实验二：Mongo的读写效率

实验预想：

MongoDB

- **数据存储方式**：MongoDB是面向文档的数据库，它使用文档的方式存储数据，文档中可以包含任何类型的数据，而且不需要事先定义其结构。这种方式使得MongoDB在存储和查询非结构化数据时更加高效。
- **索引机制**：MongoDB采用了BSON格式对数据进行存储，BSON是一种类JSON的二进制编码格式，它支持对文档中的任何字段进行索引，查询速度非常快。

基于以上特性，我们认为无论读写，MongoDB的效率都比MySQL应该更加高效。

实验设计：

实验环境

节点：华东 - 上海

服务器：

- 服务器 A
  - 操作系统：Ubuntu 22.04
  - Dorker
  - Maven
  - git
  - JDK：17
- 服务器 B
  - 操作系统：Ubuntu 22.04
  - Dorker
  - Maven
  - git
  - JMeter 5. 4 .1
  - JDK：17
- 服务器 C
  - 操作系统：Ubuntu 22.04

- Mongo 7.0
- JDK：17

实验内容设计：

- 10s：
  1. 找到服务器超限的精确区间
- 100s：
  1. 探究threads的最大值，以减小loop对实验结果的影响
  2. 依据10s结果，找出服务器大致负载超限区间
  3. 在大致区间内，缩小范围，找到服务器超限的精确区间（精度：samples=100左右）
- 总结对比mysql的读写效率，得出结论

预处理：

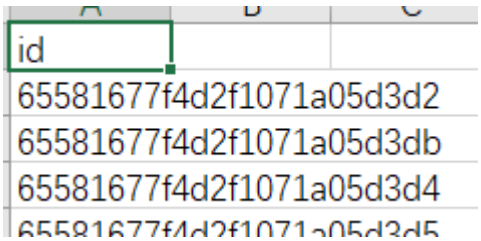
在刚开始进行试验时，我们发现了无论是读还是写的实验，在返回得到的测试结果中均有一些请求失败的结果。

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	3200	2	0.06%	1173.27	11	2488	1158.50	1778.00	1946.90	2199.96	309.03	231.56	59.45
order	3200	2	0.06%	1173.27	11	2488	1158.50	1778.00	1946.90	2199.96	309.03	231.56	59.45

经过不断地尝试，我们发现读实验和写实验中的失败请求有着各自的原因，并修改了读实验的jmx文件，避免了读的失败请求。

具体细节如下：

1. 读： 我们查看了读实验中生成的jtl文件，发现是Id.csv的第一行被作为参数用于发送请求。



因此解决方案很简单：修改jmx文件，忽略csv的表头即可。

2. 写：

原因是在程序使用到了雪花算法，而在雪花算法中又使用到了时间戳信息。

```java
package cn.edu.xmu.javaee.core.util;

/**
 * Twitter_Snowflake<br>
 * SnowFlake的结构如下(每部分用-分开):<br>
 * 0 - 0000000000 0000000000 0000000000 0000000000 0 - 00000 - 00000 - 000000000000 <br>
 * 1位标识，由于long基本类型在Java中是带符号的，最高位是符号位，正数是0，负数是1，所以id一般是正数，最高
 * 41位时间截(毫秒级)，注意，41位时间截不是存储当前时间的时间截，而是存储时间截的差值（当前时间截 - 开始
 * 得到的值），这里的的开始时间截，一般是我们的id生成器开始使用的时间，由我们程序来指定的（如下下面程序I
 * 10位的数据机器位，可以部署在1024个节点，包括3位datacenterId和7位workerId<br>
 * 12位序列，毫秒内的计数，12位的计数顺序号支持每个节点每毫秒(同一机器，同一时间截)产生4096个ID序号<br>
 * 加起来刚好64位，为一个Long型。<br>
 * SnowFlake的优点是，整体上按照时间自增排序，并且整个分布式系统内不会产生ID碰撞(由数据中心ID和机器ID作
 */
public class SnowFlakeIdWorker {

    // ==============================Fields===========================================
    /** 开始时间截 (2015-01-01) */
    private final Long twepoch = 1420041600000L;

    /** 机器id所占的位数 */
    private final static Long workerIdBits = 7L;
```

当服务器处于高并发情况下的时候，可能需要在1s内处理超过1000个请求，而雪花算法1ms内只能申请1个id，因此这时就会报错，返回500：Internal Server Error。

```
4"}, "opTime": {"ts": {"$timestamp": {"t": 1701095185, "i": 122}}, "t": 4}, "ok": 1.0, "$clusterTime": {"clusterTime": {"$timestamp": {"t": 1701095185, "
}}, "signature": {"hash": {"$binary": {"base64": "AAAAAAAAAAAAAAAAAAAAAAAAAAA=", "subType": "00"}}, "keyId": 0}}, "operationTime": {"$timestamp": {"t": 17
85, "i": 122}}}
2023-11-27 14:26:25.089 [http-nio-8080-exec-2519] ERROR o.a.c.c.C.[.[localhost].[/].[dispatcherServlet] - Servlet.service() for servlet [dispatcherServlet
ontext with path [] threw exception [Request processing failed: java.lang.RuntimeException: Clock moved backwards.  Refusing to generate id for 1 millisec
with root cause
java.lang.RuntimeException: Clock moved backwards.  Refusing to generate id for 1 milliseconds
        at cn.edu.xmu.javaee.core.util.SnowFlakeIdWorker.nextId(SnowFlakeIdWorker.java:89)
        at cn.edu.xmu.javaee.order.service.OrderService.createOrder(OrderService.java:30)
        at jdk.internal.reflect.GeneratedMethodAccessor22.invoke(Unknown Source)
        at java.base/jdk.internal.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)
        at java.base/java.lang.reflect.Method.invoke(Method.java:568)
        at org.springframework.aop.support.AopUtils.invokeJoinpointUsingReflection(AopUtils.java:343)
        at org.springframework.aop.framework.ReflectiveMethodInvocation.invokeJoinpoint(ReflectiveMethodInvocation.java:196)
```

实验过程和结果分析：

读：

10s：

实验过程：

(loop=2)

1. 测出大致区间：4000~5000

注：T-L-R指的是Thread_num - Loop - Ramp_time。

T-L-R	1000-2-10	3000-2-10	4000-2-10	5000-2-10
Response Time (ms)	5	9	5	795

2. 测出精确区间：

(测试1：11.25)

T-L-R	4500-2-10	4600-2-10	4700-2-10	4800-2-10(KEY)	4900-2-10(KEY)
Response Time (ms)	46	13	71	69	673

(测试2：验证实验，11.26)

T-L-R	4700-2-10(KEY)	4800-2-10(KEY)
Response Time (ms)	33	300

(loop=4)

测出精确区间（依据loop=2的实验结果）

(测试1：11.25)

T-L-R	2500-4-10	2600-4-10	2700-4-10
Response Time (ms)	4	4	3

T-L-R	2800-4-10（KEY)	2900-4-10(KEY)	3000-4-10
Response Time (ms)	4	272	287

(测试2：验证实验，11.26)

T-L-R	2800-4-10(KEY)	2900-4-10(KEY)
Response Time (ms)	4	453

实验分析：

在loop=2的2次测试中都存在突增问题：

- 该问题反应在Response Times Over Time中，与Latencies Over Time一致，与connection无关
- 该问题会增大平均response time
- 当服务器负载较小时，突增能较快恢复；在负载较大时，恢复速度慢
- 比较loop2和loop4的情况，发现loop数增大，突增的影响减小

关键数据：

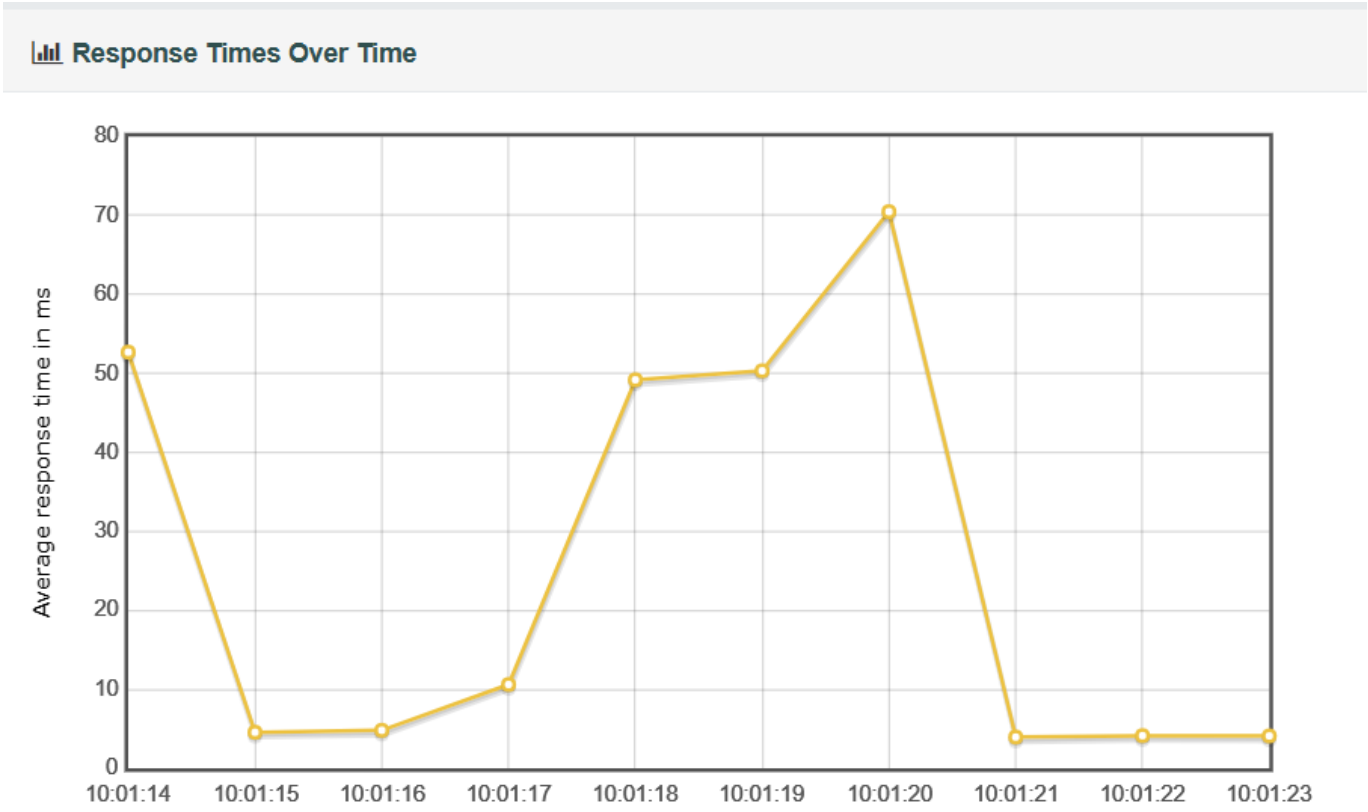
(loop=2)

- 4700-2-10

(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	**9400**	**0**	**0.00%**	**27.49**	**1**	**733**	**6.00**	**82.00**	**118.00**	**193.99**	**1033.65**	**774.81**	**198.86**
order	9400	0	0.00%	27.49	1	733	6.00	82.00	118.00	193.99	1033.65	774.81	198.86

(over time)

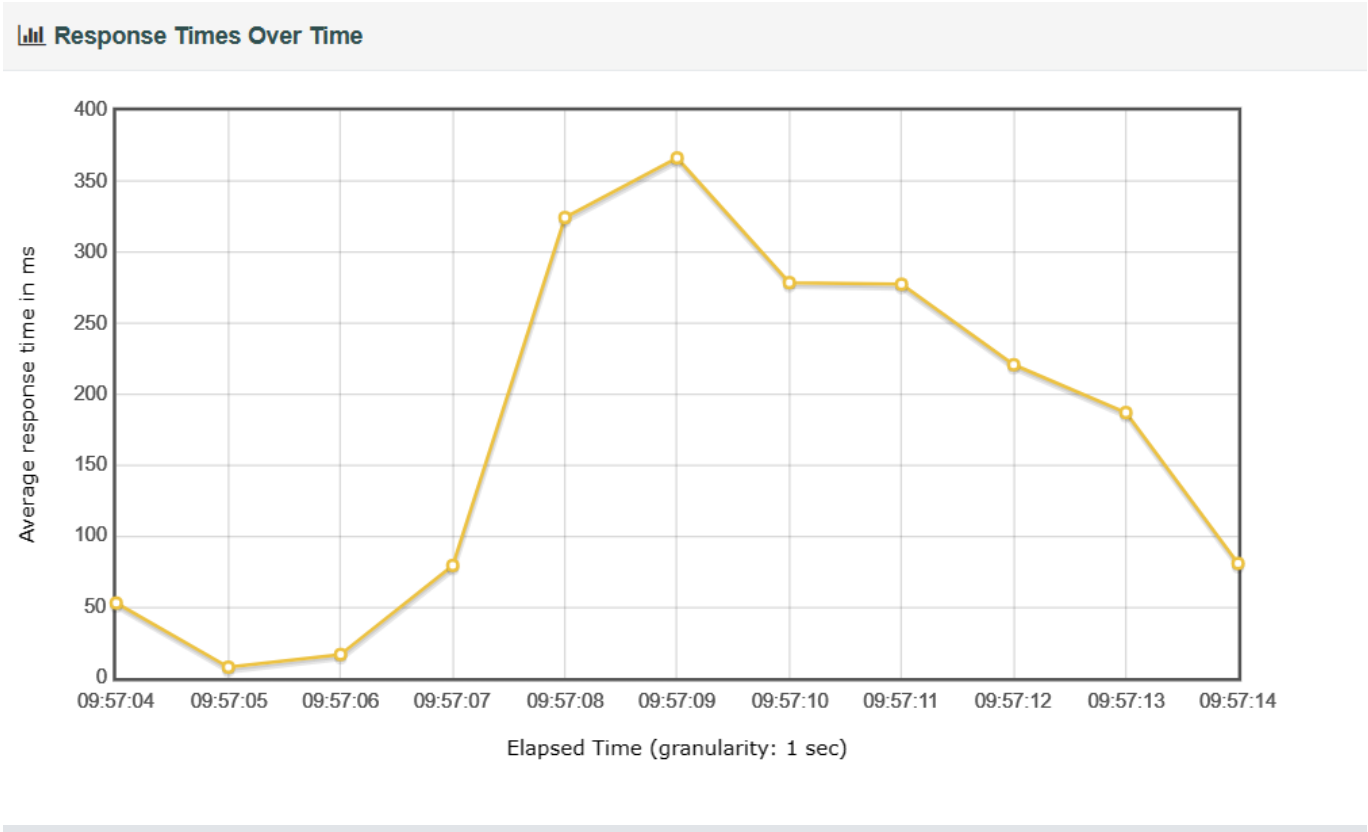


- 4800-2-10

(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	**9600**	**0**	**0.00%**	**201.40**	**1**	**721**	**203.00**	**383.00**	**438.00**	**566.98**	**1013.51**	**759.72**	**194.98**
order	9600	0	0.00%	201.40	1	721	203.00	383.00	438.00	566.98	1013.51	759.72	194.98

(over time)



(loop=4)

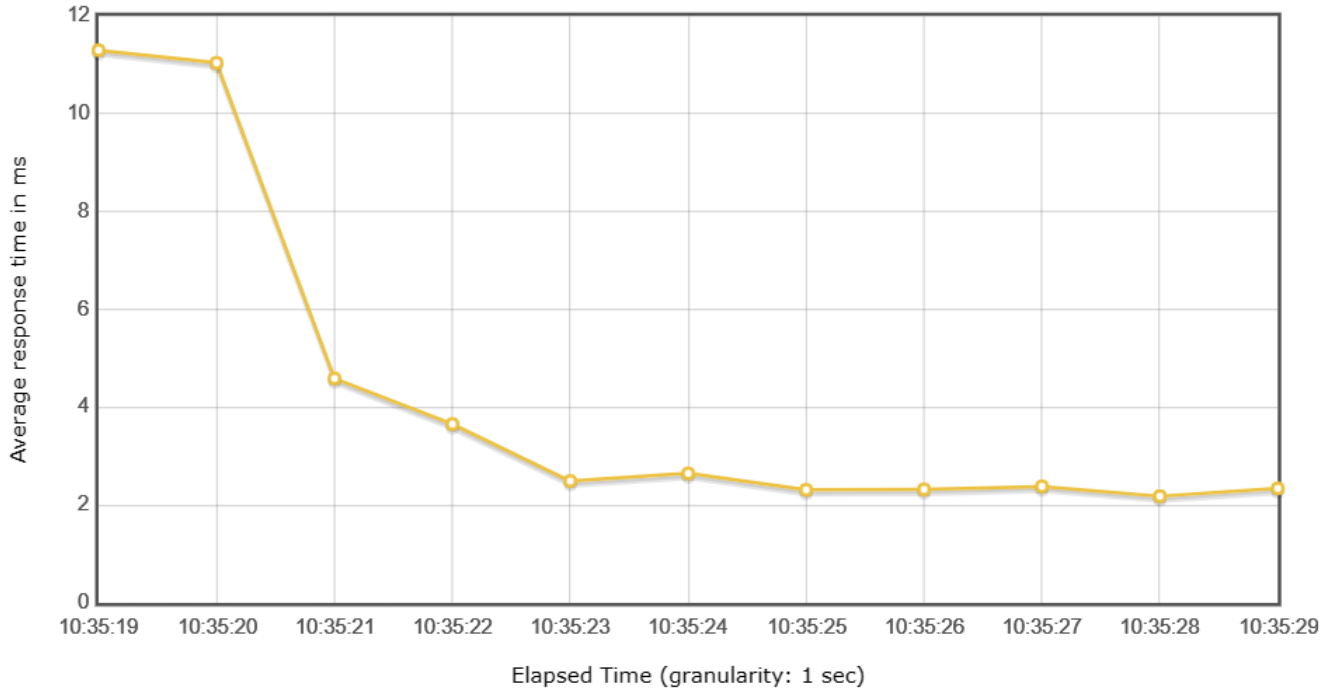
- 2800-4-10 (loop4)

(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	**11200**	**0**	**0.00%**	**4.44**	**1**	**144**	**2.00**	**7.00**	**14.00**	**44.00**	**1022.92**	**766.77**	**196.79**
order	11200	0	0.00%	4.44	1	144	2.00	7.00	14.00	44.00	1022.92	766.77	196.79

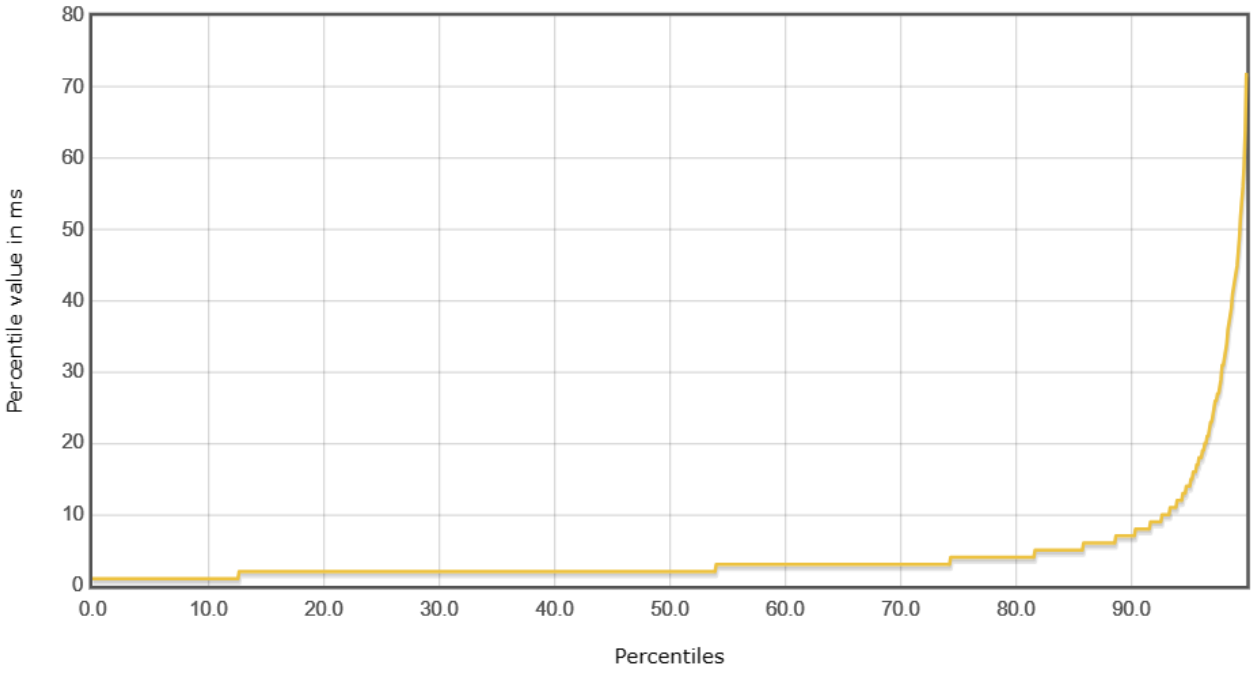
(Over Time)

Response Times Over Time



(Percentages)

Response Time Percentiles



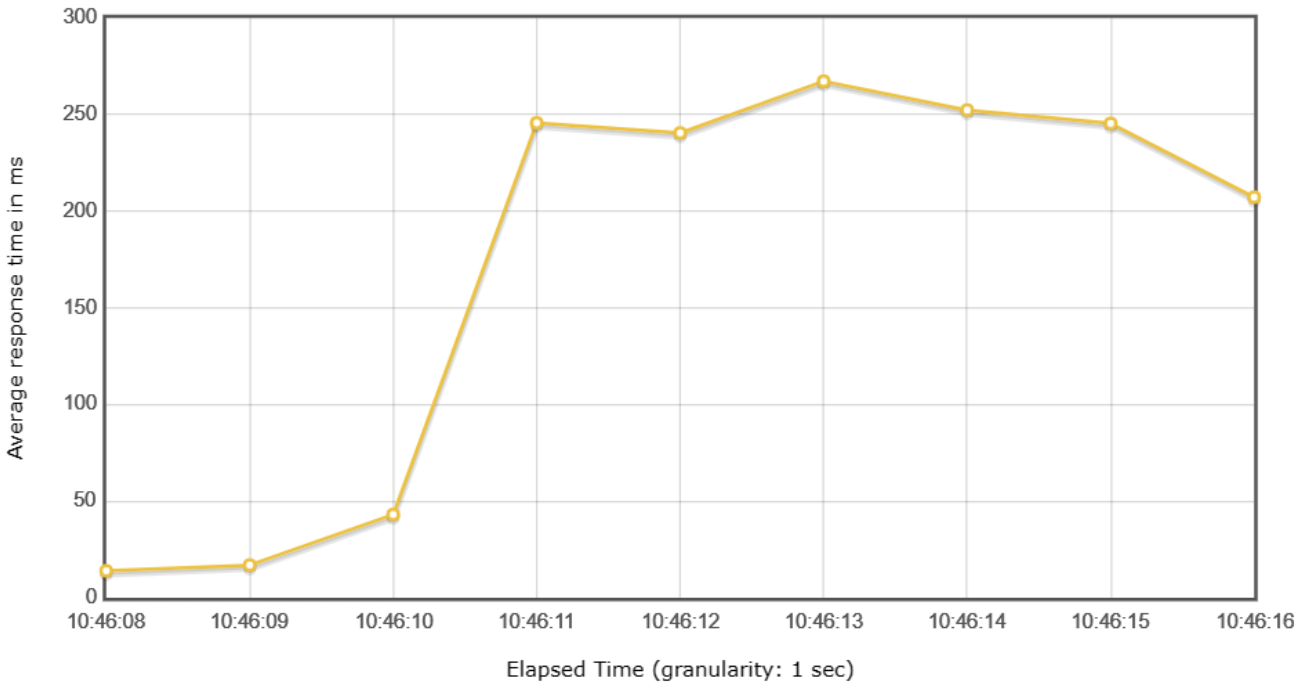
- 2900-4-10 (loop4)

(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	**11600**	**0**	**0.00%**	**179.50**	**1**	**618**	**195.00**	**335.00**	**374.00**	**448.00**	**1301.62**	**975.67**	**250.41**
order	11600	0	0.00%	179.50	1	618	195.00	335.00	374.00	448.00	1301.62	975.67	250.41

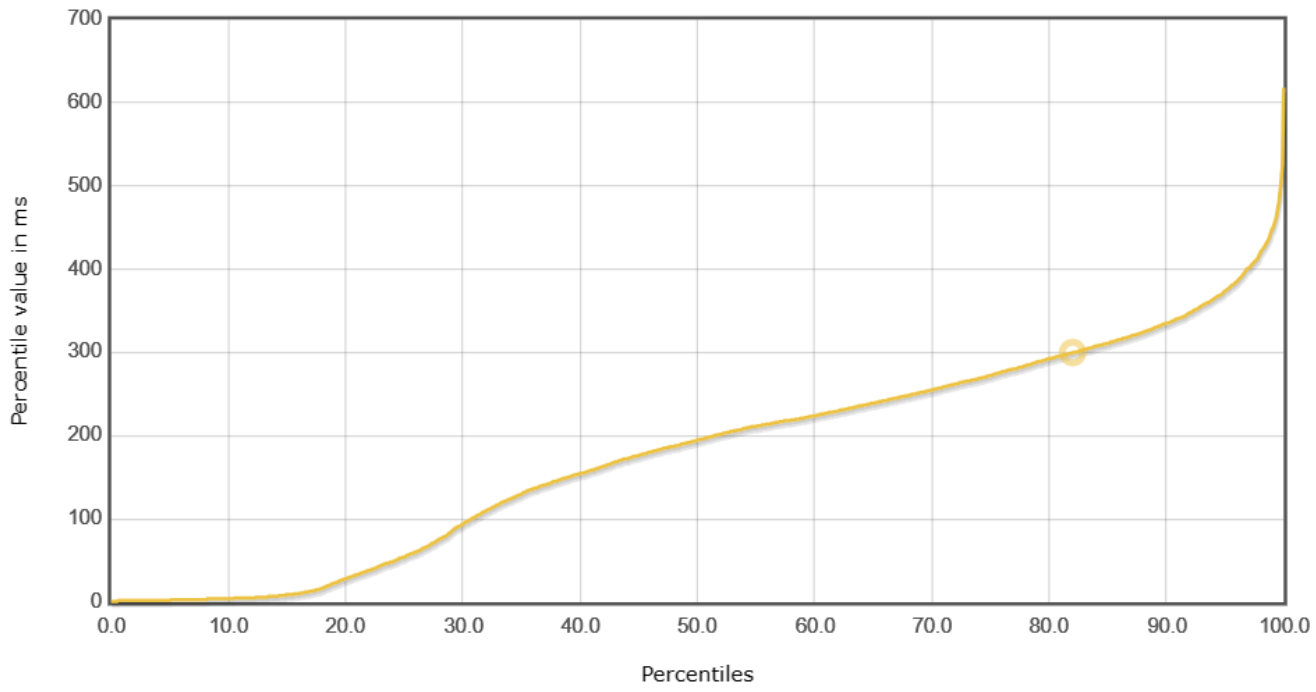
(Over time)

Response Times Over Time



(Percentages)

Response Time Percentiles



读实验10s结果总结：

(测试1：11.25)

	loop=2	loop=4
负载上限	4800-10	2800-10
平均每秒线程数（sample(s) / s）	960	1120

(测试2：11.26)

	loop=2	loop=4
负载上限	4700-10	2800-10
平均每秒线程数（sample(s) / s）	940	1120

- 可以看出：2次实验结果基本相符
- loop增大，读效率增大

100S:

实验过程：

1. 探究threads的最大值，以减小loop对实验结果的影响

   根据samples的数量确定

T-L-R	4000-30-100	4500-33-100	5000-26-100	20000-5-100	100000-1-100
samples	120000	148500	118248	27215	30538

   结论：threads数应该设置在4000-4500之间，通过loop数控制samples的数量，以进行探究实验；

2. 依据10s结果，找出服务器大致负载超限区间

   依据10s的结果，由于JVM程序需要预热，时间增加，减小了预热对于实验结果的影响，故可以在10s结果的平均每秒发出请求数目上增加，以找到服务器工作负载上限的大致区间：

T-L-R	4500-30-100	4500-33-100	4500-35-100	4500-36-100
Response Time (ms)	5	46	400	500

   锁定大致区间为samples=（148500-157500）

3. 大致区间内，缩小范围，找到服务器超限的精确区间（精度：samples=100左右）

   精度：samples= 300 左右

T-L-R	4400-35-100	4410-35-100	4420-35-100	4450-35-100
Response Time (ms)	15	10	200	300

   精度：samples=100左右 KEYDATA

T-L-R	4410-35-100	4411-35-100	4413-35-100	4415-35-100
Response Time (ms)	10	150	351	300

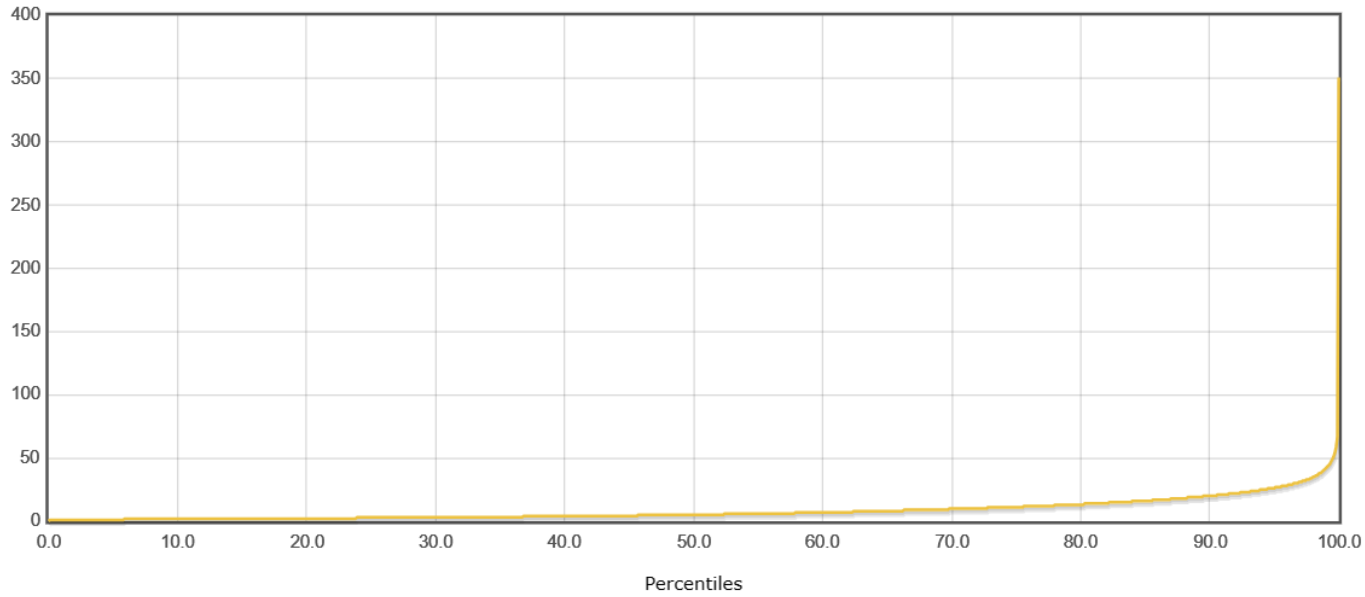
关键数据：

- 4410-35-100

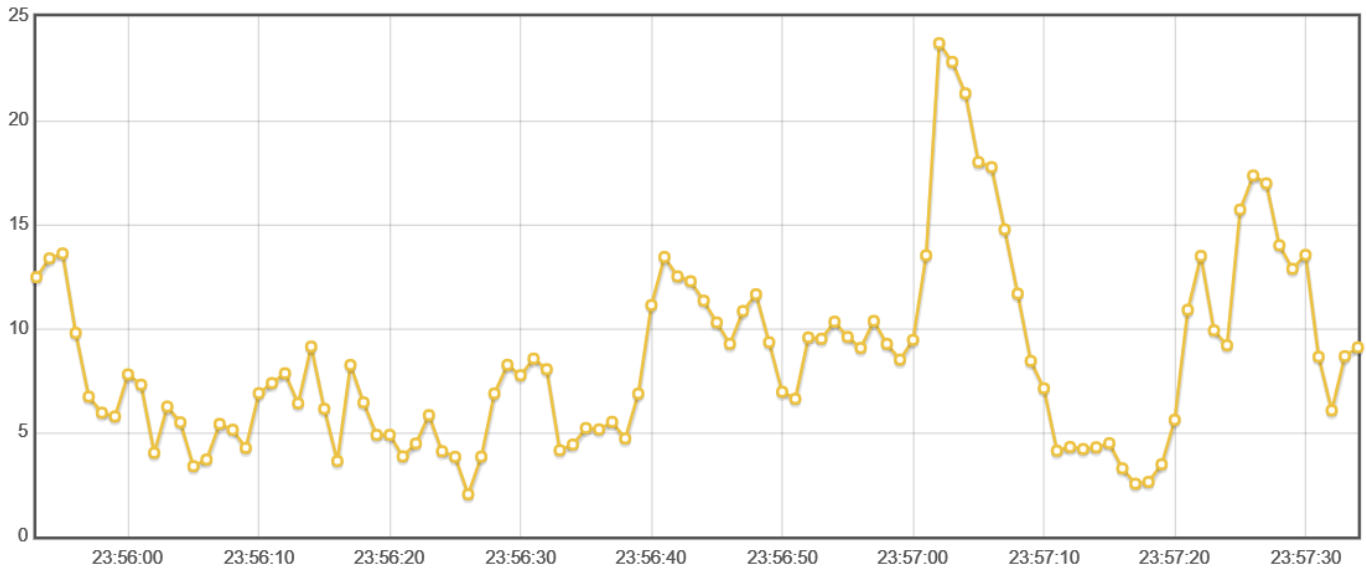
(Statistics)

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	**154350**	**0**	**0.00%**	**8.52**	**0**	**351**	**9.00**	**26.00**	**33.00**	**49.00**	**1521.18**	**1140.26**	**292.65**
order	154350	0	0.00%	8.52	0	351	9.00	26.00	33.00	49.00	1521.18	1140.26	292.65

(Response Time Percentiles)



(Response Times Over Time)

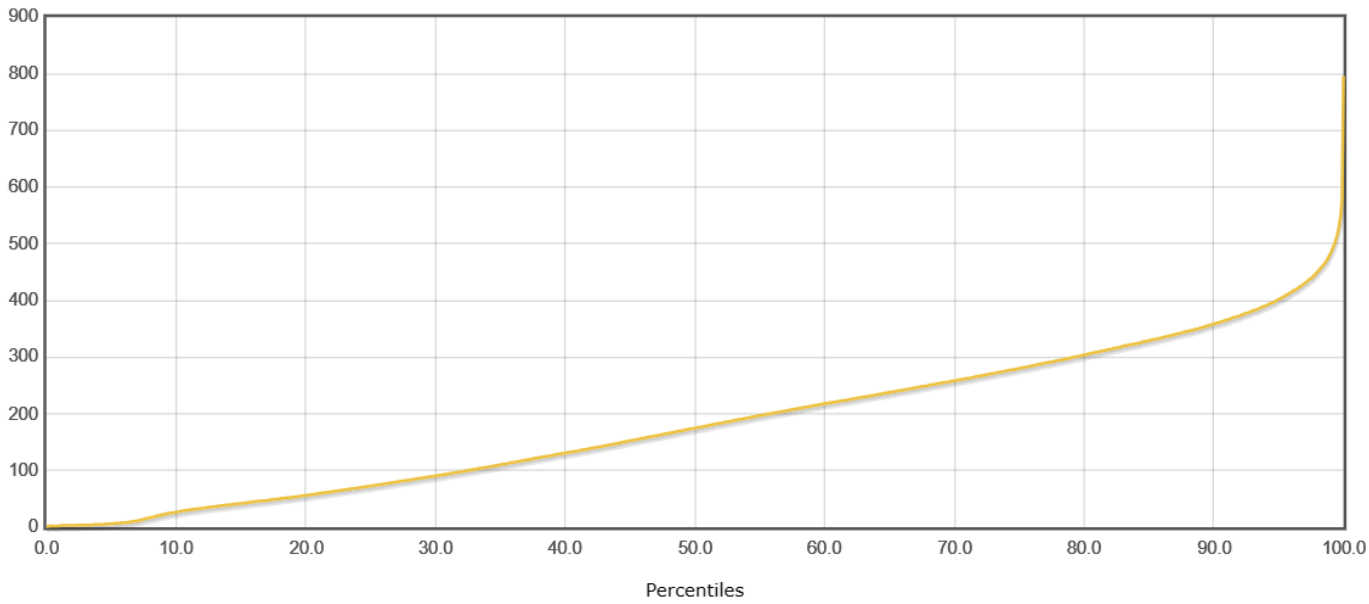


- 4411-35-100

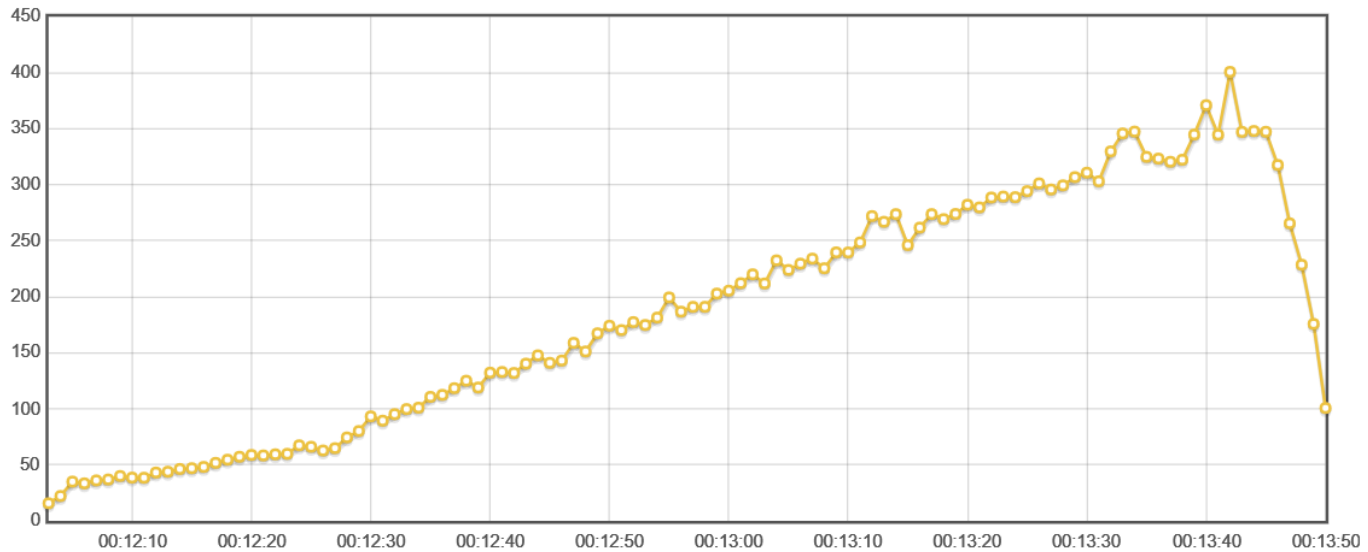
(Statistics)

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	**154385**	**0**	**0.00%**	**184.73**	**1**	**796**	**314.00**	**441.00**	**479.00**	**555.00**	**1431.32**	**1072.90**	**275.36**
order	154385	0	0.00%	184.73	1	796	314.00	441.00	479.00	555.00	1431.32	1072.90	275.36

(Response Time Percentiles)



(Response Times Over Time)



读实验结果：

服务器负载上限

	10s	100s
MogoDB（samples /s）	1120	1544
Mysql（samples /s）	150	183

读实验结论：

1. 相比MySQL，MongoDB的读效率提高了大致8.43倍，效果相当明显。
2. 延长测试时间之后，测得服务器的负载上限也有所提升。

写：

10s:

实验过程：

(loop=2)

1. 测出大致区间：5000~7000

T-L-R	5000-2-10	6000-2-10	7000-2-10
Response Time (ms)	10	12	400

2. 测出精确区间：

T-L-R	6500-2-10	6600-2-10	6700-2-10
Response Time (ms)	5	10	300

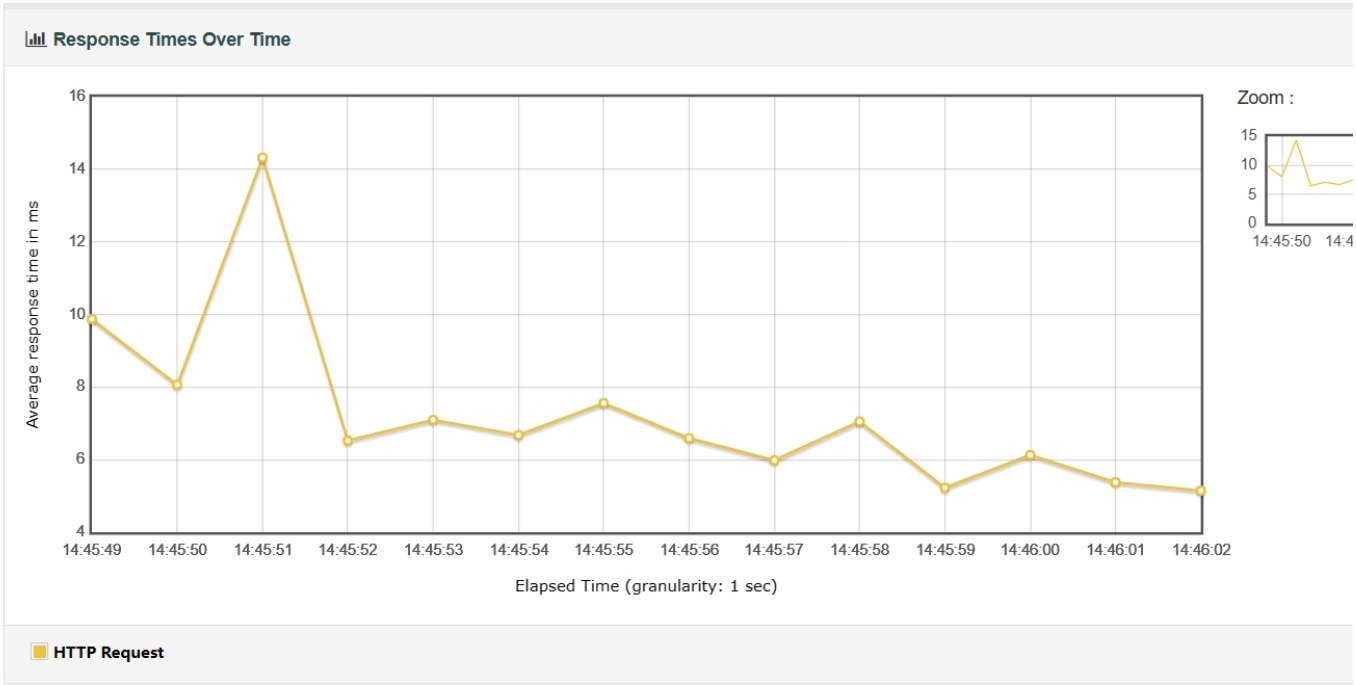
关键数据：

- 6600-2-10

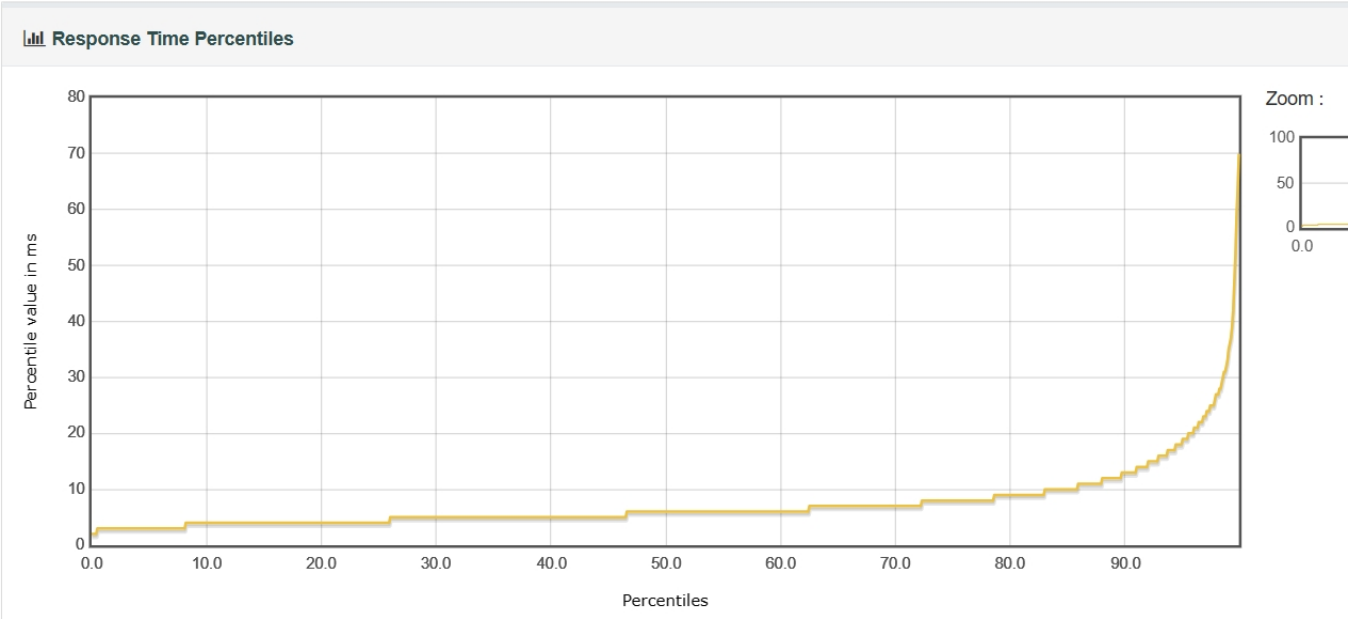
(Statistics)

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	13200	0	0.00%	7.53	2	89	6.00	13.00	19.00	35.00	1010.33	306.85	485.29
HTTP Request	13200	0	0.00%	7.53	2	89	6.00	13.00	19.00	35.00	1010.33	306.85	485.29

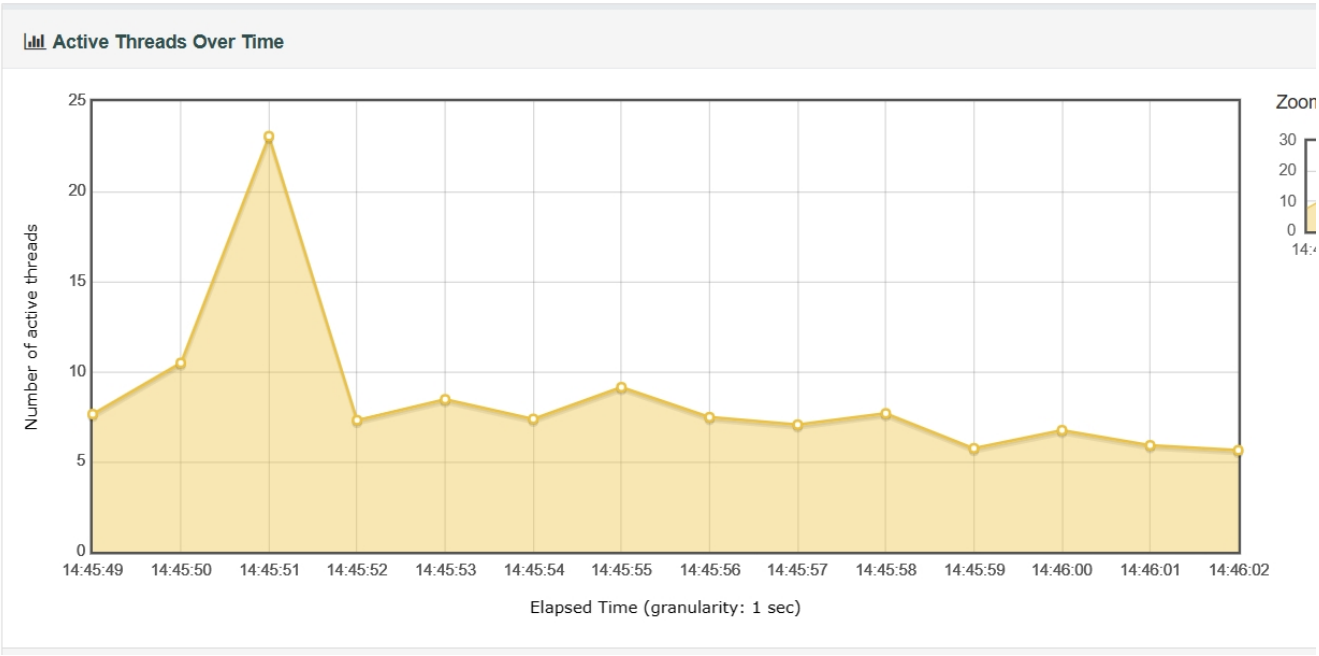
(Response Times over time)



(Response Time Percentiles)



(Active Threads Over Time)



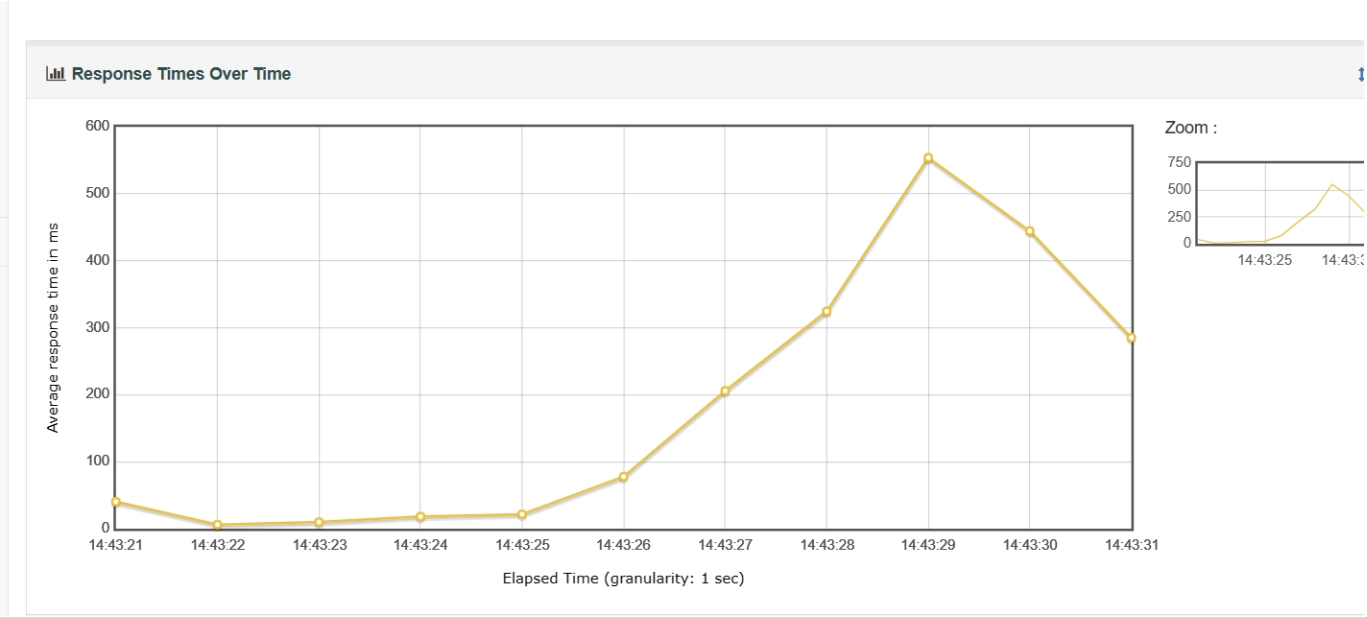
- 6700-2-10s

(Statistics)

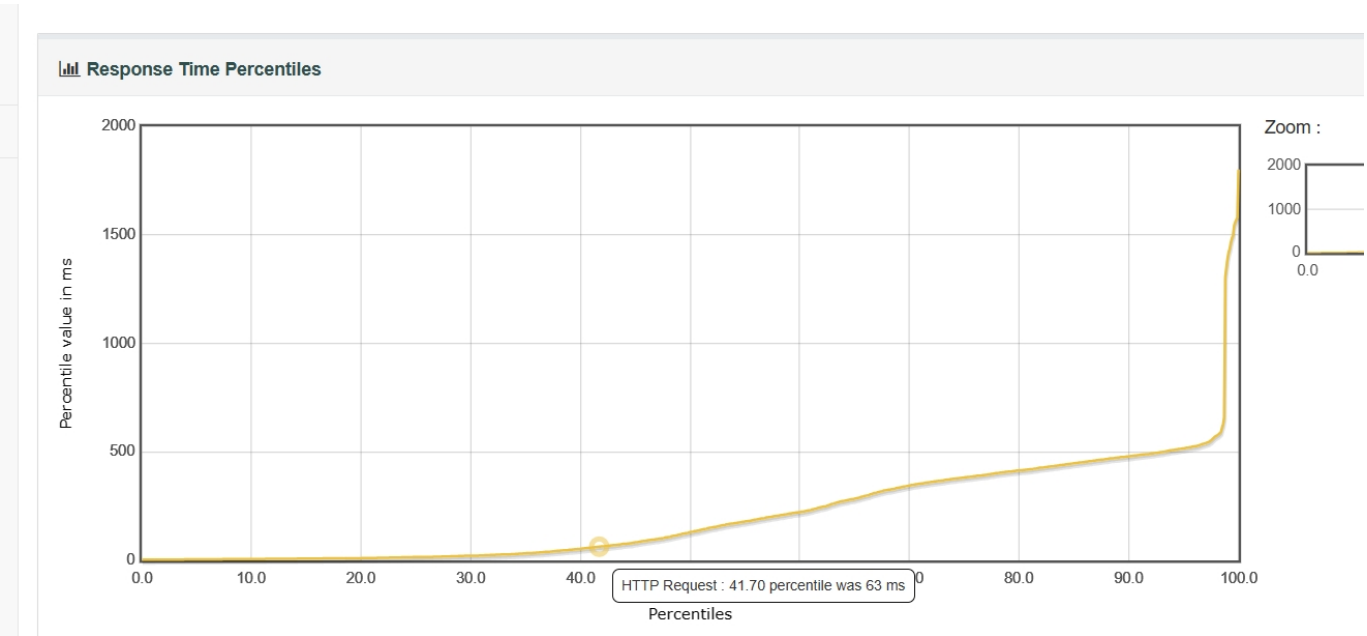
Statistics

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	**13400**	**44**	**0.33%**	**207.92**	**2**	**1802**	**130.00**	**480.00**	**516.00**	**1391.00**	**1427.35**	**433.64**	**685.63**
HTTP Request	13400	44	0.33%	207.92	2	1802	130.00	480.00	516.00	1391.00	1427.35	433.64	685.63

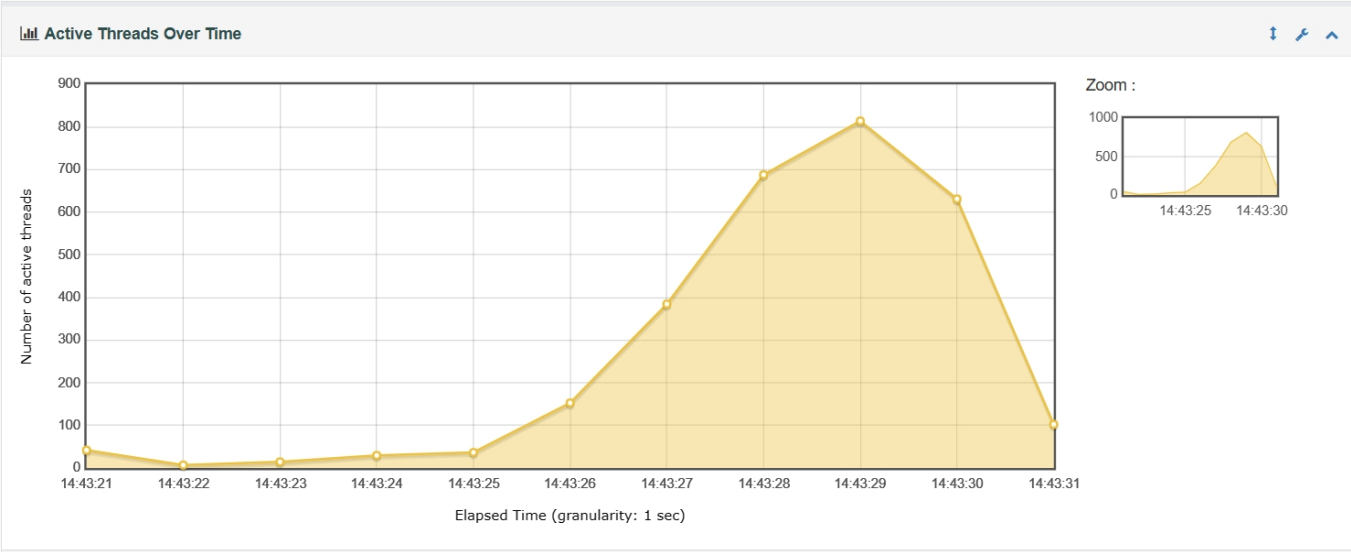
(Response Times over time)



(Response Time Percentiles)



(Active Thread Over Time)



100S:

实验过程：

1. 探究loop20-100s

   samples

T-L-R	9500-20-100	9750-20-100
samples	95300	95200

   响应时间

T-L-R	9500-20-100	9750-20-100
Response Time (ms)	24	500

   结论：sample数小于9500*20，**测试机没法发出全部请求**；但95300个sample-100s大概是服务器极限。**因此后面采用loop=40进行正式实验。**

2. 探究loop40-100s

   samples

T-L-R	3450-40-100	4000-40-100	4350-40-100	4450-40-100	5000-40-100
samples	138000	160000	174000	178000	179960

结论：测试机无法超过100s内5000*40个sample，100s内4450*40接近测试机发出请求上限。

响应时间

T-L-R	4000-40-100	4350-40-100	4450-40-100	4750-40-100
Response Time (ms)	9	14	18	400

关键数据：

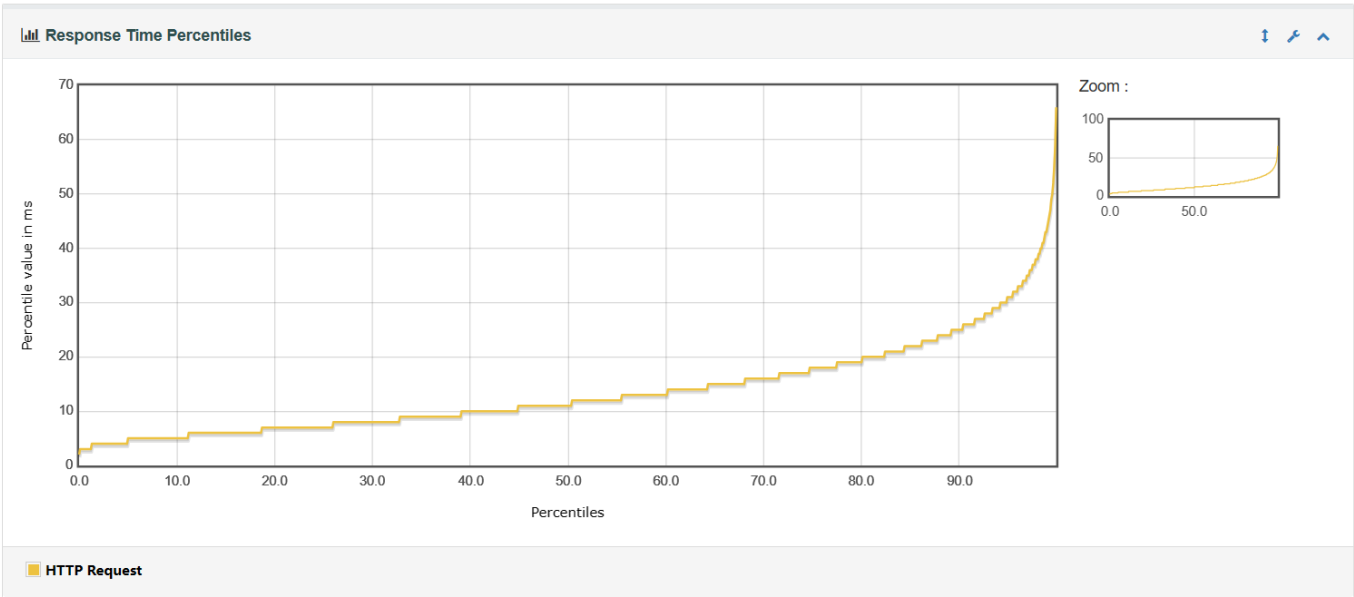
- 4450-40-100

(Statistics)

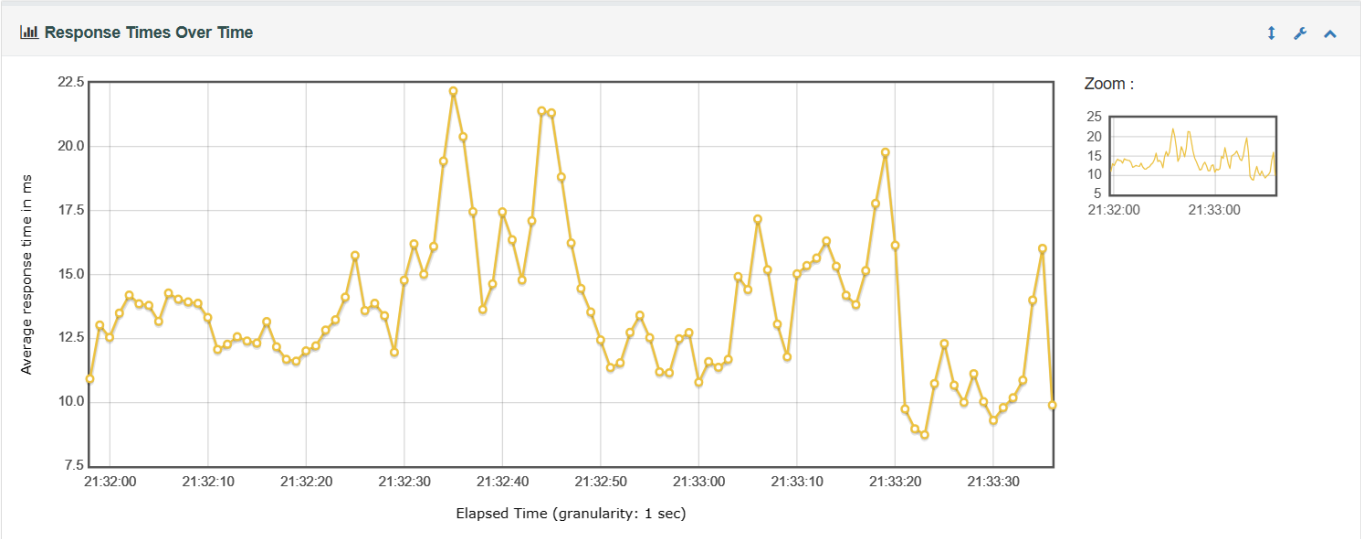
Statistics

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	**178000**	**104**	**0.06%**	**13.75**	**2**	**261**	**9.00**	**21.00**	**26.00**	**38.00**	**1814.20**	**551.02**	**871.42**
HTTP Request	178000	104	0.06%	13.75	2	261	9.00	21.00	26.00	38.00	1814.20	551.02	871.42

(Response Time Percentiles)



(Response Times Over Time)



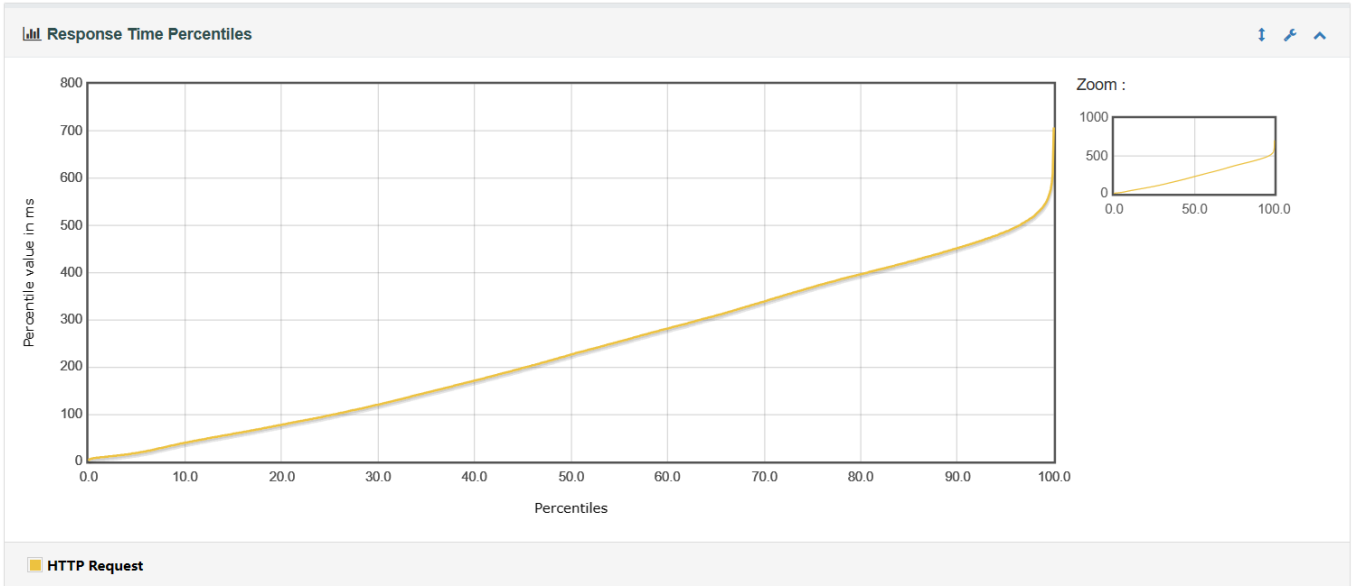
- 4750-40-100

(Statistics)

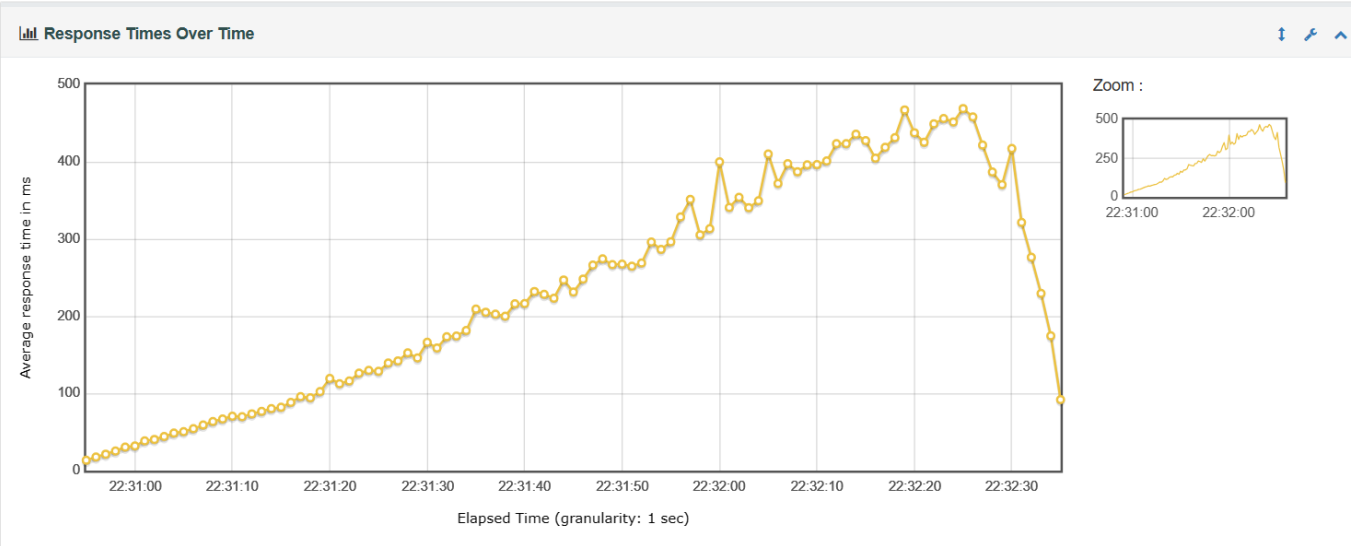
Statistics

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	**19000**	**133**	**0.07%**	**237.26**	**2**	**708**	**366.00**	**496.00**	**523.00**	**573.00**	**1803.28**	**547.71**	**866.18**
HTTP Request	19000	133	0.07%	237.26	2	708	366.00	496.00	523.00	573.00	1803.28	547.71	866.18

(Response Time Percentiles)



(Response Times Over Time)



写实验结果：

服务器负载上限

	10s	100s
MogoDB (samples / s)	1320	1780
Mysql (samples / s)	400	400

结果分析：

100s测得的服务器负载上限比10s的结果更好，可能是由于100s的实验中相较于10s的实验loop数更多，单次loop发的数据量更小，因此服务器压力会更低。

写实验结论：

1. 相比于MySQL，MongoDB的读效率提高了大致4.45倍，效果相当明显。
2. 延长测试时间之后，测得服务器的负载上限也有所提升。

附录：

实验数据：

本次实验数据与使用到的脚本均同步上传至git仓库：GitHub - impAcreat/JavaEE-Experiment2。

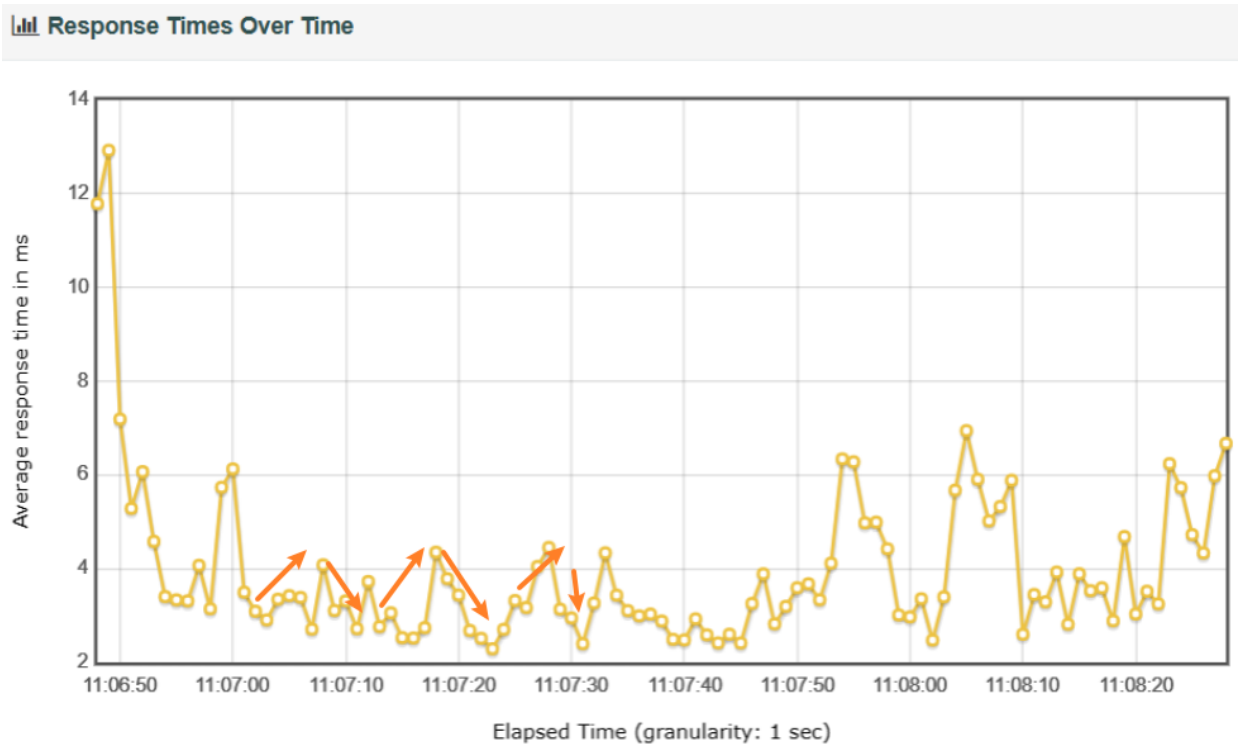
实验中的其他发现：

现象：

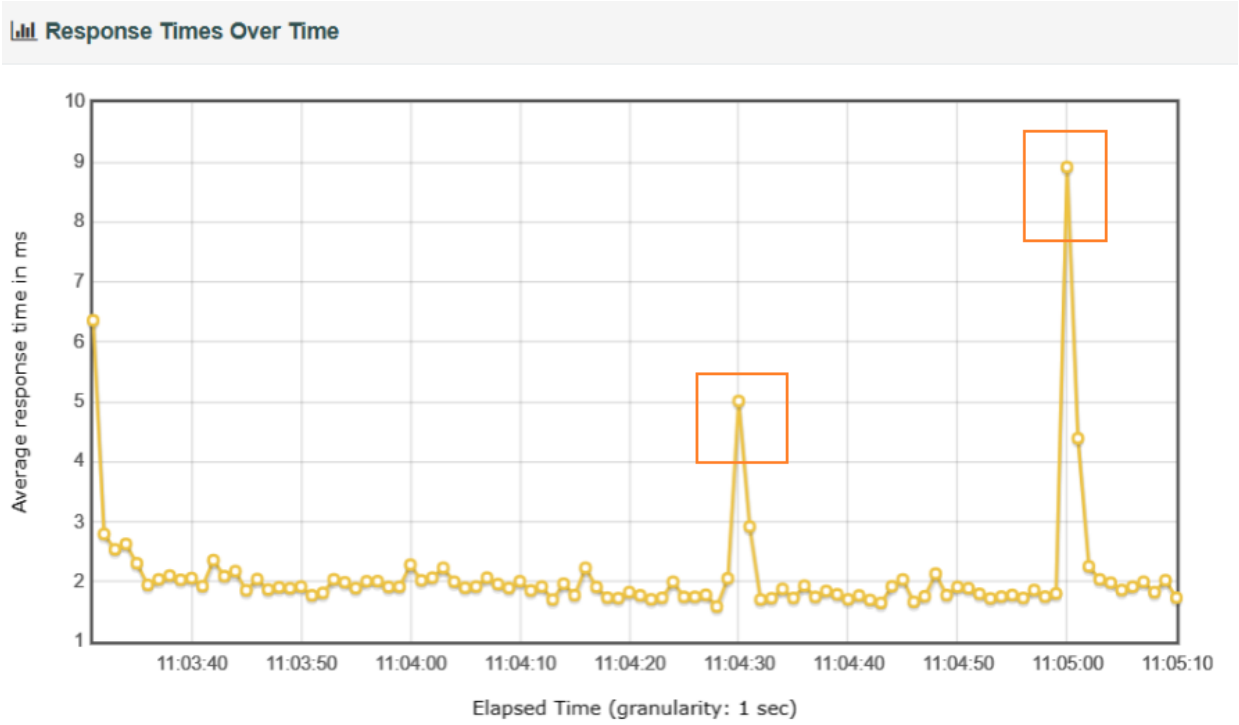
我们在实验过程中还发现了当mongo的**服务器负载压力接近极限时，反应时间并没有像mysql一样稳定下来，而是会上下波动。**

更详细地说明见下方：

- 在loop35-100s进行测试，可以发现：
  - 在低负载时，反应时间保持稳定
  - 接近负载极限，反应时间出现比较大幅的波动
  - 超过极限，反应时间变大，且随测试时间增长而变大
  - 反应时间的波动现象：



- 之前在loop2-10s出现的突变也得到了解释：
  - 回去看之前的实验数据，可以发现在低负载时，并不存在突变，突变在接近极限时才出现
  - 突变：



- loop20-100s：
  - 存在thread创建限制，创建的线程数在4500-4600（测试线程数在4800-7500），故极限samples数在100000左右
  - loop数较小时，实验结果更为明显

关键数据截图：

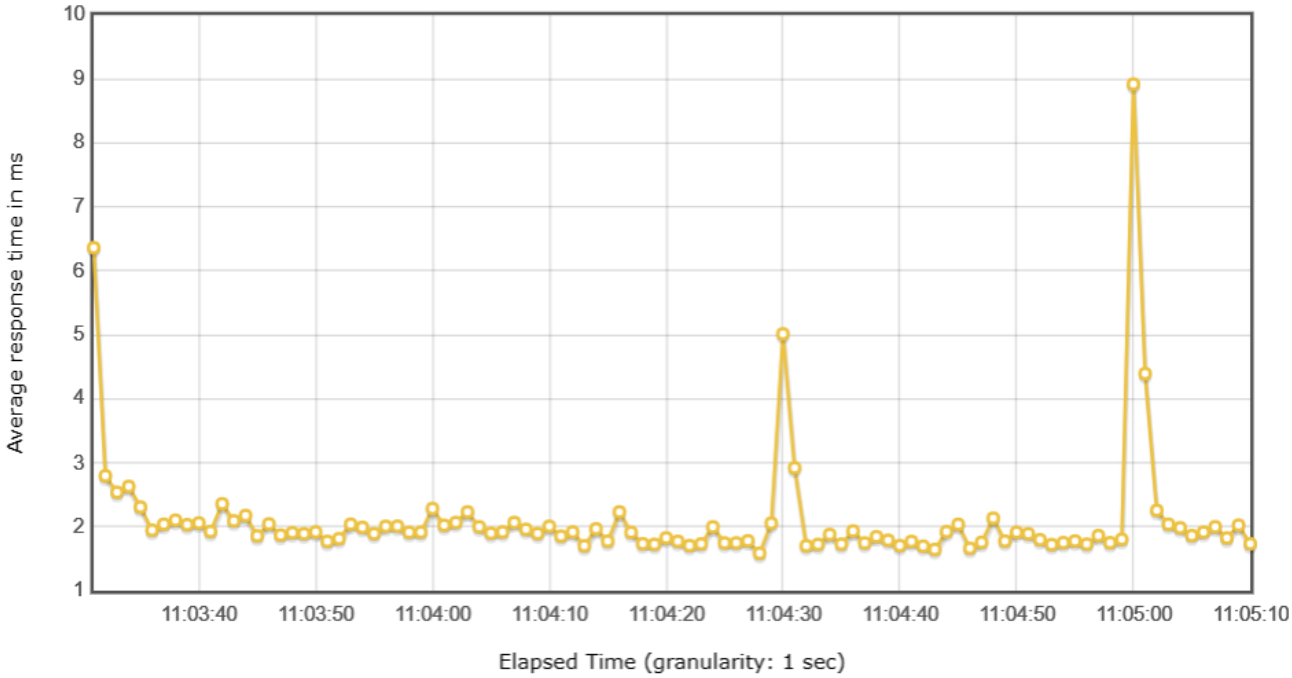
- 3000-35-100

(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	**105000**	**0**	**0.00%**	**2.10**	**1**	**75**	**2.00**	**3.00**	**5.00**	**14.00**	**1062.42**	**796.38**	**204.39**
order	105000	0	0.00%	2.10	1	75	2.00	3.00	5.00	14.00	1062.42	796.38	204.39

(Over Time)

Response Times Over Time



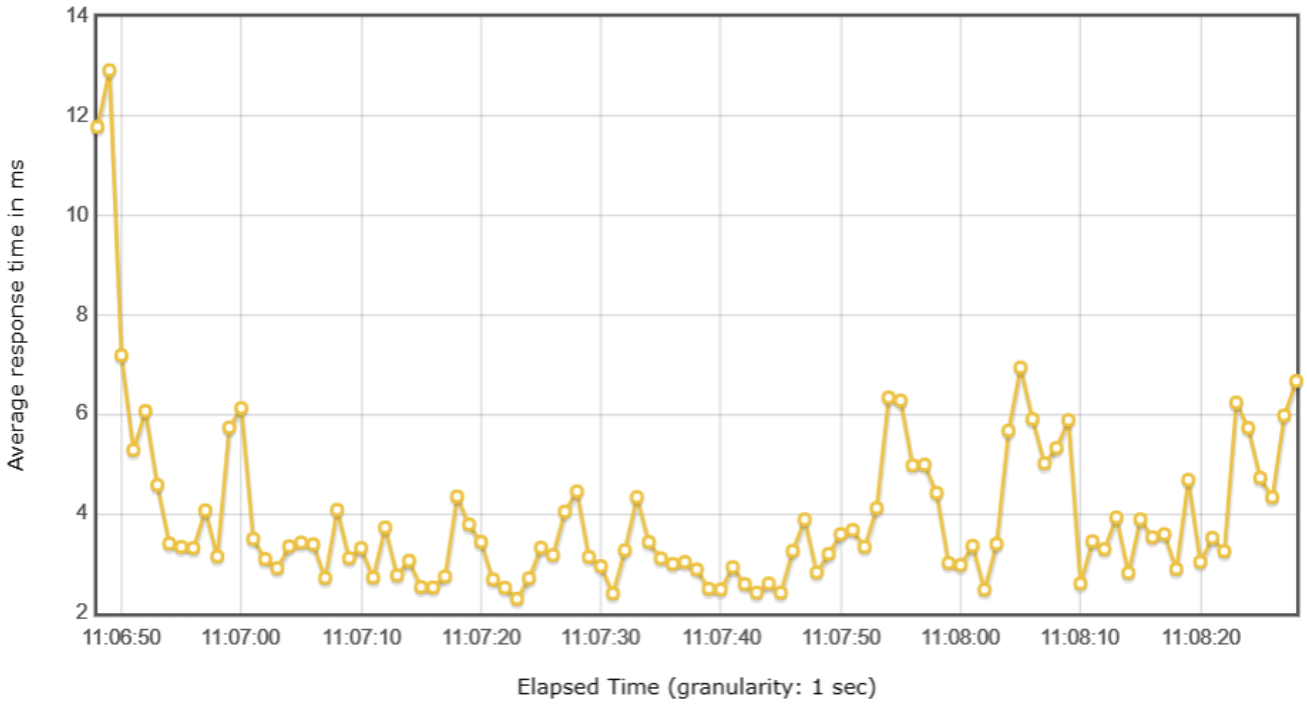
- 4000-35-100

(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	**140000**	**0**	**0.00%**	**3.89**	**1**	**85**	**3.00**	**8.00**	**12.00**	**22.00**	**1400.94**	**1050.13**	**269.52**
order	140000	0	0.00%	3.89	1	85	3.00	8.00	12.00	22.00	1400.94	1050.13	269.52

(Over Time)

Response Times Over Time



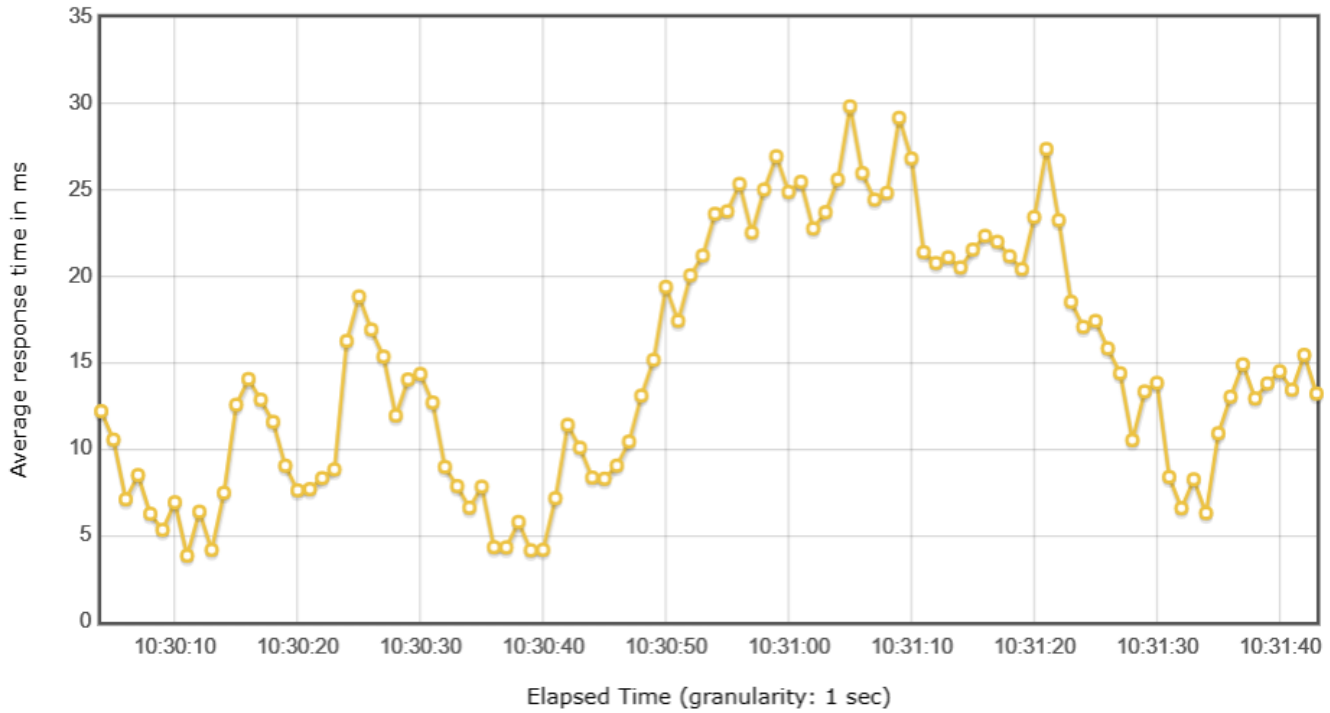
- 4300-35-10

(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	150500	0	0.00%	14.87	1	200	9.00	25.00	31.00	49.99	1520.29	1139.60	292.48
order	150500	0	0.00%	14.87	1	200	9.00	25.00	31.00	49.99	1520.29	1139.60	292.48

(Over Time)

Response Times Over Time



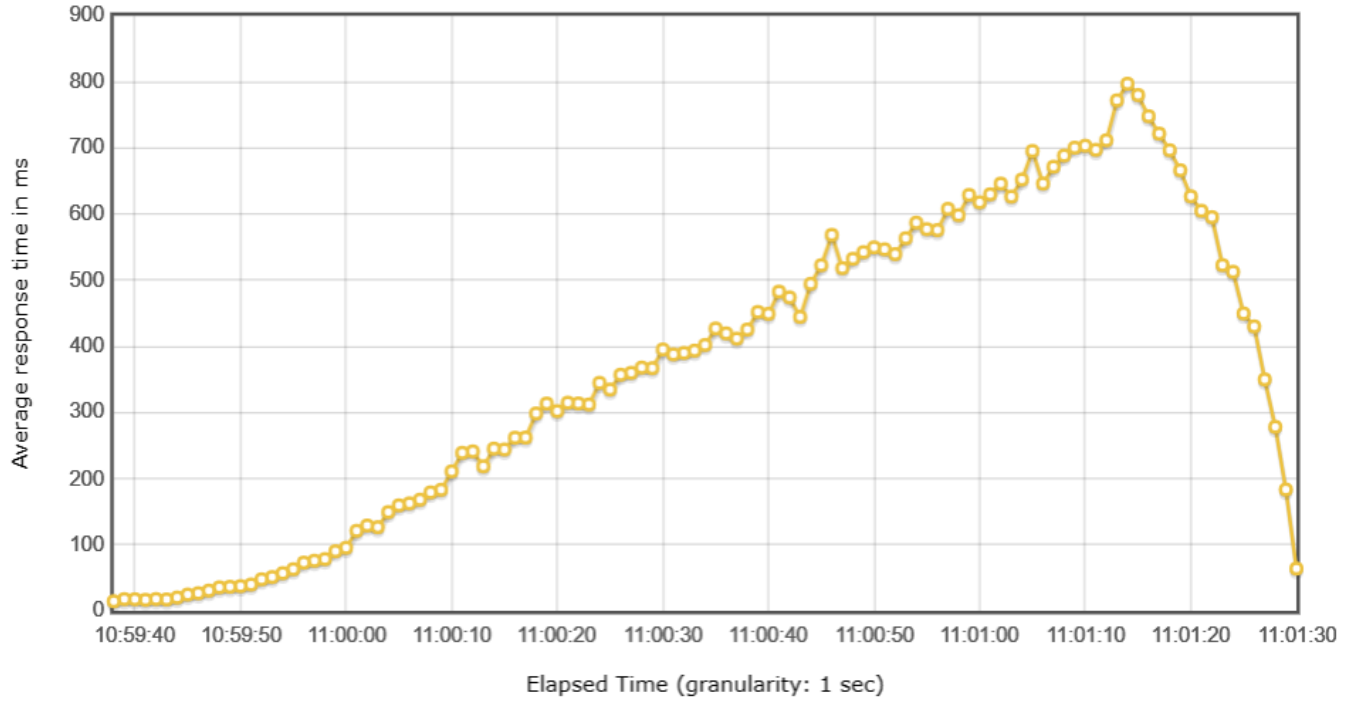
- 4450-35-100

(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	**155750**	**0**	**0.00%**	**368.07**	**1**	**1159**	**556.00**	**766.00**	**811.00**	**892.00**	**1394.14**	**1045.03**	**268.21**
order	155750	0	0.00%	368.07	1	1159	556.00	766.00	811.00	892.00	1394.14	1045.03	268.21

(Over Time)

Response Times Over Time

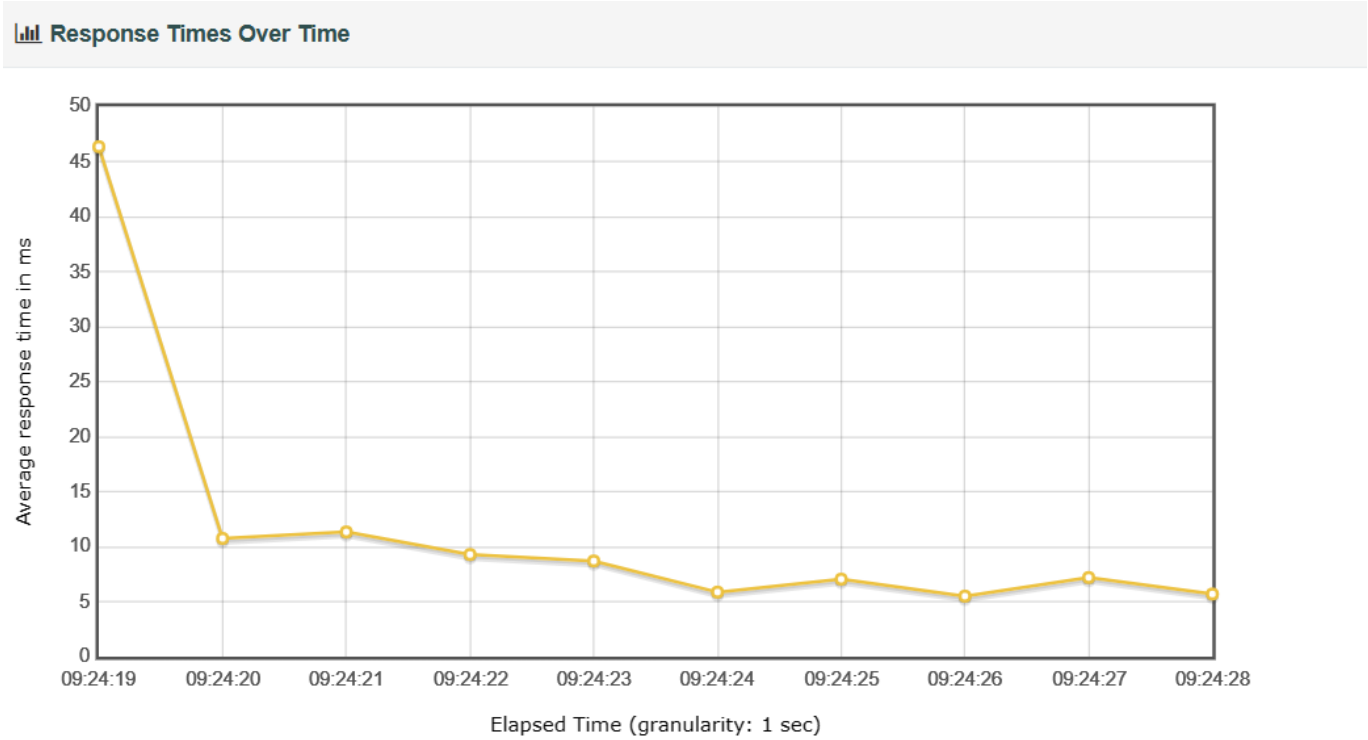


- 3000-2-10

(Statistics)

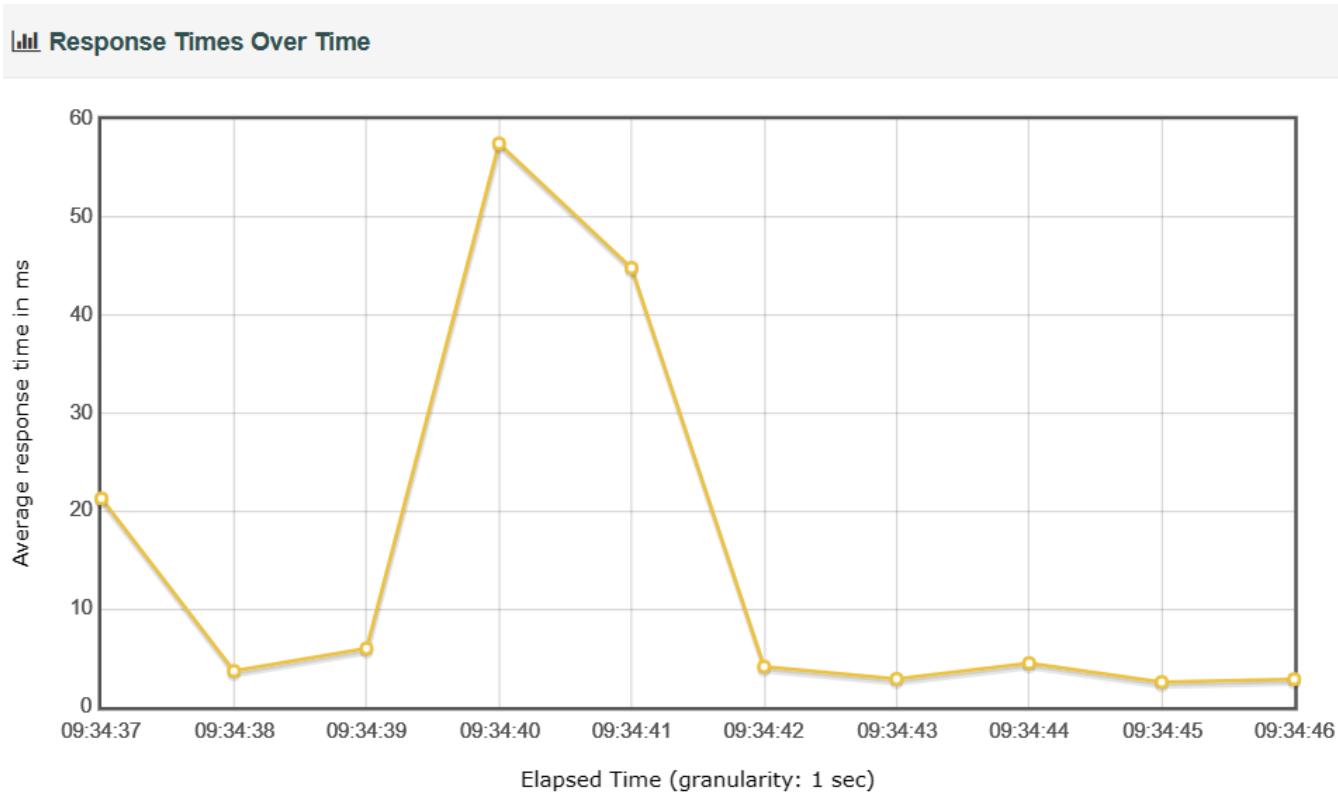
Requests	Executions			Response Times (ms)							Throughput	Network (KB/sec)	
Label	#Samples	FAIL	Error %	Average	Min	Max	Median	90th pct	95th pct	99th pct	Transactions/s	Received	Sent
Total	**6000**	**4**	**0.07%**	**8.90**	**1**	**113**	**5.00**	**19.00**	**32.00**	**59.00**	**681.12**	**510.36**	**131.03**
order	6000	4	0.07%	8.90	1	113	5.00	19.00	32.00	59.00	681.12	510.36	131.03

(Over Time)



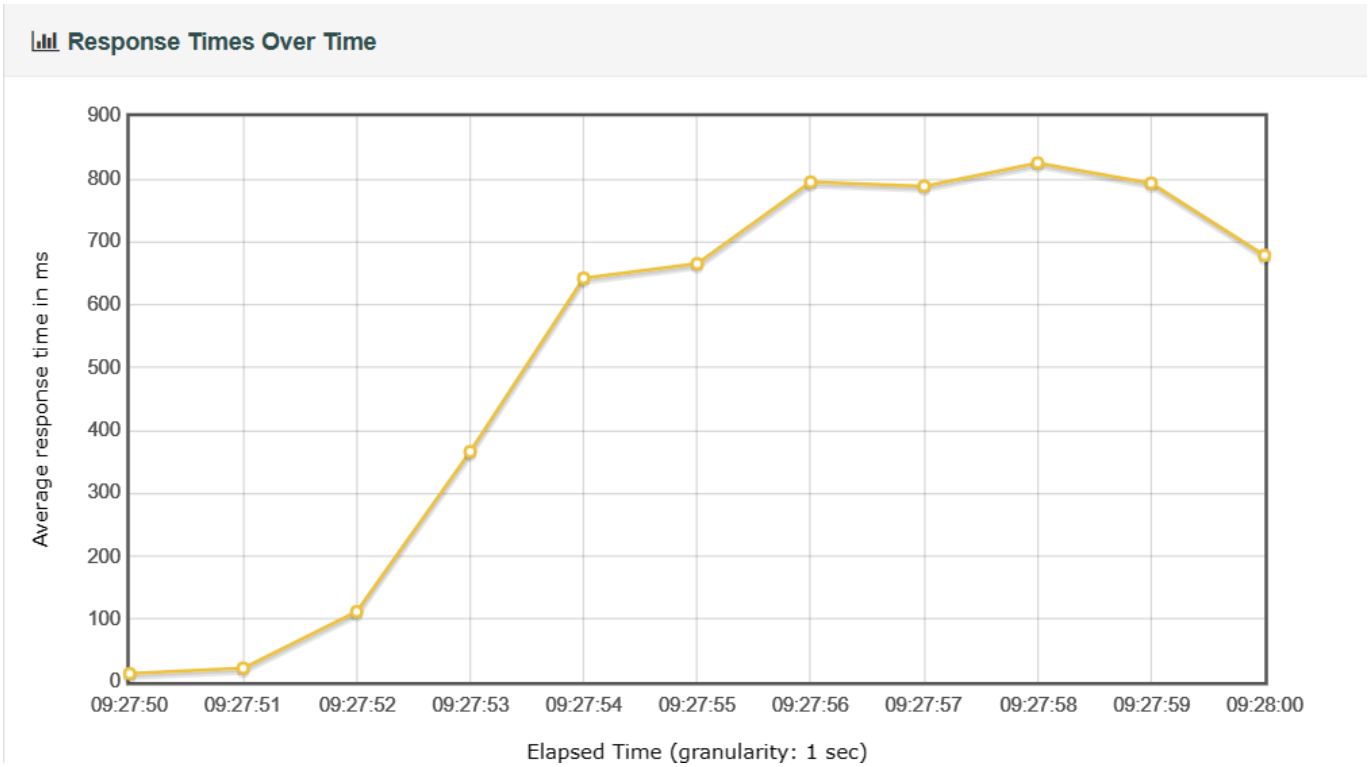
- 4600-2-10

(Over Time)



- 5000-2-10

(Over time)



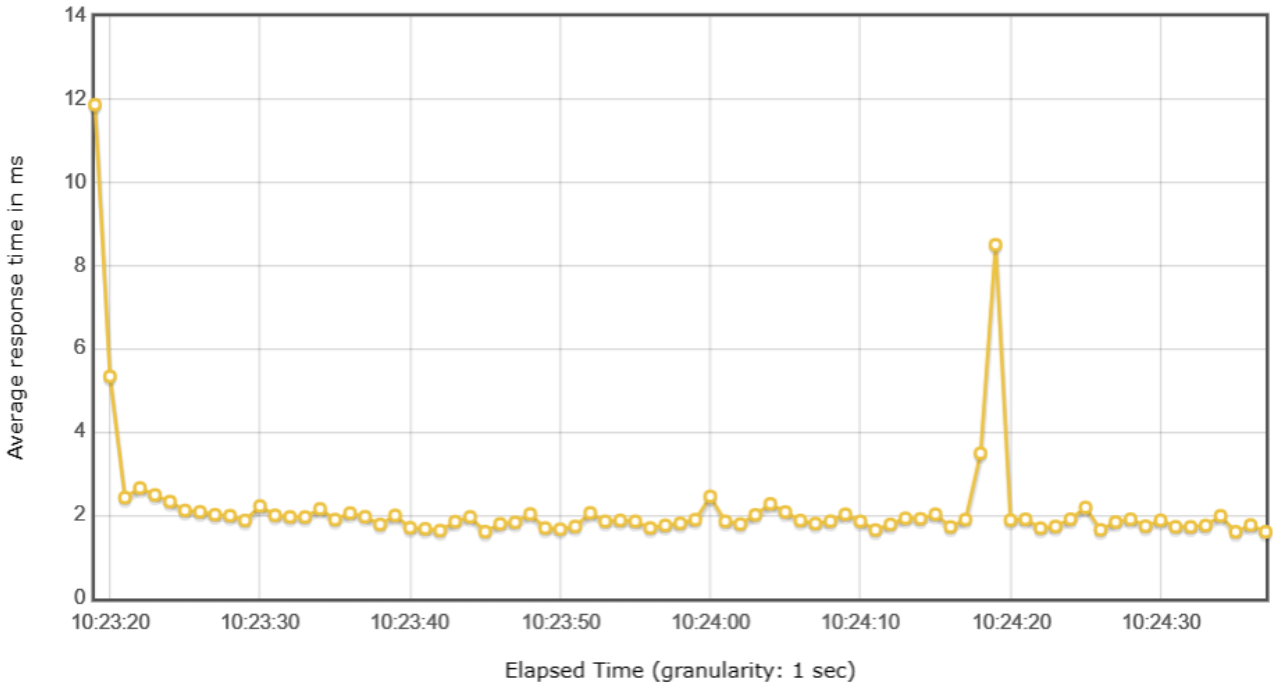
- 5800-20-100

(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	**91820**	**0**	**0.00%**	**2.14**	**0**	**63**	**2.00**	**3.00**	**3.00**	**5.00**	**1179.27**	**883.97**	**226.87**
order	91820	0	0.00%	2.14	0	63	2.00	3.00	3.00	5.00	1179.27	883.97	226.87

(Over Time)

Response Times Over Time



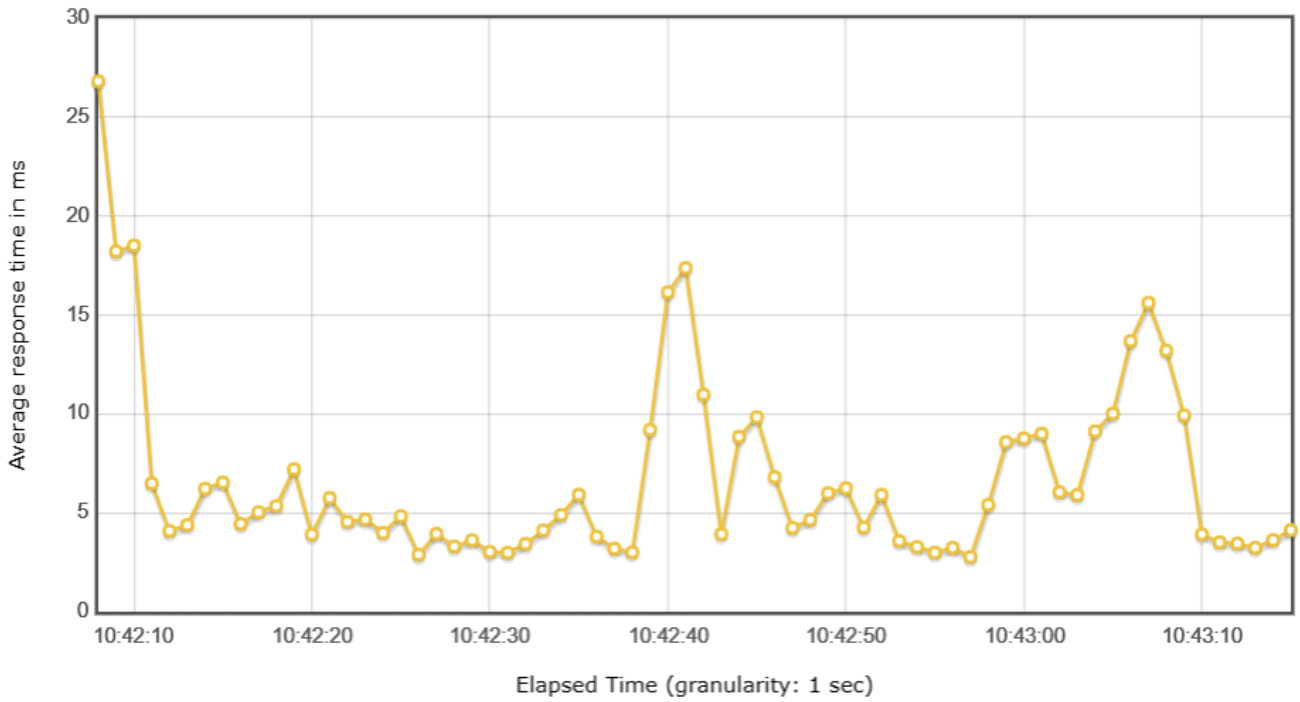
- 7000-20-100

(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	95140	0	0.00%	6.47	1	714	4.00	18.00	26.00	43.00	1432.14	1073.52	275.52
order	95140	0	0.00%	6.47	1	714	4.00	18.00	26.00	43.00	1432.14	1073.52	275.52

(Over Time)

Response Times Over Time



- 7500-20-100

(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	**93940**	**0**	**0.00%**	**222.68**	**1**	**931**	**408.00**	**543.00**	**588.00**	**679.00**	**1426.88**	**1069.57**	**274.51**
order	93940	0	0.00%	222.68	1	931	408.00	543.00	588.00	679.00	1426.88	1069.57	274.51

(Over Time)

Response Times Over Time