Kafka Best Practices

Lesson Objectives

- Learn to use Kafka effectively

Use Latest Java & Modern GC

- Use recommended Java / JDK version
  - Do not deviate from this, as you might encounter mysterious crashes ..etc
  - Kafka is a high performance system, it pushes JVM to its limits; It might expose JVM bugs that a 'normal' program might not
- Use G1 garbage collector
- Jvm heap: 8G - 32 G
- Reference

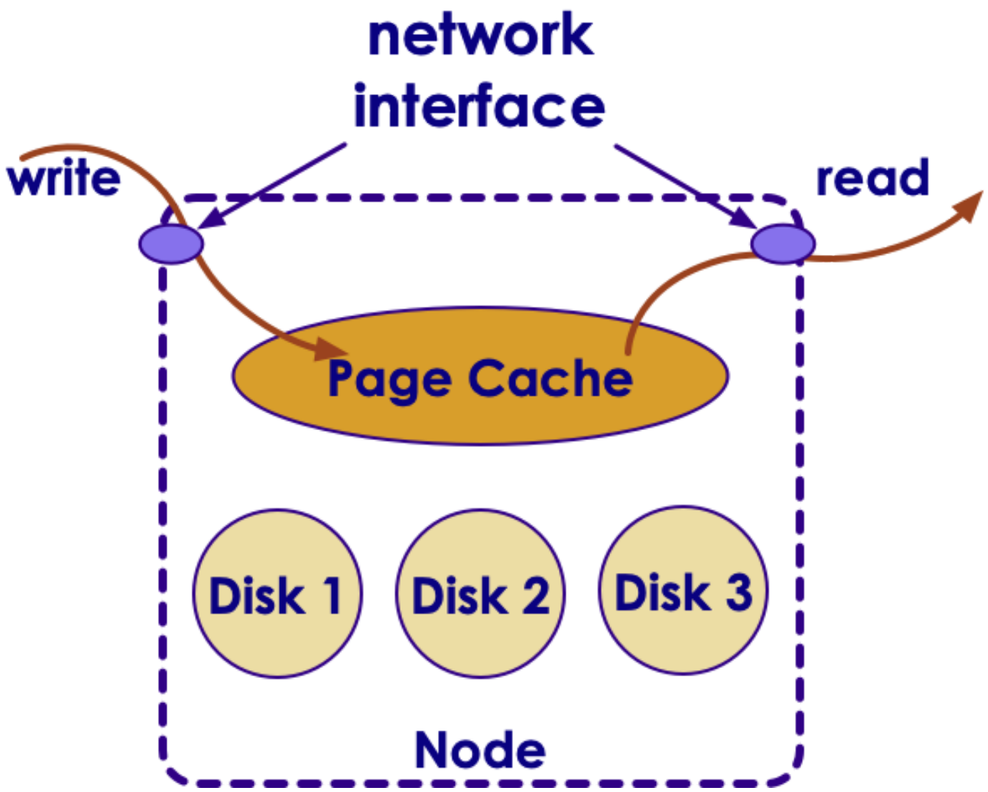
```
Conf/kafka-env.sh

export KAFKA_HEAP_OPTS="-Xmx16g -Xms16g"

export KAFKA_JVM_PERFORMANCE_OPTS=
"-XX:MetaspaceSize=96m -XX:+UseG1GC -XX:MaxGCPauseMillis=20 -XX:InitiatingHeapOccupancyPercent=35
-XX:G1HeapRegionSize=16M
-XX:MinMetaspaceFreeRatio=50
-XX:MaxMetaspaceFreeRatio=80"
```

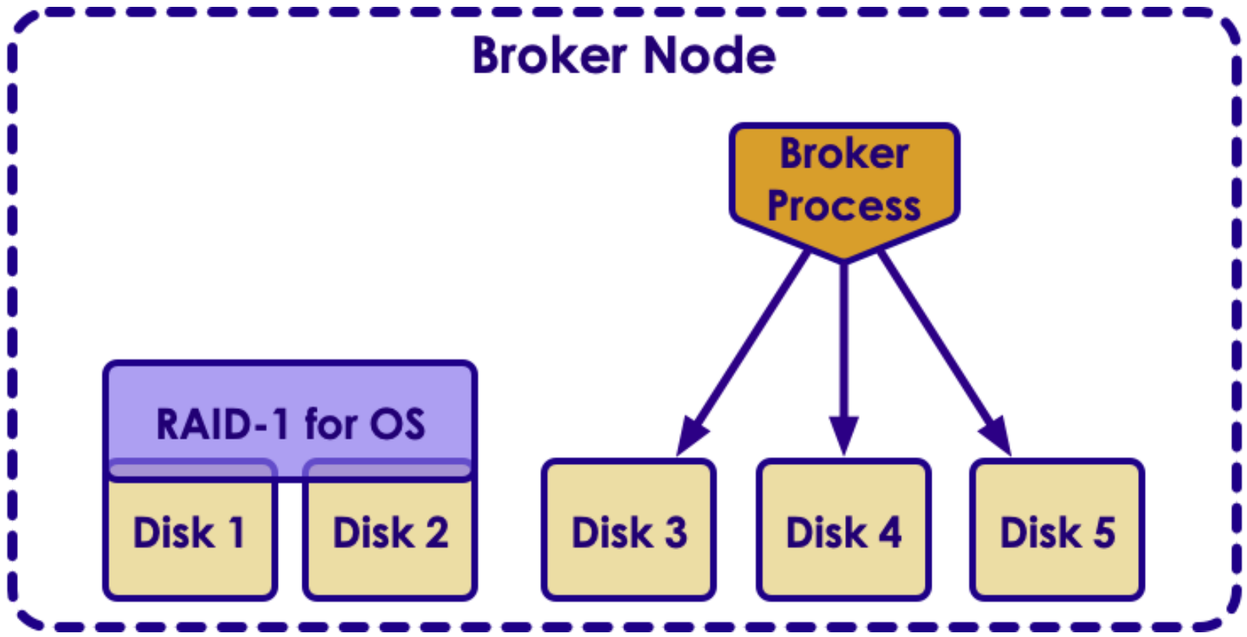
OS Setting

- Give rest of the memory (minus JVM heap) to Page Cache (Linux will do this automatically)
    - So throughput is fastest
- Kafka keeps many files open
    - Set open file descriptors to 128k
    - Use `'ulimits -a'` to verify



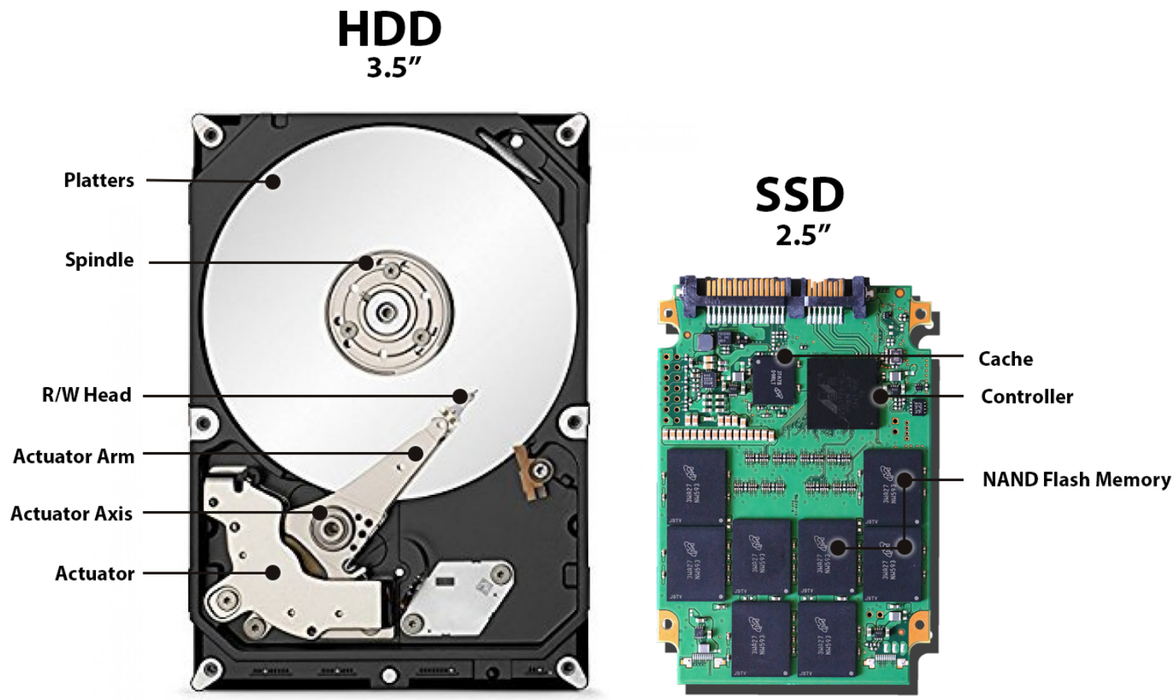
Disk Setup

- Disks tend to be first bottleneck to be hit
- Never, never, never use shared drives (NFS / SAN)
- More disks -> better throughput
- RAIDs are usually more trouble than they are worth
  - Just use individual disks (JBOD - Just a Bunch of Disks)
- Kafka will stripe data across disks using a round-robin fashion
- Highly recommended to monitor disk usage
  - And create alerts if disks are getting full



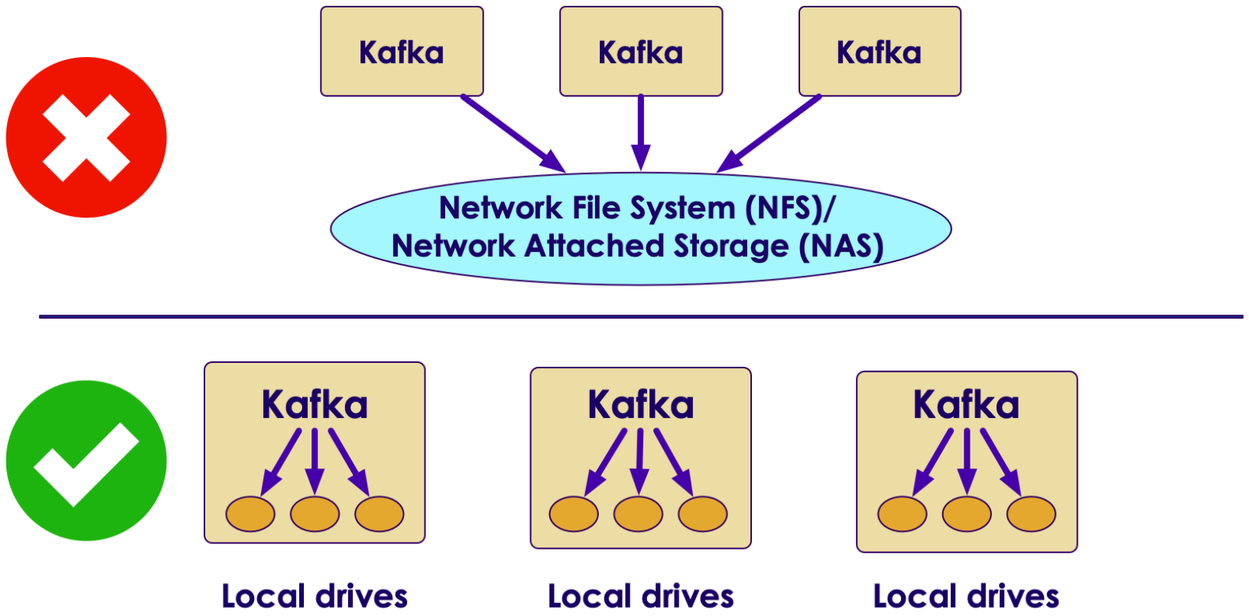
Should We Use SSD Drives?

- SSDs don't offer remarkable boost in performance
- Kafka writes/reads data sequentially to/from commit logs
    - No random seeks
    - Modern spinning disks can provide very good scan performance
    - Also Linux and Linux file systems are optimized for good sequential IO
- In Kafka write to disks are asynchronous
    - No waiting for disk ops to complete
- Zookeeper can benefit from SSD drives
- Case study from Uber link1, link2



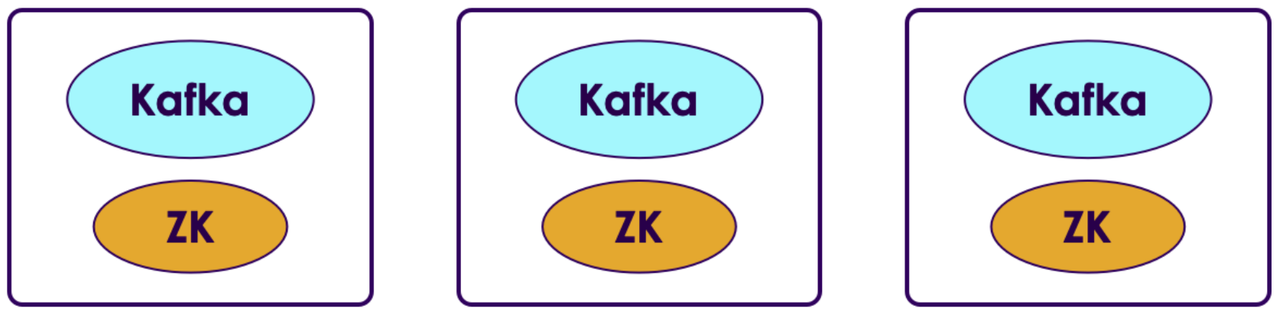
File System Settings

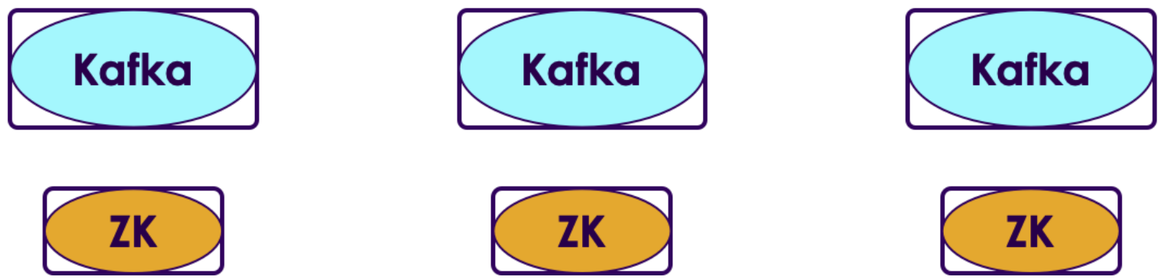
- Never, never, never use shared file systems (SAN / NFS)
- Always use MULTIPLE, LOCAL spindles
- Recommended file systems: EXT4 or XFS
- XFS probably better
- Formatting TB disk drives with XFS is significantly faster



Zookeeper Best Practices

- **Do not co-locate** Zookeeper and Kafka brokers on same nodes
- ZK and Kafka has very different IO patterns
  - Kafka is very disk IO heavy
  - ZK doesn't need a lot of horsepower, it needs to stay alive

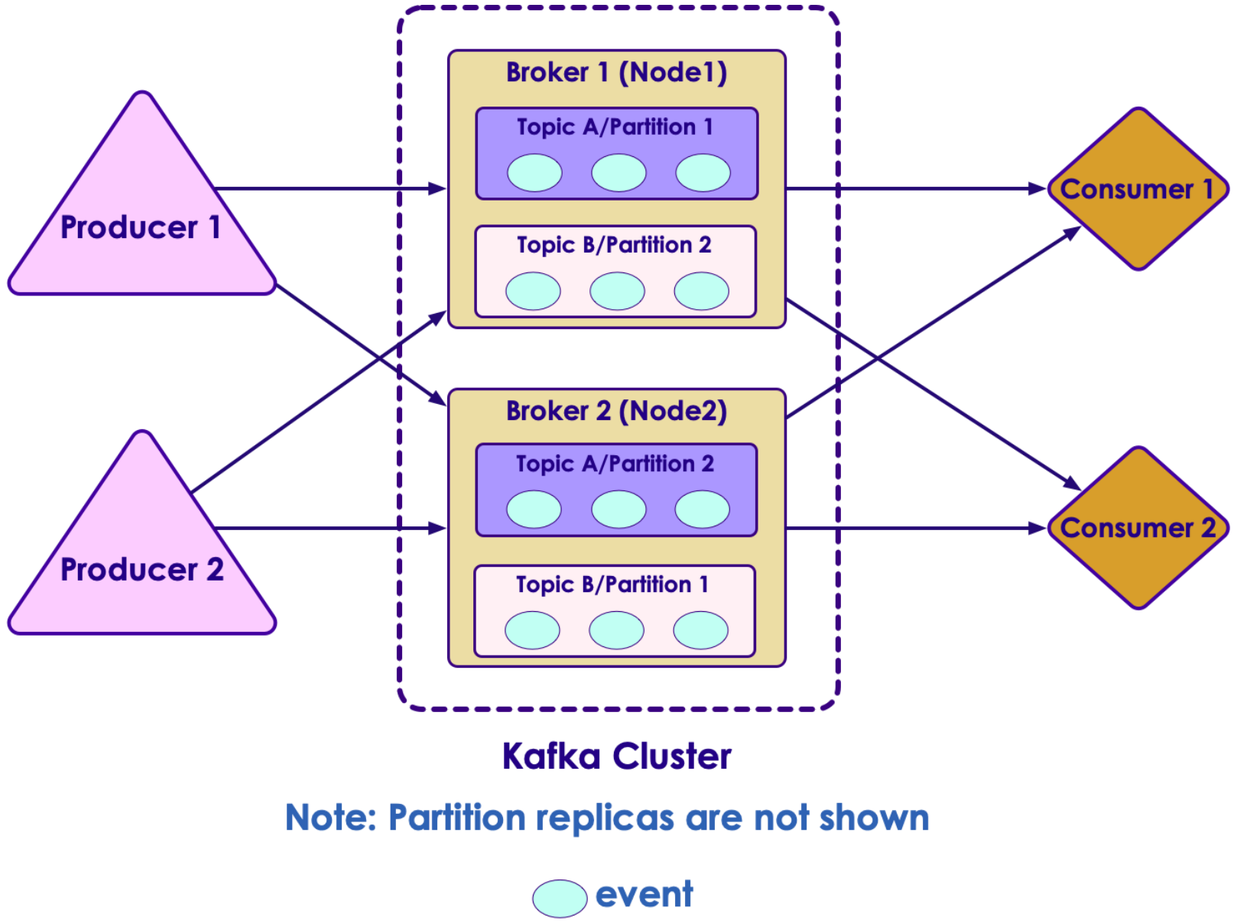




- Dedicate one ZK ensemble to Kafka, do not share this ZK with other applications (e.g. Hadoop)
  - Kafka uses ZK pretty heavily
  - Can benefit from a dedicated ZK cluster
- Make sure ZK has sufficient memory (4G+)
- Monitor memory usage of ZK using JMX or other monitoring programs

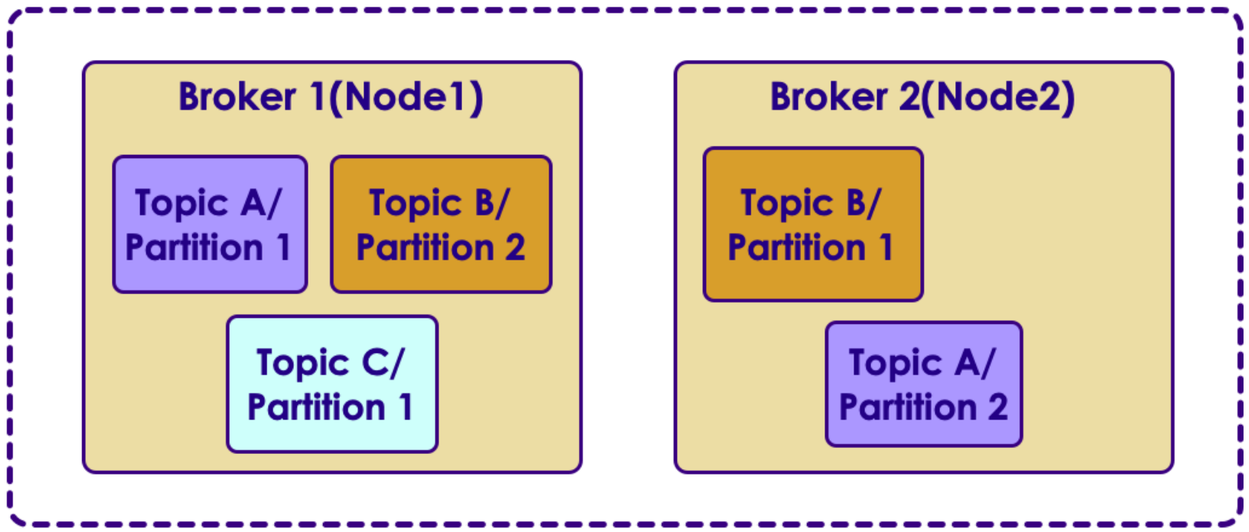
Topics & Partitions Settings

- Number of partitions correspond parallelism
- Higher the partitions -> more consumers can be added
- How to calculate optimal number of partitions?
  - Let's say Producer throughput to a single partition as P
  - Say Consumer throughput from a single partition as C
  - Target throughput T
  - Required partitions = Max (T/P, T/C)



Topics / Partitions

- Ensure **`number of partitions >= number of brokers`**
- Partitions **can always be increased later but not decreased**
- Altering number of partitions in a KEY-VALUE topic is a little tricky?
  - Keys have to be re-hashed to partitions
  - **Class Discussion: Please discuss key mappings and partitions**

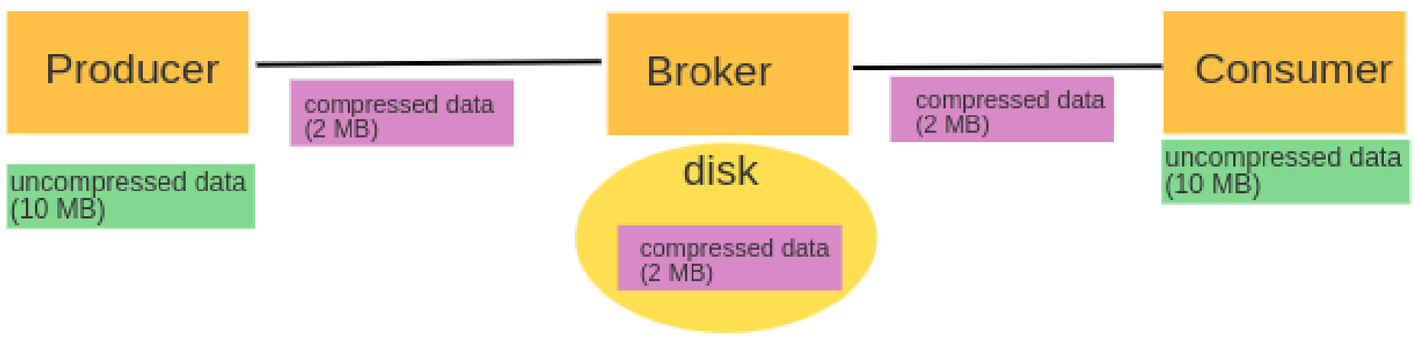


Partitions & Memory

- More partitions also need more memory on brokers & clients
- Producer side
    - New Kafka client buffers messages on producer side before sending to brokers (to reduce network round-trips)
    - The message buffer is maintained for partition
    - More partitions -> more buffer memory needed
- Consumer side
    - Consumers fetch messages in batches per partitions
    - More partitions -> more batches -> more memory needed

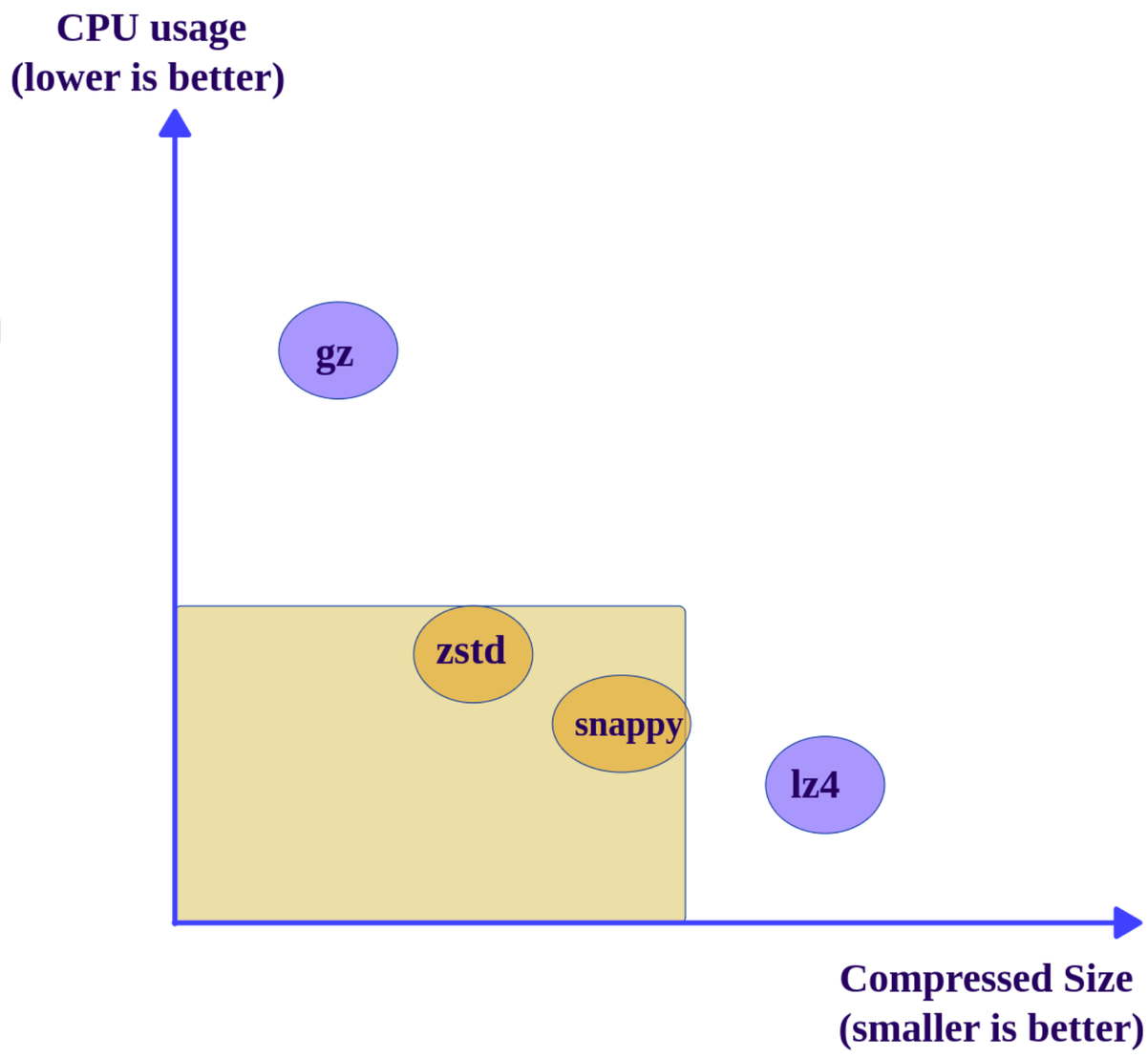
Compression

- Benefits of compression
  - Reduces network bandwidth usage
  - Reduces disk usage on Brokers
- Compression is performed on a batch
  - Larger batch size -> better compression
- Kafka API will automatically
  - Compress messages on producer side
  - De-compress messages on consumer side
  - Messages remain in compressed state in partitions



Compression

- Supported compression codecs
  - Gzip, Snappy, LZ4, Zstd
- **Snappy** (from Google) is a pretty good light weight compressor; Easy on GPU and produces medium level compresison
- Current favorite is **Zstd** (Facebook) - Good speed and produces compact size
- Configured via Producer properties:
  - `compression.type`
- Reference



Compression Data Formats

- **XML and JSON data formats are very good candidates for compression**. Since they have lot of repeating elements, they compress well.
- JSON data

```
{"id" : 1, "first_name" : "John", "last_name" : "Smith", "age" : 34, "email" : "john@me.com"}
```

- XML data

```
<CATALOG>
    <CD>
        <TITLE>Empire Burlesque</TITLE>
        <ARTIST>Bob Dylan</ARTIST>
        <YEAR>1985</YEAR>
    </CD>
</CATALOG>
```

- Also **server logs** are good candidates, as they have well defined structure

```
1.1.1.1 - [2020-09-01::19:12:06 +0000] "GET /index.html HTTP/1.1" 200  532"
2.2.2.2 - [2020-09-01::19:12:46 +0000] "GET /contact.html HTTP/1.1" 200  702"
```

- **Binary data formats won't compress well**. E.g. images, base64 encoded strings. Don't enable compression.
- Reference: Message compression in Apache Kafka

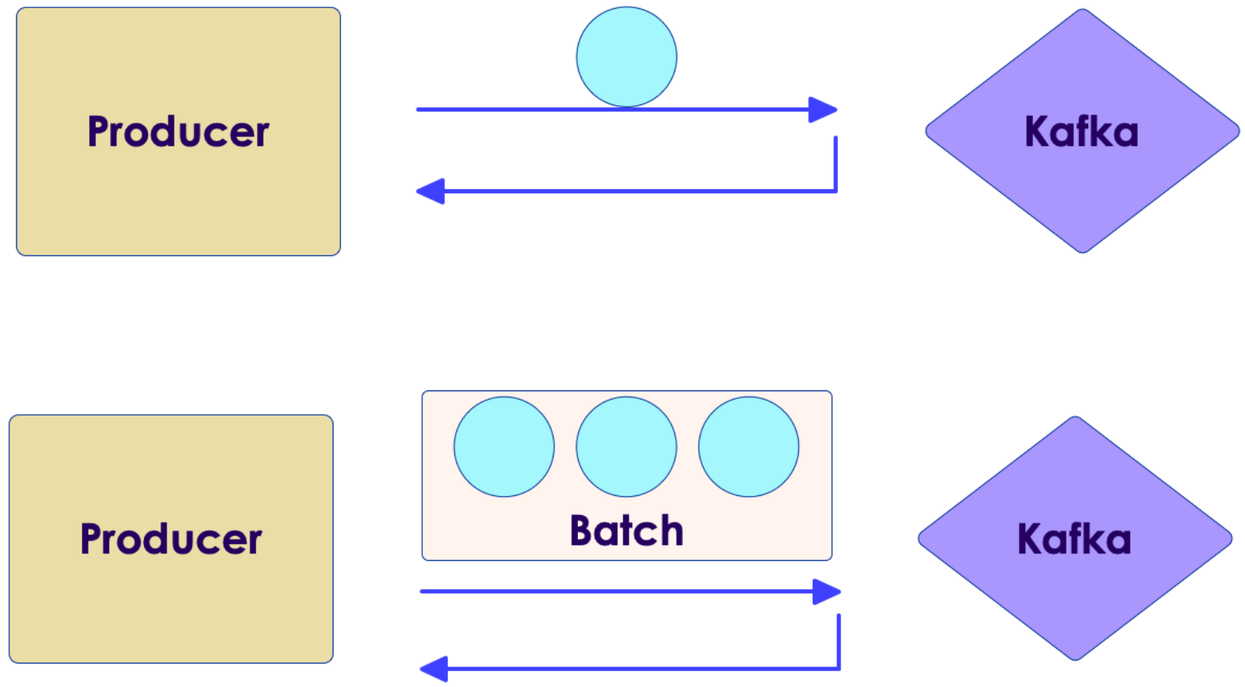
Compression

- **Compression will slightly increase CPU usage**
    - How ever, this is well worth the trade-off, as CPUs are very fast and we usually have plenty of CPU power to spare.
    - Plus modern CPUs have compression algorithms built-in silicone
- Here are some benchmark stats from Message compression in Apache Kafka
- We can see Snappy (from Google) and zstd (from Facebook) giving a good balance of CPU usage, compression ratio, speed and network utilization

Metrics	Uncompressed	Gzip	Snappy	lz4	Zstd
Avg latency (ms)	65	10.4	10.1	9.2	10.7
Disk space (mb)	10	0.92	2.2	2.8	1.5
Effective compression ratio	1	0.09	0.21	0.28	0.15
Process CPU usage %	2.35	11.46	7.25	5.89	8.93

Use Batching

- Batching will dramatically increase throughput, specially in producers
- Batching will increase latency
  - Producer will accumulate messages until desired batch size is attained, before sending it to broker



- Too small a batch size may not be effective
- Choose the batch size that gives best **latency vs. throughput** for your application
- Larger batch sizes will use more memory for buffering

Message Sizing Guidelines

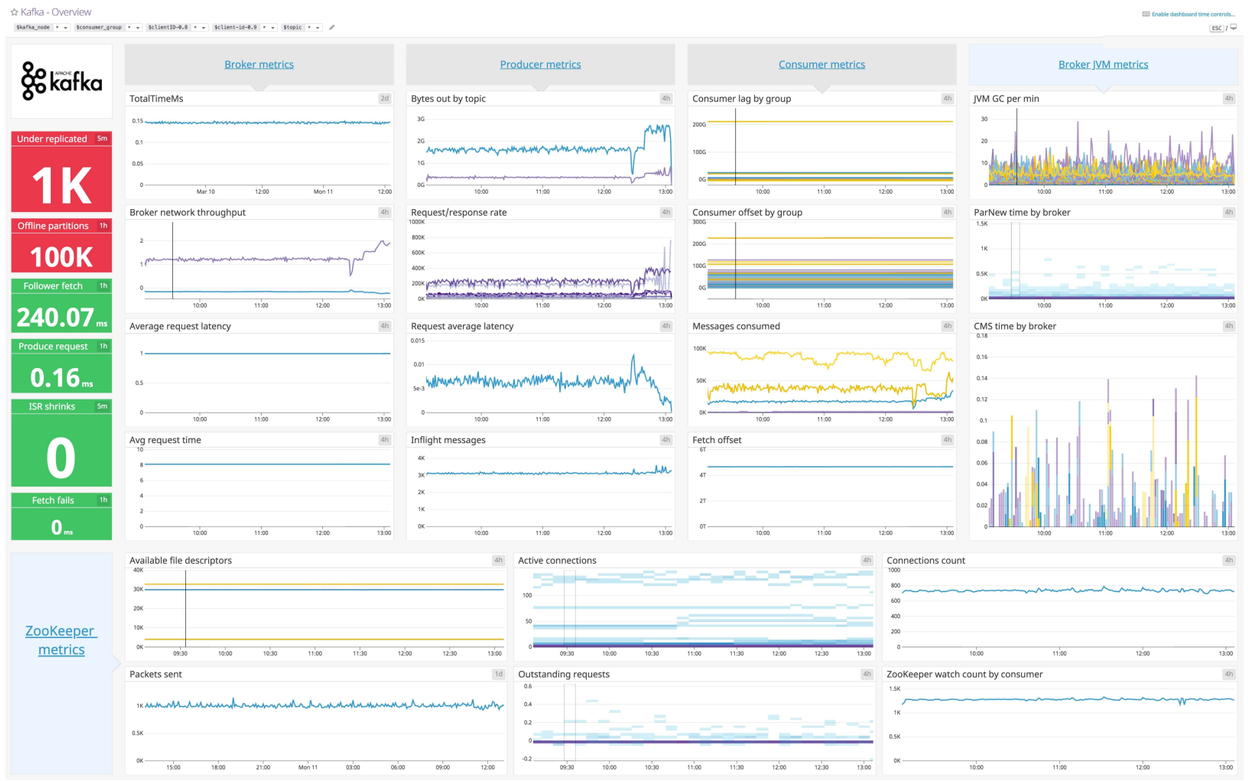
- Kafka is engineered for moving small messages
  - Few KB / message
- Max message size by default is 1 MB
- If sending large messages set the following properties:
  - **messages.max.bytes** (on broker)
  - **fetch.message.max.bytes** (on consumer)
- Reference

Small message (few KB in size)
{"custome_id": 123, "order_id": "ZJWUA", "order_total" : 32.45 ...}

Large message like image/ video file (few MB in size)

Monitor, Monitor, Monitor

- Kafka exposes lot of metrics
  - Collect them via JMX plugin
  - Or use any of the open source collectors
- Send metrics to a collector (graphite, open TSDB ..etc.)
- Use a nice graphic tool to slice & dice metrics (Grafana)
- References:
  - Datadog
  - Monitoring Kafka @ SingalFX



Monitoring Kafka

- Jump off point: Please review **Kafka-Monitoring** module

Recommendations from Netflix

- Prefer multiple modest sized Kafka clusters rather than one giant Kafka cluster. This will simplify operations
- Number of partitions per cluster around 10,000.This improves availability and latency
- Use dedicated Zookeeper cluster for each Kafka cluster
- Reference

Troubleshooting Kafka

Kafka Troubleshooting

- We are going to do these as a class / group exercise!
- Show a problem
- Class to suggest solution

Issue

- Consumer errors with Out of Memory error
- (answer next slide)

Possible Solutions

- Too many partitions
  - More partitions consume more memory
- Messages are large
  - Increase Java Heap size

Issue

- Consumer seems to stuck on one offset, can not go beyond that message.
- Gets InvalidMessageSizeException
- (answer next slide)

Possible Solutions

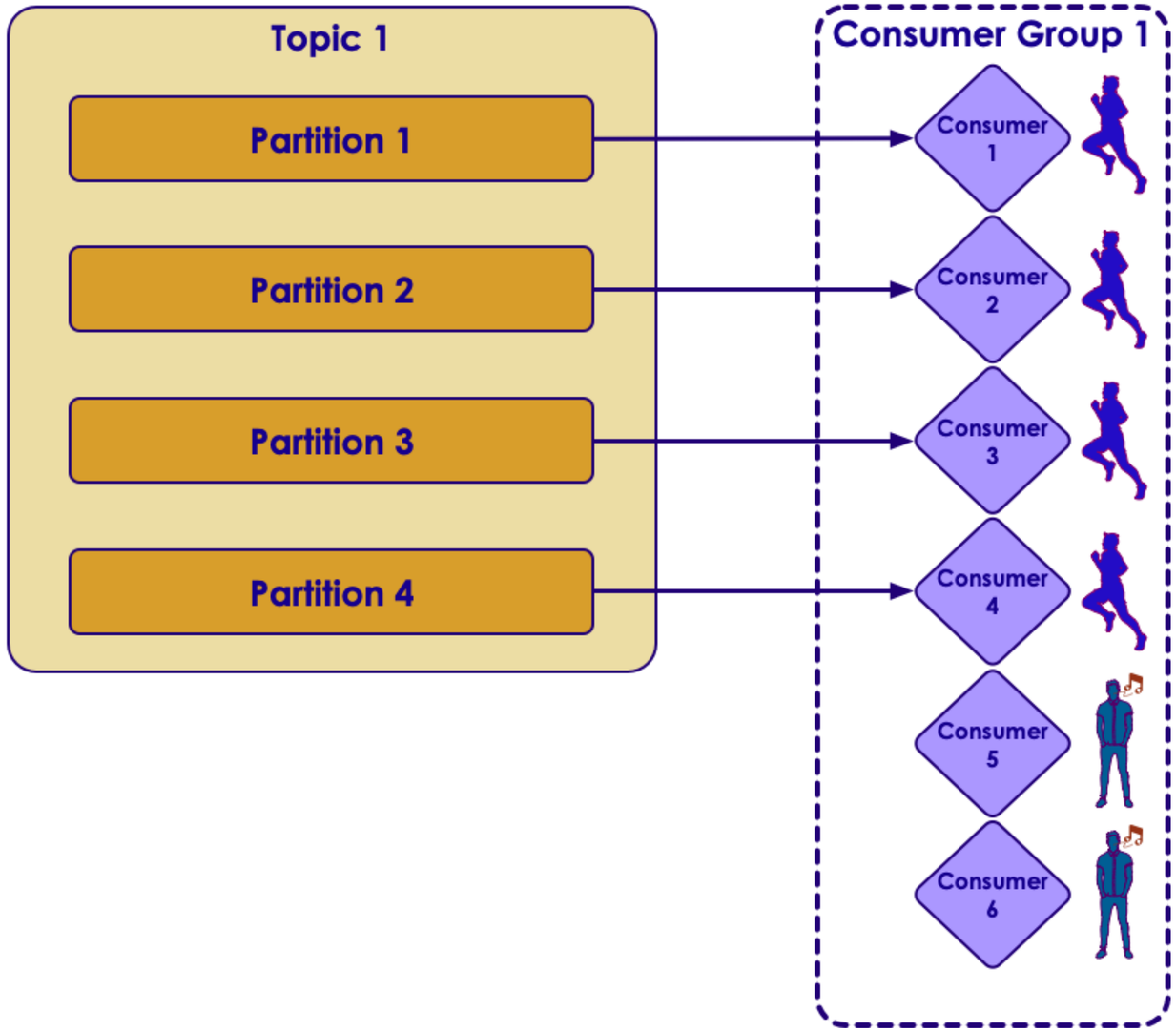
- Message size is too large
- Double check **messages.max.bytes** (on broker)
- And match **fetch.message.max.bytes** (on consumer)

Issue

- Some consumers are not receiving any messages
- (answer next slide)

Possible Solutions

- Probably have more consumers than number of partitions
- Solutions:
  - Match # consumers = # partitions in a consumer group
  - Increase number of partitions
  - Decrease number of consumers



Issue

- Producer is getting QueueFullException
- (answer next slide)

Possible Solutions

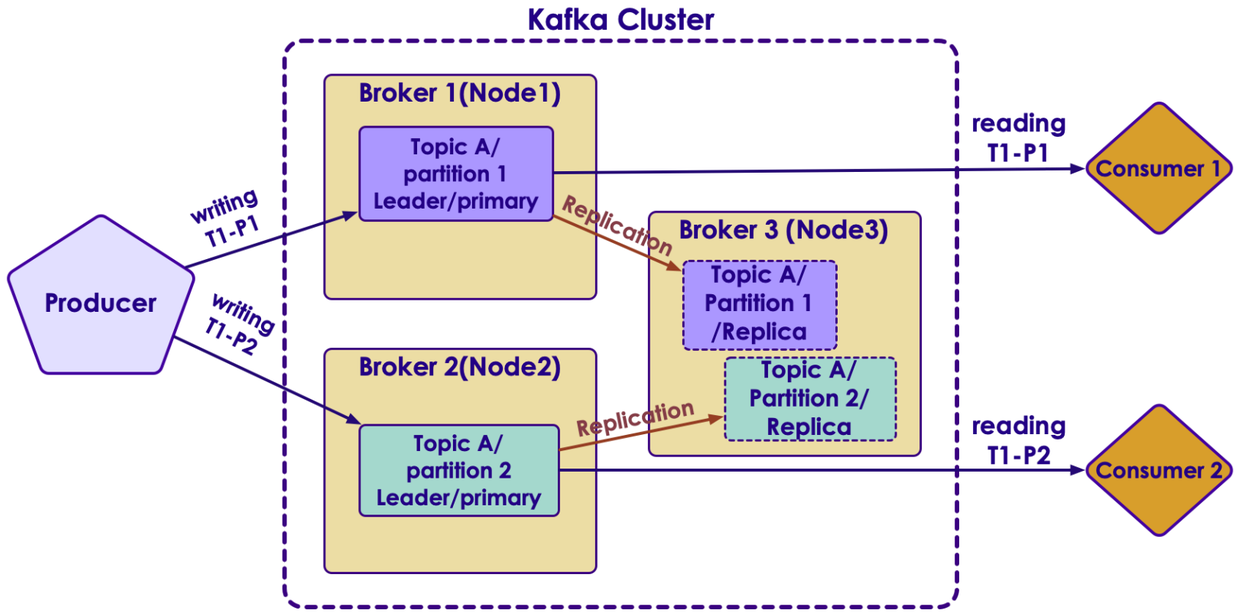
- **Reason**
  - Producer is sending events faster than Kafka brokers can handle
- Fixes:
  - Slow down producer sending
    - Switch `ack` setting to `1` or `all` to Producer will wait for acknowledgement from Broker
- Expand Kafka capacity
  - Add more partitions if possible
  - Add more broker nodes to handle the load

Issue

- Number of Under Replicated partitions are going up
- (answer next slide)

Possible Solutions

- **Reason**
  - Creating replicas is lagging behind
  - IO throughput between brokers is not keeping up with incoming data
- This is **serious issue** , as it will
  - backup write pipeline
  - Increase probability of loosing data
  - And slow down consumers! (why ?)
- **Fixes:**
  - Inspect disk bottleneck on replica machines
  - Are the disks slow / full?
  - Is the NIC saturated?



Review and Q&A

- Let's go over what we have covered so far
- Any questions?