Database Project (SWE3033) (Fall 2023)

Homework #2 (100pts, Due date: 09/13)

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1. **[10pts]** Write the system setup of your environment. Fill in the blank below.

Type	Specification
OS	Ubuntu 18.04
CPU	Intel(R) Core(TM) i5-8265U CPU @ 1.60GHz (2 Cores)
Memory (RAM)	6 GB
Kernel	Linux version 5.4.0-84-generic
Data Device (Optional)	
Log Device (Optional)	

2. **[10pts]** Write the benchmark setup of your environment. Fill in the blank below.

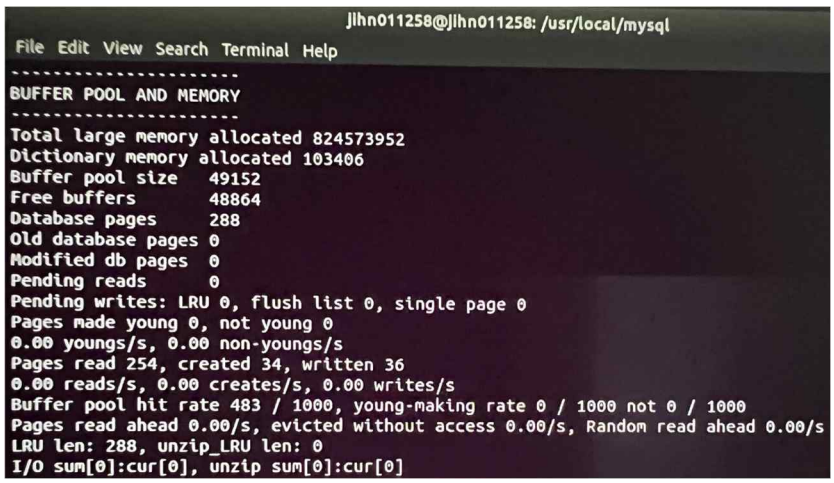
Type	Specification
DB Size	2GB
Buffer Pool Size	1GB
Benchmark Tool	tpcc-mysql
Runtime	1200s
Connections	8

3. **[50pts]** Assume that you have a database with a size of 10 warehouses. Determine the **optimal percentage of buffer pool size to maximize TPC-C benchmark performance**. Present experimental results and analyze the results yourself. You must include **1. chart of TpmC and hit ratio**, **2. result of least three buffer pool sizes**. Explain the reason for the performance shift as the buffer size varies. (The buffer pool size should not exceed the database size.)

I have conducted 3 different buffer pool sizes: 256MB (25%), 512MB (50%), 768MB (75%)

1) **256 MB**

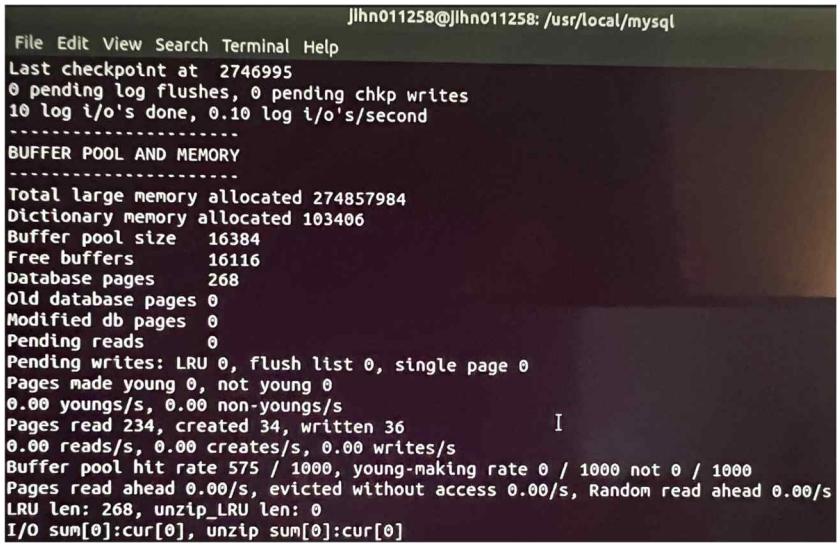
Buffer Pool Hit Rate: 48.3%
TpmC: 2574.35




```
<Raw Results>
  [0] sc:12 lt:51475  rt:0  fl:0 avg_rt: 103.0 (5)
  [1] sc:7969 lt:43511  rt:0  fl:0 avg_rt: 23.9 (5)
  [2] sc:182 lt:4966  rt:0  fl:0 avg_rt: 26.6 (5)
  [3] sc:272 lt:4875  rt:0  fl:0 avg_rt: 191.0 (80)
  [4] sc:0 lt:5148  rt:0  fl:0 avg_rt: 393.2 (20)
 in 1200 sec.

<Raw Results2(sum ver.)>
  [0] sc:12  lt:51475  rt:0  fl:0
  [1] sc:7969  lt:43514  rt:0  fl:0
  [2] sc:182  lt:4966  rt:0  fl:0
  [3] sc:272  lt:4875  rt:0  fl:0
  [4] sc:0  lt:5148  rt:0  fl:0

<Constraint Check> (all must be [OK])
 [transaction percentage]
        Payment: 43.48% (>=43.0%) [OK]
   Order-Status: 4.35% (>= 4.0%) [OK]
       Delivery: 4.35% (>= 4.0%) [OK]
    Stock-Level: 4.35% (>= 4.0%) [OK]
 [response time (at least 90% passed)]
      New-Order: 0.02%  [NG] *
        Payment: 15.48%  [NG] *
   Order-Status: 3.54%  [NG] *
       Delivery: 5.28%  [NG] *
    Stock-Level: 0.00%  [NG] *

<TpmC>
                 2574.350 TpmC
```

2) 512 MB

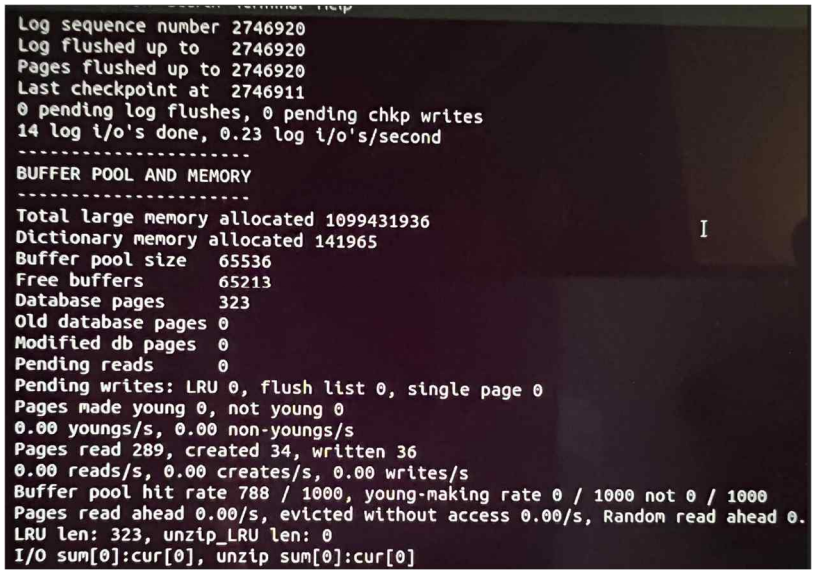
Buffer Pool Hit Rate: 57.5%
TpmC: 3734.2




```
<Raw Results>
  [0] sc:120 lt:74564  rt:0  fl:0 avg_rt: 73.8 (5)
  [1] sc:18295 lt:56384  rt:0  fl:0 avg_rt: 19.3 (5)
  [2] sc:860 lt:6608  rt:0  fl:0 avg_rt: 18.7 (5)
  [3] sc:896 lt:6573  rt:0  fl:0 avg_rt: 164.8 (80)
  [4] sc:0 lt:7471  rt:0  fl:0 avg_rt: 180.8 (20)
 in 1200 sec.

<Raw Results2(sum ver.)>
  [0] sc:120  lt:74564  rt:0  fl:0
  [1] sc:18296  lt:56392  rt:0  fl:0
  [2] sc:860  lt:6608  rt:0  fl:0
  [3] sc:896  lt:6573  rt:0  fl:0
  [4] sc:0  lt:7471  rt:0  fl:0

<Constraint Check> (all must be [OK])
 [transaction percentage]
        Payment: 43.48% (>=43.0%) [OK]
   Order-Status: 4.35% (>= 4.0%) [OK]
       Delivery: 4.35% (>= 4.0%) [OK]
    Stock-Level: 4.35% (>= 4.0%) [OK]
 [response time (at least 90% passed)]
      New-Order: 0.16%  [NG] *
        Payment: 24.50%  [NG] *
   Order-Status: 11.52%  [NG] *
       Delivery: 12.00%  [NG] *
    Stock-Level: 0.00%  [NG] *

<TpmC>
                 3734.200 TpmC
```

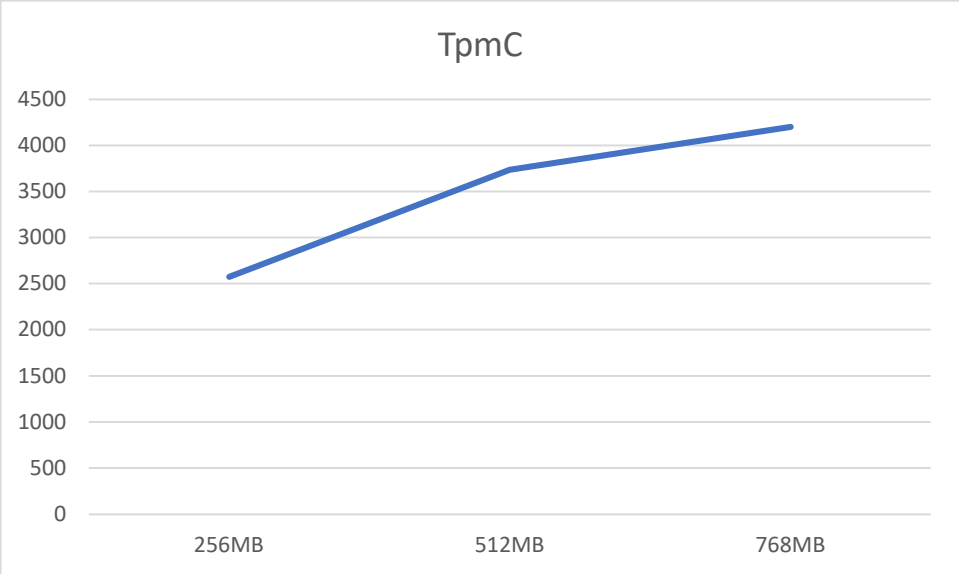
3) 768 MB

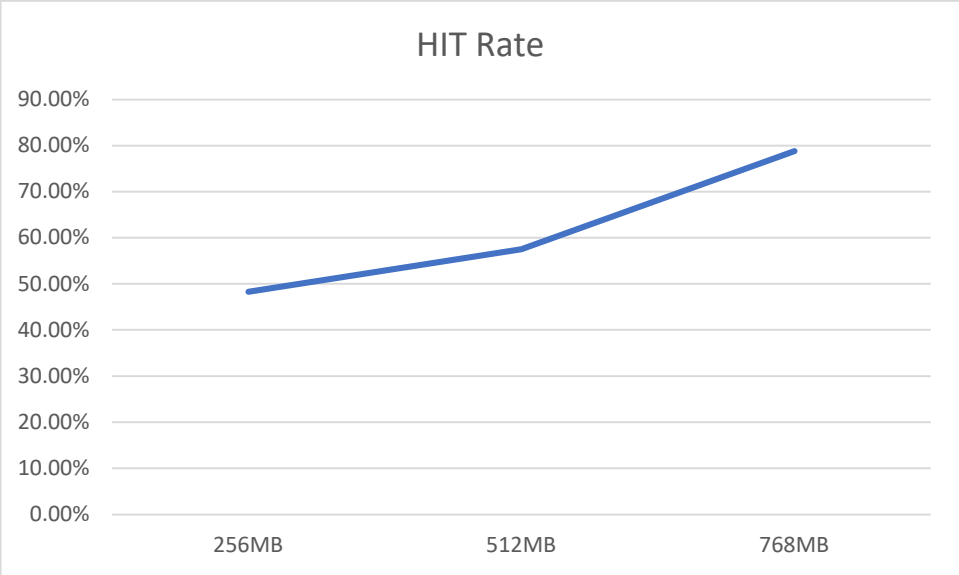
Buffer Pool Hit Rate: 78.8%
TpmC: 4202.7




```
<Raw Results>
  [0] sc:342 lt:83712  rt:0  fl:0 avg_rt: 64.8 (5)
  [1] sc:25577 lt:58468  rt:0  fl:0 avg_rt: 17.1 (5)
  [2] sc:2792 lt:5613  rt:0  fl:0 avg_rt: 11.2 (5)
  [3] sc:2300 lt:6106  rt:0  fl:0 avg_rt: 140.0 (80)
  [4] sc:0 lt:8407  rt:0  fl:0 avg_rt: 180.5 (20)
 in 1200 sec.

<Raw Results2(sum ver.)>
  [0] sc:342  lt:83712  rt:0  fl:0
  [1] sc:25577  lt:58472  rt:0  fl:0
  [2] sc:2792  lt:5613  rt:0  fl:0
  [3] sc:2300  lt:6106  rt:0  fl:0
  [4] sc:0  lt:8407  rt:0  fl:0

<Constraint Check> (all must be [OK])
 [transaction percentage]
        Payment: 43.48% (>=43.0%) [OK]
   Order-Status: 4.35% (>= 4.0%) [OK]
       Delivery: 4.35% (>= 4.0%) [OK]
    Stock-Level: 4.35% (>= 4.0%) [OK]
 [response time (at least 90% passed)]
      New-Order: 0.41%  [NG] *
        Payment: 30.43%  [NG] *
   Order-Status: 33.22%  [NG] *
       Delivery: 27.36%  [NG] *
    Stock-Level: 0.00%  [NG] *

<TpmC>
                 4202.700 TpmC
```

As a result, a chart goes as follows:





Conclusion:
Increasing the buffer pool size is expected to lead to an increase in TpmC (Transactions per Minute in the TPC-C benchmark) and the Buffer Hit Rate. As the allocated buffer size increases, the capacity to cache data grows, resulting in a higher hit rate. Consequently, this is likely to lead to an increase in the number of transactions processed per minute.

I couldn't attach the overall graph of the log files, because Gnuplot mentioned in the Github repository referred in the course slides does NOT work somehow. I followed the instructions and modified with 3 input text files from log files, however, it didn't work with even 2 inputs also.

4. **[30pts]** Why is it difficult to store the entire database in memory in real world, and why do we need to use buffer pool in database management system?

Storing an entire database in memory can be challenging for the following reasons.

- Databases tend to grow as more data is added. So it will eventually run out of memory.
- Many databases are massive in size, ranging from gigabytes to terabytes or even more.
- Storing the entire database in RAM makes it vulnerable to data loss in case of power outages or system crashes.
- RAM is more expensive than HDD or SSD. To store an entire database in RAM, it is required to invest significantly in high-capacity RAM modules, increasing the overall cost of the system.

As a result, with the above reasons, it is difficult to store the entire database in memory in real world.

While there are some difficulties, we use buffer pool for the following reasons.

- Most commonly accessed data is available in memory, providing fast access times.
- By caching data in memory, buffer pools reduce the need to read data from slower storage devices like hard drives or SSDs.
- It is cost-effective compared to the amount of RAM usage storing the entire database, since it uses only a smaller amount of RAM.
- Data is persistently stored on on-volatile storage, so ensures the durability.