Contents

1. Amazon EC2 Instance Details

Output of "lscpu":

Architecture:	x86_64
CPU op-mode(s):	32-bit, 64-bit
Byte Order:	Little Endian
CPU(s):	1
On-line CPU(s) list:	0
Thread(s) per core:	1
Core(s) per socket:	1
Socket(s):	1
NUMA node(s):	1
Vendor ID:	Genuine-Intel
CPU family:	6
Model:	45
Stepping:	7
CPU MHz:	1795.672
BogoMIPS:	3591.34
Hypervisor vendor:	Xen
Virtualization type:	para
L1d cache:	32K
L1i cache:	32K
L2 cache:	256K
L3 cache:	20480K
NUMA node0 CPU(s):	0

2. CPU Benchmarking

a. Theoretical Performance

Theoretically maximum FLOPS can be calculated as:

$$Theoretical\ Peak = Number\ of\ Cores * Average\ frequency * Operations\ per\ cycle$$

Number of cores and average frequency is known. Operations per cycle depends on the micro-architecture of the CPU which in this case is Sandy Bridge. Sandy Bridge processor (Intel(R) Xeon(R) CPU E5-2650 0 @ 2.00GHz) can perform 8 DP (Double Precision point) operations per cycle [1][2]. Therefore, theoretical peak value in this experiment is

$$Theoretical\ Peak\ FLOPS = 1 * 1.794 * 4 = \mathbf{14.358\ GFLOPS}$$

b. Linpack Performance

The Linpack run on EC2 instance gives the **best performance to be 6.2814 GFLOPS**. Please find the results in file report/LinpackRun.txt

Efficiency of Linpack compared to theoretical performance: 6.2814*100/14.358 = **43.47%**

c. Experiment Results

After running the cpu benchmarking on EC2 instance, these are the results:

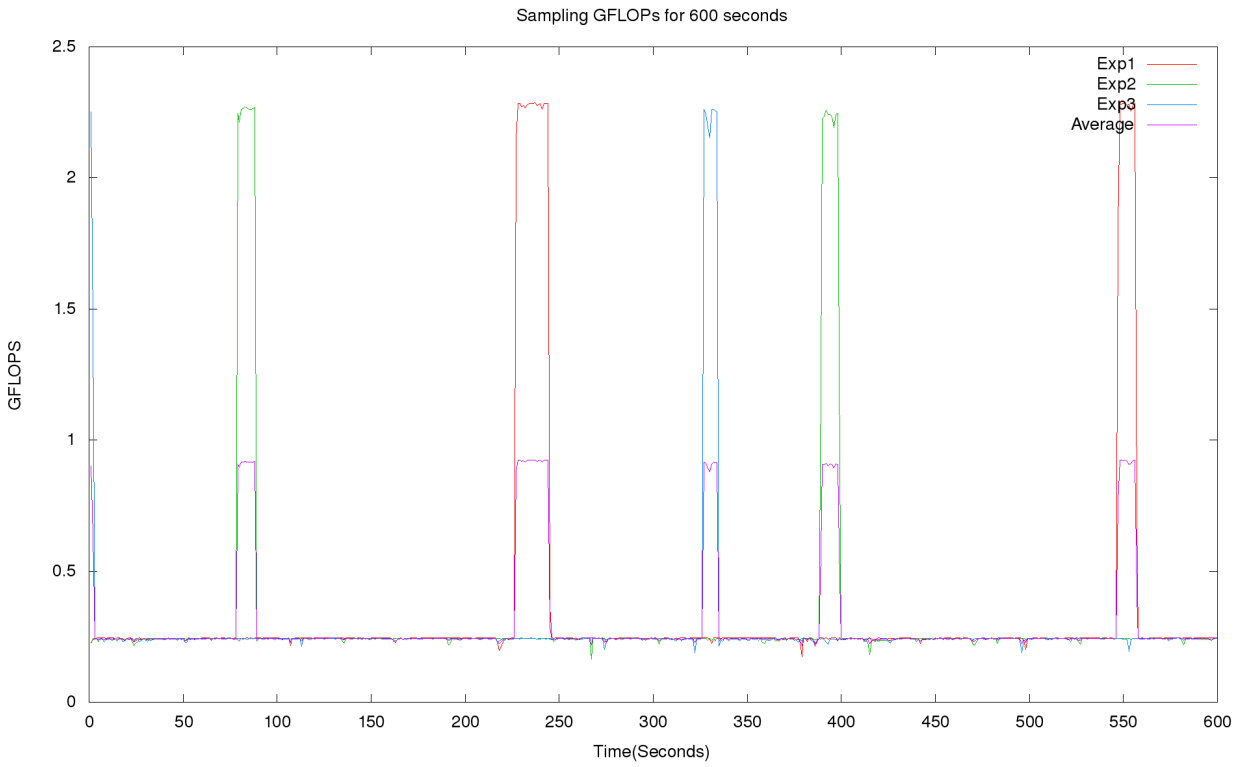
	Experiment 1		Experiment 2		Experiment 3		**Average**		**Standard Deviation**	
Threads	GFLOPS	GIOPS	GFLOPS	GIOPS	GFLOPS	GIOPS	**GIOPS**	**GIOPS**	**GFLOPS**	**GIOPS**
1	0.232	0.243	0.233	0.242	0.236	0.245	**0.23366**	**0.24333**	**0.002082**	**0.001528**
2	0.237	0.246	0.235	0.244	0.233	0.243	**0.235**	**0.24433**	**0.002**	**0.001528**
3	0.233	0.244	0.236	0.238	0.235	0.243	**0.23466**	**0.24166**	**0.001528**	**0.003215**
4	0.233	0.363	0.234	0.243	0.235	0.245	**0.234**	**0.28366**	**0.001**	**0.068712**

All the samples for different runs can be found in data/*.data

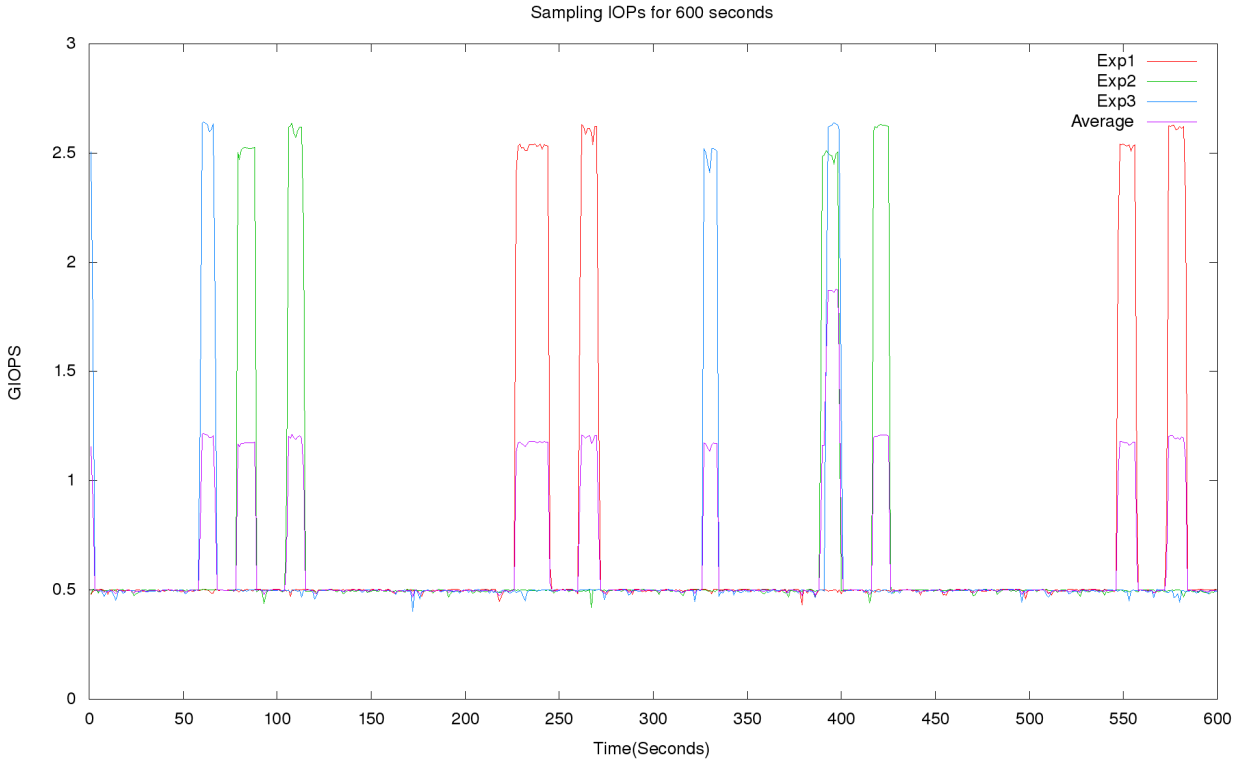
d. Analysis:

Efficiency Achieved compared to theoretical performance: 2.239*100/14.358 = **1.62%**

e. Sampling GFLOPS for 600 seconds:



f. Sampling GIOPS for 600 seconds:



3. Memory Benchmarking

a. Theoretical Performance

The type (Standard Name) of the RAM offered by the EC2 instance is not known. After running stream, it is expected to be [4] DDR3-1066/ DDR3-1333. For these RAMs the **theoretical peak throughput is 10666 MBPS.**

b. Stream

Stream's **best throughput value for copy is 8241.5 MBPS**. Please find the complete resource in report/StreamRun.txt.

c. Experimental Results

Access-Type	Block Size	Num-Threads	Experiment 1		Experiment 2		Experiment 3		Average		Standard Deviation	
			Throughput	Latency	Throughput	Latency	Throughput	Latency	Throughput	Latency	Throughput	Latency
Sequential	B	1	103.4343	9.98291	103.356	9.58496094	103.0181	10.107421	103.269467	9.89176398	0.22118233	0.27289527
Random	B	1	9.7046	41.75049	9.7278	41.7382813	9.6796	41.901855	9.704	41.7968754	0.0241056	0.09111969
Sequential	B	2	69.2802	9.564209	103.9991	19.3432617	103.1146	9.7021484	92.1313	12.869873	19.7945741	5.60654328
Random	B	2	5.4232	72.95532	4.9264	73.2629395	5.69	76.447753	5.34653333	74.2220042	0.38753009	1.93368195
Sequential	KB	1	9995.958	76.48438	10519.686	75.4882813	9162.4702	75.551757	9892.70473	75.8414728	684.473966	0.55767786
Random	KB	1	5896.176	108.5229	6046.3665	107.192383	5663.7688	107.87841	5868.77043	107.864564	192.765528	0.66536665
Sequential	KB	2	5568.277	148.0591	5724.3712	151.463623	5228.2955	146.30371	5506.98123	148.608811	253.654594	2.62351142
Random	KB	2	3005.812	208.2825	3070.4559	188.605957	2967.154	221.54296	3014.47397	206.143806	52.1928432	16.5723279
Sequential	MB	1	399.9397	1160858	535.4433	17249 49.31	382.9044	11179 82.91	439.429133	13345 96.74	83.5858272	33873 4.283
Random	MB	1	393.2001	1045826	490.4802	16196 83.24	355.671	99985 7.336	413.1171	12217 88.86	69.5765425	34535 2.335
Sequential	MB	2	249.6491	3213161	253.2895	32360 77.02	242.2831	28661 71	248.407233	31051 36.34	5.60730638	20726 7.003
Random	MB	2	262.5778	3250012	253.9837	25769 42.48	251.8725	30551 92	256.144667	29607 15.49	5.67037871	34633 7.989

d. Analysis

Peak Throughput Achieved: **9892.7 MBPS**

Efficiency Achieved compared to theoretical performance: 9892.7*100/10666 = **92.74%**

Disk Benchmarking

a. Theoretical Performance

Disks are always slower than memory. In this experiment, Amazon's t2.micro instance was having EBS General Purpose SSD (gp2) disk was used. These general purpose SSDs have Bandwidth no more than 800 MB/s [3]. Thus our **maximum theoretical value is 160 MB/s**.

b. Iozone:

Iozone run on EC2 instance gives the **best performance to be 7100.397 MBPS***. Please find the results in file report/IozoneRun.txt

Efficiency of Iozone compared to theoretical performance: 7100.397*100/160 = **4437.748125%**

*Note: This value though seems unreasonable; but that is what is computed by IOZONE for **reread**. Even though we consider it to be because of cache and look for the average performance it is **2832.759 MB/s** which again doesn't seem to be a good result.*

c. Experimental Results

Access Type	BlockSize	Operation	Threads	Average Throughput	Average Latency
Sequential	B	READ	1	0.46296	0.002059937
Random	B	READ	1	0.35461	0.002689362
Sequential	B	READ	2	1.00253	0.001180172
Random	B	READ	2	0.50736	0.002008677
Sequential	KB	READ	1	456.12472	0.002140999
Random	KB	READ	1	398.44358	0.002450943
Sequential	KB	READ	2	512.3075	0.002045631
Random	KB	READ	2	456.1854	0.00217557
Sequential	MB	READ	1	3206.87509	0.311830044
Random	MB	READ	1	420.79588	2.376449108
Sequential	MB	READ	2	167.84226	5.958064795
Random	MB	READ	2	277.02659	3.609884977
Sequential	B	WRITE	1	0.00078	1.221017838
Random	B	WRITE	1	0.00041	2.315430641
Sequential	B	WRITE	2	0.00079	1.214181185
Random	B	WRITE	2	0.00078	1.22928977
Sequential	KB	WRITE	1	0.42299	2.308728695
Random	KB	WRITE	1	0.46558	2.097499371
Sequential	KB	WRITE	2	0.7428	1.314893961
Random	KB	WRITE	2	0.67589	1.445055008
Sequential	MB	WRITE	1	37.34241	26.77920103
Random	MB	WRITE	1	898.60933	1.112830639
Sequential	MB	WRITE	2	24.40337	41.1184752
Random	MB	WRITE	2	148.83694	6.936600208

d. Analysis

e. Peak Throughput Achieved: **3206 MBPS**

f. Efficiency Achieved compared to theoretical performance:3206*100/7100 = **45.16%**

[1] http://stackoverflow.com/questions/15655835/flops-per-cycle-for-sandy-bridge-and-haswell-sse2-avx-avx2

[2] http://www.nas.nasa.gov/hecc/support/kb/sandy-bridge-processors_301.html

[3] https://aws.amazon.com/ebs/details/

[4] https://en.wikipedia.org/wiki/DDR3_SDRAM