Root Cause Analysis on MySQL

10	46:38	Active
Responses	Average time to complete	Status

1. # Workload Spike

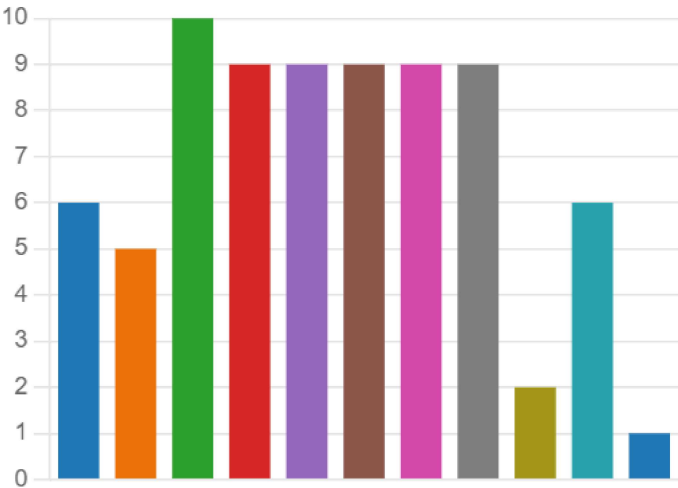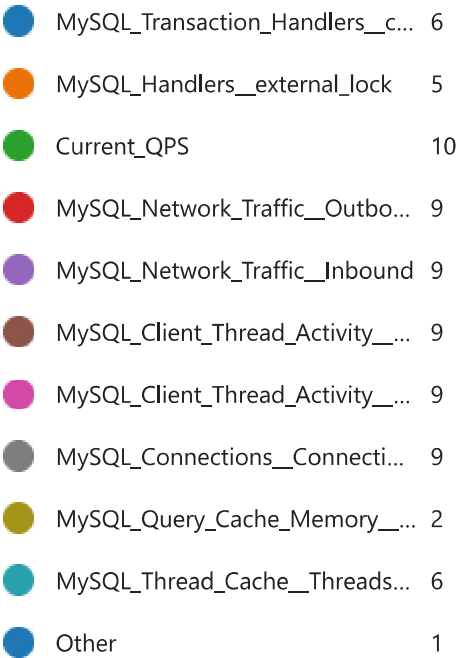   1. **Implementation (root cause):**
      We greatly increase the number of clients simulated by BenchBase to connect to MySQL server.
   2. **Description:**
      This anomaly will drastically increase the number of connections to the MySQL server, then increase the workload on the server. This is reflected in the increased number of queries processed by the server, more IO activity and increased network traffic.
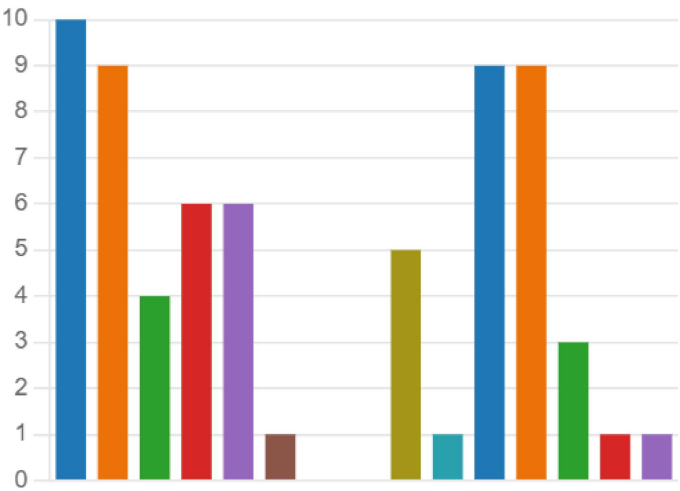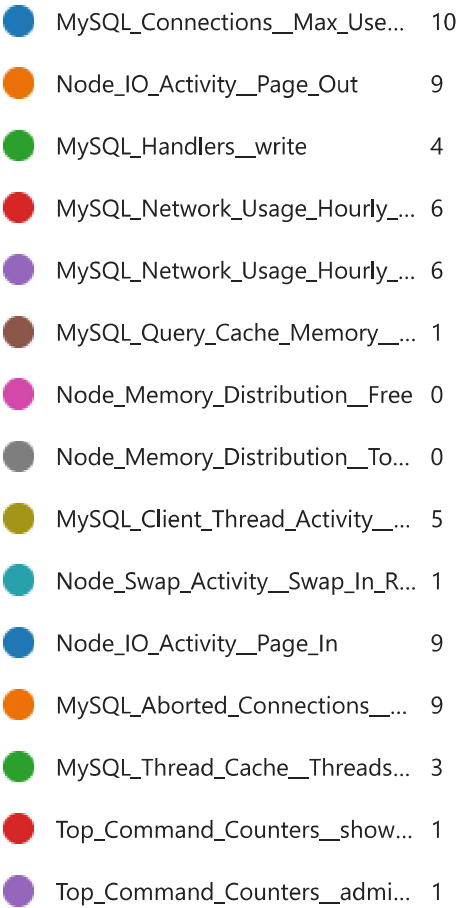   3. **Impact on query duration:**
      In this case, the query duration is much larger than the normal average value.

🔵	MySQL_Transaction_Handlers__c...	6
🟠	MySQL_Handlers__external_lock	5
🟢	Current_QPS	10
🔴	MySQL_Network_Traffic__Outbo...	9
🟣	MySQL_Network_Traffic__Inbound	9
🟤	MySQL_Client_Thread_Activity__...	9
🩷	MySQL_Client_Thread_Activity__...	9
⚫	MySQL_Connections__Connecti...	9
🟡	MySQL_Query_Cache_Memory__...	2
🔵	MySQL_Thread_Cache__Threads...	6
🔵	Other	1

2. **I/O Latency**

1. **Implementation (root cause)**:
   We create a 100ms delay on the pod (here, "pod" simply refers to the container) of MySQL.
2. **Description**:
   Delay caused by this anomaly will lead to a decrease in the MySQL pod's I/O activity, and also lead to the client's current connection timeout or encounter some error, then the client will frequently trying to reconnect the MySQL server, increasing the max used connection count.
3. **Impact on query duration**
   In this case, the query duration is much larger than the normal average value.

🔵 MySQL_Connections__Max_Use...	10
🟠 Node_IO_Activity__Page_Out	9
🟢 MySQL_Handlers__write	4
🔴 MySQL_Network_Usage_Hourly_...	6
🟣 MySQL_Network_Usage_Hourly_...	6
🟤 MySQL_Query_Cache_Memory__...	1
🟣 Node_Memory_Distribution__Free	0
⚫ Node_Memory_Distribution__To...	0
🟡 MySQL_Client_Thread_Activity_...	5
🔵 Node_Swap_Activity__Swap_In_R...	1
🔵 Node_IO_Activity__Page_In	9
🟠 MySQL_Aborted_Connections__...	9
🟢 MySQL_Thread_Cache__Threads...	3
🔴 Top_Command_Counters__show...	1
🟣 Top_Command_Counters__admi...	1

3. I/O Fault-1

1. **Implementation (root cause):**
   We create an I/O fault with error number 1, which can simulate a *Operation not permitted* error in the MySQL pod's file system, this error has 50% probability to happen per operation.
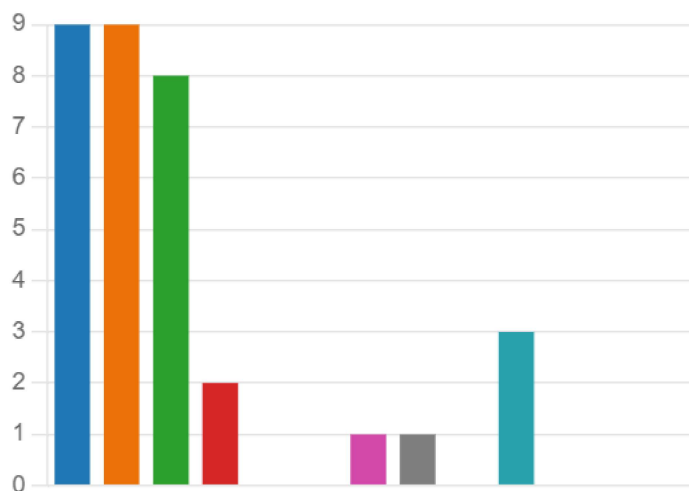2. **Description**:
   This anomaly will have an impact on I/O activity, then decrease the number queries processed per seconds. Further, the usage of network will also get slight impact.
3. **Impact on query duration**
   In this case, the query duration is slightly smaller than the normal average value.

🔵	Node_IO_Activity__Page_Out	9
🟠	Node_IO_Activity__Page_In	9
🟢	MySQL_Network_Usage_Hourly_...	8
🔴	MySQL_Query_Cache_Memory__...	2
🟣	Node_Memory_Distribution__Free	0
🟤	Node__Memory_Distribution__T...	0
🩷	MySQL_Client_Thread_Activity__...	1
⚪	Node_Swap_Activity__Swap_In_R...	1
🟡	MySQL_Connections__Max_Use...	0
🔵	MySQL_Aborted_Connections__...	3
🔵	MySQL_Thread_Cache__Threads...	0
🟠	Top_Command_Counters__show...	0
🟢	Top_Command_Counters__admi...	0

4. **I/O Fault-5**

1. **Implementation (root cause)**:
   We create an I/O fault with error number 5, which can simulate an *I/O error* in the MySQL pod's file system, this error has 50% probability to happen per operation.
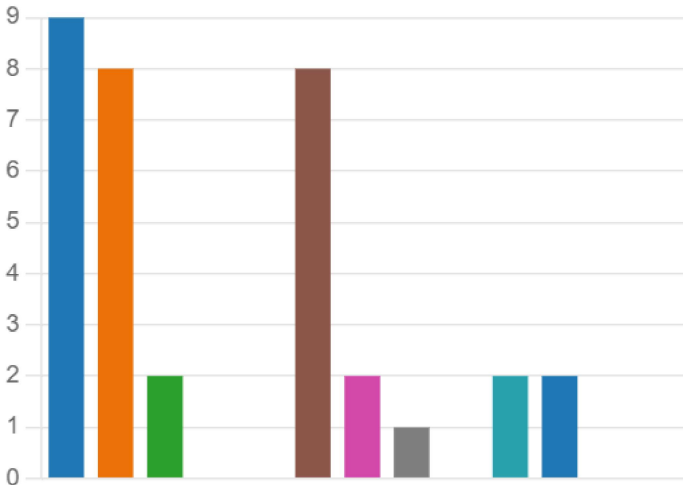2. **Description**:
   This anomaly will have an impact on I/O activity, then decrease the number queries processed per seconds. Further, the usage of network will also get slight impact.
3. **Impact on query duration**
   In this case, the query duration is slightly smaller than the normal average value.

🔵	Node_IO_Activity__Page_In	9
🟠	MySQL_Network_Usage_Hourly_...	8
🟢	MySQL_Query_Cache_Memory__...	2
🔴	Node_Memory_Distribution__Free	0
🟣	Node_Memory_Distribution__To...	0
🟤	MySQL_File_Openings	8
🟣	MySQL_Thread_Cache__Threads...	2
⚫	Node_Swap_Activity__Swap_In_R...	1
🟡	MySQL_Connections__Max_Use...	0
🟢	MySQL_Aborted_Connections__...	2
🔵	MySQL_Thread_Cache__Threads...	2
🟠	Top_Command_Counters__show...	0
🟢	Top_Command_Counters__admi...	0

5. ## I/O Saturation

1. **Implementation (root cause)**:
   We use stress-ng spawns multiple processes that spin on write()/unlink()/sync() system calls on the server where we deploy the cluster.
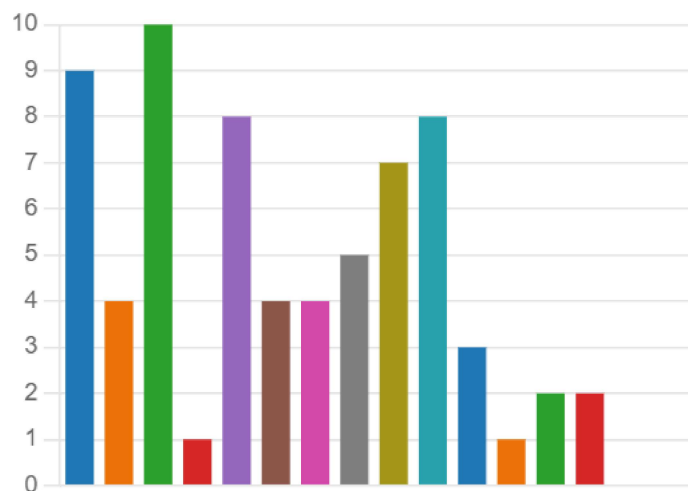2. **Description**:
   This anomaly will have an big impact on memory distribution and I/O activity, then decrease the number queries processed per seconds.
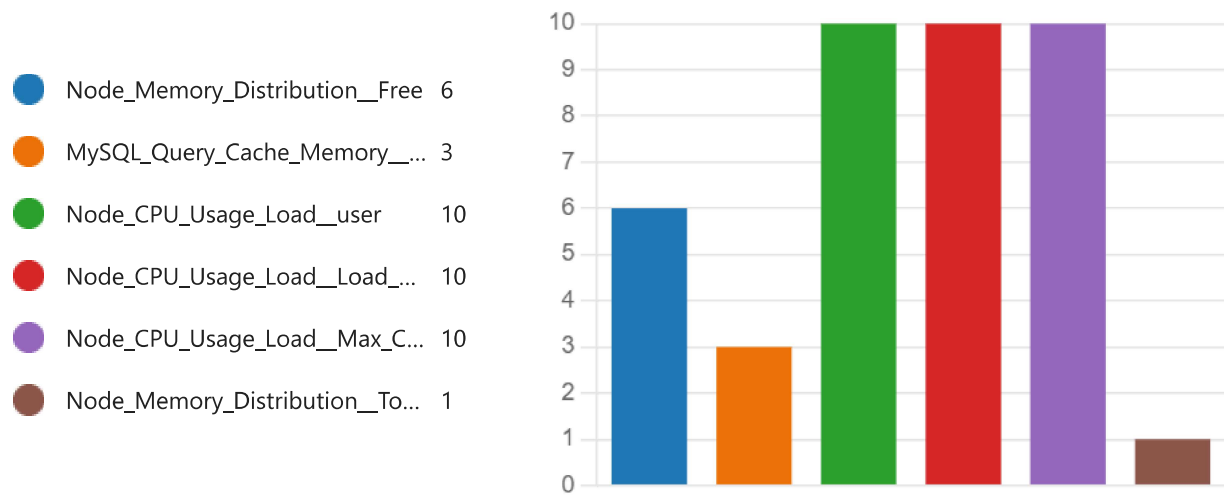3. **Impact on query duration**
   In this case, the query duration is much larger than the normal average value.

- Node_IO_Activity__Page_In   9
- MySQL_Transaction_Handlers__c...   4
- Node_Memory_Distribution__Free   10
- MySQL_Handlers__external_lock   1
- Current_QPS   8
- MySQL_Network_Usage_Hourly_...   4
- MySQL_Network_Usage_Hourly_...   4
- MySQL_Query_Cache_Memory__...   5
- Node_CPU_Usage_Load__iowait   7
- Node_Disk_Latency   8
- Node_Swap_Activity__Swap_In_R...   3
- MySQL_Connections__Max_Use...   1
- MySQL_Aborted_Connections__...   2
- MySQL_Thread_Cache__Threads...   2
- Top_Command_Counters__show...   0
- Top_Command_Counters__admi...   0

6. **CPU Stress**

1. **Implementation (root cause)**:
   We create an cpu-stress fault with 32 full load threads, which can simulate an *CPU stress test* on the MySQL pod.
2. **Description**:
   This anomaly will have a significant impact on the MySQL pod's CPU, then this impact is transmitted to node where the MySQL pod is located. It will also influence the memory distribution and I/O activity.
3. **Impact on query duration**
   In this case, the query duration is slightly smaller than the normal average value since the number of queries processed per second drastically decrease.

- Node_Memory_Distribution__Free 6
- MySQL_Query_Cache_Memory__... 3
- Node_CPU_Usage_Load__user 10
- Node_CPU_Usage_Load__Load_... 10
- Node_CPU_Usage_Load__Max_C... 10
- Node_Memory_Distribution__To... 1

7. Memory Stress

1. **Implementation (root cause)**:
   We create a mem-stress fault that contains 4 threads each occupied 128 MB in the MySQL pod's memory, which can simulate an *Memory stress test* on the MySQL pod.
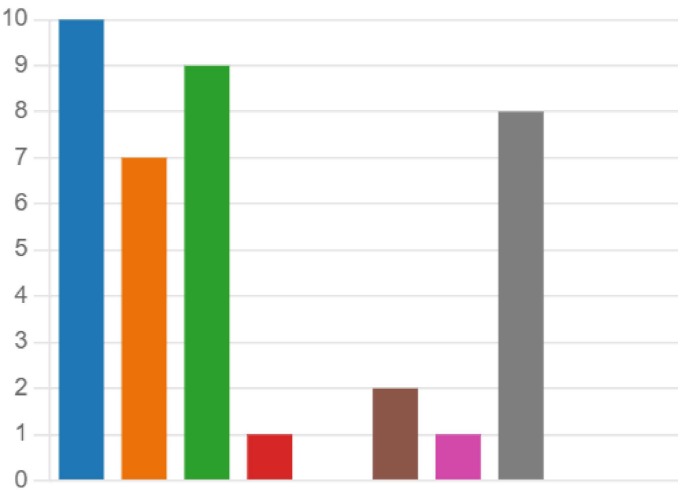2. **Description**:
   This anomaly will have a significant impact on the MySQL pod's memory distribution, then this impact is transmitted to node where the MySQL pod is located. It will also influence the I/O activity.
3. **Impact on query duration**
   In this case, the query duration is larger than the normal average value since the delay of I/O longer the processing times of queries.

|	
🔵 Node_Memory_Distribution__Free	10
🟠 MySQL_Query_Cache_Memory__...	7
🟢 Node_IO_Activity__Page_In	9
🔴 MySQL_Connections__Max_Use...	1
🟣 Node_CPU_Usage_Load__user	0
🟤 Node_Memory_Distribution__To...	2
🟣 MySQL_Network_Usage_Hourly_...	1
⚪ Node_Swap_Activity__Swap_In_R...	8
🟡 Top_Command_Counters__show...	0
🔵 Top_Command_Counters__admi...	0

8. **Network Delay**

1. **Implementation (root cause)**:
   We create a network-delay fault that cause 100ms delay on all network connection to the MySQL pod.
2. **Description**:
   Because our MySQL client is outside the cluster, this network delay will delay the traffic between the client and the server, which results in a lower workload on the server, i,e., low QPS and less IO activity.
3. **Impact on query duration**
   In this case, the query duration is much smaller than the normal average value. We think this result from the delay of network decrease the workload on the server, or some queries' duration is missed and be set as 0.

🔵 Node_IO_Activity__Page_Out	9
🟠 Node_IO_Activity__Page_In	9
🟢 MySQL_Network_Usage_Hourly_...	8
🔴 MySQL_Network_Usage_Hourly_...	8
🟣 MySQL_Query_Cache_Memory__...	1
🟤 Node_Memory_Distribution__Free	0
🟣 Node_Memory_Distribution__To...	0
⚫ MySQL_Aborted_Connections__t...	6
🟡 MySQL_Handlers__read_rnd	2
🔵 Node_Swap_Activity__Swap_In_R...	0
🔵 MySQL_Connections__Max_Use...	3
🟠 MySQL_Aborted_Connections__...	2
🟢 Node_Memory_Distribution__Free	0
🔴 MySQL_Thread_Cache__Threads...	2
🟣 Top_Command_Counters__show...	0
🟤 Top_Command_Counters__admi...	0
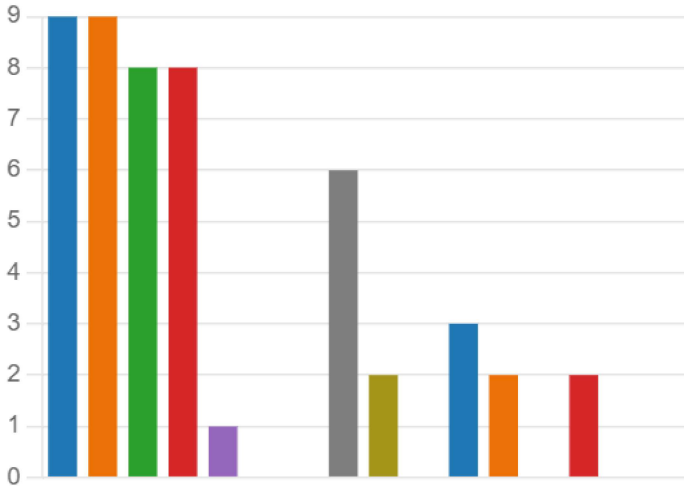
9. **Network Partition**

   1. **Implementation (root cause)**:
      We create a network-partition fault that blocks all network connection to the MySQL pod.
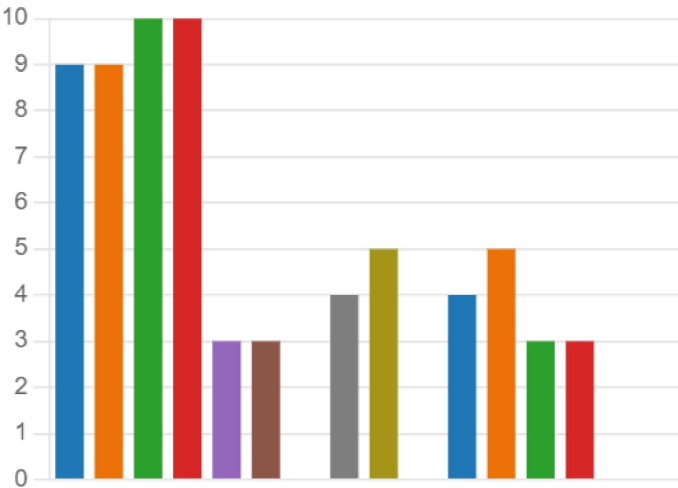   2. **Description**:
      Because our MySQL client is outside the cluster, this network delay will block the traffic between the client and the server, which results in a lower workload on the server, i,e., low QPS and less IO activity.
   3. **Impact on query duration**
      In this case, the query duration is much less than the normal average value. We think this result from the delay of network decrease the workload on the server, or some queries' duration is missed and be set as 0.

🔵 Node_IO_Activity__Page_Out	9
🟠 Node_IO_Activity__Page_In	9
🟢 MySQL_Network_Usage_Hourly_...	10
🔴 MySQL_Network_Usage_Hourly_...	10
🟣 MySQL_Query_Cache_Memory__...	3
🟤 Node_Memory_Distribution__Free	3
🟣 Node_Memory_Distribution__To...	0
⚫ MySQL_Handlers__delete	4
🟡 MySQL_Handlers__read_next	5
🔵 Node_Swap_Activity__Swap_In_R...	0
🔵 MySQL_Connections__Max_Use...	4
🟠 MySQL_Aborted_Connections__...	5
🟢 Node_Memory_Distribution__Free	3
🔴 MySQL_Thread_Cache__Threads...	3
🟣 Top_Command_Counters__show...	0
🟤 Top_Command_Counters__admi...	0

10. **Database Backup**

1. **Implementation (root cause)**:
   We run mysqldump on the TPCC database instance to dump the database to the client over the network.
2. **Description**:
   Because our MySQL client is outside the cluster, this anomaly will drastically influence the nework traffic between the server and the client. Queries will also be influenced because of lock.
3. **Impact on query duration**
   In this case, the query duration is larger than the normal average value since the task of backup increase the server's workload.

🔵	MySQL_Transaction_Handlers__c...	5
🟠	Current_QPS	9
🟢	MySQL_Network_Traffic__Inbound	9
🔴	MySQL_Handlers__external_lock	10
🟣	MySQL_Network_Usage_Hourly_...	9
🟤	MySQL_Handlers__read_next	6
🟣	MySQL_Handlers__read_rnd_nex	5
⚫	MySQL_Network_Traffic__Outbo...	10
🟡	MySQL_Query_Cache_Memory__...	3
🔵	Node_Swap_Activity__Swap_In_R...	2
🔵	Node_IO_Activity__Page_In	5
🟠	Node_Memory_Distribution__Free	3
🟢	MySQL_Connections__Max_Use...	3
🔴	MySQL_Aborted_Connections__...	0
🟣	Node_Memory_Distribution__Free	3
🟤	MySQL_Thread_Cache__Threads...	3
🟣	Top_Command_Counters__show...	0
⚫	Top_Command_Counters__admi...	0
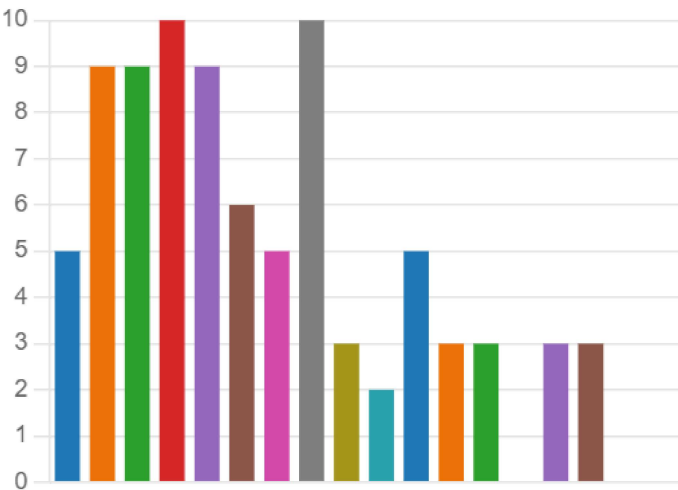
11. **Database Restore**

1. **Implementation (root cause)**:
   We dump the history of TPCC database back to the server over the network.
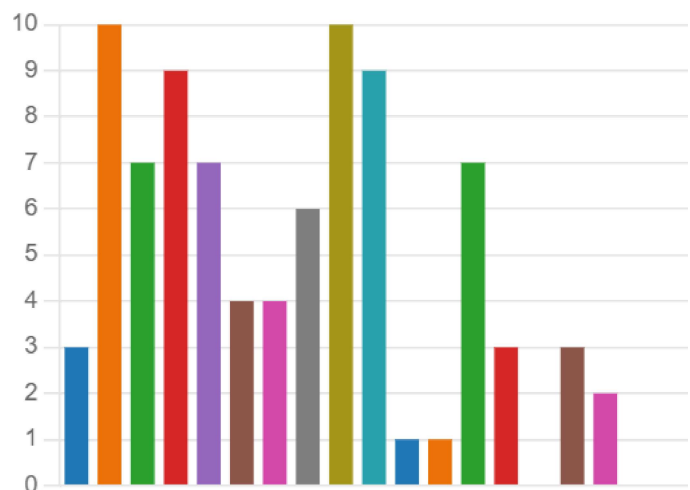2. **Description**:
   Because our MySQL client is outside the cluster, this anomaly will drastically influence the nework traffic between the server and the client. Queries will also be influenced because of lock.
3. **Impact on query duration**
   In this case, the query duration is larger than the normal average value since the task of restore increase the server's workload.

🔵 Node_Memory_Distribution__Free 3

🟠 MySQL_Network_Traffic__Outbo... 10

🟢 Current_QPS__None 7

🔴 MySQL_Handlers__external_lock 9

🟣 MySQL_Transaction_Handlers__c... 7

🟤 MySQL_Handlers__read_next 4

🟣 MySQL_Handlers__read_rnd 4

⚫ MySQL_Handlers__write 6

🟡 MySQL_Network_Traffic__Inbound 10

🔵 MySQL_Network_Usage_Hourly_... 9

🔵 MySQL_Query_Cache_Memory__... 1

🟠 Node_Swap_Activity__Swap_In_R... 1

🟢 Node_IO_Activity__Page_In 7

🔴 MySQL_Connections__Max_Use... 3

🟣 MySQL_Aborted_Connections__... 0

🟤 Node_Memory_Distribution__Free 3

🟣 MySQL_Thread_Cache__Threads... 2

⚫ Top_Command_Counters__show... 0

🟡 Top_Command_Counters__admi... 0

12. **Flush Logs**

1. **Implementation (root cause)**:
   We flush all logs by invoking mysqladmin commands 'flush-logs'.
2. **Description**:
   Flushing the binary log creates a new binary log file. Whereas flushing the general query log closes and reopens the log file. The same goes with the slow query log and error log, it just closes and reopens the log file. This command has very tiny impact on our cluster.
3. **Impact on query duration**
   In this case, the query duration is slightly larger than the normal average value.

🔵	MySQL_Transaction_Handlers__c...	0
🟠	MySQL_Handlers__external_lock	0
🟢	MySQL_Network_Traffic__Outbo...	0
🔴	MySQL_Network_Traffic__Inbound	0
🟣	Current_QPS	2
🟤	MySQL_Handlers__read_rnd	1
🩷	MySQL_Network_Usage_Hourly_...	0
⚪	MySQL_Network_Usage_Hourly_...	0
🟡	MySQL_Query_Cache_Memory__...	0
🔵	MySQL_Sorts__Sort_Rows	0
🔵	Node_Swap_Activity__Swap_In_R...	1
🟠	Node_IO_Activity__Page_In	6
🟢	Node_Memory_Distribution__Free	1
🔴	MySQL_Connections__Max_Use...	0
🟣	MySQL_Aborted_Connections__...	0
🟤	Node_Memory_Distribution__Free	1
🩷	MySQL_Thread_Cache__Threads...	0
⚪	Top_Command_Counters__show...	0
🟡	Top_Command_Counters__admi...	0
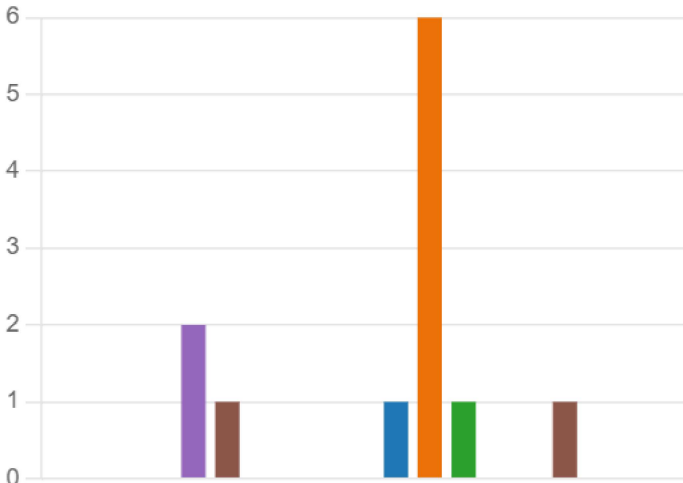
13. **Flush Tables**

1. **Implementation (root cause)**:
   We flush all tables by invoking mysqladmin commands 'flush-tables'.
2. **Description**:
   The idea of flush tables is to force all tables to be closed. Relative IO and qureies, transactions processing may be influenced, too. Same as flush logs, this command has tiny impact on our cluster.
3. **Impact on query duration**
   In this case, the query duration is slightly larger than the normal average value.

🔵 MySQL_Handlers__external_lock	7
🟠 MySQL_Handlers__write	6
🟢 MySQL_Network_Traffic__Outbo...	1
🔴 MySQL_Transaction_Handlers__c...	8
🟣 MySQL_File_Openings	5
🟤 MySQL_Handlers__read_rnd	6
🌸 MySQL_Network_Usage_Hourly_...	1
⚫ MySQL_Network_Usage_Hourly_...	1
🟡 MySQL_Query_Cache_Memory__...	3
🔵 Node_Swap_Activity__Swap_In_R...	2
🔵 Node_IO_Activity__Page_In	8
🟠 Node_Memory_Distribution__Free	4
🟢 MySQL_Connections__Max_Use...	0
🔴 MySQL_Aborted_Connections__...	0
🟣 MySQL_Thread_Cache__Threads...	1
🟤 Top_Command_Counters__show...	0
🌸 Top_Command_Counters__admi...	0