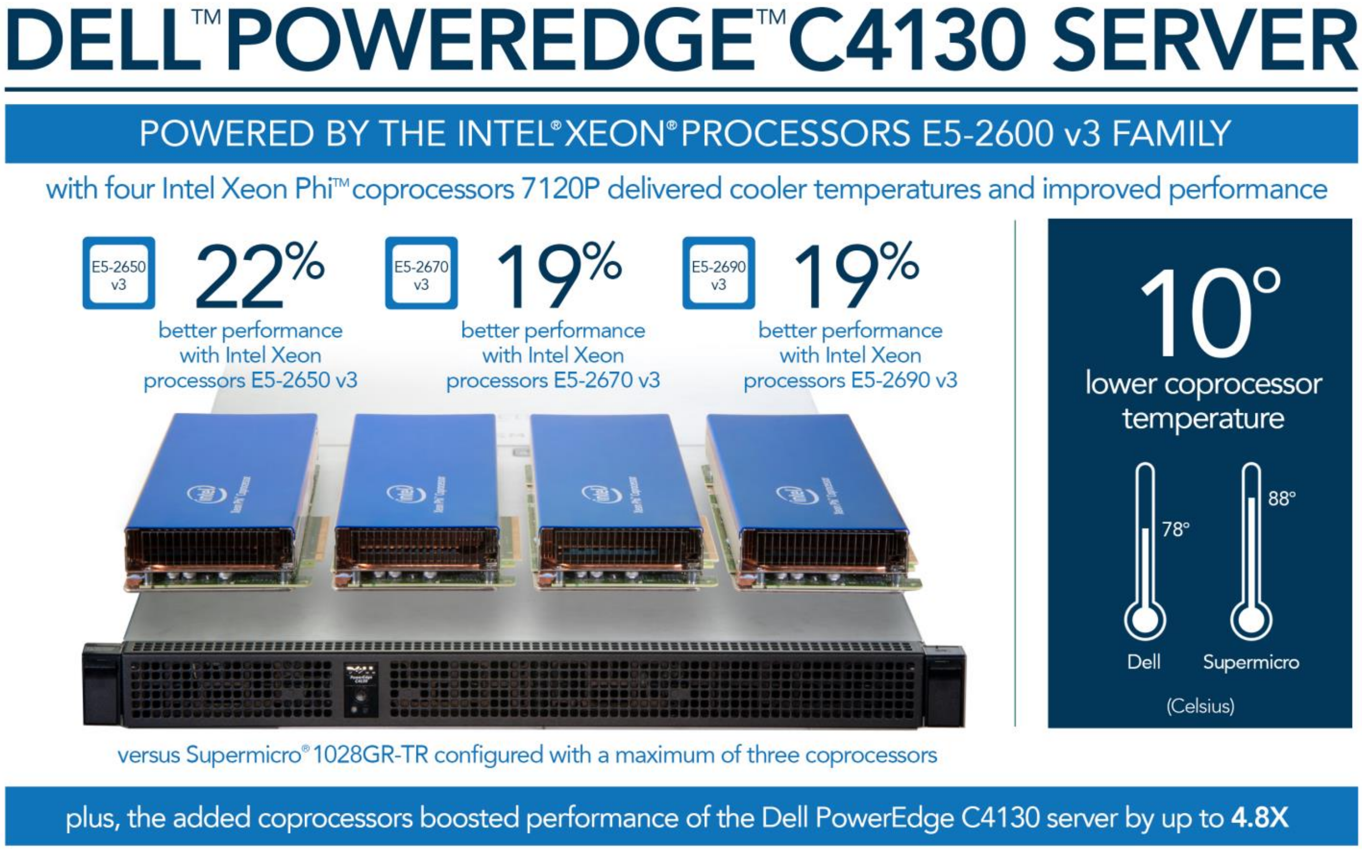
DELL POWEREDGE C4130 & INTEL XEON PHI COPROCESSOR 7120P



For organizations running high-performance computing (HPC) workloads, strong computational performance means getting results faster. In recent years, adding coprocessors, such as Intel Xeon Phi coprocessors 7120P, to existing rack servers in datacenters has become a popular approach to addressing these complex and demanding compute requirements. These solutions, with optional coprocessor upgrades, allow businesses to get more computing power out of each server. The Intel processor-powered Dell PowerEdge C4130 provides a unique platform to support the accelerated performance of coprocessors with a physical design intended to facilitate airflow and reduce overheating.

At Principled Technologies, we first compared the floating-point performance of an Intel processor-powered Dell PowerEdge C4130 without any coprocessors (baseline) and then with the maximum amount of Intel Xeon Phi coprocessors 7120P (maximum) in three different Intel Xeon processor configurations: pairs of E5-2650 v3, E5-2670 v3, and E5-2690 v3 processors. We found that adding the four coprocessors to the Dell PowerEdge C4130 delivered as much as 4.8 times more performance than the Dell PowerEdge C4130 without any coprocessors. Improved performance from coprocessors means getting more from HPC workloads.

FEBRUARY 2015

A PRINCIPLED TECHNOLOGIES TEST REPORT

Commissioned by Dell Inc.

We then compared the performance of the Dell PowerEdge C4130 with four coprocessors against a Supermicro 1028GR-TR with the maximum amount of Intel Xeon Phi coprocessors 7120P (three) in all three processor configurations. We found that the Dell PowerEdge C4130 consistently outperformed the Supermicro server solution, delivering up to 22 percent better performance. In addition, when we looked at coprocessor temperatures as an indicator of airflow through both the Dell and Supermicro servers, we found the coprocessor temperatures of the Dell PowerEdge C4130 were up to 10 degrees (Celsius) cooler than the Supermicro 1028GR-TR. These cooler running temperatures may help prevent deterioration of the silicon from overheating and may extend the lifetime of the chips.

For more information about the testing components, see Appendix A. For more information on the system configuration of each system, see Appendix B. For detailed steps on how we tested, see Appendix C.

GET MORE COMPUTING POWER WITH INTEL XEON PHI COPROCESSORS 7120P

Organizations running HPC applications specialize in areas ranging from molecular dynamics to animation to weather forecasting. In recent years, the addition of coprocessors to servers has seen increased performance for these organizations. The coprocessors add computational power, which can offload or supplement the workload on the CPU.

We used Intel's version of the high-performance LINPACK (Intel HPL) benchmark to test the floating-point performance of the baseline and maximum configurations, which aggregates all available compute power from the CPUs and coprocessors in each configuration. Our tests measured CPU performance for the baseline configuration and coprocessor and CPU performance combined for the maximum configuration. The HPL benchmark solves a set of linear equations and returns the time required and the average floating point performance achieved in giga-floating-point operations per second (Gflops). In our tests, we chose a problem size of 99,968 and a block size of 1,408 to make full use of the memory and to maximize performance. Our testing occurred in a datacenter at 25 degrees Celsius.

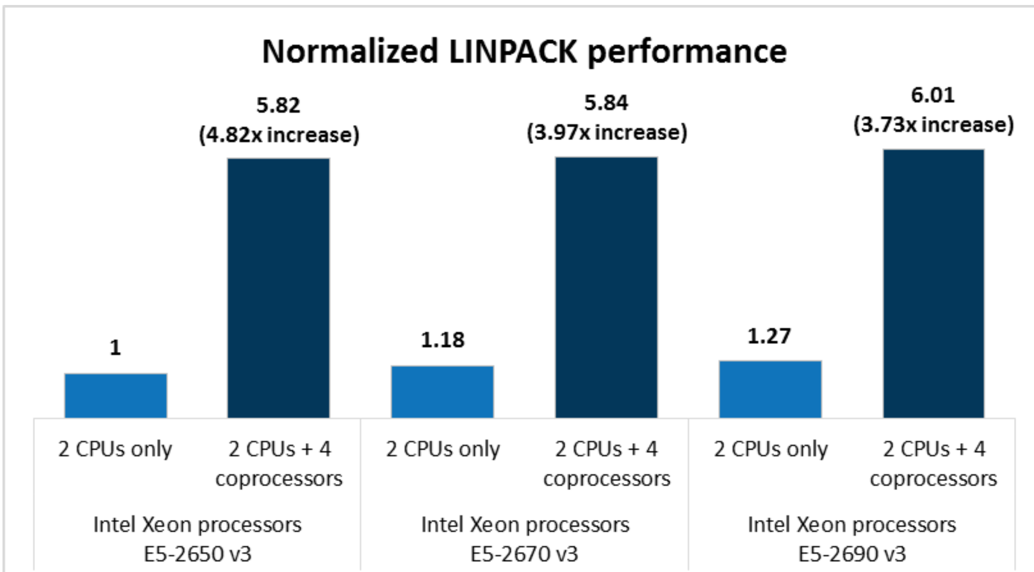
We first tested the baseline configuration of the PowerEdge C4130 in three different processors. Having three processor configurations allowed us to see how changes in processor affected the floating-point performance. Next, we tested the maximum configuration of the PowerEdge C4130 in the same three Intel Xeon processor configurations. Figure 1 presents information for each Intel Xeon processor we used.

	Intel Xeon processor E5-2650 v3	Intel Xeon processor E5-2670 v3	Intel Xeon processor E5-2690 v3
TDP (watts)	105	120	135
Frequency (GHz)	2.3	2.3	2.6
Cores	10	12	12

Figure 1: CPU information for the processors we used in testing.

Our tests showed that adding coprocessors to each processor configuration could dramatically increase floating-point performance. Figure 2 provides the normalized Gflops performance numbers for baseline and maximum coprocessor configurations for each processor. The Dell PowerEdge C4130 maximum coprocessor configuration delivered as much as 4.8 times, 3.9 times, and 3.7 times more floating-point performance than the baseline configuration with Intel Xeon processors E5-2650 v3, E5-2670 v3, and E5-2690 v3, respectively.

Figure 2: Normalized LINPACK floating-point performance for the baseline and maximum configuration of the PowerEdge C4130 using multiple Intel Xeon processor configurations. Higher numbers are better.



This increase in compute power can put servers in a dangerous position. Running too long at higher-than-normal temperatures can diminish workload performance for these HPC applications and can decrease hardware life. The design of the Dell PowerEdge C4130 positions the coprocessors to receive significant airflow for cooling. In addition, the design includes more openings that allow air to move out of the server, helping air warmed by coprocessors and processors to leave.

We found that peak coprocessor temperatures for the Dell PowerEdge C4130 maximum configuration were generally consistent with each of the three Intel Xeon processors (see Figure 3). All three maximum coprocessor temperatures were within a standard safe-operation temperature range.[1]

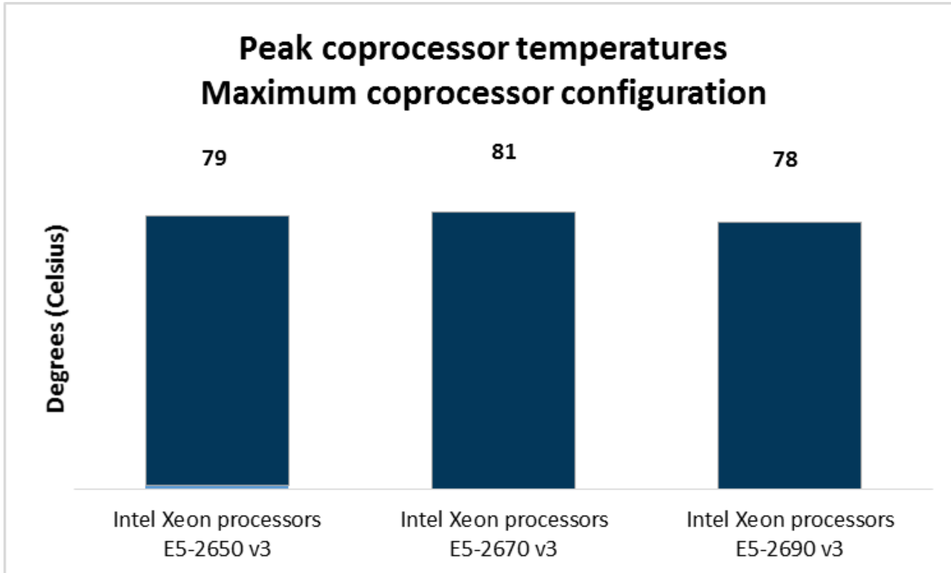


Figure 3: Peak coprocessor temperature for the maximum configurations of the Dell PowerEdge C4130 with each of the three Intel Xeon processors.

If your organization needs the power of coprocessors to run graphic-heavy design applications or complex scientific simulations, the Dell PowerEdge C4130 can provide the hardware to support your demanding workloads. Keeping the silicon of coprocessors at a reasonable temperature, as the PowerEdge C4130 did, could extend the lifetime of the chips, while reducing diminished performance and power inefficiency.

BETTER PERFORMANCE FROM THE DELL POWEREDGE C4130 WITH COOLER INTEL XEON PHI COPROCESSORS 7120P

After realizing the performance benefits of adding Intel Xeon Phi coprocessors 7120P to the Dell PowerEdge C4130, we compared the maximum configuration of the PowerEdge C4130 to a Supermicro 1028GR-TR server with the maximum number of supported Intel Xeon Phi coprocessors 7120P in the three Intel Xeon processor configurations. The PowerEdge C4130 can house four Intel Xeon Phi coprocessors 7120P simultaneously, while the Supermicro 1028GR-TR can hold only three. Not only did the Dell PowerEdge C4130 maximum configuration outperform the Supermicro 1028GR-TR maximum configuration, but it also kept the coprocessor temperatures cooler for all three processors. Figure 4 shows coprocessor temperatures for both solutions in each processor configuration.

[1] Intel Xeon Phi coprocessors typically have maximum operating temperatures of approximately 95°C. https://www-ssl.intel.com/content/www/us/en/processors/xeon/xeon-phi-coprocessor-datasheet.html

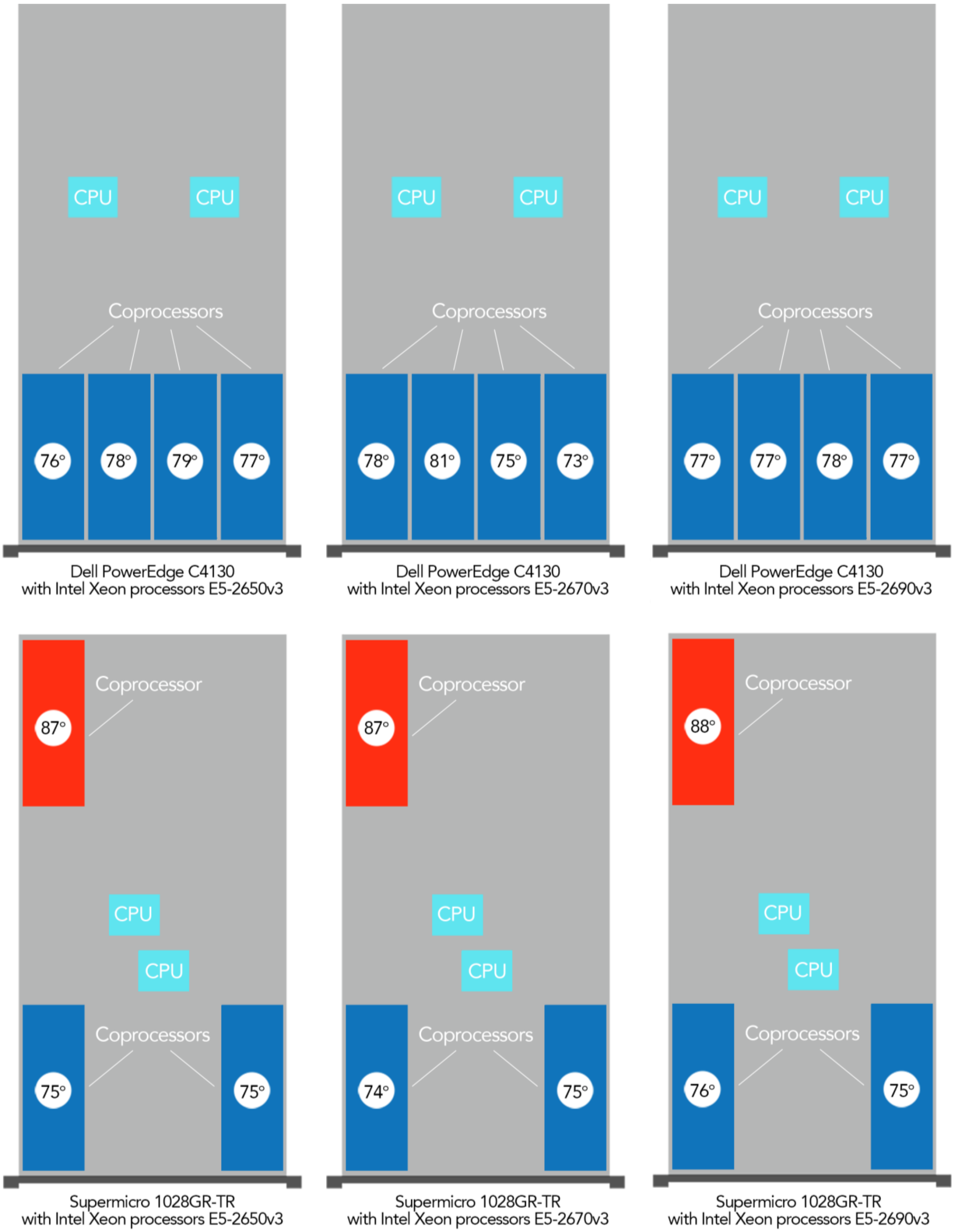


Figure 4: Coprocessor and CPU placement in the two servers we tested showing sensor temperatures with multiple Intel Xeon processor configurations. Lower temperatures are better.

In the following sections, we show how the maximum configurations for each solution performed in each of the processor configurations we tested.

Intel Xeon processor E5-2650 v3

Floating-point performance

We found that the Dell PowerEdge C4130 with the maximum configuration of Intel Xeon Phi coprocessors 7120P achieved 22 percent greater floating-point performance than the Supermicro 1028GR-TR maximum configuration. Figure 5 shows the normalized Gflops achieved by the two configurations with the Intel Xeon processors E5-2650 v3.

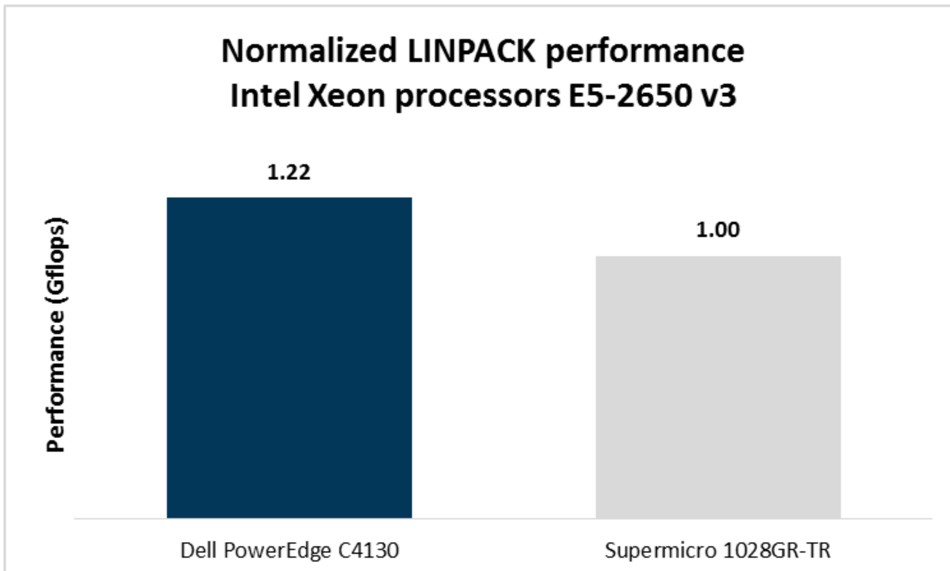
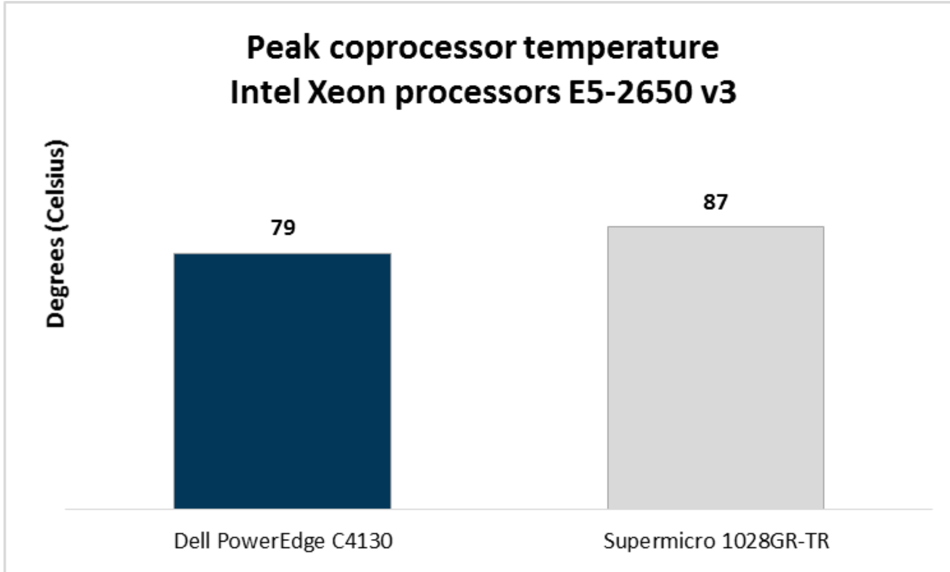


Figure 5: Normalized LINPACK floating-point performance for each system. Higher numbers are better.

Coprocessor temperature

We found that peak coprocessor temperature for the Dell PowerEdge C4130 with the maximum configuration of Intel Xeon Phi coprocessors 7120P was 8 degrees cooler than peak coprocessor temperature of the Supermicro 1028GR-TR (see Figure 6).

Figure 6: Peak coprocessor temperature for the two systems. Lower numbers are better.

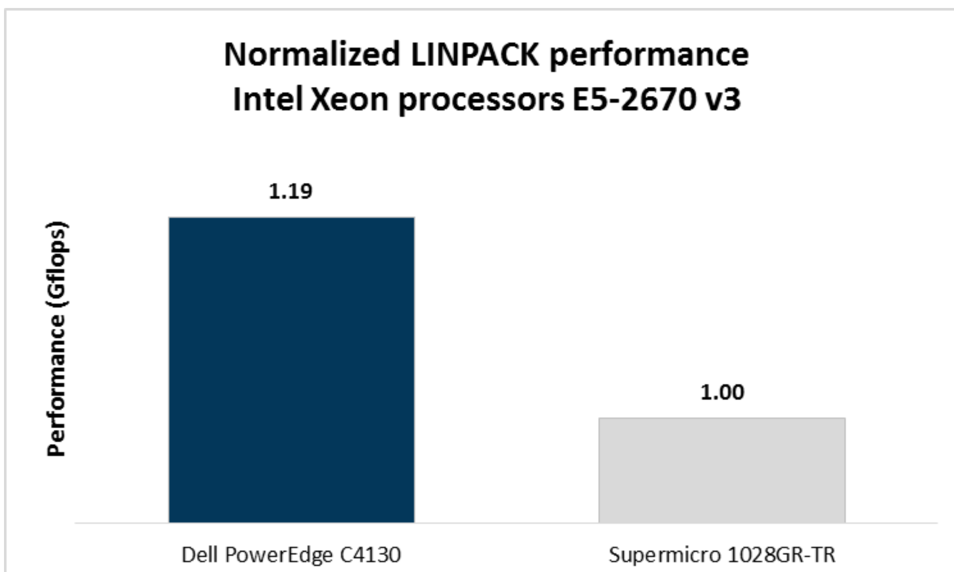


Intel Xeon processor E5-2670 v3

Floating-point performance

We found that the Dell PowerEdge C4130 maximum configuration achieved 19 percent greater floating-point performance than the Supermicro 1028GR-TR maximum configuration. Figure 7 shows the normalized Gflops achieved by the two configurations with the Intel Xeon processors E5-2670 v3.

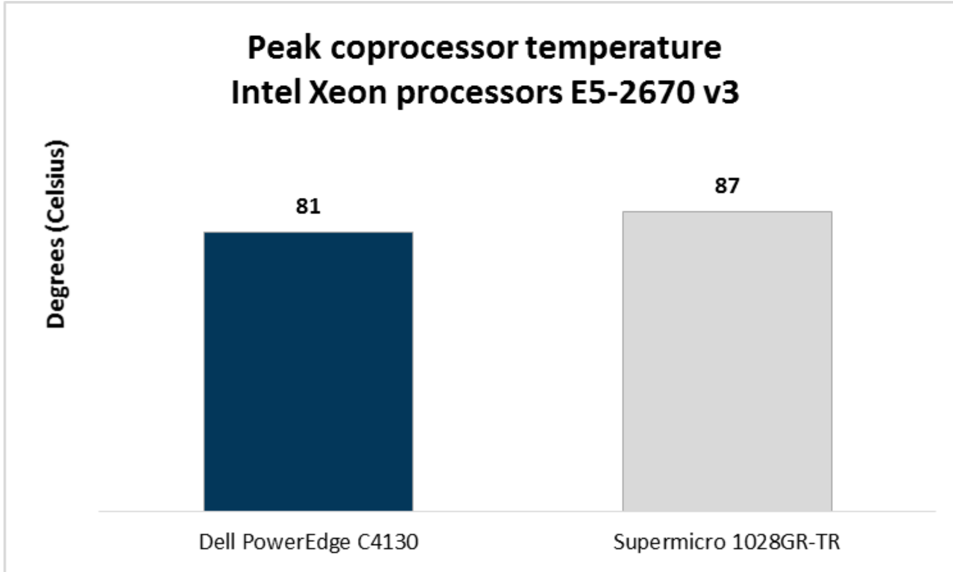
Figure 7: Normalized LINPACK floating-point performance for each system. Higher numbers are better.



Coprocessor temperature

For the maximum configuration of Intel Xeon Phi coprocessors 7120P, peak coprocessor temperature of the Dell PowerEdge C4130 was 6 degrees cooler than the Supermicro 1028GR-TR solution (see Figure 8).

Figure 8: Peak coprocessor temperature for the two systems. Lower numbers are better.

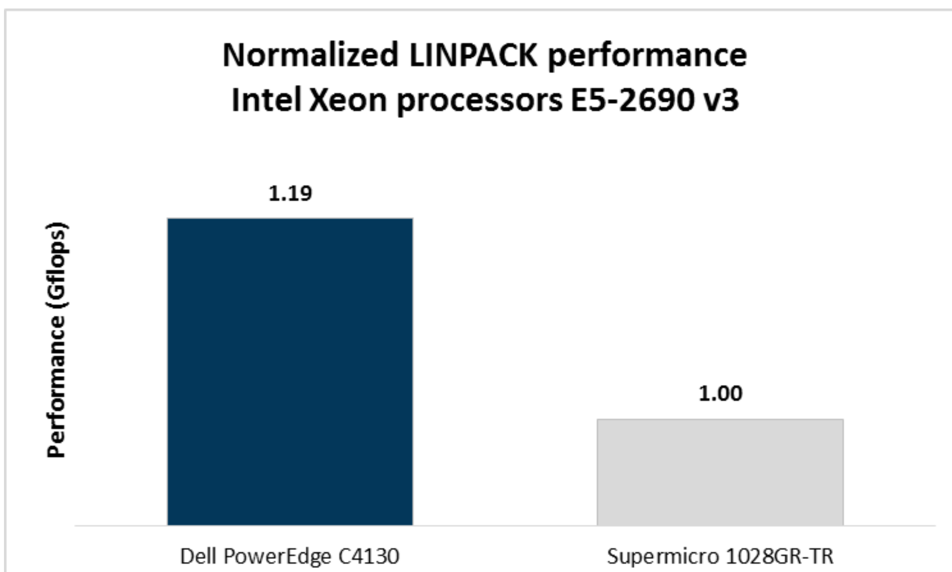


Intel Xeon processor E5-2690 v3

Floating-point performance

We found that the Dell PowerEdge C4130 with the maximum configuration of Intel Xeon Phi coprocessors 7120P achieved 19 percent greater floating-point performance than the Supermicro 1028GR-TR maximum configuration. Figure 9 shows the normalized Gflops achieved by the two configurations with the Intel Xeon processors E5-2690 v3.

Figure 9: Normalized LINPACK floating-point performance for each system. Higher numbers are better.



Coprocessor temperature

For the maximum configuration of Intel Xeon Phi coprocessors 7120P, peak coprocessor temperature of the Dell PowerEdge C4130 was 10 degrees cooler than the Supermicro 1028GR-TR solution (see Figure 10).

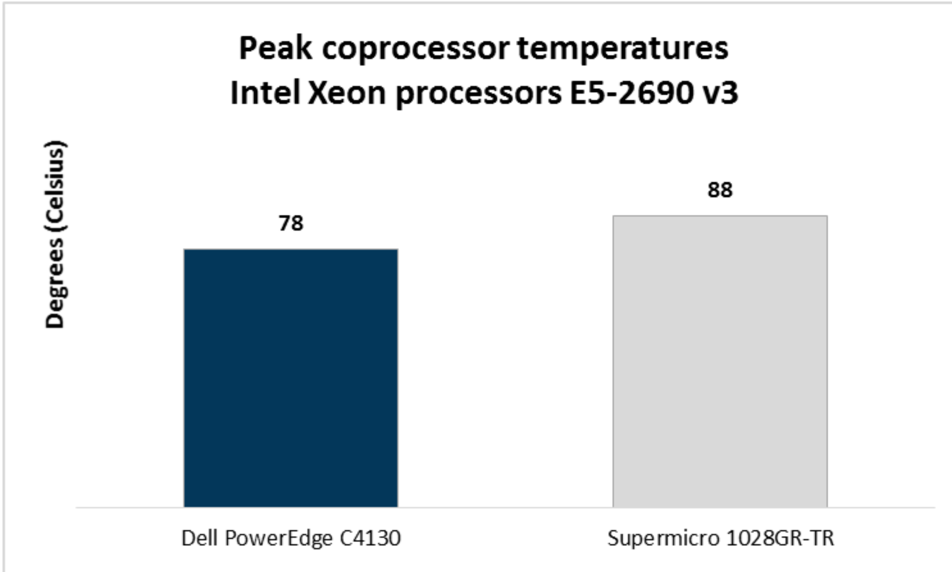


Figure 10: Peak coprocessor temperature for both configurations of the two systems. Lower numbers are better.

CONCLUSION

Choosing a server solution that supports additional coprocessors is a great option for offloading your HPC workloads and maximizing server performance. We found that the maximum configuration of the Dell PowerEdge C4130 delivered up to 4.8 times more performance than the baseline configuration. In addition, servers need to provide reliable and powerful performance while maintaining reasonable coprocessor temperatures. We found that the maximum configuration of the Dell PowerEdge C4130 with four Intel Xeon Phi coprocessors 7120P delivered up to 22 percent better performance than the maximum configuration of the Supermicro 1028GR-TR with three Intel Xeon Phi coprocessors 7120P. In our testing of internal temperatures, we found the peak coprocessor temperature of the Dell PowerEdge C4130 in the maximum configuration to be up to 10 degrees cooler than the Supermicro 1028GR-TR maximum configuration.

The added performance of Intel Xeon Phi coprocessors 7120P can mean a lot for organizations running anything from advanced algorithms to rendering 3D graphics. The new Dell PowerEdge C4130 provides the platform your organization needs to handle these compute-intensive workloads. The design of the PowerEdge C4130 helps lower internal coprocessor temperatures via internal airflow—bringing another benefit for your organization by potentially extending hardware and chip life.

APPENDIX A – ABOUT THE COMPONENTS

About Dell PowerEdge C4130

The Dell PowerEdge C4130 is, according to Dell, "designed to accelerate a range of demanding workloads including high-performance computing (HPC)," and powered by up to two Intel Xeon processors for the Intel Xeon processor E5-2600 v3 product family. The Dell PowerEdge C4130 houses up to four 300W double-width GPU accelerators or coprocessors in 1U of space, can offer up to 256GB of DDR4 memory, and features two rear PCIe® 3.0 slots and support for InfiniBand® FDR.

For more information about the Dell PowerEdge C4130, visit www.dell.com/us/business/p/poweredge-c4130/pd.

About the Intel Xeon Phi coprocessor 7120P

Designed to give highly parallel applications a performance boost, the Intel Xeon Phi coprocessor is a PCI Express form factor add-in card that works in conjunction with a server's Intel Xeon processors. Part of the 7100 Series, the Intel Xeon Phi coprocessor 7120P has 16GB memory, 61 cores, and runs at 1.238 GHz. The Intel Xeon Phi coprocessor 7100 Series supports more features than the other Intel coprocessor lines, including Intel Turbo Boost Technology 1.0 and the highest performance and memory capacity of the series. Intel Xeon Phi coprocessors and Intel Xeon processors use common languages, models, and development tools, so there's no need to alter code to use them.

To learn more about the Intel Xeon Phi coprocessor 7120P, visit www.intel.com/content/www/us/en/processors/xeon/xeon-phi-detail.html.

About LINPACK

The LINPACK benchmark runs a program that solves a system of linear equations to measure the floating-point rate of execution of a system. Often used to test the performance of supercomputers, LINPACK can help determine the peak performance of which a system is capable by using complex calculations to stress the processor. For more information about LINPACK, visit www.top500.org/project/linpack/.

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 11 provides detailed configuration information for the test systems.

System	Dell PowerEdge C4130	Supermicro 1028GR-TR
Power supplies		
Total number	2	2
Vendor and model number	Dell D1600E-S0	Delta Electronics DPS-1600CB
Wattage of each (W)	1,600	1,600
Cooling fans		
Total number	8	10
Vendor and model number	Delta Electronics GFM0412SS-D	Delta Electronics GFC0412DS
Dimensions (h × w) of each	1″ × 1″	1″ × 1″
Volts	12	12
Amps	2.0	1.5
General		
Number of processor packages	2	2
Number of cores per processor	20, 24, 24	20, 24, 24
Number of hardware threads per core	2, 2, 2	2, 2, 2
System power management policy	Performance	Default (performance)
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2650 v3, E5-2670 v3, E5-2690 v3	E5-2650 v3, E5-2670 v3, E5-2690 v3
Socket type	FCLGA2011-3	FCLGA2011-3
Core frequency (GHz)	2.3, 2.3, 2.6	2.3, 2.3, 2.6
Bus frequency (GT/s)	9.6, 9.6, 9.6	9.6, 9.6, 9.6
L1 cache	768 KB (all processors)	768 KB (all processors)
L2 cache	3072 KB (all processors)	3072 KB (all processors)
L3 cache	25, 30, 30 MB	25, 30, 30 MB
Platform		
Vendor and model number	Dell PowerEdge C4130	Supermicro 1028GR-TR
Motherboard model number	0797FV	X10DRG-H
BIOS name and version	Dell 0.3.5	American Megatrends 1.0
BIOS settings	Performance	Default (performance)

System	Dell PowerEdge C4130	Supermicro 1028GR-TR
Memory module(s)		
Total RAM in system (GB)	128	128
Vendor and model number	Hynix HMA41GR7MFR8N	Hynix HMA41GR7MFR8N
Type	PC4-2133P	PC4-2133P
Speed (MHz)	2,133	2,133
Speed running in the system (MHz)	2,133	2,133
Timing/Latency (tCL-tRCD-tRP-tRASmin)	11-11-11-33	11-11-11-33
Size (GB)	8	8
Number of RAM module(s)	16	16
Chip organization	Dual-sided	Dual-sided
Rank	Double	Double
Operating system		
Name	CentOS 7	CentOS 7
Build number	3.10.0-123.9.2.el7.x86_64	3.10.0-123.9.2.el7.x86_64
File system	XFS	XFS
Language	English	English
RAID controller		
Vendor and model number	Embedded Intel SATA Controller	Embedded Intel SATA Controller
Driver version	3.0	3.0
Cache size (MB)	N/A	N/A
Solid-state drives		
Vendor and model number	Dell 1H4WG	Samsung MZ-7PA2560/0D1
Number of drives	1	1
Size (GB)	60	256
Type	SATA SSD	SATA SSD
Ethernet adapters		
Vendor and model number	Intel I350 Gigabit NIC	Intel I350 Gigabit NIC
Type	Ethernet	Ethernet
Driver	5.0.5-k	5.0.5-k

Figure 11: System configuration information for the test systems.

APPENDIX C – HOW WE TESTED

On both the Dell PowerEdge C4130 and the Supermicro 1028GR-TR, we configured the BIOS settings for HPL performance and then installed minimal CentOS 7 onto the local storage. We installed the Intel Xeon Phi coprocessor software and Intel's distribution of the HPL 2.1 benchmark, which comes bundled with Intel Parallel Studio XE 2015.

Installing and configuring the BIOS and operating system

On both servers, we configured the BIOS to run on physical cores only and in the best possible performance settings. This included leaving Intel Turbo Boost Technology enabled on both the server board and coprocessor boards. We then created a single-drive RAID0 volume using the onboard storage controllers and installed the minimal installation of CentOS 7 onto the local storage. We then installed necessary packages and updated the kernel.

Configuring the BIOS

1. During POST, press the appropriate key to enter the BIOS menu (F2 on the Dell PowerEdge C4130, and Delete on the Supermicro 1028GR-TR).
2. In BIOS, navigate to the Processor menu and turn off Intel Virtualization Technology and disable Hyper-Threading.
3. On the Dell PowerEdge C4130, navigate to the System Profile menu and choose the Performance profile.
4. On both servers, save the BIOS settings and exit the BIOS menu.

Installing CentOS 7

1. Connect the installation media to the server. We used the virtual optical drive available on both servers' out-of-band management consoles.
2. Boot to the installation media.
3. At the splash screen, select Install CentOS 7 and press Enter.
4. Choose English (United States) as the language and click Continue.
5. At the Installation Summary screen, configure the Date & Time to match your time zone.
6. Set the Software Selection to Minimal Install.
7. Set the Installation Destination to Automatic partitioning.
8. Configure the Network & Hostname for your testing network.
9. Click Begin Installation.
10. During the installation process, set the Root Password. We elected not to create another user for this setup.
11. Once the installation is completed, disconnect the installation media and click Reboot.

Updating the operating system and installing the required software

1. Begin an SSH session with the server and log in as the root user.
2. Enter the following command to install the necessary packages for our setup:

```
yum -y install kernel-devel pciutils lm_sensors gtk gtk2
```

3. Disable Networking Manager by running the following commands:

```
chkconfig NetworkManager off
chkconfig network on
service NetworkManager stop
```

```
service network start
```

4. Disable SELinux on the server by modifying `/etc/sysconfig/selinux`.
5. Reboot the server.
6. Download the Intel package `mpss-3.4.2-linux.tar` and extract the contents.
7. Enter the extraction location and run the following commands to copy and install the relevant RPMs:

```
cp ./modules/*`uname -r`*.rpm .
yum -y localinstall *.rpm
```

8. Load the MIC driver and initialize default settings by running the following commands:

```
modprobe mic
micctrl --initdefaults
```

9. Start the MPSS service by running the following command:

```
service mpss start
```

Installing and running the HPL benchmark

We used Intel's version of HPL that comes bundled with Intel Parallel Studio XE 2015. We completed testing on the coprocessors in offload mode. We used the provided scripts to create library paths and then compiled the HPL executable from the given source code.

Installing Intel Parallel Studio XE 2015

1. Download the package `parallel_studio_xe_2015_update1.tgz` and extract the contents.
2. Run `install.sh` and choose the default settings to install the evaluation version of Intel Parallel Studio XE 2015.
3. Modify `~/.bashrc` to contain the following line and source the file to set the path:

```
export
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/root/bin:/sbin:/o
pt/intel/impi/5.0.2.044/intel64/bin:/opt/intel/composer_xe_2015.1.133/bin
/intel64
```

4. Reboot the server and run the following commands to initialize the MPSS environment (run these commands after every boot):

```
source /opt/intel/composer_xe_2015.1.133/bin/compilervars.sh intel64
mpdboot
service mpss start
```

5. Navigate to `/opt/intel/mkl/benchmarks/mp_linpack`.
6. Run the following command to create the HPL executable:

```
make arch=intel64
```

7. Navigate to `./bin_intel/intel64`.
8. For the Dell PowerEdge C4130 maximum configuration, modify the following environment variables in `runme_offload_intel64`:

```
export MPI_PROC_NUM=2
export MPI_PER_NODE=2
export NUMMIC=4
```

9. For the Supermicro 1028GR-TR maximum configuration, use the following environment variables:

```
export MPI_PROC_NUM=2
export MPI_PER_NODE=2
export NUMMIC=3
```

10. Edit `HPL_offload.dat` to reflect the following:

```
HPLinpack benchmark input file
Innovative Computing Laboratory, University of Tennessee
HPL.out      output file name (if any)
6            device out (6=stdout,7=stderr,file)
1            # of problems sizes (N)
99968         Ns
1            # of NBs
1408          NBs
1            PMAP process mapping (0=Row-,1=Column-major)
1            # of process grids (P x Q)
1            Ps
2            Qs
16.0         threshold
1            # of panel fact
1            PFACTs (0=left, 1=Crout, 2=Right)
1            # of recursive stopping criterium
4            NBMINs (>= 1)
1            # of panels in recursion
2            NDIVs
1            # of recursive panel fact.
1            RFACTs (0=left, 1=Crout, 2=Right)
1            # of broadcast
6            BCASTs (0=1rg,1=1rM,2=2rg,3=2rM,4=Lng,5=LnM,6=Psh,7=Psh2)
1            # of lookahead depth
0            DEPTHs (>=0)
0            SWAP (0=bin-exch,1=long,2=mix)
1           swapping threshold
1            L1 in (0=transposed,1=no-transposed) form
1            U  in (0=transposed,1=no-transposed) form
0            Equilibration (0=no,1=yes)
```

```
8             memory alignment in double (> 0)
```

11. Run `runme_offload_intel64` to start the HPL benchmark.

ABOUT PRINCIPLED TECHNOLOGIES

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When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.