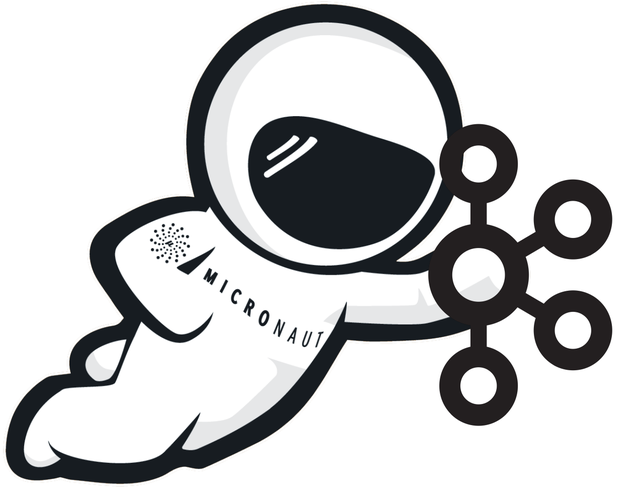
APACHECON

OBJECT COMPUTING
HOME TO GRAILS & MICRONAUT

Event-Driven Microservices With Apache Kafka and Micronaut

Zachary Klein, Principal Software Engineer, 2GM Team



kafka

About me

- Zachary Klein - Developer & Architect
- Principal Software Engineer at Object Computing, Inc
- 12+ years of software development experience
- OSS contributor
- Training instructor

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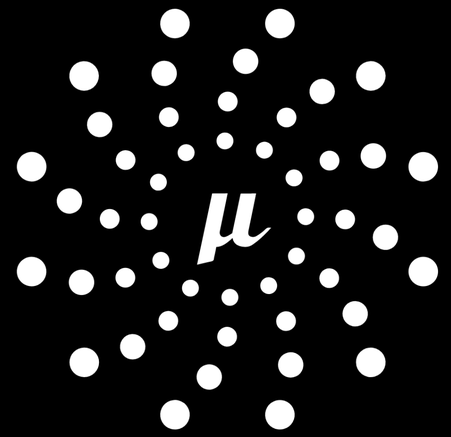
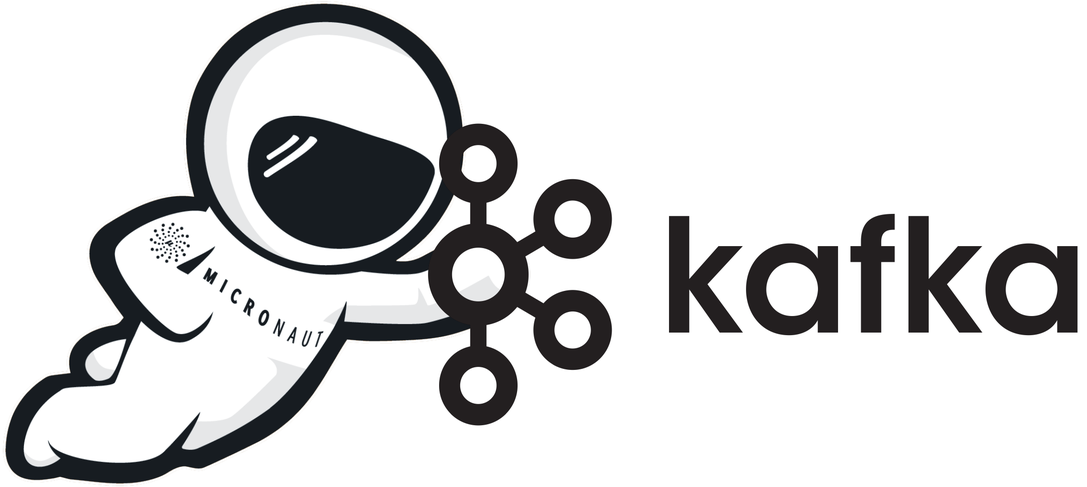


MICRONAUT®

A modern, JVM-based, full-stack framework for building modular,
easily testable microservice and serverless applications.

Agenda

- Introduce Event-Driven Architecture
- Introduce Apache Kafka
- Introduce Micronaut
- Building Event-Driven Microservices using Micronaut Kafka

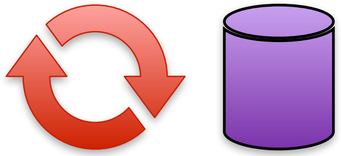


What is **Event-Driven** Architecture?

1. Event Notification

2. State Transfer 

3. Event Sourcing 

4. CQRS* 

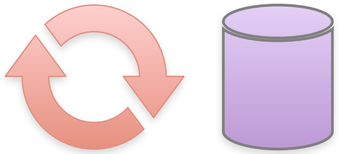
* Command & Query Responsibility Segregation

What is **Event-Driven** Architecture?

1. Event Notification

2. State Transfer 

3. Event Sourcing 

4. CQRS* 

* Command & Query Responsibility Segregation

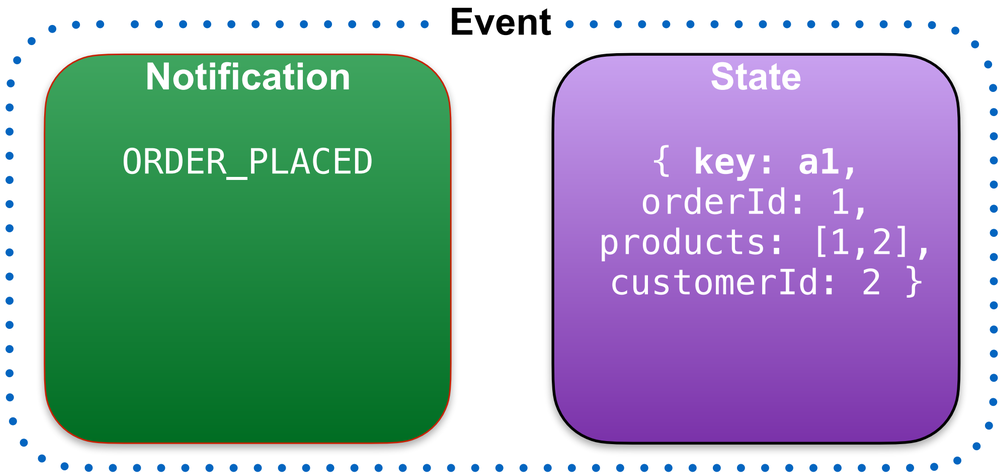
Event-Driven architecture: Key points

- Events are the Source of Truth
- Event-modeling: define the “shape” of you data
  - Schemas (e.g, with Apache Avro)
- Single-Writer Principle: Only one service writes to a given topic, N service[s] read from it
- Event-Driven does not equal No Database

What is Apache Kafka?

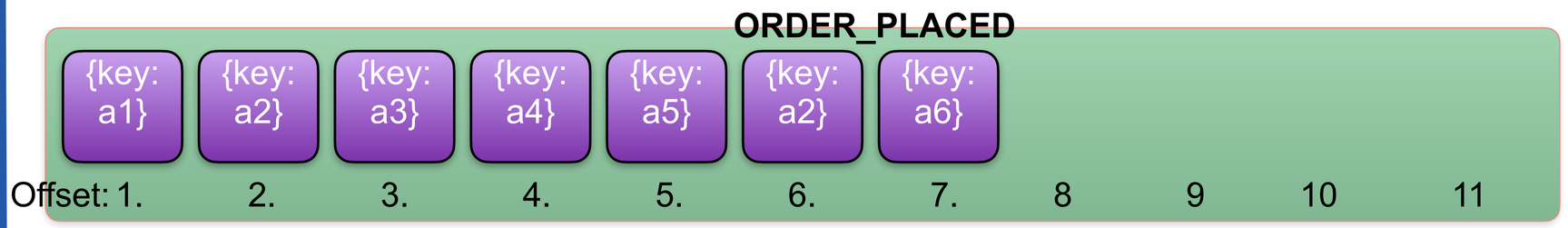
- Event-Streaming Platform
- Based on the concept of a **commit log**
  - Immutable
  - Persistent
  - Divided by “topics”
  - Partitioned
  - Events (log entries) are optionally keyed

What is an Event?

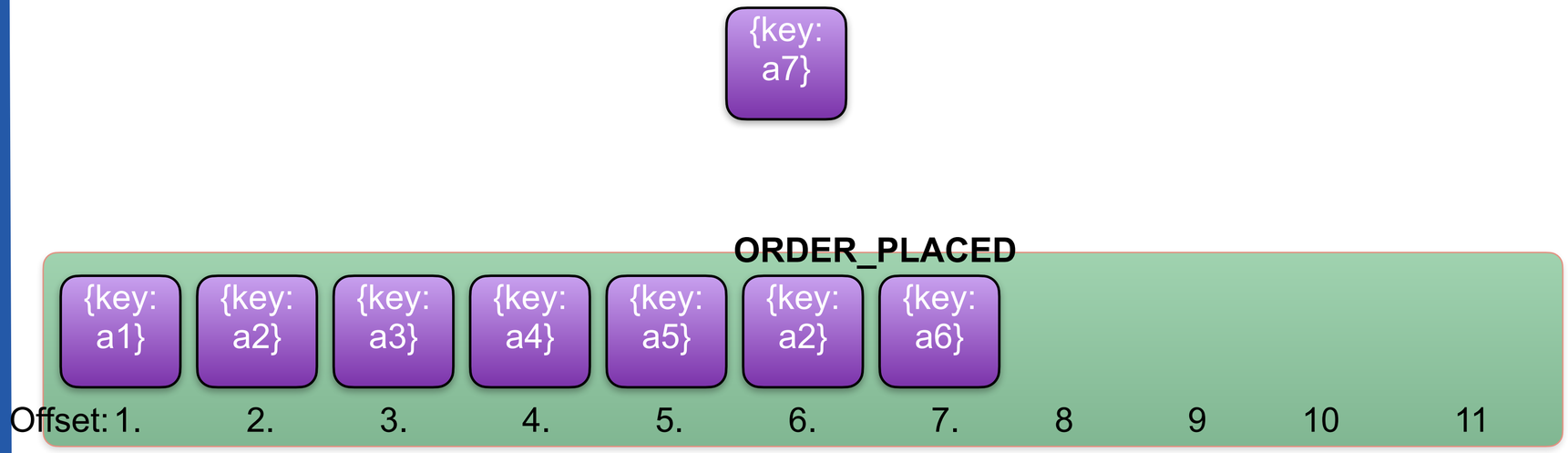


What is a Topic?

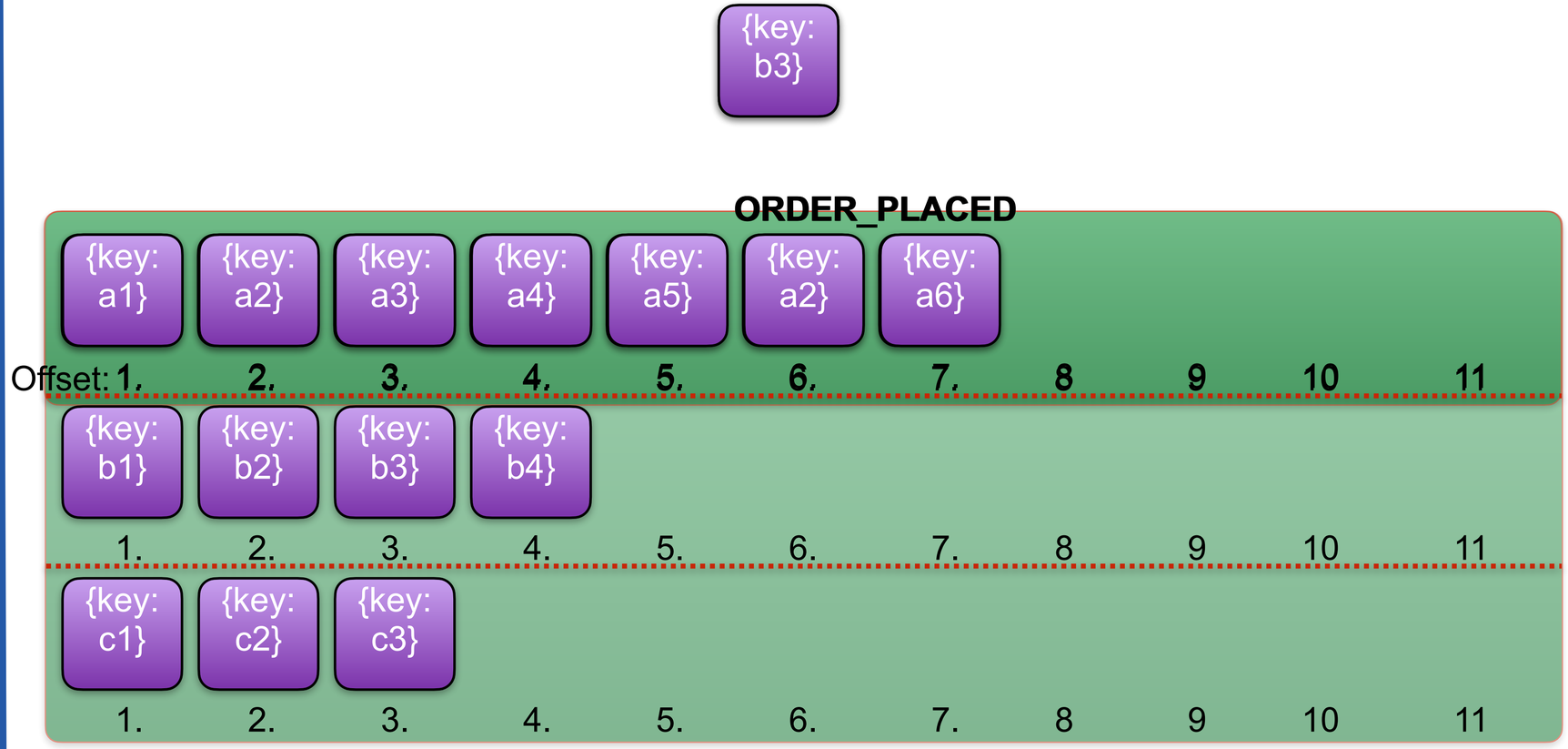
- Topics are persistent queues
- Events in the topic have an **offset**
- Events can be read from the topic in multiple modes - latest, all events from the beginning, batches, and even queried (e.g, using ksqlDB)



Adding an event to a topic

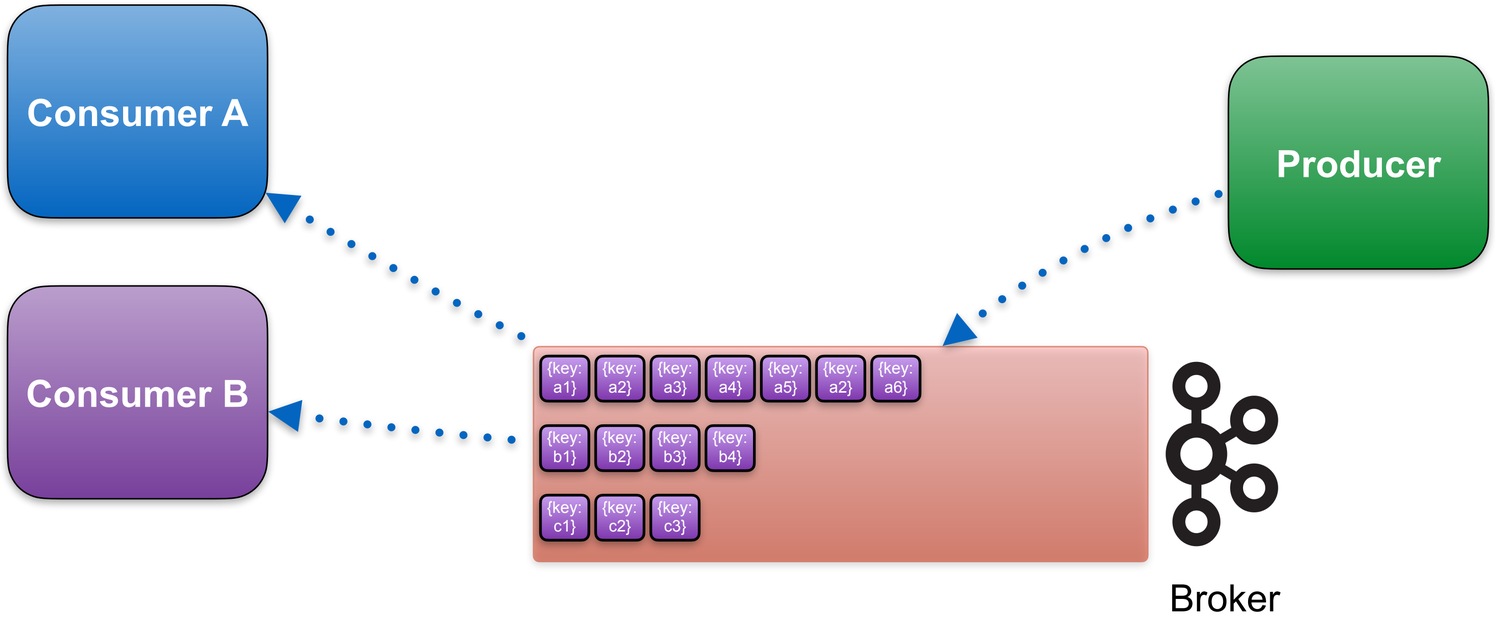


Topic partitions

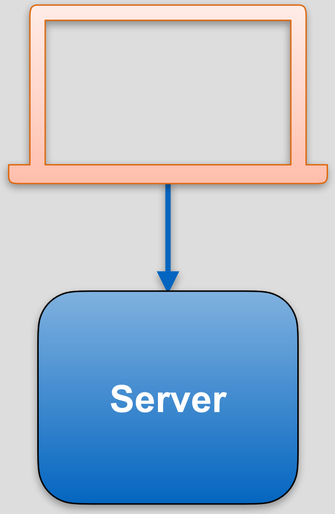


Producers and Consumers

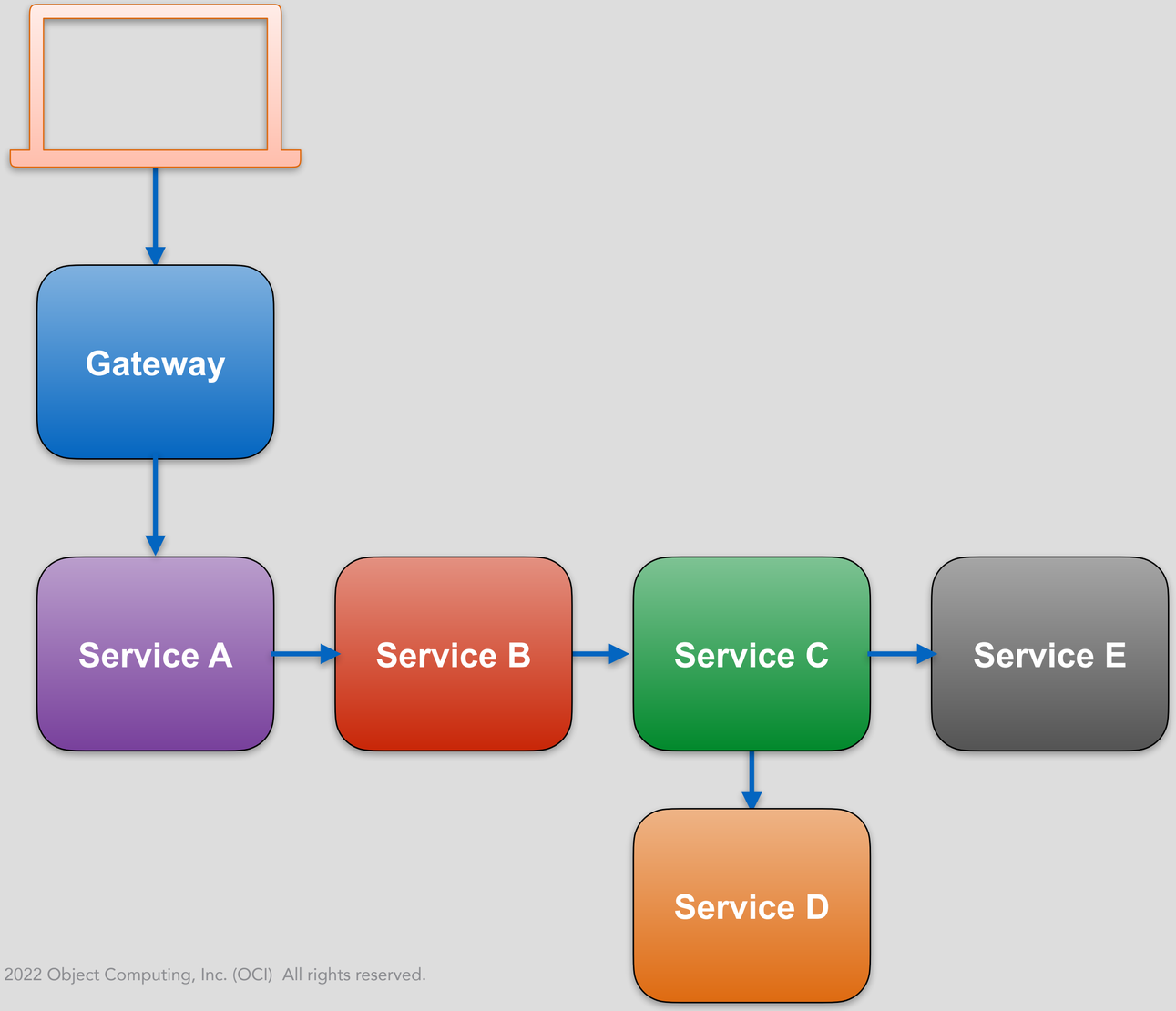
- Producers write events **to** topic/s
- Consumers read events **from** topics
- Events are read sequentially



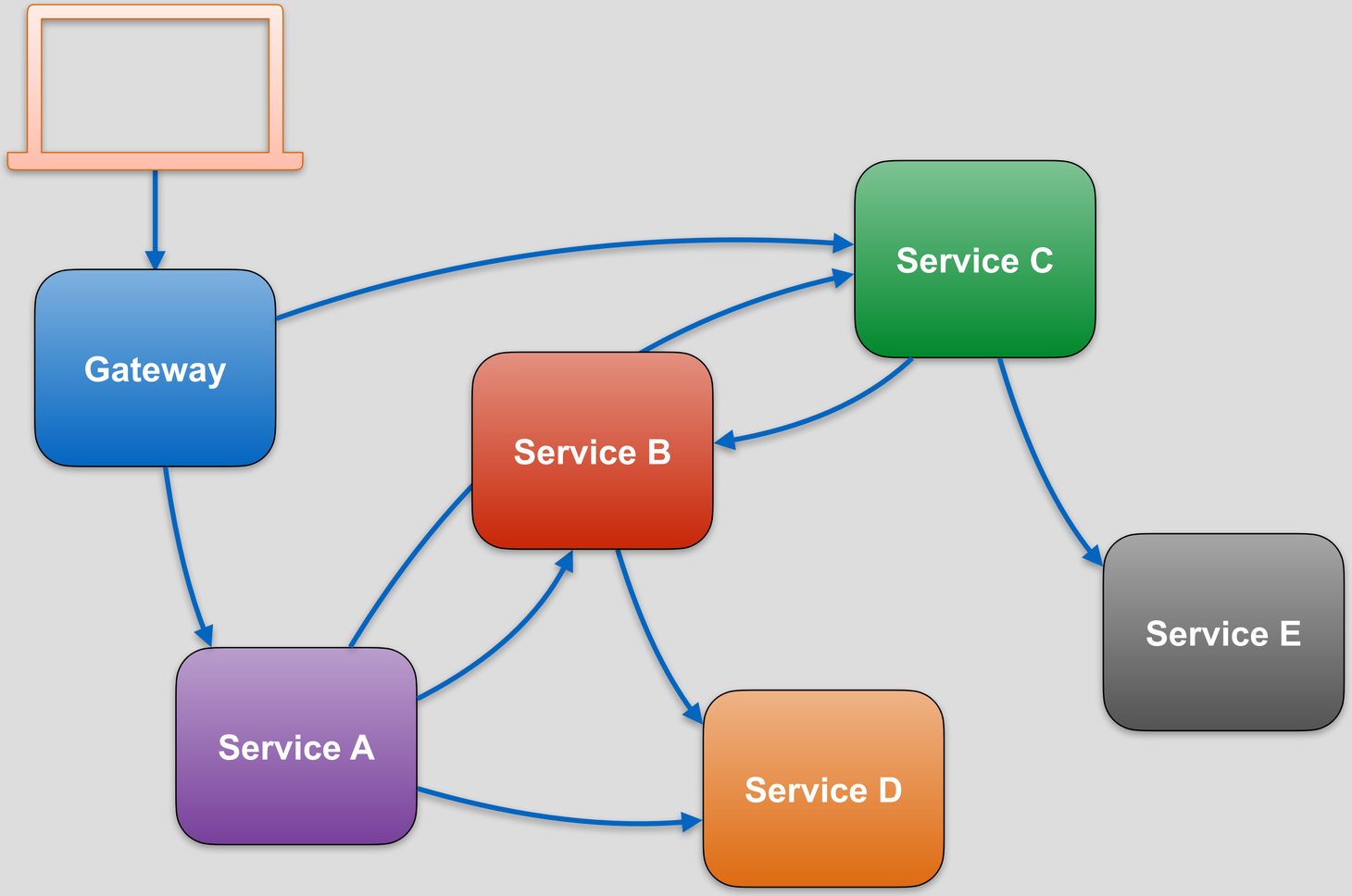
Inter-Service Communication



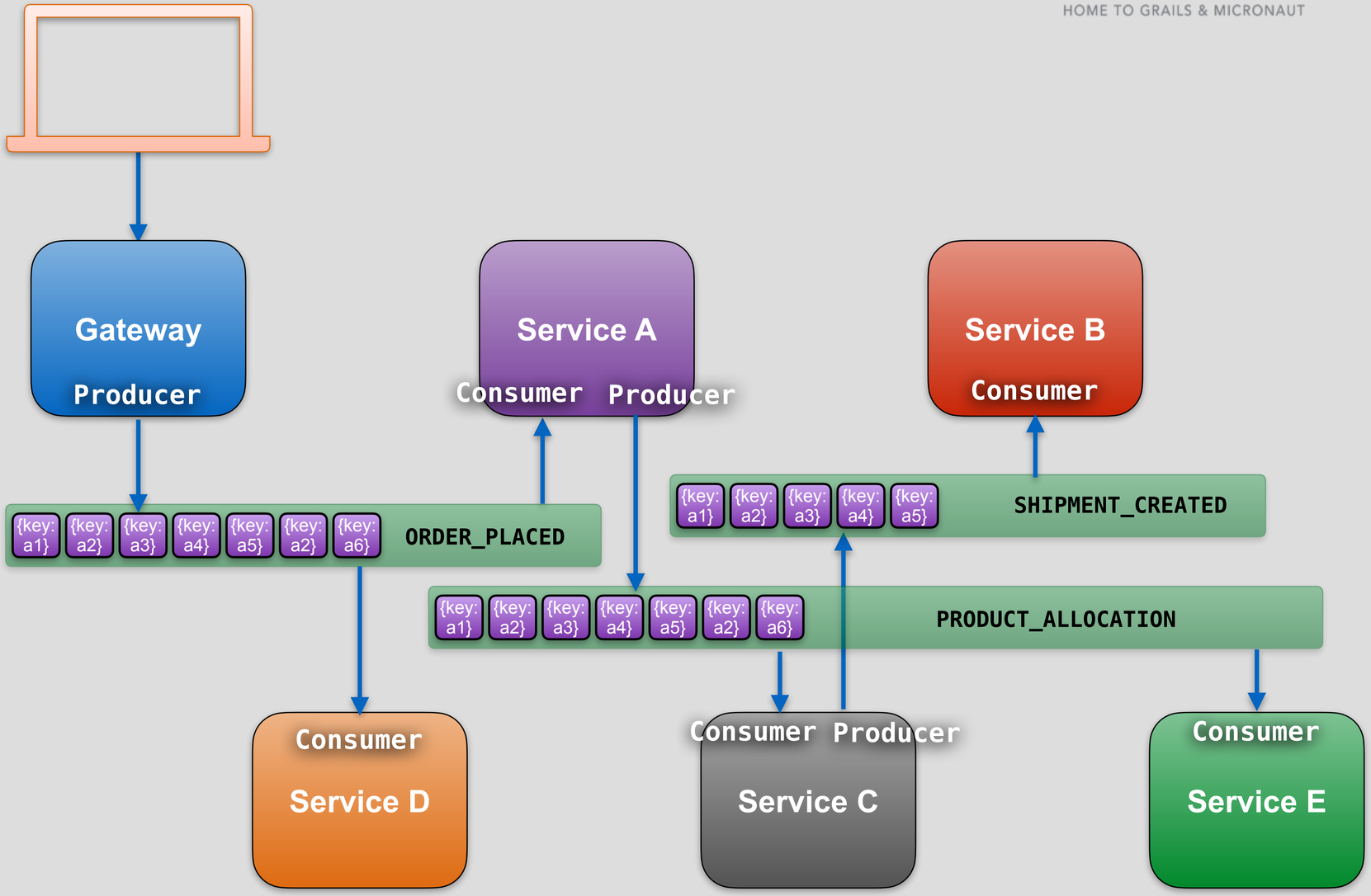
Inter-Service Communication



Inter-Service Communication

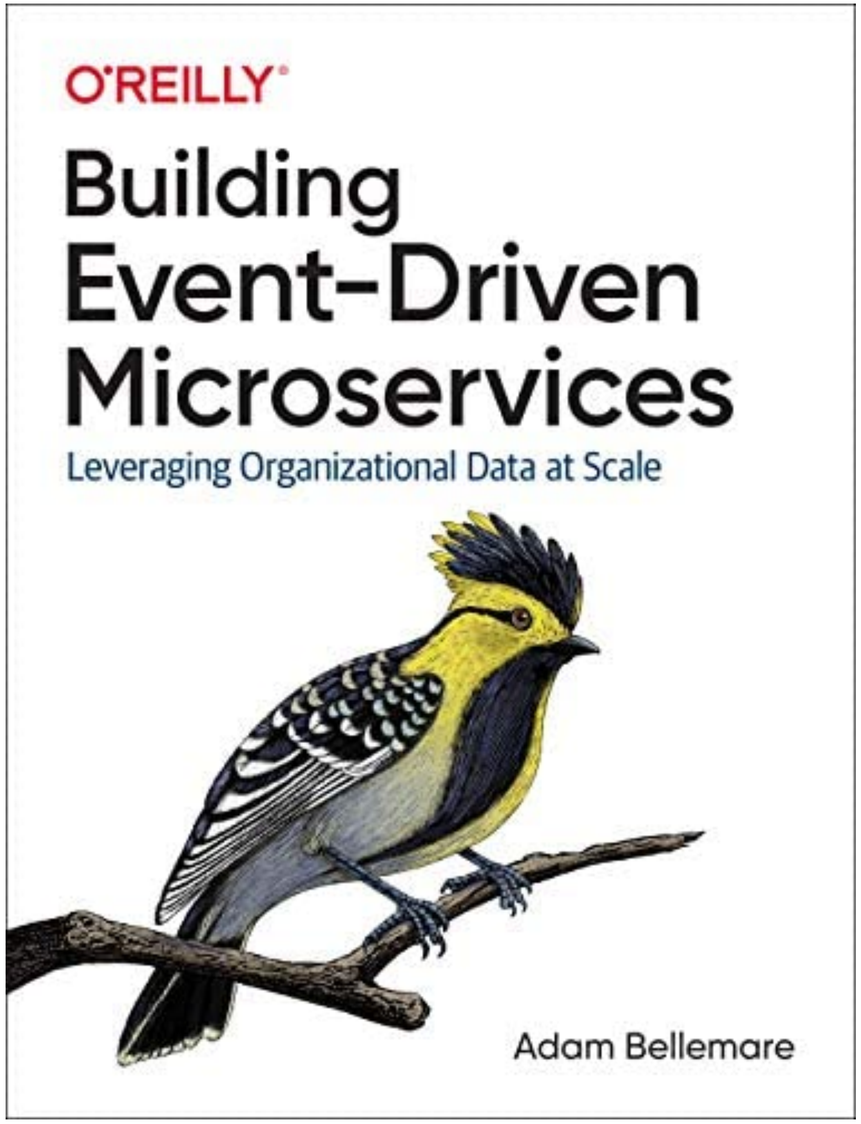


Event-Driven Microservices



Event-Driven Microservices

- Event-driven architecture plays to microservices' strengths
  - Bounded context
  - Loose coupling
- Multiple services can consume events from same topic/s
- Events are persistent (replayable)
- Events can be materialized as tables for traditional querying (ksqlDB)
- Events replace REST calls for inter-service communication



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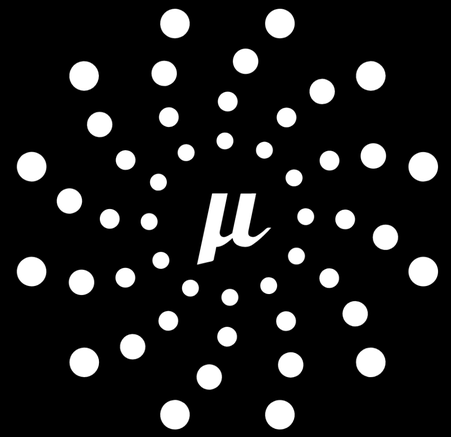
- Communication structures
- Event-modeling
- Scalability
- Stream processing
- Event scheduling
- Integration with request/response

https://www.oreilly.com/library/view/building-event-driven-microservices/9781492057888/

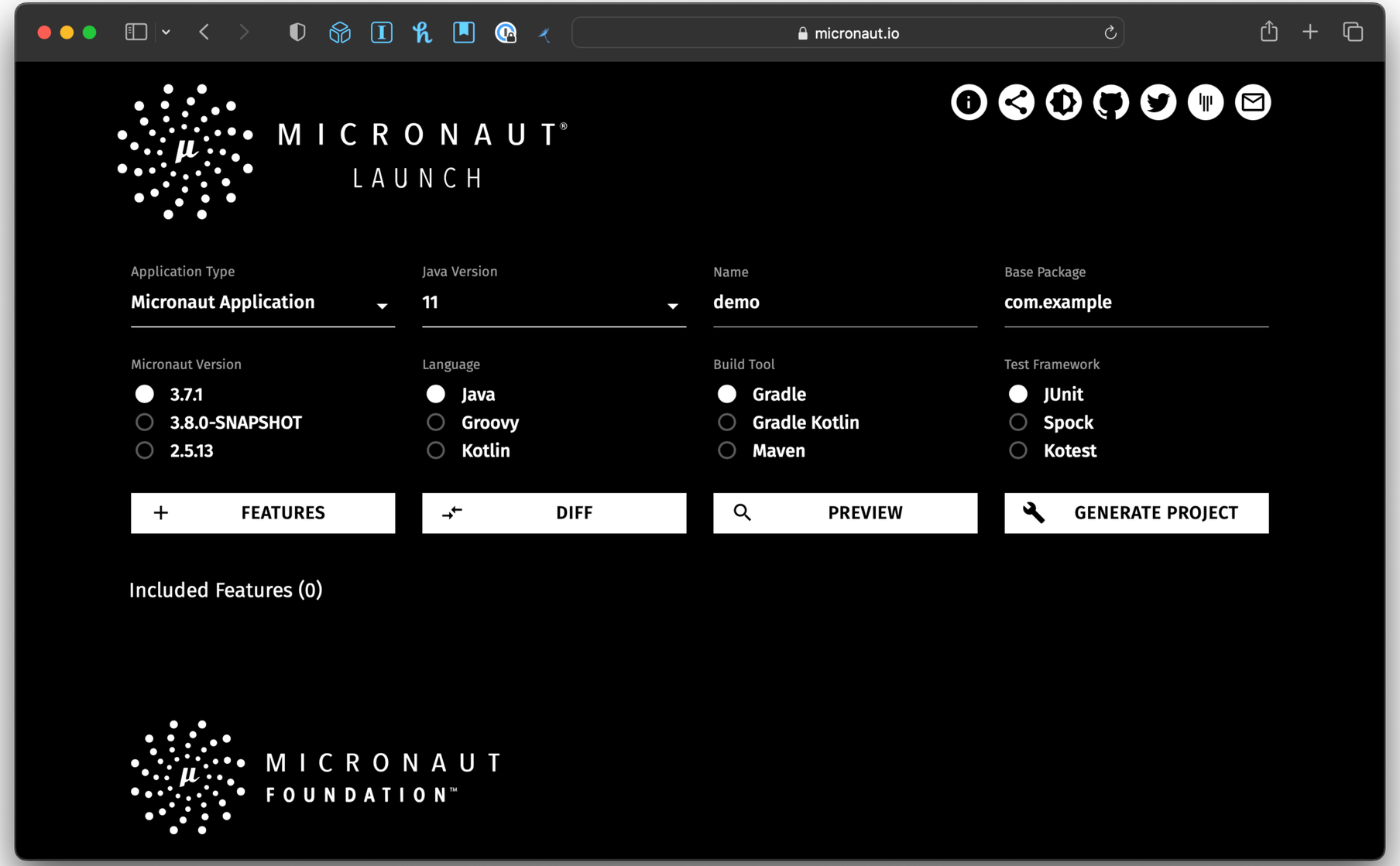


MICRONAUT®

A modern, JVM-based, full-stack framework for building modular,
easily testable microservice and serverless applications.

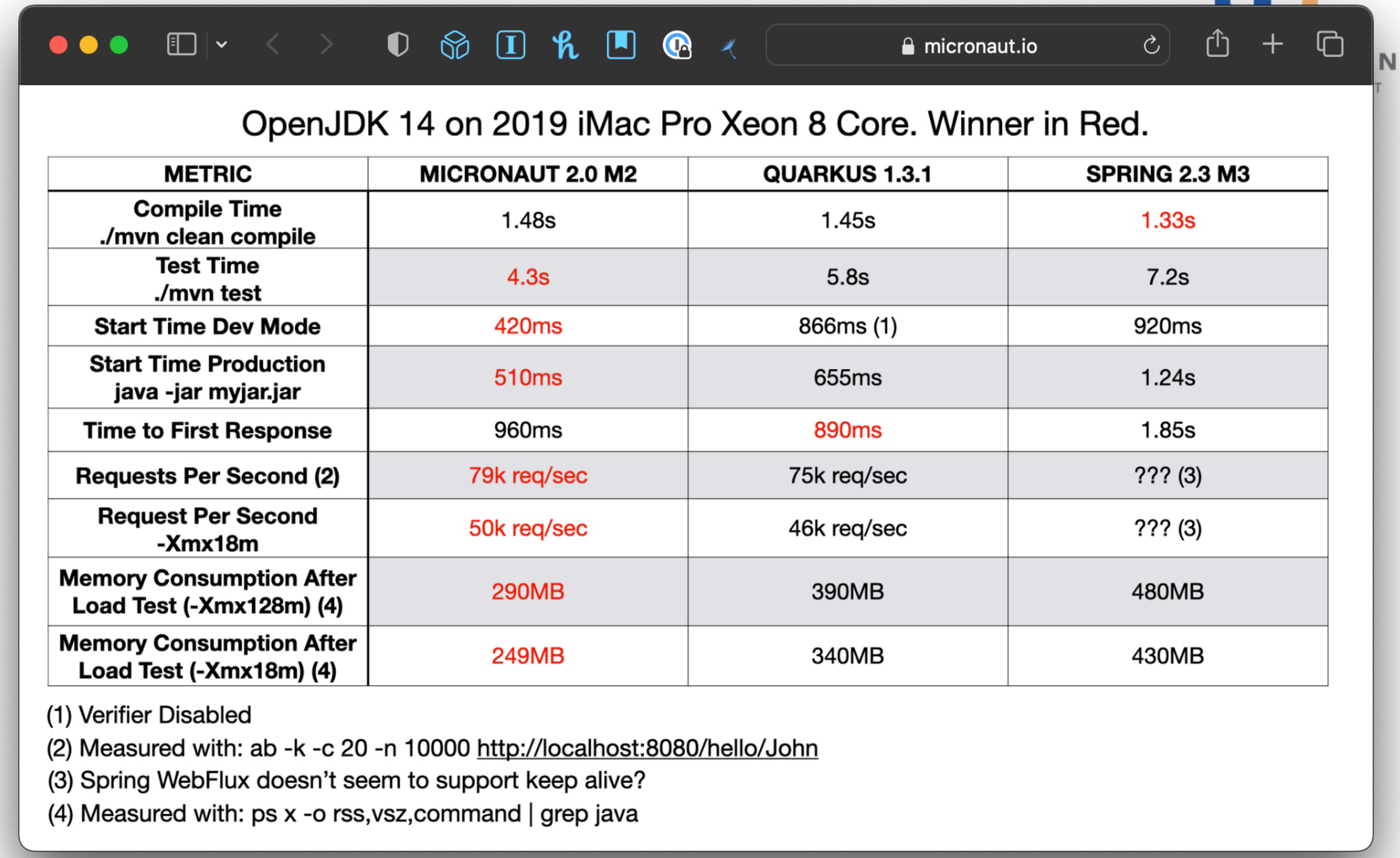
What is Micronaut?

- A modern framework for microservice & serverless applications
- Ahead Of Time (AOT) Compilation for DI, AOP, and configuration injection
- Reactive HTTP layer built on Netty
- Declarative HTTP Client
- Natively Cloud Native
- A suite of official and community-contributed integrations and libraries



https://micronaut.io/launch

```java
package com.example;

import io.micronaut.http.HttpResponse;
import io.micronaut.http.MediaType;
import io.micronaut.http.annotation.Controller;
import io.micronaut.http.annotation.Get;
import io.micronaut.http.annotation.Produces;

@Controller
public class HelloController {

  @Get("/{name}")
  @Produces(MediaType.TEXT_PLAIN)
  HttpResponse<String> greet(String name) {
    return HttpResponse.ok( body: "Hello, " + name);
  }

}

```



OpenJDK 14 on 2019 iMac Pro Xeon 8 Core. Winner in Red.

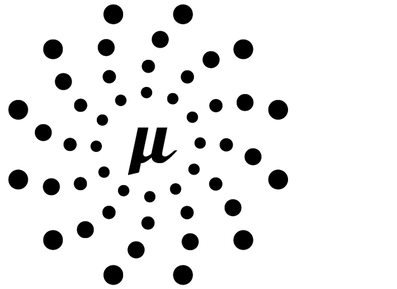
METRIC	MICRONAUT 2.0 M2	QUARKUS 1.3.1	SPRING 2.3 M3
Compile Time ./mvn clean compile	1.48s	1.45s	1.33s
Test Time ./mvn test	4.3s	5.8s	7.2s
Start Time Dev Mode	420ms	866ms (1)	920ms
Start Time Production java -jar myjar.jar	510ms	655ms	1.24s
Time to First Response	960ms	890ms	1.85s
Requests Per Second (2)	79k req/sec	75k req/sec	??? (3)
Request Per Second -Xmx18m	50k req/sec	46k req/sec	??? (3)
Memory Consumption After Load Test (-Xmx128m) (4)	290MB	390MB	480MB
Memory Consumption After Load Test (-Xmx18m) (4)	249MB	340MB	430MB

(1) Verifier Disabled
(2) Measured with: ab -k -c 20 -n 10000 http://localhost:8080/hello/John
(3) Spring WebFlux doesn't seem to support keep alive?
(4) Measured with: ps x -o rss,vsz,command | grep java

https://micronaut.io/2020/04/07/micronaut-vs-quarkus-vs-spring-boot-performance-on-jdk-14/

Micronaut Kafka

- https://micronaut-projects.github.io/micronaut-kafka/
- Provides declarative API for publishing/consuming events in Kafka
- Reflection-free serialization/ deserialization of events
- Create messaging apps without a HTTP server



Getting started

- Create an app (from the CLI or Micronaut Launch) with the **kafka** feature
- Or add the dependency and minimum required configuration
- Requires a working Kafka installation

Getting started

Add dependency:

Gradle Gradle | Maven Maven

```
implementation("io.micronaut.kafka:micronaut-kafka")
```

Minimum configuration:

Configuring Kafka

```
kafka:
    bootstrap:
        servers: localhost:9092
```

Advanced Configuration

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```
kafka:
  bootstrap:
    servers: localhost:9092
  ssl:
    keystore:
      location: /path/to/client.keystore.p12
      password: secret
    truststore:
      location: /path/to/client.truststore.jks
      password: secret
      type: PKCS12
  security:
    protocol: ssl
    producers:
        default:
            retries: 5
  consumers:
        default:
            session:
                timeout:
                    ms: 30000
```

Producer: **@KafkaClient**

OrderPlacedProducer.java

```
1  package com.example;
2
3  import io.micronaut.configuration.kafka.annotation.KafkaClient;
4  import io.micronaut.configuration.kafka.annotation.Topic;
5
   2 usages
6  @KafkaClient
7  public interface OrderPlacedProducer {
8
     1 usage
9    @Topic("order-placed")
10   void sendProduct(String product);
11
12 }
13
```

Specify Topic with **@Topic**


```
@Topic("my-products")
void sendProduct(@KafkaKey String brand, String name);
```

Topics can also be specified as arrays, Regular Expressions, and configuration properties:

```
@Topic({"fun-products", "awesome-products"})
```

JAVA

```
@Topic(patterns="products-\\w+")
```

```
@Topic("${custom.topic.name}")
```

Add Headers with **@MessageHeader**

Method-level:

```
@Topic("my-products")
void sendProduct(
    @KafkaKey String brand,
    String name,
    @MessageHeader("My-Header") String myHeader);
```

Interface-level (all methods):

JAVA

```
import io.micronaut.configuration.kafka.annotation.KafkaClient;
import io.micronaut.messaging.annotation.MessageHeader;

@KafkaClient(id="product-client")
@MessageHeader(name = "X-Token", value = "${my.application.token}")
public interface ProductClient {
    ...
}
```

Producer: **@KafkaClient**

OrderPlacedProducer.java

```java
package com.example;

import io.micronaut.configuration.kafka.annotation.KafkaClient;
import io.micronaut.configuration.kafka.annotation.Topic;

2 usages
@KafkaClient
public interface OrderPlacedProducer {

    1 usage
    @Topic("order-placed")
    void sendProduct(String product);

}
```

Inject and use Producer


```
2 usages
12  private final OrderPlacedProducer producer;
13
14  public HelloController(OrderPlacedProducer producer) { this.producer = producer; }
17
18  @Post("/{product}")
19  @Produces(MediaType.TEXT_PLAIN)
20  HttpResponse<?> placeOrder(String product) {
21
22      producer.sendProduct(product);
23
24      return HttpResponse.ok();
25  }
```

Consumer: **@KafkaListener**

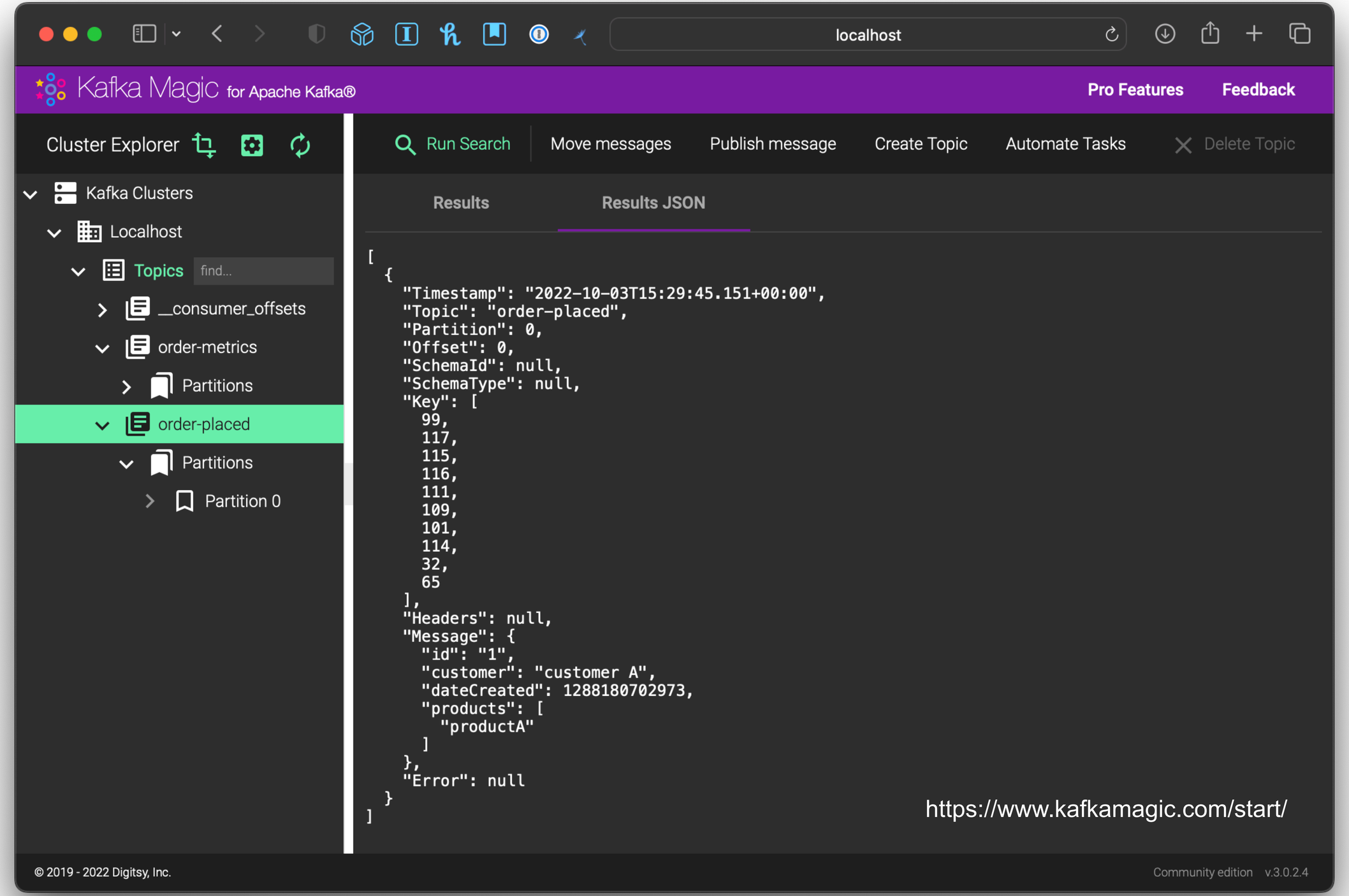
OrderPlacedConsumer.java

```java
package com.example;

import io.micronaut.configuration.kafka.annotation.KafkaListener;
import io.micronaut.configuration.kafka.annotation.Topic;

@KafkaListener
public class OrderPlacedConsumer {

  @Topic("order-placed")
  void receiveOrder(String product) {
    System.out.println("Received order for product: " + product);

    //TODO: Handle order

  }

}
```

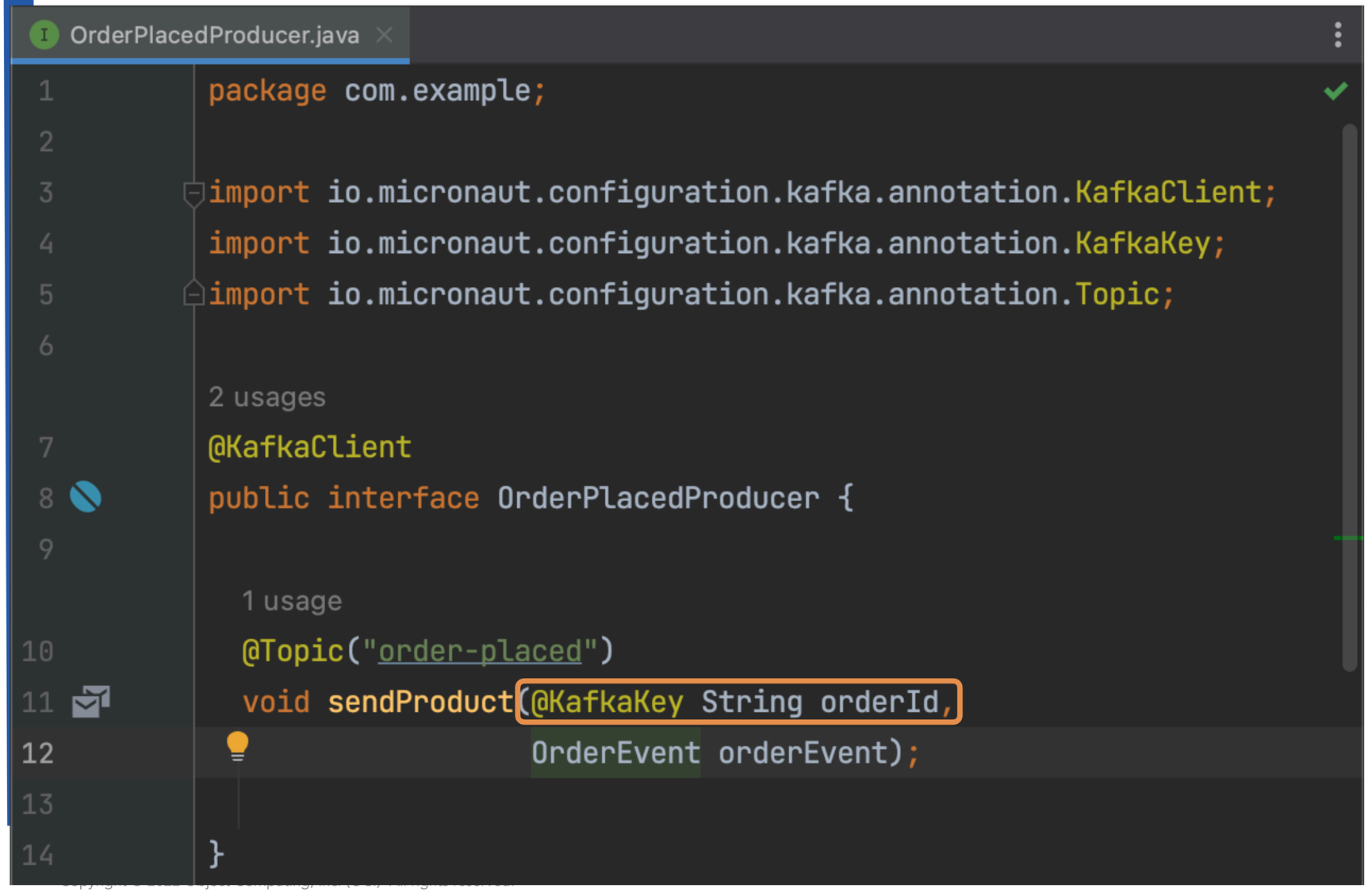
Use POJO as Event Payload

OrderEvent.java

```
1   package com.example;                                                    ⚠ 3
2
3   import ...
7
    1 usage
8   @Introspected
9   public class OrderEvent {
      2 usages
10      private final Long id;
        2 usages
11      private final String customer;
        2 usages
12      private final Date dateCreated;
        2 usages
13      private final List<String> products;
14
15      public OrderEvent(Long id, String customer, Date dateCreated, List<String> products) {
16          this.id = id;
17          this.customer = customer;
```


localhost
Kafka Magic for Apache Kafka®
Pro Features
Feedback
Cluster Explorer
Run Search
Move messages
Publish message
Create Topic
Automate Tasks
Delete Topic
Kafka Clusters
Localhost
Topics
find...
__consumer_offsets
order-metrics
Partitions
order-placed
Partitions
Partition 0
Results
Results JSON
[
{
"Timestamp": "2022-10-03T15:29:45.151+00:00",
"Topic": "order-placed",
"Partition": 0,
"Offset": 0,
"SchemaId": null,
"SchemaType": null,
"Key": [
99,
117,
115,
116,
111,
109,
101,
114,
32,
65
],
"Headers": null,
"Message": {
"id": "1",
"customer": "customer A",
"dateCreated": 1288180702973,
"products": [
"productA"
]
},
"Error": null
}
]
https://www.kafkamagic.com/start/
© 2019 - 2022 Digitsy, Inc.
Community edition v.3.0.2.4

@KafkaKey to specify Event key



@KafkaKey to specify Event key

OrderPlacedConsumer.java

```
6
7   @KafkaListener
8   public class OrderPlacedConsumer {
9
10    @Topic("order-placed")
11    void receiveOrder(@KafkaKey String orderId,
12                      OrderEvent orderEvent) {
13      System.out.println("Received order with id: " +
14          orderId +
15          " for products: " +
16          orderEvent.getProducts().size());
17
18      //TODO: Handle order
19
20    }
21  }
22
```

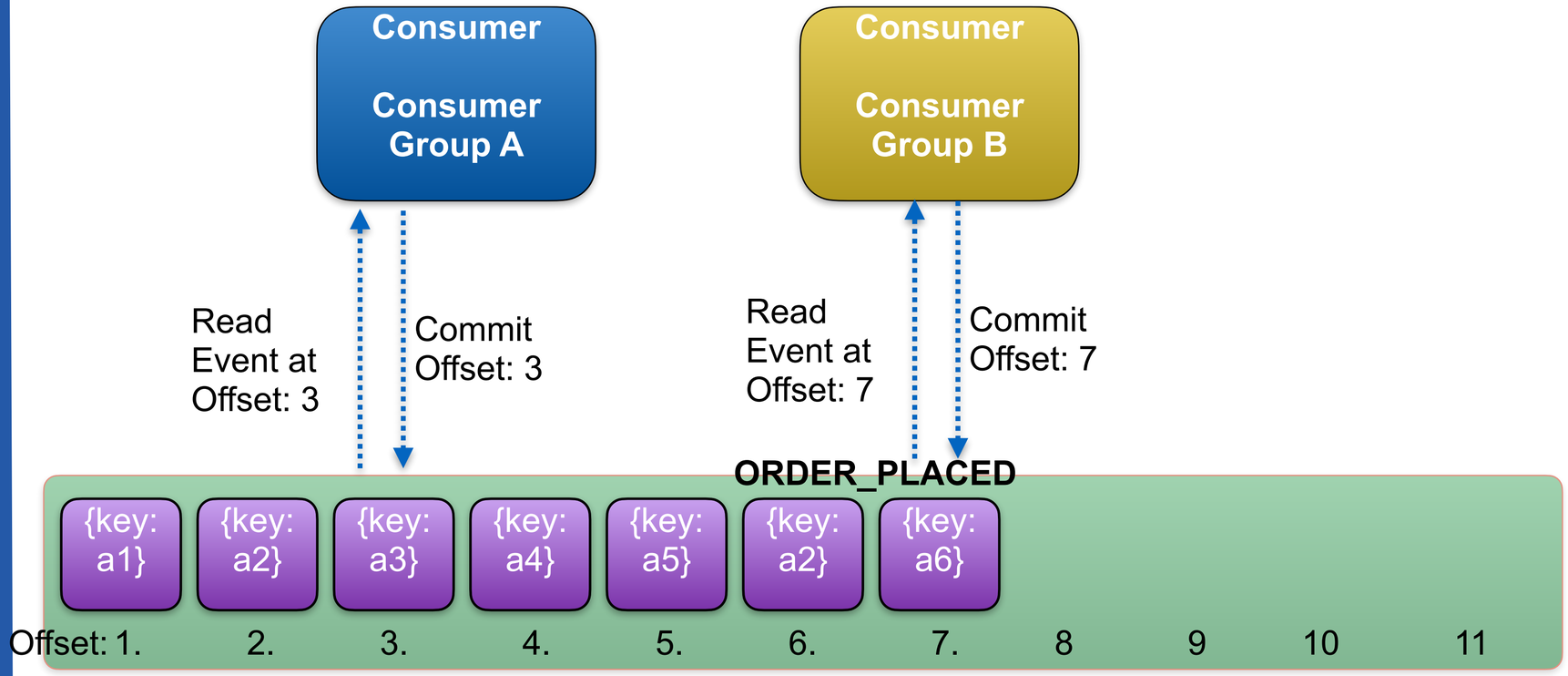
Specify **Consumer Groups**

OrderPlacedConsumer.java

```
6
7       @KafkaListener(
8           groupId="order-placed-group",
9           threads=10)
10      public class OrderPlacedConsumer {
11
12        @Topic("order-placed")
13        void receiveOrder(@KafkaKey String customer,
14                          OrderEvent orderEvent) {
15          System.out.println("Received order from customer: " +
16              customer +
17              " for products: " +
18              orderEvent.getProducts().size());
19
20          //TODO: Handle order
21
22        }
23      }
```

Configure **OffsetStrategy**

Default: Auto-commit



Configure **OffsetStrategy**

Example: Disabled (Manual Acknowledgement

OrderPlacedConsumer.java

```
9   @KafkaListener(
10      offsetStrategy = OffsetStrategy.DISABLED,
11      groupId="order-placed-group",
12      threads=10)
13  public class OrderPlacedConsumer {
14
15    @Topic("order-placed")
16    void receiveOrder(@KafkaKey String customer,
17                      OrderEvent orderEvent,
18                      Acknowledgement acknowledgement) {
19      System.out.println("Received order from customer: " +
20          customer +
21          " for products: " +
22          orderEvent.getProducts().size());
23
24      //TODO: Handle order
25
26      acknowledgement.ack();
```

Route Events with **@SendTo**

OrderPlacedConsumer.java

```
10  @KafkaListener(
11      offsetStrategy = OffsetStrategy.DISABLED,
12      groupId="order-placed-group",
13      threads=10)
14  public class OrderPlacedConsumer {
15
16      @Topic("order-placed")
17      @SendTo("order-metrics")
18      Integer receiveOrder(@KafkaKey String customer,
19                           OrderEvent orderEvent,
20                           Acknowledgement acknowledgement) {
21          System.out.println(
22              "Received order from customer: " + customer
23          );
24
25          acknowledgement.ack();
26
```

Exception handling: **ErrorStrategy**

OrderPlacedConsumer.java [demo.main]

demo 〉 src 〉 main 〉 java 〉 com 〉 example 〉 OrderPlacedConsumer

OrderPlacedConsumer.java

```
8
9       @KafkaListener(
10          offsetStrategy = OffsetStrategy.DISABLED,
11          errorStrategy = @ErrorStrategy(value = RETRY_ON_ERROR, retryDelay = "50ms", retryCount=3),
12          groupId="order-placed-group",
13          threads=10)
14
15      public class OrderPlacedConsumer {
16
17          @Topic("order-placed")
18          @SendTo("order-metrics")
19          Integer receiveOrder(@KafkaKey String customer,
20                               OrderEvent orderEvent,
21                               Acknowledgement acknowledgement) {
22              System.out.println(
23                  "Received order from customer: " + customer
```

KafkaListenerExceptionHandler

Reader Mode

```java
@Singleton
@Primary
public class DefaultKafkaListenerExceptionHandler implements KafkaListenerExceptionHandler {
    6 usages
    private static final Logger LOG = LoggerFactory.getLogger(KafkaListenerExceptionHandler.class);
    1 usage
    private static final Pattern SERIALIZATION_EXCEPTION_MESSAGE_PATTERN = Pattern.compile( regex: ".+ for partiti

    2 usages
    private boolean skipRecordOnDeserializationFailure = true;

    @Override
    public void handle(KafkaListenerException exception) {
        final Throwable cause = exception.getCause();
        final Object consumerBean = exception.getKafkaListener();
        if (cause instanceof SerializationException) {...} else {
            if (LOG.isErrorEnabled()) {
                Optional<ConsumerRecord<?, ?>> consumerRecord = exception.getConsumerRecord();
                if (consumerRecord.isPresent()) {...} else {
                    LOG.error("Kafka consumer [{}] produced error: {}", consumerBean, cause.getMessage(), cause);
                }
            }
        }
    }
```

KafkaListenerExceptionHandler

CustomKafkaListenerExceptionHandler.java

```
11
12  @Singleton
13  @Replaces(DefaultKafkaListenerExceptionHandler.class)
14  public class CustomKafkaListenerExceptionHandler implements KafkaListenerExceptionHandler {
15    @Override
16    public void handle(KafkaListenerException exception) {
17
18      Optional<ConsumerRecord<?, ?>> consumerRecord = exception.getConsumerRecord();
19      if (consumerRecord.isPresent()) {
20        //TODO Handle the consumer record
21      }
22    }
23  }
24
25
```

Health Checks, Metrics, & Tracing

- Micronaut Kafka provides Kafka-specific health information to Micronaut's **management** endpoints (if enabled)
  - https://docs.micronaut.io/latest/guide/#management

http:localhost:8080/health

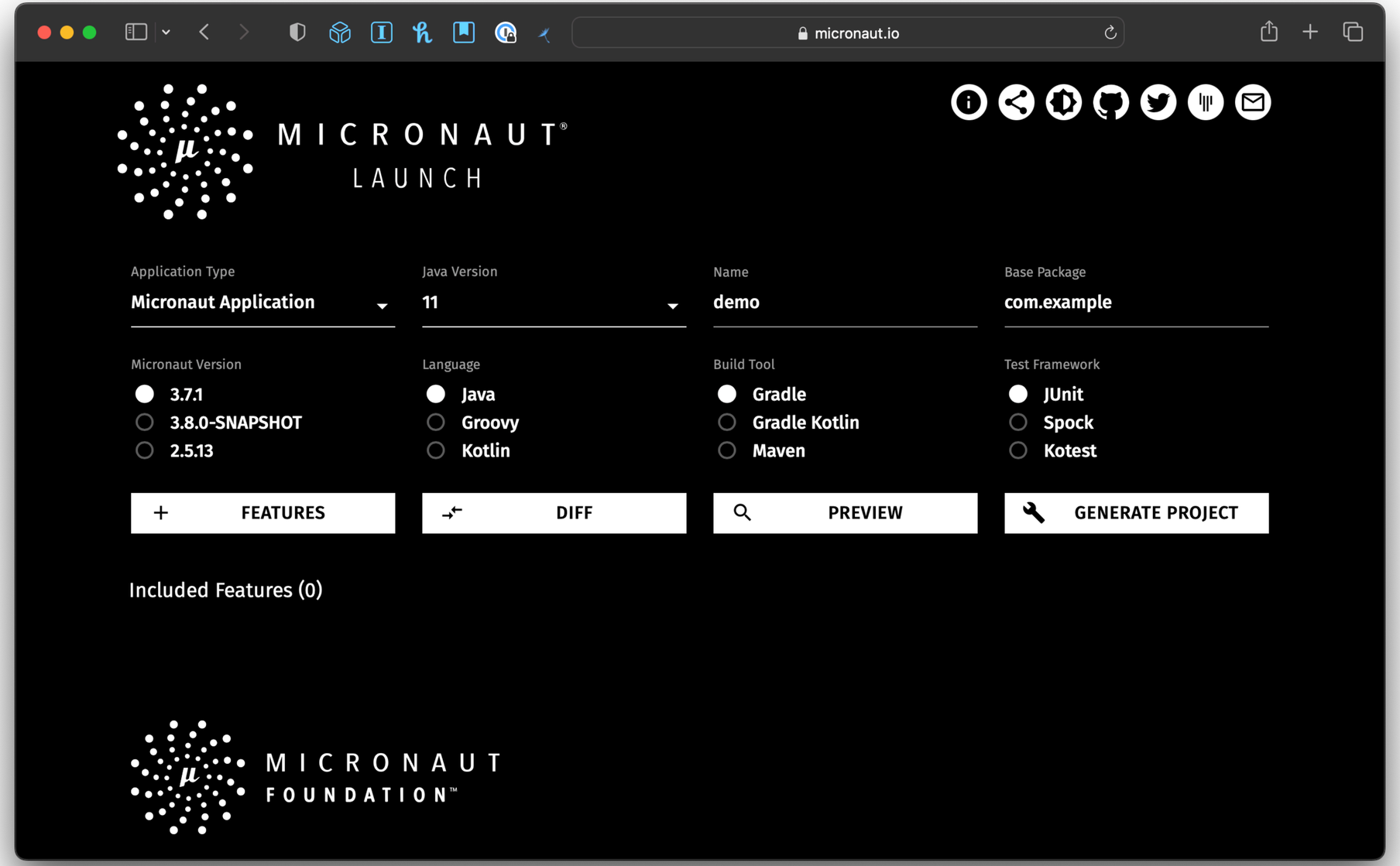
```
{
    "status": "DOWN",
    "details": {
        "kafka": {
            "status": "DOWN",
            "details": {
  “error": "java.util.concurrent.ExecutionException:
org.apache.kafka.common.errors.TimeoutException: Timed out waiting for a node
assignment."
            }
        }
    }
}
```

Health Checks, Metrics, & Tracing

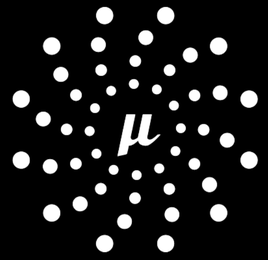
- Micronaut Kafka provides metrics to Micronaut's **metrics** endpoint via Micrometer (if enabled)
  - https://micronaut-projects.github.io/micronaut-micrometer/latest/guide/
- Micronaut Kafka support **distributed tracing** via Micronaut Tracing, using Jaeger or Zipkin
  - https://micronaut-projects.github.io/micronaut-tracing/latest/guide/

Kafka Streams

- Kafka Streams is an additional library that provides advanced processing capabilities on top of Kafka topics
- Streams accept one/more input topics, define one or more operators/transformations, and publish results to an output topic
- Micronaut Kafka supports creation of **KStreams** that can be injected as **@Singleton** beans
- Kafka Stream's **InteractiveQueryService** is also exposed as an injectable bean
- More: https://micronaut-projects.github.io/micronaut-kafka/latest/guide/#kafkaStreams



https://micronaut.io/launch



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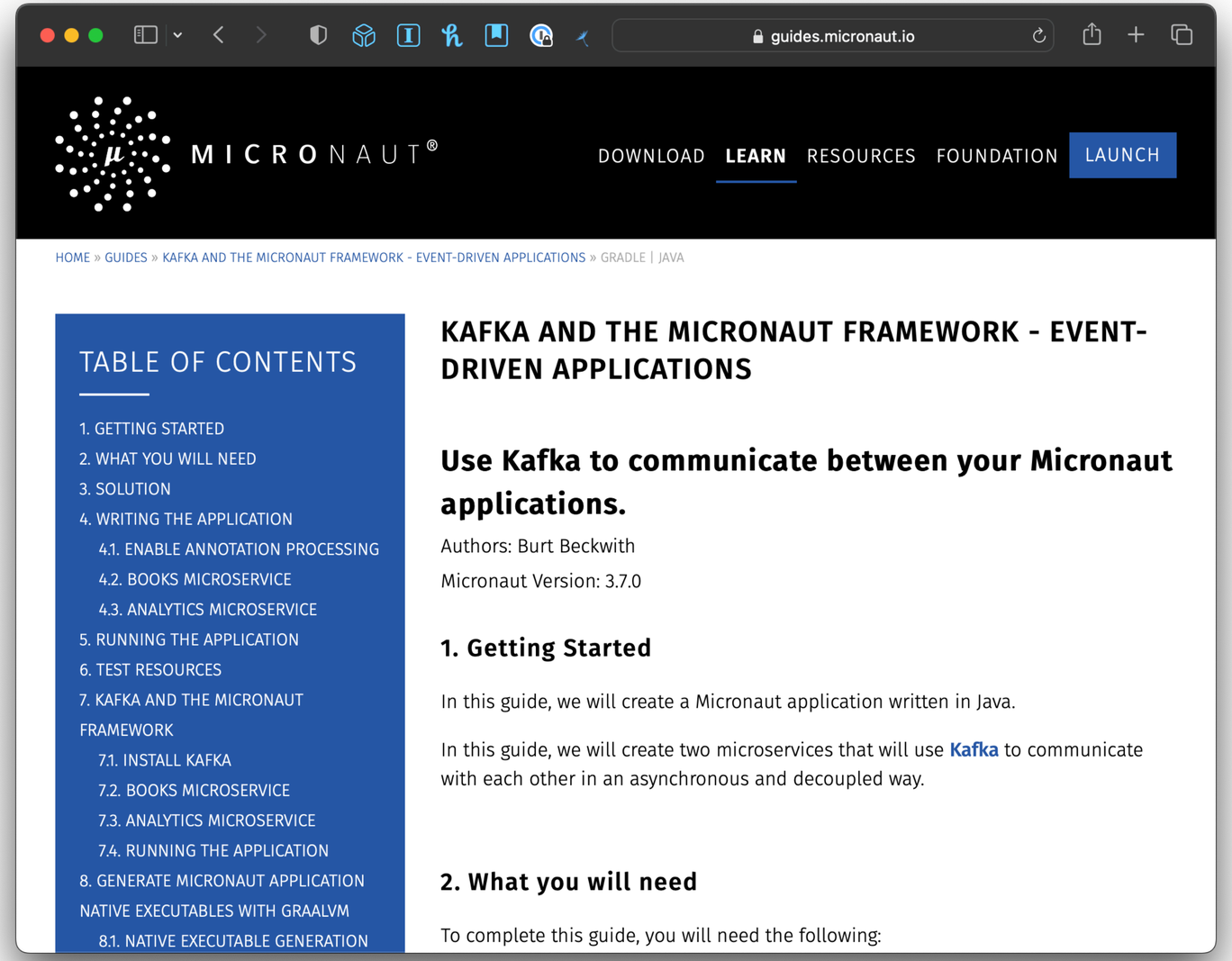
Micronaut Guides



https://guides.micronaut.io/latest/micronaut-kafka-gradle-java.html

Micronaut Resources

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Books:

https://www.packtpub.com/product/building-microservices-with-micronaut/9781800564237

Podcast:

https://micronautpodcast.com/

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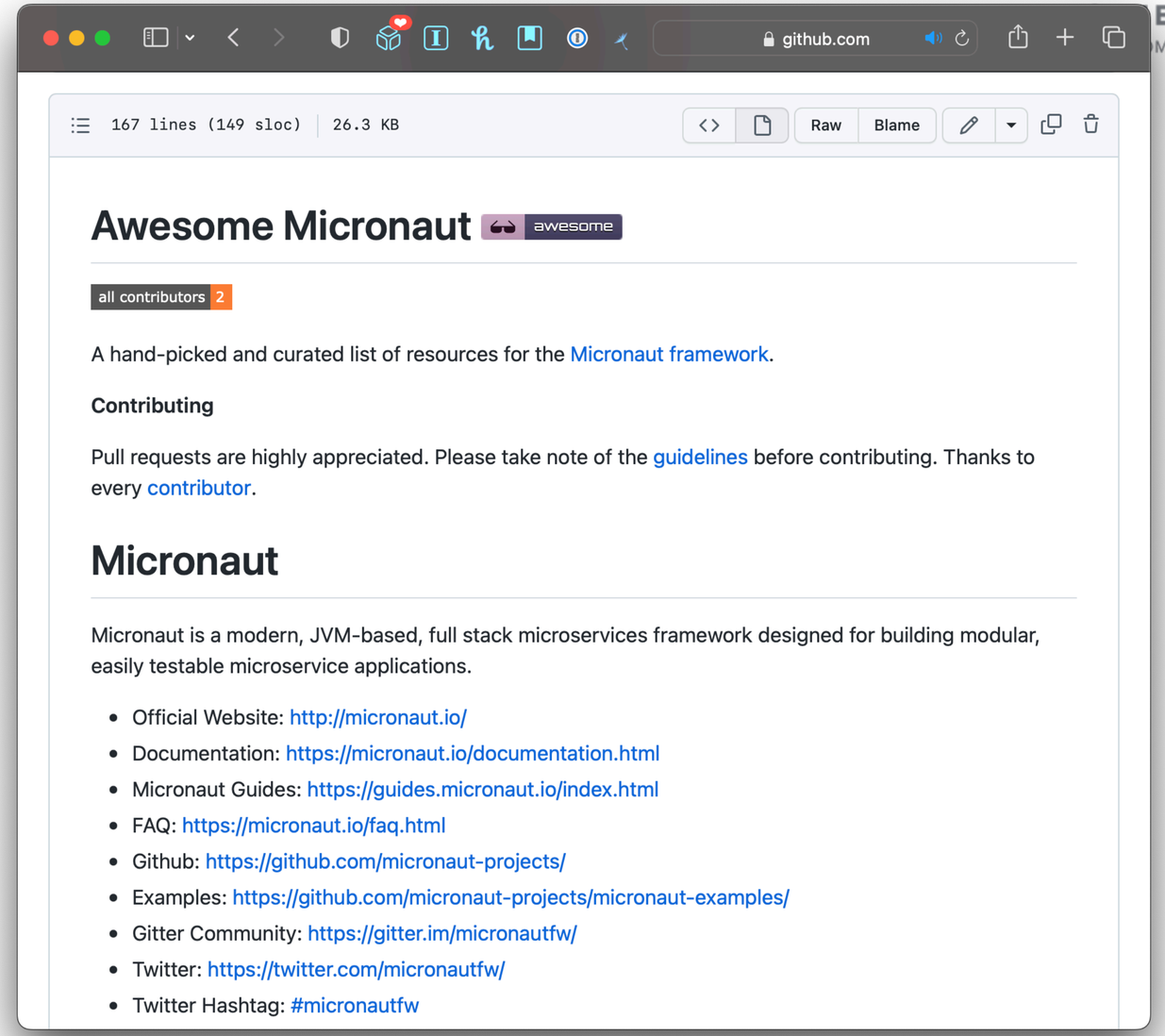

https://github.com/JonasHavers/awesome-micronaut

Kafka/Event-Driven Resources

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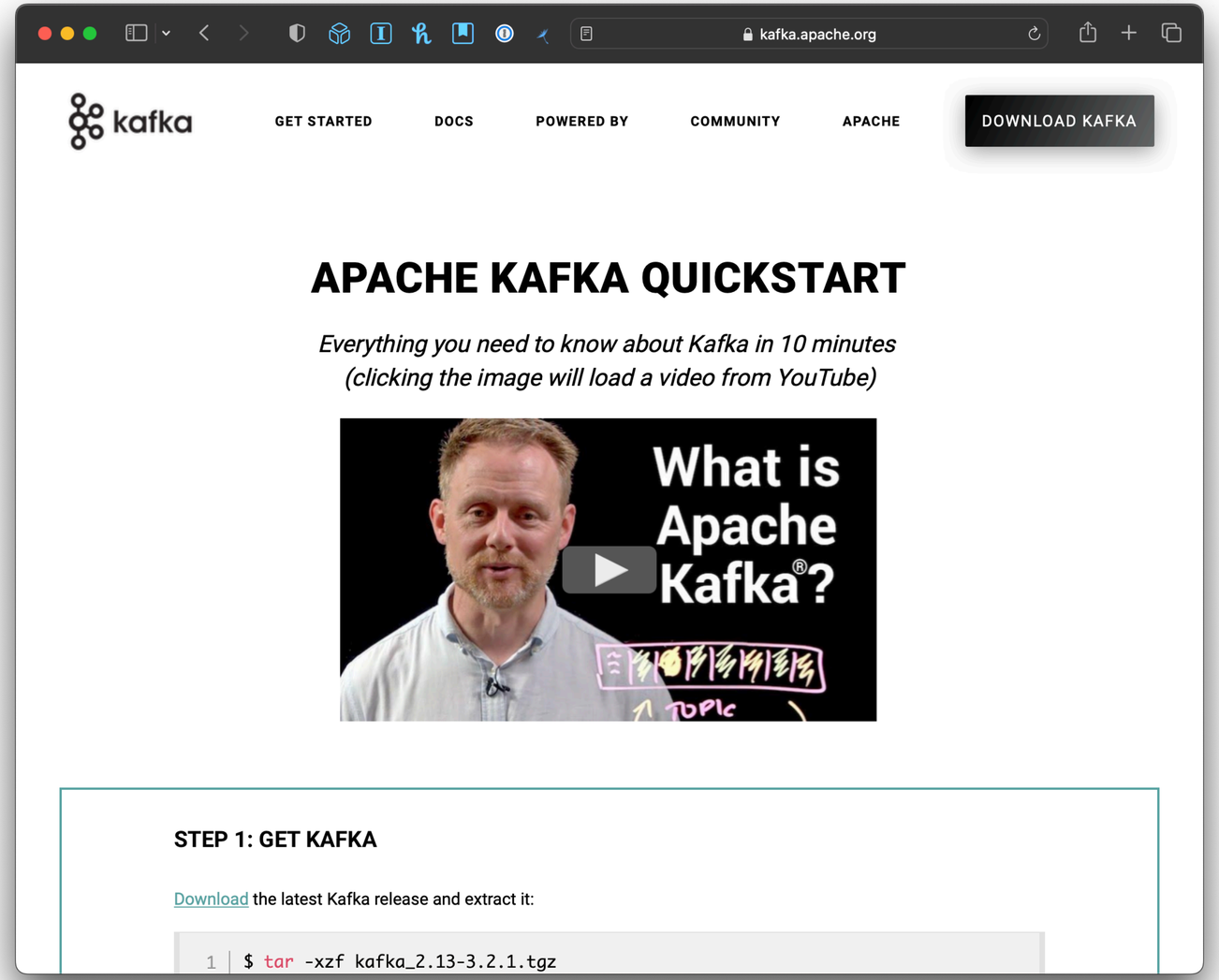

https://kafka.apache.org/quickstart

Kafka/Event-Driven Resources

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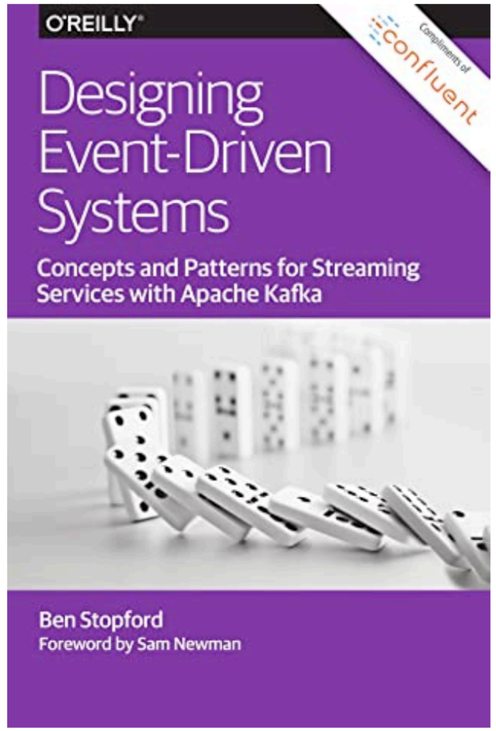
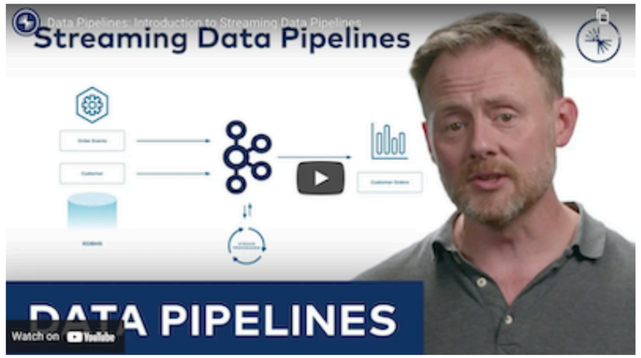


https://cnfl.io/book-bundle

https://developer.confluent.io/learn-kafka/event-sourcing



https://developer.confluent.io/learn-kafka/data-pipelines

Learn More: OCI Training Event

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This 12-hour workshop is a great fit for those who want to gain a productive understanding of the Micronaut® framework, Apache Kafka, and event-driven architecture in cloud-based microservices. Engage in hands-on exercises to gain experience and working examples of event-driven microservices using the Micronaut framework and Apache Kafka.

NEXT OPEN-ENROLLMENT CLASS

Dates: November 14 to November 17

Time: 9:00 a.m. to 12:00 p.m. CST

Duration: 12 hours (3 hours per day for 4 days)

https://micronaut.io/professional-training/event-driven-microservices-with-micronaut/

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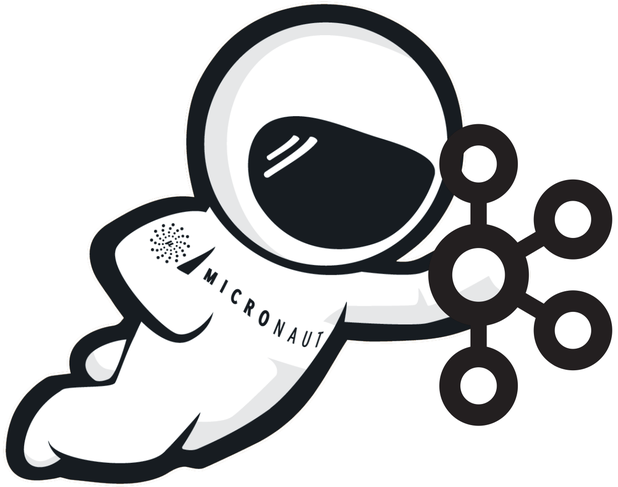
Thank you!

Zachary Klein, Principal Software Engineer, 2GM Team



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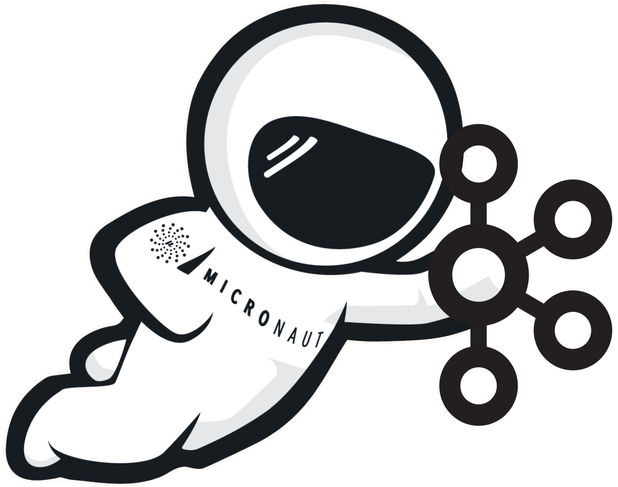

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