

## Assignment 2

### Server Design:

#### 1. Classes:

##### A. SkierServlet.java

It is the main class which receive and respond to the request from Skiers API. It performs the necessary validation(ie. URL, parameters). If all the validation passed, It will call LiftRideDao to write/update/read from database. The corresponding response will then be returned to the client.

##### B. LiftRide.java

It is a POJO class which stores ResortID, DayID, SkierID, Time, LiftID.

##### C. LiftRideDao.java

The main functionalities of this class is to write/update/read from database.

a. createLiftRide() write the LiftRide entry in the database. It write one row in database every time this method gets invoked. I tried to optimize the method to to batch transaction for optimization. However, it performs worse than single write transaction(the time takes longer). So I revert back to write one single row approach.

b. queryLiftRideVerticalPerDay() finds the corresponded LiftRide data from the database based on skierID and dayID.

c. queryLiftRideVerticalPerResort() finds the corresponded LiftRide data from the database based on skierID and resortID.

##### D. DBCPDataSource.java

It is the connection manager class between my program and MySQL database. I increased the initial pool size and the maxTotal in order to optimize the performance of database operations.

#### 2. Class relationship

The SkierServlet class receives the request from the client and performs all necessary checks, including url, parameters checks. If the request is invalid, it returns an error code with corresponding message. If the request is valid, it create a new LiftRide instance and invokes LiftRideDao to write/update/read entry in the database table. The DBCPDataSource is a class that make connection to the MySql database.

## Single Server Test:

### 1. 32 threads:

#### Result Screenshot:

```
-----Part 1-----
number of successful requests sent: 48360
number of unsuccessful requests sent: 0
Wall time: 357901
Throughput: 135
-----Part 2-----
mean response time (milliseconds): 202.92427626137302
median response time (milliseconds): 16.0
throughput (total number of requests/wall time): 135.12116479138086
p99 response time (99th percentile, milliseconds): 35858.0
max response time(milliseconds): 37398.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 22938.475
median response time (milliseconds): 28049.0
p99 response time (99th percentile, milliseconds): 36657.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 7945.75
median response time (milliseconds): 7906.0
p99 response time (99th percentile, milliseconds): 8445.0
```

### 2. 64 threads:

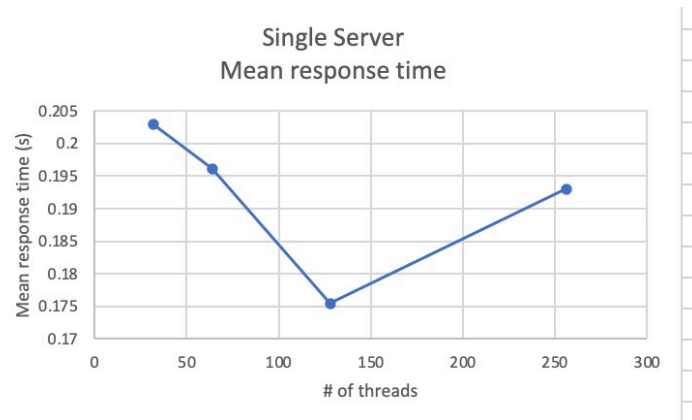
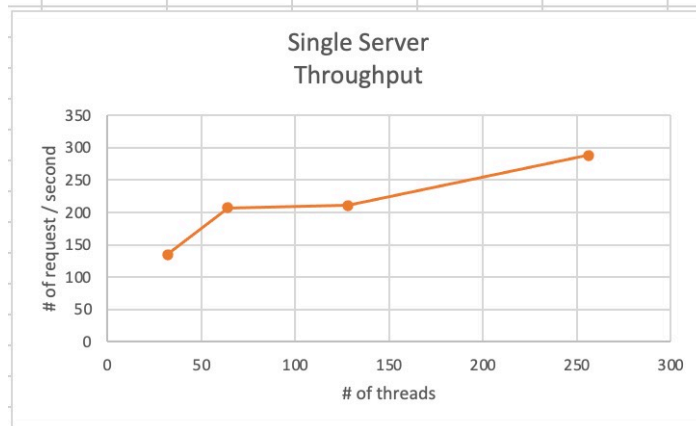
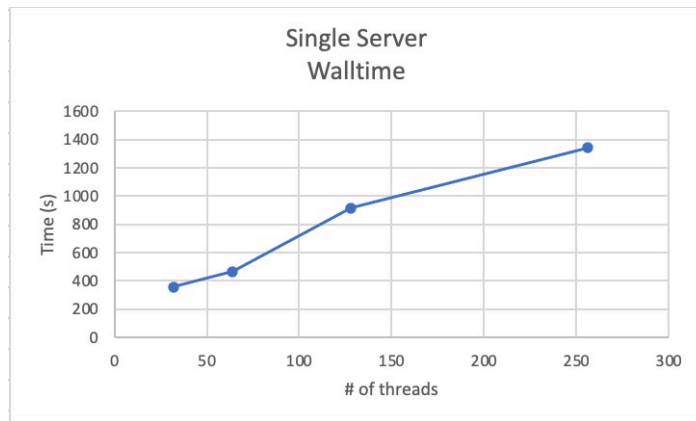
```
-----Part 1-----
number of successful requests sent: 96720
number of unsuccessful requests sent: 0
Wall time: 465907
Throughput: 207
-----Part 2-----
mean response time (milliseconds): 196.17975599669148
median response time (milliseconds): 18.0
throughput (total number of requests/wall time): 207.59507798766705
p99 response time (99th percentile, milliseconds): 28166.0
max response time(milliseconds): 30989.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 17887.2125
median response time (milliseconds): 25418.5
p99 response time (99th percentile, milliseconds): 28592.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 9403.88125
median response time (milliseconds): 9367.5
p99 response time (99th percentile, milliseconds): 9955.0
```

### 3. 128 threads:

```
-----Part 1-----
number of successful requests sent: 191053
number of unsuccessful requests sent: 2387
Wall time: 915873
Throughput: 211
-----Part 2-----
mean response time (milliseconds): 175.4323983397277
median response time (milliseconds): 30.0
throughput (total number of requests/wall time): 211.20832255127075
p99 response time (99th percentile, milliseconds): 9511.0
max response time(milliseconds): 9982.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 3264.52
median response time (milliseconds): 2217.0
p99 response time (99th percentile, milliseconds): 9856.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 2691.0
median response time (milliseconds): 2581.0
p99 response time (99th percentile, milliseconds): 9787.0
```

### 4. 256 threads:

```
-----Part 1-----
number of successful requests sent: 379198
number of unsuccessful requests sent: 7682
Wall time: 1341607
Throughput: 288
-----Part 2-----
mean response time (milliseconds): 193.00144251815675
median response time (milliseconds): 106.0
throughput (total number of requests/wall time): 288.37058840629186
p99 response time (99th percentile, milliseconds): 9782.0
max response time(milliseconds): 9919.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 2684.968253968254
median response time (milliseconds): 2202.0
p99 response time (99th percentile, milliseconds): 9833.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 1194.6333333333334
median response time (milliseconds): 1251.5
p99 response time (99th percentile, milliseconds): 1303.0
```



## Load Balanced Test:

### 1. 32 threads:

```
-----Part 1-----
number of successful requests sent: 48360
number of unsuccessful requests sent: 0
Wall time: 142875
Throughput: 338
-----Part 2-----
mean response time (milliseconds): 89.75787841191067
median response time (milliseconds): 15.0
throughput (total number of requests/wall time): 338.4776902887139
p99 response time (99th percentile, milliseconds): 8470.0
max response time(milliseconds): 9541.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 5834.996428571429
median response time (milliseconds): 7401.5
p99 response time (99th percentile, milliseconds): 9238.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 2164.7375
median response time (milliseconds): 2157.5
p99 response time (99th percentile, milliseconds): 2267.0
```

### 2. 64 threads:

```

-----Part 1-----
number of successful requests sent: 96720
number of unsuccessful requests sent: 0
Wall time: 263810
Throughput: 366
-----Part 2-----
mean response time (milliseconds): 117.67744003308519
median response time (milliseconds): 18.0
throughput (total number of requests/wall time): 366.62749706227964
p99 response time (99th percentile, milliseconds): 11191.0
max response time(milliseconds): 11713.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 6864.296428571429
median response time (milliseconds): 9439.5
p99 response time (99th percentile, milliseconds): 11393.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 4339.75625
median response time (milliseconds): 4261.5
p99 response time (99th percentile, milliseconds): 5257.0

```

### 3. 128 threads:

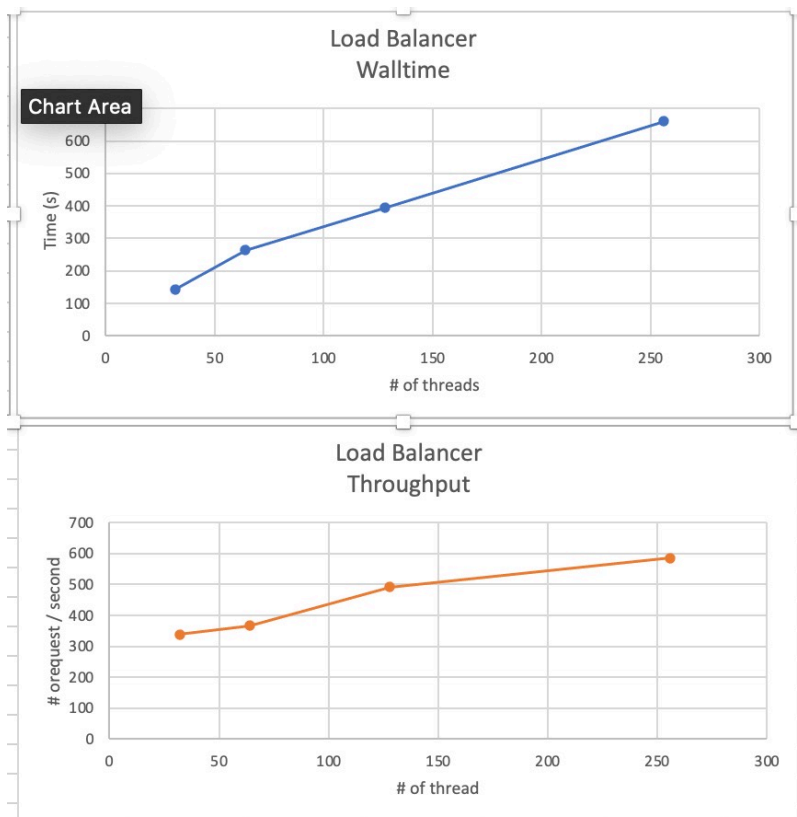
```

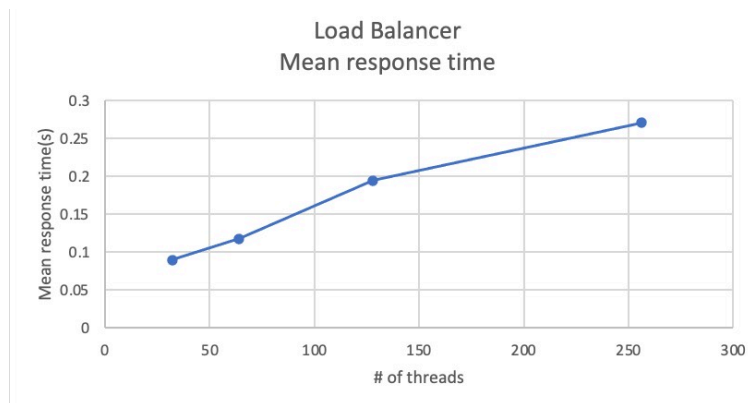
-----Part 1-----
number of successful requests sent: 193352
number of unsuccessful requests sent: 88
Wall time: 393869
Throughput: 491
-----Part 2-----
mean response time (milliseconds): 194.65451611568537
median response time (milliseconds): 30.0
throughput (total number of requests/wall time): 491.1277607529407
p99 response time (99th percentile, milliseconds): 6050.0
max response time(milliseconds): 9514.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 3819.1491071428572
median response time (milliseconds): 4683.0
p99 response time (99th percentile, milliseconds): 7039.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 2747.30625
median response time (milliseconds): 2522.5
p99 response time (99th percentile, milliseconds): 4072.0

```

#### 4. 256 threads:

```
-----Part 1-----
number of successful requests sent: 386627
number of unsuccessful requests sent: 253
Wall time: 661085
Throughput: 585
-----Part 2-----
mean response time (milliseconds): 270.995491778898
median response time (milliseconds): 83.0
throughput (total number of requests/wall time): 585.2197523767745
p99 response time (99th percentile, milliseconds): 8288.0
max response time(milliseconds): 9565.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 5967.665625
median response time (milliseconds): 7064.0
p99 response time (99th percentile, milliseconds): 8826.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 6561.08125
median response time (milliseconds): 6733.5
p99 response time (99th percentile, milliseconds): 7025.0
```





### Implementation tried to improve the performance:

Initially, I get failed requests when running 64, 128, and 256 threads. The console in the client side shows `timeoutException`. I tried to increase the `initialSize` (initial pool size) to 20 and `maxTotal` (max number of active connections that can be allocated from this pool at the same time) to 100 in the `DBCPDataSource` class. In addition, I set the request read and write time out to be no time out limit in the client side. Those changes only solve the failed request problem when running 64 threads.

In order to further optimize the performance, I tried to implement batch transaction (write multiple rows in every transaction) in the `LiftRideDao` class for POST request. This change give me worse result so I revert back to the original approach (write single row in every transaction). For GET request, I change the sql table schema and the SELECT query to use index for 2 GET queries. This change gives me less failed request when running 128 and 256 threads but did not solve the problem.

### Bonus: 512 max threads:

```
-----Part 1-----
number of successful requests sent: 773427
number of unsuccessful requests sent: 333
Wall time: 1591736
Throughput: 486
-----Part 2-----
mean response time (milliseconds): 497.7645737736076
median response time (milliseconds): 159.0
throughput (total number of requests/wall time): 486.1107620861751
p99 response time (99th percentile, milliseconds): 236025.0
max response time(milliseconds): 237313.0
-----SkierDayVerticalGET-----
mean response time (milliseconds): 22289.106473214284
median response time (milliseconds): 16420.5
p99 response time (99th percentile, milliseconds): 236783.0
-----SkierResortVerticalGET-----
mean response time (milliseconds): 21414.115625
median response time (milliseconds): 23961.5
p99 response time (99th percentile, milliseconds): 28055.0
```



