

Performance Improvement with Intel Xeon® Phi

by Ashish Kumar Singh and Calvin Jacob

This blog details the performance improvement that has been achieved using Intel Xeon® Phi on the current generation Dell servers as compared to the same server of CPU configuration only. Though the performance runs carried out consisted of multiple iterations of runs along with multiple BIOS options, only the best results are recorded in this blog. For each of the application, the settings which yielded the best performance are recorded in the results description for each of the applications. All the performance runs were carried out with hyper threading (logical processor) disabled. The system configuration of the systems used are as below:

	<i>Dell PowerEdge® R730</i>
<i>Operating System</i>	<i>Red Hat Enterprise Linux 6.5</i>
<i>CPU</i>	<i>2x Intel Xeon® E5-2695v3</i>
<i>Memory</i>	<i>16x 16GB DDR4 DIMMs, 2133MHz</i>
<i>Co-processor</i>	<i>2x Intel Xeon® Phi 7120P</i>
<i>Power Supply</i>	<i>2x 1100W (non-redundant)</i>
<i>Intel Compiler</i>	<i>Intel Parallel Studio XE 2015</i>
<i>Driver for co-processor</i>	<i>MPSS 3.3</i>

The applications chosen along with the respective versions and the domains are as below:

<i>Application</i>	<i>Version</i>	<i>Domain</i>
<i>High Performance Linpack</i>	<i>v2.1</i>	<i>System Benchmark</i>
<i>STREAM</i>	<i>5.10</i>	<i>System Benchmark</i>
<i>SHOC</i>	<i>v.1.1.4a-mic</i>	<i>System Benchmark</i>
<i>NAMD</i>	<i>v2.10</i>	<i>Molecular Dynamics</i>
<i>ANSYS Mechanical</i>	<i>v15.0</i>	<i>Finite Element Analysis</i>

The BIOS options selected for this blog as below:

<i>System BIOS Options</i>	<i>Settings</i>
<i>Memory Settings > Snoop Mode</i>	<i>Cluster on Die</i>
<i>Processor Settings > Logical Processor</i>	<i>Disabled</i>

<i>Processor Settings > QPI Speed</i>	<i>Maximum Data Rate</i>
<i>Processor Settings > Configurable TDP</i>	<i>Nominal</i>
<i>System Profile Settings > System Profile</i>	<i>Performance</i>

Specification of Intel Xeon® E5-2695v3:

<i>Cores</i>	<i>14 Cores</i>
<i>Clock speed</i>	<i>2.3GHz</i>
<i>Intel QPI Speed</i>	<i>9.6GT/s</i>
<i>Maximum TDP</i>	<i>120W</i>
<i>Cache</i>	<i>35MB</i>
<i>Memory Channels</i>	<i>4</i>

Specification of Intel Xeon® Phi 7120P:

<i>Cores</i>	<i>61</i>
<i>Clock Speed</i>	<i>1.238GHz</i>
<i>Memory</i>	<i>16GB GDDR5</i>
<i>Memory Channels</i>	<i>16</i>
<i>Maximum Memory Bandwidth</i>	<i>352GB/s</i>
<i>L2 Cache</i>	<i>30.5MB</i>
<i>Maximum TDP</i>	<i>300W</i>

The comparison has been made between 3 configurations:

1. R730 with two Intel Xeon® E5-2695v3 only
2. R730 with two Intel Xeon® E5-2695v3 and one Intel Xeon® Phi 7120P
3. R730 with two Intel Xeon® E5-2695v3 and two Intel Xeon® Phi 7120P

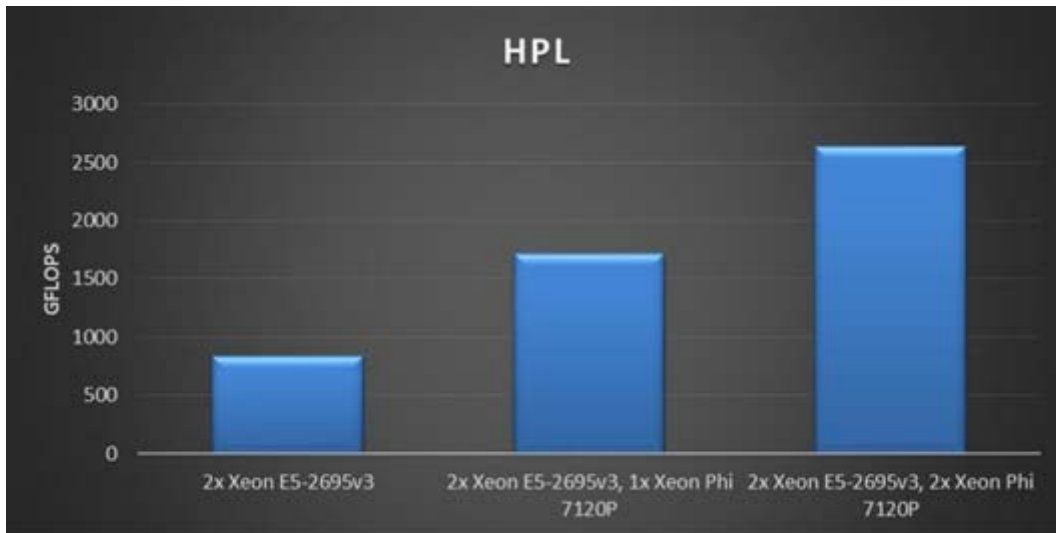
Throughout this blog, the performance has been expressed comparing configuration 1 through configuration 3. There has been a considerable amount of performance gain that has been seen while scaling from CPU only configurations to servers with one and two Intel Xeon® Phi 7120P.

Below are the details of the applications used for the study and the results obtained.

[High Performance Linpack](#) is the benchmark that would calculate the total throughput (sustained throughput) obtained from a system, this data can be used for calculating the overall efficiency by comparing it against the maximum theoretical throughput. For the below recorded run, CPU was set to Performance Mode and the Intel

Xeon® Phi was set to ECC ON and Turbo OFF. The achieved throughput on CPU only was taken as the baseline. Below is the comparison of the scale-up performance runs carried out on configurations with processors and Intel Xeon Phi.

<i>High Performance Linpack (GFLOPS) on Dell PowerEdge® R730</i>		
<i>2x Intel Xeon E5-2695v3</i>	<i>2x Intel Xeon® E5-2695v3, 1x Intel Xeon® Phi 7120P</i>	<i>2x Intel Xeon® E5-2695v3, 2x Intel Xeon® Phi 7120P</i>
839.3	1720.5	2634.5



(Click on images to enlarge.)

We observe a 100% and 200% performance improvement on configurations with one Intel Xeon® Phi 7120P and two Intel Xeon® Phi 7120P respectively. The runs on Intel Xeon® Phi were done in the offload mode. In offload mode, the program is launched on the host CPU but executed on the Intel Xeon® Phi.

STREAM benchmark is used for measuring the memory bandwidth in a system. This measures the rate at which the data transfers happen within system or within Intel Xeon® Phi. The performance numbers were recorded for CPU set to performance mode and the Intel Xeon® Phi set to ECC OFF and Turbo ON. Below is the data from the STREAM performance runs:

<i>STREAM Bandwidth (MB/s) on Dell PowerEdge® R730</i>				
<i>2x Intel Xeon® E5-2695v3</i>	<i>Intel Xeon® Phi 7120P (ECC-ON, Turbo-OFF)</i>	<i>Intel Xeon® Phi 7120P (ECC-ON, Turbo-ON)</i>	<i>Intel Xeon® Phi 7120P (ECC-OFF, Turbo-OFF)</i>	<i>Intel Xeon® Phi 7120P (ECC-OFF, Turbo-ON)</i>
119075.16	177991.86	181407.99	192767.70	199397.42



The achieved stream bandwidth on CPU only configuration on R730 was taken as the baseline. We observe performance improvements of 50% to 70% on configurations with one Intel Xeon® Phi 7120P and two Intel Xeon® Phi 7120P as against the CPU only configuration. The best STREAM bandwidth was observed on Intel Xeon® Phi 7120P with ECC set to OFF and turbo set to ON.

SHOC measures the maximum device memory bandwidth for different levels of the memory hierarchy and different access patterns. Results are reported in GB/s. Host-to-Device bandwidth is measured by SHOCDownload and Device-to-Host bandwidth is measured by SHOCReadback. There is an overall bandwidth of approximately 6.9GB/s seen across SHOCDownload and SHOCReadback. The details are as provided below.

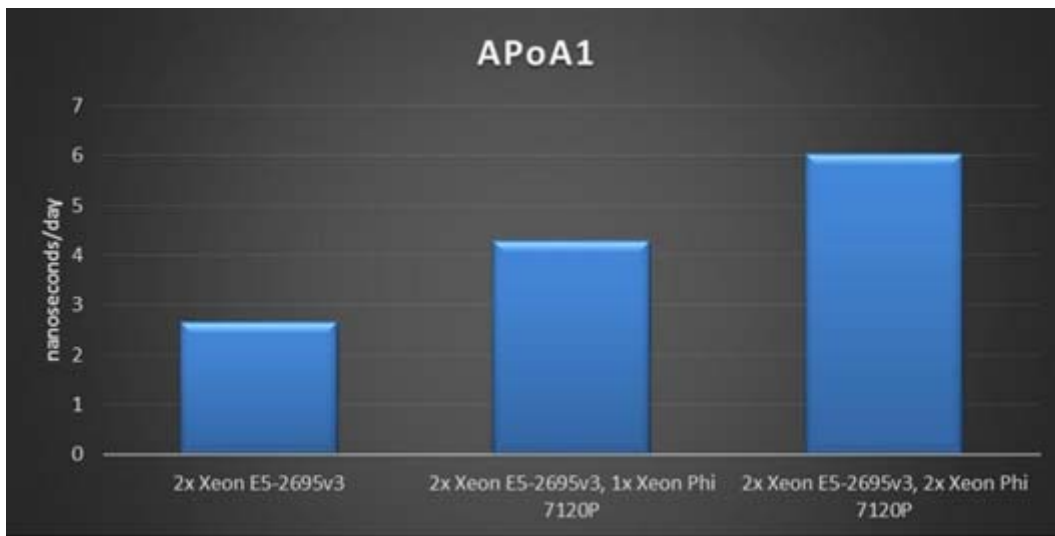
<i>Processor 1</i>		<i>Processor 2</i>	
<i>Intel Xeon® Phi-1</i>	<i>Intel Xeon® Phi-2</i>	<i>Intel Xeon® Phi-1</i>	<i>Intel Xeon® Phi-2</i>
SHOCDownload (GB/s)			
6.91	6.84	6.86	6.87
SHOCReadback (GB/s)			
6.92	6.89	6.91	6.90

NAMD (NANoscale Molecular Dynamics program) is a molecular dynamics simulation package which uses the Charm++ parallel programming model. It has good parallel efficiency and is used to simulate large systems. Here the metric used is nano seconds/day. The benchmark has been run with three different datasets, namely ApoA1, ATPase and STMV. The performance numbers were recorded for CPU set to performance mode and the Intel Xeon® Phi set to ECC OFF and Turbo ON.

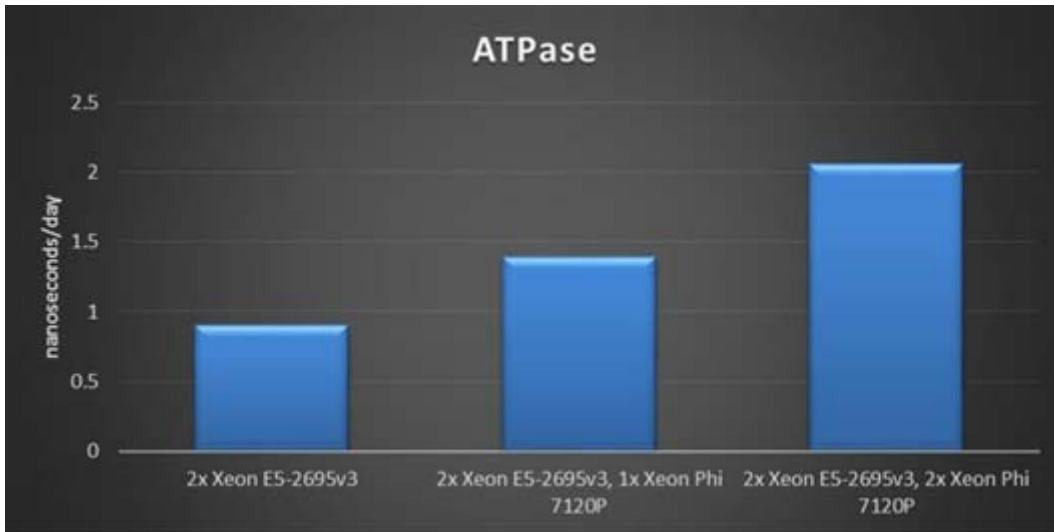
<i>NAMD (nano seconds/day) on Dell PowerEdge® R730</i>		
<i>2x Intel Xeon E5-2695v3</i>	<i>2x Intel Xeon E5-2695v3, 1x Intel Xeon® Phi 7120P</i>	<i>2x Intel Xeon E5-2695v3, 2x Intel Xeon® Phi 7120P</i>

<i>APoA1</i>		
2.65	4.29	6.02
<i>ATPase</i>		
0.9	1.39	2.06
<i>STMV</i>		
0.25	0.4	0.58

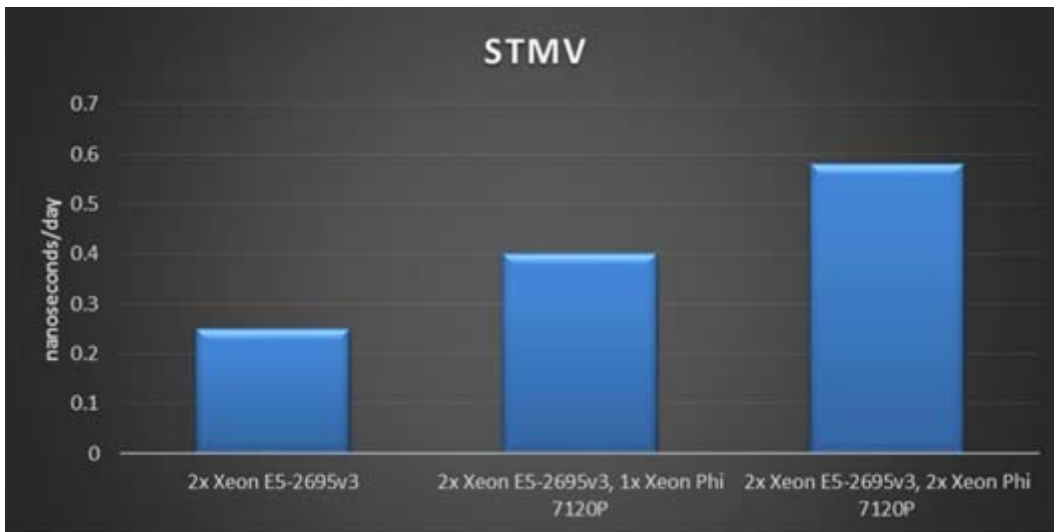
ApoA1 gene provides instructions for making a protein called Apolipoprotein A-I. With the ApoA1 dataset, we observe 60% and 130% performance improvements on configuration with one and two Intel Xeon® Phi 7120P respectively as compared to CPU only configurations.



ATPase are a class of enzymes that catalyze the decomposition of ATP into ADP and free phosphate ion. With the ATPase dataset, we observe 55% and 130% performance improvements on configuration with one and two Intel Xeon® Phi 7120P respectively as compared to CPU only configurations.

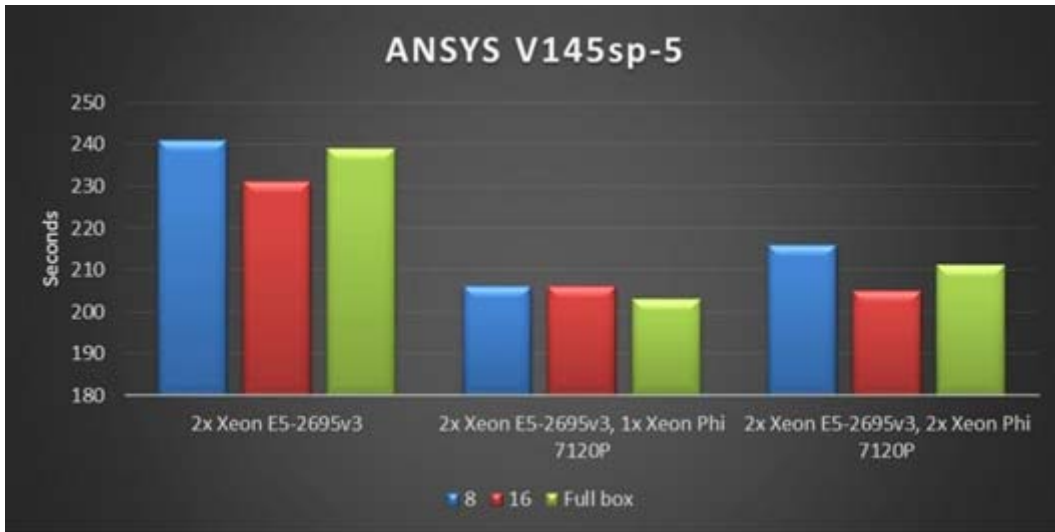


STMV (Satellite Tobacco Mosaic Virus) is a small, icosahedral plant virus. With the STMV dataset, we observe 60% and 130% performance improvements on configuration with one and two Intel Xeon® Phi 7120P respectively as compared to CPU only configurations.



ANSYS Mechanical is a comprehensive FEA analysis (finite element) tool for structural analysis, including linear, nonlinear and dynamic studies. The performance numbers were recorded for CPU set to performance mode and the Intel Xeon® Phi set to ECC ON and Turbo OFF. The best performance was seen with 16 cores. The behavior is as expected and the details for the same can be found [here](#).

ANSYS Mechanical V15.0 with input dataV145sp-5 (seconds) with Dell PowerEdge® R730			
	Xeon E5-2695v3 (Performance Mode)	Xeon E5-2695v3 (Performance Mode), Xeon® Phi (ECC-ON, Turbo-OFF)	Xeon E5-2695v3 (Performance Mode), Xeon® Phi (ECC-ON, Turbo-OFF)
Dell PowerEdge® R730 - 8 Cores	241	206	216
Dell PowerEdge® R730 - 16 Cores	231	206	205
Dell PowerEdge® R730 - All Cores	239	203	211



Concluding remarks:

It has been noted from the results as recorded above that there is a considerable amount of performance gain for most of the applications when using Intel Xeon® Phi with performance improvements in the range of up to 300% across the chosen spectrum of applications and the add-on Intel Xeon® Phi configuration. Overall the users can take advantage of superior performance of the latest Dell PowerEdge® Server powered by Intel Xeon® E5-26xxv3 with support for new extensions coupled with increased memory speed from DDR3 to DDR4.