Performance Evaluation Report

CSE 503 Rapid Prototype Development and Creative Programming

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The experiments selected as a part of these evaluation report are –

1. Apache web server performance evaluation on different AWS instance types
2. MySQL Performance evaluation on different AWS instance types

We have used two AWS instances for the running the experiments. The configurations are tabulated below [1]

Instance type System parameters	t2.micro	t2.xlarge
vCPUs	1	4
Baseline Performance	10%	90%
Memory (GiB)	1	16

Experiment #1 - Apache web server performance evaluation on different AWS instance types

- **Environmental Setup**:

The webserver benchmarking tool we are using is ApacheBench, which can be run from linux command line ab. Since the ApacheBench is installed automatically with apache, no complicated setup is needed for the environment if your apache is correctly installed.

Site: /~Lars/md3/ (Dummy page on my instance)

Web Server: Apache/2.4.25

1. Running test on t2.micro instance

Applied command line:

$$ab\ -c\ 10\ -n\ 1000\ -g\ out.data\ http://ec2-54-89-49-182.compute-1.amazonaws.com/\sim Lars/md3/$$

This command will run for 1000 requests in total with 10 current requests, and output the data log to out.data file.

Result:

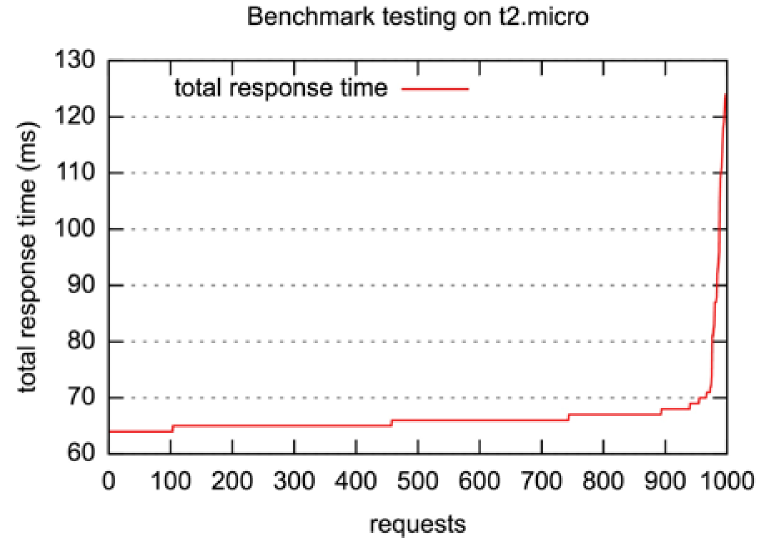
```
Document Path:          /~Lars/md3/
Document Length:         781 bytes
Concurrency Level:          10
Time taken for tests:      6.684 seconds
Complete requests:         1000
Failed requests:           0
Total transferred:         1055000 bytes
HTML transferred:          781000 bytes
Requests per second:       149.62 [#/sec] (mean)
Time per request:          66.836 [ms] (mean)
Time per request:          6.684 [ms] (mean, across all concurrent requests)
Transfer rate:             154.15 [Kbytes/sec] received
```

Connection Times (ms)

```
              min     mean    [+/-sd]  median  max
Connect:      32      33      2.6      33      90
Processing:   31      34      5.2      33      91
Waiting:      31      34      5.2      33      91
Total:        63      67      5.9      66      124
```

Observation:

It can be observed that Apache can serve around 149 requests per second and the mean time to send one request is 6.684 ms. Visualization of “requests v. total response time”:



Next, we increase the current request to 50 and remain the other parameters to have the command line as follow:

$$ab\ -c\ 50\ -n\ 1000\ -g\ out2.data\ http://ec2-54-175-149-197.compute-1.amazonaws.com/\sim Lars/md3/$$

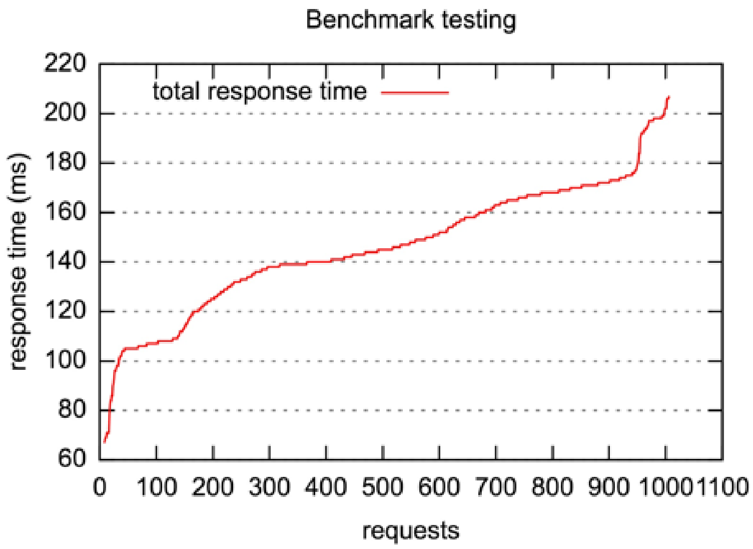
And the result is:

```
Document Path:          /~Lars/md3/
Document Length:        781 bytes
Concurrency Level:      50
Time taken for tests:   2.974 seconds
Complete requests:      1000
Failed requests:        0
Total transferred:      1055000 bytes
HTML transferred:       781000 bytes
Requests per second:    336.25 [#/sec] (mean)
Time per request:       148.698 [ms] (mean)
Time per request:       2.974 [ms] (mean, across all concurrent requests)
Transfer rate:          346.43 [Kbytes/sec] received
```

Connection Times (ms)

```
              min    mean   [+/-sd]  median  max
Connect:      32     35     6.4      34      104
Processing:   35     111    24.9     111     172
Waiting:      35     111    25.0     110     172
Total:        67     146    25.4     145     207
```

The number of request/second is now 336 and the mean time to send one request is 2.974 ms. These numbers are half of the amount when the current request number was set as 10. And the new visualization of requests vs total response time is as shown below:



In our expectation, the new numbers should be 5 times smaller than the original numbers instead of merely 2 times since the current requests are 5 times larger. We conclude the reason to be the type of AWS instance. The current instance type is t2.micro, which has limited memory of 1 GiB. Such limited memory may affect the processing of server, so we decided to change the type to t2.xlarge, with 16 GiB of memory, to see whether it will work as our expectation.

Running test on t2.xlarge instance

Applied command line:

$$ab\ -c\ 10\ -n\ 1000\ -g\ out2.data\ \ http://ec2-54-175-149-197.compute \\ -1.amazonaws.com/{\sim}Lars/md3/$$

This command runs for 1000 requests in total with 10 current requests.

Results:

```
Document Path:          /~Lars/md3/
Document Length:        781 bytes
Concurrency Level:      10
Time taken for tests:   6.612 seconds
```

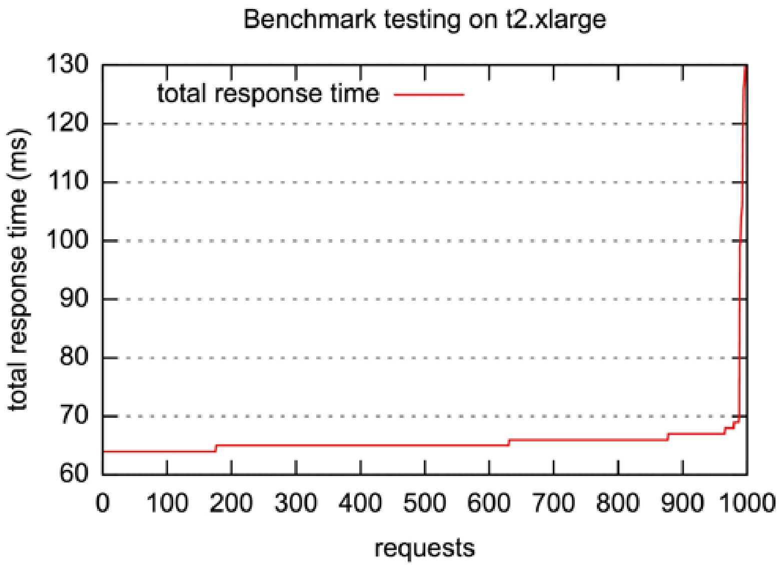
```
Complete requests:       1000
Failed requests:         0
Total transferred:       1055000 bytes
HTML transferred:        781000 bytes
Requests per second:     151.24 [#/sec] (mean)
Time per request:        66.122 [ms] (mean)
Time per request:        6.612 [ms] (mean, across all concurrent requests)
Transfer rate:           155.81 [Kbytes/sec] received
```

```
Connection Times (ms)

              min     mean    [+/-sd]   median   max

Connect:      32      33      3.7       33       95
Processing:   32      33      3.4       33       96
Waiting:      31      33      3.4       32       96
Total:        63      66      5.1       65       130
```

Observation:

It can be observed that Apache can serve around 151 requests per second and the mean time to send one request is 6.612 ms.

Visualization of “requests v. total response time”:



From the visualization and observation, we can see that there the test result on a different instance type is pretty much the same as before. And what will be the case if we change some of the parameters?

Applied command:

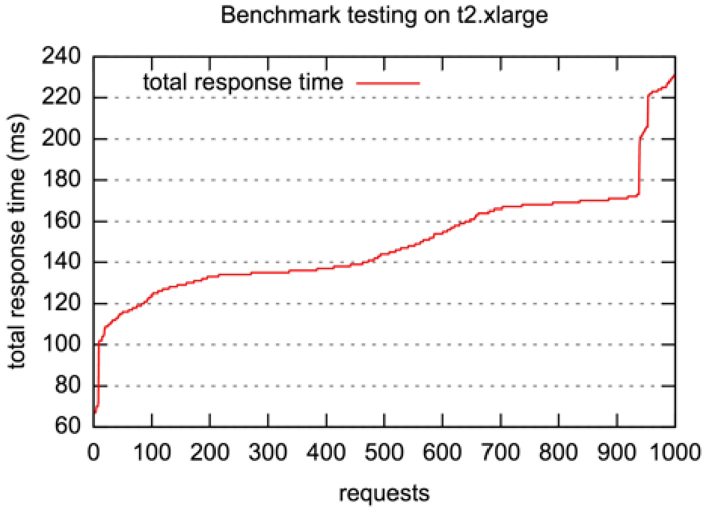
```
ab -c 50 -n 1000 -g out2.data http://ec2-54-175-149-197.compute-1.amazonaws.com/~Lars/md3/
```

this command increases the current requests to 50, and the result is:

```
Document Path:          /~Lars/md3/
Document Length:        781 bytes
Concurrency Level:      50
Time taken for tests:   3.041 seconds
Complete requests:      1000
Failed requests:        0
Total transferred:      1055000 bytes
HTML transferred:       781000 bytes
Requests per second:    328.82 [#/sec] (mean)
Time per request:       152.057 [ms] (mean)
Time per request:       3.041 [ms] (mean, across all concurrent requests)
Transfer rate:          338.78 [Kbytes/sec] received
```

```
Connection Times (ms)

              min     mean    [+/-sd]  median  max
Connect:      32      34      5.6      33      94
Processing:   33      115     25.1     111     197
Waiting:      33      115     25.1     111     197
Total:        66      150     26.2     144     231
```

With the 328 requests/second and the 3.041 ms of mean time to send one request, which are also very close to the results from the instance type with much smaller memory. The visualization of it states the same case as well:



Even after the number of total request is increased, the two instance types have the similar results.

Putting all results together we have:

AWS Instance Type	Total Request #	Current Request #	Requests per Second	Time per Request (ms)
t2.micro	1000	10	149.62	6.684
t2.xlarge	1000	10	151.24	6.612
t2.micro	1000	50	336.25	2.947
t2.xlarge	1000	50	328.82	3.041
t2.micro	10000	50	631.30	1.584
t2.xlarge	10000	50	644.64	1.551

By comparing the results from evaluation different AWS instance types, we find that the there is almost no major difference. There could be to two possible reasons of it. First, the application we are testing is very easy to process, therefore the difference of the processing results from different AWS instances is too little to be observed. However, if that is the case, it is hard to explain why after the current request number was enlarged five times yet the results did not change as expect. This problem leads to the second possibility, when the server was dealing with the requests, it met a bottleneck.

Experiment #2 - MySQL Performance evaluation on different AWS instance types

In this experiment, we are evaluating the number of operations/queries that a mysql database can handle on two different instances of AWS i.e. t2.micro and t2.xlarge

The parameters that we are looking to evaluate are the number of requests (or queries) that the instance can support for various multithreaded configurations.

- **Environment Setup**

The tests were performed using Sysbench, which is one of the most common benchmarking tools. It can be used for CPU performance test, OLTP performance test and file I/O tests. Here, we use the Sysbench for the OLTP performance tests.

The following steps were followed to install Sysbench

```
wget http://pkgs.fedoraproject.org/repo/pkgs/sysbench/sysbench
        -0.4.12.tar.gz/3a6d54fdd3fe002328e4458206392b9d/sysbench-0.4.12.tar.gz
```

```
tar zxvf sysbench-0.4.12.tar.gz
```

```
yum install libtool.x86_64 openssl-devel.x86_64 openssl-static.x86_64
```

```
cd sysbench-0.4.12/
```

```
libtoolize --force --copy
```

```
./autogen.sh
```

```
./configure
```

```
make
```

```
make install
```

mysql.h header file was not located while running the *make* command. This was resolved by running *sudo yum install mysql-devel* command to install dependencies.

A database was created with a table having 1000000 records

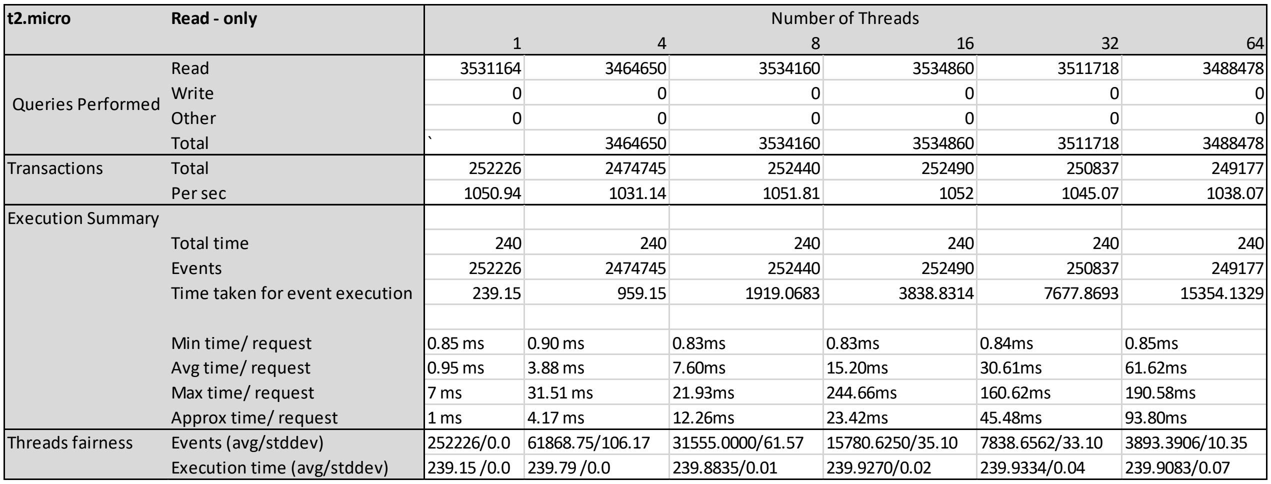
```
sysbench --test=oltp --db-driver=mysql --oltp-table-size=1000000 --mysql-db
        =sysbench --mysql-user=test --mysql-password=test prepare
```

Now, we run 2 separate tests – one with read-only operations and the other with both read-write operations.

- **Results**
  1. **Read-only operations**

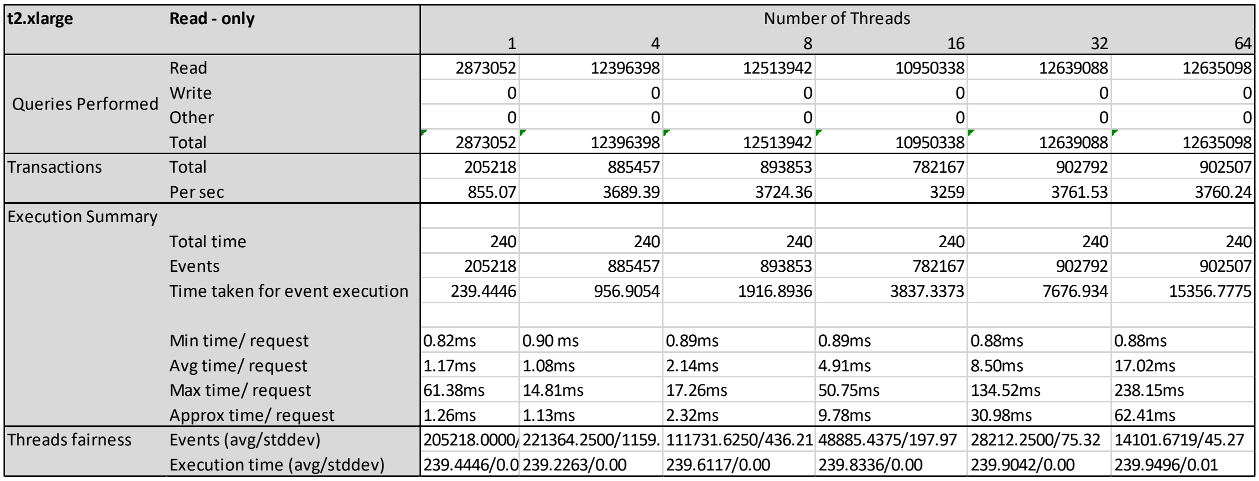
Running test to execute Read-only operations for multiple configurations for number of threads [2]

```
for each in 1 4 8 16 32 64; do sysbench --test=oltp --db-driver=mysql --oltp-table-size
        =1000000 --mysql-db=sysbench --mysql-user=test --mysql-password
        =test --max-time=240 --max-requests
        =0 --oltp-read-only --oltp-skip-trx --oltp-nontrx-mode
        =select --num-threads=$each run; sleep 10; done
```



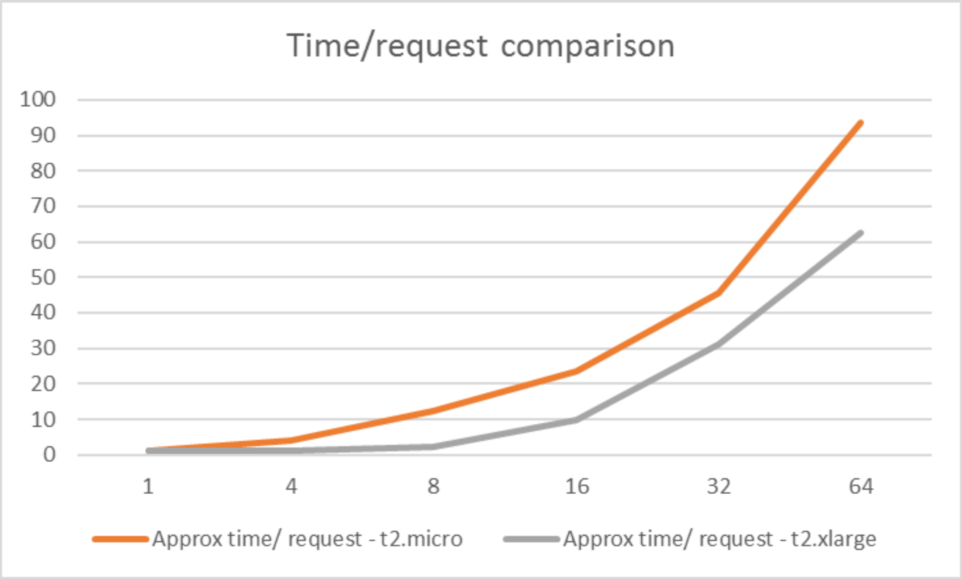
t2.micro	Read - only	Number of Threads					
		1	4	8	16	32	64
Queries Performed	Read	3531164	3464650	3534160	3534860	3511718	3488478
	Write	0	0	0	0	0	0
	Other	0	0	0	0	0	0
	Total	`	3464650	3534160	3534860	3511718	3488478
Transactions	Total	252226	2474745	252440	252490	250837	249177
	Per sec	1050.94	1031.14	1051.81	1052	1045.07	1038.07
Execution Summary							
	Total time	240	240	240	240	240	240
	Events	252226	2474745	252440	252490	250837	249177
	Time taken for event execution	239.15	959.15	1919.0683	3838.8314	7677.8693	15354.1329
	Min time/ request	0.85 ms	0.90 ms	0.83ms	0.83ms	0.84ms	0.85ms
	Avg time/ request	0.95 ms	3.88 ms	7.60ms	15.20ms	30.61ms	61.62ms
	Max time/ request	7 ms	31.51 ms	21.93ms	244.66ms	160.62ms	190.58ms
	Approx time/ request	1 ms	4.17 ms	12.26ms	23.42ms	45.48ms	93.80ms
Threads fairness	Events (avg/stddev)	252226/0.0	61868.75/106.17	31555.0000/61.57	15780.6250/35.10	7838.6562/33.10	3893.3906/10.35
	Execution time (avg/stddev)	239.15 /0.0	239.79 /0.0	239.8835/0.01	239.9270/0.02	239.9334/0.04	239.9083/0.07

Next, we evaluate the performance of a t2.xlarge instance. The environment setup was done to change the existing instance to the new one. The tests were run and the results obtained are plotted next.



t2.xlarge	Read - only	Number of Threads					
		1	4	8	16	32	64
Queries Performed	Read	2873052	12396398	12513942	10950338	12639088	12635098
	Write	0	0	0	0	0	0
	Other	0	0	0	0	0	0
	Total	2873052	12396398	12513942	10950338	12639088	12635098
Transactions	Total	205218	885457	893853	782167	902792	902507
	Per sec	855.07	3689.39	3724.36	3259	3761.53	3760.24
Execution Summary							
	Total time	240	240	240	240	240	240
	Events	205218	885457	893853	782167	902792	902507
	Time taken for event execution	239.4446	956.9054	1916.8936	3837.3373	7676.934	15356.7775
	Min time/ request	0.82ms	0.90 ms	0.89ms	0.89ms	0.88ms	0.88ms
	Avg time/ request	1.17ms	1.08ms	2.14ms	4.91ms	8.50ms	17.02ms
	Max time/ request	61.38ms	14.81ms	17.26ms	50.75ms	134.52ms	238.15ms
	Approx time/ request	1.26ms	1.13ms	2.32ms	9.78ms	30.98ms	62.41ms
Threads fairness	Events (avg/stddev)	205218.0000/	221364.2500/1159.	111731.6250/436.21	48885.4375/197.97	28212.2500/75.32	14101.6719/45.27
	Execution time (avg/stddev)	239.4446/0.0	239.2263/0.00	239.6117/0.00	239.8336/0.00	239.9042/0.00	239.9496/0.01

The approx. time per request increases as we increase the number of threads for both the instances. The results clearly show that more number of queries are serviced in a fixed time interval by t2.xlarge as compared to t2.micro. The comparison of time required (in ms) per request vs the number of threads used in the setup for both the instances is shown below.

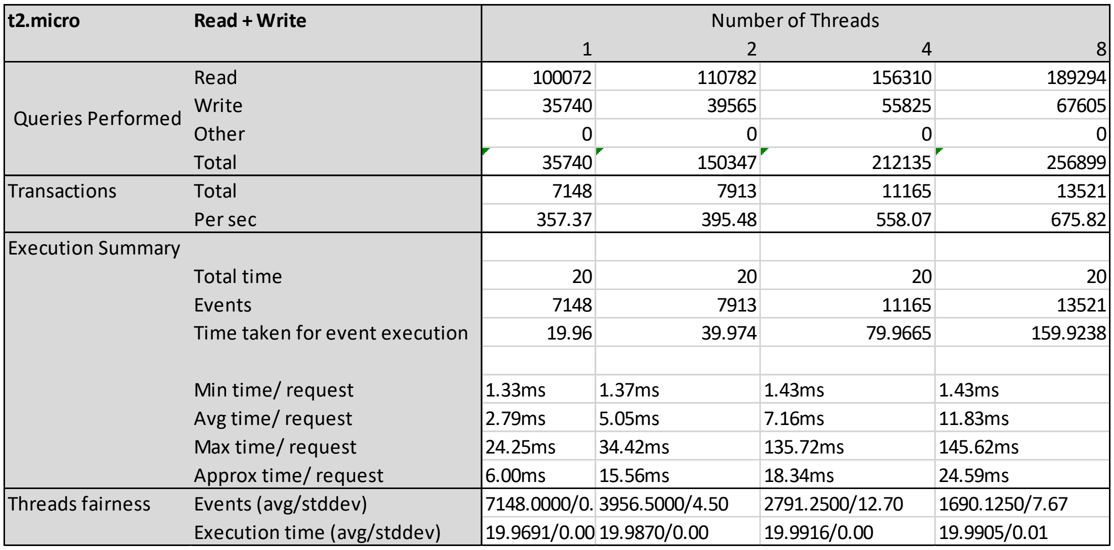


2. Read + Write operations

The following command was executed to trigger a test for read-write operations on the AWS instance.

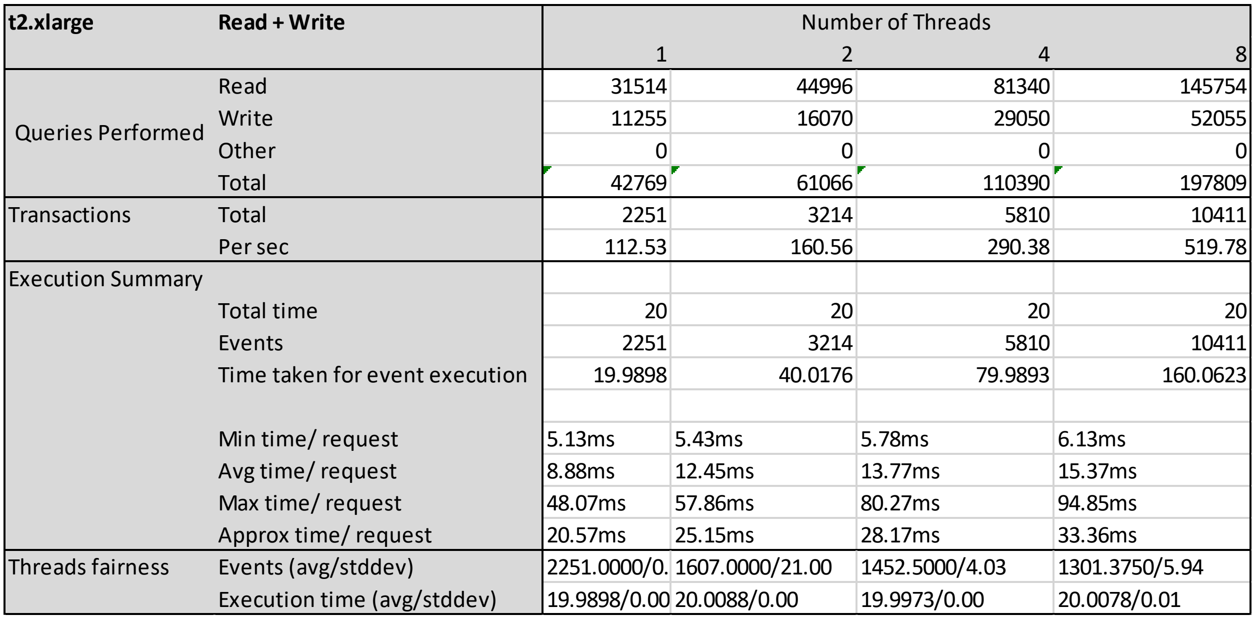
$$\begin{aligned} &for\ each\ in\ 1\ 2\ 4\ 8;\ do\ sysbench\ \ --test = oltp\ \ --db - driver = mysql\ \ --oltp - table - size \\ &\qquad = 1000000\ \ --mysql - db = sysbench\ \ --mysql - user = test\ \ --mysql - password \\ &\qquad = test\ \ --max - time = 20\ \ --max - requests \\ &\qquad = 0\ \ --oltp - skip - trx\ \ \ --oltp - nontrx - mode = select\ \ --num - threads \\ &\qquad = \$each\ run;\ sleep\ 10;\ done \end{aligned}$$

The results for the above command are tabulated next:



t2.micro	Read + Write	Number of Threads			
		1	2	4	8
Queries Performed	Read	100072	110782	156310	189294
	Write	35740	39565	55825	67605
	Other	0	0	0	0
	Total	35740	150347	212135	256899
Transactions	Total	7148	7913	11165	13521
	Per sec	357.37	395.48	558.07	675.82
Execution Summary					
	Total time	20	20	20	20
	Events	7148	7913	11165	13521
	Time taken for event execution	19.96	39.974	79.9665	159.9238
	Min time/ request	1.33ms	1.37ms	1.43ms	1.43ms
	Avg time/ request	2.79ms	5.05ms	7.16ms	11.83ms
	Max time/ request	24.25ms	34.42ms	135.72ms	145.62ms
	Approx time/ request	6.00ms	15.56ms	18.34ms	24.59ms
Threads fairness	Events (avg/stddev)	7148.0000/0.	3956.5000/4.50	2791.2500/12.70	1690.1250/7.67
	Execution time (avg/stddev)	19.9691/0.00	19.9870/0.00	19.9916/0.00	19.9905/0.01

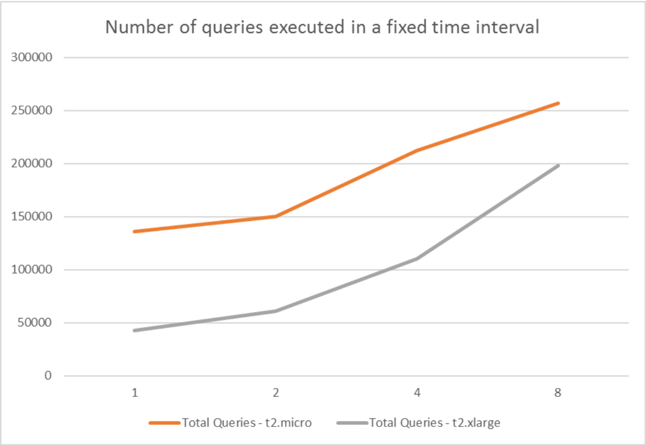
The same set of tests were run on a t2.xlarge instance and the results are tabulated below.



t2.xlarge	**Read + Write**	Number of Threads			
		1	2	4	8
Queries Performed	Read	31514	44996	81340	145754
	Write	11255	16070	29050	52055
	Other	0	0	0	0
	Total	42769	61066	110390	197809
Transactions	Total	2251	3214	5810	10411
	Per sec	112.53	160.56	290.38	519.78
Execution Summary					
	Total time	20	20	20	20
	Events	2251	3214	5810	10411
	Time taken for event execution	19.9898	40.0176	79.9893	160.0623
	Min time/ request	5.13ms	5.43ms	5.78ms	6.13ms
	Avg time/ request	8.88ms	12.45ms	13.77ms	15.37ms
	Max time/ request	48.07ms	57.86ms	80.27ms	94.85ms
	Approx time/ request	20.57ms	25.15ms	28.17ms	33.36ms
Threads fairness	Events (avg/stddev)	2251.0000/0.	1607.0000/21.00	1452.5000/4.03	1301.3750/5.94
	Execution time (avg/stddev)	19.9898/0.00	20.0088/0.00	19.9973/0.00	20.0078/0.01

Now, we plot the number of queries executed vs number of threads in 20s for each of the two instances. This graph proves that the t2.micro instance executes more number of queries than the t2.xlarge instance. From previous graph (having read-only operations), we know that, t2.xlarge outperforms t2.micro.

Based on the above two observations, we can conclude that the Write operation is executed slowly on t2.xlarge as compared to t2.micro instance of AWS.



It is clear from the graph that, as the number of threads increase, the number of queries that can be executed in time t, increase too. However, it is not possible to keep increasing the number of threads. We discuss this in the bottlenecks section.

While testing for the read-write operations using the following query,

$$\begin{aligned} for\ each\ in\ 1\ 4\ 8\ 16\ 32\ 64;\ do\ sysbench\ --test = oltp\ --db - driver = mysql\ --oltp - table - size& \\ = 1000000\ --mysql - db = sysbench\ --mysql - user = test\ --mysql - password& \\ = test\ --max - time = 240\ --max - requests& \\ = 0\ --oltp - skip - trx\ \ --oltp - nontrx - mode = select\ --num - threads& \\ = \$each\,run;\ sleep\ 10;\ done& \end{aligned}$$

, we ran into Duplicate primary key issues while running this test on 16, 32 and 64 threads for both the t2.micro and t2.xlarge instances. Hence, the tests were executed on 1, 2, 4, 8 threads' configurations.

- **Bottlenecks:**

In case of read-only operations, the database gave an error when attempting to create 256 or more threads. The error received was "FATAL: error 1040: Too many connections". Thus, increasing the number of threads to execute more number of operations per second results in a system bottleneck as the number of threads increase. Similarly, increasing the number of threads caused 'Duplicate Entry for Primary Key' Error while performing multi-threaded Read-write operations. This is another potential system bottleneck. These two factors need to be considered while determining multithreaded configurations for the AWS instance to be used for your application.

CONCLUSION

The evaluations of the above two experiments give us a clear picture regarding the capabilities of each instance based on the selected parameters. Hence, the decision of selecting a configuration depends on the application that the server or database needs to handle. An analysis of expected number of users, amount of memory required, estimated number of database requests that the instance should be able to handle, etc. should be done in the design phase before recommending any instance. As we have seen from the results, the t2.xlarge instance executes more number of read-only queries as compared to the t2.micro instance. However, if the requirement of the application is well and truly satisfied with a t2.micro instance, then a recommendation of t2.xlarge instance would be futile resulting in extra costs.

During this course, the applications built had very low system requirements in terms of number of users, page requests to the server, database queries, etc. The performance of t2.micro instance is comparable to the high end t2.xlarge instance for such requirements. Hence, we recommend the t2.micro instance for all similar applications. Another factor that needs to be considered is scaling. If the application is expected to be scaled in future, then cost of migration to a new instance should be evaluated. If such a cost is cheap and the process is simple, then, the recommendation would be for the instance that satisfies the current requirements. However, if the cost of migration is high, then the best approach (cheaper/easier) should be taken.

References

[1] https://aws.amazon.com/blogs/aws/new-t2-xlarge-and-t2-2xlarge-instances/

[2] https://wiki.mikejung.biz/Sysbench

[3] http://lowrank.net/gnuplot/datafile-e.html

[4] http://www.bradlanders.com/2013/04/15/apache-bench-and-gnuplot-youre-probably-doing-it-wrong

[5] http://infoheap.com/ab-apache-bench-load-testing/