Apache Kafka

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"Every enterprise is powered by data"

Multifaceted Apache Kafka

- scalable real-time messaging platform
  - able to process millions of messages per second
- event streaming platform for massive volumes of big data analytics
- distributed storage
  - with support for replayability of events
  - and with guaranteed ordering
- data integration framework for streaming ETL
- data processing framework
  - continuous stateless or stateful stream processing

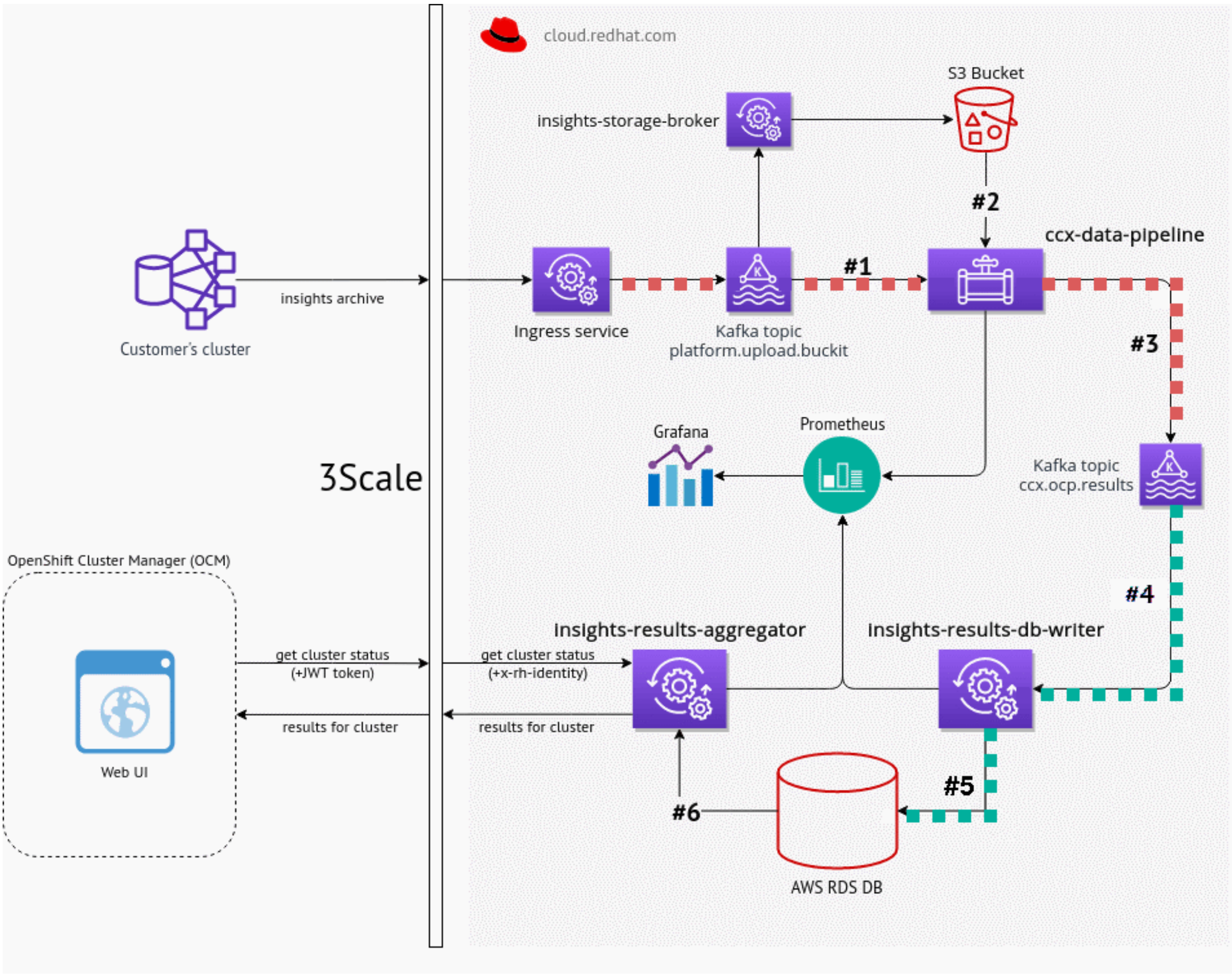
Kafka in not:

- proxy for millions of clients
  - like mobile apps
- API Management platform
- database for complex queries and batch analytics workloads
  - simple aggregations possible thanks to ksqlDB
- IoT platform with features such as device management
- technology for hard real-time applications

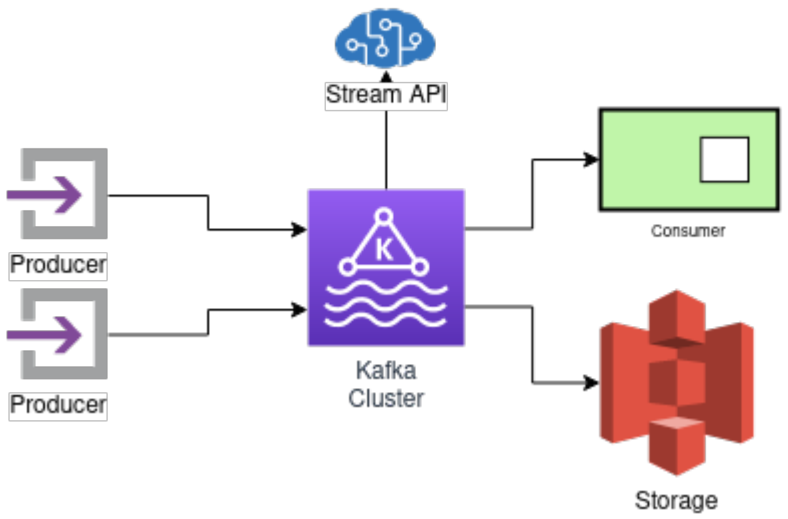
    - safety-critical systems
    - deterministic systems

Typical usage of Kafka

- Message broker on steroids
- Central part of Lambda architecture
- Central part of Kappa architecture
- Logging platform
- ETL with capability to "replay" data

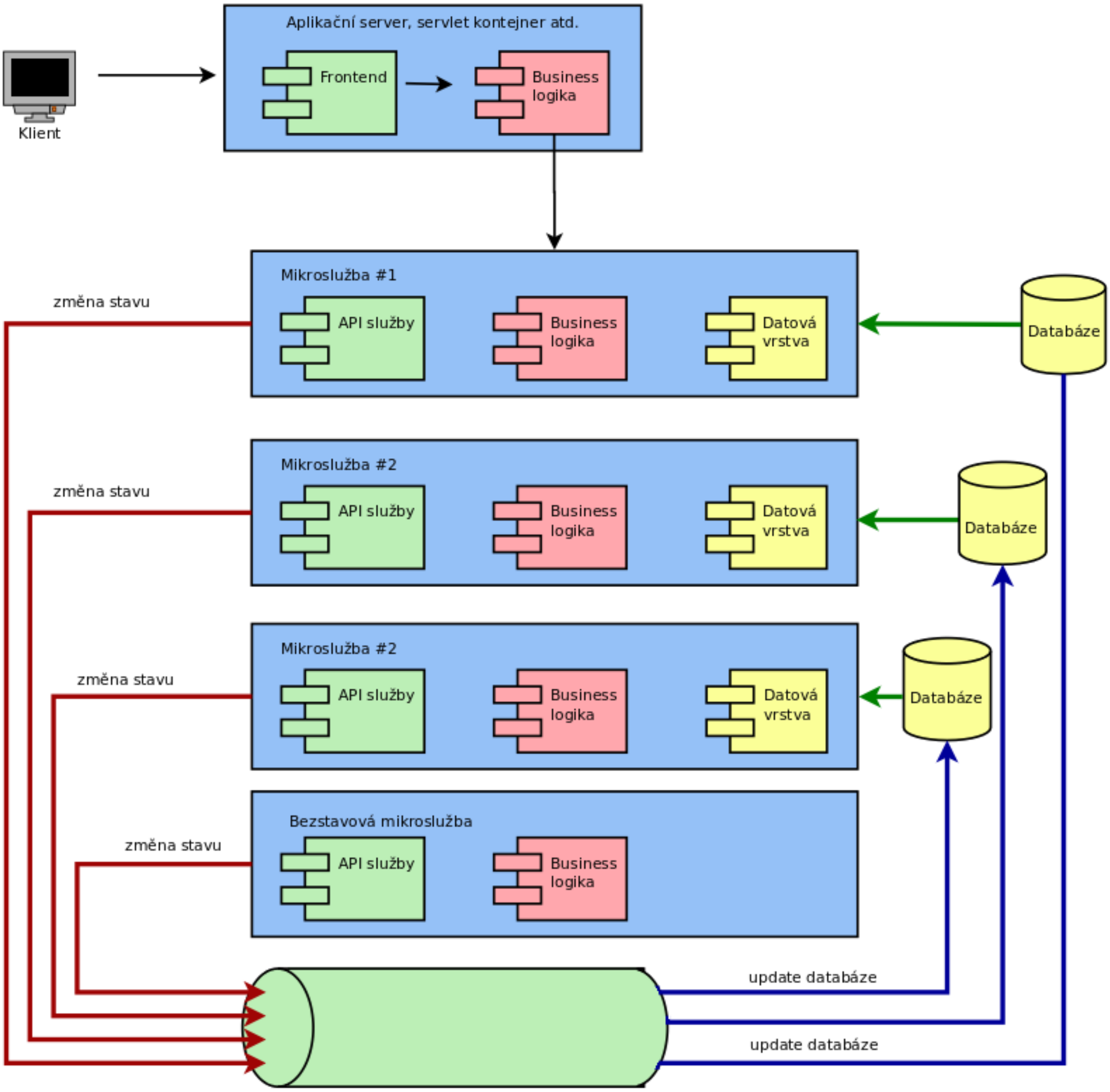


Kafka streams



Source of truth

full image

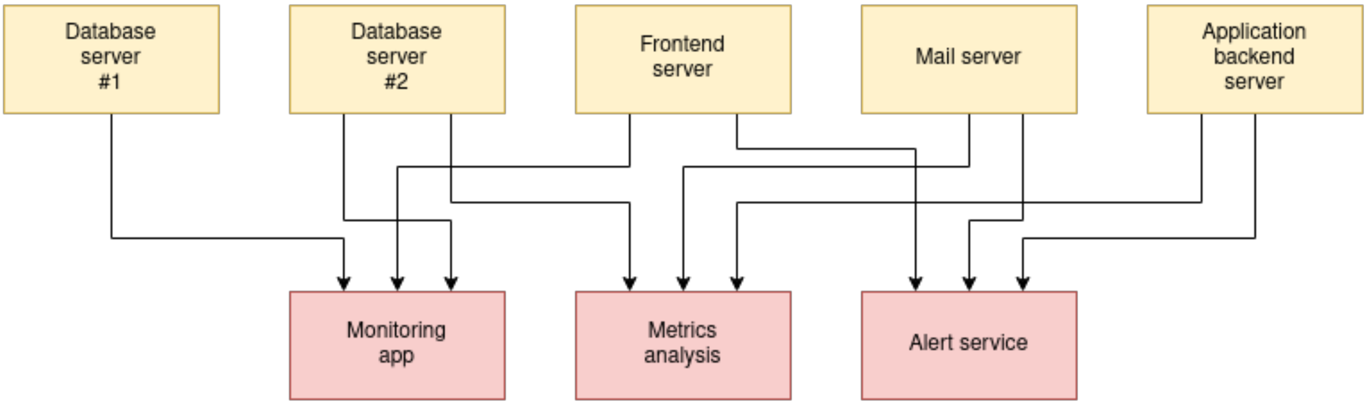


Kafka: Message broker on steroids

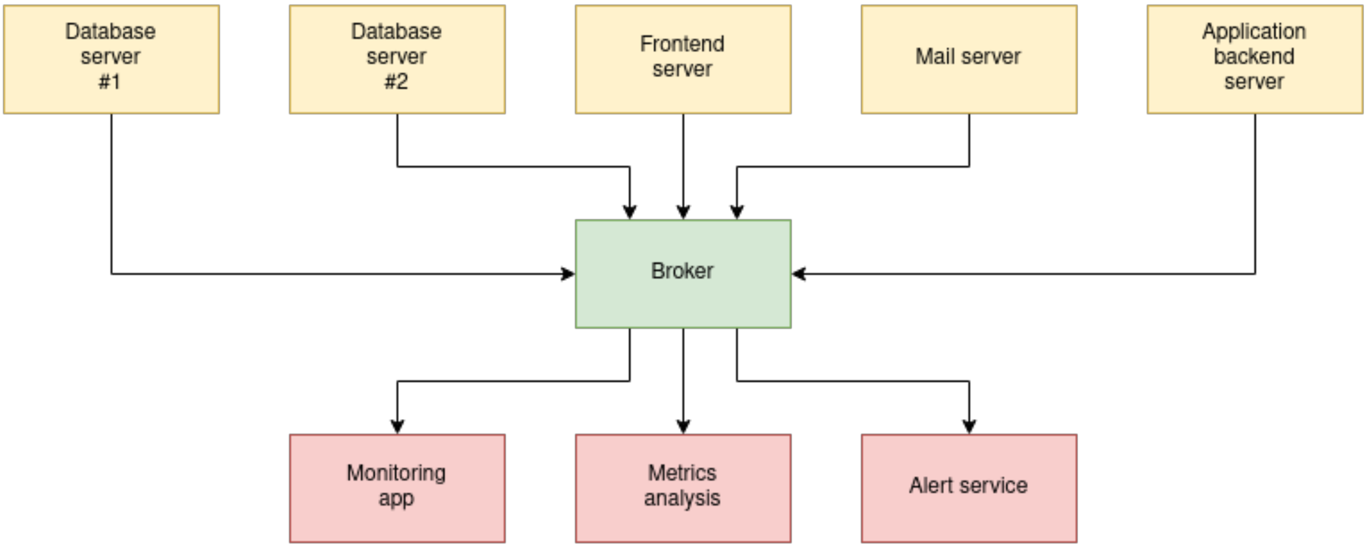
Message brokers

- Classic ones
  - ActiveMQ (Artemis)
  - RabbitMQ
  - IBM MQ
  - etc.

Why message brokers?



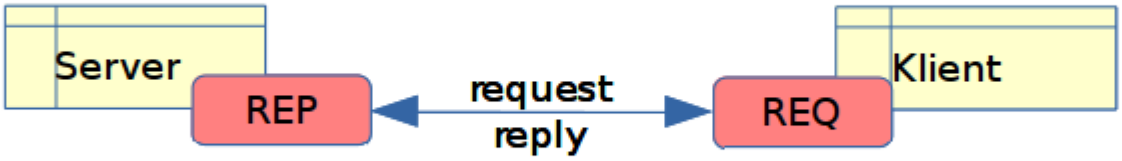
Why message brokers?



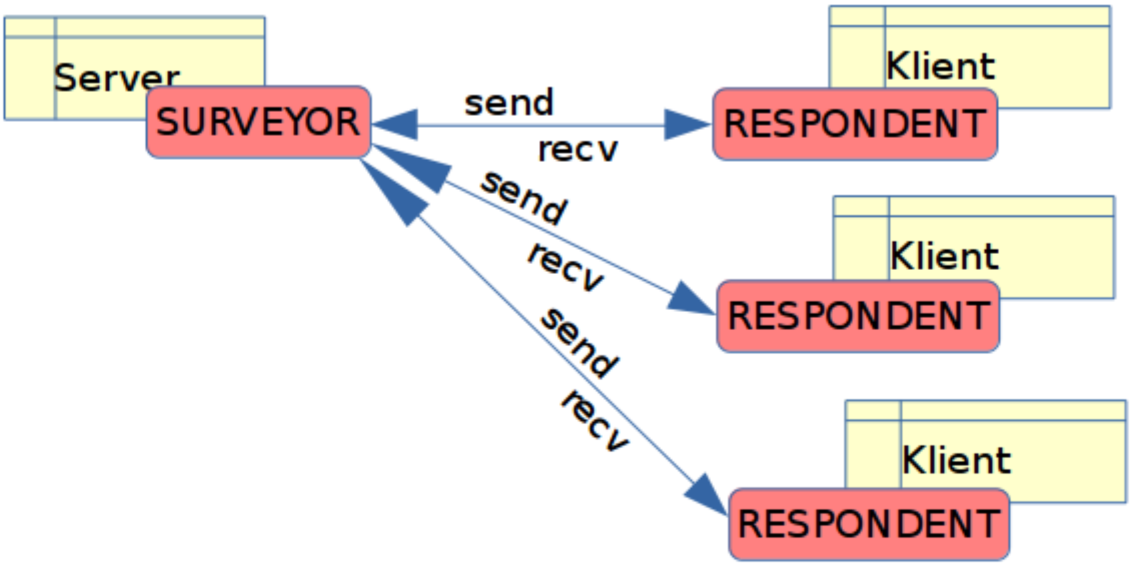
Message brokers: communication strategies

- Enterprise integration patterns (EIP)

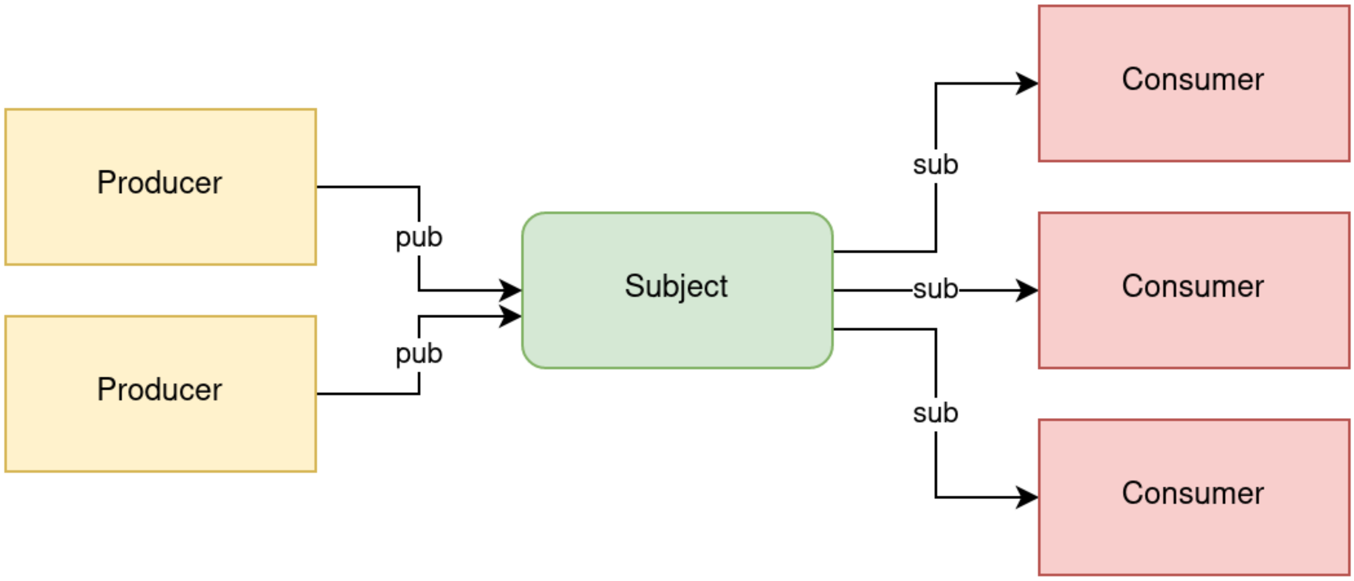
Request reply



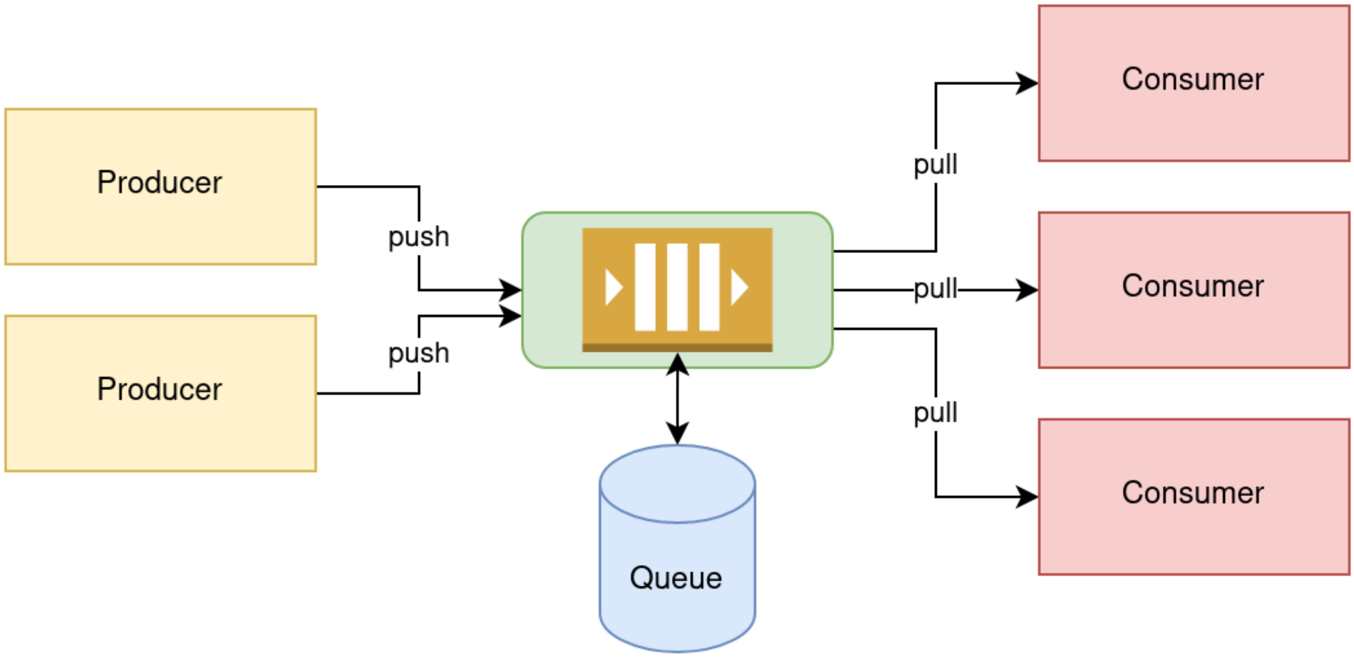
Surveyor



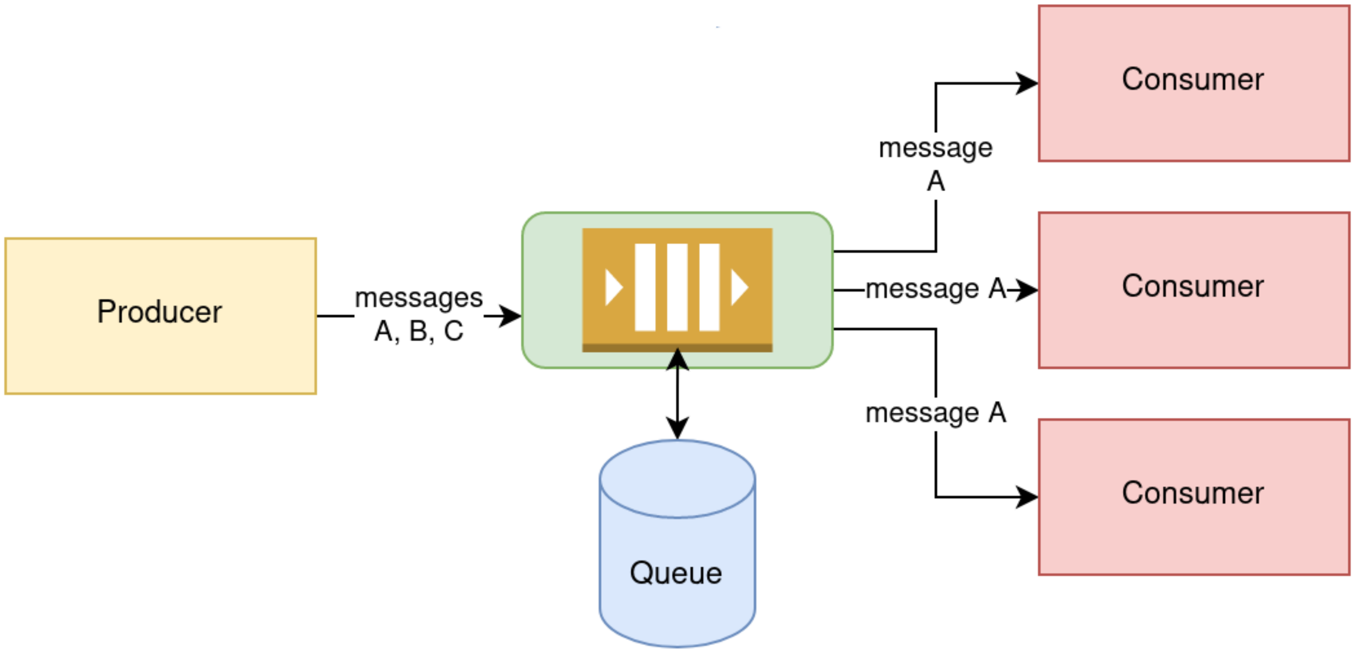
Pub-sub



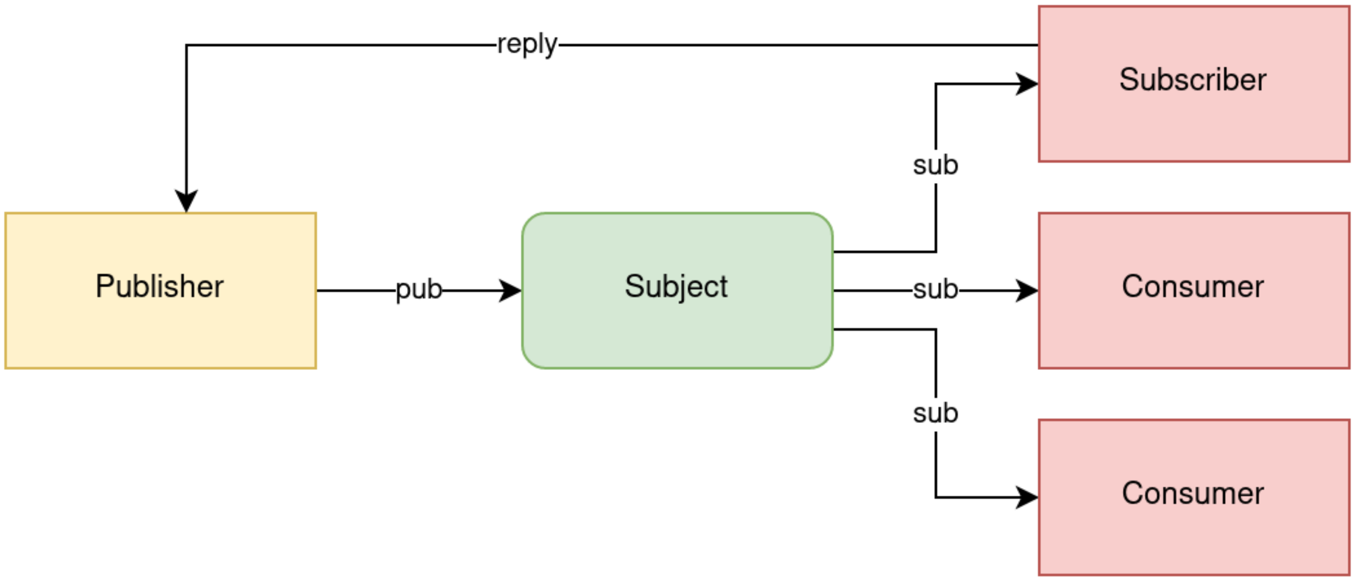
Push-pull



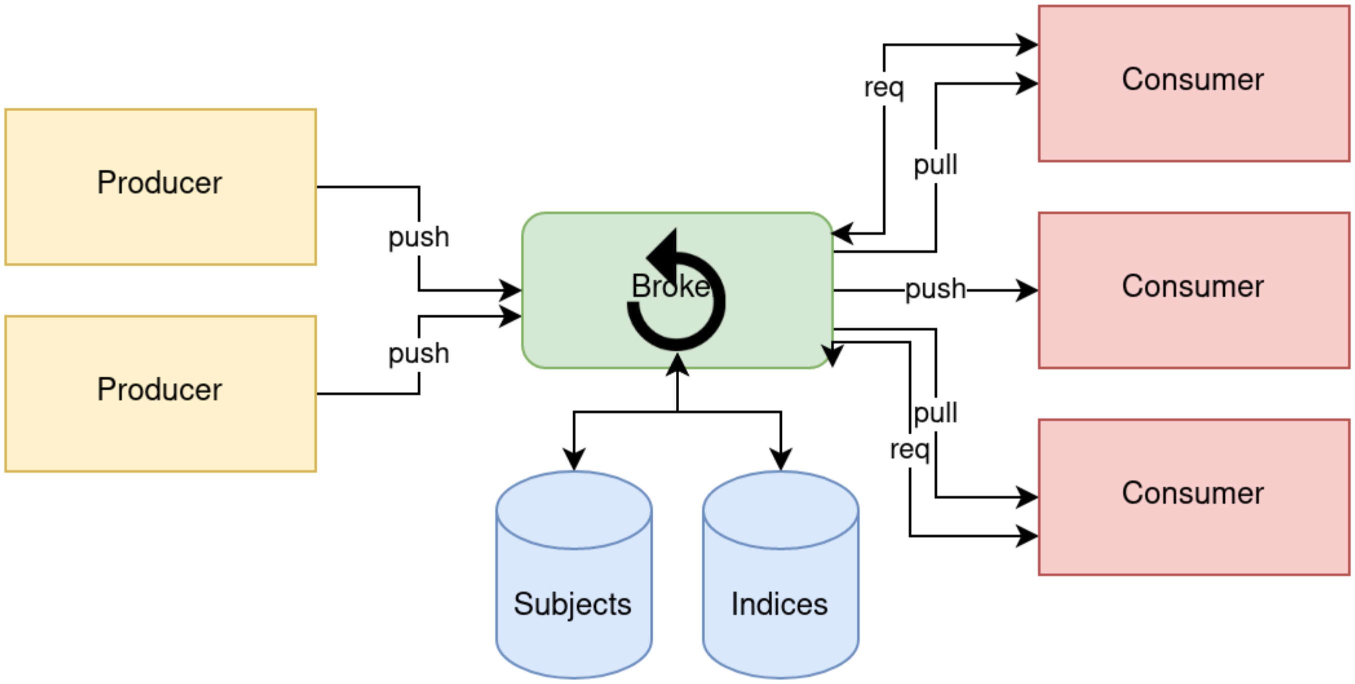
Push-pull with messages redistribution



Push-pull with reply to producer



Other strategies (NATS etc.)

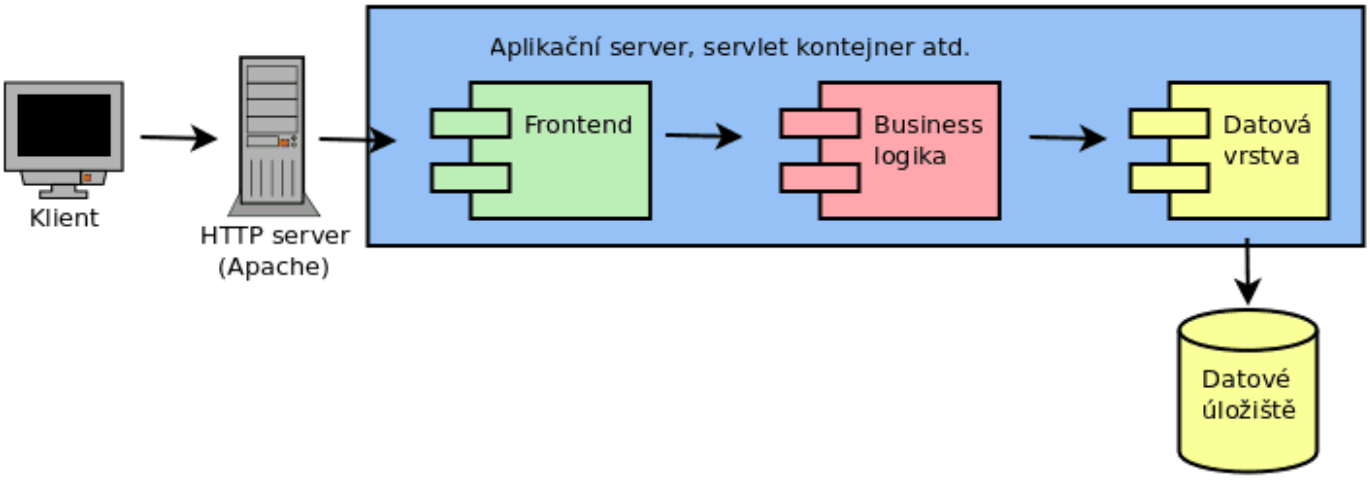


Microservices

- Apache Kafka is sometimes used as a key component in microservice-based architectures
- "Design the organisation you want, the architecture will follow (kicking and screaming)"

Classic architecture

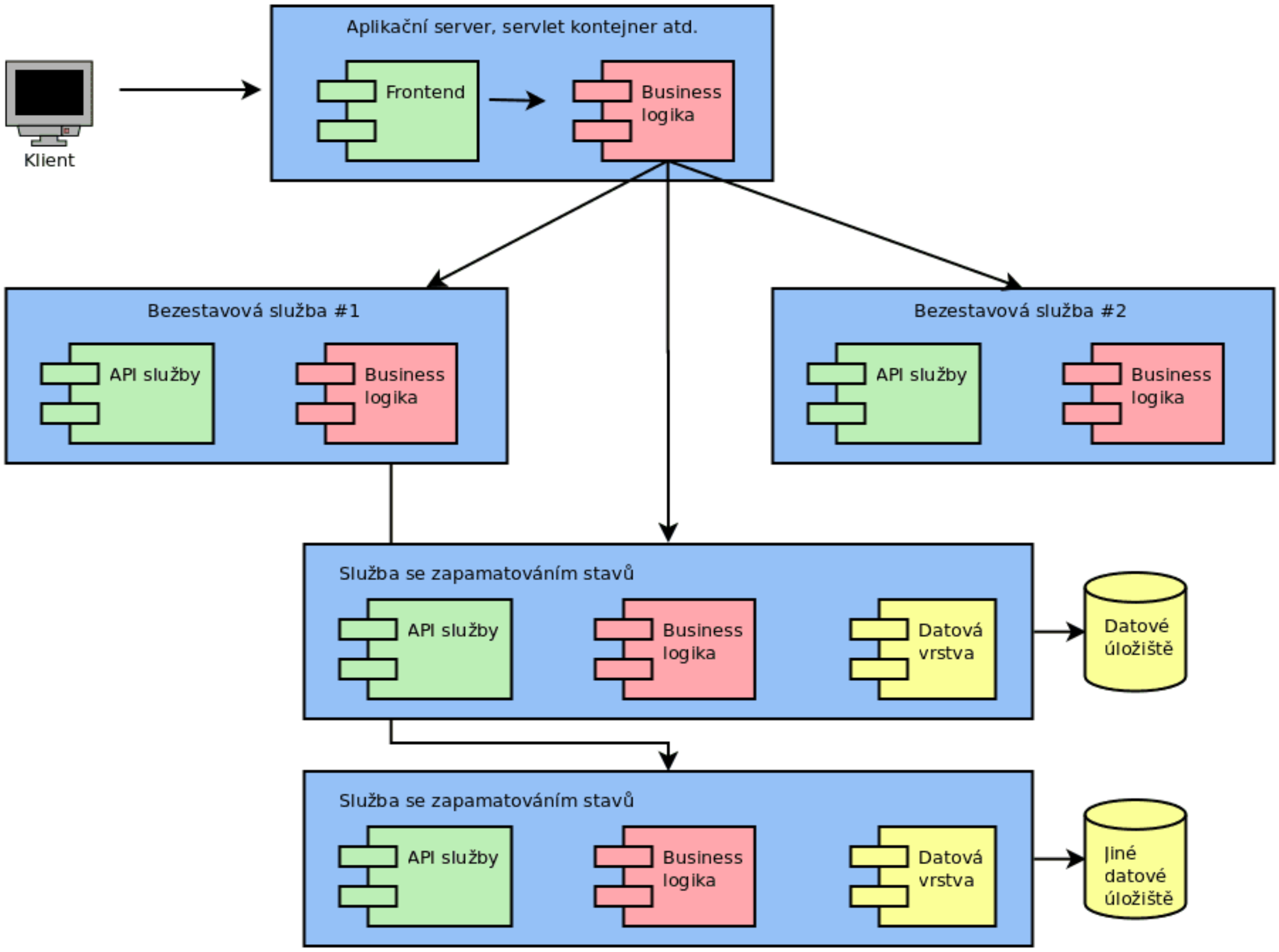
- Front-end
- Back-end
  - business logic
  - data layer
- Storage



Stateless and stateful microservices

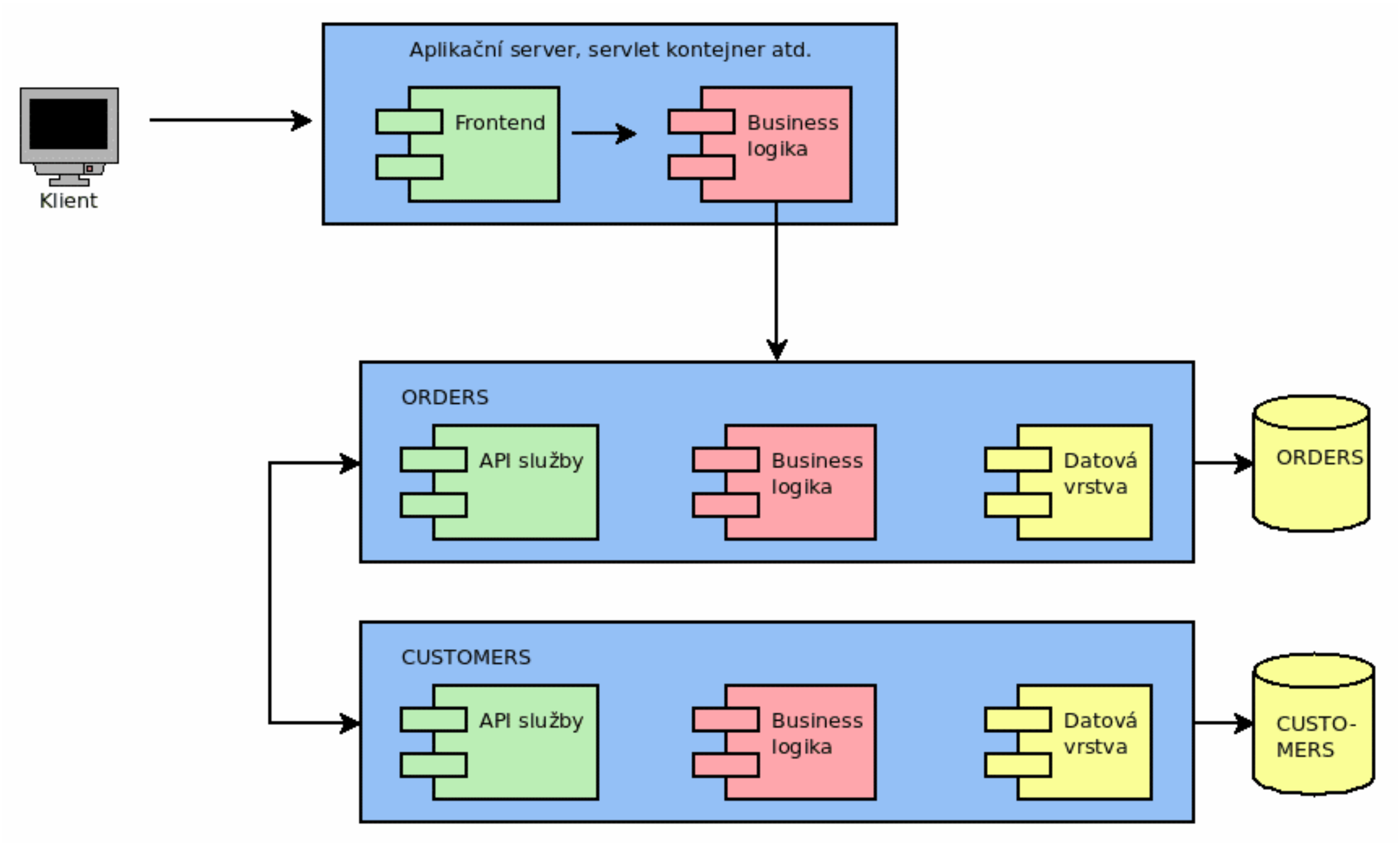
- Services w/o state
  - super easy to test
  - usually very easy to scale up
  - restarts are usually not a big deal
- Stateful service
  - the opposite is true

Full image



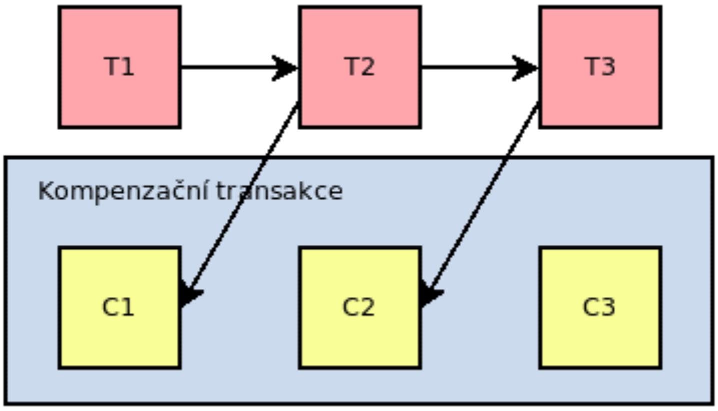
Communication between stateful microservices

- Not as easy as it might seem
  - "compound" transactions
  - should one service synchronously wait for second one?



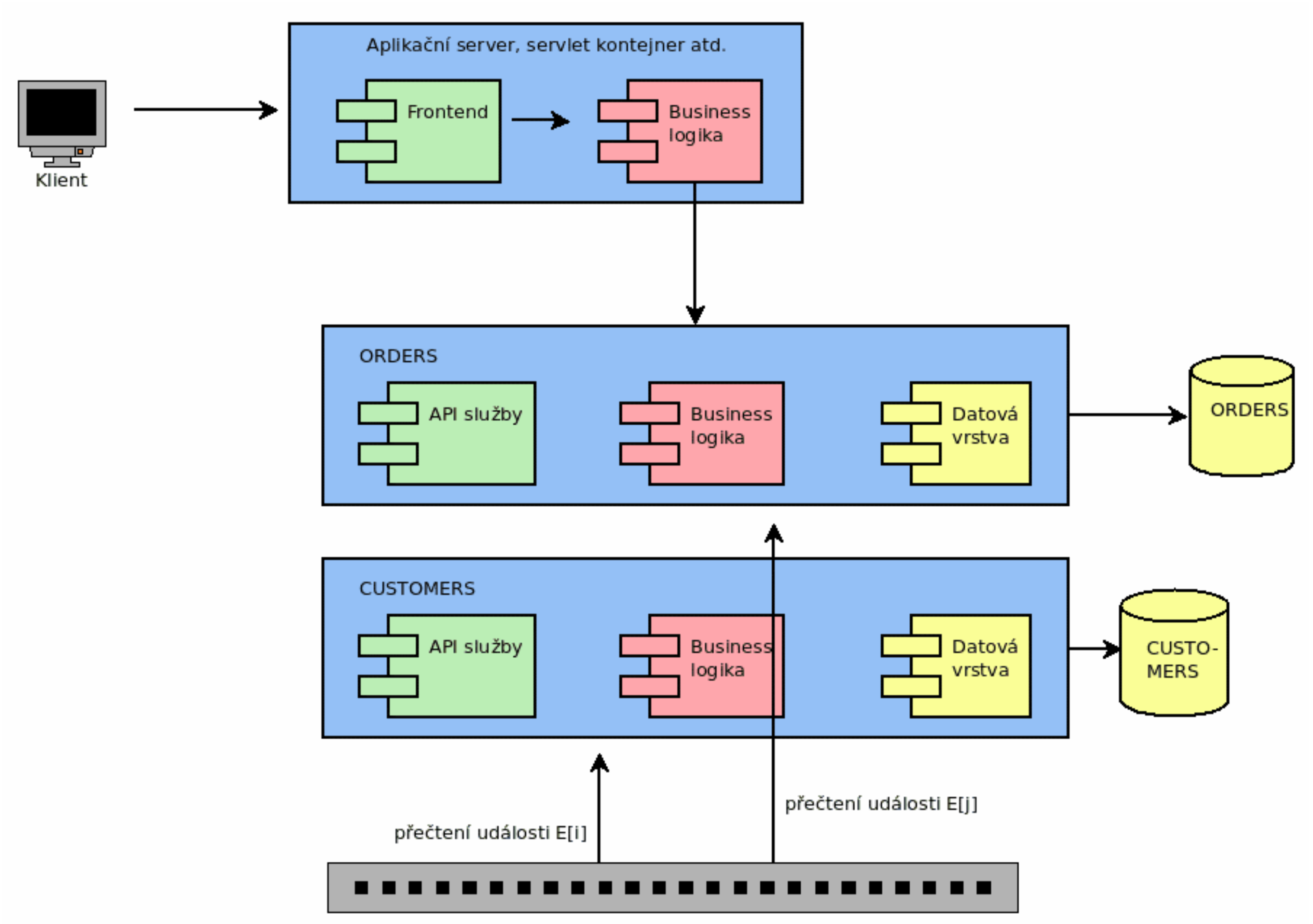
Compensation transactions

- One possible solution

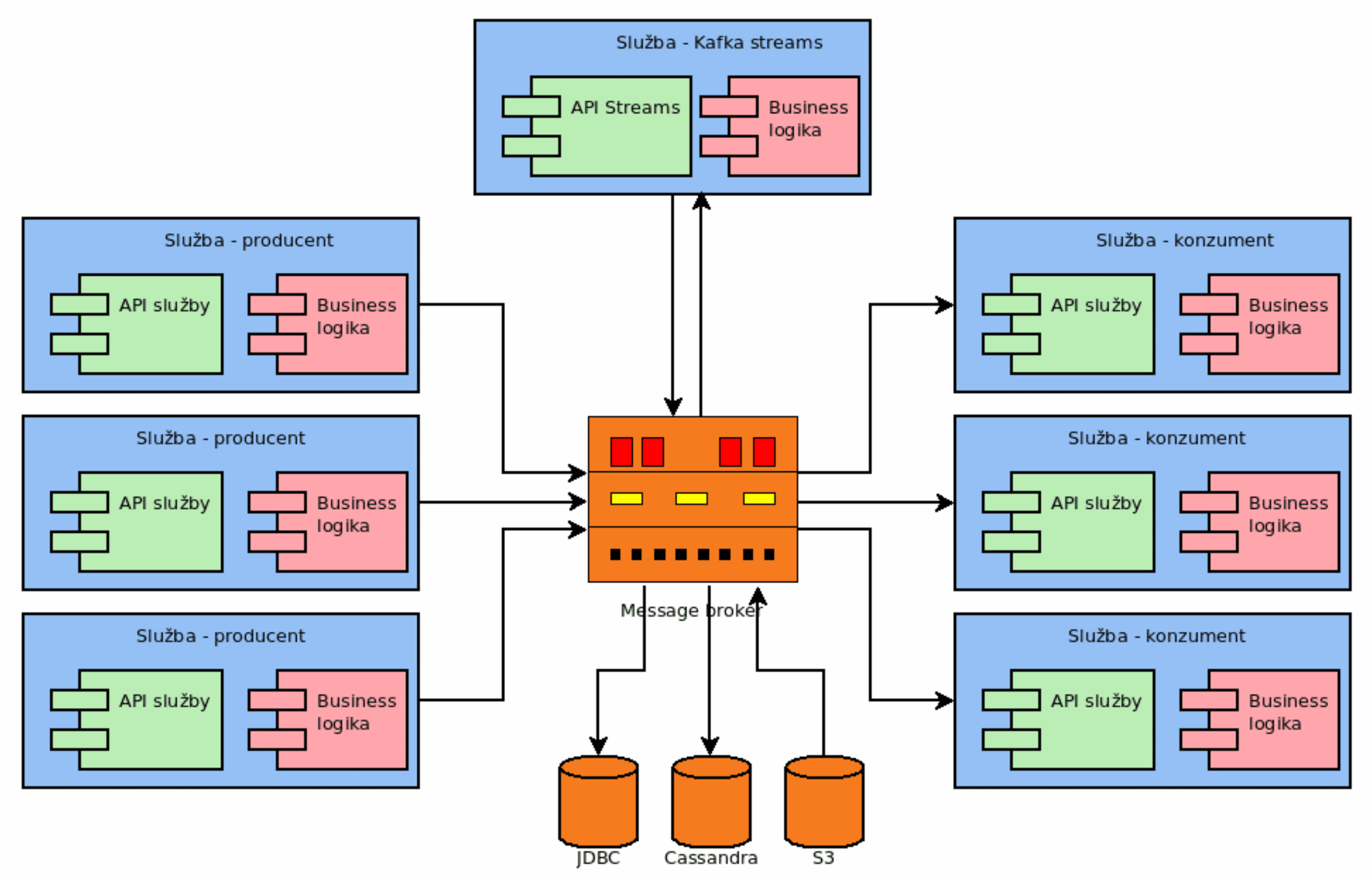


Apache Kafka as source of events

Full image

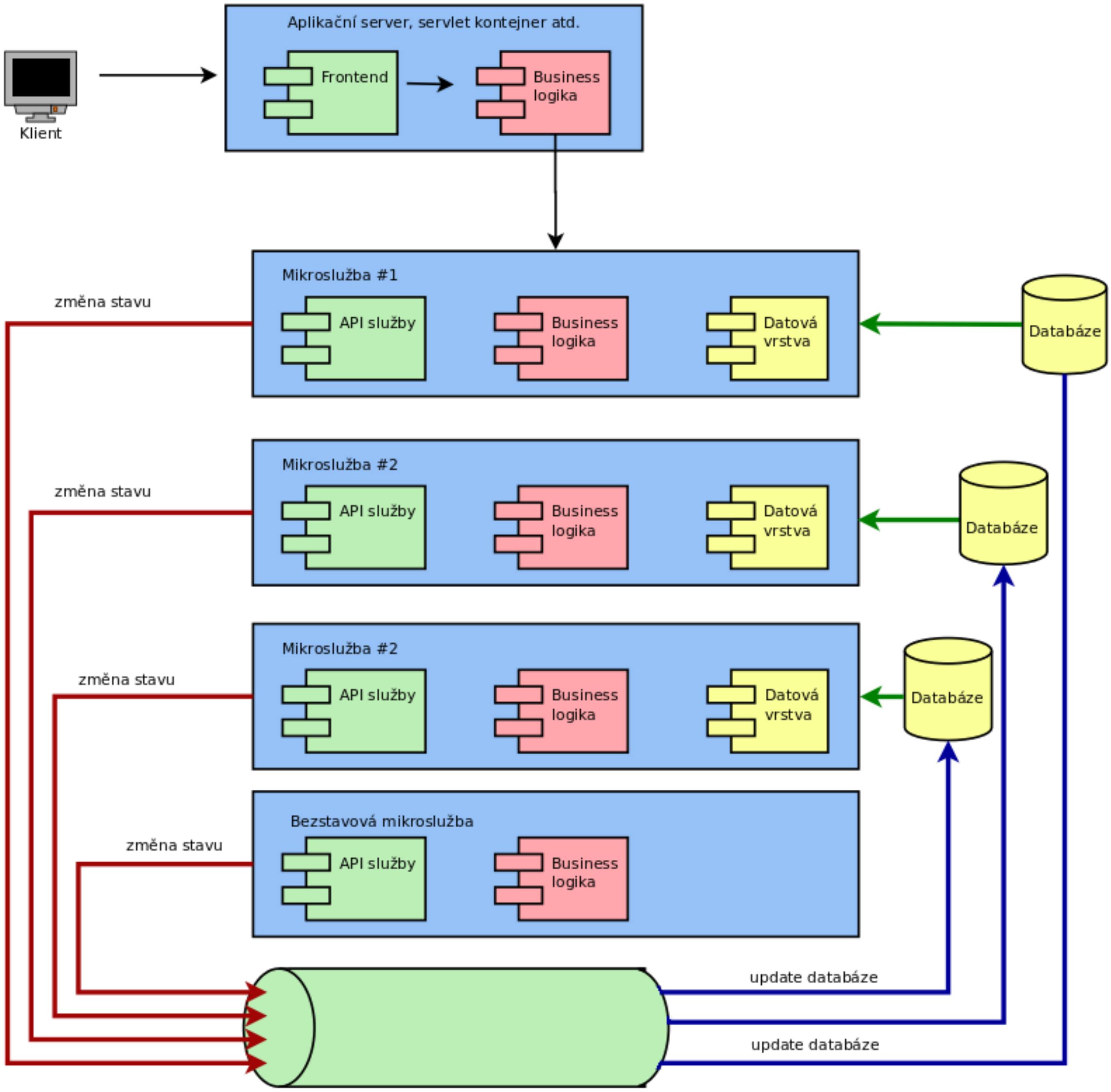


Apache Kafka as message broker



Kappa architecture

Full image



Messaging

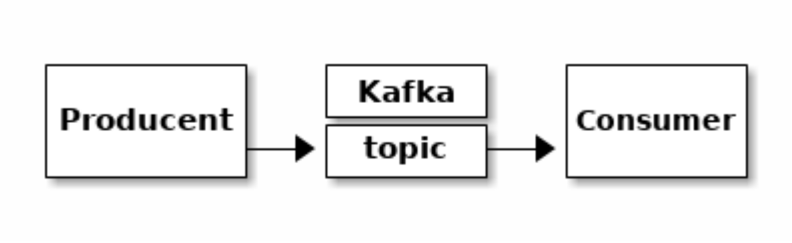
- Command–query separation (CQS)
- Command-query responsibility segregation (CQRS)
- How to communicate between components
  - COMMAND message
  - EVENT message
  - QUERY message
- Sometimes different buses are used
  - CommandBus

    - EventBus
    - QueryBus

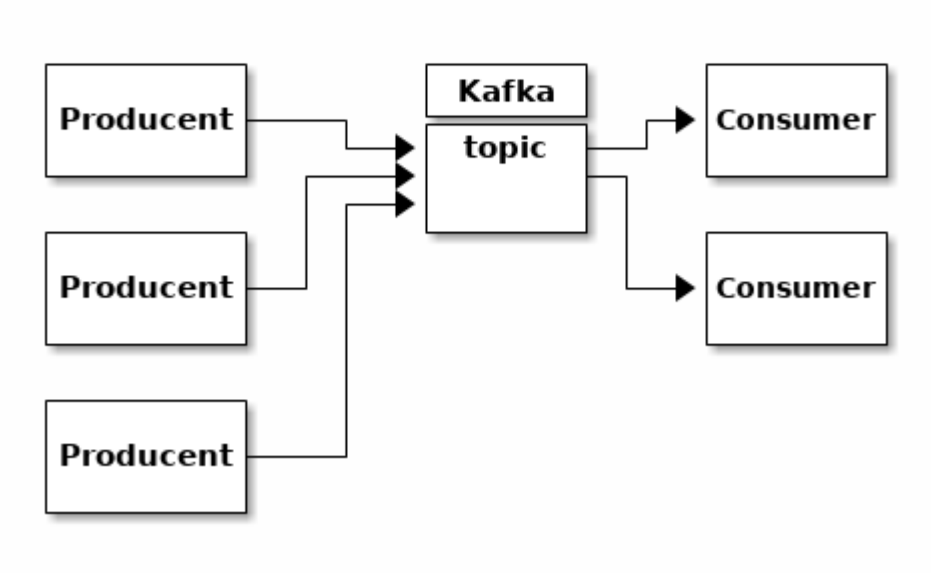
Basic concepts

- Message
    - also called event
- Topic
    - a named log of events
- Producer
    - sends messages/events into selected topic
- Consumer
    - retrieves messages/events from selected topic

Producer and consumer



More producers and consumers



Messages in Kafka

- Array of bytes
  - no prior knowledge about format
- Optional key
- Batch(es)
  - multiple messages for the same topic+partition
  - written as one block
  - efficiency

Topics and partitions

- Messages are categorized into topics
- Topic is splitted into partitions

Append-only log

- new mesage/event is always written on the end of one partition
- messages/events are immutable
- can be read by
  - seeking and arbitrary offset
  - sequential scanning

Three basic operations

- Producer
  - produce (send) message to given topic
- Consumer
  - rewind (seek) to message X
  - consume message + update offset

Topic is NOT a queue

- Topic is basically stateless
    - consumers have to maintain their state
    - by storing their offsets "somewhere"
- Message is not deleted after consumption
    - just messages past the retention period are deleted
- FIFO model is not followed

Topic with one partition only

```
+---+---+---+---+---+---+---+---+---+
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...
+---+---+---+---+---+---+---+---+---+
                ^                           ^
                |                           |
               read                       write
```

Kafka technology is much more difficult though

- Partitions
- Multiple replicas per partition
- Sharding

Multiple partitions for one topic

```
              +---+---+---+---+---+---+
partition #0  | 0 | 1 | 2 | 3 | 4 | 5 | ...
              +---+---+---+---+---+---+
partition #1  | 0 | 1 | 2 | ...
              +---+---+---+
partition #2  | ...
              +---+---+---+---+---+---+---+---+---+
partition #3  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...
              +---+---+---+---+---+---+---+---+---+
```

Key features

- Scalability
- Reliability
- Log compaction

Scalability

- Topic can be partitioned
  - across different servers

Reliability

- Replication
- Changing leadership role

Multiple replicas per partition

```
                                     write
                                       |
+---+---+---+---+---+---+---+---+---+  v
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...    (leader)
+---+---+---+---+---+---+---+---+---+
                  ^               ^
                read              |
                                 sync
                                  |
                                  v
+---+---+---+---+---+---+---+---+---+
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |        (follower)
+---+---+---+---+---+---+---+---+---+
                                  ^
                                  |
                                 sync
                                  |
                                  v
+---+---+---+---+---+---+---+---+---+
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |        (follower)
+---+---+---+---+---+---+---+---+---+
```

Multiple replicas for partitioned topic

```
              +---+---+---+---+---+---+
partition #0  | 0 | 1 | 2 | 3 | 4 | 5 | ...
              +---+---+---+---+---+---+
partition #1  | 0 | 1 | 2 | ...
              +---+---+---+                               (leader)
partition #2  | ...
              +---+---+---+---+---+---+---+---+---+
partition #3  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...
              +---+---+---+---+---+---+---+---+---+
                                      ^
                                      |
                                     sync
                                      |
                                      v
              +---+---+---+---+---+---+
partition #0  | 0 | 1 | 2 | 3 | 4 | 5 | ...
              +---+---+---+---+---+---+
partition #1  | 0 | 1 | 2 | ...
              +---+---+---+
partition #2  | ...                                       (follower)
              +---+---+---+---+---+---+---+---+---+
partition #3  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...
              +---+---+---+---+---+---+---+---+---+
                                      ^
                                      |
                                     sync
                                      |
                                      v
              +---+---+---+---+---+---+
partition #0  | 0 | 1 | 2 | 3 | 4 | 5 | ...
              +---+---+---+---+---+---+
partition #1  | 0 | 1 | 2 | ...
              +---+---+---+
partition #2  | ...                                       (follower)
              +---+---+---+---+---+---+---+---+---+
partition #3  | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ...
              +---+---+---+---+---+---+---+---+---+
```

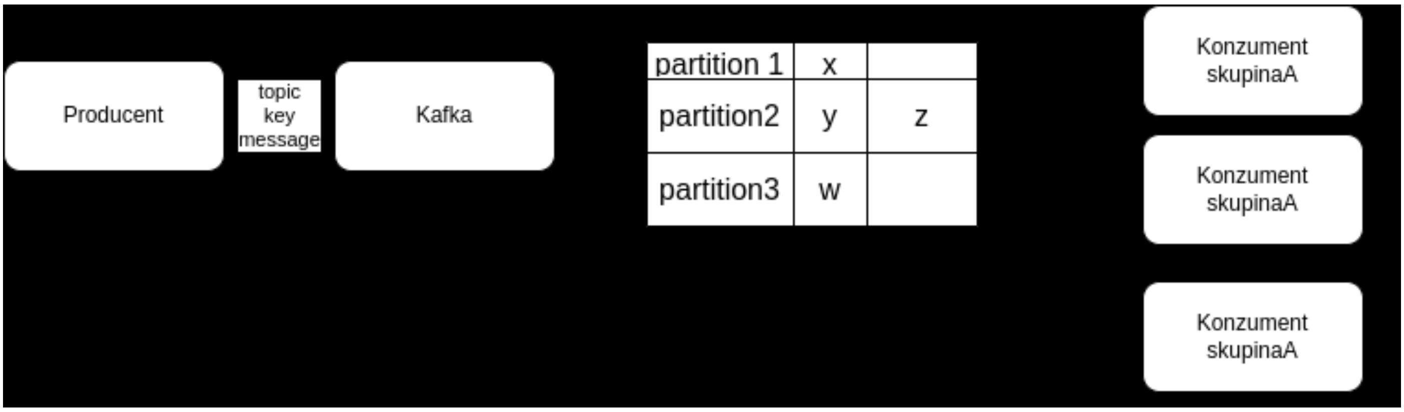
Log compaction

- Keeps the latest known value for each record key
- Preserves the most recent version of a record during deletion

Consumer groups, clusters, multiple brokers

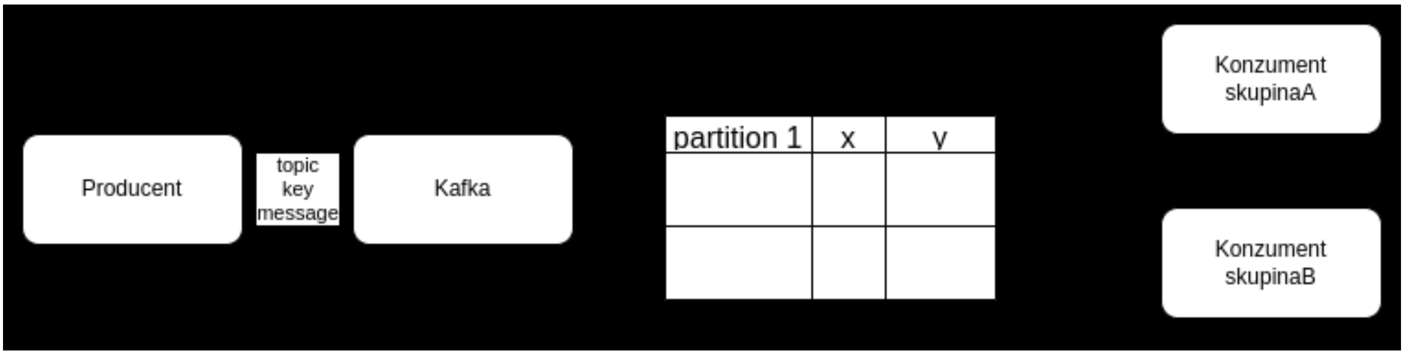
- Consumer groups
  - at most one consumer per partition
  - scalability
- Clusters
  - one broker is controller
  - elected automatically
  - assigning partitions
  - monitoring broker failures

Multiple consumers in one group



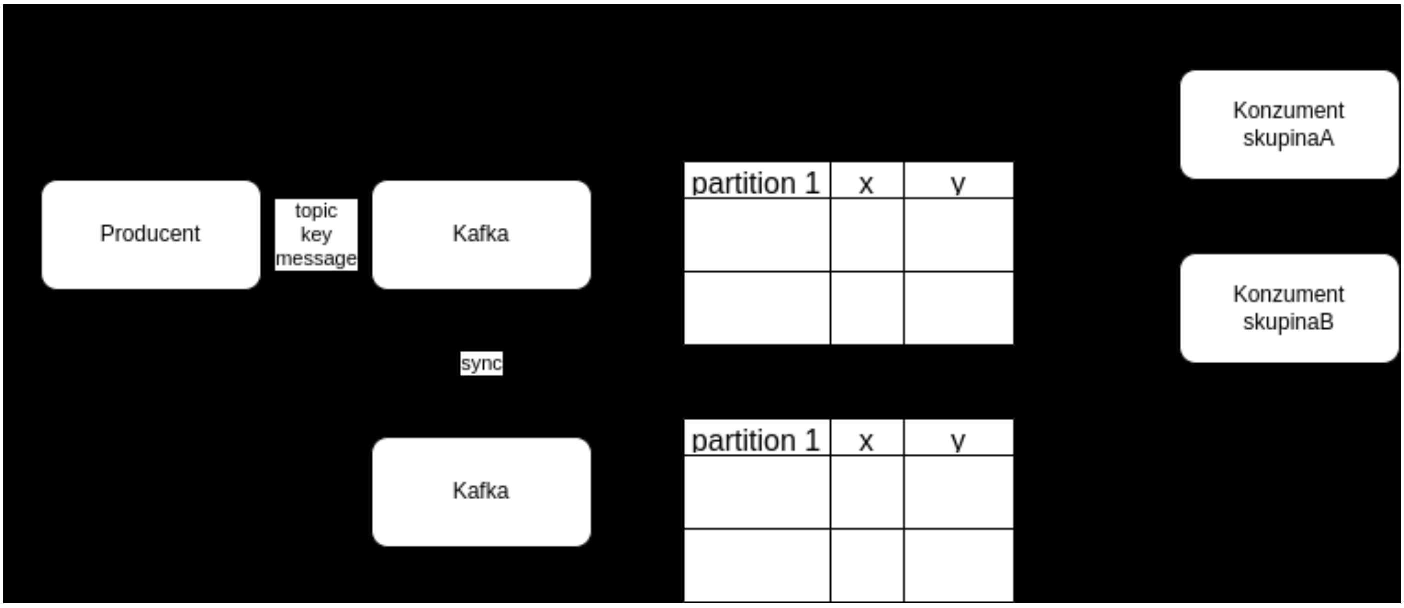
partition 1	x	
partition2	y	z
partition3	w	

Consumers from different groups



partition 1	x	y

Multiple brokers



Consumer groups, clusters, multiple brokers

- Partition can be assigned to more brokers
  - replication
  - redundancy
  - can survive broker(s) failure

Retention

- Retention policy
  - setup globally
  - and possible to setup for topic
  - retention limits are minimum guarantees
  - just one criterium might be met

```
log.retention.hours
log.retention.bytes
log.segment.bytes
log.retention.check.interval.ms
log.roll.hours
```

Retention

- The messages on a topic are not immediately removed after they are consumed/expired
- Once either of the limit is breached, the messages are marked deleted

CLI

- Apache Kafka with batteries included

Starting Zookeeper and broker(s)

Zookeeper configuration

- Stored in `config/zookeeper.properties` file

```
dataDir=/tmp/zookeeper
clientPort=2181
maxClientCnxns=0
```

Starting Zookeeper

```
bin/zookeeper-server-start.sh config/zookeeper.properties
```

```
bin\windows\zookeeper-server-start.bat config/zookeeper.properties
```

Checking Zookeeper by telnet

```
$ telnet localhost 2181
```

```
Trying ::1...
Connected to localhost.
Escape character is '^]'.
srvr
Zookeeper version: 3.6.3--6401e4ad2087061bc6b9f80dec2d69f2e3c8660a, built on 04/08/2
Latency min/avg/max: 0/0.0/0
```

```
Received: 1
Sent: 0
Connections: 1
Outstanding: 0
Zxid: 0x16e
Mode: standalone
Node count: 174
Connection closed by foreign host.
```

Broker(s) configuration

- Stored in `config/server.properties`
- Better to use IDs greater that #replicas

Broker(s) configuration

```
broker.id=100
listeners=PLAINTEXT://:9092
num.network.threads=3
num.io.threads=8

socket.send.buffer.bytes=102400
socket.receive.buffer.bytes=102400
socket.request.max.bytes=104857600

log.dirs=/tmp/kafka-logs
num.partitions=1
num.recovery.threads.per.data.dir=1
log.retention.hours=168
log.segment.bytes=1073741824

zookeeper.connect=localhost:2181
zookeeper.connection.timeout.ms=6000
```

Starting server

```
bin/kafka-server-start.sh config/server.properties
```

```
bin\windows\kafka-server-start.bat config/server.properties
```

Number of zookeepers

- Zookeeper cluster:
  - called ensemble
- Quorum
  - so odd number of Zookepers are preferred
  - better to keep <=7 Zookepers
- Writes to Zookeeper
  - changes membership of consumer groups
  - changes in Kafka cluster itself
  - pretty low frequency of changes (usually)
  - (+ commit offsets if configured)

How Zookeepers know about each other

- Common configuration
  - ID (small number)
  - peer port
  - leader port

Config

```
tickTime=2000
dataDir=/var/lib/zookeeper
clientPort=2181
initLimit=20
syncLimit=5
server.1=zoo1.example.com:2888:3888
server.2=zoo2.example.com:2888:3888
server.3=zoo3.example.com:2888:3888
```

- Each server `myid` file in `dataDir`
  - specifies unique ID

More brokers

- Configuration files
    - `config/server0.properties`
    - `config/server1.properties` etc.
- Rules
    - `broker.id` must be unique
    - `listeners` must have unique port numbers
    - `log.dirs` better to be different

Starting more brokers

- On one machine:

```
$ nohup bin/kafka-server-start.sh config/server1.properties &
$ nohup bin/kafka-server-start.sh config/server2.properties &
$ nohup bin/kafka-server-start.sh config/server3.properties &
```

```
bin\windows\kafka-server-start.bat config/server1.properties
bin\windows\kafka-server-start.bat config/server2.properties
bin\windows\kafka-server-start.bat config/server3.properties
```

CLI producers and consumers

- Stored in `bin` subdirectory
- Two scripts
    - `bin/kafka-console-producer.sh`
    - `bin/kafka-console-consumer.sh`

Other standard CLI tools

```
connect-distributed.sh
connect-mirror-maker.sh
connect-standalone.sh
kafka-acls.sh
kafka-broker-api-versions.sh
kafka-cluster.sh
kafka-configs.sh
kafka-consumer-groups.sh
```

```
kafka-consumer-perf-test.sh
kafka-delegation-tokens.sh
kafka-delete-records.sh
kafka-dump-log.sh
kafka-features.sh
kafka-get-offsets.sh
kafka-leader-election.sh
kafka-log-dirs.sh
kafka-metadata-quorum.sh
kafka-metadata-shell.sh
kafka-mirror-maker.sh
kafka-producer-perf-test.sh
kafka-reassign-partitions.sh
kafka-replica-verification.sh
kafka-run-class.sh
kafka-server-start.sh
kafka-server-stop.sh
kafka-storage.sh
kafka-streams-application-reset.sh
kafka-topics.sh
kafka-transactions.sh
kafka-verifiable-consumer.sh
kafka-verifiable-producer.sh
trogdor.sh
zookeeper-security-migration.sh
zookeeper-server-start.sh
zookeeper-server-stop.sh
zookeeper-shell.sh
```

Create topic with #partitions

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic topic3 --part
```

```
bin\windows\kafka-topics.bat --bootstrap-server localhost:9092 --create --topic topi
```

List all topics

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --list
```

```
bin\windows\kafka-topics.bat --bootstrap-server localhost:9092 --list
```

List all consumer groups

```
bin/kafka-consumer-groups.sh --bootstrap-server localhost:9092 --list
```

```
bin\windows\kafka-consumer-groups.bat --bootstrap-server localhost:9092 --list
```

Info about one group

```
bin/kafka-consumer-groups.sh --bootstrap-server localhost:9092 --group test-group --
```

```
bin\windows\kafka-consumer-groups.bat --bootstrap-server localhost:9092 --group test
```

Reset offsets

```
bin/kafka-consumer-groups.sh --reset-offsets --to-earliest --topic topic3 --execute
```

```
bin\windows\kafka-consumer-groups.bat --reset-offsets --to-earliest --topic topic3 -
```

Multiple consumers example #1

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic T3 --partitio
```

```
bin\windows\kafka-topics.bat --bootstrap-server localhost:9092 --create --topic T3 -
```

Multiple consumers example #2

```
bin/kafka-console-consumer.sh --bootstrap-server localhost:9092 --topic T3 --group G
bin/kafka-console-consumer.sh --bootstrap-server localhost:9092 --topic T3 --group G
bin/kafka-console-consumer.sh --bootstrap-server localhost:9092 --topic T3 --group G
```

```
bin\windows\kafka-console-consumer.bat --bootstrap-server localhost:9092 --topic T3
bin\windows\kafka-console-consumer.bat --bootstrap-server localhost:9092 --topic T3
bin\windows\kafka-console-consumer.bat --bootstrap-server localhost:9092 --topic T3
```

Multiple consumers example #3

```
bin/kafka-console-producer.sh --broker-list localhost:9092 --topic T3 --property par
```

```
bin\windows\kafka-console-producer.bat --broker-list localhost:9092 --topic T3 --prc
```

Multiple consumers example #4

```
bin/kafka-consumer-groups.sh --bootstrap-server localhost:9092 --group G3 --describe
```

```
bin\windows\kafka-consumer-groups.bat --bootstrap-server localhost:9092 --group G3 -
```

Partition replications

- Examples below expects 3 brokers to run
  - with different IDs
  - with different port
  - and with different log.dirs

Partition replications

- Topic with one partition that is replicated 3 times

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic test_topic_2

bin/kafka-topics.sh --bootstrap-server localhost:9092 --describe --topic test_topic_
```

- Topic with three partitions that are replicated

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic test_topic_3

bin/kafka-topics.sh --bootstrap-server localhost:9092 --describe --topic test_topic_
```

Partition replications

- Specify replica assignments

```
bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic test_topic_4

bin/kafka-topics.sh --bootstrap-server localhost:9092 --create --topic test_topic_5
```

kcli

- Topic, partitions and messages browser
- Works in console
- Windows + Linux
- https://github.com/cswank/kcli

Kafkacat (kcat)

- List topics

```
kafkacat -L -b localhost:9092
```

Kafkacat as producer

- Messages on standard input

```
kafkacat -P -b localhost:9092 -t "upload"
```

- Messages from files

```
kafkacat -P -b localhost:9092 -t filedrop -p 0 file1.bin file2.txt /etc/motd dalsi_s
```

Kafkacat as consumer

- Standard consumer for topic

```
kafkacat -C -b localhost:9092 -t "upload"
```

- Consumer mode
  - 1000 messages from topic topic1
  - does not wait for new messages

```
kafkacat -C -b localhost:9092 -t topic1 -p 0 -o -1000 -e
```

Kafkacat as consumer (2)

- Consumer mode for with consumer group spec.

```
kafkacat -b localhost:9092 -G skupina_konzumentů topic1
```

- Consumer for multiple topics

```
kafkacat -b localhost:9092 -G skupina_konzumentů téma1 téma2
```

Clients for Apache Kafka

- Supported languages/ecosystems
  - C/C++
  - Python
  - Go (AKA golang)
  - Erlang
  - PowerShell

    - .NET
    - Ruby
    - Node.js
    - Proxy (HTTP REST, etc)
    - Perl
    - stdin/stdout
    - PHP
    - Rust
    - Alternative Java
    - Storm
    - Scala DSL
    - Clojure
    - Swift

Client examples

- Examples for Python
- Examples for Go
- Examples for Java
- Examples for Clojure

Examples for Python

- Libraries used
    - kafka-python
    - confluent-kafka

```
pip3 install --user kafka-python
```

Messages producer

```
#!/usr/bin/env python3
```

```
from kafka import KafkaProducer
from time import sleep
from json import dumps

server = "localhost:9092"
topic = "upload"

print("Connecting to Kafka")
producer = KafkaProducer(
    bootstrap_servers=[server],
    value_serializer=lambda x: dumps(x).encode("utf-8")
)
print("Connected to Kafka")

for i in range(1000):
    data = {"counter": i}
    producer.send(topic, value=data)
    sleep(5)
```

Messages consumer

```
#!/usr/bin/env python3

import sys
from kafka import KafkaConsumer

server = "localhost:9092"
topic = "upload"
group_id = "group1"

print("Connecting to Kafka")
consumer = KafkaConsumer(
    topic, group_id=group_id,
    bootstrap_servers=[server],
    auto_offset_reset="earliest"
)
print("Connected to Kafka")

try:
    for message in consumer:
        print(
            "%s:%d:%d: key=%s value=%s"
            % (
                message.topic,
                message.partition,
                message.offset,
                message.key,
                message.value,
            )
        )
except KeyboardInterrupt:
    sys.exit()
```

Consumer with "replay" ability

```
#!/usr/bin/env python3

import sys
from kafka import KafkaConsumer, TopicPartition

server = 'localhost:9092'
topic = 'upload'
group_id = 'group1'

print('Connecting to Kafka')
consumer = KafkaConsumer(group_id=group_id,
                         bootstrap_servers=[server])
print('Connected to Kafka')

tp = TopicPartition(topic=topic, partition=0)
consumer.assign([tp])
consumer.seek(tp, 0)

try:
    for message in consumer:
        print("%s:%d:%d: key=%s value=%s" % (message.topic, message.partition, messa
except KeyboardInterrupt:
    sys.exit()
```

Examples for Go

- Two libraries can be used
  - Sarama
  - Confluent-kafka-go

Messages producer

```
package main

import (
        "log"

        "github.com/Shopify/sarama"
)

const (
        // KafkaConnectionString obsahuje jméno počítače a port, na kterém běží Kafk
        KafkaConnectionString = "localhost:9092"

        // KafkaTopic obsahuje jméno tématu
        KafkaTopic = "test-topic"
)

func main() {
        // konstrukce konzumenta
        producer, err := sarama.NewSyncProducer([]string{KafkaConnectionString}, nil

        // kontrola chyby při připojování ke Kafce
        if err != nil {
                log.Fatal(err)
        }

        log.Printf("Connected to %s", KafkaConnectionString)

        // zajištění uzavření připojení ke Kafce
        defer func() {
                if err := producer.Close(); err != nil {
                        log.Fatal(err)
                }
        }()

        // poslání (produkce) zprávy
        msg := &sarama.ProducerMessage{Topic: KafkaTopic, Value: sarama.StringEncode
        partition, offset, err := producer.SendMessage(msg)
        if err != nil {
                log.Printf("FAILED to send message: %s\n", err)
        } else {
                log.Printf("> message sent to partition %d at offset %d\n", partitio
        }

        log.Print("Done")
}
```

Messages consumer

```
package main

import (
        "log"

        "github.com/Shopify/sarama"
)

const (
        // KafkaConnectionString obsahuje jméno počítače a port, na kterém běží Kafk
        KafkaConnectionString = "localhost:9092"

        // KafkaTopic obsahuje jméno tématu
        KafkaTopic = "test-topic"
)

func main() {
        // konstrukce konzumenta
        consumer, err := sarama.NewConsumer([]string{KafkaConnectionString}, nil)

        // kontrola chyby při připojování ke Kafce
        if err != nil {
                log.Fatal(err)
        }

        log.Printf("Connected to %s", KafkaConnectionString)

        // zajištění uzavření připojení ke Kafce
        defer func() {
                if err := consumer.Close(); err != nil {
                        log.Fatal(err)
                }
        }()

        // přihlášení ke zvolenému tématu
        partitionConsumer, err := consumer.ConsumePartition(KafkaTopic, 0, sarama.Of
        if err != nil {
                log.Fatal(err)
        }

        // zajištění ukončení přihlášení ke zvolenému tématu
        defer func() {
                if err := partitionConsumer.Close(); err != nil {
                        log.Fatal(err)
                }
        }()

        // postupné čtení zpráv, které byly do zvoleného tématu publikovány
        consumed := 0
        for {
                msg := <-partitionConsumer.Messages()
                // vypíšeme pouze offset zprávy, její klíč a tělo (value, payload)
                log.Printf("Consumed message offset %d: %s:%s", msg.Offset, msg.Key,
                consumed++
        }
        // výpis počtu zpracovaných zpráv (ovšem sem se stejně nedostaneme :-)
        log.Printf("Consumed: %d", consumed)
        log.Print("Done")
}
```

Message producer (confluent-kafka)

```
package main

import (
        "fmt"
        "gopkg.in/confluentinc/confluent-kafka-go.v1/kafka"
)

const (
        server   = "localhost:9092"
        topic    = "upload"
        group_id = "group1"
)

func main() {
        consumer, err := kafka.NewConsumer(&kafka.ConfigMap{
                "bootstrap.servers": server,
                "group.id":          group_id,
                "auto.offset.reset": "earliest",
        })
        defer consumer.Close()

        if err != nil {
                panic(err)
        }

        consumer.SubscribeTopics([]string{topic}, nil)

        for {
                message, err := consumer.ReadMessage(-1)
                if err == nil {
                        fmt.Printf("Message on %s: %s %s\n", message.TopicPartition,
                } else {
                        fmt.Printf("Consumer error: %v (%v)\n", err, message)
                }
        }
}
```

Message consumer (confluent-kafka)

```go
package main

import (
        "fmt"
        "gopkg.in/confluentinc/confluent-kafka-go.v1/kafka"
)

const (
        server   = "localhost:9092"
        topic    = "upload"
        group_id = "group1"
)

func main() {
        consumer, err := kafka.NewConsumer(&kafka.ConfigMap{
                "bootstrap.servers": server,
                "group.id":          group_id,
                "auto.offset.reset": "earliest",
        })
        defer consumer.Close()

        if err != nil {
                panic(err)
        }

        consumer.SubscribeTopics([]string{topic}, nil)

        for {
                message, err := consumer.ReadMessage(-1)
                if err == nil {
                        fmt.Printf("Message on %s: %s %s\n", message.TopicPartition,
                } else {
                        fmt.Printf("Consumer error: %v (%v)\n", err, message)
                }
        }
}
```

Examples for Java

Messages producer

```java
import java.util.Properties;

import org.apache.kafka.clients.producer.KafkaProducer;
import org.apache.kafka.clients.producer.ProducerConfig;
import org.apache.kafka.clients.producer.ProducerRecord;
import org.apache.kafka.common.serialization.StringSerializer;

public class SimpleProducer {
    public static void main(String args[])
    {
        String bootstrapServers="127.0.0.1:9092";
        Properties properties=new Properties();
        properties.setProperty(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, bootstrapSer
        properties.setProperty(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, StringSer
        properties.setProperty(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringS

        KafkaProducer<String,String> producer = new KafkaProducer<String, String>(pr

        ProducerRecord<String, String> record = new ProducerRecord<String, String>('
        producer.send(record);
        producer.flush();
        producer.close();
    }
}
```

Compilation and running

```
javac -cp kafka_2.12-3.3.2/libs/kafka-clients-3.3.2.jar SimpleProducer.java
```

```
java -cp .:kafka_2.12-3.3.2/libs/kafka-clients-3.3.2.jar:kafka_2.12-3.3.2/libs/slf4j
```

Messages consumer

```java
import java.util.Arrays;
import java.time.Duration;
import java.util.Properties;

import org.apache.kafka.clients.consumer.KafkaConsumer;
import org.apache.kafka.clients.consumer.ConsumerConfig;
import org.apache.kafka.clients.consumer.ConsumerRecord;
import org.apache.kafka.clients.consumer.ConsumerRecords;
import org.apache.kafka.common.serialization.StringDeserializer;

public class SimpleConsumer {
    public static void main(String args[])
    {
        String bootstrapServers="127.0.0.1:9092";
        String group_id="my_consumer_group";
        String topic="topic";

        Properties properties=new Properties();
        properties.setProperty(ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG, bootstrapSer
        properties.setProperty(ConsumerConfig.GROUP_ID_CONFIG, group_id);
        properties.setProperty(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG, StringD
        properties.setProperty(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG, Strin
        properties.setProperty(ConsumerConfig.AUTO_OFFSET_RESET_CONFIG, "earliest");

        KafkaConsumer<String,String> consumer= new KafkaConsumer<String,String>(prop
        consumer.subscribe(Arrays.asList(topic));

        while(true) {
            ConsumerRecords<String,String> records=consumer.poll(Duration.ofMillis(1
            for(ConsumerRecord<String,String> record: records){
                System.out.println("Key: "+ record.key() + ", Value:" +record.value(
                System.out.println("Partition:" + record.partition()+",Offset:"+reco
            }
        }
    }
}
```

Compilation and running

```
javac -cp kafka_2.12-3.3.2/libs/kafka-clients-3.3.2.jar SimpleConsumer.java
```

```
java -cp .:kafka_2.12-3.3.2/libs/kafka-clients-3.3.2.jar:kafka_2.12-3.3.2/libs/slf4j
```

```
javac -cp kafka_2.12-3.3.2\libs\kafka-clients-3.3.2.jar SimpleConsumer.java
```

```
java -cp .;kafka_2.12-3.3.2\libs\kafka-clients-3.3.2.jar;kafka_2.12-3.3.2\libs\slf4j
```

Examples for Clojure

Messages producer

```
(ns produce-messages-2.core
  (:require [jackdaw.client :as jc]
            [clojure.pprint :as pp]))

(def producer-config
  {"bootstrap.servers" "localhost:9092"
   "key.serializer" "org.apache.kafka.common.serialization.StringSerializer"
   "value.serializer" "org.apache.kafka.common.serialization.StringSerializer"
   "acks" "all"
   "client.id" "foo"})

(defn -main
  [& args]
  (with-open [producer (jc/producer producer-config)]
    (doseq [i (range 1 101)]
      (let [key (str i)
            value (str "Message #" i)]
        (println "Publishing message with key '" key "' and value '" value "'")
        (let [record-metadata (jc/produce! producer {:topic-name "test2"} key value)
          (pp/pprint @record-metadata))
      )))
```

Messages consumer

```
(ns consume-messages-1.core
  (:require [jackdaw.client :as jc]
            [jackdaw.client.log :as jl]
            [clojure.pprint :as pp]))

(def consumer-config
  {"bootstrap.servers" "localhost:9092"
   "key.deserializer" "org.apache.kafka.common.serialization.StringDeserializer"
   "value.deserializer" "org.apache.kafka.common.serialization.StringDeserializer"
   "group.id"  "group-A"})

(defn -main
  [& args]
  (with-open [consumer (-> (jc/consumer consumer-config)
                           (jc/subscribe [{:topic-name "test1"}]))]
    (doseq [{:keys [key value partition timestamp offset]} (jl/log consumer 10)]
      (println "key: " key)
      (println "value: " value)
      (println "partition: " partition)
      (println "timestamp: " timestamp)
      (println "offset: " offset))))
```

Kafka connect

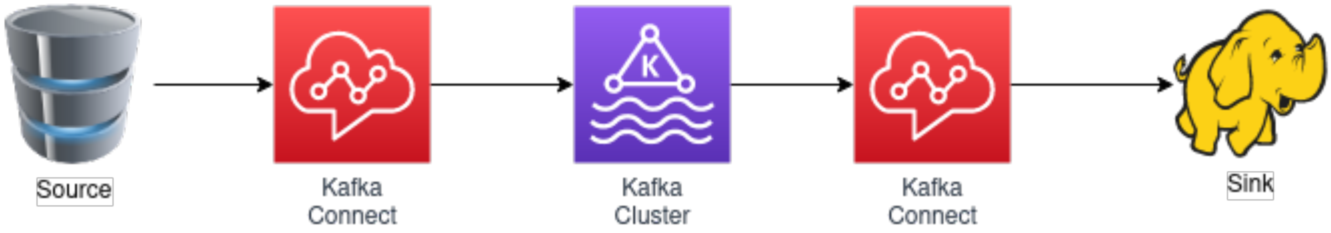
- "Distributed scalable framework"
- Automatic consuming or producing data
    - with data persistence in-between
- Part of Apache Kafka
- Just configuration files
- And connectors

Kafka Connect components

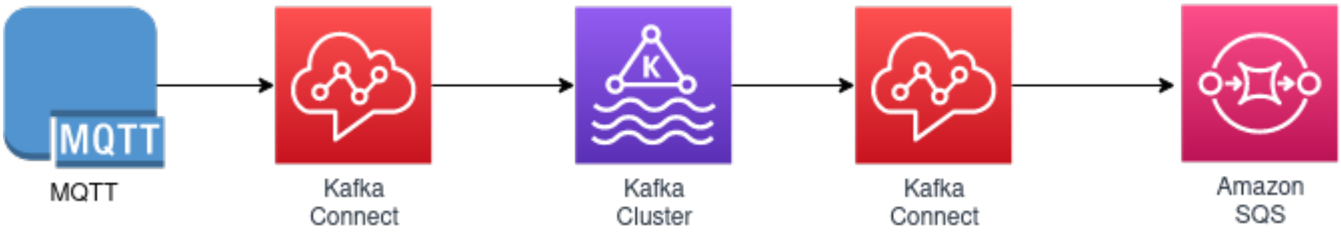
- Sources
- Kafka Cluster
- Sinks

Kafka Connect use cases

Moving data from one DB to another one

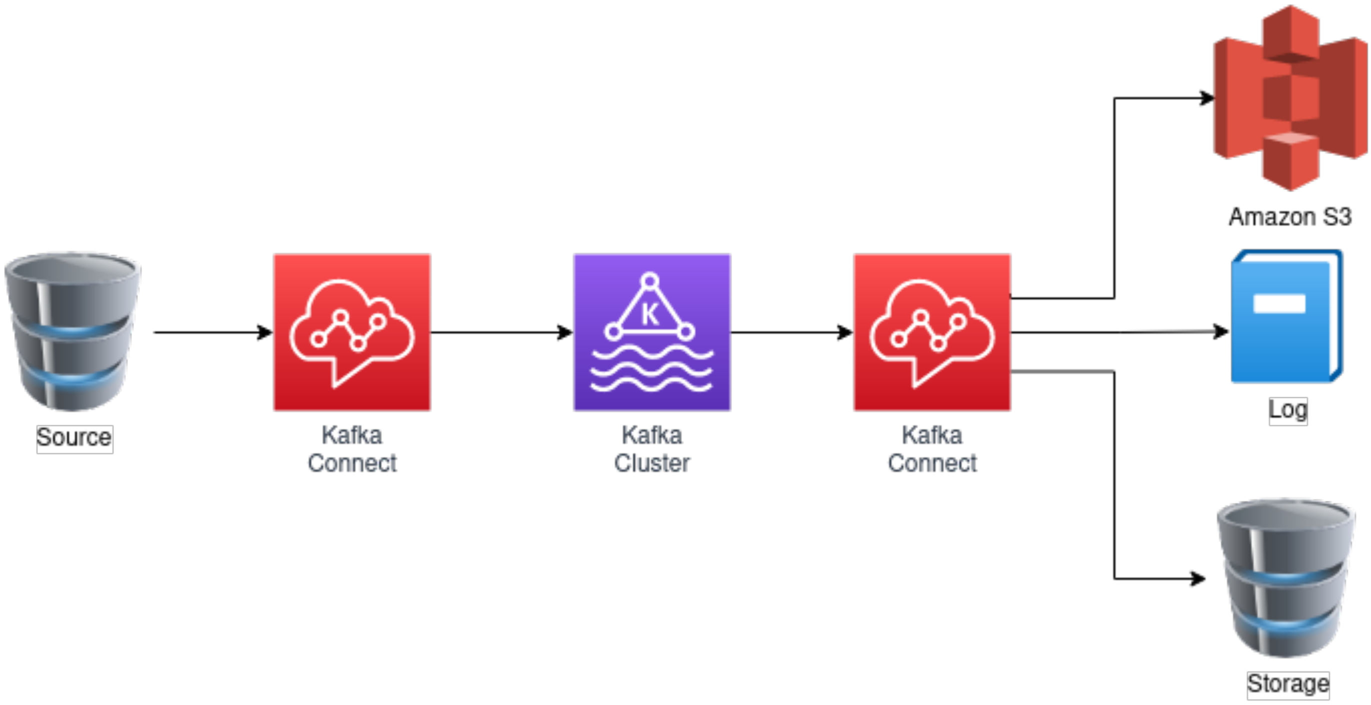


Connection between MQTT and AWS SQS



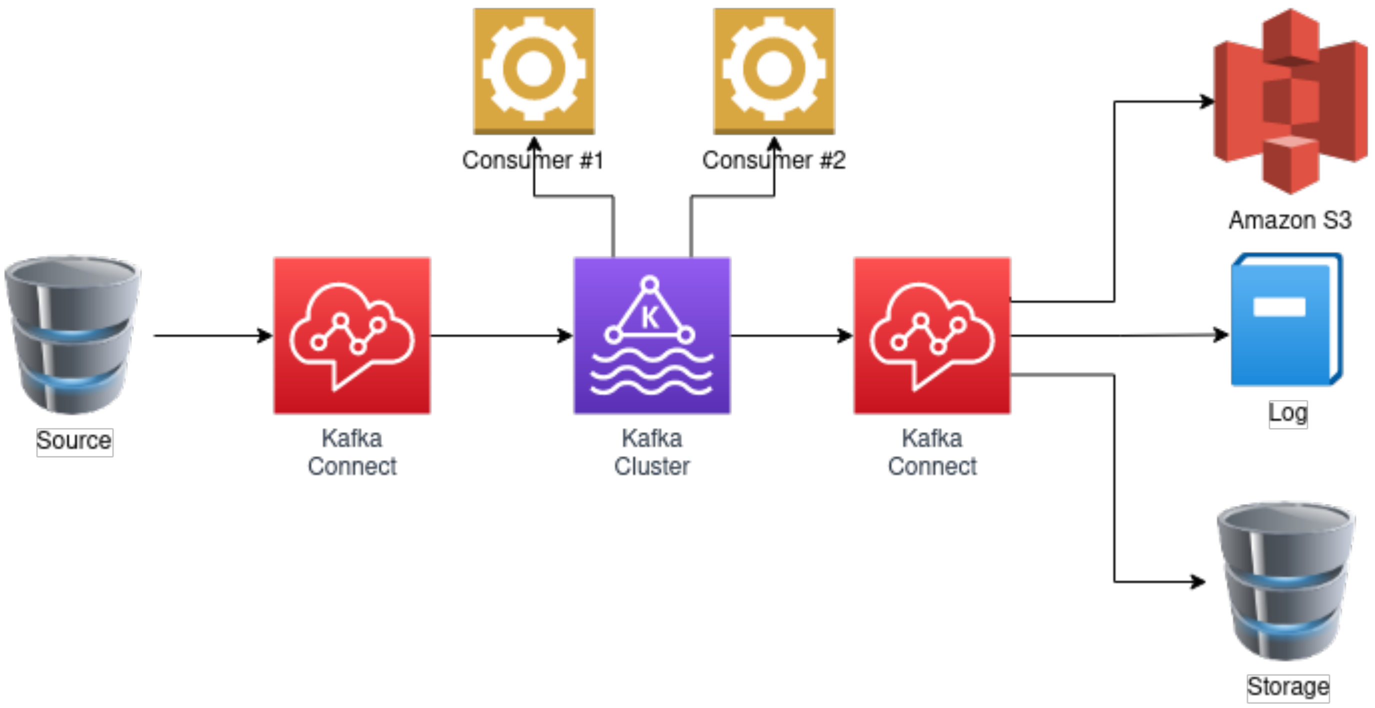
From one source to various sinks

- Amazon S3
- Logs
- Storage (database)



Custom consumers are possible

- Amazon S3
- Logs
- Storage (database)
- And bunch of custom consumers



Kafka Connect from developers PoV

- Is separate process
- It requires no programming
  - failures handling
  - logging
  - monitoring
  - scaling
  - migrating
  - sec. handling etc.

Kafka Connect from developers PoV (cont.)

- Lightweight data transformations
- Sometimes defined by one simple property file

Simple file sink

- Connector that read all messages from selected topic
- Such messages are written into selected text file

  - line by line

Configuration file

```
name=local-file-sink
connector.class=FileStreamSink
tasks.max=1
file=test.sink.txt
topics=connect-test-1
key.converter=org.apache.kafka.connect.storage.StringConverter
value.converter=org.apache.kafka.connect.storage.StringConverter
key.converter.schemas.enable=false
value.converter.schemas.enable=false
```

Use the connector

- Starting

```
cd kafka/kafka_2.12-3.3.2/
bin/connect-standalone.sh config/connect-standalone.properties config/connect-file-s
```

```
cd kafka\kafka_2.12-3.3.2\
bin\windows\connect-standalone.bat config\connect-standalone.properties config\conne
```

Use the connector (Linux)

- Producing messages

```
bin/kafka-console-producer.sh --broker-list localhost:9092 --topic connect-test-1
```

- Key+value

```
bin/kafka-console-producer.sh --broker-list localhost:9092 --topic connect-test-1 -p
```

Use the connector (Windows)

- Producing messages

```
bin\windows\kafka-console-producer.bat --broker-list localhost:9092 --topic connect-
```

- Key+value

```
bin\windows\kafka-console-producer.bat --broker-list localhost:9092 --topic connect-
```

Messages in JSON format

- Common requirement

```
name=local-file-sink
connector.class=FileStreamSink
tasks.max=1
file=test.sink.txt
topics=connect-test-1
key.converter=org.apache.kafka.connect.json.JsonConverter
value.converter=org.apache.kafka.connect.json.JsonConverter
key.converter.schemas.enable=false
value.converter.schemas.enable=false
```

Handling messages with improper format

- Stop the connector
- Ignore incorrect message
- Send incorrect message into DLQ
  - dead letter queue
  - pretty common approach in message brokers world

Stop the connector

- We already know how to do it

Ignore incorrect message

- property named `errors.tolerance`

```
name=local-file-sink-json
connector.class=FileStreamSink
tasks.max=1
file=test.sink3.jsons
topics=connect-test-json
key.converter=org.apache.kafka.connect.json.JsonConverter
value.converter=org.apache.kafka.connect.json.JsonConverter
key.converter.schemas.enable=false
value.converter.schemas.enable=false
errors.tolerance=all
```

Send incorrect message into DLQ

```
name=local-file-sink-json
connector.class=FileStreamSink
tasks.max=1
file=test.sink4.jsons
topics=connect-test-json
key.converter=org.apache.kafka.connect.json.JsonConverter
value.converter=org.apache.kafka.connect.json.JsonConverter
key.converter.schemas.enable=false
value.converter.schemas.enable=false
errors.tolerance=all
errors.deadletterqueue.topic.name=dlq_bad_jsons
errors.deadletterqueue.topic.replication.factor=1
```

Retrieve incorrect messages

- Using standard tools

```
bin/kafka-console-consumer.sh  --bootstrap-server localhost:9092 --topic dlq_bad_jso
```

```
bin\windows\kafka-console-consumer.bat  --bootstrap-server localhost:9092 --topic dl
```

- Using *Kafkacat*

```
kafkacat -b localhost:9092 -t dlq_bad_jsons -C
```

JDBC-based sink

```
name=db-sink
connector.class=io.confluent.connect.jdbc.JdbcSinkConnector
tasks.max=1
topics=connect-test-3
key.converter=org.apache.kafka.connect.json.JsonConverter
value.converter=org.apache.kafka.connect.json.JsonConverter
key.converter.schemas.enable=true
value.converter.schemas.enable=true
connection.url=jdbc:postgresql://localhost:5432/kafka_sink?user=postgres&password=po
auto.create=true
delete.enabled=false
```

JDBC-based sink

- It will work
- But it will use table named `connect-test-3`
  - a bit problematic

JDBC-based sink

```
name=db-sink
connector.class=io.confluent.connect.jdbc.JdbcSinkConnector
tasks.max=1
topics=test_table
key.converter=org.apache.kafka.connect.json.JsonConverter
value.converter=org.apache.kafka.connect.json.JsonConverter
key.converter.schemas.enable=true
value.converter.schemas.enable=true
connection.url=jdbc:postgresql://localhost:5432/kafka_sink?user=postgres&password=po
auto.create=true
delete.enabled=false
```

Monitoring

- JMX
- Prometheus metrics

JMX

- Java Management Extensions
- Standard in Java world for a long time
- Ability to monitor **any** JVM-based application
- Metrics etc. available through *MBeans*
- Standard tool named **jconsole**

(example of **jconsole** usage)

Simple example of custom MBeans

MBean definition via interface named `xxxMBean` :

```
public interface StatusMBean {
    Integer getAnswer();
    String getProgramName();
    Boolean getSwitchStatus();
}
```

Interface implementation:

```
public class Status implements StatusMBean {
   private Integer answer;
   private String programName;
   private Boolean switchStatus;

   public Status(String programName) {
       this.answer = 42;
       this.programName = programName;
       this.switchStatus = false;
   }
```

Interface implementation (cont.):

- getters
- setters

```
   @Override
   public Integer getAnswer() {
       return this.answer;
   }

   @Override
   public String getProgramName() {
       return this.programName;
   }

   @Override
   public Boolean getSwitchStatus() {
       return switchStatus;
   }
}
```

MBean export

```
import java.util.Scanner;

import javax.management.*;
import java.lang.management.ManagementFactory;

public class Main {
   public static void main(String[] args) {
       try {
           String programName = (args.length == 0) ? "foobar" : args[0];

           StatusMBean systemStatus = new Status(programName);

           MBeanServer platformMBeanServer = ManagementFactory.getPlatformMBeanServe
           ObjectName objectName = new ObjectName("cz.amend.app:name=StatusExample")
           platformMBeanServer.registerMBean(systemStatus, objectName);

       } catch (Exception e) {
           e.printStackTrace();
       }

       new Scanner(System.in).nextLine();
   }
}
```

Example of jconsole usage

(live)

JMX can be used to *control* applications as well

- MBean definition via interface named `xxxMBean` :

```
public interface StatusMBean {
    Integer getAnswer();
    Long    getCounter();
    String  getProgramName();
    Boolean getSwitchStatus();
    void    setSwitchStatus(Boolean newStatus);
    void    flipSwitchStatus();
}
```

Interface implementation

```
public class Status implements StatusMBean {
   private Integer answer;
   private String programName;
   private Boolean switchStatus;
   private Long counter;

   public Status(String programName) {
       this.answer = 42;
       this.programName = programName;
       this.switchStatus = false;
       this.counter = 0L;
   }

   @Override
   public Integer getAnswer() {
       return this.answer;
   }

   @Override
   public Long getCounter() {
       this.counter++;
       return this.counter;
   }

   @Override
   public String getProgramName() {
       return this.programName;
   }

   @Override
   public Boolean getSwitchStatus() {
       return switchStatus;
   }
   @Override
   public void setSwitchStatus(Boolean newStatus) {
       this.switchStatus = newStatus;
   }

   @Override
   public void flipSwitchStatus() {
       System.out.println("Flip switch status called!");
       this.switchStatus = !this.switchStatus;
   }
}
```

MBean export

```
import java.util.Scanner;

import javax.management.*;
import java.lang.management.ManagementFactory;

public class Main {
   public static void main(String[] args) {
       try {
           String programName = (args.length == 0) ? "foobar" : args[0];

           StatusMBean systemStatus = new Status(programName);

           MBeanServer platformMBeanServer = ManagementFactory.getPlatformMBeanServe
           ObjectName objectName = new ObjectName("cz.amend.app:name=StatusExample")
           platformMBeanServer.registerMBean(systemStatus, objectName);

       } catch (Exception e) {
           e.printStackTrace();
       }

       new Scanner(System.in).nextLine();
   }
}
```

(example of **jconsole** usage)

JMX Exporter

- Tool to provide metrics via Prometheus-like HTTP responses

- Used as `agent` for JVM

JMX exporter setup and usage

- Setup

```
wget https://repo1.maven.org/maven2/io/prometheus/jmx/jmx_prometheus_javaagent/0.15.
touch config.yaml
```

- Usage

```
java -javaagent:./jmx_prometheus_javaagent-0.15.0.jar=8080:config.yaml Main
```

- Getting metrics

```
curl localhost:8080/metrics
```

JMX Exporter setup for Kafka broker

```
if [ $# -lt 1 ];
then
    echo "USAGE: $0 [-daemon] server.properties [--override property=value]*"
    exit 1
fi
base_dir=$(dirname $0)

if [ "x$KAFKA_LOG4J_OPTS" = "x" ]; then
    export KAFKA_LOG4J_OPTS="-Dlog4j.configuration=file:$base_dir/../config/log4j.pr
fi

if [ "x$KAFKA_HEAP_OPTS" = "x" ]; then
    export KAFKA_HEAP_OPTS="-Xmx1G -Xms1G"
fi

EXTRA_ARGS=${EXTRA_ARGS-'-name kafkaServer -loggc'}

COMMAND=$1
case $COMMAND in
  -daemon)
    EXTRA_ARGS="-daemon "$EXTRA_ARGS
    shift
    ;;
  *)
    ;;
esac

export KAFKA_OPTS=' -javaagent:jmx_prometheus_javaagent-0.15.0.jar=9999:./config/kaf

exec $base_dir/kafka-run-class.sh $EXTRA_ARGS kafka.Kafka "$@"
```

Kafka metrics

- Kafka server (broker) metrics
- Producer metrics
- Consumer metrics
- ZooKeeper metrics
- JVM-related metrics

Kafka server (broker) metrics

```
UnderReplicatedPartitions         kafka.server:type=ReplicaManager,name=UnderReplica
IsrShrinksPerSec/IsrExpandsPerSec kafka.server:type=ReplicaManager,name=IsrShrinksPe
ActiveControllerCount             kafka.controller:type=KafkaController,name=ActiveC
OfflinePartitionsCount            kafka.controller:type=KafkaController,name=Offline
LeaderElectionRateAndTimeMs       kafka.controller:type=ControllerStats,name=LeaderE
UncleanLeaderElectionsPerSec      kafka.controller:type=ControllerStats,name=Unclear
TotalTimeMs                       kafka.network:type=RequestMetrics,name=TotalTimeMs
PurgatorySize                     kafka.server:type=DelayedOperationPurgatory,name=F
BytesInPerSec/BytesOutPerSec      kafka.server:type=BrokerTopicMetrics,name={BytesIr
RequestsPerSecond                 kafka.network:type=RequestMetrics,name=RequestsPer
```

Producer metrics

```
compression-rate-avg    kafka.producer:type=producer-metrics,client-id=([-.w]+)
response-rate           kafka.producer:type=producer-metrics,client-id=([-.w]+)
request-rate            kafka.producer:type=producer-metrics,client-id=([-.w]+)
request-latency-avg     kafka.producer:type=producer-metrics,client-id=([-.w]+)
outgoing-byte-rate      kafka.producer:type=producer-metrics,client-id=([-.w]+)
io-wait-time-ns-avg     kafka.producer:type=producer-metrics,client-id=([-.w]+)
batch-size-avg          kafka.producer:type=producer-metrics,client-id=([-.w]+)
```

Consumer metrics

```
records-lag             kafka.consumer:type=consumer-fetch-manager-metrics,client-id
records-lag-max         kafka.consumer:type=consumer-fetch-manager-metrics,client-id
                        kafka.consumer:type=consumer-fetch-manager-metrics,client-id
bytes-consumed-rate     kafka.consumer:type=consumer-fetch-manager-metrics,client-id
                        kafka.consumer:type=consumer-fetch-manager-metrics,client-id
records-consumed-rate   kafka.consumer:type=consumer-fetch-manager-metrics,client-id
                        kafka.consumer:type=consumer-fetch-manager-metrics,client-id
fetch-rate              kafka.consumer:type=consumer-fetch-manager-metrics,client_id
```

ZooKeeper metrics

```
outstanding_requests        Number of requests queued
avg_latency                 Amount of time it takes to respond to a client
num_alive_connections       Number of clients connected to ZooKeeper
followers                   Number of active followers
pending_syncs               Number of pending syncs from followers
open_file_descriptor_count  Number of file descriptors in use
```

JVM-related metrics

```
CollectionCount             java.lang:type=GarbageCollector,name=G1 (Young|Old) Gene
CollectionTime              java.lang:type=GarbageCollector,name=G1 (Young|Old) Gene
```

Useful links 1/2

1. Getter and Setter in Java
2. Enterprise Integration Patterns
3. Apache Kafka vs. Middleware (MQ, ETL, ESB) – Slides + Video
4. Discover Kafka® connectors and more
5. JDBC Connector (Source and Sink)
6. From Zero to Hero with Kafka Connect by Robin Moffatt
7. Apache Kafka Queue 101: Messaging Made Easy
8. What is Apache Kafka?

Useful links 2/2

1. Kafka Is Not A Queue
2. Sharding Kafka for Increased Scale and Reliability
3. Kafka clients