

Recitation 2

Apache Kafka





What is Kafka?

- Distributed large-scale messaging system / event-streaming platform / event log
- Based on publish-subscribe pattern
- Provides the ability to store, process / reprocess streaming data in real-time
- Reliable, scalable, and high-throughput platform
- Facilitates event-driven architecture (event notifications, event sourcing, etc.)



Where is it used in the industry?

Companies:

- Twitter
- Netflix
- Uber
- LinkedIn
- PayPal
- ...

Use Cases:

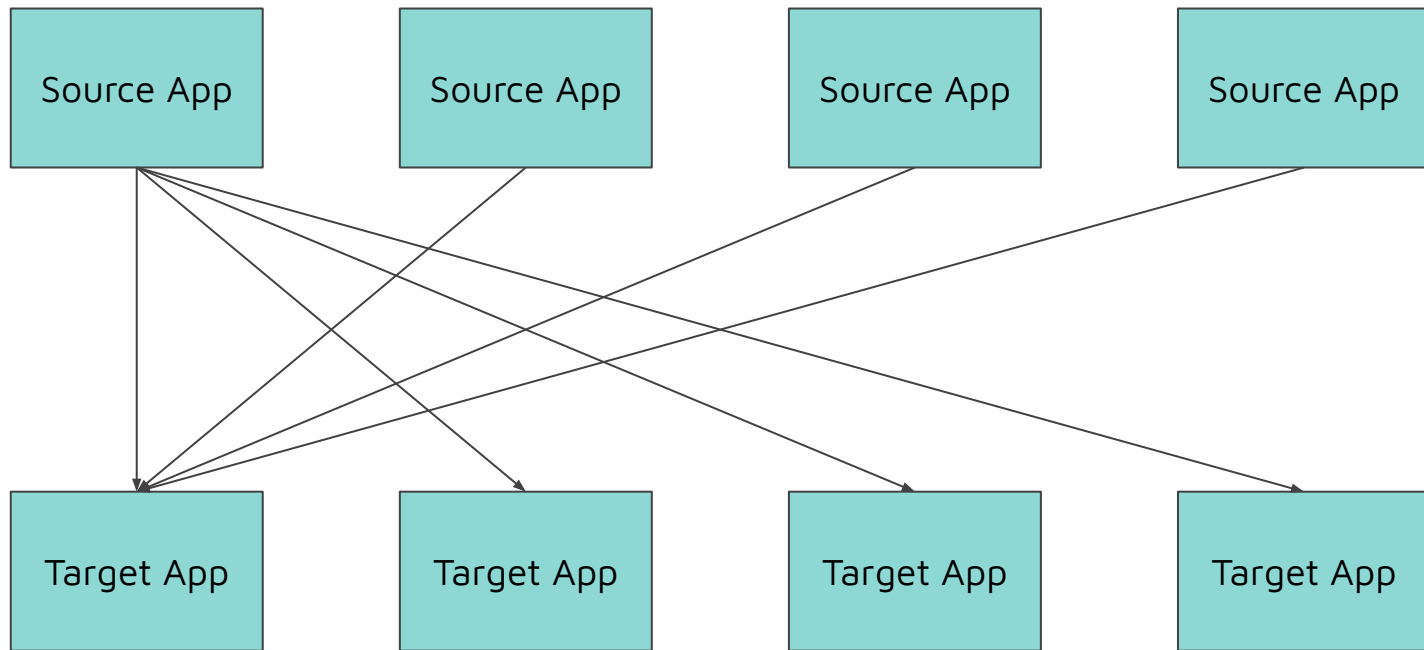
- ETL (Extract Transform Load)
- CDC (Change Data Capture)
- Big data
- Metrics
- Log aggregation
- Data pipelines for ML
- Task workflows
- Activity tracking
- Stream processing
- ...



Example scenario

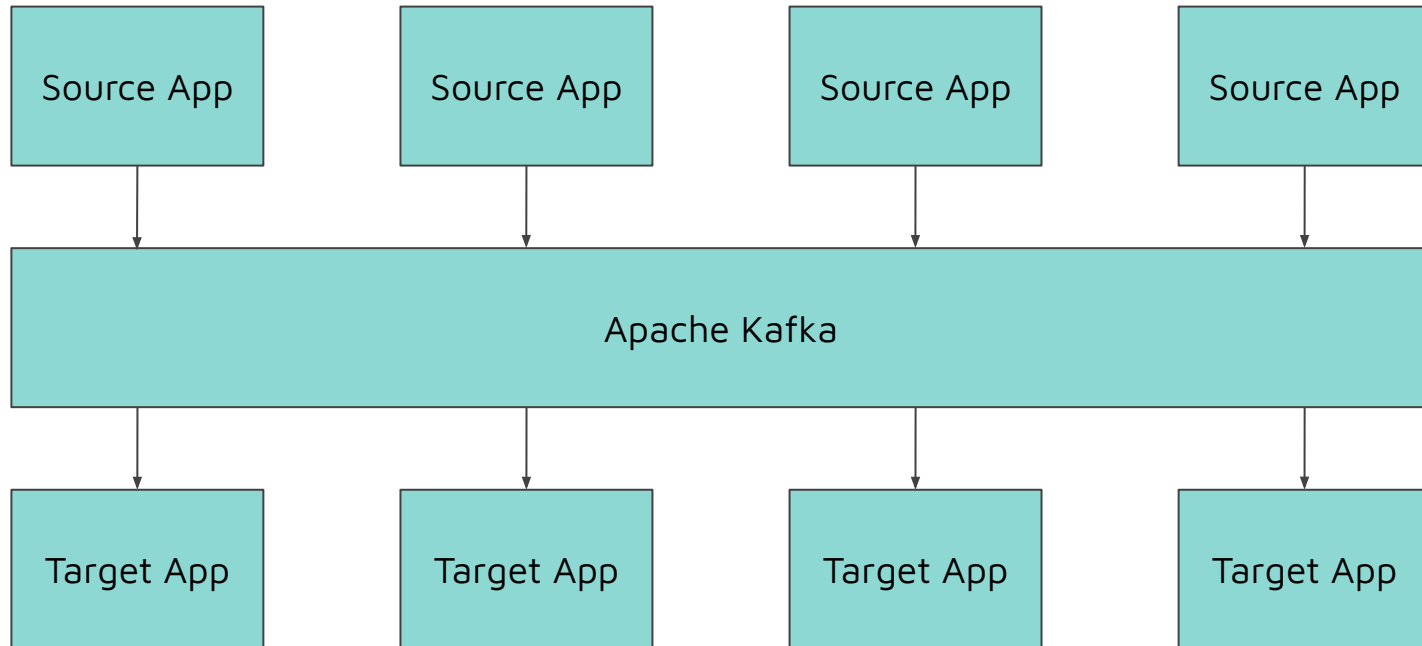
- There are hundreds of services that produce messages simultaneously
 - Sensor readings, Log messages, Messages that indicate the happening of some event, etc.
- There are hundreds of services that consume and process these messages
- There can be multiple services that consume data produced from a single service
- We should be able to quickly ramp up the services that produce/consume messages
- All messages should be processed without fail

Is this design scalable?



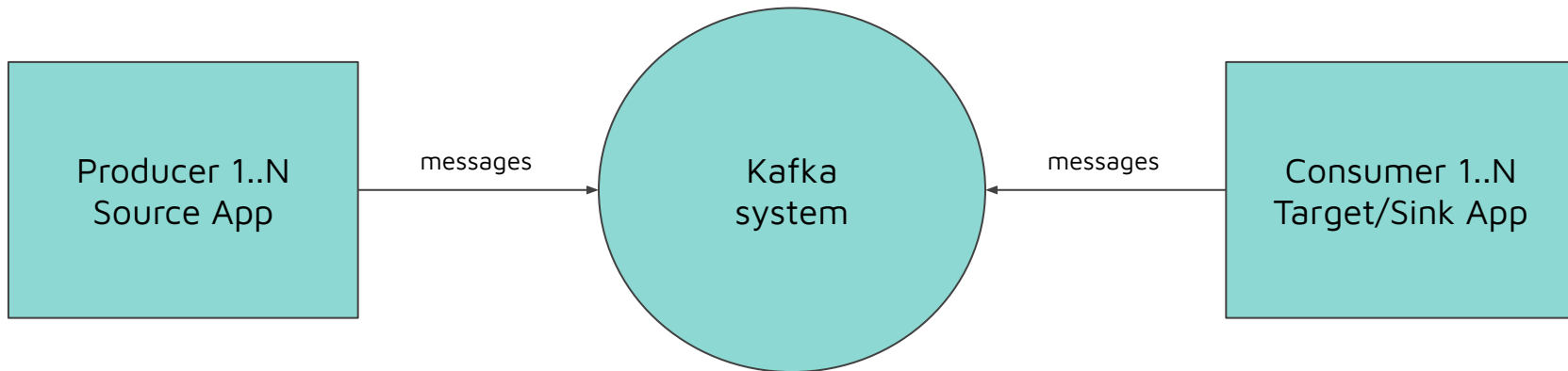


Use an intermediary. But what's the trade-off with this design?





High-level Context diagram - Kafka



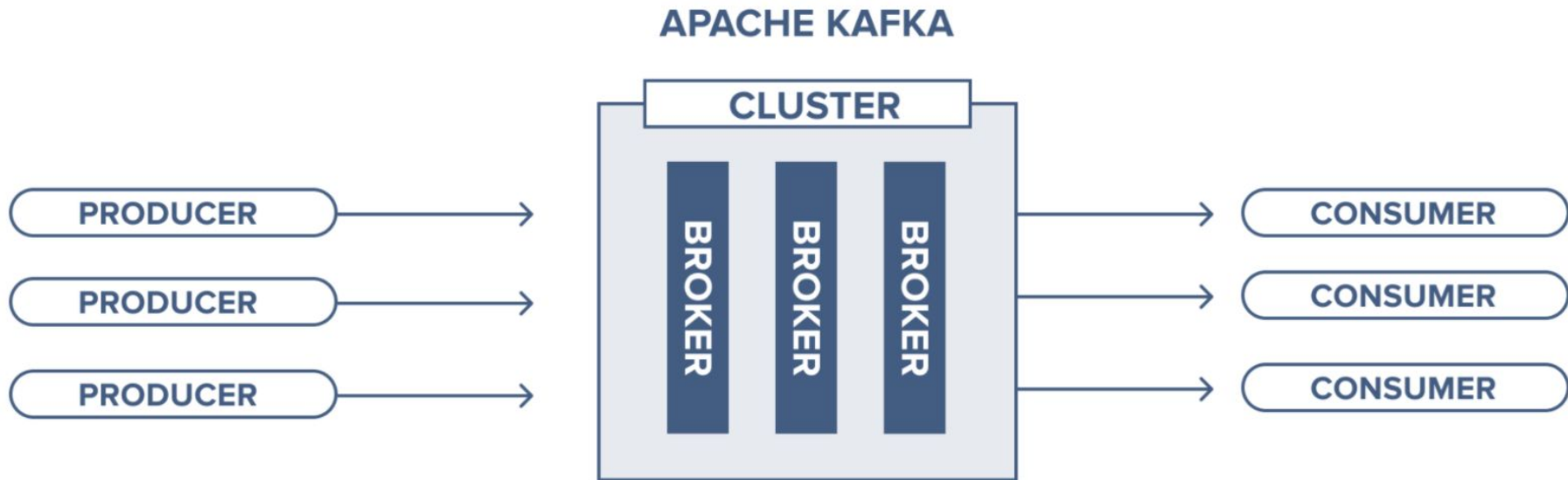


Parts of a Kafka system

- Producer : An application or process that produce messages or “events”
- Consumer : An application or process that consume messages or “events”
- Broker : A server running Kafka that handle requests from clients
- Zookeeper : Keeps track of the state of the Kafka cluster



Kafka cluster. Why do we need multiple brokers? Why not just one?





Kafka topic

- A category (name) to which events can be produced to, and consumed from
- Producers produce to topics
- Consumers subscribe to topics
- A topic can have one or more partitions
- Each partition has its own commit log
- Each message in a partition is assigned an ID (or offset)
- Message - A single unit of data that can be sent or received
 - It is just a byte array



Topic partitions





Kafka broker

- One or more servers responsible for:
 - Receiving messages from producers
 - Assigning offsets
 - Committing messages to the disc
 - Responds to consumer's fetch requests with messages
- One broker will act as the cluster controller
 - Responsible for assigning partitions to brokers
 - Monitoring for broker failures



Consumers

- Can subscribe to one or more topics
- Consumers keep track of their positions in the data stream
- Consumers within a consumer group work together to consume a topic
 - Group makes sure that each partition is consumed only by one member of the group
 - Consumers can scale horizontally to consume topics with a large number of messages
 - To consume the same messages multiple times, we need different consumer groups



Design considerations

- Is it acceptable to lose messages?
- Should all messages be processed at least once?
- Should it be possible to process old messages again?
 - Should messages be available even after they've been processed?
- Is the order in which messages are processed important?
- Is the system under consideration a real-time system (low latency)?
- Do you have a need to buffer messages?
- Do the messages contain state, or are they just notifications?
- Consider scalability, modifiability, etc.



Kafka setup

- Open a new terminal
- Run `ssh -L 9092:localhost:9092 tunnel@128.2.204.215 -NT`
 - This command forwards the port 9092 of the course server to your localhost's port 9092
 - Use the password given in Canvas
- Alternatively, use the SSH key found [here](#) and run `ssh -L 9092:localhost:9092 tunnel@128.2.204.215 -NT -i id_rsa`
 - You need to have "400" permission for the file (`chmod 400`)
- Keep this running in the background
- Install [kafkacat](#) (CLI tool for Kafka)
 - `brew install kafkacat` OR `sudo apt-get install kafkacat`
- Test your connection
 - `kafkacat -b localhost -L`



Expected output

```
[VaithyathansMBP:~ vaithya$ kafkacat -b localhost -L
Metadata for all topics (from broker 1: localhost:9092/1):
 1 brokers:
   broker 1 at localhost:9092 (controller)
16 topics:
  topic "lol" with 1 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
  topic "movielog2" with 2 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
    partition 1, leader 1, replicas: 1, isrs: 1
  topic "movielog" with 1 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
  topic "movielog-2" with 1 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
  topic "movielog1" with 2 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
    partition 1, leader 1, replicas: 1, isrs: 1
  topic "__consumer_offsets" with 50 partitions:
    partition 0, leader 1, replicas: 1, isrs: 1
    partition 1, leader 1, replicas: 1, isrs: 1
```




Create a project to practice

- Create a directory and navigate to it, say "recitation-2"
- Install pip
 - (sudo) pip install [virtualenv](#)
- Set up your virtualenv
 - (python -m) virtualenv -p python3 venv
- Activate the virtualenv
 - source venv/bin/activate
- Install kafka library for python
 - (sudo) pip install kafka-python



Writing to Kafka (code)

 `producer.py`

```
1  from time import sleep
2  from json import dumps
3  from kafka import KafkaProducer
4
5  # Create a producer to write data to kafka
6  producer = KafkaProducer(bootstrap_servers=['localhost:9092'],
7                           value_serializer=lambda x: dumps(x).encode('utf-8'))
8
9  # Write data via the producer
10 for e in range(10):
11     data = {'number' : e}
12     producer.send(topic='numtest', value=data)
13     sleep(1)
```



Expected output

```
[VaithyathansMBP:~ vaithya$ kafkacat -b localhost -t recitation2_vaithyan  
% Auto-selecting Consumer mode (use -P or -C to override)  
{"number": 0}  
{"number": 1}  
{"number": 2}  
{"number": 3}  
{"number": 4}  
{"number": 5}  
{"number": 6}  
{"number": 7}  
{"number": 8}  
{"number": 9}  
% Reached end of topic recitation2_vaithyan [0] at offset 10  
█
```



Reading from Kafka (code)

```
from kafka import KafkaConsumer
from json import loads

# Create a consumer to read data from kafka
consumer = KafkaConsumer(
    'numtest-<andrewid>',
    bootstrap_servers=['localhost:9092'],
    # Read from the start of the topic; Default is latest
    auto_offset_reset='earliest'
)

# Prints all messages, again and again!
for message in consumer:
    # Default message.value type is bytes!
    print(loads(message.value))
```



Expected output

```
[(venv) VaithyathansMBP:~ vaithya$ python3 consumer.py  
{'number': 0}  
{'number': 1}  
{'number': 2}  
{'number': 3}  
{'number': 4}  
{'number': 5}  
{'number': 6}  
{'number': 7}  
{'number': 8}  
{'number': 9}
```



Make reads fault-tolerant

```
17 consumer = KafkaConsumer(  
18     'numtest',  
19     bootstrap_servers=['localhost:9092'],  
20     auto_offset_reset='earliest',  
21     # Consumer group id  
22     group_id='numtest-group-<andrew_id>',  
23     # Commit that an offset has been read  
24     enable_auto_commit=True,  
25     # How often to tell Kafka, an offset has been read  
26     auto_commit_interval_ms=1000  
27 )  
28  
29 # Prints messages once, then only new ones!  
30 for message in consumer:  
31     print(loads(message.value))
```



Expected output

```
(venv) VaithyathansMBP:~ vaithya$ python3 consumer.py
{'number': 0}
{'number': 1}
{'number': 2}
{'number': 3}
{'number': 4}
{'number': 5}
{'number': 6}
{'number': 7}
{'number': 8}
{'number': 9}
```

```
(venv) VaithyathansMBP:~ vaithya$ python3 consumer.py
```



Try this!

Run `producer.py` in one tab, and `consumer.py` in another

What is the output?



Resources

- <https://kafka-python.readthedocs.io/en/master/>
- <https://github.com/edenhill/kafkacat>
- <https://www.youtube.com/watch?v=JaIUUBKdcAQ>
- <https://towardsdatascience.com/kafka-python-explained-in-10-lines-of-code-800e3e07dad1>



Thank you!