

Throughput Benchmarks

AArch64 vs x86_64



The background of the slide features a series of diagonal stripes in two shades of yellow, creating a modern and energetic visual effect.

We have standard hardware benchmark

<https://clickhouse.com/benchmark/hardware/>

How we run this benchmark(simplified)

<https://clickhouse.com/docs/en/operations/performance-test/>

1

Download ClickHouse build

```
curl https://clickhouse.com/ | sh
```

2

Download dataset

```
wget https://datasets.clickhouse.com/hits/partitions/hits\_100m\_obfuscated
```

3

Run each query three times

```
./clickhouse client --time --format=Null  
--query="$query"
```

4

Reset cache before each query type

```
echo 3 | sudo tee  
/proc/sys/vm/drop_caches >/dev/null
```

5

Add JSON with results to repo

```
https://github.com/ClickHouse/ClickHouse/tree/master/website/benchmark/hardware/results
```



How to run hardware benchmark on your own

```
wget  
https://raw.githubusercontent.com/ClickHouse/ClickHouse/master/benchmark/  
hardware.sh  
  
chmod a+x ./hardware.sh  
./hardware.sh  
  
#  
#  
#  
# PROFIT!
```

We have results like that

<https://clickhouse.com/benchmark/hardware>

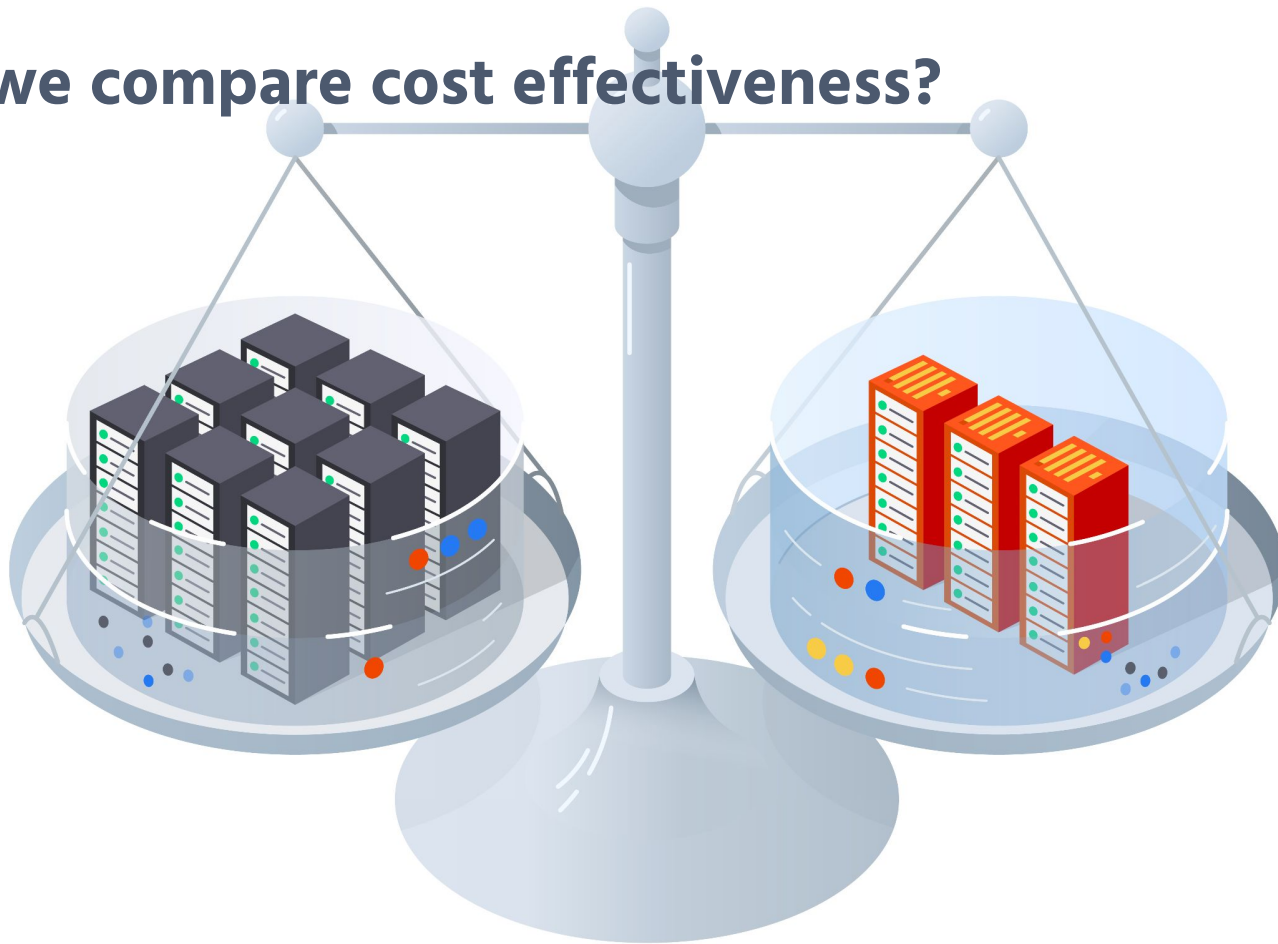
- Allow to see faster CPU/Disk/etc.
- Standardised and easy to reproduce

But

- No throughput
- No cost comparison

Query	AWS c5a.24xlarge		AWS c5a.24xlarge		AWS c6i.32xlarge		AWS c7g.16xlarge (Graviton 3)	
SELECT count() FROM hits	[0.001 s.]	[0.002 s.]	[0.001 s.]	[0.002 s.]	[0.001 s.]	[0.001 s.]	[0.002 s.]	[0.002 s.]
SELECT count() FROM hits WHERE AdvEng	[0.009 s.]	[0.006 s.]	[0.010 s.]	[0.009 s.]	[0.006 s.]	[0.006 s.]	x2.20 [0.022 s.]	x2.30 [0.023 s.]
SELECT sum(AdvEngineID, count()), avgRe	x1.30 [0.013 s.]	x1.20 [0.012 s.]	x1.30 [0.013 s.]	x1.30 [0.013 s.]	[0.006 s.]	[0.006 s.]	x2.50 [0.023 s.]	x2.50 [0.023 s.]
SELECT sum(UserID) FROM hits	x1.38 [0.016 s.]	x1.42 [0.017 s.]	x1.31 [0.017 s.]	x1.33 [0.016 s.]	[0.013 s.]	[0.012 s.]	x4.69 [0.050 s.]	x4.92 [0.051 s.]
SELECT uniq(UserID) FROM hits	[0.064 s.]	[0.053 s.]	[0.064 s.]	x1.02 [0.064 s.]	x1.09 [0.070 s.]	x1.11 [0.070 s.]	x1.14 [0.073 s.]	x1.21 [0.076 s.]
SELECT uniq(SearchPhrase) FROM hits	x1.22 [0.123 s.]	x1.20 [0.118 s.]	x1.25 [0.126 s.]	x1.27 [0.124 s.]	x1.21 [0.122 s.]	x1.27 [0.124 s.]	[0.101 s.]	[0.098 s.]
SELECT min(EventDate), max(EventDate) FI	[0.010 s.]	[0.010 s.]	x1.10 [0.011 s.]	x1.10 [0.011 s.]	[0.007 s.]	[0.007 s.]	[0.002 s.]	[0.002 s.]
SELECT AdvEngineID, count() FROM hits W	[0.008 s.]	[0.006 s.]	[0.009 s.]	[0.009 s.]	[0.006 s.]	[0.006 s.]	x3.00 [0.030 s.]	x3.00 [0.030 s.]
SELECT RegionID, uniq(UserID) AS u FROM	x1.25 [0.141 s.]	x1.21 [0.139 s.]	x1.22 [0.138 s.]	x1.19 [0.137 s.]	x1.27 [0.143 s.]	x1.22 [0.140 s.]	[0.103 s.]	[0.105 s.]
SELECT RegionID, sum(AdvEngineID), coun	x1.24 [0.158 s.]	x1.20 [0.152 s.]	x1.24 [0.158 s.]	x1.26 [0.160 s.]	x1.19 [0.151 s.]	x1.16 [0.147 s.]	[0.127 s.]	[0.127 s.]
SELECT MobilePhoneModel, uniq(UserID) A	x1.10 [0.077 s.]	x1.33 [0.093 s.]	x1.24 [0.087 s.]	x1.19 [0.083 s.]	x1.03 [0.072 s.]	x1.06 [0.074 s.]	[0.070 s.]	[0.070 s.]
SELECT MobilePhone, MobilePhoneModel, l	x1.14 [0.079 s.]	x1.09 [0.073 s.]	x1.28 [0.088 s.]	x1.28 [0.086 s.]	[0.059 s.]	[0.057 s.]	x1.07 [0.074 s.]	x1.07 [0.072 s.]
SELECT SearchPhrase, count() AS c FROM	x1.33 [0.196 s.]	x1.28 [0.185 s.]	x1.41 [0.208 s.]	x1.37 [0.197 s.]	x1.27 [0.186 s.]	x1.21 [0.174 s.]	[0.147 s.]	[0.144 s.]
SELECT SearchPhrase, uniq(UserID) AS u F	x1.36 [0.258 s.]	x1.30 [0.244 s.]	x1.39 [0.264 s.]	x1.37 [0.256 s.]	x1.18 [0.225 s.]	x1.14 [0.213 s.]	[0.190 s.]	[0.187 s.]
SELECT SearchEngineID, SearchPhrase, co	x1.36 [0.239 s.]	x1.29 [0.226 s.]	x1.45 [0.256 s.]	x1.41 [0.247 s.]	x1.17 [0.206 s.]	x1.18 [0.207 s.]	[0.176 s.]	[0.175 s.]
SELECT UserID, count() FROM hits GROUP	x1.17 [0.236 s.]	x1.32 [0.248 s.]	x1.28 [0.258 s.]	x1.39 [0.262 s.]	[0.202 s.]	x1.07 [0.201 s.]	x1.02 [0.206 s.]	[0.188 s.]
SELECT UserID, SearchPhrase, count() FRC	x1.46 [0.693 s.]	x1.48 [0.686 s.]	x1.54 [0.734 s.]	x1.53 [0.709 s.]	x1.08 [0.514 s.]	x1.08 [0.502 s.]	[0.476 s.]	[0.464 s.]
SELECT UserID, SearchPhrase, count() FRC	x1.44 [0.435 s.]	x1.35 [0.413 s.]	x1.49 [0.450 s.]	x1.37 [0.420 s.]	[0.393 s.]	x1.02 [0.312 s.]	x1.15 [0.349 s.]	[0.397 s.]
SELECT UserID, toMinute(EventTime) AS m,	x1.46 [1.279 s.]	x1.77 [1.270 s.]	x1.54 [1.346 s.]	x1.79 [1.288 s.]	x1.22 [1.072 s.]	x1.46 [1.051 s.]	[0.676 s.]	[0.719 s.]
SELECT UserID FROM hits WHERE UserID	[0.035 s.]	x1.04 [0.029 s.]	x1.09 [0.038 s.]	x1.11 [0.031 s.]	x1.49 [0.052 s.]	[0.029 s.]	x2.26 [0.079 s.]	x2.54 [0.071 s.]
SELECT count() FROM hits WHERE URL LI	x1.16 [0.313 s.]	x1.08 [0.280 s.]	x1.11 [0.301 s.]	x1.05 [0.271 s.]	x1.20 [0.324 s.]	[0.298 s.]	[0.270 s.]	x1.13 [0.293 s.]
SELECT SearchPhrase, any(URL), count() A	x1.22 [0.287 s.]	x1.18 [0.248 s.]	x1.19 [0.281 s.]	x1.21 [0.255 s.]	x1.04 [0.246 s.]	[0.210 s.]	[0.236 s.]	x1.06 [0.222 s.]
SELECT SearchPhrase, any(URL), any(Title)	x1.25 [0.617 s.]	x1.14 [0.558 s.]	x1.25 [0.615 s.]	x1.19 [0.582 s.]	[0.493 s.]	[0.490 s.]	x1.59 [0.783 s.]	x1.71 [0.838 s.]
SELECT * FROM hits WHERE URL LIKE %r	x1.35 [0.410 s.]	x1.19 [0.367 s.]	x1.24 [0.376 s.]	x1.14 [0.350 s.]	[0.304 s.]	[0.308 s.]	x3.83 [1.166 s.]	x3.87 [1.169 s.]
SELECT SearchPhrase FROM hits WHERE :	x1.39 [0.086 s.]	x1.34 [0.082 s.]	x1.34 [0.083 s.]	x1.30 [0.079 s.]	[0.082 s.]	[0.091 s.]	x1.81 [0.112 s.]	x1.87 [0.114 s.]
SELECT SearchPhrase FROM hits WHERE :	x1.39 [0.075 s.]	x1.29 [0.067 s.]	x1.43 [0.077 s.]	x1.40 [0.073 s.]	[0.054 s.]	[0.053 s.]	x1.15 [0.062 s.]	x1.15 [0.060 s.]
SELECT SearchPhrase FROM hits WHERE :	x1.05 [0.080 s.]	x1.29 [0.080 s.]	x1.12 [0.085 s.]	x1.29 [0.080 s.]	[0.076 s.]	[0.082 s.]	x1.36 [0.103 s.]	x1.82 [0.113 s.]
SELECT CounterID, avglength(URL) AS l, c	x1.13 [0.270 s.]	x1.05 [0.253 s.]	x1.15 [0.274 s.]	x1.07 [0.257 s.]	[0.239 s.]	[0.241 s.]	x1.08 [0.257 s.]	x1.02 [0.245 s.]
SELECT domainWithoutWWW(Referrer) AS k	x1.37 [0.373 s.]	x1.30 [0.339 s.]	x1.42 [0.388 s.]	x1.40 [0.363 s.]	[0.273 s.]	[0.290 s.]	x1.05 [0.288 s.]	x1.10 [0.285 s.]
SELECT sum(ResolutionWidth), sum(Resol	x2.12 [0.868 s.]	x2.10 [0.866 s.]	x2.13 [0.870 s.]	x2.11 [0.870 s.]	[0.406 s.]	[0.413 s.]	x2.05 [0.837 s.]	x2.03 [0.837 s.]
SELECT SearchEngineID, ClientIP, count() A	x1.18 [0.168 s.]	x1.11 [0.154 s.]	x1.30 [0.184 s.]	x1.20 [0.167 s.]	[0.142 s.]	[0.139 s.]	x1.06 [0.151 s.]	x1.02 [0.142 s.]
SELECT WatchID, ClientIP, count() AS c, sun	x1.12 [0.240 s.]	x1.09 [0.223 s.]	x1.17 [0.251 s.]	x1.14 [0.233 s.]	[0.214 s.]	[0.208 s.]	x1.05 [0.224 s.]	x1.05 [0.214 s.]
SELECT WatchID, ClientIP, count() AS c, sun	x1.89 [1.787 s.]	x2.02 [1.804 s.]	x1.91 [1.809 s.]	x2.10 [1.870 s.]	[0.947 s.]	[0.892 s.]	x1.31 [1.236 s.]	x1.53 [1.366 s.]
SELECT URL, count() AS c FROM hits GRO	x1.47 [1.079 s.]	x1.41 [1.019 s.]	x1.65 [1.211 s.]	x1.47 [1.063 s.]	[0.734 s.]	[0.725 s.]	x1.10 [0.805 s.]	x1.08 [0.780 s.]
SELECT 1, URL, count() AS c FROM hits GR	x1.42 [1.066 s.]	x1.50 [1.023 s.]	x1.49 [1.117 s.]	x1.54 [1.050 s.]	[0.749 s.]	[0.581 s.]	x1.11 [0.830 s.]	x1.16 [0.792 s.]
SELECT ClientIP AS x, x - 1, x - 2, x - 3, cour	x1.43 [0.349 s.]	x1.36 [0.331 s.]	x1.35 [0.329 s.]	x1.39 [0.340 s.]	[0.244 s.]	[0.244 s.]	x1.25 [0.304 s.]	x1.20 [0.294 s.]
SELECT URL, count() AS PageViews FR	x1.13 [0.149 s.]	x1.10 [0.152 s.]	x1.23 [0.163 s.]	x1.20 [0.166 s.]	[0.132 s.]	[0.138 s.]	x1.08 [0.143 s.]	x1.27 [0.175 s.]
SELECT Title, count() AS PageViews FR	x1.03 [0.061 s.]	x1.11 [0.061 s.]	x1.17 [0.069 s.]	x1.27 [0.070 s.]	[0.059 s.]	[0.055 s.]	x1.12 [0.066 s.]	x1.24 [0.068 s.]
SELECT URL, count() AS PageViews FR	x1.02 [0.056 s.]	x1.04 [0.055 s.]	x1.09 [0.060 s.]	x1.11 [0.059 s.]	[0.055 s.]	[0.053 s.]	x1.33 [0.073 s.]	x1.21 [0.064 s.]
SELECT TrafficSourceID, SearchEngineID	x1.10 [0.342 s.]	x1.10 [0.347 s.]	x1.17 [0.366 s.]	x1.19 [0.378 s.]	[0.312 s.]	[0.316 s.]	x1.24 [0.386 s.]	x1.18 [0.372 s.]
SELECT URLHash, EventDate, count()	x1.14 [0.025 s.]	x1.67 [0.025 s.]	x1.14 [0.025 s.]	x2.13 [0.032 s.]	[0.082 s.]	[0.016 s.]	x1.36 [0.030 s.]	x2.13 [0.032 s.]
SELECT WindowClientWidth, WindowClic	[0.014 s.]	x1.17 [0.014 s.]	x1.64 [0.023 s.]	x1.17 [0.014 s.]	x1.21 [0.017 s.]	[0.015 s.]	x2.14 [0.030 s.]	x2.33 [0.028 s.]
SELECT toStartOfMinute(EventTime) AS M	[0.010 s.]	[0.002 s.]	[0.004 s.]	x2.10 [0.021 s.]	[0.008 s.]	[0.002 s.]	x1.60 [0.016 s.]	[0.004 s.]
Geometric mean of ratios	x1.23	x1.24	x1.28	x1.31	x1.06	x1.04	x1.33	x1.36
	x1.23		x1.29		x1.05		x1.34	

How we compare cost effectiveness?



Process Slide

3 Steps Treatment



Check throughput



Normalize to costs



Decide



Throughput check

```
cat queries.sql | clickhouse-benchmark -c 10 --timelimit 600 --cumulative
```

```
# same 43 queries from hardware benchmark
```

```
# -c 10 - run 10 threads in parallel
```

```
# --timelimit 600 - run for 10 minutes
```

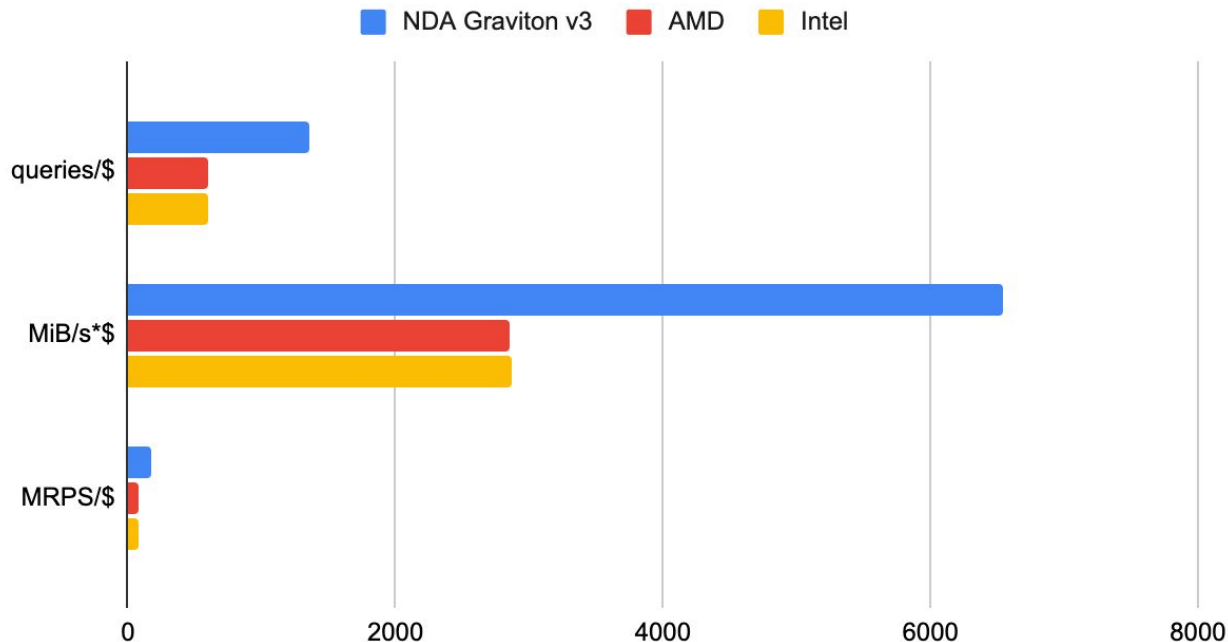
```
# You can play with parallelism to fit memory or have higher server CPU  
utilisation
```



Should we use AArch64(ARM) or x86_64(Intel/AMD)?

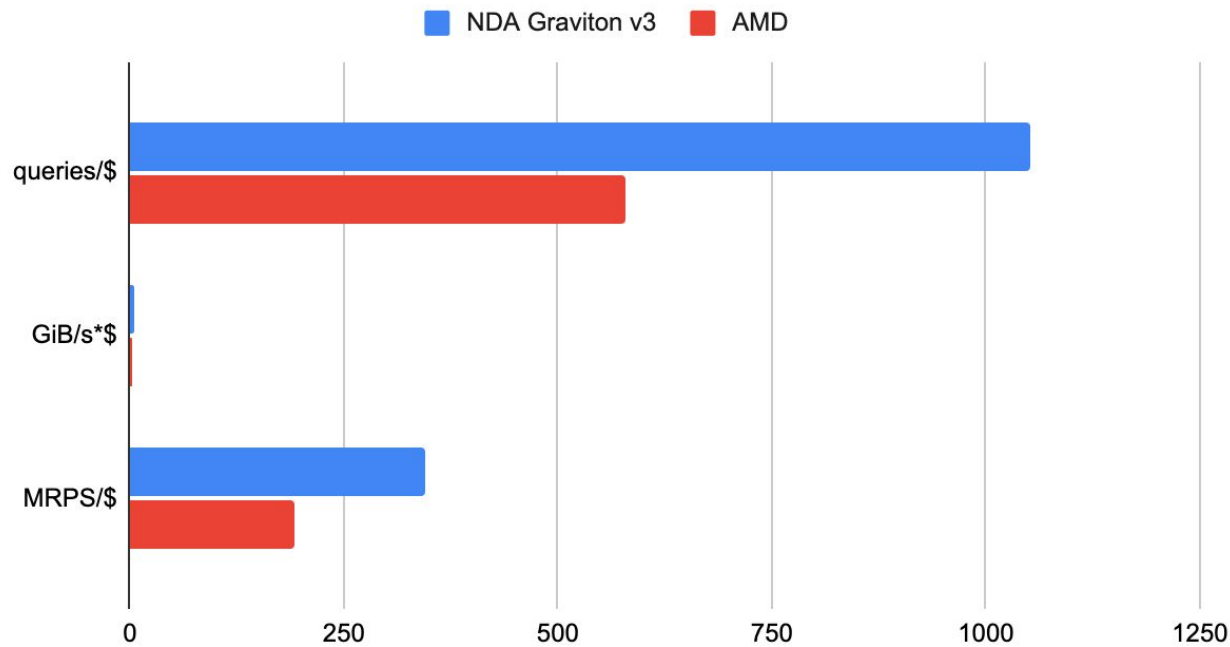
Example

All 43 tests



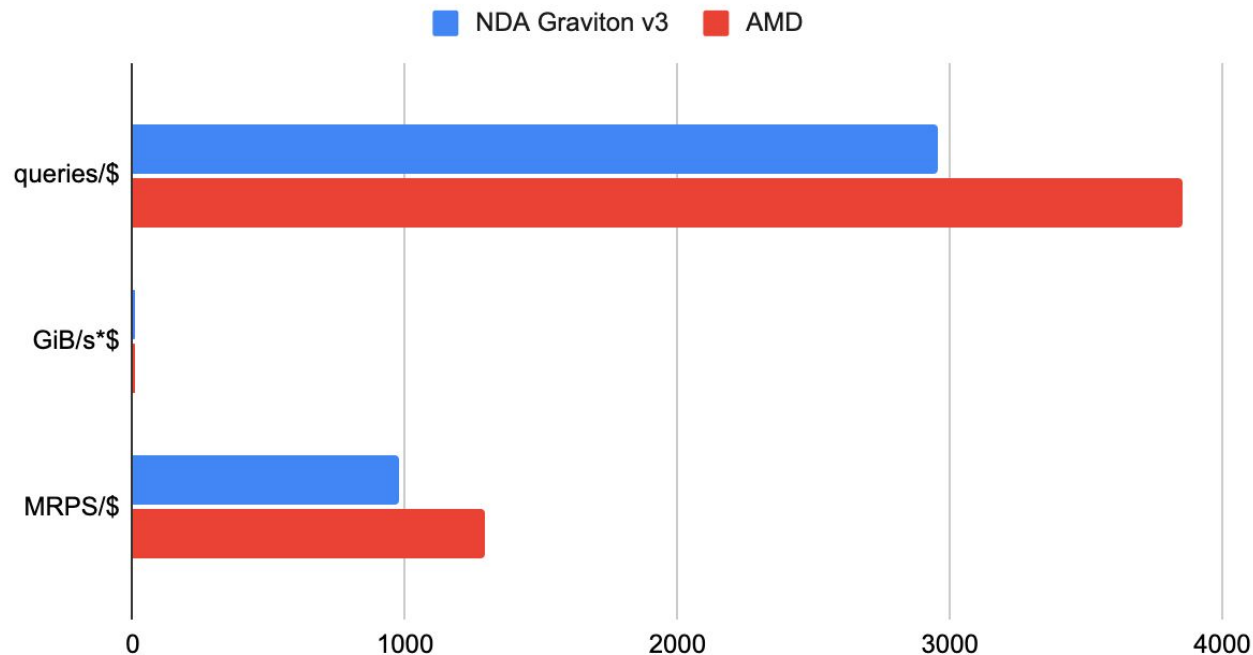
Should we use AArch64(ARM) or x86_64(Intel/AMD)?

Test 10



Should we use AArch64(ARM) or x86_64(Intel/AMD)?

Test 20



What we do next?

- We added performance tests for AArch64 in CI
- Optimize code for both platforms
- Try to find better way to choose parallelism
- Analyse results for each test