7	150.8	175.6	200.5	225.1	233.8	234.5	234.7
<b>Median</b>	25.2	50.4	75.6	100.7	125.7	150.8	175.6	200.5	225.1	234.0	234.4	234.8
<b>Target</b>	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0

Table 2: Frametest read results, in frames per second, that the four-NIC solution achieved. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Instance number											
Run	1	2	3	4	5	6	7	8	9	10	11	12
1	25.1	50.3	75.4	100.0	108.5	106.0	157.9	162.8	162.9	212.8	189.7	227.0
2	25.1	50.3	75.0	100.1	125.3	108.4	157.1	140.5	163.3	138.1	138.9	190.9
3	25.1	49.9	75.4	100.2	125.3	132.7	156.5	180.9	171.5	187.0	207.4	196.3
4	25.1	49.9	75.0	100.3	108.3	115.7	156.9	131.8	188.9	165.2	187.3	189.9
5	25.1	49.9	75.4	100.3	107.5	131.7	132.7	157.0	188.6	190.1	211.9	173.0
6	25.1	50.3	75.4	100.3	125.0	150.3	156.2	140.2	164.6	213.9	213.9	190.4
7	25.1	50.0	75.4	100.6	108.3	150.3	157.0	164.1	165.3	163.5	189.4	164.2
8	25.1	50.3	75.4	82.1	125.3	132.1	175.3	181.4	189.3	213.4	189.9	171.9
9	25.2	50.3	75.2	100.2	108.0	132.8	157.0	107.1	158.2	158.0	213.2	187.2
10	25.1	50.3	75.4	83.1	108.5	107.7	175.1	162.7	188.6	189.2	165.1	206.7
11	25.1	49.9	75.1	100.3	107.3	131.9	156.6	164.1	165.0	159.0	219.3	194.8
12	25.1	49.9	75.4	100.5	108.4	149.9	175.3	200.0	181.4	189.0	157.5	189.0
13	25.1	49.9	57.5	100.1	125.4	132.1	133.1	108.2	141.3	212.8	190.1	170.8
14	25.1	50.3	75.4	100.3	125.3	150.1	157.2	132.7	181.9	194.9	212.4	213.5
15	25.1	50.1	75.1	83.1	125.3	133.4	112.4	158.6	206.4	189.8	187.8	218.9
<b>Average</b>	25.1	50.1	74.1	96.8	116.1	131.0	154.4	152.8	174.5	185.1	191.6	192.3
<b>Median</b>	25.1	50.1	75.4	100.2	108.5	132.1	157.0	158.6	171.5	189.2	189.9	190.4
<b>Target</b>	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0

## Frames per second: Write summary

Table 3: Frametest write results, in frames per second, that the Broadcom 57508 solution achieved. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Instance number											
Run	1	2	3	4	5	6	7	8	9	10	11	12
1	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.9	214.7	230.2	230.5	231.7
2	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.9	214.7	231.0	230.9	231.1
3	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.9	214.7	230.6	230.6	230.9
4	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.9	214.6	230.1	230.8	231.2
5	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.8	214.7	230.5	231.0	231.0
6	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.9	214.7	231.0	231.1	231.1
7	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.9	214.7	230.4	231.9	231.7
8	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.8	214.7	231.2	230.8	231.8
9	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.9	214.7	230.8	230.2	231.0
10	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.8	214.7	230.2	230.9	231.4
11	23.9	47.7	71.6	95.5	119.3	143.2	167.0	190.8	214.7	230.8	231.5	231.3
12	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.8	214.7	231.2	230.9	231.2
13	23.9	47.7	71.6	95.4	119.3	143.1	167.0	190.9	214.7	230.5	228.9	231.2
14	23.9	47.7	71.6	95.4	119.3	143.1	167.0	190.8	214.7	230.8	231.1	229.8
15	23.9	47.7	71.6	95.4	119.3	143.1	167.0	190.8	214.7	230.4	230.4	230.7
<b>Average</b>	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.8	214.7	230.6	230.8	231.1
<b>Median</b>	23.9	47.7	71.6	95.4	119.3	143.2	167.0	190.9	214.7	230.6	230.9	231.2
<b>Target</b>	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0

Table 4: Frametest write results, in frames per second, that the four-NIC solution achieved. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Instance number											
Run	1	2	3	4	5	6	7	8	9	10	11	12
1	23.9	47.7	71.6	95.4	104.5	143.1	152.5	176.9	175.2	160.6	193.2	185.6
2	23.9	47.7	71.6	81.3	81.4	128.8	150.7	176.7	162.2	161.5	206.5	184.1
3	23.9	47.7	71.6	95.4	105.1	143.1	138.7	190.8	160.0	152.7	213.6	193.9
4	23.9	47.7	71.5	95.4	119.3	128.1	166.9	136.8	183.3	183.9	204.6	193.0
5	23.9	47.7	71.5	95.4	119.0	129.0	166.9	175.2	176.0	139.2	139.5	212.6
6	23.9	47.7	71.5	95.4	119.2	105.3	150.7	176.9	185.0	152.9	205.9	213.8
7	23.9	47.7	71.6	95.4	105.0	143.1	138.9	129.1	153.2	184.8	163.6	213.4
8	23.9	47.7	71.6	95.4	105.1	143.1	151.5	151.2	163.9	163.1	193.5	184.9
9	23.9	47.7	71.6	80.6	104.9	104.7	151.1	161.1	183.1	169.2	185.6	213.1
10	23.9	47.7	71.6	95.4	104.9	128.1	166.9	159.7	161.7	152.4	159.8	205.2
11	23.9	47.7	71.6	95.4	119.3	127.6	151.0	175.4	161.3	160.7	186.1	194.0
12	23.9	47.7	71.6	81.2	104.9	143.1	151.2	162.6	175.5	205.3	193.0	185.5
13	23.9	47.7	71.6	95.4	105.2	143.1	151.0	153.2	129.4	183.1	162.1	193.9
14	23.9	47.7	71.6	81.3	119.3	127.5	153.0	176.9	153.2	175.5	162.6	193.9
15	23.9	47.7	71.5	95.4	119.3	129.0	128.1	175.2	175.2	160.9	184.0	205.8
<b>Average</b>	23.9	47.7	71.6	91.6	109.1	131.1	151.3	165.2	166.5	167.1	183.6	198.2
<b>Median</b>	23.9	47.7	71.6	95.4	105.1	129.0	151.1	175.2	163.9	161.5	186.1	193.9
<b>Target</b>	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0

## One instance

Table 5: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at one instance. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.2	25.2	25.2	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
<b>Std. Deviation</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6: Frametest results, in average FPS, that the four-NIC solution achieved at one instance. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.1	25.1	24.9	25.0	25.0	25.1	25.0	25.1	25.1	25.1	25.0	25.0	25.0	25.1	25.0
<b>Std. Deviation</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

### Frametest performance for 1 instances

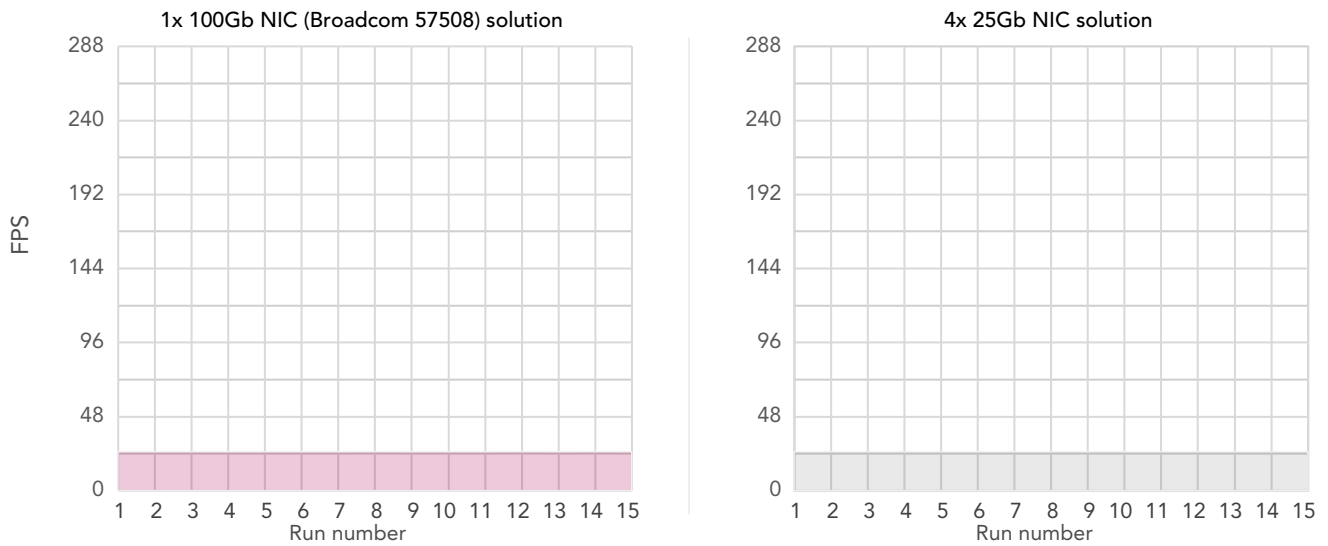


Figure 5: Frametest results, in frames per second, for one instance. Higher numbers and more consistency is better. Source: Principled Technologies.

## Two instances

Table 7: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at two instances. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.2	25.2	25.2	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
<b>Instance 2</b>	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2
<b>Sum</b>	50.4	50.4	50.4	50.4	50.4	50.3	50.4	50.4	50.4	50.3	50.4	50.4	50.5	50.4	50.4
<b>Average</b>	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
<b>Std. Deviation</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8: Frametest results, in average FPS, that the four-NIC solution achieved at two instances. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.1	25.1	24.9	25.0	25.0	25.1	25.0	25.1	25.1	25.1	25.0	25.0	25.0	25.1	25.0
<b>Instance 2</b>	25.1	25.1	24.9	25.0	25.0	25.1	25.0	25.1	25.1	25.1	25.0	25.0	25.0	25.1	25.1
<b>Sum</b>	50.3	50.3	49.9	49.9	49.9	50.3	50.0	50.3	50.3	50.3	49.9	49.9	49.9	50.3	50.1
<b>Average</b>	25.1	25.1	24.9	25.0	25.0	25.1	25.0	25.1	25.1	25.1	25.0	25.0	25.0	25.1	25.0
<b>Std. Deviation</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

### Frametest performance for 2 instances

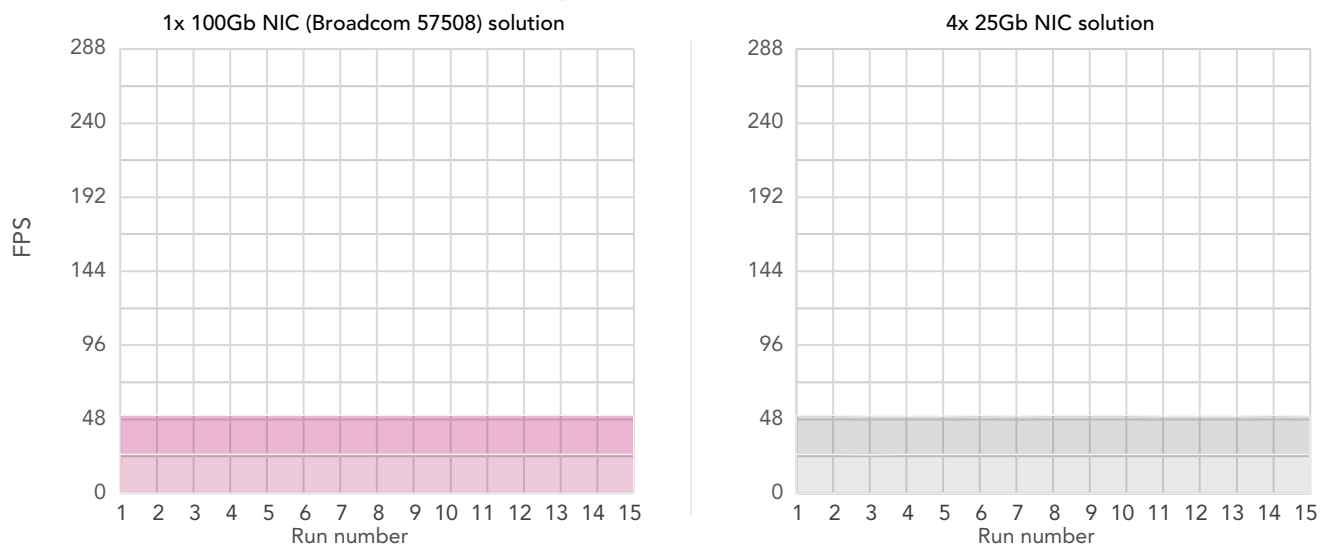


Figure 6: Frametest results, in frames per second, for two instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## Three instances

Table 9: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at three instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2
<b>Instance 2</b>	25.1	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
<b>Instance 3</b>	25.1	25.2	25.1	25.2	25.2	25.1	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.1	25.2
<b>Sum</b>	75.5	75.6	75.5	75.6	75.6	75.5	75.6	75.6	75.6	75.5	75.6	75.6	75.6	75.5	75.6
<b>Average</b>	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2
<b>Std. Deviation</b>	0.03	0.02	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.02	0.00	0.02	0.02	0.00

Table 10: Frametest results, in average FPS, that the four-NIC solution achieved at three instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.1	24.9	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.1	25.1	25.1	18.9	25.1	25.1
<b>Instance 2</b>	25.2	24.9	25.1	24.9	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.1	19.2	25.1	25.0
<b>Instance 3</b>	25.1	25.1	25.1	25.0	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.1	19.4	25.1	25.0
<b>Sum</b>	75.4	75.0	75.4	75.0	75.4	75.4	75.4	75.4	75.2	75.4	75.1	75.4	57.5	75.4	75.1
<b>Average</b>	25.1	25.0	25.1	25.0	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.1	19.2	25.1	25.0
<b>Std. Deviation</b>	0.02	0.09	0.00	0.09	0.00	0.00	0.00	0.00	0.06	0.00	0.07	0.00	0.21	0.00	0.08

### Frametest performance for 3 instances

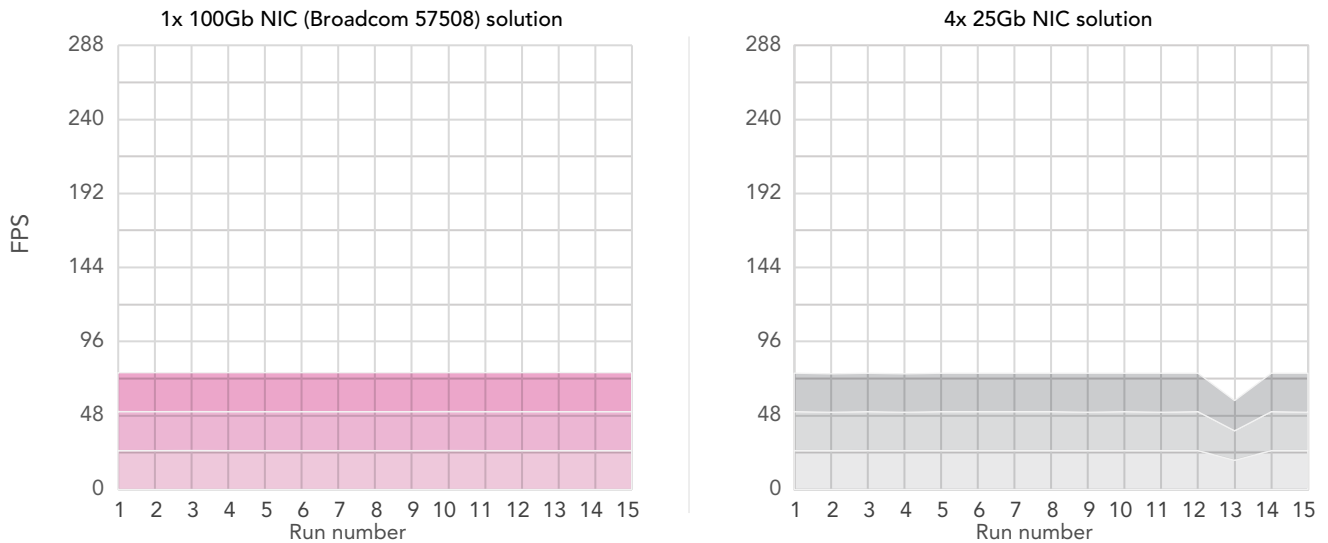


Figure 7: Frametest results, in frames per second, for three instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## Four instances

Table 11: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at four instances. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	25.19	25.13	25.17	25.23	25.19	25.23	25.17	25.19	25.14	25.14	25.14	25.14	25.19	25.18	25.19
<b>Instance 2</b>	25.19	25.19	25.22	25.14	25.19	25.14	25.19	25.14	25.19	25.23	25.14	25.24	25.19	25.13	25.14
<b>Instance 3</b>	25.13	25.14	25.18	25.14	25.13	25.14	25.14	25.19	25.09	25.14	25.13	25.16	25.17	25.13	25.18
<b>Instance 4</b>	25.14	25.14	25.14	25.19	25.14	25.19	25.14	25.14	25.19	25.14	25.14	25.19	25.14	25.13	25.14
<b>Sum</b>	100.65	100.60	100.71	100.70	100.65	100.70	100.64	100.66	100.61	100.65	100.55	100.73	100.69	100.57	100.65
<b>Average</b>	25.16	25.15	25.18	25.18	25.16	25.18	25.16	25.17	25.15	25.16	25.14	25.18	25.17	25.14	25.16
<b>Std. Deviation</b>	0.03	0.02	0.03	0.04	0.03	0.04	0.02	0.03	0.04	0.04	0.00	0.04	0.02	0.02	0.02

Table 12: Frametest results, in average FPS, that the four-NIC solution achieved at four instances. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Instance 1</b>	24.98	24.97	24.96	25.16	24.97	25.12	25.13	19.69	24.96	25.13	25.04	25.13	25.13	25.13	19.44
<b>Instance 2</b>	25.13	25.13	25.13	25.13	25.13	24.97	25.13	18.59	25.13	19.55	25.12	25.12	24.97	24.97	18.96
<b>Instance 3</b>	24.95	25.13	25.13	25.04	25.05	25.11	25.16	25.13	25.13	19.18	25.13	25.12	25.08	25.03	19.60
<b>Instance 4</b>	24.94	24.91	24.96	24.97	25.13	25.13	25.13	18.68	24.96	19.20	24.98	25.13	24.94	25.13	25.13
<b>Sum</b>	100.00	100.14	100.18	100.30	100.28	100.33	100.55	82.09	100.18	83.06	100.27	100.50	100.12	100.26	83.13
<b>Average</b>	25.00	25.04	25.05	25.08	25.07	25.08	25.14	20.52	25.05	20.77	25.07	25.13	25.03	25.07	20.78
<b>Std. Deviation</b>	0.08	0.10	0.08	0.08	0.07	0.07	0.01	2.69	0.08	2.52	0.06	0.00	0.08	0.07	2.52

### Frametest performance for 4 instances

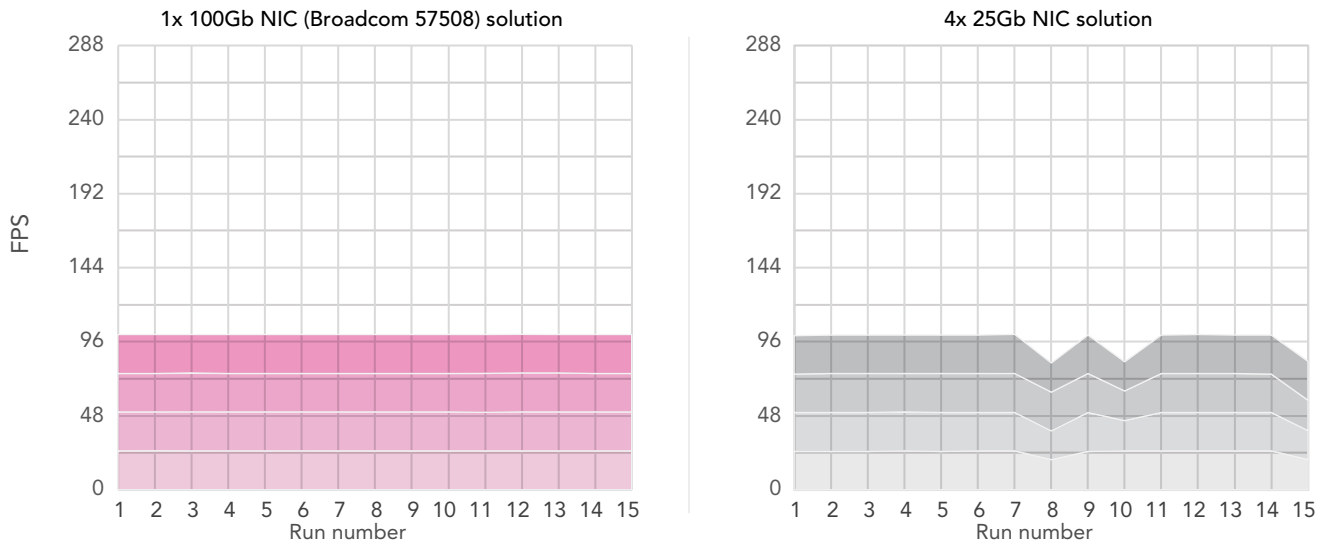


Figure 8: Frametest results, in frames per second, for four instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## Five instances

Table 13: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at five instances. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	25.2	25.2	25.1	25.1	25.2	25.2	25.2	25.1	25.2	25.1	25.2	25.2	25.2	25.2	25.1
Instance 2	25.1	25.1	25.1	25.2	25.2	25.2	25.2	25.2	25.1	25.2	25.2	25.2	25.1	25.2	25.1
Instance 3	25.1	25.1	25.2	25.1	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.1	25.1	25.1	25.2
Instance 4	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.2
Instance 5	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.2	25.1	25.1	25.1
Sum	125.8	125.7	125.7	125.8	125.7	125.8	125.8	125.8	125.6	125.6	125.8	125.8	125.7	125.7	125.7
Average	25.2	25.1	25.1	25.2	25.1	25.2	25.2	25.2	25.1	25.1	25.2	25.2	25.1	25.1	25.1
Std. Deviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

Table 14: Frametest results, in average FPS, that the four-NIC solution achieved at five instances. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	19.6	25.1	25.1	25.1	19.1	25.0	19.3	25.1	25.1	19.4	25.1	19.6	25.1	25.1	25.1
Instance 2	25.1	25.1	25.1	19.7	19.1	25.0	19.2	25.0	18.1	19.6	25.1	25.1	25.1	25.1	25.1
Instance 3	19.6	25.0	25.1	19.3	19.0	25.1	25.1	25.1	21.4	25.1	18.8	19.2	25.0	25.1	25.0
Instance 4	19.0	25.1	25.0	25.1	25.1	25.0	19.6	25.0	18.4	25.1	19.2	19.3	25.1	25.0	25.1
Instance 5	25.1	25.0	25.0	19.1	25.1	25.0	25.1	25.1	25.0	19.2	19.1	25.1	25.1	25.0	25.0
Sum	108.5	125.3	125.3	108.3	107.5	125.0	108.3	125.3	108.0	108.5	107.3	108.4	125.4	125.3	125.3
Average	21.7	25.1	25.1	21.7	21.5	25.0	21.7	25.1	21.6	21.7	21.5	21.7	25.1	25.1	25.1
Std. Deviation	2.8	0.1	0.1	2.8	3.0	0.1	2.8	0.1	3.0	2.8	3.0	2.8	0.1	0.1	0.1

### Frametest performance for 5 instances

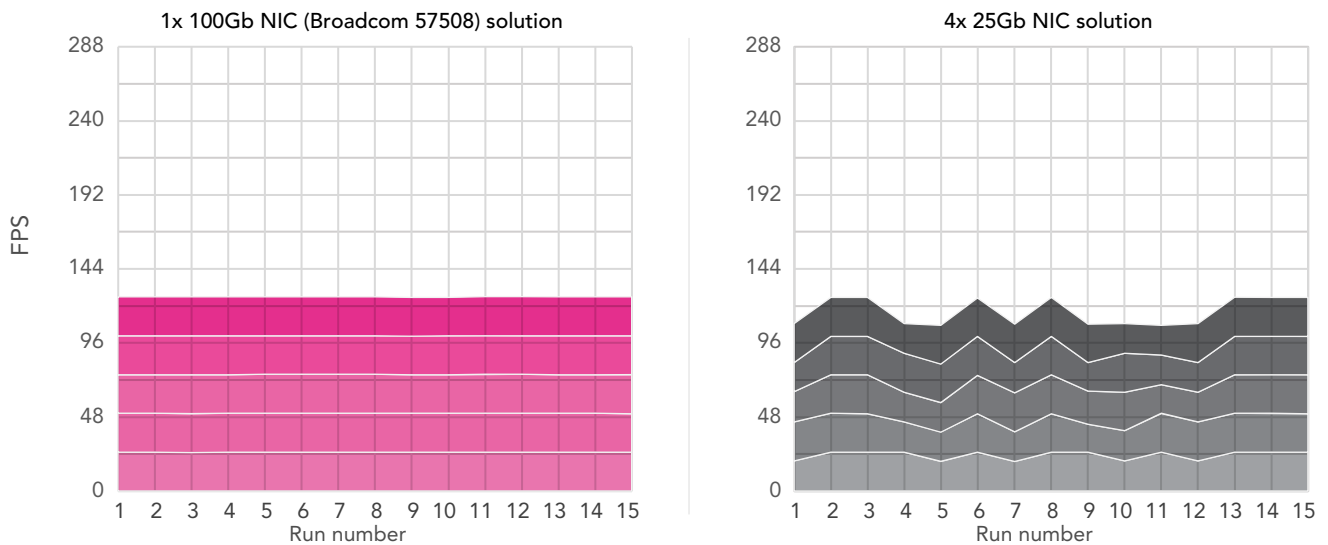


Figure 9: Frametest results, in frames per second, for five instances. Higher numbers and more consistency is better. Source: Principled Technologies.



## Six instances

Table 15: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at six instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	25.2	25.2	25.1	25.2	25.2	25.2	25.1	25.2	25.1	25.2	25.1	25.2	25.2	25.2	25.2
Instance 2	25.2	25.1	25.2	25.1	25.2	25.1	25.2	25.2	25.2	25.1	25.2	25.1	25.1	25.2	25.2
Instance 3	25.2	25.2	25.1	25.1	25.1	25.2	25.1	25.2	25.1	25.1	25.1	25.2	25.2	25.1	25.1
Instance 4	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1
Instance 5	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.2
Instance 6	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.2	25.1	25.1	25.1	25.1
Sum	150.9	150.7	150.7	150.9	150.8	150.7	150.8	150.8	150.8	150.7	150.8	150.8	150.7	150.7	150.8
Average	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1
Std. Deviation	0.04	0.05	0.03	0.05	0.04	0.05	0.04	0.05	0.05	0.04	0.06	0.04	0.05	0.03	0.05

Table 16: Frametest results, in average FPS, that the four-NIC solution achieved at six instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	13.7	25.1	19.0	19.1	25.1	25.1	25.1	25.1	25.1	14.3	25.1	25.0	25.1	25.1	25.1
Instance 2	25.0	14.8	25.1	19.2	19.3	25.1	25.0	19.1	19.1	25.0	25.0	25.1	18.8	24.9	25.1
Instance 3	25.0	14.3	25.1	19.2	25.1	25.0	25.0	25.0	19.6	25.1	18.8	25.0	25.1	25.1	19.4
Instance 4	14.4	14.8	19.5	19.9	25.0	25.1	25.1	18.5	25.0	14.6	19.4	25.0	19.3	24.9	19.4
Instance 5	14.1	25.1	25.0	19.1	18.8	25.1	25.1	25.1	25.1	13.9	18.5	25.0	18.6	25.1	19.4
Instance 6	13.9	14.3	19.1	19.3	18.4	25.0	25.0	19.3	18.9	14.8	25.1	25.0	25.1	25.0	25.0
Sum	106.0	108.4	132.7	115.7	131.7	150.3	150.3	132.1	132.8	107.7	131.9	149.9	132.1	150.1	133.4
Average	17.7	18.1	22.1	19.3	22.0	25.1	25.1	22.0	22.1	18.0	22.0	25.0	22.0	25.0	22.2
Std. Deviation	5.15	5.00	2.94	0.27	3.12	0.06	0.08	3.07	2.94	5.02	3.10	0.06	3.12	0.07	2.84

### Frametest performance for 6 instances

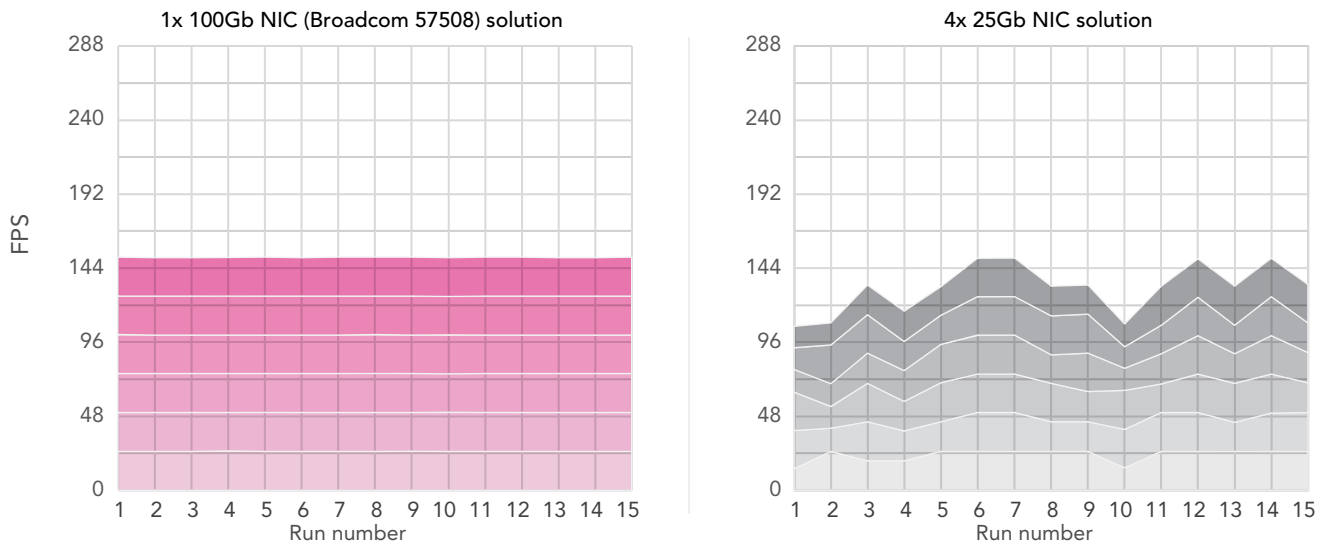


Figure 10: Frametest results, in frames per second, for six instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## Seven instances

Table 17: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at seven instances. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	25.0	25.2	25.1	25.2	25.2	25.2	25.1	25.1	25.0	25.2	25.1	25.1	25.1	25.0	25.1
Instance 2	25.2	25.0	25.1	25.2	25.0	25.0	25.2	25.1	25.0	25.0	25.1	25.2	25.2	25.2	25.2
Instance 3	25.0	25.2	25.2	25.0	25.0	25.2	25.2	25.1	25.0	25.0	25.1	25.2	25.2	25.0	25.0
Instance 4	25.2	25.0	25.0	25.2	25.0	25.2	25.0	25.2	25.2	25.0	25.1	25.0	25.0	25.1	25.0
Instance 5	25.1	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.0	25.1
Instance 6	25.0	25.0	25.0	25.0	25.0	25.1	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.1
Instance 7	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.1	25.0	25.0	25.0	25.0
<b>Sum</b>	175.6	175.5	175.5	175.7	175.4	175.8	175.6	175.7	175.5	175.2	175.6	175.6	175.7	175.5	175.7
<b>Average</b>	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.1	25.0	25.1	25.1	25.1	25.1	25.1
<b>Std. Deviation</b>	0.06	0.08	0.05	0.07	0.07	0.07	0.08	0.06	0.05	0.06	0.04	0.07	0.08	0.07	0.07

Table 18: Frametest results, in average FPS, that the four-NIC solution achieved at seven instances. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	18.9	25.0	25.1	25.1	15.2	25.0	18.7	25.0	25.1	25.1	25.0	25.0	14.1	19.2	13.4
Instance 2	24.9	25.1	25.0	25.1	25.1	25.1	25.1	25.0	25.1	25.0	25.1	25.1	25.1	25.1	13.9
Instance 3	19.5	25.1	25.1	19.3	25.1	25.1	25.1	25.1	19.2	25.1	19.2	25.1	25.0	25.2	19.2
Instance 4	19.3	19.0	18.9	18.7	15.1	18.4	25.0	25.1	18.7	24.9	18.6	25.1	14.9	18.7	14.3
Instance 5	25.1	25.1	18.7	25.0	25.1	18.9	18.8	25.1	25.0	25.1	25.1	25.0	14.6	25.1	14.2
Instance 6	25.0	18.9	18.8	18.8	13.6	18.7	19.3	25.1	18.9	25.0	25.0	25.0	25.1	18.8	18.8
Instance 7	25.1	18.8	25.0	25.0	13.4	25.0	24.9	25.0	25.1	24.9	18.5	25.0	14.2	25.0	18.7
<b>Sum</b>	157.9	157.1	156.5	156.9	132.7	156.2	157.0	175.3	157.0	175.1	156.6	175.3	133.1	157.2	112.4
<b>Average</b>	22.6	22.4	22.4	22.4	19.0	22.3	22.4	25.0	22.4	25.0	22.4	25.0	19.0	22.5	16.1
<b>Std. Deviation</b>	2.88	3.06	3.11	3.04	5.39	3.15	3.01	0.07	3.06	0.08	3.13	0.07	5.26	3.06	2.46

### Frametest performance for 7 instances

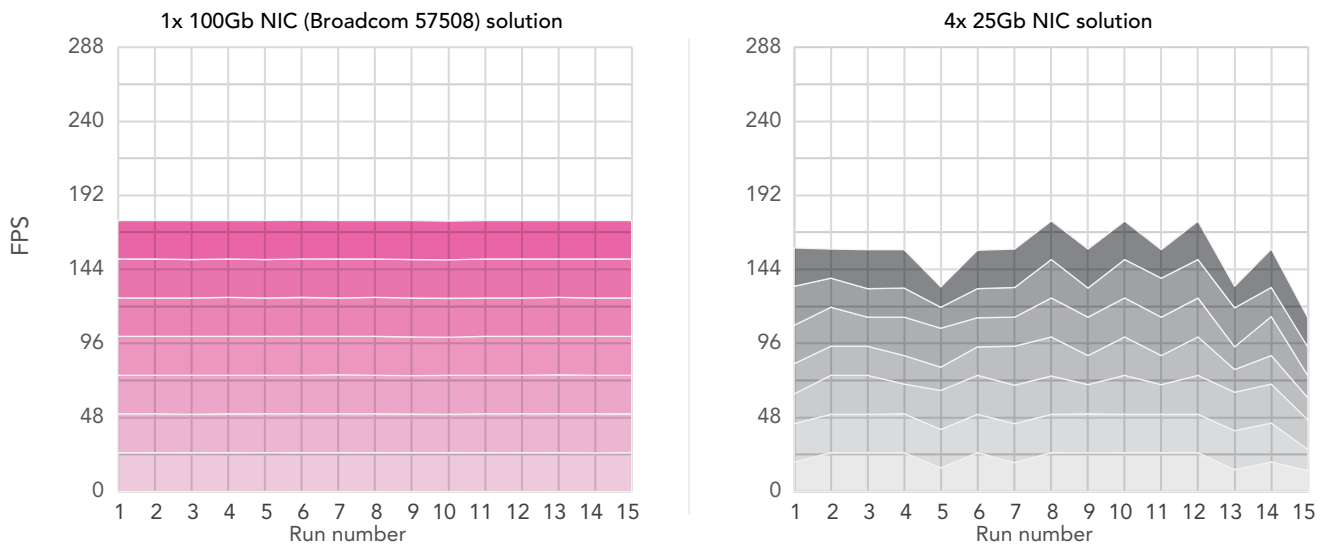


Figure 11: Frametest results, in frames per second, for seven instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## Eight instances

Table 19: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at eight instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	25.1	25.1	25.1	25.2	25.2	25.2	25.1	25.2	25.1	25.2	25.0	25.2	25.0	25.2	25.2
Instance 2	25.0	25.1	25.0	25.0	25.1	25.1	25.2	25.0	25.2	25.1	25.1	25.0	25.1	25.0	25.2
Instance 3	25.2	25.0	25.2	25.0	25.0	25.1	25.2	25.2	25.2	25.2	25.2	25.0	25.2	25.0	25.2
Instance 4	25.0	25.1	25.2	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.2	25.0	25.0	25.2	25.0
Instance 5	25.0	25.0	25.2	25.0	25.2	25.0	25.0	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.0
Instance 6	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.0	25.1
Instance 7	25.0	25.1	25.0	25.2	25.0	25.0	25.0	25.2	25.0	25.0	25.0	25.0	25.2	25.0	25.0
Instance 8	25.0	25.0	25.0	25.0	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.1	25.0	25.0
Sum	200.4	200.5	200.6	200.5	200.6	200.3	200.4	200.5	200.5	200.6	200.6	200.0	200.6	200.5	200.7
Average	25.0	25.1	25.1	25.1	25.1	25.0	25.1	25.1	25.1	25.1	25.1	25.0	25.1	25.1	25.1
Std. Deviation	0.07	0.06	0.09	0.08	0.08	0.08	0.08	0.10	0.09	0.09	0.08	0.07	0.08	0.08	0.08

Table 20: Frametest results, in average FPS, that the four-NIC solution achieved at eight instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	18.7	19.1	25.1	11.5	14.8	19.4	19.6	25.1	25.1	25.1	18.8	25.1	9.5	11.5	25.0
Instance 2	18.9	19.5	25.0	11.3	24.9	15.3	25.1	19.0	25.1	19.1	25.1	25.1	10.2	11.2	15.1
Instance 3	25.0	19.7	18.7	25.1	24.9	19.3	18.8	24.9	9.1	17.9	25.1	25.0	10.3	25.1	14.3
Instance 4	19.0	25.1	18.7	11.7	25.1	25.1	19.0	24.9	10.0	18.0	19.1	24.9	9.9	11.4	25.0
Instance 5	19.0	14.5	18.7	11.0	14.1	18.8	18.7	25.0	9.5	18.7	18.8	25.0	25.1	11.8	14.2
Instance 6	19.1	15.2	24.9	11.2	14.0	14.2	25.0	25.1	9.1	25.1	19.2	25.0	25.2	11.5	25.1
Instance 7	25.0	13.8	25.0	25.0	25.1	13.9	18.8	18.6	9.3	18.8	18.9	25.0	9.6	25.1	25.1
Instance 8	18.3	13.6	25.0	25.0	14.0	14.2	19.2	18.7	9.9	19.9	19.1	24.9	8.5	25.1	14.8
Sum	162.8	140.5	180.9	131.8	157.0	140.2	164.1	181.4	107.1	162.7	164.1	200.0	108.2	132.7	158.6
Average	20.4	17.6	22.6	16.5	19.6	17.5	20.5	22.7	13.4	20.3	20.5	25.0	13.5	16.6	19.8
Std. Deviation	2.67	3.76	3.07	6.64	5.41	3.65	2.64	3.02	6.78	2.83	2.67	0.07	6.73	6.59	5.21

### Frametest performance for 8 instances

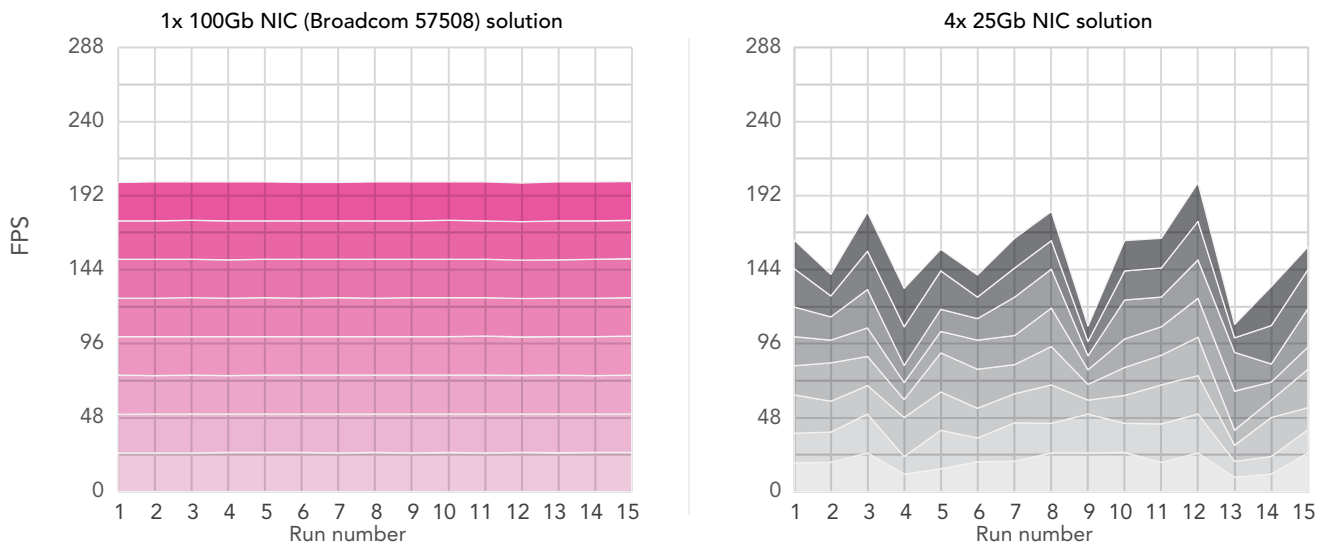


Figure 12: Frametest results, in frames per second, for eight instances. Higher numbers and more consistency is better.  
Source: Principled Technologies.

## Nine instances

Table 21: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at nine instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	25.0	25.2	25.0	25.0	25.2	25.2	25.2	25.2	25.2	24.9	25.2	25.0	25.0	24.9	25.0
Instance 2	25.1	25.2	24.9	24.9	25.2	25.2	24.9	25.0	25.0	25.2	25.0	25.2	25.0	25.2	25.2
Instance 3	24.9	24.9	25.2	25.2	25.1	25.1	25.2	25.2	25.0	24.9	24.9	25.0	25.1	24.9	24.9
Instance 4	25.2	24.9	25.0	25.0	25.1	24.8	25.0	24.9	25.2	25.2	25.1	24.9	25.2	25.0	24.9
Instance 5	24.9	25.2	25.0	25.2	25.1	24.9	25.0	24.9	25.0	25.0	25.0	25.1	25.0	25.0	24.9
Instance 6	24.9	24.9	25.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	25.0	24.9	25.0	24.9	25.1
Instance 7	24.9	25.0	25.1	25.0	24.8	25.0	24.9	24.9	25.1	25.2	24.9	25.0	25.0	25.0	24.9
Instance 8	24.9	25.1	25.0	24.9	24.9	24.8	25.2	25.2	25.0	24.9	24.9	25.0	25.0	25.0	25.0
Instance 9	24.9	25.0	24.9	25.0	24.9	25.1	24.9	25.0	25.0	24.9	24.9	24.9	25.0	25.0	24.9
Sum	224.8	225.4	225.1	225.1	225.2	225.1	225.3	225.2	225.4	225.1	225.1	224.8	225.2	225.0	224.9
Average	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Std. Deviation	0.10	0.11	0.07	0.10	0.13	0.12	0.11	0.11	0.09	0.11	0.09	0.08	0.08	0.08	0.09

Table 22: Frametest results, in average FPS, that the four-NIC solution achieved at nine instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	18.7	15.4	19.3	19.1	18.7	14.2	19.0	19.0	11.6	25.0	25.1	13.9	14.9	14.0	24.9
Instance 2	13.5	13.9	18.8	19.0	19.1	14.7	19.9	19.5	25.1	25.1	19.1	14.0	25.1	25.1	25.0
Instance 3	15.4	18.8	19.6	25.0	18.9	14.0	19.1	25.0	11.5	18.8	18.9	25.1	15.0	14.8	19.0
Instance 4	25.1	13.7	19.0	18.5	25.1	25.0	25.1	25.1	11.0	25.1	15.1	25.1	15.3	25.0	25.1
Instance 5	25.1	25.1	18.2	19.1	18.7	25.0	14.1	18.9	25.0	18.4	14.3	25.0	15.0	25.0	18.8
Instance 6	18.6	14.2	18.9	19.4	25.0	19.0	14.1	25.0	25.0	19.2	14.3	25.0	13.3	14.0	18.6
Instance 7	18.7	25.1	19.4	25.2	24.9	19.0	14.2	18.9	11.9	19.3	25.1	14.0	13.8	25.0	25.0
Instance 8	14.2	18.5	19.3	18.8	19.0	19.5	14.6	18.6	25.0	18.8	14.2	25.0	14.5	25.1	25.1
Instance 9	13.8	18.6	19.1	25.0	19.2	14.2	25.1	19.2	12.2	19.0	18.8	14.2	14.4	14.0	25.0
Sum	162.9	163.3	171.5	188.9	188.6	164.6	165.3	189.3	158.2	188.6	165.0	181.4	141.3	181.9	206.4
Average	18.1	18.1	19.1	21.0	21.0	18.3	18.4	21.0	17.6	21.0	18.3	20.2	15.7	20.2	22.9
Std. Deviation	4.24	4.21	0.41	2.86	2.88	4.18	4.25	2.84	6.65	2.92	4.13	5.48	3.39	5.38	2.93

### Frametest performance for 9 instances

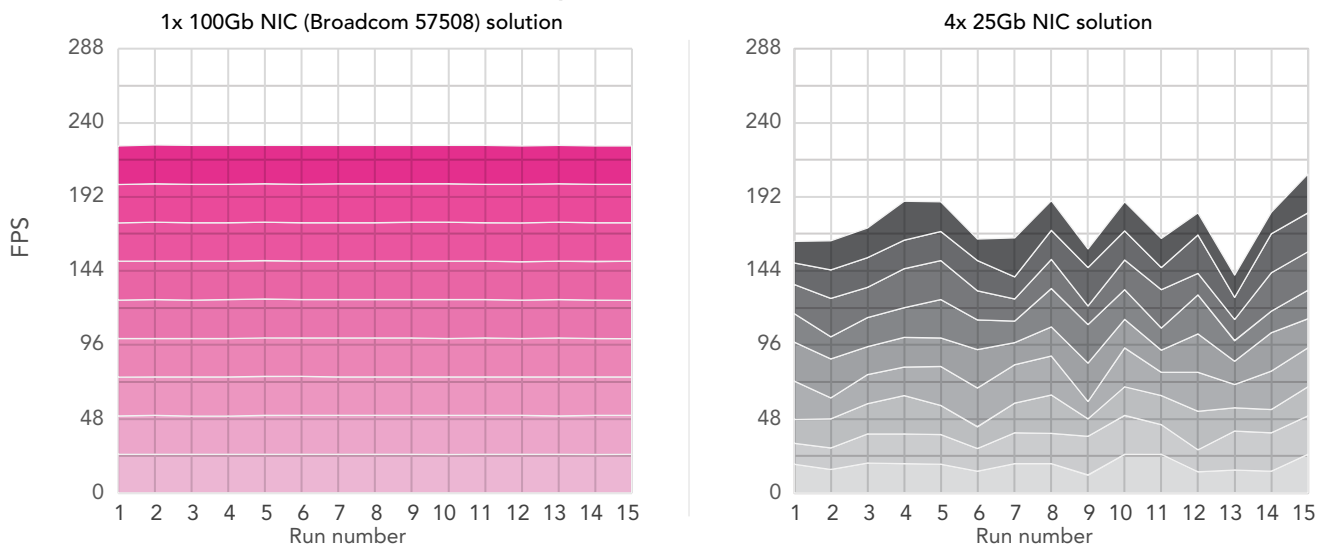


Figure 13: Frametest results, in frames per second, for nine instances. Higher numbers and more consistency is better.  
Source: Principled Technologies.

## Ten instances

Table 23: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at ten instances. Higher numbers are better. Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	20.4	23.3	24.1	18.1	18.4	24.8	23.2	24.9	23.1	23.4	25.1	25.1	23.4	24.6	25.1
Instance 2	21.5	23.4	23.5	19.2	24.6	24.6	23.1	25.1	23.0	24.3	24.9	24.9	23.8	25.1	24.5
Instance 3	25.0	23.3	24.0	24.8	25.1	17.9	24.3	25.1	23.2	23.3	24.6	18.0	23.1	25.1	24.5
Instance 4	25.2	24.3	23.2	25.1	24.6	25.1	23.1	21.6	23.9	23.1	18.8	24.6	23.3	24.6	18.0
Instance 5	25.0	23.4	23.2	24.5	24.6	24.5	23.2	20.8	23.0	23.7	18.0	18.3	23.2	25.1	24.4
Instance 6	20.5	23.4	23.2	24.6	24.7	24.7	23.3	21.0	23.1	23.2	24.6	24.5	24.4	24.6	25.0
Instance 7	25.0	23.5	23.2	24.5	18.1	24.7	23.3	25.0	23.1	23.5	24.7	24.6	23.2	18.2	24.7
Instance 8	20.9	23.4	23.2	24.9	24.5	17.9	23.4	25.0	23.1	23.2	24.6	24.6	23.1	18.2	24.5
Instance 9	25.0	23.3	23.2	24.6	24.9	24.7	23.2	25.0	23.1	23.2	24.5	24.7	23.1	24.6	18.0
Instance 10	24.9	23.3	23.2	24.9	24.8	24.8	23.1	20.9	23.1	23.2	24.6	24.7	22.8	24.6	24.5
Sum	233.3	234.6	233.9	235.1	234.2	233.6	233.0	234.4	231.6	234.1	234.5	234.0	233.4	234.7	233.3
Average	23.3	23.5	23.4	23.5	23.4	23.4	23.3	23.4	23.2	23.4	23.5	23.4	23.3	23.5	23.3
Std. Deviation	2.05	0.29	0.33	2.45	2.60	2.73	0.33	1.94	0.25	0.32	2.53	2.63	0.41	2.64	2.67

Table 24: Frametest results, in average FPS, that the four-NIC solution achieved at ten instances. Higher numbers are better. Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	19.4	14.6	25.0	19.1	25.0	19.3	11.9	18.9	25.1	25.1	9.2	25.0	18.9	19.4	25.1
Instance 2	18.7	13.6	13.9	25.0	19.9	19.3	11.5	19.4	24.9	18.3	9.7	25.1	18.7	19.2	15.0
Instance 3	19.2	14.2	25.1	18.9	25.0	19.0	18.6	25.0	9.0	25.0	11.0	19.5	25.1	25.1	19.9
Instance 4	25.0	11.9	14.0	12.0	14.6	18.4	11.3	25.0	10.7	17.8	9.3	13.9	18.7	18.6	14.0
Instance 5	18.8	11.5	25.1	25.0	14.6	25.1	25.0	19.3	9.5	14.1	10.4	18.8	25.1	19.2	18.6
Instance 6	18.4	14.5	13.9	11.5	14.1	19.0	25.1	25.0	8.8	13.9	25.0	14.2	18.6	18.9	14.2
Instance 7	25.0	25.1	18.8	11.7	25.1	24.9	11.0	18.6	10.1	21.3	25.0	18.9	18.9	20.6	25.0
Instance 8	18.5	10.6	18.6	11.2	19.0	24.9	11.3	18.7	9.8	14.2	25.1	14.2	18.8	18.5	13.9
Instance 9	25.0	11.2	14.4	19.4	13.9	19.0	19.2	18.5	25.2	14.5	25.1	14.1	25.0	17.8	25.1
Instance 10	25.0	10.9	18.3	11.6	18.9	25.0	18.6	25.0	24.9	25.0	9.2	25.1	25.0	17.7	19.1
Sum	212.8	138.1	187.0	165.2	190.1	213.9	163.5	213.4	158.0	189.2	159.0	189.0	212.8	194.9	189.8
Average	21.3	13.8	18.7	16.5	19.0	21.4	16.4	21.3	15.8	18.9	15.9	18.9	21.3	19.5	19.0
Std. Deviation	3.04	4.05	4.57	5.35	4.46	2.95	5.39	2.98	7.56	4.57	7.48	4.55	3.08	2.04	4.49

### Frametest performance for 10 instances

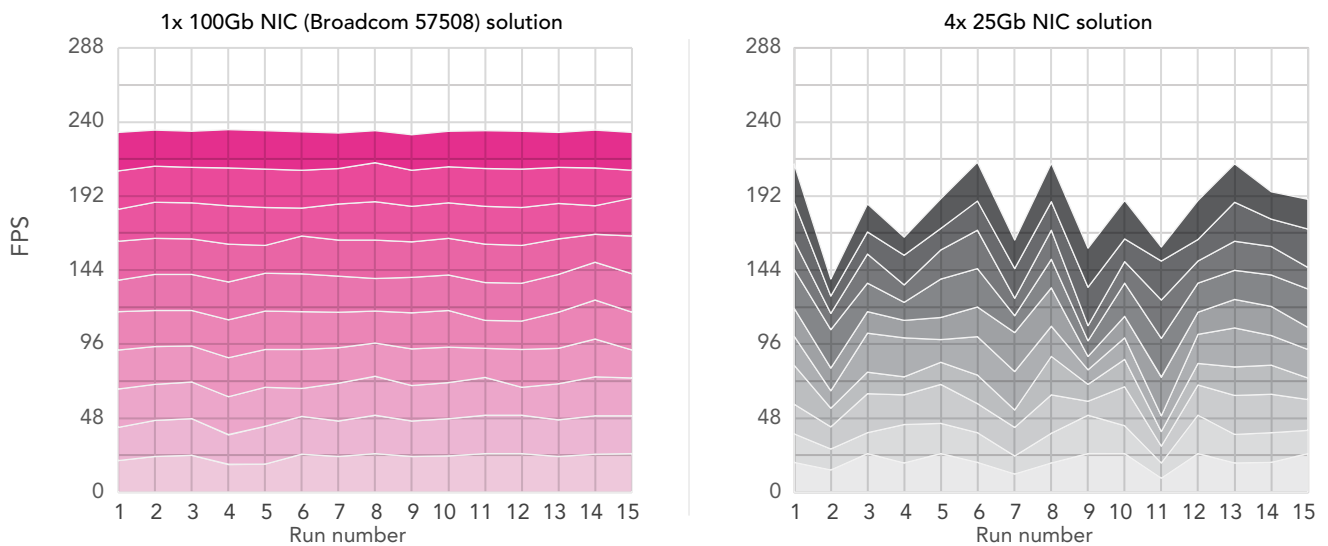


Figure 14: Frametest results, in frames per second, for ten instances. Higher numbers and more consistency is better. Source: Principled Technologies.

## 11 instances

Table 25: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at 11 instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	24.8	23.2	21.3	21.1	22.4	23.3	23.5	23.5	22.2	22.5	22.2	22.6	17.4	21.1	22.1
Instance 2	24.7	22.6	21.2	22.2	22.4	22.8	15.3	22.8	21.0	22.4	21.0	22.8	23.7	22.3	22.0
Instance 3	19.3	22.6	22.2	21.8	23.6	23.3	22.4	22.4	21.8	22.4	21.4	22.5	16.8	21.1	21.5
Instance 4	18.0	22.5	21.1	21.1	23.1	22.4	22.8	15.2	21.2	23.5	21.0	23.5	17.8	21.6	21.2
Instance 5	18.9	15.6	21.2	21.1	22.4	22.5	15.6	22.4	21.1	22.7	21.8	22.7	23.7	21.1	21.2
Instance 6	18.3	22.6	21.1	21.1	22.5	22.5	22.4	22.3	21.1	23.3	21.0	22.4	24.0	21.2	21.3
Instance 7	24.7	22.9	21.5	21.1	22.4	22.7	22.4	22.4	21.1	22.4	21.1	22.5	23.6	21.5	21.2
Instance 8	24.7	22.5	21.1	21.1	15.2	15.3	22.4	23.2	21.1	22.4	21.1	22.5	23.7	21.4	21.2
Instance 9	24.7	22.4	21.2	21.3	15.1	15.4	22.4	22.4	21.1	15.5	21.1	15.3	16.6	21.2	21.2
Instance 10	17.9	22.4	21.1	21.5	22.5	22.8	22.4	15.3	21.2	22.8	21.0	15.3	23.7	21.3	21.1
Instance 11	18.1	15.5	21.1	21.2	22.4	22.7	22.4	22.4	21.1	15.6	21.1	22.5	23.6	21.0	21.2
Sum	234.0	234.7	234.0	234.4	233.9	235.5	233.8	234.2	233.9	235.5	233.9	234.7	234.5	234.9	235.3
Average	21.3	21.3	21.3	21.3	21.3	21.4	21.3	21.3	21.3	21.4	21.3	21.3	21.3	21.4	21.4
Std. Deviation	3.17	2.74	0.31	0.36	2.91	2.88	2.77	2.87	0.37	2.80	0.37	2.85	3.18	0.34	0.33

Table 26: Frametest results, in average FPS, that the four-NIC solution achieved at 11 instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	11.5	11.1	25.0	13.9	25.0	14.5	11.3	14.4	18.6	9.5	18.4	8.7	25.1	25.0	14.1
Instance 2	12.7	12.1	12.4	14.7	25.1	18.6	19.1	14.2	19.6	18.6	18.9	7.7	25.0	13.8	14.5
Instance 3	25.2	11.2	11.9	13.8	13.9	25.1	11.4	14.3	13.6	25.1	19.0	8.5	19.8	14.6	14.0
Instance 4	10.7	25.1	25.0	25.1	14.1	14.7	25.1	14.8	25.1	11.1	18.9	8.0	12.4	25.1	25.0
Instance 5	25.0	10.9	10.9	14.4	14.1	18.9	11.6	14.5	25.0	25.1	19.1	8.0	11.2	18.6	14.4
Instance 6	25.0	11.6	25.0	25.0	19.9	19.1	24.9	14.5	24.9	9.4	25.0	8.2	11.2	18.6	14.4
Instance 7	19.1	10.8	25.1	14.0	13.9	25.0	19.2	25.0	14.3	19.1	25.0	25.1	19.1	25.0	13.6
Instance 8	19.2	12.2	25.0	25.1	18.0	25.0	11.4	25.1	14.1	9.4	20.1	24.9	19.2	18.7	25.1
Instance 9	11.5	11.1	10.9	13.8	25.0	13.8	19.4	13.9	24.9	9.2	18.1	24.9	11.3	14.6	14.0
Instance 10	11.4	11.5	11.3	13.9	17.9	14.3	11.0	14.4	14.2	19.2	18.9	8.5	25.0	13.5	13.9
Instance 11	18.7	11.4	25.0	13.6	25.1	25.0	25.0	25.0	18.9	9.4	18.0	25.0	10.9	25.0	25.0
Sum	189.7	138.9	207.4	187.3	211.9	213.9	189.4	189.9	213.2	165.1	219.3	157.5	190.1	212.4	187.8
Average	17.2	12.6	18.9	17.0	19.3	19.4	17.2	17.3	19.4	15.0	19.9	14.3	17.3	19.3	17.1
Std. Deviation	5.69	3.98	6.75	4.94	4.75	4.58	5.79	4.77	4.68	6.21	2.43	8.08	5.78	4.67	4.87

### Frametest performance for 11 instances

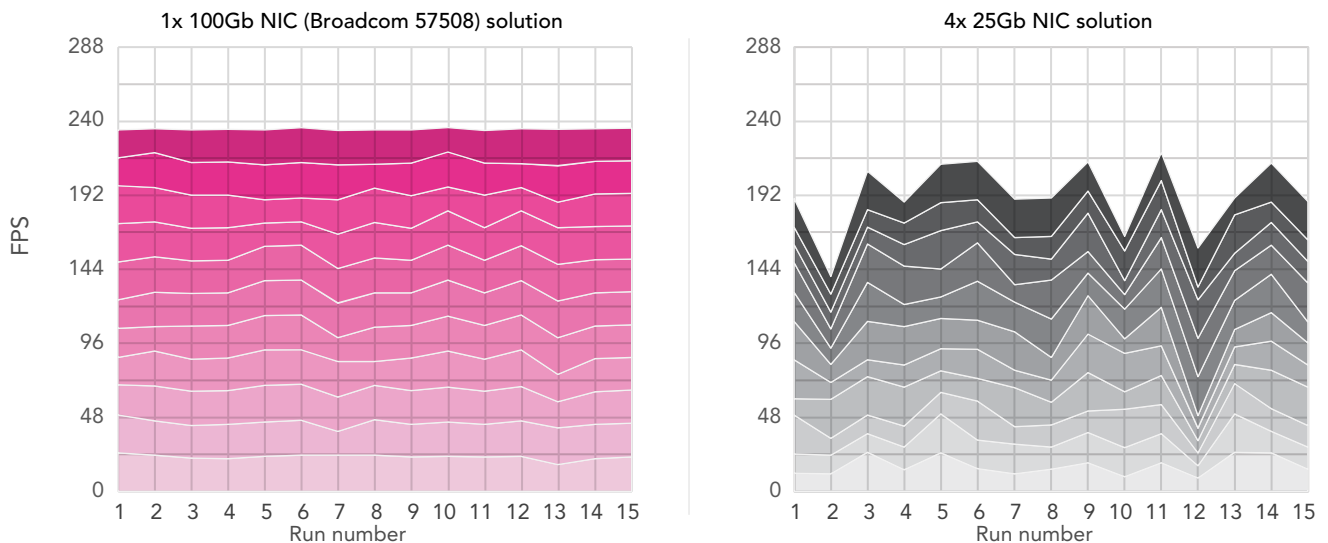


Figure 15: Frametest results, in frames per second, for 11 instances. Higher numbers and more consistency is better.  
Source: Principled Technologies.

## 12 instances

Table 27: Frametest results, in average FPS, that the Broadcom 57508 solution achieved at 12 instances. Higher numbers are better.  
Source: Principled Technologies.

1x100 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	21.8	21.2	15.3	19.9	19.4	19.4	23.6	23.5	14.3	13.2	20.6	19.6	14.3	20.6	22.3
Instance 2	21.8	13.2	21.8	19.3	20.6	19.4	16.6	23.5	22.0	20.8	19.7	19.3	15.8	20.7	10.3
Instance 3	13.2	14.5	22.0	20.6	19.4	20.6	12.5	11.6	22.9	21.8	19.6	20.5	21.7	21.8	22.4
Instance 4	20.6	20.5	23.0	19.3	19.4	20.4	11.1	22.4	21.9	21.1	19.4	20.5	14.3	20.6	23.6
Instance 5	20.6	20.8	21.8	19.4	19.4	19.4	23.6	22.4	21.5	20.6	19.4	19.5	22.6	13.0	22.3
Instance 6	20.6	20.5	14.3	20.3	19.3	19.4	24.2	22.4	14.4	20.9	20.3	19.3	21.8	20.5	22.4
Instance 7	20.6	20.6	21.8	19.3	19.5	19.4	23.6	22.4	21.8	20.8	19.6	19.2	21.9	20.5	22.6
Instance 8	21.3	20.6	21.8	19.3	19.4	20.0	23.5	10.4	14.4	13.2	19.5	19.4	21.8	13.1	10.8
Instance 9	20.6	20.5	14.5	19.5	19.7	19.4	16.3	22.4	22.0	20.6	19.4	19.3	21.8	20.6	22.4
Instance 10	13.2	20.9	14.6	19.3	19.4	19.5	11.0	22.4	21.9	20.9	19.5	19.5	21.7	20.6	22.4
Instance 11	20.6	20.8	22.0	19.3	19.5	19.7	23.6	10.4	21.9	20.7	20.0	19.3	21.7	20.5	22.8
Instance 12	20.6	20.8	21.8	19.4	19.5	19.5	23.6	22.4	14.4	20.6	19.5	19.4	14.6	20.7	10.2
Sum	235.4	234.8	234.7	234.8	234.3	235.9	233.2	236.1	233.4	235.0	236.4	234.8	233.8	233.2	234.4
Average	19.6	19.6	19.6	19.6	19.5	19.7	19.4	19.7	19.4	19.6	19.7	19.6	19.5	19.4	19.5
Std. Deviation	2.91	2.57	3.46	0.42	0.33	0.42	5.26	5.14	3.60	2.88	0.37	0.43	3.39	2.86	5.27

Table 28: Frametest results, in average FPS, that the four-NIC solution achieved at 12 instances. Higher numbers are better.  
Source: Principled Technologies.

4x25 Gb NIC	Run number														
Avg. FPS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Instance 1	18.7	25.1	25.1	10.4	11.1	25.0	15.1	19.1	25.0	9.9	19.0	19.4	11.3	25.1	18.4
Instance 2	19.4	10.8	19.0	19.0	19.7	12.9	10.4	10.8	9.7	25.1	11.3	25.1	15.3	14.2	14.1
Instance 3	19.3	19.0	18.8	25.1	15.0	25.1	9.2	9.7	9.6	9.1	11.0	9.9	11.1	14.0	18.6
Instance 4	18.7	19.0	15.8	10.1	19.2	25.0	9.1	19.3	25.1	25.1	11.6	9.6	18.3	14.8	25.0
Instance 5	19.1	19.4	13.9	9.1	20.3	13.6	25.0	19.4	9.1	9.4	19.3	9.7	14.0	25.0	15.2
Instance 6	19.4	9.7	14.0	18.5	10.5	14.6	9.9	19.1	18.8	25.0	25.1	18.8	11.6	13.8	13.9
Instance 7	18.5	9.0	13.8	10.2	12.4	10.9	9.2	18.6	9.1	9.8	18.7	9.6	12.0	25.0	18.8
Instance 8	18.5	10.2	19.5	18.9	13.9	14.3	25.0	9.0	9.3	25.0	10.8	25.2	13.4	14.1	18.8
Instance 9	18.6	25.1	14.3	25.1	14.0	14.5	9.4	19.2	25.0	25.0	11.4	9.1	18.6	14.0	25.0
Instance 10	18.7	25.0	13.8	9.3	11.0	11.2	13.7	8.9	18.8	8.8	18.8	18.5	18.9	14.1	14.2
Instance 11	19.0	9.4	14.3	9.2	14.3	11.7	14.3	9.2	9.2	9.6	19.2	25.0	11.6	14.5	18.6
Instance 12	19.1	9.3	14.1	25.0	11.6	11.7	13.9	9.7	18.6	25.0	18.7	9.2	14.7	24.9	18.4
Sum	227.0	190.9	196.3	189.9	173.0	190.4	164.2	171.9	187.2	206.7	194.8	189.0	170.8	213.5	218.9
Average	18.9	15.9	16.4	15.8	14.4	15.9	13.7	14.3	15.6	17.2	16.2	15.7	14.2	17.8	18.2
Std. Deviation	0.32	6.55	3.39	6.50	3.36	5.43	5.51	4.81	6.65	7.80	4.56	6.62	2.83	5.10	3.57

### Frametest performance for 12 instances

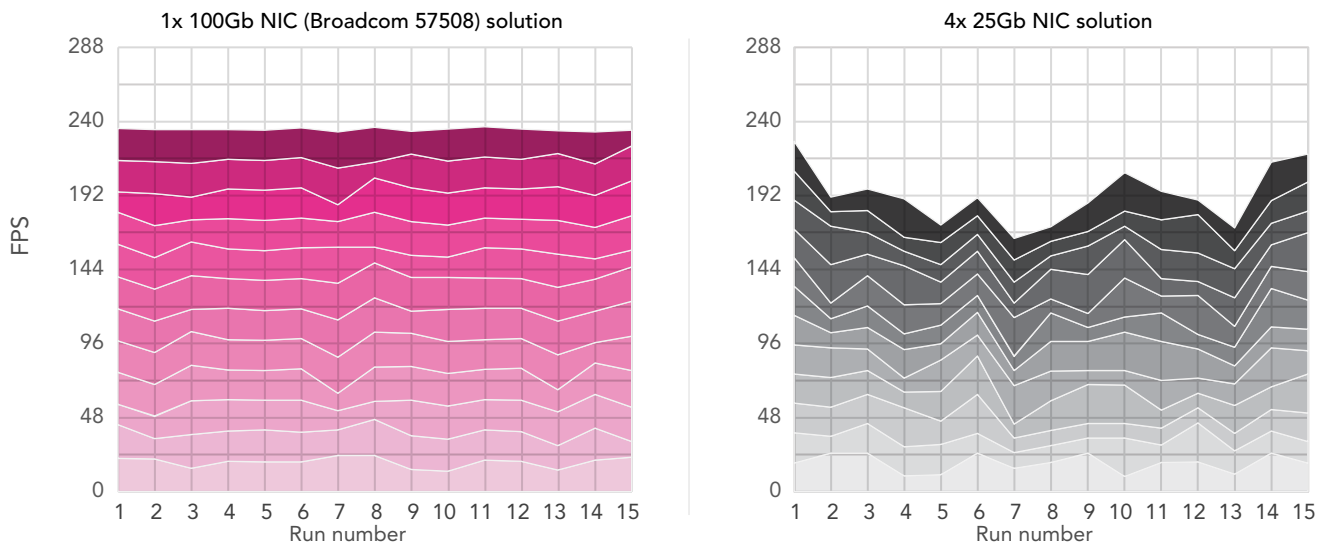


Figure 16: Frametest results, in frames per second, for 12 instances. Higher numbers and more consistency is better.  
Source: Principled Technologies.

# System configuration information

Table 29: Detailed information on the systems we tested.

System configuration information	Dell PowerEdge R750 (SUT)	Dell PowerEdge R750 (client)
BIOS name and version	Dell 1.6.5	Dell 1.6.5
Operating system name and version/build number	Red Hat® Enterprise Linux® release 8.6 (Ootpa) 4.18.0-372.19.1.el8_6.x86_64	Red Hat Enterprise Linux release 8.6 (Ootpa) 4.18.0-372.19.1.el8_6.x86_64
Date of last OS updates/patches applied	8/23/22	8/23/22
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6330	Intel Xeon Gold 6330
Core count (per processor)	28	28
Core frequency (GHz)	2.00	2.00
Stepping	6	6
Memory module(s)		
Total memory in system (GB)	256	256
Number of memory modules	16	16
Vendor and model	Samsung® M393A2K43DB3-CWE	Samsung M393A2K43DB3-CWE
Size (GB)	16	16
Type	DDR4	DDR4
Speed (MHz)	3,200	3,200
Speed running in the server (MHz)	2,933	2,933
Storage controller		
Vendor and model	Broadcom® PEX880xx PCIe® Gen 4 Switch	PERC H755 front SAS (PCIe® Gen4)
Firmware version	N/A	52.16.1-4158
Local storage		
Number of drives	24	12
Drive vendor and model	Dell Ent NVMe™ CM6 MU 3.2 TB	KIOXIA KRM6VVUG3T84
Drive size (GB)	3,200	3,840
Drive information (speed, interface, type)	PCIe Gen 4 NVMe SSD	12 Gbps SAS SSD



System configuration information	Dell PowerEdge R750 (SUT)	Dell PowerEdge R750 (client)
Network adapter (LOM)		
Number of drives	Broadcom NetXtreme® BCM5720 2-port Gigabit Ethernet PCIe	Broadcom NetXtreme BCM5720 2-port Gigabit Ethernet PCIe
Drive vendor and model	2 x 1GbE	2 x 1GbE
Drive size (GB)	tg3 4.18.0-372.19.1.el8_6.x86_64	tg3 4.18.0-372.19.1.el8_6.x86_64
Drive information (speed, interface, type)	FFV22.00.6 bc 5720-v1.39	FFV22.00.6 bc 5720-v1.39
Network adapter (OCP)		
Vendor and model	Broadcom NetXtreme-E BCM57412 2-port 10Gb RDMA Ethernet (rev 01)	Broadcom NetXtreme-E BCM57412 2-port 10Gb RDMA Ethernet (rev 01)
Number and type of ports	2 x 10GbE	2 x 10GbE
Driver version	bnxt_en 1.10.2-222.0.142.0	bnxt_en 1.10.2-222.0.142.0
Firmware version	222.0.138.0/pkg 22.21.06.80	222.0.138.0/pkg 22.21.06.80
Network adapter		
Vendor and model	Broadcom BCM57414 NetXtreme-E BCM57508 2-port 100Gb Ethernet (rev 11)	Broadcom BCM57414 NetXtreme-E BCM57508 2-port 100Gb Ethernet (rev 11)
Number and type of ports	2 x 10GbE	2 x 10GbE
Driver version	bnxt_en 1.10.2-222.0.142.0	bnxt_en 1.10.2-222.0.142.0
Firmware version	222.0.138.0/pkg 22.21.06.80	222.0.138.0/pkg 22.21.06.80
Network adapter		
Vendor and model	2x Intel XXV710-DA2T 2-port 25Gb Ethernet Controller	N/A
Number and type of ports	2 x 25GbE, 2 x 25GbE	N/A
Driver version	i40e 2.19.3	N/A
Cooling fans		
Vendor and model	Dell 7002W-A00	Dell 7002W-A00
Number of cooling fans	6	6
Power supplies		
Vendor and model	Dell 0M63JNA00	Dell 0M63JNA00
Number of power supplies	2	2
Wattage of each (W)	2,400	750

# How we tested

## Testing overview

For the system under test (SUT), we used a PowerEdge R750 configured with a single 100Gb Broadcom dual-port NIC and two 25Gb Intel dual-port NICs (four ports total). We configured the Broadcom 100Gb NIC using just the first port. We combined the four Intel 25Gb NIC ports into an LACP network bond in Linux with layer 3+4 load balancing. We configured an additional R750 with a single 100Gb Broadcom dual-port NIC to operate as a load generating client. We connected everything to a single Dell Networking S5048F-ON switch using direct attached cables. We configured the four 25Gb ports used by the SUT as an active (LACP) port-channel on the switch.

## Installing Red Hat Enterprise Linux 8.6

### Install the operating system on both the SUT and client system

1. Open a browser window, and connect to the iDRAC.
2. Log into the iDRAC.
3. Click Virtual Console.
4. Click Connect Virtual Media.
5. Next to Map CD/DVD, click Browse.
6. Browse to the ISO for Red Hat 8.6.
7. Click Map Device.
8. Click Boot.
9. Click the Virtual CD/DVD/ISO text.
10. Click Yes.
11. Click Power, and boot the machine.
12. At the Red Hat Enterprise Linux boot menu, press Up, select Install Red Hat Enterprise Linux 8.6.0, and press Enter.
13. At the Welcome screen, make sure English is selected, and click Continue.
14. At the Installation Summary screen, click Time & Date.
15. To adjust your location, use the down arrows next to Region and City, and click Done.
16. At the Installation Summary screen, click Software Selection.
17. At the Software Selection screen, click Minimal Install, and click Done.
18. At the Installation Summary screen, click Installation Destination.
19. At the Installation Destination screen, select the internal JBOSS drive. Leave Automatic selected for the Storage Configuration, and click Done.
20. At the Installation Summary screen, click Network & Host Name.
21. At the Network & Host Name screen, where it says Host Name, enter r750-server or r750-client, and click Apply.
22. At the top-right of the screen, next to Ethernet information, click the OFF slider to ON, allow the NIC to connect, pick up an IP address from DHCP, and click Done.
23. Click Begin Installation.
24. At the Configuration screen, click Root Password. Next to Root Password and Confirm, type in your preferred password, and click Done.
25. When the Reboot button appears, click it.
26. Wait for the system to reboot.

## Configuring Red Hat Enterprise Linux 8.6

Run the following commands on both the SUT and client system.

1. Set the time zone, disable SELinux, disable the firewall, and set the tuned profile:

```
sudo timedatectl set-timezone America/New_York
setenforce 0
sed -i 's/SELINUX=.*SELINUX=disabled/' /etc/selinux/config
systemctl disable --now firewalld
tuned-adm profile throughput-performance
```

2. Register the system with RHN, and configure subscriptions:

```
subscription-manager register
subscription-manager service-level --set="Self-Support"
subscription-manager usage --set="Development/Test"
subscription-manager role --set="Red Hat Enterprise Linux Server"
subscription-manager attach
subscription-manager release --set=8.6
```

3. Install updates, and reboot if new kernel is installed:

```
dnf update -y
reboot
```

4. Install EPEL and extra packages:

```
subscription-manager repos --enable codeready-builder-for-rhel-8-$(arch)-rpms
dnf install -y https://dl.fedoraproject.org/pub/epel/epel-release-latest-8.noarch.rpm
dnf install -y wget tar smartmontools vim sysstat numactl pcp-system-tools nvme-cli
net-tools usbutils
```

5. Install the iPerf3 package from RHN:

```
dnf install -y iperf3
```

6. Install the Broadcom bnxt\_en driver:

```
dnf groupinstall -y "Development Tools"
dnf install -y libibverbs-devel qperf perftest infiniband-diags make gcc kernel kernel-devel autoconf
libtool libibverbs-utils rdma-core-devel
cd ~
mkdir broadcom
cd broadcom
wget https://docs.broadcom.com/docs-and-downloads/ethernet-network-adapters/NXE/BRCM_222.1.68.0/
bcm_222.1.68.0.tar.gz
tar -xf bcm_222.1.68.0.tar.gz
cd bcm_222.1.68.0/Linux/Linux_Driver/
tar -xf netxtreme-bnxt_en-1.10.2-222.0.142.0.tar.gz
cd netxtreme-bnxt_en-1.10.2-222.0.142.0
make
make install
depmod -a
dracut -f
```

7. Install the Intel i40e driver:

```
cd ~
mkdir intel
cd intel
wget https://versaweb.dl.sourceforge.net/project/e1000/i40e%20stable/2.19.3/i40e-2.19.3.tar.gz
tar -xf i40e-2.19.3.tar.gz
cd i40e-2.19.3/src/
make install
cp ../scripts/set_irq_affinity /usr/local/sbin/
```

8. Reboot the system:

```
reboot
```

## Configuring networking on the SUT

1. For the Broadcom 100Gb connection, we used the interface ens6f0np0.
2. Run the following commands to configure the 100Gb single port interface:

```
nmcli connection delete ens6f0np0
nmcli connection add type ethernet ifname ens6f0np0 con-name ens6f0np0
nmcli connection modify ens6f0np0 ipv4.addresses '192.168.100.1/24'
nmcli connection modify ens6f0np0 ipv4.method manual ipv6.method ignore
nmcli connection up ens6f0np0
```

3. For the Intel 4x25Gb connection, we used the following interfaces: ens4f0, ens4f1, ens5f0, ens5f1.
4. Run the following commands to configure the bonded network interface:

```
nmcli connection delete bond0
nmcli connection delete ens4f0
nmcli connection delete ens4f1
nmcli connection delete ens5f0
nmcli connection delete ens5f1
nmcli connection delete bond0-port1
nmcli connection delete bond0-port2
nmcli connection delete bond0-port3
nmcli connection delete bond0-port4
nmcli con add type bond con-name bond0 ifname bond0 bond.options "mode=802.3ad,miimon=100,xmit_hash_policy=layer3+4" ethernet.mtu 9000
nmcli connection add type ethernet con-name bond0-port1 ifname ens4f0 master bond0 ethernet.mtu 9000
nmcli connection add type ethernet con-name bond0-port2 ifname ens4f1 master bond0 ethernet.mtu 9000
nmcli connection add type ethernet con-name bond0-port3 ifname ens5f0 master bond0 ethernet.mtu 9000
nmcli connection add type ethernet con-name bond0-port4 ifname ens5f1 master bond0 ethernet.mtu 9000
nmcli connection modify bond0 ipv4.addresses '192.168.25.1/24'
nmcli connection modify bond0 ipv4.method manual ipv6.method ignore
nmcli connection up bond0
```

## Configuring networking on client

1. For the Broadcom 100Gb connection, we used the interface ens6f0np0.
2. Run the following commands to configure the 100Gb single port interface:

```
nmcli connection delete ens6f0np0
nmcli connection add type ethernet ifname ens6f0np0 con-name ens6f0np0
nmcli connection modify ens6f0np0 ethernet.mtu 9000
nmcli connection modify ens6f0np0 ipv4.addresses "192.168.100.11/24"
nmcli connection modify ens6f0np0 ipv4.addresses "192.168.25.11/24"
nmcli connection modify ens6f0np0 ipv4.method manual ipv6.method ignore
nmcli connection up ens6f0np0
>
```

## Configuring NFS on the SUT

1. Install nfs packages and disable unused services:

```
dnf install nfs-utils
systemctl mask --now rpc-statd.service rpcbind.service rpcbind.socket
```

2. Modify the /etc/nfs.conf file in the [nfsd] section to set the number of threads to 112 and disable NFSv3:

```
[nfsd]
threads=112
vers3=n
```

3. Start and enable the nfs-server process:

```
systemctl enable --now nfs-server
```

## Configuring storage on the SUT

1. Run the following commands to wipe and format the NVMe storage (this assumes 24x NVMe drives labeled /dev/nvme0n1 to /dev/nvme23n1):

```
systemctl stop nfs-server
mdadm --manage --stop /dev/md0
wipefs -a /dev/nvme{0..23}n1
for i in {0..23}; do mkfs.xfs -f /dev/nvme${i}n1 & done ; wait
```

2. Run the following commands to configure the /etc/fstab file and mount the formatted drives to the /stor directory:

```
systemctl stop nfs-server
STORPATHROOT=/stor
umount ${STORPATHROOT}/*
rmdir ${STORPATHROOT}/*
for i in `seq -w 1 24`;
do
    DRIVE=nvme$(expr ${i} - 1)n1
    STORPATH=${STORPATHROOT}/c${i}
    umount ${STORPATH}
    mkdir -p ${STORPATH}
    echo -e "$(blkid /dev/${DRIVE} | cut -d' ' -f2)\t${STORPATH}\txfs\tx-systemd.device-timeout=5\t0" >> /etc/fstab
done
mount -va
chmod 777 ${STORPATHROOT}/*
```

3. Run the following commands to configure the NFS exports and restart NFS:

```
STORPATHROOT=/stor
echo -n > /etc/exports
for i in `seq -w 1 24`; do echo "/stor/c${i} 192.168.0.0/16(rw)" >> /etc/exports; done
systemctl restart nfs-server
```

## Building the Frametest benchmark container on client

1. Install the container tools on the client:

```
yum module install container-tools
```

2. Create the Frametest container file: Frametest.Dockerfile

```
# syntax=docker/dockerfile:1
FROM rhel8

# Install NFS client and benchmark prerequisites
RUN yum install -y nfs-utils ncurses && yum clean all

# Install frametest benchmark
RUN curl -o /usr/local/sbin/frametest https://support.dvsus.com/hc/en-us/article_
  attachments/5745555781780/frametest-rs \
  && chmod +x /usr/local/sbin/frametest

ENTRYPOINT mount "${NFSMOUNT}" "/mnt" ; /usr/local/sbin/frametest ${FTP_PARAMS}
```

3. Build the frametest image using the container file:

```
podman build --tag frametest-image -f Frametest.Dockerfile
```

## Preparing scripts and running tests

Prepare the bash script files to automate testing and gathering results. We modified a number of parameters (e.g., nfs threads, frametest threads, async/sync mode, buffer size). We then ran the test with 1 through 12 instances of the Frametest benchmark running simultaneously using containers on the client system.

1. Create the following bash scripts and run as instructed:

- On the client, create and run the following script after every boot to tune the network interface: `tune_client.sh`

```
#!/bin/bash
systemctl stop irqbalance ; sleep 3 ; pgrep irqbalance ;

for IFNAME in ens6f0np0 ;
do
  ethtool -L ${IFNAME} combined 56
  sleep 1
  set_irq_affinity local ${IFNAME}
done
```

- On the SUT, create and run the following script after every boot to tune the network interfaces: `tune_server.sh`

```
#!/bin/bash
systemctl stop irqbalance ; sleep 3 ; pgrep irqbalance ;

for IFNAME in ens6f0np0 ens4f0 ens4f1 ens5f0 ens5f1;
do
  ethtool -L ${IFNAME} combined 56
  sleep 1
  set_irq_affinity local ${IFNAME}
done
blockdev --setra 16384 /dev/nvme*n1
• On the client, create the following script: run_frametest.sh
#!/bin/bash

APP=frametest
RW=${1} # "read" or "write" or "prepare"
FRAMESIZE=4k
```

```

NIC_SPEED=${3:-100}
TARGET_IP=192.168.${NIC_SPEED}.1
PORT_BASE=5200
SERVER_HOST=r750-server
CLIENT_HOST=r750-client
THREADS=4
MTFLAG="a" # "a" or "t"
FPSLIMIT=24 # 0 for unlimited
INSTANCES=${2:-1}
RUNS=15
WARMUP=3
RUNTIME=20
PAUSE=3
RAMPDELAY=0
PREPARE_FRAMES_FACTOR=240 # Only used when FPSLIMIT is unlimited; 240 is enough to saturate 100Gb @
4k raw framesize with a single instance
STORPATHROOT=/stor
PODMAN_FLAGS="--cpuset-mems=1 --cpuset-cpus=$(seq -s, 1 2 111)"

STEP=1
TIMESTAMP=$(date +%Y%m%d %H%M%S')
TOTAL_TIME=$((WARMUP+RUNTIME))

if [ $RW = prepare ]; then
    if [ $FPSLIMIT -gt 0 ]; then
        PREPARE_FRAMES=$((FPSLIMIT*2+10)*(RUNTIME+(PAUSE*2)+(RAMPDELAY*INSTANCES)))
    else
        PREPARE_FRAMES=$((PREPARE_FRAMES_FACTOR*RUNTIME))
    fi

    RWFLAG="-w $FRAMESIZE"
    echo "Preparing ${PREPARE_FRAMES} \"${FRAMESIZE}\" frames on ${INSTANCES} instances:"
    echo
    sleep ${PAUSE}

    echo "PREPARE_TEST: Cleaning all files from the server and trimming SSDs"
    ssh ${SERVER_HOST} 'sync ; systemctl restart nfs-server ; sync ; for d in /stor/*/ ; do rm
-f $d/*\.{tst, csv} & done ; time wait ; sync ; echo 1 > /proc/sys/vm/drop_caches & for d in /
stor/*/ ; do fstrim -v $d & done ; time wait ; sync ; for d in /stor/*/ ; do fstrim -v $d & done ;
time wait ; sync'
    sleep ${PAUSE}

    RESULTS_DIR=results/${APP}_${RW}_${INSTANCES}I_${NIC_SPEED}G_${TIMESTAMP}
    mkdir -p ${RESULTS_DIR}

    echo "RESULTS_DIR: ${RESULTS_DIR}"
    for INSTANCE in `seq -w 1 ${INSTANCES}`;
    do
        CLIENT_FILE=${RESULTS_DIR}/${APP}_${RW}_client_R${RUN}_I${INSTANCE}
        STORPATH=${STORPATHROOT}/d`expr ${INSTANCE} + 0`"
        echo "INSTANCE: ${INSTANCE}"
        time ssh ${CLIENT_HOST} "podman run ${PODMAN_FLAGS} --privileged --rm --env NFSMOUNT='${TARGET_
IP}:${STORPATH}' --env FTPARAMS='-p${WARMUP} -a4 -n${PREPARE_FRAMES} ${RWFLAG} /mnt/' frametest-
image" | tee ${CLIENT_FILE}.txt &
        done
        wait
        sync
        sleep ${PAUSE}

    exit

elif [ $RW == write ]; then
    RWFLAG="-w $FRAMESIZE"

elif [ $RW == read ]; then
    RWFLAG="-r"

else
    echo "INVALID RW VALUE: ${RW}"
    echo 'Must be "read" or "write" or "prepare"'
    exit
fi

```

```

echo "RWFLAG: ${RWFLAG}"

if [ $FPSLIMIT -gt 0 ]; then
    FPSFLAG="-f${FPSLIMIT}"
else
    FPSFLAG=
fi

for THREAD in ${THREADS};
do
    # Make results folder
    RESULTS_DIR=results/${APP}_${RW}_${INSTANCES}I_${THREAD}${MTFLAG}_${RUNS}RC_${NIC_
SPEED}G_${TIMESTAMP}
    mkdir -p ${RESULTS_DIR}
    RESULTS_FINAL=${RESULTS_DIR}/${APP}_${RW}_${INSTANCES}I_${THREAD}${MTFLAG}_${RUNS}RC_${NIC_
SPEED}G_${TIMESTAMP}
    echo "RESULTS_DIR: ${RESULTS_DIR}"
    echo
    if [ $THREAD -gt 0 ]; then
        MTFLAGS="-${MTFLAG}${THREAD}"
    else
        MTFLAGS=
    fi
    # Prepare nmon on client and server
    ssh ${CLIENT_HOST} "sudo killall -q -w nmon ; sudo sync ; sudo rm -f /tmp/client.nmon"
    ssh ${SERVER_HOST} "sudo killall -q -w nmon ; sudo sync ; sudo rm -f /tmp/server.nmon"

    # Start nmon on client and server and wait 1 step
    ssh ${CLIENT_HOST} "sudo nmon -F /tmp/client.nmon -s${STEP} -J -t"
    ssh ${SERVER_HOST} "sudo nmon -F /tmp/server.nmon -s${STEP} -J -t"
    sleep ${STEP}

    for RUN in `seq -w 1 ${RUNS}`;
    do
        echo "RUN: ${RUN}"
        if [ $RW == write ]; then
            echo "WRITE TEST: Cleaning all files from the server and trimming SSDs"
            ssh ${SERVER_HOST} 'sync ; systemctl restart nfs-server ; sync ; for d in /stor/*/ ; do rm
-f $d/*\.{tst,csv} & done ; time wait ; sync ; echo 1 > /proc/sys/vm/drop_caches & for d in /
stor/*/ ; do fstrim -v $d & done ; time wait ; sync ; for d in /stor/*/ ; do fstrim -v $d & done ;
time wait ; sync'
        else
            echo "READ TEST: Flushing buffer cache and trimming SSDs"
            ssh ${SERVER_HOST} 'sync ; systemctl restart nfs-server ; sync ; echo 1 > /proc/sys/vm/drop_
caches & for d in /stor/*/ ; do rm -f $d/*\.{tst,csv} ; fstrim -v $d & done ; time wait ; sync ; for d in
/stor/*/ ; do fstrim -v $d & done ; time wait ; sync'
        fi
        sleep ${PAUSE}
        for INSTANCE in `seq -w 1 ${INSTANCES}`;
        do
            SERVER_FILE=${RESULTS_DIR}/${APP}_${RW}_server_R${RUN}_I${INSTANCE}
            CLIENT_FILE=${RESULTS_DIR}/${APP}_${RW}_client_R${RUN}_I${INSTANCE}
            STORPATH="${STORPATHROOT}/d`expr ${INSTANCE} + 0`"
            echo "INSTANCE: ${INSTANCE}"
            #TOTAL_TIME=${RUNTIME}
            echo "TOTAL_TIME: ${TOTAL_TIME}"
            time ssh ${CLIENT_HOST} "podman run ${PODMAN_FLAGS} --privileged --rm --env
NFSMOUNT='${TARGET_IP}:${STORPATH}' --env FTPARAMS='-p${WARMUP} ${MTFLAGS} ${FPSFLAG} -k${TOTAL_
TIME} -n28800 ${RWFLAG} -x /mnt/${APP}_${RW}_timing_R${RUN}_I${INSTANCE}.csv /mnt/' frametest-image"
            | tee ${CLIENT_FILE}.txt &
            #sleep ${RAMPDELAY}
            done
            wait
            sync
            sleep ${PAUSE}
            scp -p ${SERVER_HOST}:${STORPATHROOT}/d*/${APP}_${RW}_timing_R${RUN}_I*.csv ${RESULTS_DIR}/
            echo

            echo -n "Combined average throughput (MB/s): "
            awk -F'[ ]' '/Overall frame rate/{sum+=$10}END{printf("%f\n",sum / 1048576)}' ${RESULTS_
DIR}/${APP}_${RW}_client_R${RUN}_I*.txt | tee -a ${RESULTS_FINAL} bw.csv
            awk -F'[ ]' '/Overall frame rate/{printf("%f\n",$10 / 1048576)}' ${RESULTS_DIR}/${APP}_${RW}_

```



```

client_R${RUN}_I*.txt > ${RESULTS_DIR}/${APP}_${RW}_client_R${RUN}_bw.csv

    echo -n "Combined average throughput (fps): "
    awk -F'[ ]' '/Overall frame rate/{sum+=$7}END{printf("%.2f\n",sum)}' ${RESULTS_
DIR}/${APP}_${RW}_client_R${RUN}_I*.txt | tee -a ${RESULTS_FINAL} fps.csv
    awk -F'[ ]' '/Overentll frame rate/{printf("%.2f\n", $7)}' ${RESULTS_DIR}/${APP}_${RW}_client_
R${RUN}_I*.txt > ${RESULTS_DIR}/${APP}_${RW}_client_R${RUN}_fps.csv
    echo
    sleep ${PAUSE}
done

echo "Final results (MB/s):"
paste ${RESULTS_DIR}/${APP}_${RW}_client_R[0-9]*_bw.csv | tee ${RESULTS_
DIR}/${APP}_${RW}_client_bw.csv
echo
echo "Final combined results (MB/s):"
cat ${RESULTS_FINAL}_bw.csv
echo

echo "Final results (fps):"
paste ${RESULTS_DIR}/${APP}_${RW}_client_R[0-9]*_fps.csv | tee ${RESULTS_
DIR}/${APP}_${RW}_client_fps.csv
echo
echo "Final combined results (fps):"
cat ${RESULTS_FINAL}_fps.csv
echo

# Stop and save nmon on client and server
ssh ${CLIENT_HOST} "sudo killall -q -w nmon ; sudo sync"
ssh ${SERVER_HOST} "sudo killall -q -w nmon ; sudo sync"
scp ${CLIENT_HOST}:/tmp/client.nmon ${RESULTS_DIR}/${APP}_${RW}_client.nmon
scp ${SERVER_HOST}:/tmp/server.nmon ${RESULTS_DIR}/${APP}_${RW}_server.nmon

# Parse nmon files using nmonchart
for nmonfile in `find ${RESULTS_DIR}/*.nmon`;
do
    ./nmonchart $nmonfile
done
done
echo

# Save script, timestamp, and environment variables to results directory
cp -pvf ${0} ${RESULTS_DIR}/
echo ${TIMESTAMP} > ${RESULTS_DIR}/timestamp.txt
set > ${RESULTS_DIR}/set.txt
echo

```

2. Modify the variables at the top of the `run_frametest.sh` script as needed.
3. To run a test, execute the script using the command the parameters as follows:
  - a. `<MODE>`: Sets the operating mode for the script. Acceptable values: "read", "write" or "prepare". You must run prepare at least once before doing a read test. If you run a write test, this will erase all data and you will need to prepare again.
  - b. `<NUMBER_OF_INSTANCES>`: Sets the number of instances to run simultaneously. This can be any positive integer value.
  - c. `<SPEED>`: Sets the benchmark speed, used to pick the SUT target interface and labeling used in results. Acceptable values are 25 or 100
  - d. `./run_frametest.sh <MODE> <NUMBER_OF_INSTANCES> <SPEED>`
  - e. Results will be saved in a created results subfolder, labeled using the set variables, parameters, and timestamp.
  - f. Here is an example to run the benchmark at multiple modes/instances/speeds using the same parameters as our testing:

```
for i in {1..12}; do
  for s in 25 100; do
    ./run_frametest.sh write $i $s
  done
done
./run_frametest.sh prepare 12 100
for i in {1..12}; do
  for s in 25 100; do
    ./run_frametest.sh read $i $s
  done
done
```

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