基于 MySQL 的 Spring 应用的读写效率
实验报告
2-4 组

一、实验目的

1、掌握 SpringBoot 应用读写 MyBatis 数据库的方法
2、掌握用 SpringMVC 实现 RESTful API 的方法
3、掌握用 JMeter 测试 RESTful API 应用的方法
4、验证通过 MyBatis 读写数据库的效率

二、实验环境

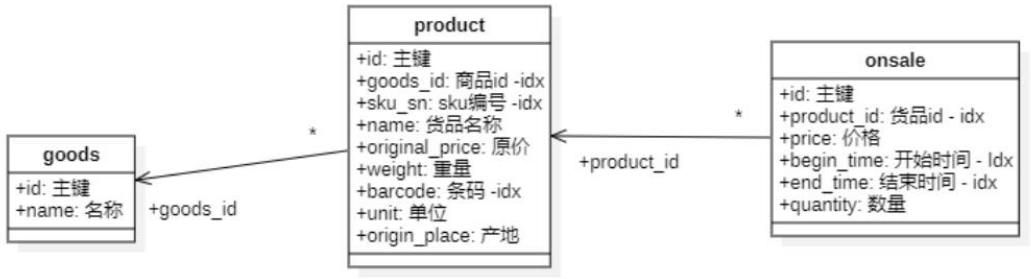
1、服务器 A: Ubuntu 18.04 服务器 2 核 1G 内存虚拟机一台，安装 docker，Maven、git，作为管理机，用于编译 productdemoaop
2、服务器 B：Ubuntu 18.04 服务器 2 核 1G 内存虚拟机一台，安装 docker，部署 productdemoaop Docker
3、服务器 C：Ubuntu 18.04 服务器 2 核 1G 内存虚拟机一台，安装 docker，部署 MySQL Docker
4. 服务器 D：Ubuntu 18.04 服务器 2 核 1G 内存虚拟机一台，安装 JMeter 5.6.3,用于测试

三、实验内容

在基于数据库的应用中，数据库的访问是系统的主要瓶颈之一。设计一个实验对比使用 MyBatis 读写数据库的效率。要求测试 productdemoaop 中两个 RESTful API：

API	API 描述链接
管理员查询产品信息	GET /admin/products/{id}
管理员新建产品	POST /admin/products

其中数据的 ER 图如下图所示：



四、实验报告

1.实验设计

一：读取状态下的最大负载

测试条件：固定时间 10 秒，优先逐级增加线程数，其次为循环次数递增。

测试指标：Response Times Over Times、Active Threads Over Times、Response Time Percentiles。

关键指标：Active Threads Over Times，用于判断系统在不同线程数下的处理能力

二：写入状态下的最大负载

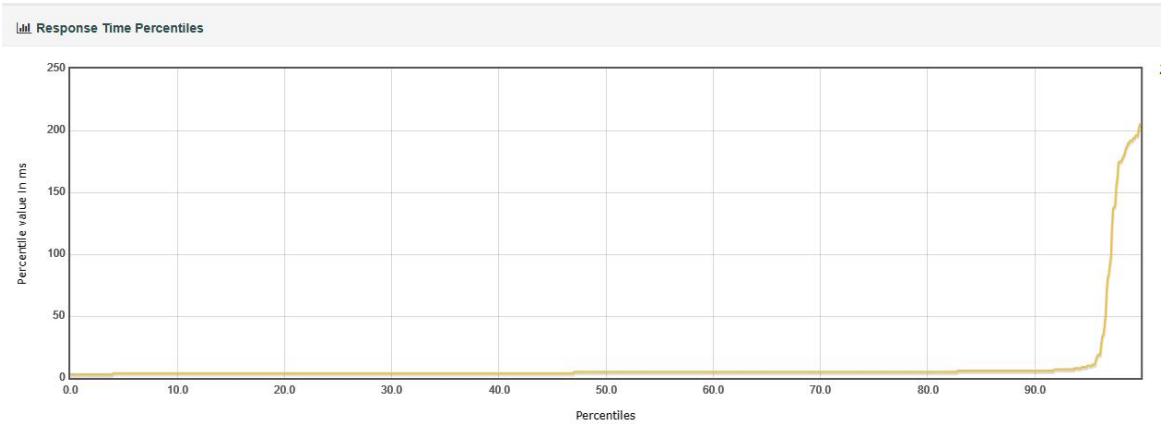
测试条件：固定时间 10 秒，优先逐级增加线程数，其次为循环次数递增。

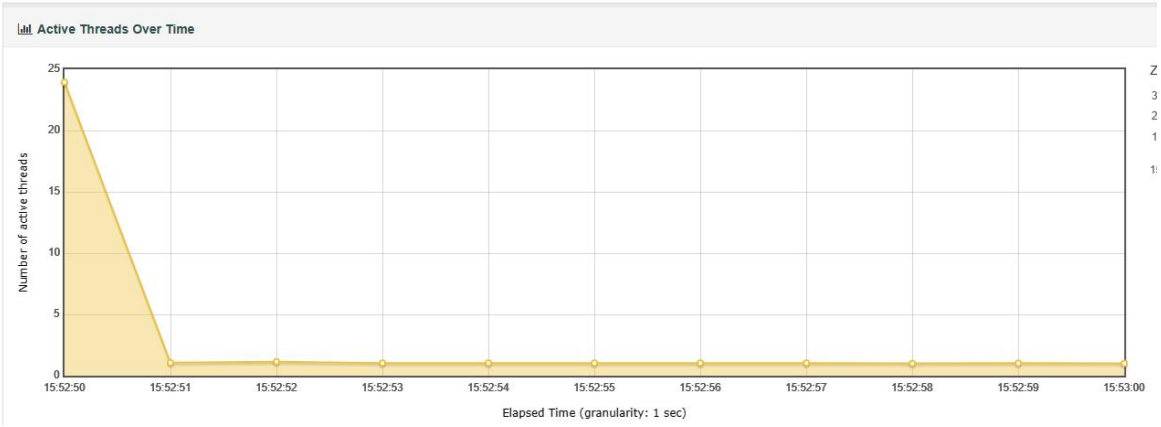
测试指标：Response Times Over Times、Active Threads Over Times、Response Time Percentiles。

关键指标：Active Threads Over Times，用于判断系统在不同线程数下的处理能力

2.实验数据与分析

Read_1000_10_1



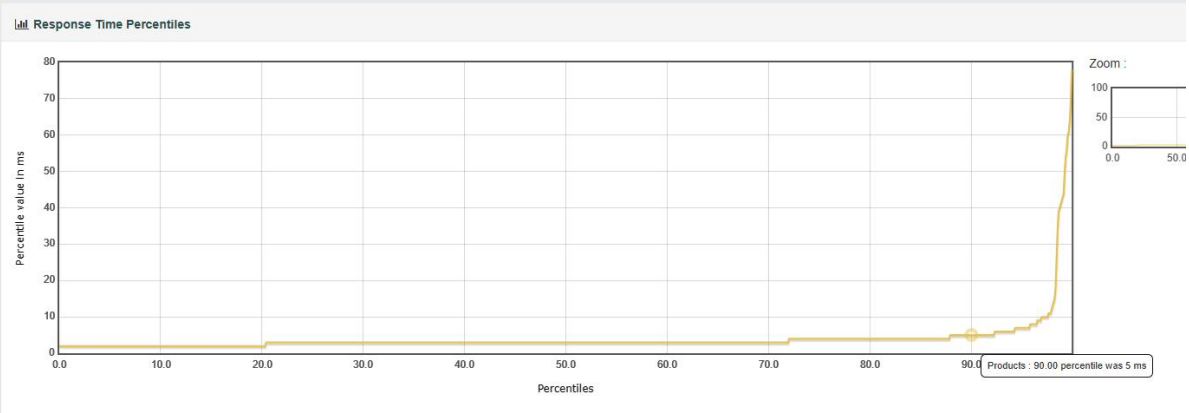


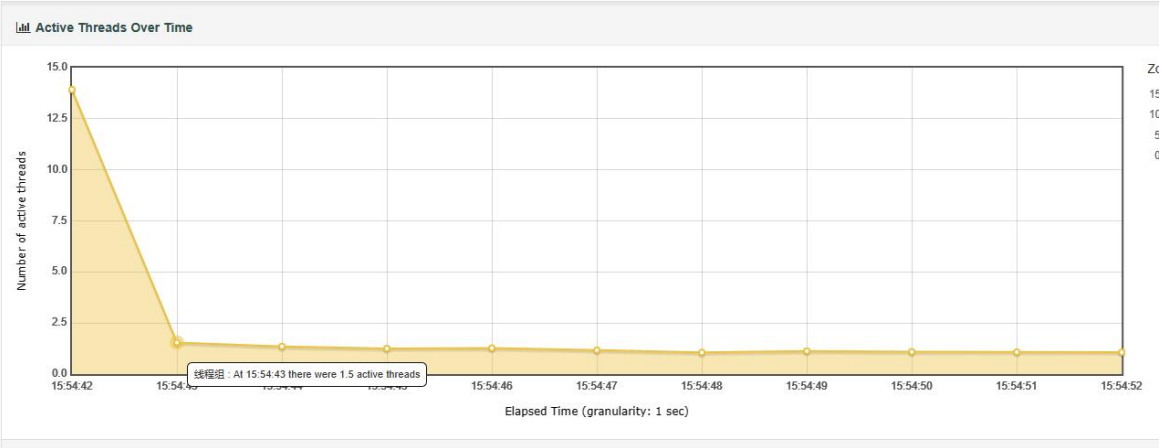
Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**1000**	**0**	**0.00%**	**10.20**	**3**	**205**	**5.00**	**6.00**	**10.00**	**192.00**	**101.76**	**57.96**	**18.38**
Products	1000	0	0.00%	10.20	3	205	5.00	6.00	10.00	192.00	101.76	57.96	18.38

系统能够稳定处理请求，Active Threads Over Times 显示系统负载较低，响应时间稳定。

read_2000_10_1





Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**2000**	**0**	**0.00%**	**4.12**	**2**	**80**	**3.00**	**5.00**	**7.00**	**43.00**	**203.23**	**115.83**	**36.72**
Products	2000	0	0.00%	4.12	2	80	3.00	5.00	7.00	43.00	203.23	115.83	36.72

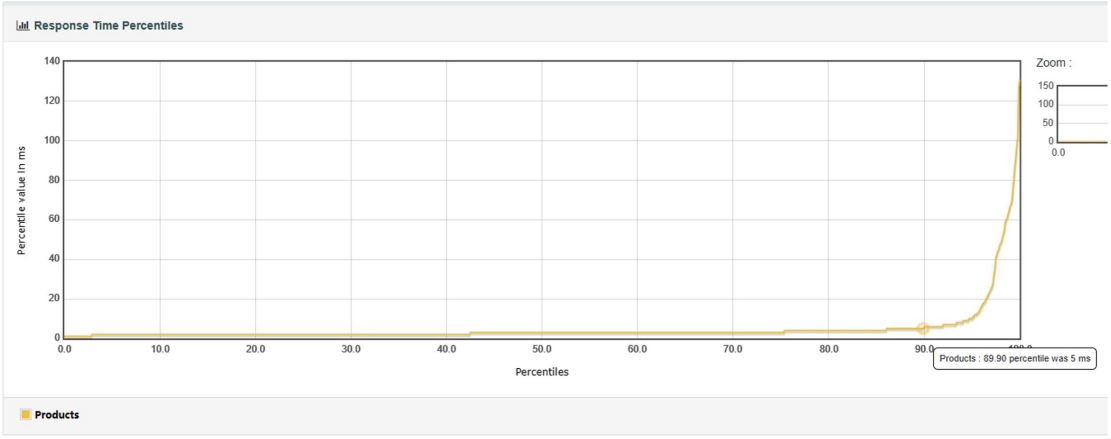
系统负载略有增加

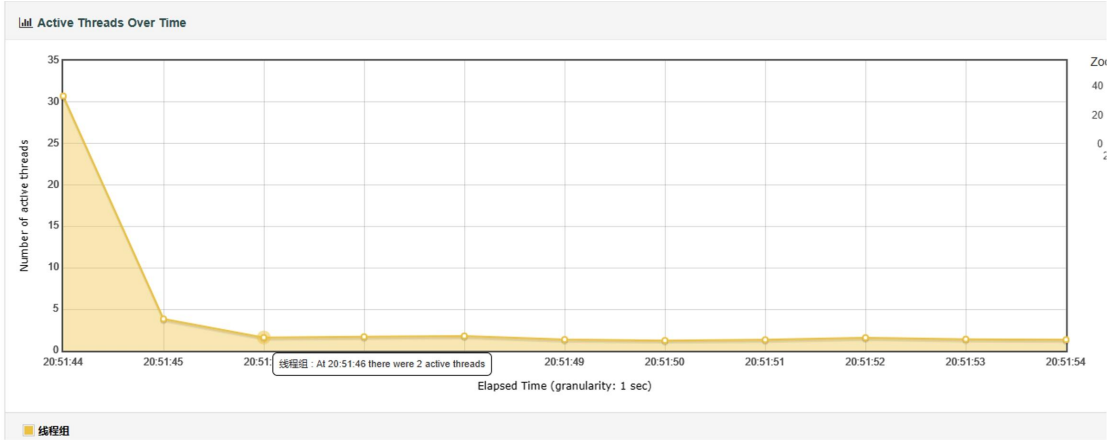
read_3000_10_1

```
root@Test:~/test# vim ReadProduct.jmx
root@Test:~/test# jmeter -n -t ReadProduct.jmx -l read-3000-10-1.jtl -e -o read/read-3000-10-1
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
Creating summariser <summary>
Created the tree successfully using ReadProduct.jmx
Starting standalone test @ 2024 Oct 15 15:55:44 CST (1728978944632)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
[3.786s][warning][os,thread] Failed to start thread "Unknown thread" - pthread_create failed (EAGAIN) for attributes: stacksi
ze: 1024k, guardsize: 0k, detached.
[3.786s][warning][os,thread] Failed to start the native thread for java.lang.Thread "线程组 1-2689"
```

系统无法分出 3000 个线程

Read_2000_10_2



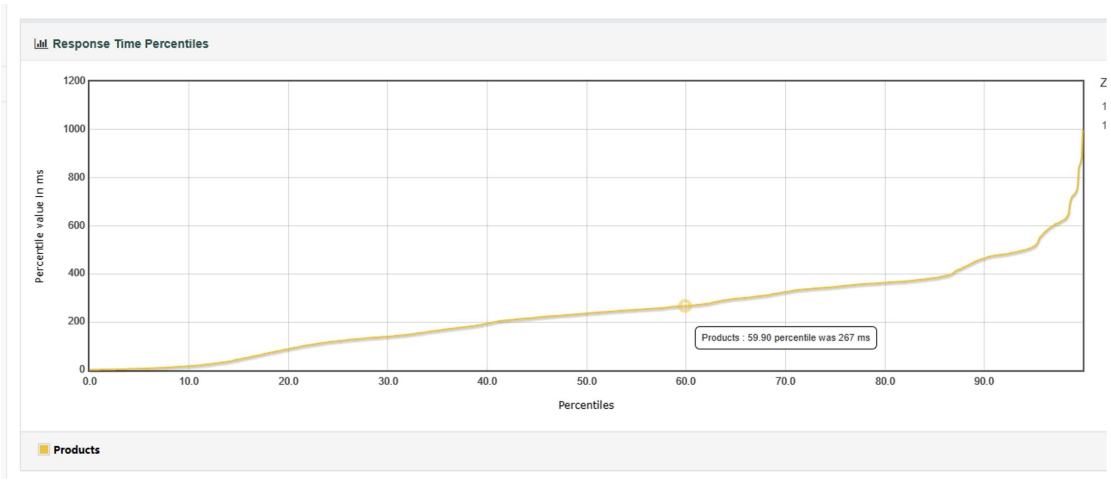


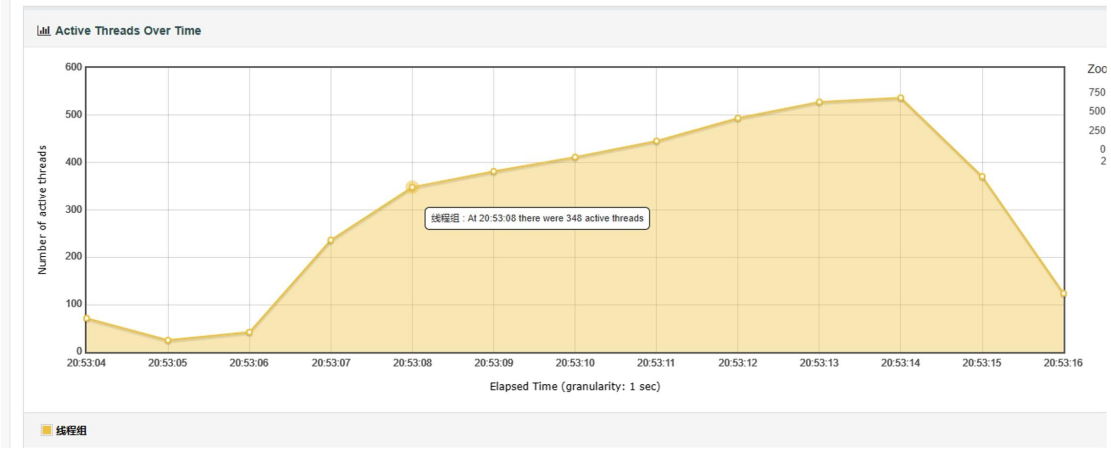
Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**4000**	**0**	**0.00%**	**4.99**	**1**	**131**	**3.00**	**6.00**	**10.95**	**67.00**	**408.87**	**232.96**	**73.87**
Products	4000	0	0.00%	4.99	1	131	3.00	6.00	10.95	67.00	408.87	232.96	73.87

系统负载相较 1000_10_1 与 2000_10_1 进一步增加，响应时间继续上升，但系统仍能处理请求

read_2000_10_8



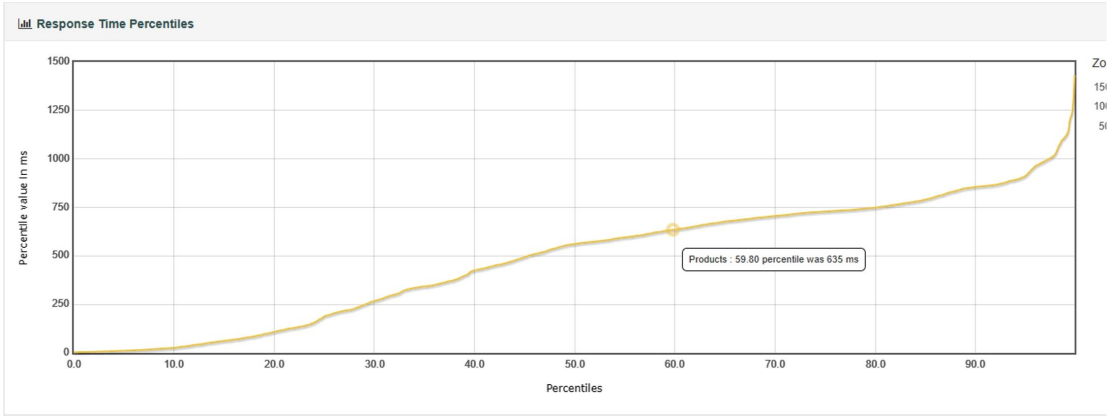


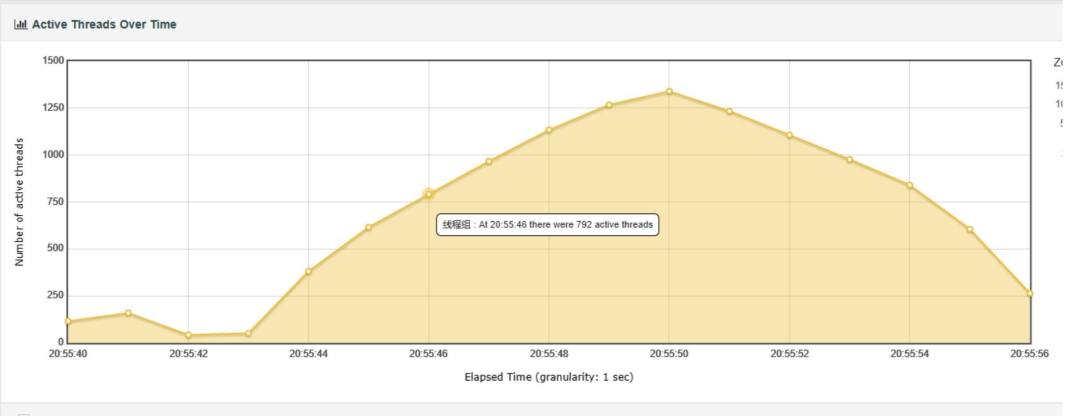
Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**16000**	**0**	**0.00%**	**241.42**	**1**	**1332**	**236.00**	**465.00**	**514.00**	**729.00**	**1375.28**	**783.55**	**248.46**
Products	16000	0	0.00%	241.42	1	1332	236.00	465.00	514.00	729.00	1375.28	783.55	248.46

系统负载达到较高水平，响应时间显著增加，部分请求可能未能及时处理

Read_2000_10_12





Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	24000	0	0.00%	485.09	2	1905	623.00	864.00	955.95	1130.00	1512.19	861.47	273.20
Products	24000	0	0.00%	485.09	2	1905	623.00	864.00	955.95	1130.00	1512.19	861.47	273.20

系统负载极高，响应时间大幅上升，系统性能开始下降

Read_2000_10_14

```
root@Test:~/test# vim ReadProduct.jmx
root@Test:~/test# jmeter -n -t ReadProduct.jmx -l read-2000-10-14.jtl -e -o read/read-2000-10-14
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
Creating summariser <summary>
Created the tree successfully using ReadProduct.jmx
Starting standalone test @ 2024 Oct 15 20:56:32 CST (1728996992673)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
summary +      1 in 00:00:01 =    1.7/s Avg:     2 Min:     2 Max:     2 Err:     0 (0.00%) Active: 111 Started: 111 Finished
: 0
Killed
root@Test:~/test#
```

系统崩了，负载已超荷

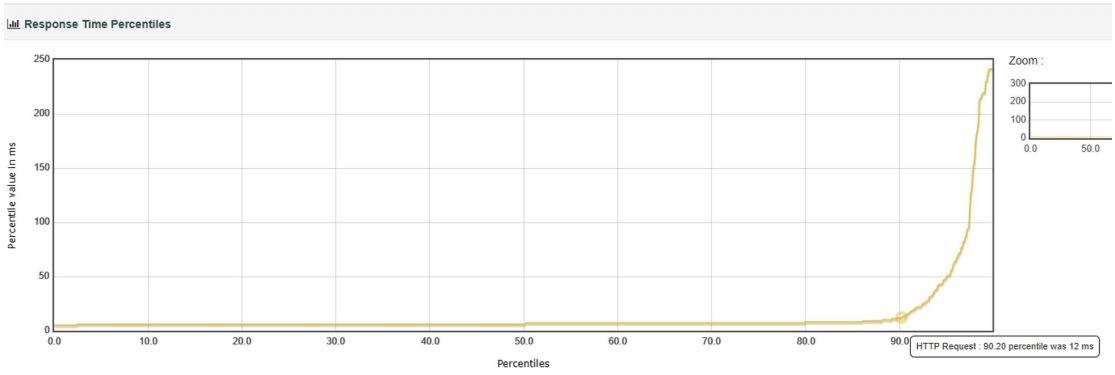
读写小结：

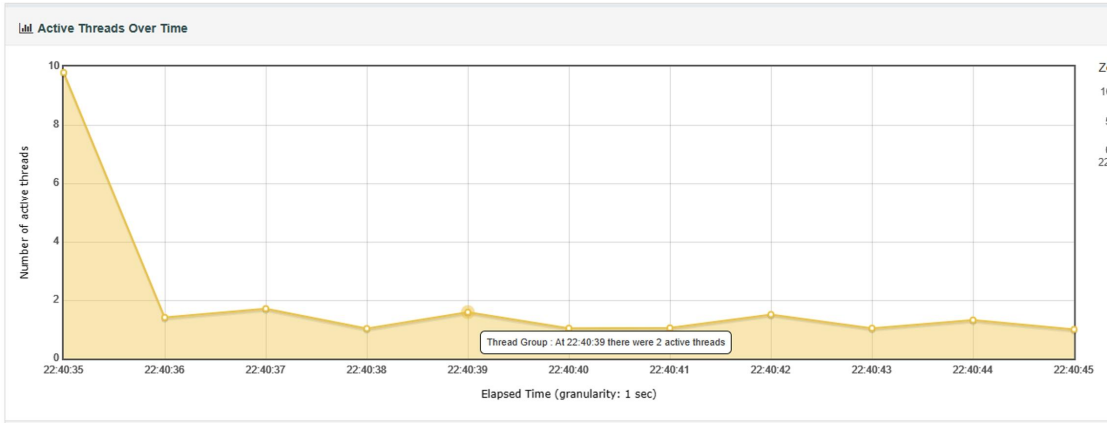
性能瓶颈：随着线程数的增加，系统性能逐渐下降，尤其在 2000 线程的 8 和 12 循环中，系统性能已有显著下降。

最大线程数：根据测试结果，系统在 1000 线程下表现最佳，2000 线程下仍可接受，但超过 2000 线程后性能急剧下降。

最大负载：由于多次测试后数据库性能不稳定，跑崩需要的请求频率难以测出，测试能够无错误运行的最大负载：成功请求 2400 次/秒

Write_1000_10_1



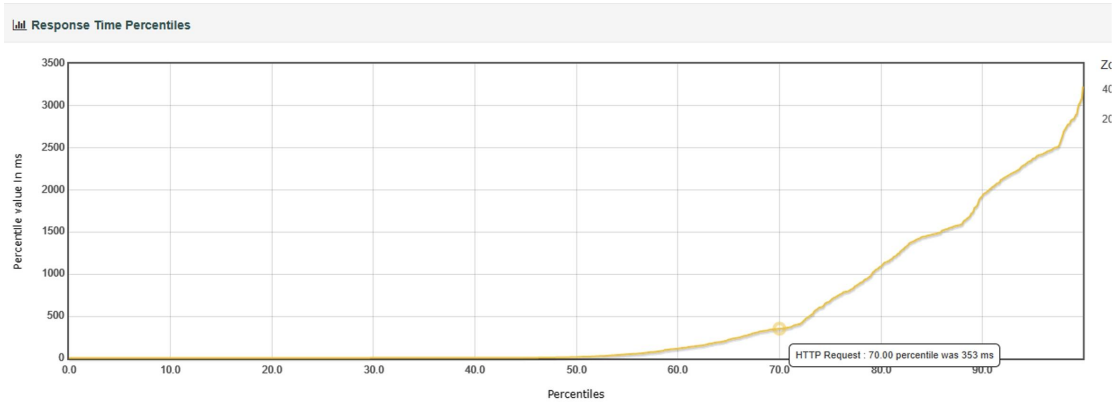


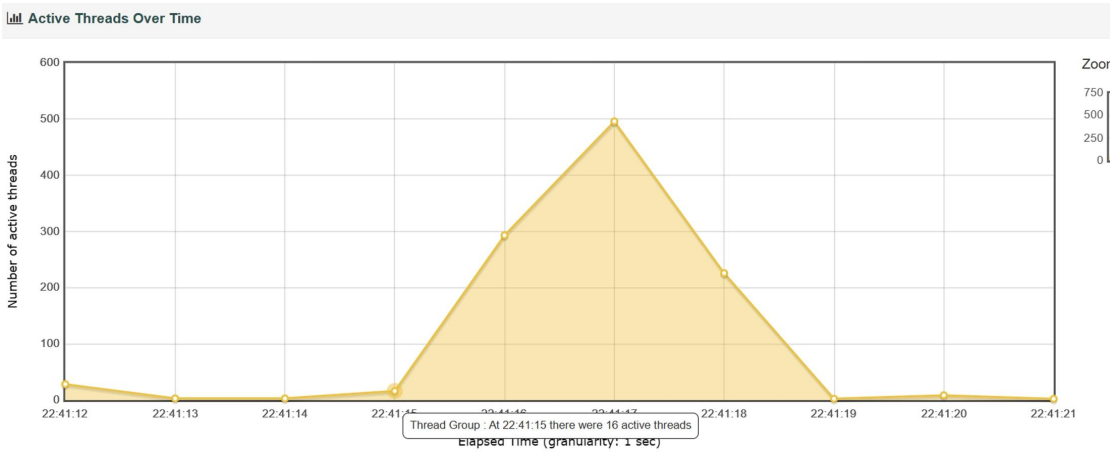
Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**1000**	**0**	**0.00%**	**14.00**	**5**	**242**	**6.00**	**12.00**	**48.95**	**219.00**	**101.16**	**46.30**	**31.88**
HTTP Request	1000	0	0.00%	14.00	5	242	6.00	12.00	48.95	219.00	101.16	46.30	31.88

Active Threads Over Times 显示系统负载较低但是略有波动。，响应时间较为稳定。

Write_2000_10_1





Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**2000**	**0**	**0.00%**	**485.42**	**5**	**3243**	**16.00**	**1931.60**	**2374.60**	**2843.99**	**202.76**	**92.82**	**63.92**
HTTP Request	2000	0	0.00%	485.42	5	3243	16.00	1931.60	2374.60	2843.99	202.76	92.82	63.92

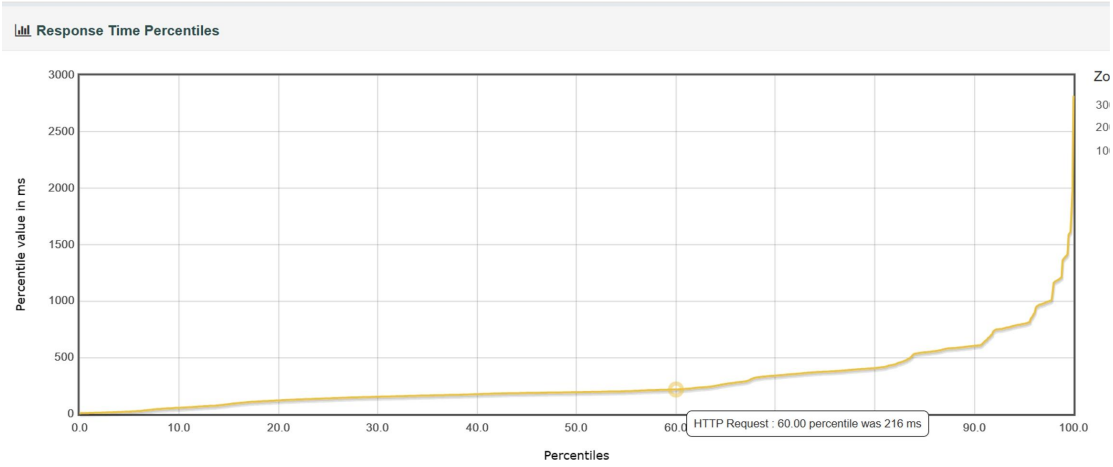
系统负载有所增加，响应时间开始上升

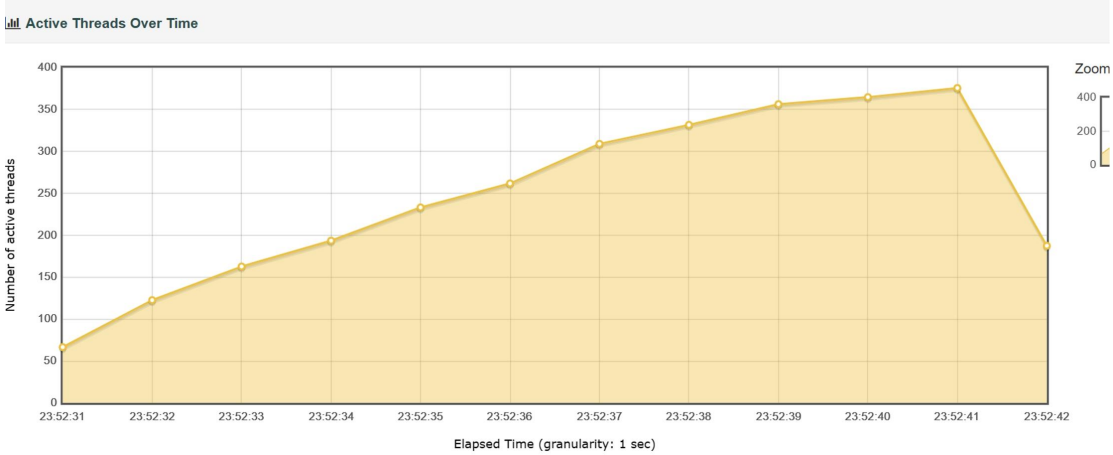
Write_3000_10_1

```
root@Test:~/test# vim WriteProduct.jmx
root@Test:~/test# jmeter -n -t WriteProduct.jmx -l write-3000-10-1.jtl -e -o write/write-3000-10-1
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
Creating summariser <summary>
Created the tree successfully using WriteProduct.jmx
Starting standalone test @ 2024 Oct 15 22:41:51 CST (1729003311401)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
[3.367s][warning][os,thread] Failed to start thread "Unknown thread" - pthread_create failed (EAGAIN) for attributes: stacksi
ze: 1024k, guardsize: 0k, detached.
[3.367s][warning][os,thread] Failed to start the native thread for java.lang.Thread "Thread Group 1-2546"
```

系统无法分出 3000 个线程

Write_2000_10_5

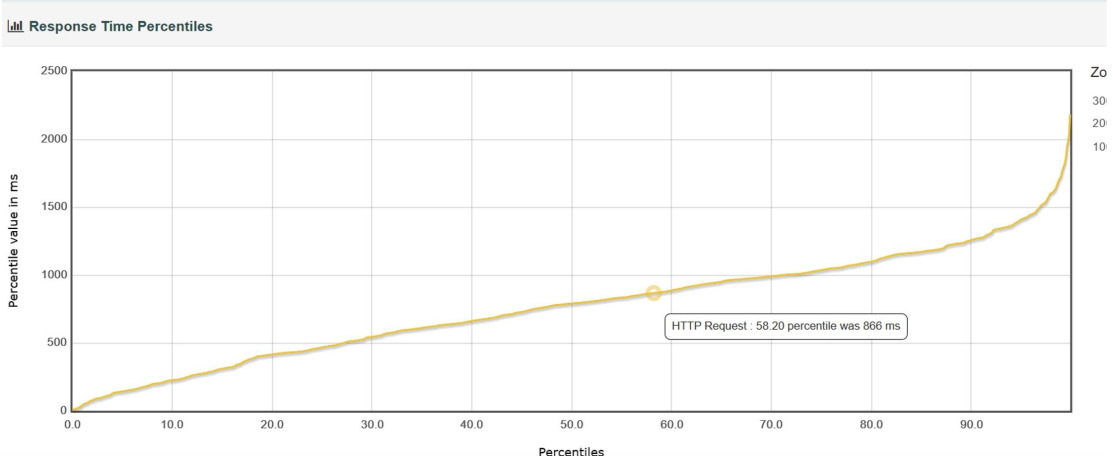


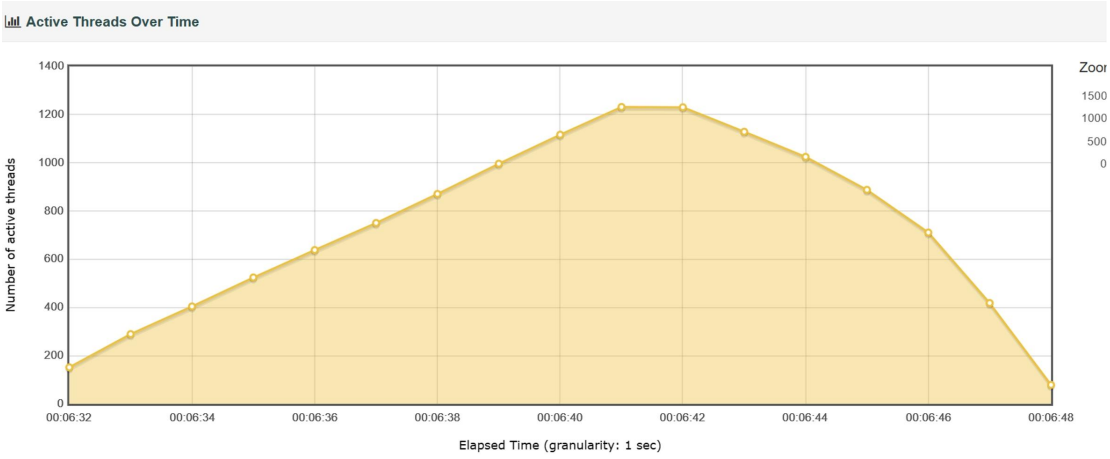


Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**10000**	**0**	**0.00%**	**288.93**	**5**	**2819**	**193.00**	**603.00**	**799.00**	**1374.00**	**900.58**	**412.29**	**283.88**
HTTP Request	10000	0	0.00%	288.93	5	2819	193.00	603.00	799.00	1374.00	900.58	412.29	283.88

系统在高并发写入下开始出现瓶颈

Write_2000_10_8





Statistics

Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	16000	0	0.00%	771.10	6	2517	790.00	1257.00	1409.00	1727.00	997.69	456.75	314.50
HTTP Request	16000	0	0.00%	771.10	6	2517	790.00	1257.00	1409.00	1727.00	997.69	456.75	314.50

性能进一步下降，即将崩溃

Write_2000_10_9 与 Write_2000_10_10

```
root@Test:~/test# vim WriteProduct.jmx
root@Test:~/test# jmeter -n -t WriteProduct.jmx -l write-2000-10-9.jtl -e -o write/write-2000-10-9
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
Creating summariser <summary>
Created the tree successfully using WriteProduct.jmx
Starting standalone test @ 2024 Oct 16 00:07:33 CST (1729008453706)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
summary +      1 in 00:00:00 =    2.2/s Avg:   199 Min:   199 Max:   199 Err:     0 (0.00%) Active: 83 Started: 83 Finished:
0
[4.735s][warning][os,thread] Failed to start thread "Unknown thread" - pthread_create failed (EAGAIN) for attributes: stacksi
ze: 1024k, guardsize: 0k, detached.
[4.736s][warning][os,thread] Failed to start the native thread for java.lang.Thread "Thread Group 1-1970"
```

```
root@Test:~/test# jmeter -n -t WriteProduct.jmx -l write-2000-10-5.jtl -e -o write/write-2000-10-5
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future releas
e
Creating summariser <summary>
Created the tree successfully using WriteProduct.jmx
Starting standalone test @ 2024 Oct 15 23:31:05 CST (1729006265140)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
[2.623s][warning][os,thread] Failed to start thread "Unknown thread" - pthread_create failed (EAGAIN) for attributes: stacksi
ze: 1024k, guardsize: 0k, detached.
[2.623s][warning][os,thread] Failed to start the native thread for java.lang.Thread "Thread Group 1-1885"
Killed
```

崩了

写入小结：

性能瓶颈：随着线程数的增加，尤其是在 2000 线程的高循环次数下，系统性能急剧下降，无法有效处理请求。

最大线程数：系统在 1000 线程下表现最佳，2000 线程下开始出现性能问题，超过 2000 线程后系统稳定性受到严重影响。
系统稳定性：在高并发写入下，系统稳定性受到影响。
最大负载：由于多次测试后数据库性能不稳定，跑崩需要的请求频率难以测出，测试能够无错误运行的最大负载：成功请求 1600 次/秒

3. 读操作与写操作的性能差异：

读操作与写操作的性能差异：
通常，数据库的读操作比写操作要快，因为读操作只需访问数据，而写操作则涉及数据的写入、锁定和可能的索引更新。测试结果往往会显示 GET 请求的响应时间明显低于 POST 请求。

并发性能：
在高并发环境下，读操作的响应时间可能更稳定，因为它们通常不涉及数据修改的复杂性。写操作在并发情况下可能会出现较高的响应时间，特别是当多个请求尝试更新同一条记录时，可能导致锁竞争。

数据库负载的影响：
随着并发用户数的增加，写操作的性能可能会迅速下降，尤其是在大数据量和复杂事务的情况下。读操作可能保持相对稳定，但在极高负载下，也可能受到影响，导致响应时间增加。根据读写速率的对比，可以为应用选择合适的架构。例如，如果读操作远远超过写操作，可以考虑使用缓存（如 Redis）来减少数据库压力。

稳定性和可靠性：
如果写操作的错误率较高（例如超时或失败），这可能表明数据库在处理写请求时的稳定性不足，需要进行进一步的调优。