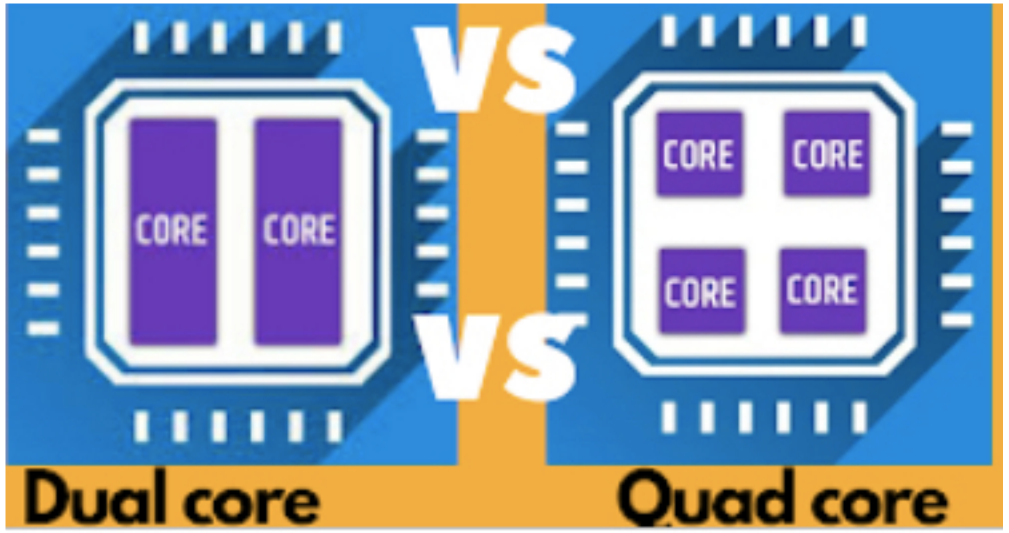
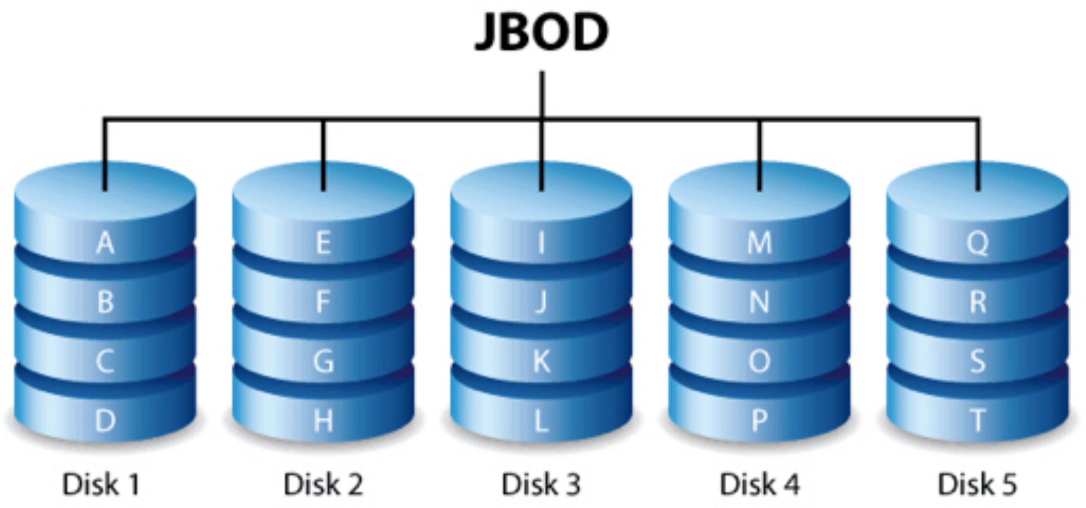
Kafka Monitoring & Tuning

Hardware and OS

Tos

- Dual quad-core Intel Xeon machines with 24GB of memory or higher
  - for production mission critical system
  - 24 GB total but only 25% of that for JVM (6 GB)
- Kafka Broker needs memory to buffer active readers and writers
  - to buffer for 30 seconds and memory needed is write_throughput*30
- Disk throughput is important
  - 8x7200 rpm SATA drives
  - Disk throughput is often performance bottleneck
  - JBOD - more disks is better





OS

Tos

- Kafka production usually runs on Linux
- Ensure you have enough file descriptors
  - Kafka uses file descriptors for log segments and open connections
  - (number_of_partitions)*(partition_size/segment_size) + number_of_producer_connections + number_of_consumer_connections
  - Start with 100,000 or more file descriptors
- Max socket buffer size:
  - increased to enable high-performance data transfer between data centers
- Use JBOD instead of RAID, RAID ok, JBOD better
- Check flusher threads and PDFlush but defaults should be ok
- Prefer filesystem XFS (largeio, nobarrier), EXT4 ok too (data=writeback, commit=num_secs, nobh, delalloc)

not preserve data ordering when writing to the disk

Important Metrics

Description	**JMX MBEAN NAME**
Message in rate	Kafka.server:type=BrokerTopicMetrices, name=MessagesInPerSec
Byte in rate	Kafka.server:type=BrokerTopicMetrics,name=BytesInPerSec
Time request waits in request queue	Kafka.network:type=RequestMetrics,name=RequestQueueTimeMs, Request={Produce|FetchConsumer|FetchFollower}
Messages count consumer lags behind producer	Kafka.consumer:type=consumer-fetch-manager-metrics, client-id ={client-id} Attribute:records-lag-max
ISR shrink rate	Kafka.server:type=ReplicaManager, name=IsrShrinksPerSec
ISR	Kafka.server:type=ReplicaManage,name=IsrExpandsPerSec
waiting-threads	User threads blocked count waiting for buffer memory to enqueue their records. JMX MBean Name kafka.producer:type=producer- metrics,client-id=([-.\w]+)
record-queue-time-avg	Average time in ms record batches spent in record accumulator.
record-queue-time-max	The maximum time in ms record batches spent in the record accumulator.
requests-in-flight	Current number of in-flight requests - waiting for a response.
bytes-consumed-rate	Average byte count consumed per second
fetch-latency-avg	Average fetch request duration
fetch-latency-max	Max fetch request duration
records-per-request-avg	Average record count per request for specific topic
records-consumed-rate	Average record count consumed per second for specific topic

Important Metrics

Performance tuning involves two important metrics:

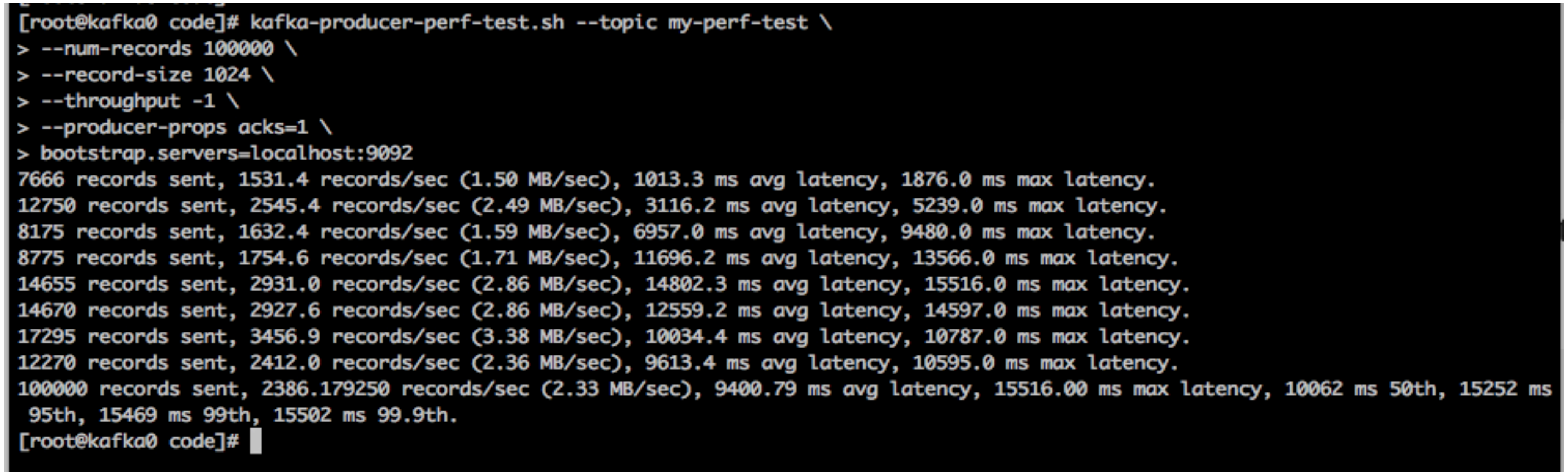
- Latency measures how long it takes to process one event,
- Throughput measures how many events arrive within a specific amount of time.

Most systems are optimized for either latency or throughput. Kafka is balanced for both. A well-tuned Kafka system has just enough brokers to handle topic throughput, given the latency required to process information as it is received.

Tuning your producers, brokers, and consumers to send, process, and receive the largest possible batches within a manageable amount of time results in the best balance of latency and throughput for your Kafka cluster.

Perfomance Metrics - Producer

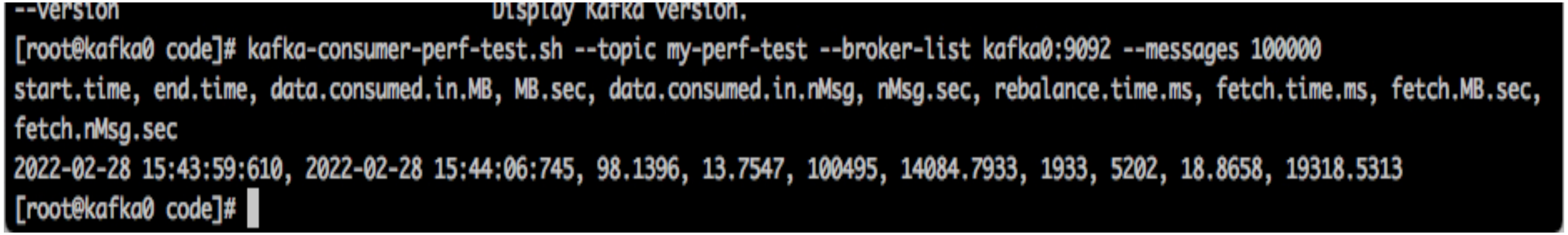
kafka-producer-perf-test.sh --topic my-perf-test \
--num-records 100000 \
--record-size 1024 \
--throughput -1 \
--producer-props acks=1 \
bootstrap.servers=localhost:9092



```
[root@kafka0 code]# kafka-producer-perf-test.sh --topic my-perf-test \
> --num-records 100000 \
> --record-size 1024 \
> --throughput -1 \
> --producer-props acks=1 \
> bootstrap.servers=localhost:9092
7666 records sent, 1531.4 records/sec (1.50 MB/sec), 1013.3 ms avg latency, 1876.0 ms max latency.
12750 records sent, 2545.4 records/sec (2.49 MB/sec), 3116.2 ms avg latency, 5239.0 ms max latency.
8175 records sent, 1632.4 records/sec (1.59 MB/sec), 6957.0 ms avg latency, 9480.0 ms max latency.
8775 records sent, 1754.6 records/sec (1.71 MB/sec), 11696.2 ms avg latency, 13566.0 ms max latency.
14655 records sent, 2931.0 records/sec (2.86 MB/sec), 14802.3 ms avg latency, 15516.0 ms max latency.
14670 records sent, 2927.6 records/sec (2.86 MB/sec), 12559.2 ms avg latency, 14597.0 ms max latency.
17295 records sent, 3456.9 records/sec (3.38 MB/sec), 10034.4 ms avg latency, 10787.0 ms max latency.
12270 records sent, 2412.0 records/sec (2.36 MB/sec), 9613.4 ms avg latency, 10595.0 ms max latency.
100000 records sent, 2386.179250 records/sec (2.33 MB/sec), 9400.79 ms avg latency, 15516.00 ms max latency, 10062 ms 50th, 15252 ms
 95th, 15469 ms 99th, 15502 ms 99.9th.
[root@kafka0 code]#
```

Perfomance Metrics - Consumer

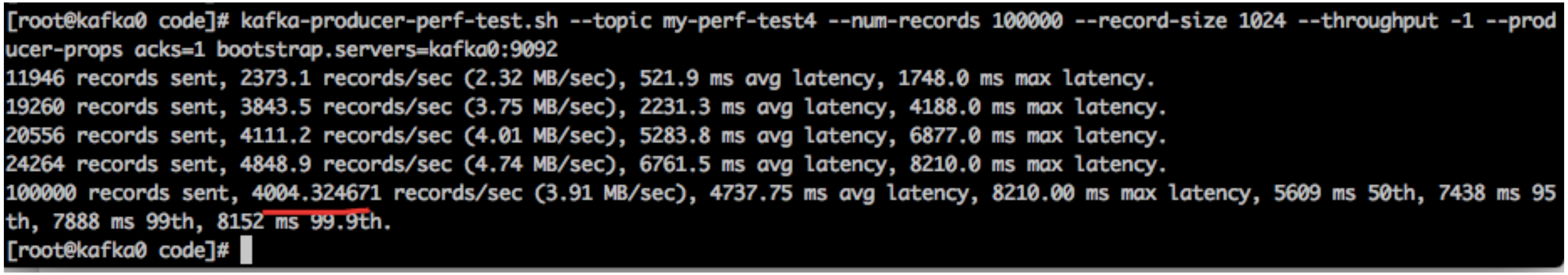
#kafka-consumer-perf-test.sh --topic my-perf-test --broker-list kafka0:9092 --messages 100000



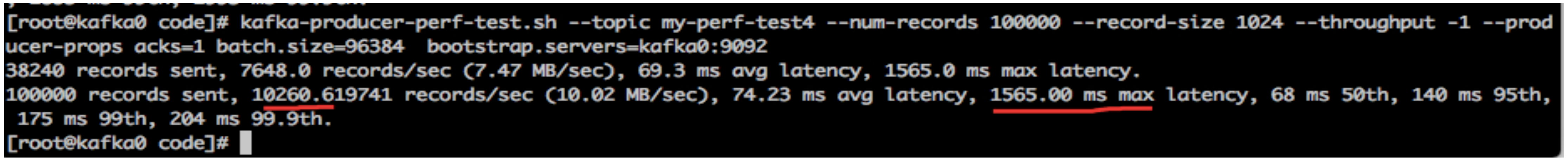
```
--version                              Display Kafka version.
[root@kafka0 code]# kafka-consumer-perf-test.sh --topic my-perf-test --broker-list kafka0:9092 --messages 100000
start.time, end.time, data.consumed.in.MB, MB.sec, data.consumed.in.nMsg, nMsg.sec, rebalance.time.ms, fetch.time.ms, fetch.MB.sec, 
fetch.nMsg.sec
2022-02-28 15:43:59:610, 2022-02-28 15:44:06:745, 98.1396, 13.7547, 100495, 14084.7933, 1933, 5202, 18.8658, 19318.5313
[root@kafka0 code]# 
```

Perfomance Tuning - Producer & Consumer

Increase the no of partitions
Acks – Recommended 2 or 3
Buffer setting – Set as per the batch size
ISR – Set the minimum as per the requirement – 2 or 3 is the optimal
Two parameters are particularly important for latency and throughput:
batch size and linger time



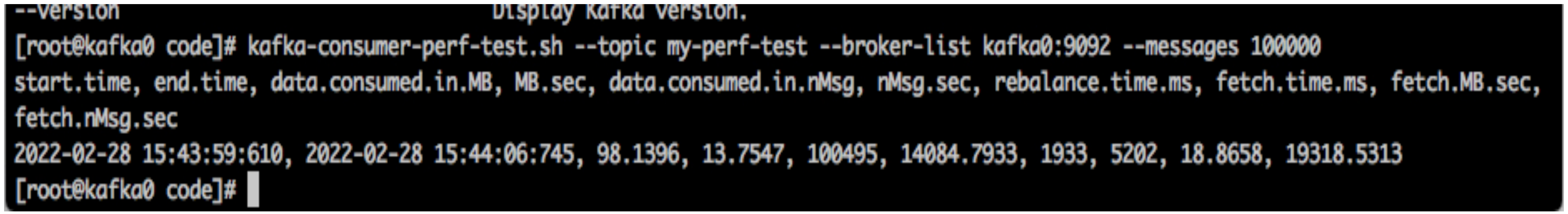
```
[root@kafka0 code]# kafka-producer-perf-test.sh --topic my-perf-test4 --num-records 100000 --record-size 1024 --throughput -1 --prod
ucer-props acks=1 bootstrap.servers=kafka0:9092
11946 records sent, 2373.1 records/sec (2.32 MB/sec), 521.9 ms avg latency, 1748.0 ms max latency.
19260 records sent, 3843.5 records/sec (3.75 MB/sec), 2231.3 ms avg latency, 4188.0 ms max latency.
20556 records sent, 4111.2 records/sec (4.01 MB/sec), 5283.8 ms avg latency, 6877.0 ms max latency.
24264 records sent, 4848.9 records/sec (4.74 MB/sec), 6761.5 ms avg latency, 8210.0 ms max latency.
100000 records sent, 4004.324671 records/sec (3.91 MB/sec), 4737.75 ms avg latency, 8210.00 ms max latency, 5609 ms 50th, 7438 ms 95
th, 7888 ms 99th, 8152 ms 99.9th.
[root@kafka0 code]#
```



```
[root@kafka0 code]# kafka-producer-perf-test.sh --topic my-perf-test4 --num-records 100000 --record-size 1024 --throughput -1 --prod
ucer-props acks=1 batch.size=96384  bootstrap.servers=kafka0:9092
38240 records sent, 7648.0 records/sec (7.47 MB/sec), 69.3 ms avg latency, 1565.0 ms max latency.
100000 records sent, 10260.619741 records/sec (10.02 MB/sec), 74.23 ms avg latency, 1565.00 ms max latency, 68 ms 50th, 140 ms 95th,
 175 ms 99th, 204 ms 99.9th.
[root@kafka0 code]#
```

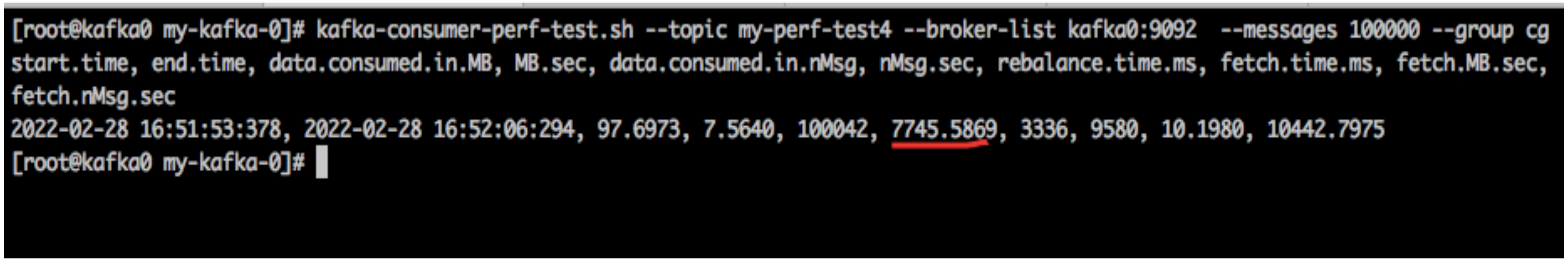
Perfomance Tuning - Producer & Consumer

The maximum number of consumers in a consumer group for a topic is equal to the number of partitions



```
--version                          Display Kafka version.
[root@kafka0 code]# kafka-consumer-perf-test.sh --topic my-perf-test --broker-list kafka0:9092 --messages 100000
start.time, end.time, data.consumed.in.MB, MB.sec, data.consumed.in.nMsg, nMsg.sec, rebalance.time.ms, fetch.time.ms, fetch.MB.sec,
fetch.nMsg.sec
2022-02-28 15:43:59:610, 2022-02-28 15:44:06:745, 98.1396, 13.7547, 100495, 14084.7933, 1933, 5202, 18.8658, 19318.5313
[root@kafka0 code]#
```

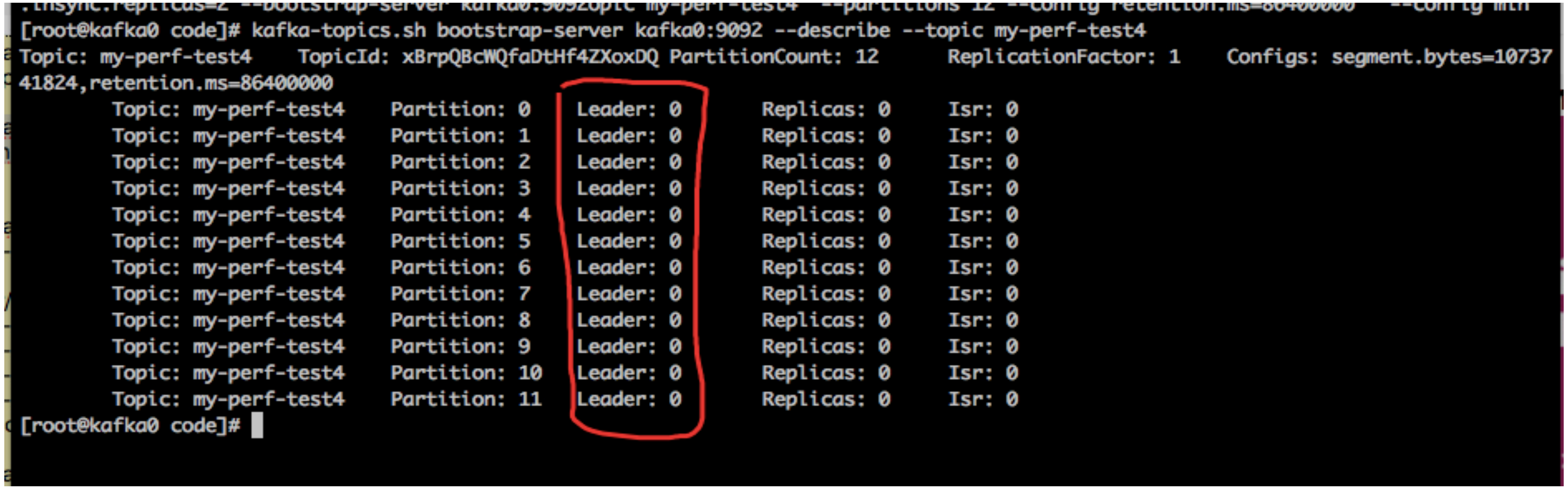
2 consumer group



```
[root@kafka0 my-kafka-0]# kafka-consumer-perf-test.sh --topic my-perf-test4 --broker-list kafka0:9092  --messages 100000 --group cg
start.time, end.time, data.consumed.in.MB, MB.sec, data.consumed.in.nMsg, nMsg.sec, rebalance.time.ms, fetch.time.ms, fetch.MB.sec,
fetch.nMsg.sec
2022-02-28 16:51:53:378, 2022-02-28 16:52:06:294, 97.6973, 7.5640, 100042, 7745.5869, 3336, 9580, 10.1980, 10442.7975
[root@kafka0 my-kafka-0]#
```

Perfomance Tuning - Broker

- Leader balanced properly
- It is recommends starting with one partition per physical storage disk and one consumer per partition



```
.insync.replicas=2 --bootstrap-server kafka0:9092opic my-perf-test4  --partitions 12 --config retention.ms=86400000   --config min
[root@kafka0 code]# kafka-topics.sh bootstrap-server kafka0:9092 --describe --topic my-perf-test4
Topic: my-perf-test4    TopicId: xBrpQBcWQfaDtHf4ZXoxDQ PartitionCount: 12      ReplicationFactor: 1    Configs: segment.bytes=10737
41824,retention.ms=86400000
        Topic: my-perf-test4    Partition: 0    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 1    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 2    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 3    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 4    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 5    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 6    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 7    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 8    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 9    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 10   Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 11   Leader: 0       Replicas: 0     Isr: 0
[root@kafka0 code]# 
```

Perfomance Tuning – MirrorMaker

num.streams parameter controls the number of consumer threads in Mirror Maker.
kafka-producer-perf-test can be used to generate load on the source cluster.

You can test and measure performance of Mirror Maker with
different **num.streams** values (start from 1 and increase it gradually).

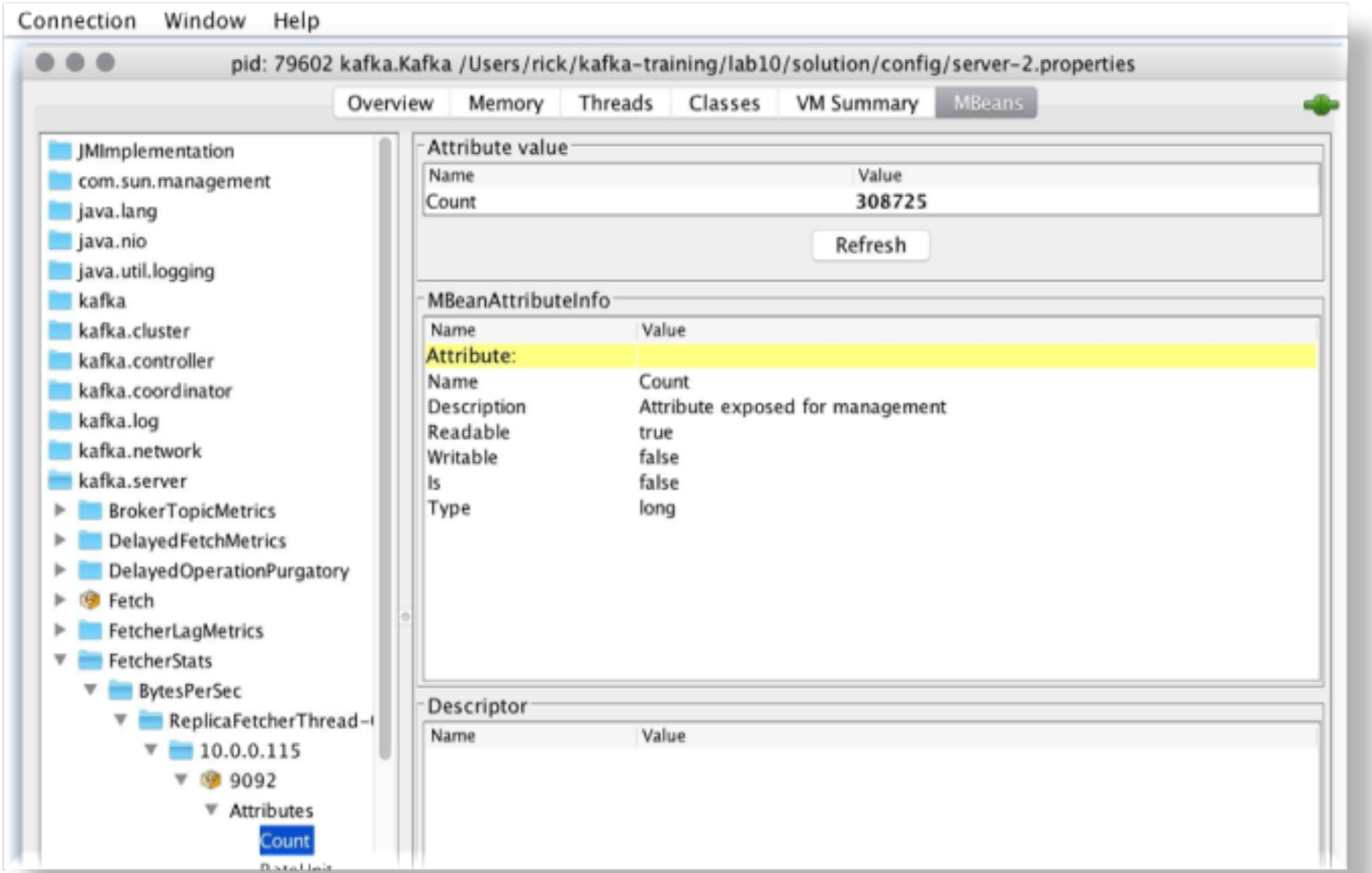
Other Metrics

Tos

- Low level metrics
- Thread metrics
- Task Metrics
- Processor Node Metrics
  - Forwarding to other nodes
- State Store Metrics
- Good idea to monitor GC, JVM threads, etc.
- See metrics available with JConsole

Kafka Broker Metrics via JConsole 1 of 2

Tos



pid: 79602 kafka.Kafka /Users/rick/kafka-training/lab10/solution/config/server-2.properties

```
JMImplementation
com.sun.management
java.lang
java.nio
java.util.logging
kafka
kafka.cluster
kafka.controller
kafka.coordinator
kafka.log
kafka.network
kafka.server
  ▶ BrokerTopicMetrics
  ▶ DelayedFetchMetrics
  ▶ DelayedOperationPurgatory
  ▶ Fetch
  ▶ FetcherLagMetrics
  ▼ FetcherStats
    ▼ BytesPerSec
      ▼ ReplicaFetcherThread-
        ▼ 10.0.0.115
          ▼ 9092
            ▼ Attributes
                Count
```

Attribute value

Name	Value
Count	308725

MBeanAttributeInfo

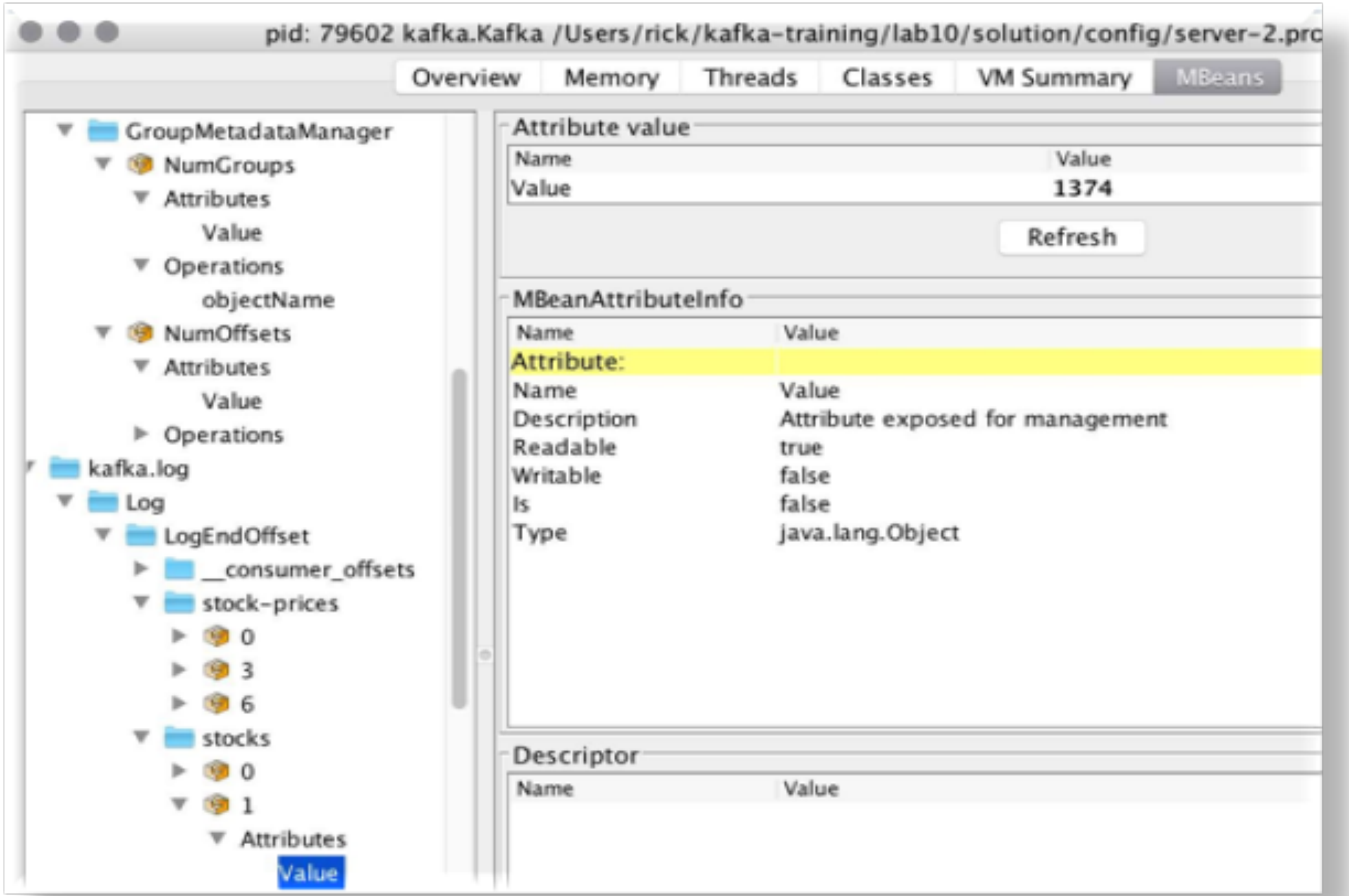
Name	Value
Attribute:	
Name	Count
Description	Attribute exposed for management
Readable	true
Writable	false
Is	false
Type	long

Descriptor

Name	Value

Kafka Broker JConsole Metrics 2 of 2

Tos



```
pid: 79602 kafka.Kafka /Users/rick/kafka-training/lab10/solution/config/server-2.pro
```

```
▼ GroupMetadataManager
  ▼ NumGroups
    ▼ Attributes
        Value
    ▼ Operations
        objectName
  ▼ NumOffsets
    ▼ Attributes
        Value
    ▶ Operations
kafka.log
  ▼ Log
    ▼ LogEndOffset
      ▶ __consumer_offsets
      ▼ stock-prices
        ▶ 0
        ▶ 3
        ▶ 6
      ▼ stocks
        ▶ 0
        ▼ 1
          ▼ Attributes
              Value
```

Attribute value

Name	Value
Value	1374

MBeanAttributeInfo

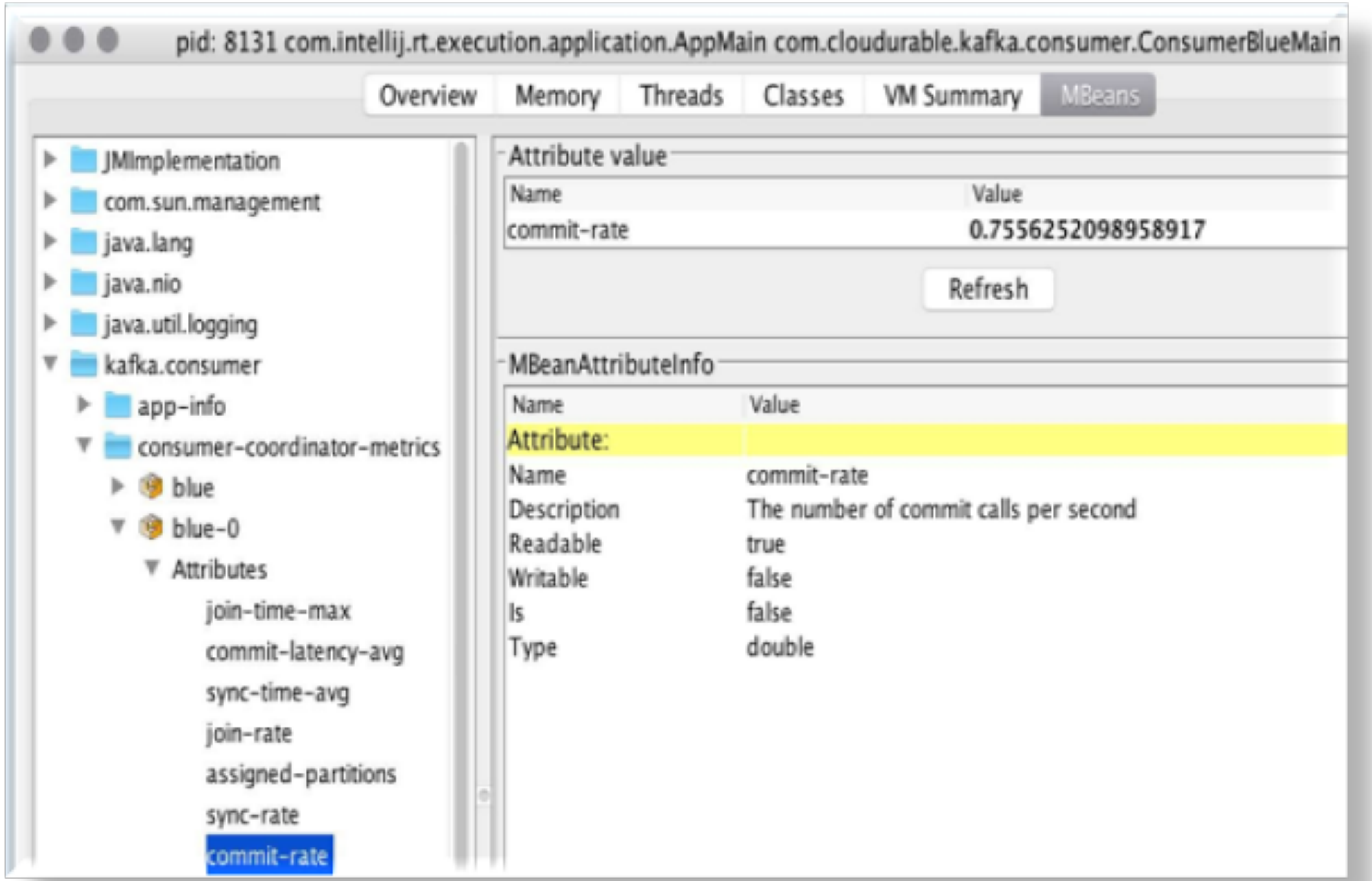
Name	Value
Attribute:	
Name	Value
Description	Attribute exposed for management
Readable	true
Writable	false
Is	false
Type	java.lang.Object

Descriptor

Name	Value

Kafka Consumer JConsole Metrics

Tos



pid: 8131 com.intellij.rt.execution.application.AppMain com.cloudurable.kafka.consumer.ConsumerBlueMain

```
JMImplementation
com.sun.management
java.lang
java.nio
java.util.logging
kafka.consumer
    app-info
    consumer-coordinator-metrics
        blue
        blue-0
            Attributes
                join-time-max
                commit-latency-avg
                sync-time-avg
                join-rate
                assigned-partitions
                sync-rate
                commit-rate
```

Attribute value

Name	Value
commit-rate	0.7556252098958917

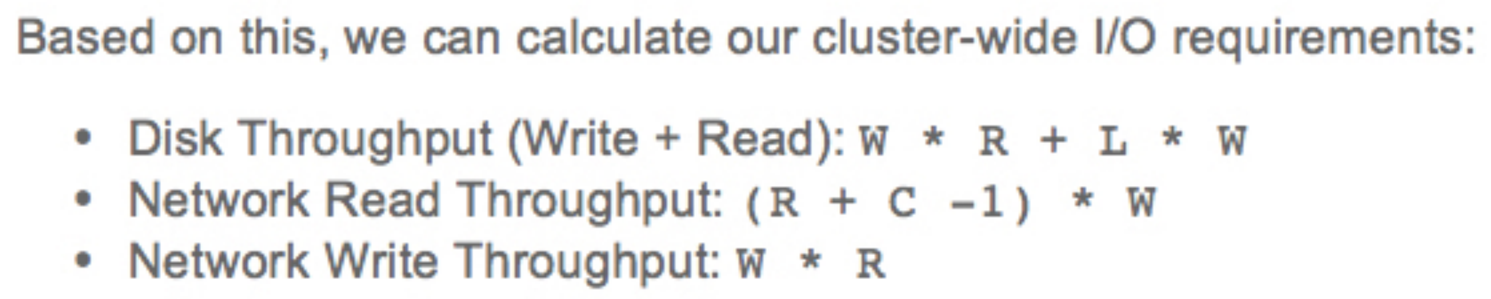
MBeanAttributeInfo

Name	Value
Attribute:	
Name	commit-rate
Description	The number of commit calls per second
Readable	true
Writable	false
Is	false
Type	double

Cluster Sizing - Network and Disk Message Throughput

Tos

W - MB/sec of data that will be written
R - Replication factor
C - Number of consumer groups, that is the number of readers for each write
L- all consumers are lagging all the time


Based on this, we can calculate our cluster-wide I/O requirements:

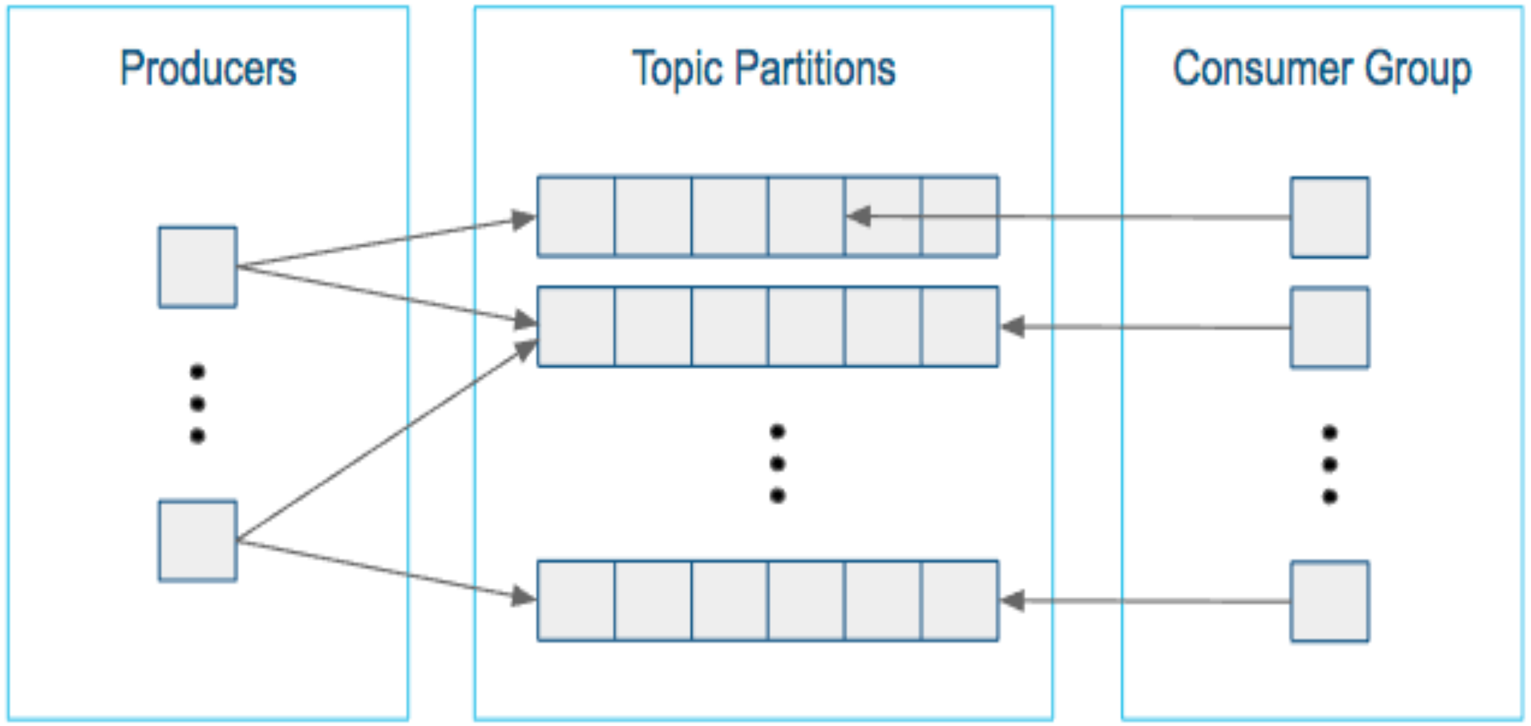
- Disk Throughput (Write + Read): `W * R + L * W`
- Network Read Throughput: `(R + C -1) * W`
- Network Write Throughput: `W * R`

For example, if you have a 1 Gigabit Ethernet card with full duplex, then that would give 125 MB/sec read and 125 MB/sec write; likewise 6 7200 SATA drives might give roughly 300 MB/sec read + write throughput. Once we know the total requirements, as well as what is provided by one machine, you can divide to get the total number of machines needed

Choosing the Number of Partitions for a Topic

Tos

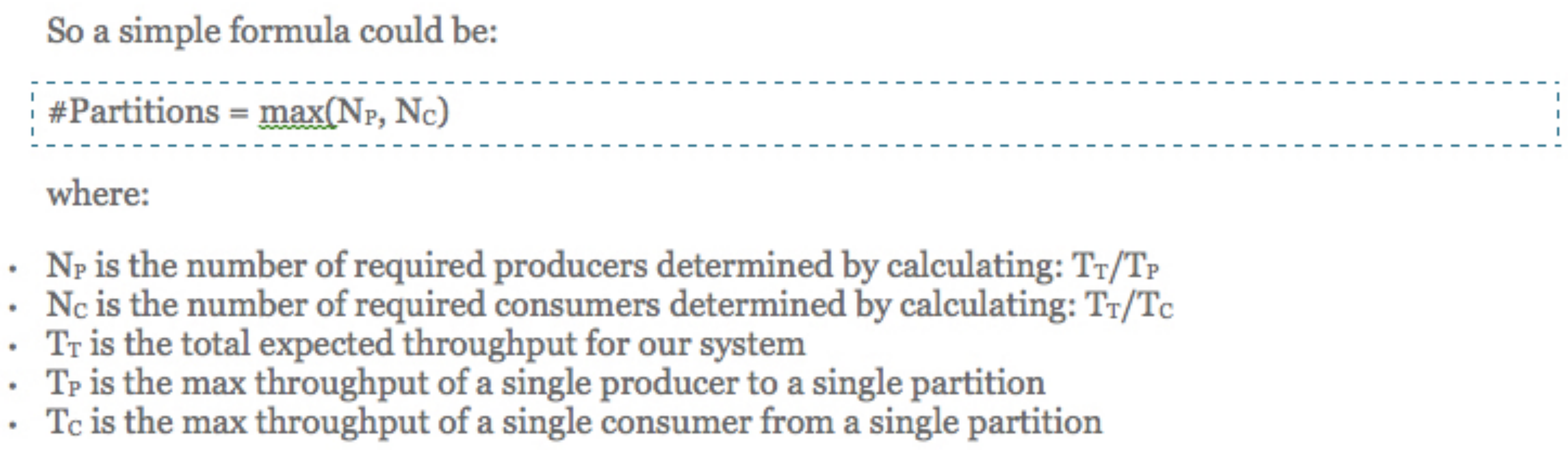
is the key to achieving a high degree of parallelism with respect to writes to and reads and to distribute load



For example, if you want to be able to read 1 GB/sec, but your consumer is only able process 50 MB/sec, then you need at least 20 partitions and 20 consumers in the consumer group. Similarly, if you want to achieve the same for producers, and 1 producer can only write at 100 MB/sec, you need 10 partitions.

Choosing the Number of Partitions for a Topic

Tos



So a simple formula could be:

#Partitions = max(N_P, N_C)

where:

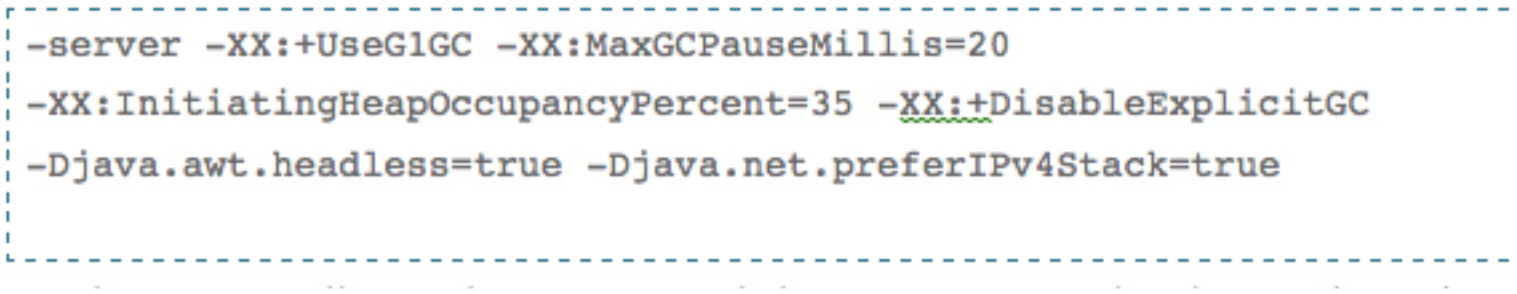
- N_P is the number of required producers determined by calculating: T_T/T_P
- N_C is the number of required consumers determined by calculating: T_T/T_C
- T_T is the total expected throughput for our system
- T_P is the max throughput of a single producer to a single partition
- T_C is the max throughput of a single consumer from a single partition

As guideline for optimal performance, you should not have more than 3000 partitions per broker and not more than 30,000 partitions in a cluster

Kafka Performance Broker Configuration

Tos

JVM and Garbage Collection



```
-server -XX:+UseG1GC -XX:MaxGCPauseMillis=20
-XX:InitiatingHeapOccupancyPercent=35 -XX:+DisableExplicitGC
-Djava.awt.headless=true -Djava.net.preferIPv4Stack=true
```

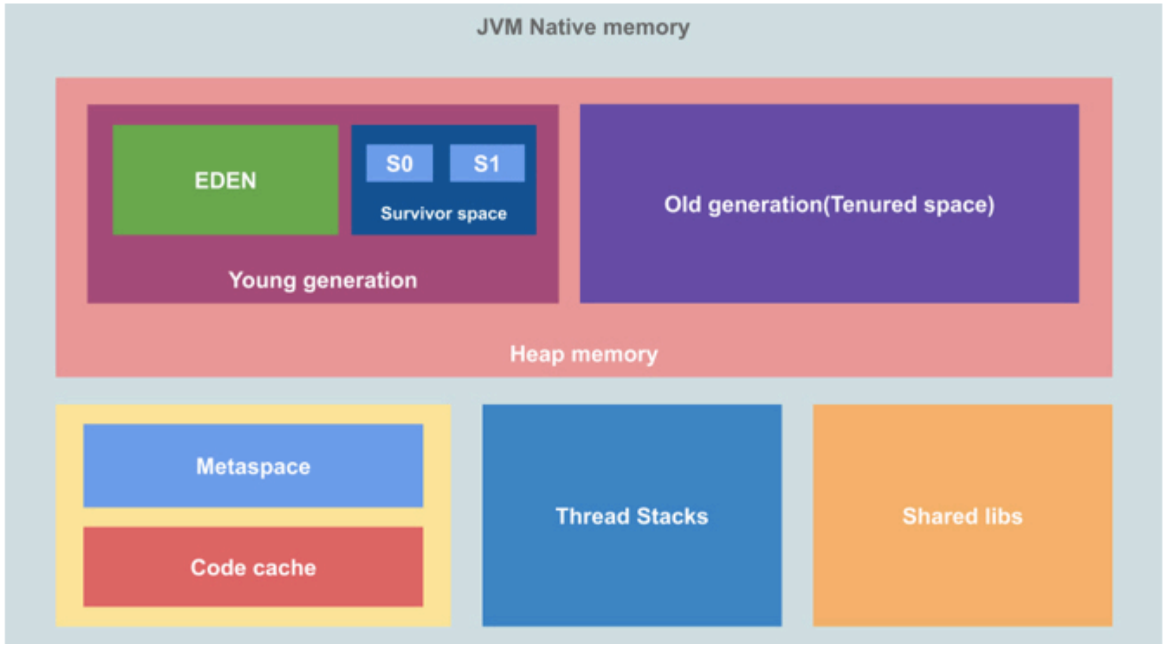
Network and I/O Threads

num.network.threads : Set this value mainly based on number of producers, consumers and replica fetchers.
queued.max.requests: controls how many requests are allowed in the request queue before blocking network threads.
num.io.threads: specifies the number of threads that a broker uses for processing requests from the request queue (might include disk I/O).

Java GC config

Tos

```
Xms6g   Xmx6g

-XX:MetaspaceSize=96m

-XX:+UseG1GC

-XX:MaxGCPauseMillis=20

-XX:InitiatingHeapOccupancyPercent=35

-XX:G1HeapRegionSize=16M
```



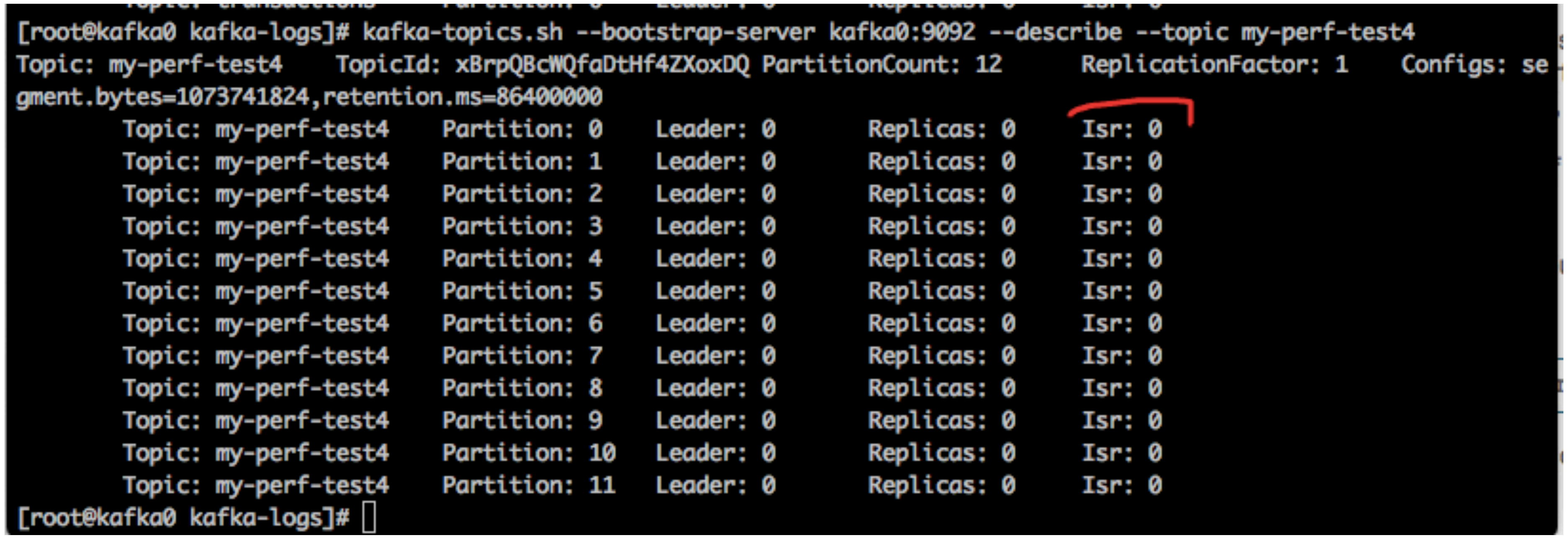
- Heap Space should be 25% to 35% of available space for server
- Leave 50% for OS, Remember Kafka uses OS page cache
- Other tweaks for GC to limit overhead

Kafka Performance Broker Configuration

Tos

ISR Management

•**num.replica.fetchers** These threads are responsible for replicating messages from a source broker (that is, where partition leader resides). Increasing this value results in higher I/O parallelism and fetcher throughput. Of course, there is a trade-off: brokers use more CPU and network.
•**replica.fetch.min.bytes** controls the minimum number of bytes to fetch from a follower replica. If there is not enough bytes, wait up to replica.fetch.wait.max.ms.
•**replica.fetch.wait.max.ms** controls how long to sleep before checking for new messages from a fetcher replica. This value should be less than **replica.lag.time.max.ms**, otherwise the replica is kicked out of the ISR set.



```
[root@kafka0 kafka-logs]# kafka-topics.sh --bootstrap-server kafka0:9092 --describe --topic my-perf-test4
Topic: my-perf-test4    TopicId: xBrpQBcWQfaDtHf4ZXoxDQ PartitionCount: 12      ReplicationFactor: 1    Configs: se
gment.bytes=1073741824,retention.ms=86400000
        Topic: my-perf-test4    Partition: 0    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 1    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 2    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 3    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 4    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 5    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 6    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 7    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 8    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 9    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 10   Leader: 0       Replicas: 0     Isr: 0
        Topic: my-perf-test4    Partition: 11   Leader: 0       Replicas: 0     Isr: 0
[root@kafka0 kafka-logs]# 
```

Kafka Performance Broker Configuration

Tos

Log Cleaner :

- **log.cleaner.threads** : controls how many background threads are responsible for log compaction. Increasing this value improves performance of log compaction at the cost of increased I/O activity.
- **log.cleaner.io.max.bytes.per.second**: throttles log cleaner's I/O activity so that the sum of its read and write is less than this value on average.
- **log.cleaner.dedupe.buffer.size**: specifies memory used for log compaction across all cleaner threads.
- **log.cleaner.io.buffer.size** :controls total memory used for log cleaner I/O buffers across all cleaner threads.
- **log.cleaner.min.compaction.lag.ms** : controls how long messages are left uncompacted.
- **log.cleaner.backoff.ms**: controls how long to wait until the next check if there is no log to compact

Lab : Monitoring, Performance & Tuning