How to develop your first cloud-native Applications with Java

Niklas Heidloff
Developer Advocate, IBM
@nheidloff

IBM **Developer**

IBM

“Microservices are a software development technique [...] that structures an application as a collection of loosely coupled services.”

Wikipedia

What are cloud-native Applications?

Elasticity

→ App stays responsive

Continuous delivery

→ DevOps

New Options → New Challenges

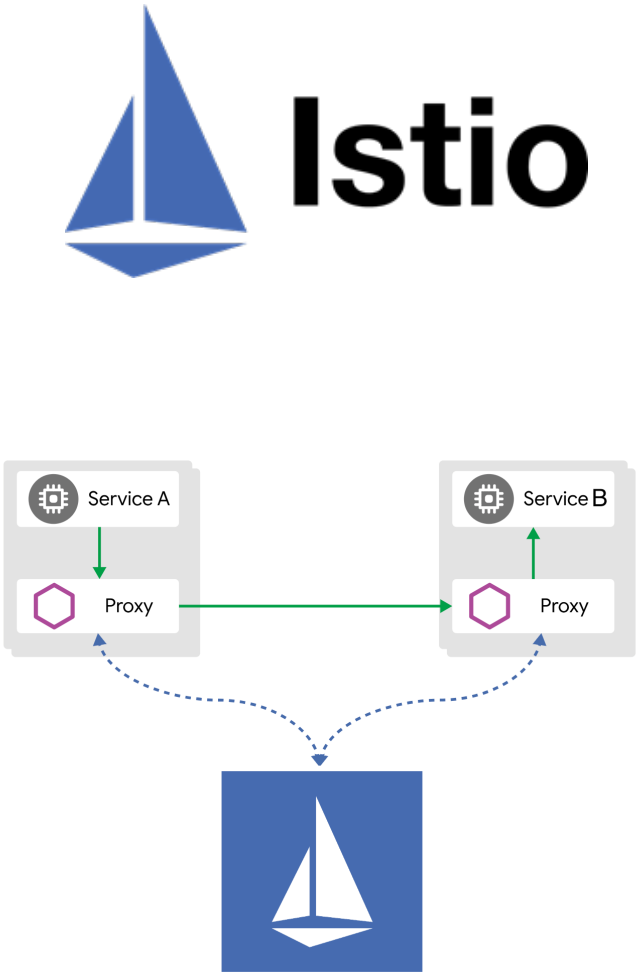
“Kubernetes (K8s) is an open-source system for automating deployment, scaling, and management of containerized applications.”

kubernetes.io

kubernetes

“Istio is an open platform for providing a uniform way to integrate microservices, manage traffic flow across microservices, enforce policies and aggregate telemetry data.”

`github.com/istio/istio`

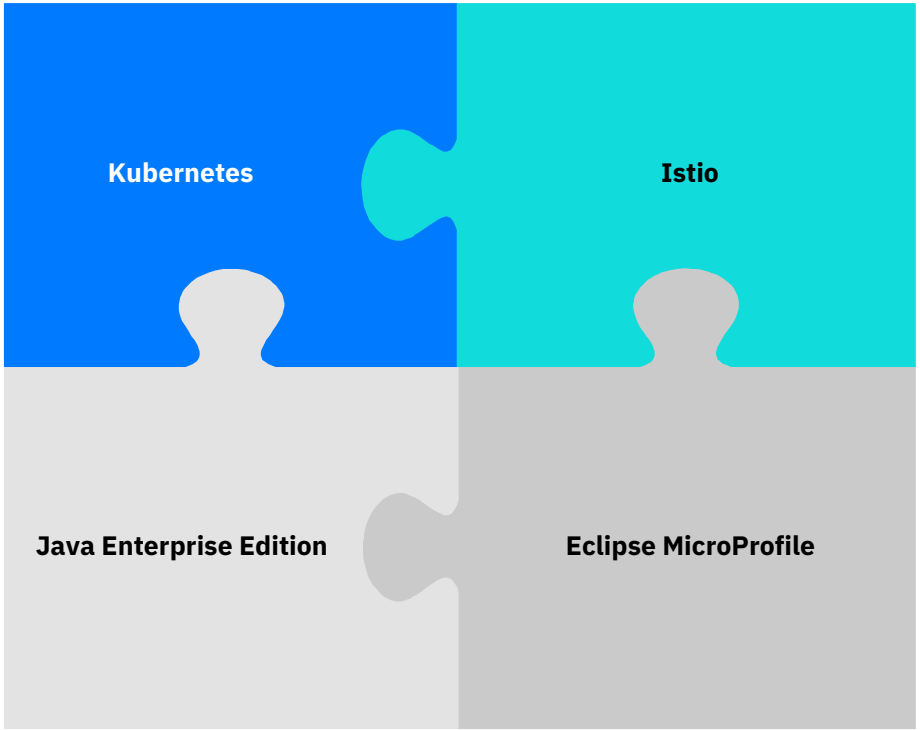


“Optimizing Enterprise Java for a Microservices Architecture.

[...] by innovating [...] with a goal of standardization.”

`microprofile.io`

How to use all Pieces together?



Leverage platforms as much as possible.

Use frameworks for app specific logic.

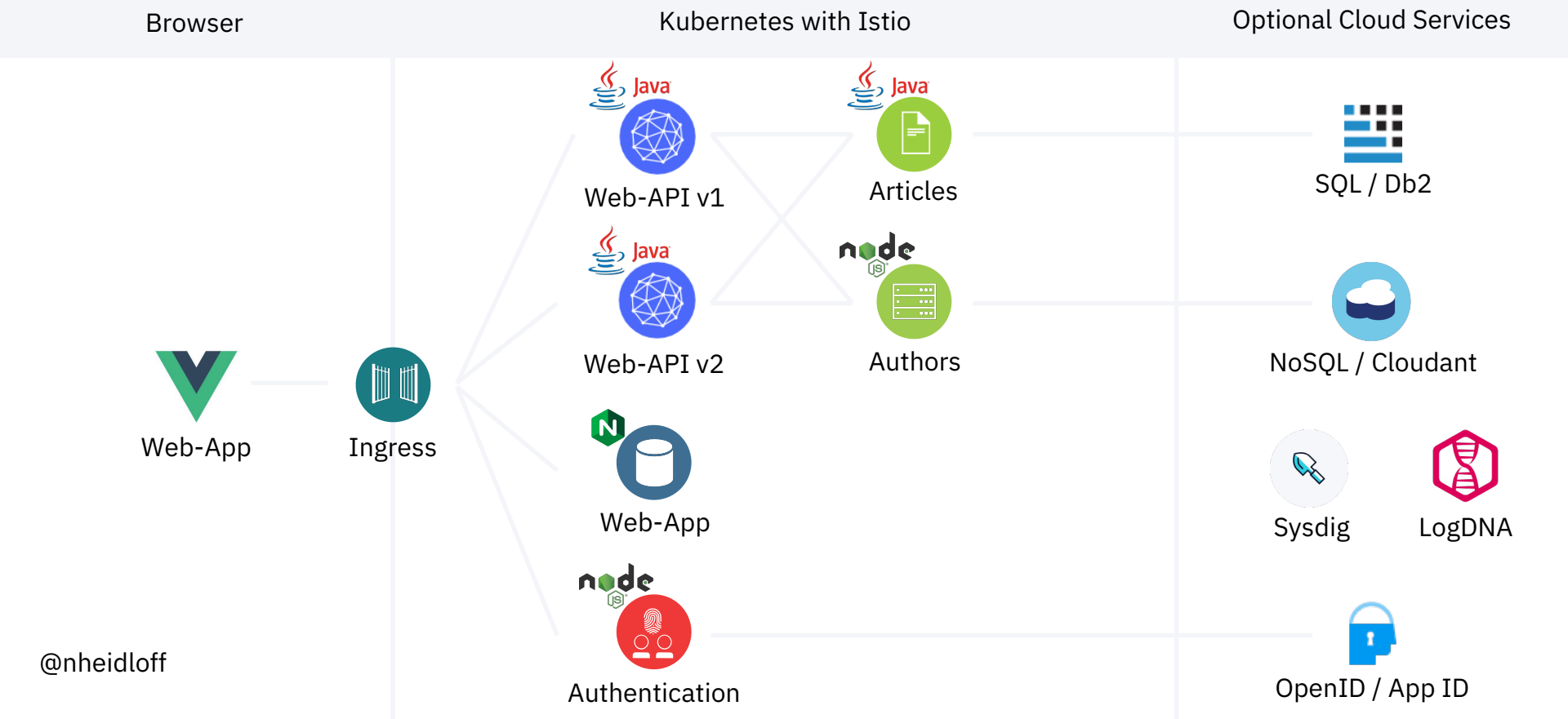
Design principles for the end-to-end example ‘cloud-native-starter’

Use only open-source components for the core services of the application

Make the first time experience as simple as possible

Be able to run the application in different environments

Architecture: End-to-End Example ‘cloud-native-starter’



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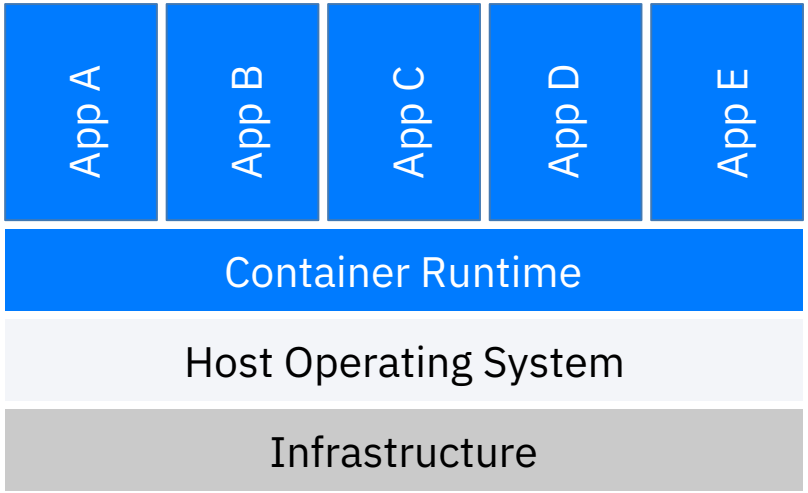
“A container image is a lightweight, standalone, executable package of software that includes everything needed to run an application.”

docker.com



Portable Containers

Java Image

Open source stack

OpenJ9 0.14.0

OpenJDK 11.0.3+7 from AdoptOpenJDK

Open Liberty 19.0.0.5

MicroProfile 2.2

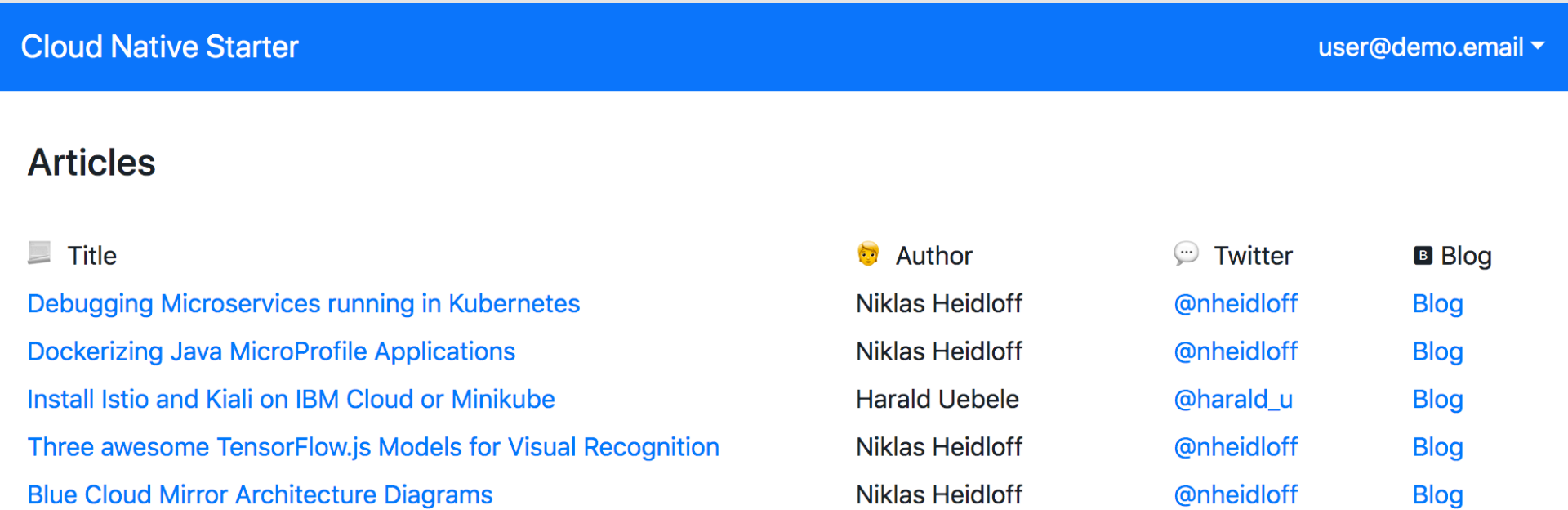
Dockerfile

```
FROM open-liberty:microProfile2-java11

COPY liberty/server.xml /config/

COPY target/authors.war /config/apps/
```

Example Application



Example Application – REST APIs

Browser

Kubernetes with Istio

Exposing REST APIs

JAX-RS

Java API for RESTful Web Services

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GetArticles.java

```
@RequestScoped
@Path("/v1")
@OpenAPIDefinition(info = @Info(title = "Web-API Service",
  version = "1.0", description = "Web-API Service APIs"))
public class GetArticles {

  @Inject
  com.ibm.webapi.business.Service service;

  @GET
  @Path("/getmultiple")
  @Produces(MediaType.APPLICATION_JSON)
  @APIResponses(value = {
      @APIResponse(responseCode = "200",
        description = "Get most recently added articles",
        content = @Content(mediaType = "application/json",
        schema = @Schema(type = SchemaType.ARRAY,
          implementation = Article.class))),
      @APIResponse(responseCode = "500",
        description = "Internal service error") })
  @Operation(summary = "Get most recently added articles",
    description = "Get most recently added articles")
  public Response getArticles() {
```

Exposing REST APIs

Open API (formerly Swagger)

API description format for REST APIs

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GetArticles.java

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@RequestScoped
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    description = "Get most recently added articles")
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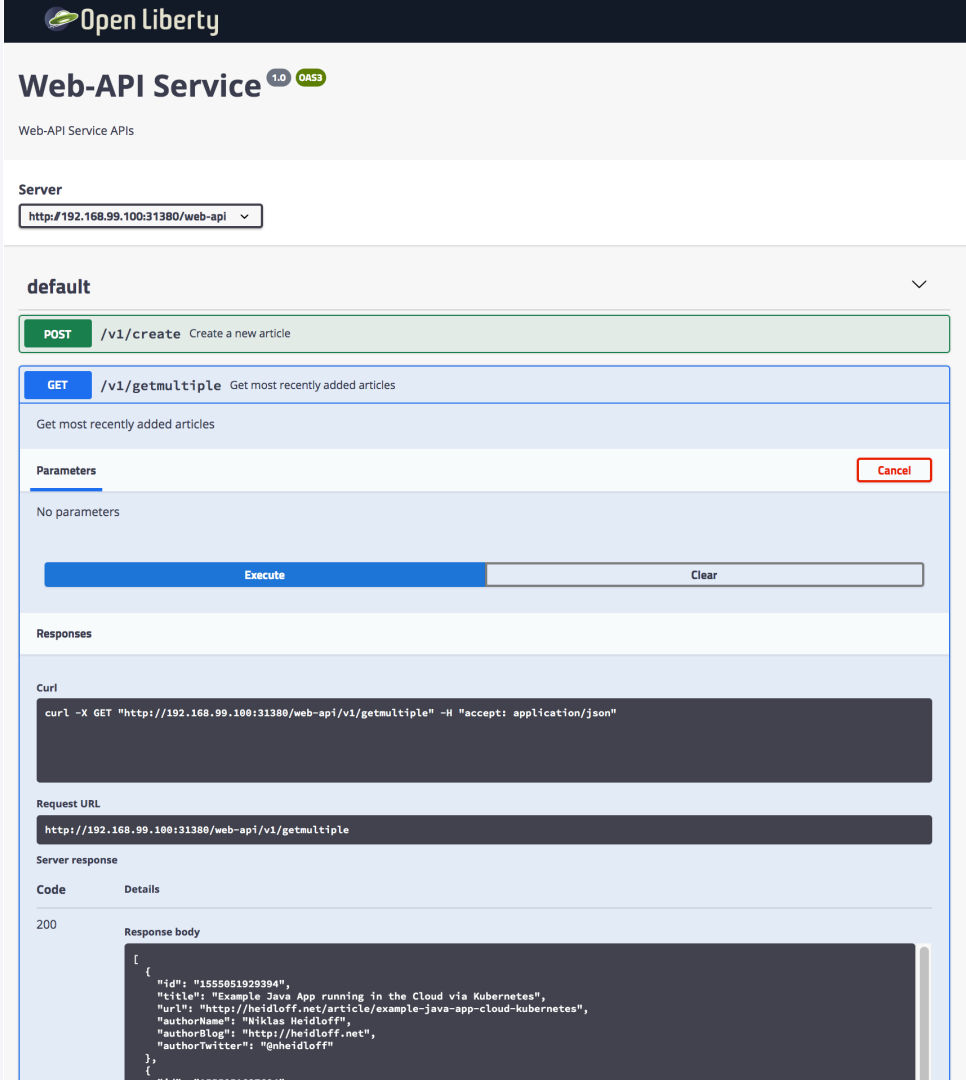
```

Exposing REST APIs

Open API (formerly Swagger)

API description format for REST APIs



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Consuming REST APIs

MicroProfile Rest Client

Type-safe approach to invoke RESTful services

@nheidloff

AuthorsService.java

```
@RegisterProvider(ExceptionMapperArticles.class)
public interface AuthorsService {

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  public Author getAuthor(String name) throws NonexistentAuthor;
}
```

AuthorsServiceDataAccess.java

```
public class AuthorsServiceDataAccess implements AuthorsDataAccess {
  public AuthorsServiceDataAccess() {}

  static final String BASE_URL = "http://authors:3000/api/v1/";

  public Author getAuthor(String name) throws NoConnectivity, NonexistentAuthor {
    try {
      name = URLEncoder.encode(name, "UTF-8").replace("+", "%20");
      URL apiUrl = new URL(BASE_URL + "getauthor?name=" + name);
      AuthorsService customRestClient;
      customRestClient = RestClientBuilder.newBuilder().baseUrl(apiUrl)
          .register(ExceptionMapperAuthors.class).build(AuthorsService.class);

      Author output = customRestClient.getAuthor(name);
      return output;
    } catch (NonexistentAuthor e) {
      e.printStackTrace();
      throw new NonexistentAuthor(e);
    } catch (Exception e) {
      throw new NoConnectivity(e);
```

Consuming REST APIs

MicroProfile Rest Client

Type-safe approach to invoke RESTful services

@nheidloff

AuthorsService.java

```java
@RegisterProvider(ExceptionMapperArticles.class)
public interface AuthorsService {

  @GET
  @Produces(MediaType.APPLICATION_JSON)
  public Author getAuthor(String name) throws NonexistentAuthor;
}
```

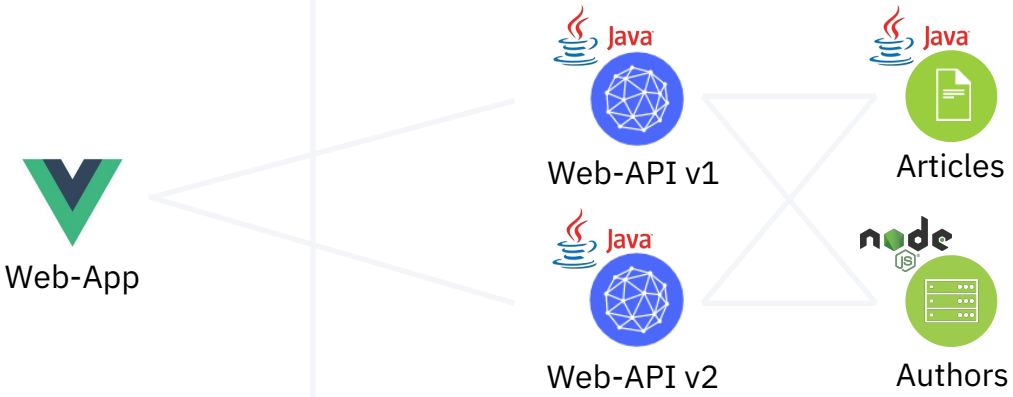
AuthorsServiceDataAccess.java

```java
public class AuthorsServiceDataAccess implements AuthorsDataAccess {
  public AuthorsServiceDataAccess() {}

  static final String BASE_URL = "http://authors:3000/api/v1/";

  public Author getAuthor(String name) throws NoConnectivity, NonexistentAuthor {
    try {
      name = URLEncoder.encode(name, "UTF-8").replace("+", "%20");
      URL apiUrl = new URL(BASE_URL + "getauthor?name=" + name);
      AuthorsService customRestClient;
      customRestClient = RestClientBuilder.newBuilder().baseUrl(apiUrl)
          .register(ExceptionMapperAuthors.class).build(AuthorsService.class);

      Author output = customRestClient.getAuthor(name);
      return output;
    } catch (NonexistentAuthor e) {
      e.printStackTrace();
      throw new NonexistentAuthor(e);
    } catch (Exception e) {
      throw new NoConnectivity(e);
```

Example Application – Traffic Management

Browser

Kubernetes with Istio



Traffic Management – Web API Version 1

Cloud Native Starter

Articles

Title	Author	Twitter	Blog
Debugging Microservices running in Kubernetes	Niklas Heidloff	@nheidloff	Blog
Dockerizing Java MicroProfile Applications	Niklas Heidloff	@nheidloff	Blog
Install Istio and Kiali on IBM Cloud or Minikube	Harald Uebele	@harald_u	Blog
Three awesome TensorFlow.js Models for Visual Recognition	Niklas Heidloff	@nheidloff	Blog
Blue Cloud Mirror Architecture Diagrams	Niklas Heidloff	@nheidloff	Blog

Traffic Management – Web API Version 2

Cloud Native Starter

Articles

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Debugging Microservices running in Kubernetes	Niklas Heidloff	@nheidloff	Blog
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Three Minutes Demo of Blue Cloud Mirror	Niklas Heidloff	@nheidloff	Blog
IBM announced Managed Istio and Managed Knative	Niklas Heidloff	@nheidloff	Blog
Developing and debugging Microservices with Java	Niklas Heidloff	@nheidloff	Blog
Recent Java Updates from IBM	Niklas Heidloff	@nheidloff	Blog
Blue Cloud Mirror — (Don't) Open The Doors!	Harald Uebele	@harald_u	Blog

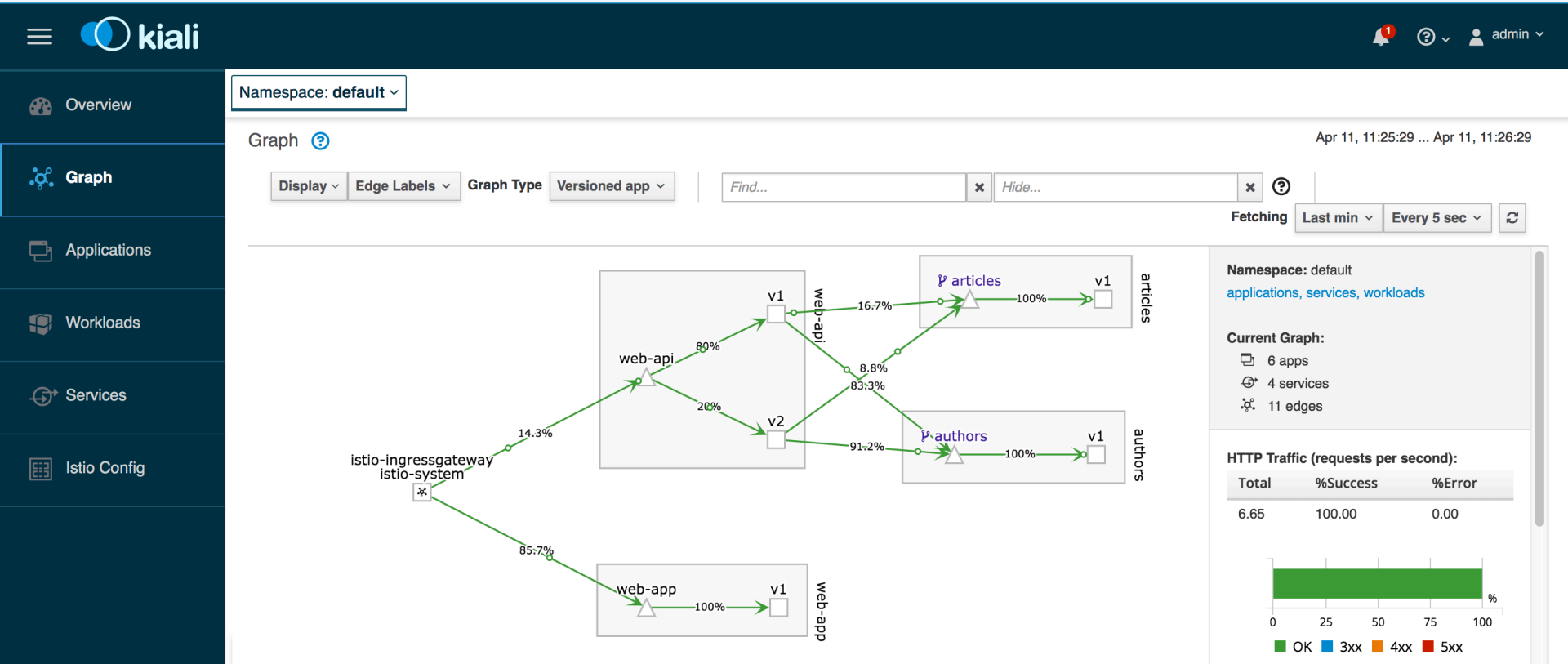
Traffic Management

Example: 80% / 20% splitting

ingress.yaml

```yaml
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: virtualservice-ingress-web-api-web-app
spec:
  hosts:
  - "*"
  gateways:
  - default-gateway-ingress-http
  http:
  - match:
    - uri:
        prefix: /web-api/v1/getmultiple
    route:
      - destination:
          host: web-api
          subset: v1
        weight: 80
      - destination:
          host: web-api
          subset: v2
        weight: 20
```

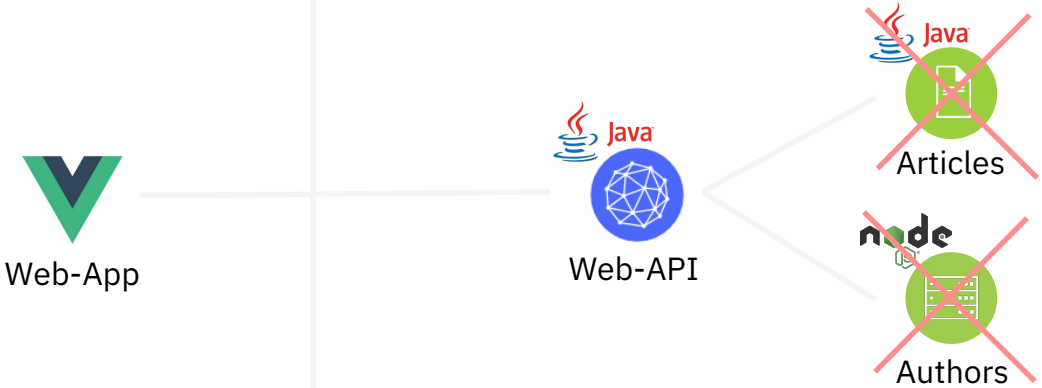
Traffic Management Demo



Example Application – Resiliency

Browser

Kubernetes with Istio



Resiliency

Authors service not available

Usage of default values

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Service.java

```
private List<Article> lastReadArticles;

public List<Article> fallbackNoArticlesService() {
  return lastReadArticles;
}

@Fallback(fallbackMethod = "fallbackNoArticlesService")
public List<Article> getArticles() throws NoDataAccess {

  List<Article> articles = new ArrayList<Article>();
  List<CoreArticle> coreArticles = new ArrayList<CoreArticle>();

  try {
    coreArticles = DataAccessManager.getArticlesDataAccess().getArticles(5);
  } catch (NoConnectivity e) {
    throw new NoDataAccess(e);
  }

  for (int index = 0; index < coreArticles.size(); index++) {
    CoreArticle coreArticle = coreArticles.get(index);
    Article article = new Article(coreArticle.id, coreArticle.title,
    coreArticle.title, coreArticle.author);
    try {
      Author author;
      author = DataAccessManager.getAuthorsDataAccess().getAuthor(coreArticle.author);
      article.authorBlog = author.blog;
      article.authorTwitter = author.twitter;
    } catch (Exception e) {
      article.authorBlog = "";
      article.authorTwitter = "";
    }
    articles.add(article);
  }
```

Resiliency

Articles service not available

MicroProfile fallback annotation

@nheidloff

Service.java

```
private List<Article> lastReadArticles;

public List<Article> fallbackNoArticlesService() {
  return lastReadArticles;
}

@Fallback(fallbackMethod = "fallbackNoArticlesService")
public List<Article> getArticles() throws NoDataAccess {

  List<Article> articles = new ArrayList<Article>();
  List<CoreArticle> coreArticles = new ArrayList<CoreArticle>();

  try {
    coreArticles = DataAccessManager.getArticlesDataAccess().getArticles(5);
  } catch (NoConnectivity e) {
    throw new NoDataAccess(e);
  }

  for (int index = 0; index < coreArticles.size(); index++) {
    CoreArticle coreArticle = coreArticles.get(index);
    Article article = new Article(coreArticle.id, coreArticle.title,
    coreArticle.title, coreArticle.author);
    try {
      Author author;
      author = DataAccessManager.getAuthorsDataAccess().getAuthor(coreArticle.author);
      article.authorBlog = author.blog;
      article.authorTwitter = author.twitter;
    } catch (Exception e) {
      article.authorBlog = "";
      article.authorTwitter = "";
    }
    articles.add(article);
  }
```

Resiliency Demo

Cloud Native Starter user@demo.email

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Resiliency Demo

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Authentication and Authorization

OpenID Connect

Identity layer on top of the OAuth 2.0 protocol

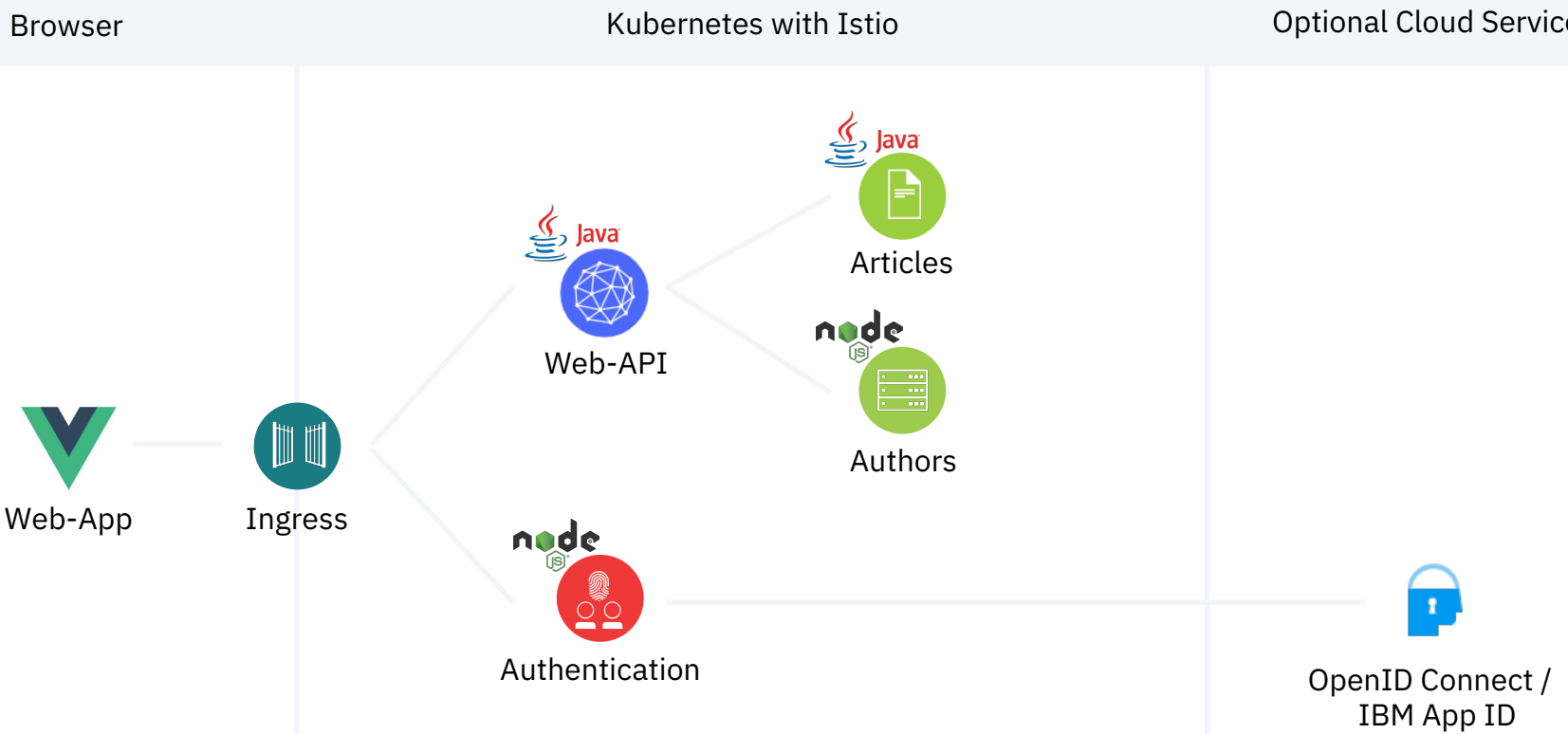
IBM App ID

IBM service to authenticate users and protect APIs

policy.yaml

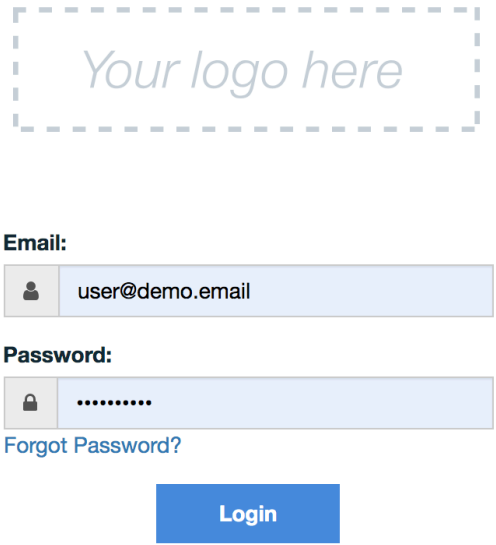
```yaml
apiVersion: "authentication.istio.io/v1alpha1"
kind: "Policy"
metadata:
  name: "protect-web-api"
spec:
  targets:
  - name: web-api
  origins:
  - jwt:
      issuer: "https://us-south.appid.cloud.ibm.com/oauth/v4/xxx"
      jwksUri: "https://us-south.appid.cloud.ibm.com/oauth/v4/xxx/publickeys"
      trigger_rules:
      - included_paths:
        - exact: /web-api/v1/create
  principalBinding: USE_ORIGIN
```

Example Application – Authentication and Authorization

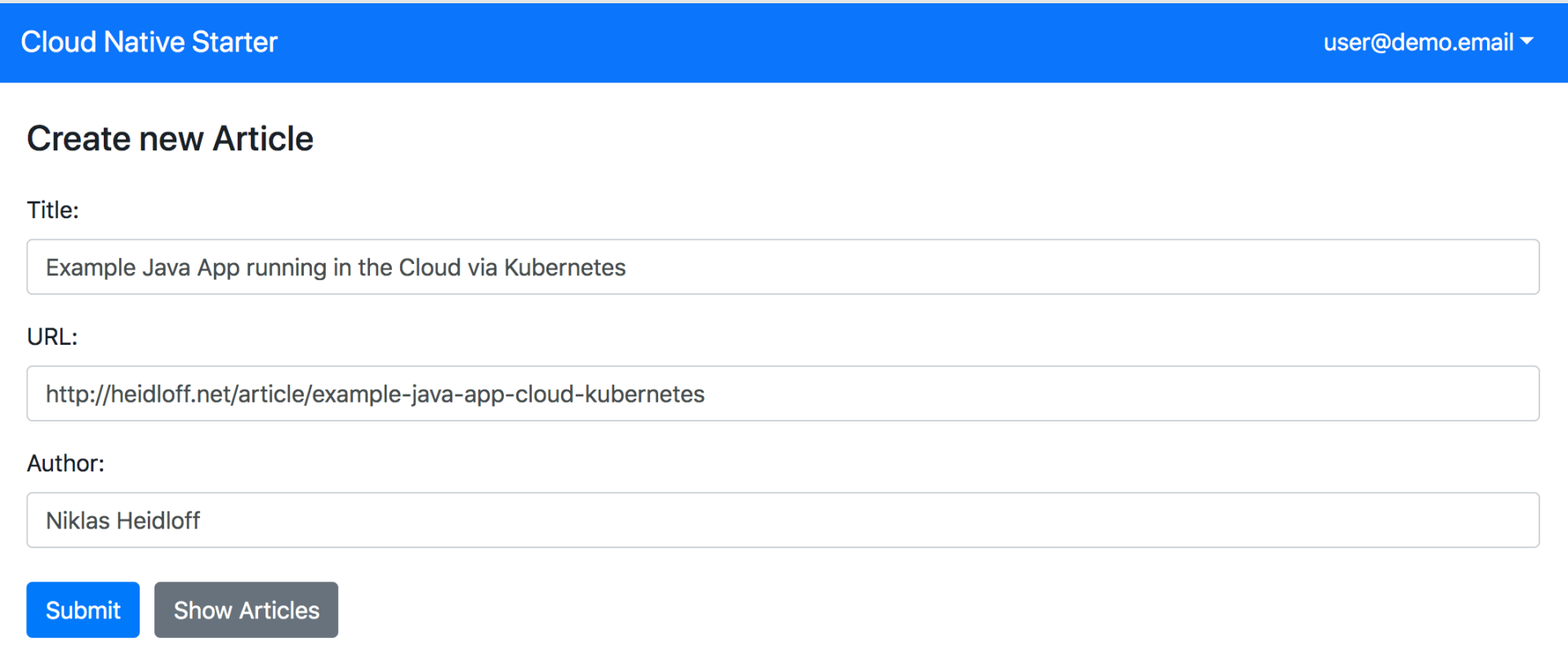


@nheidloff

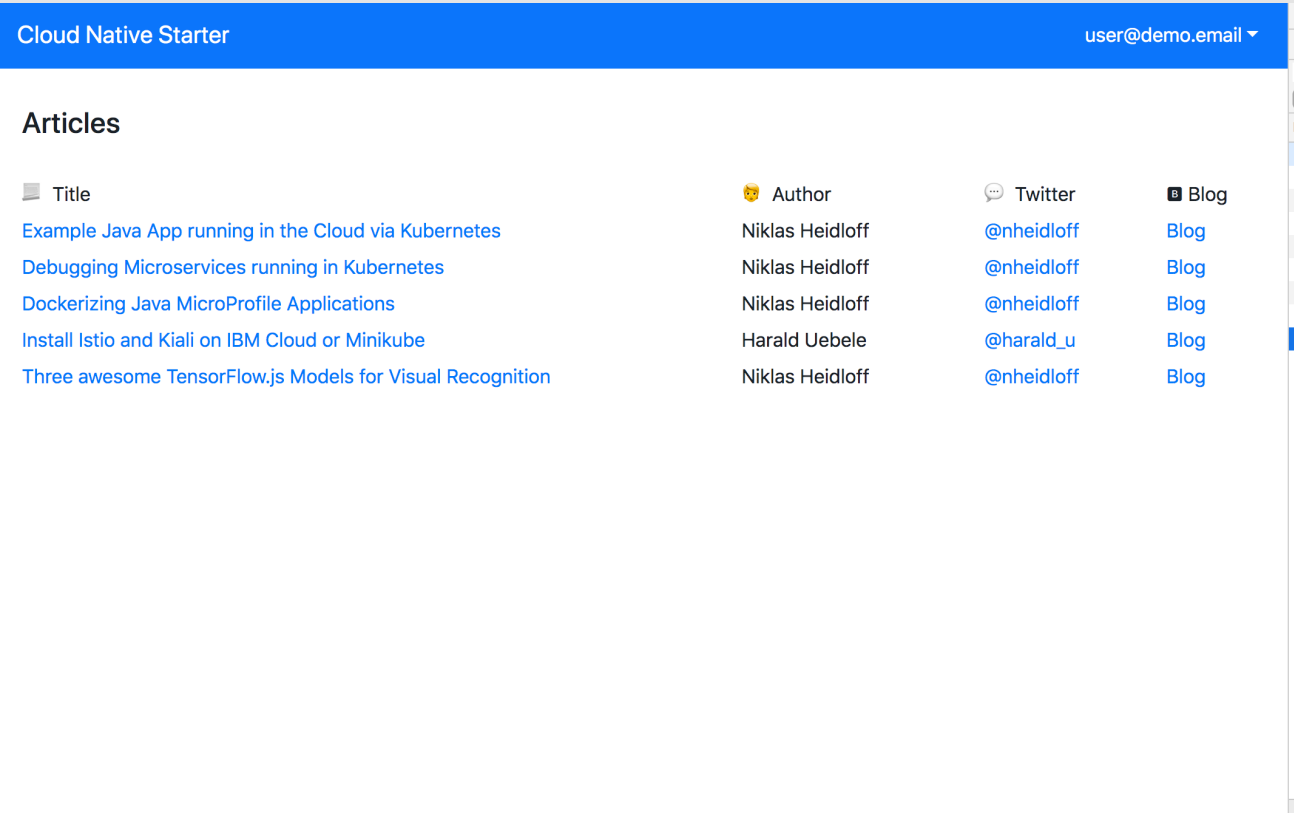
Authentication

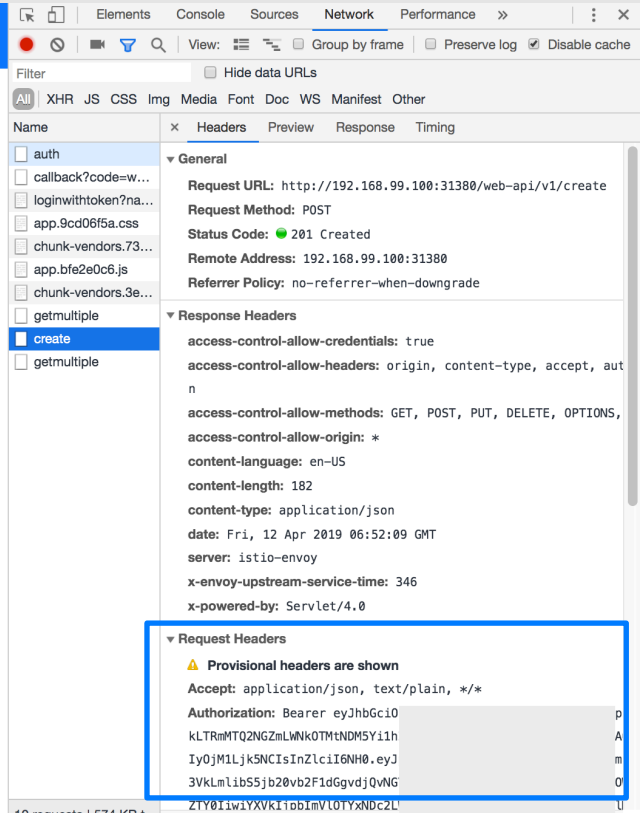


Authorization



Authorization





Authorization

Via MicroProfile

server.xml

```
<server description="OpenLiberty Server">

    <featureManager>
        <feature>webProfile-8.0</feature>
        <feature>microProfile-2.1</feature>
        <feature>usr:opentracingZipkin-0.31</feature>
        <feature>monitor-1.0</feature>
        <feature>mpJwt-1.1</feature>
        <feature>appSecurity-3.0</feature>
    </featureManager>

    <httpEndpoint id="defaultHttpEndpoint" host="*"
        httpPort="9080" httpsPort="9443"/>

    <mpMetrics authentication="false"/>

    <mpJwt id="jwt"
        issuer="https://us-south.appid.cloud.ibm.com/oauth/v4/xxx"
        jwksUri="https://us-south.appid.cloud.ibm.com/oauth/v4/xxx/publickeys"
        userNameAttribute="sub"
        audiences="ALL_AUDIENCES"/>

    <sslDefault sslRef="RpSSLConfig"/>
    <ssl id="RpSSLConfig" keyStoreRef="defaultKeyStore"
        trustStoreRef="validationKeystore"/>
    <keyStore id="defaultKeyStore" location="keystore.jceks"
        type="JCEKS" password="secret" />
    <keyStore id="validationKeystore" location="/config/key.jks"
        type="jks" password="changeit"/>
</server>
```

Authorization

Via MicroProfile

Manage.java

```
@RequestScoped
@Path("/v1")
public class Manage {

  @Inject
  private JsonWebToken jwtPrincipal;

  @POST
  @Path("/manage")
  @Produces(MediaType.APPLICATION_JSON)
  @Operation(summary = "Manage app", description = "Manage app")
  public Response manage() {
    System.out.println("com.ibm.web-api.apis.Manage.manage");
    System.out.println(this.jwtPrincipal);

    String principalEmail = this.jwtPrincipal.getClaim("email");
    if (principalEmail.equalsIgnoreCase("admin@demo.email")) {
      JsonObject output = Json.createObjectBuilder().
        add("message", "success").build();
      return Response.ok(output).build();
    }
```

Observability

Tracing

Logging

Monitoring

Metrics

Healthchecks

Microservices vs monolith

→ Higher complexity

→ Ephemeral

Chained invocations

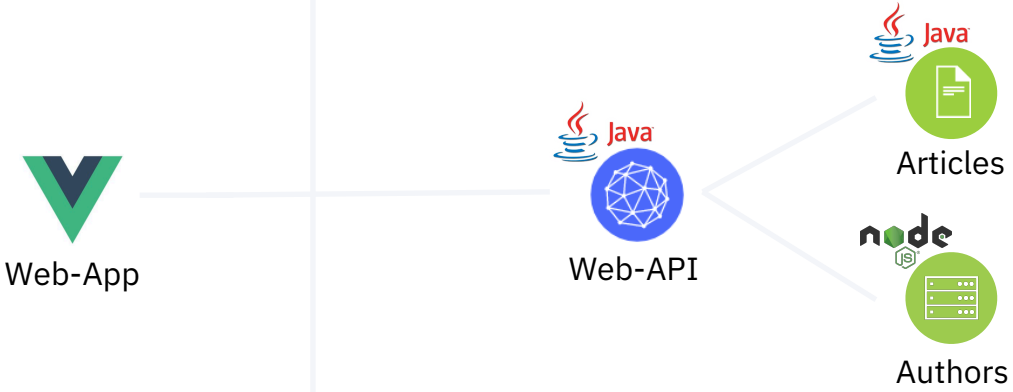
Kubernetes

→ 1 service = N pods

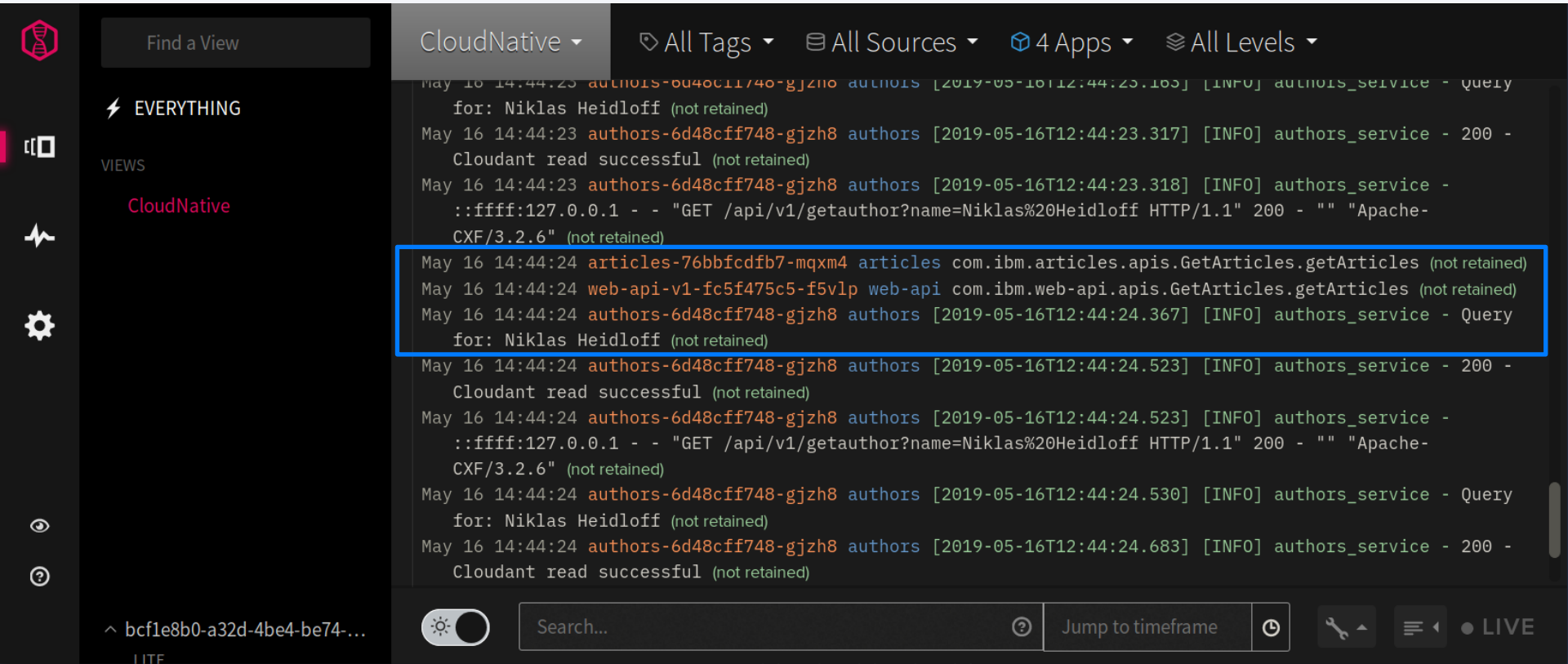
Example Application – Distributed Logging

Browser

Kubernetes with Istio



Distributed Logging



Example Application – Distributed Logging

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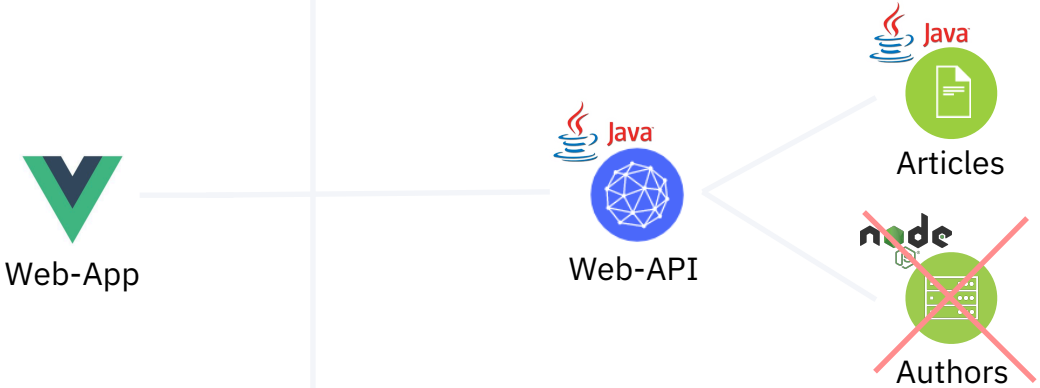
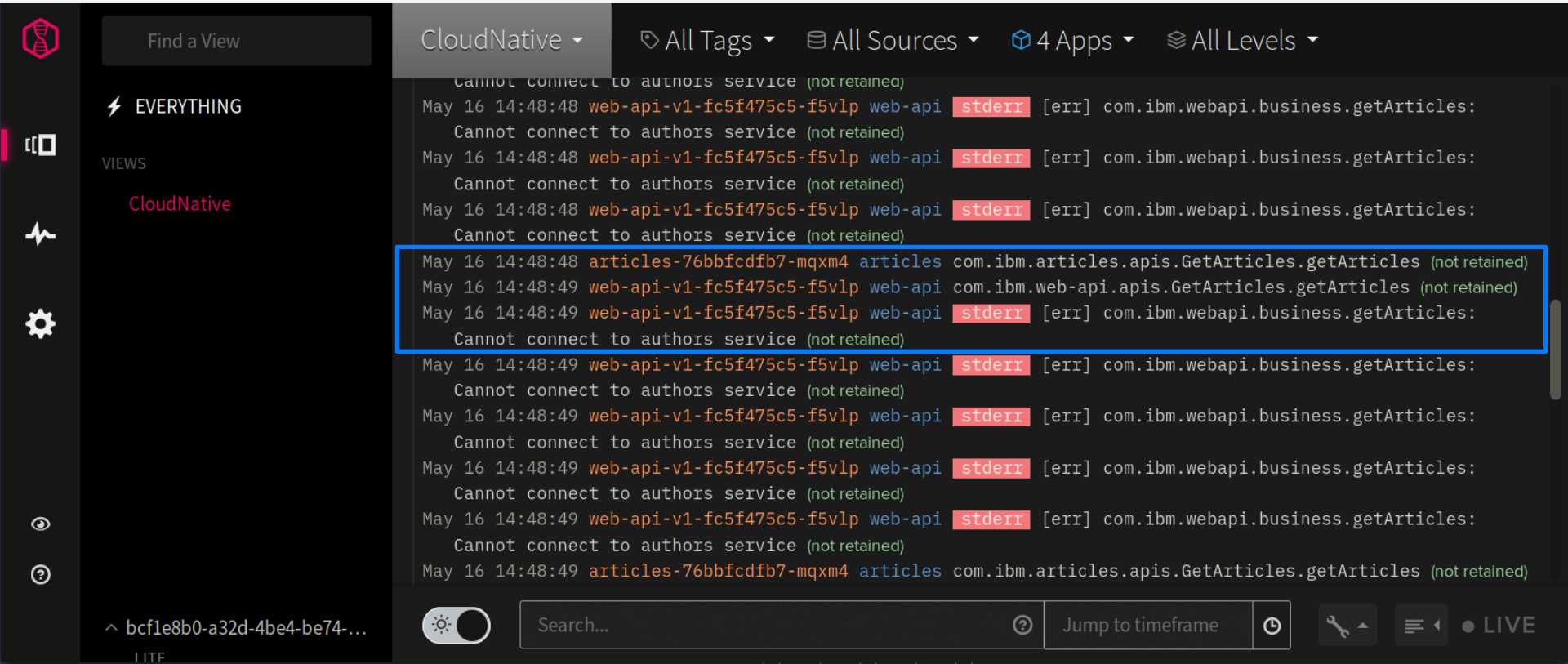


Distributed Logging



Tracing

OpenTracing

Vendor-neutral APIs and instrumentation for distributed tracing

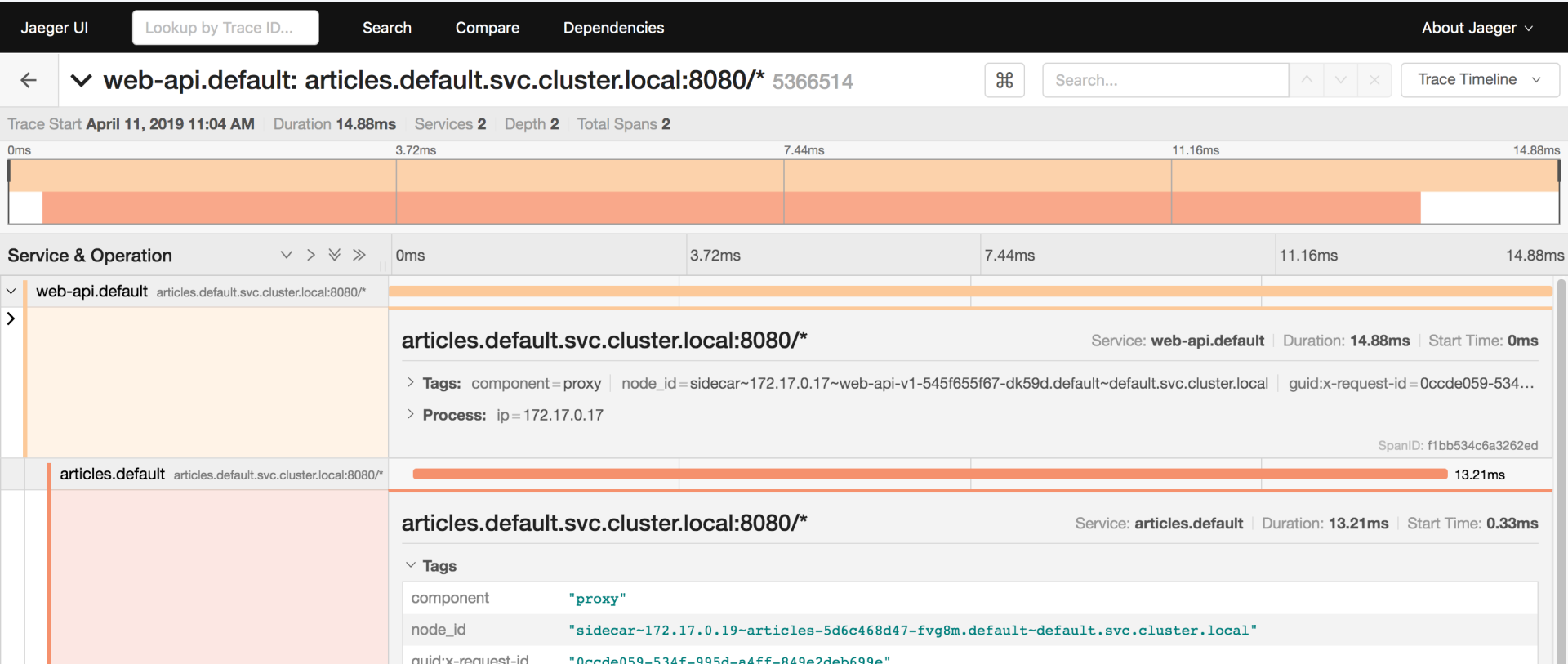
Jaeger and Zipkin

Open source distributed tracing systems

server.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="OpenLiberty Server">

    <featureManager>
        <feature>webProfile-8.0</feature>
        <feature>microProfile-2.1</feature>
        <feature>usr:opentracingZipkin-0.31</feature>
    </featureManager>

    <httpEndpoint id="defaultHttpEndpoint" host="*"
        httpPort="8080" httpsPort="9443"/>

</server>
```

Distributed Tracing



Metrics

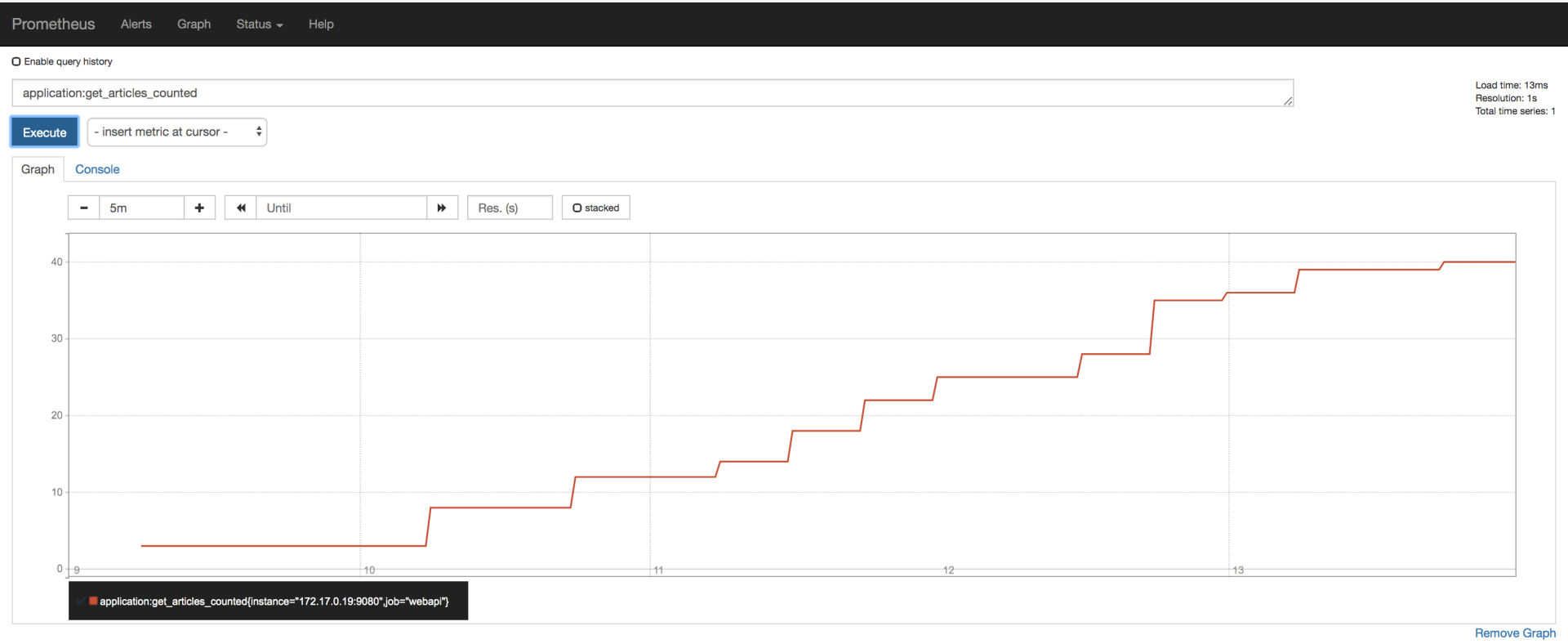
Prometheus

Monitoring system and time series database

GetArticles.java

```
@Timed(name = "getArticlesTimed",
       absolute = true,
       displayName = "web-api /getmultiple timer",
       description = "Time taken by getArticles")
@Counted(name = "getArticlesCounted",
       absolute = true,
       displayName = "web-api /getmultiple count",
       description = "Number of times getArticles has been invoked",
       monotonic = true)
@Metered(name = "getArticlesMetered",
       displayName = "web-api /getmultiple frequency",
       description = "Rate the throughput of getArticles")
@GET
@Path("/getmultiple")
@Produces(MediaType.APPLICATION_JSON)
public Response getArticles() {
```

Metrics


Prometheus
Alerts
Graph
Status
Help
Enable query history
application:get_articles_counted
Load time: 13ms
Resolution: 1s
Total time series: 1
Execute
- insert metric at cursor -
Graph
Console
5m
Until
Res. (s)
stacked
40
30
20
10
0
9
10
11
12
13
application:get_articles_counted{instance="172.17.0.19:9080",job="webapi"}
Remove Graph

Healthchecks

MicroProfile Health

Liveness probes and readiness probes

@nheidloff

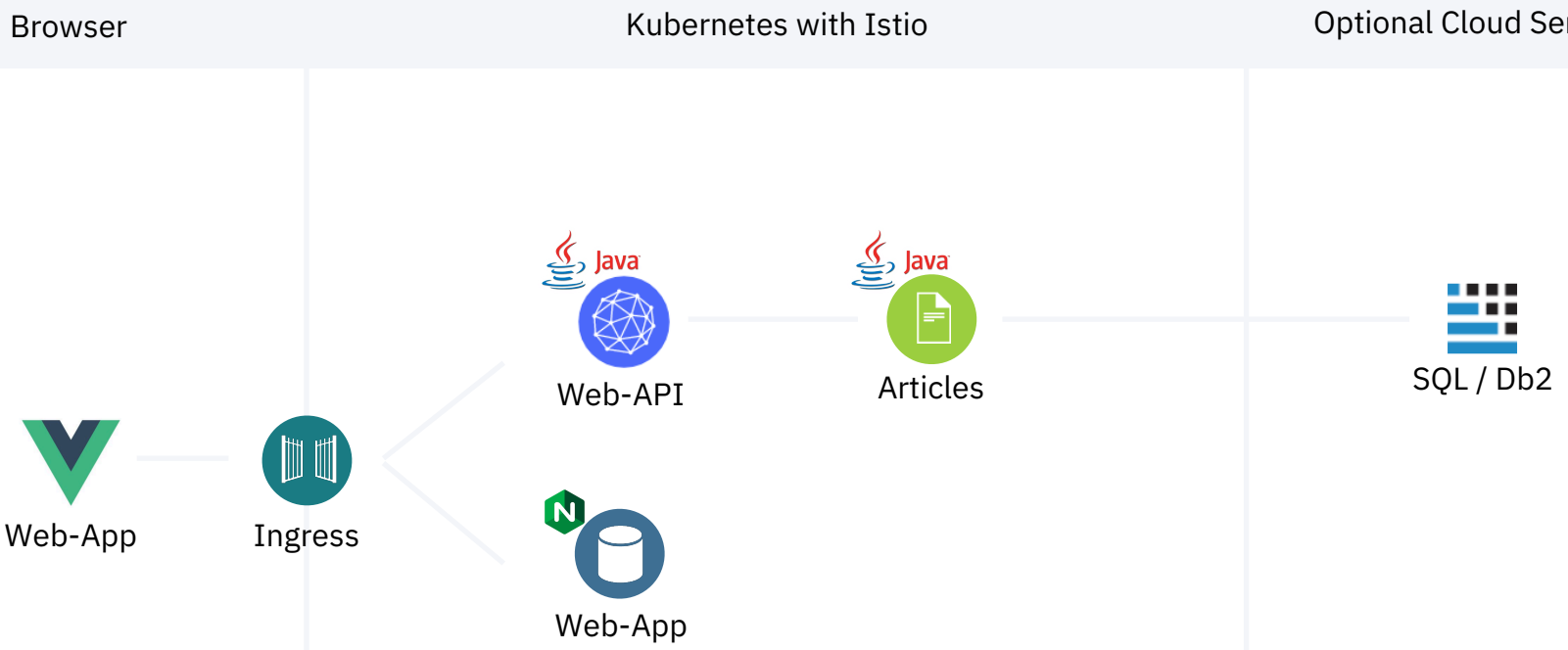
HealthEndpoint.java

```java
@Health
@ApplicationScoped
public class HealthEndpoint implements HealthCheck {

    @Override
    public HealthCheckResponse call() {
        return HealthCheckResponse.named("web-api").withData("web-api", "ok").up().build();
    }
}
```

Service.yaml

```yaml
kind: Deployment
apiVersion: apps/v1beta1
metadata:
  name: web-api-v1
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: web-api
        version: v1
    spec:
      containers:
      - name: web-api
        image: web-api:1
        ports:
        - containerPort: 9080
        livenessProbe:
          exec:
            command: ["sh", "-c", "curl -s http://localhost:9080/"]
          initialDelaySeconds: 20
        readinessProbe:
          exec:
            command: ["sh", "-c", "curl -s http://localhost:9080/health | grep -q web-api"]
          initialDelaySeconds: 40
      restartPolicy: Always
```

Persistence via JPA



Persistence

Via JPA

server.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<server description="OpenLiberty Server">

    <featureManager>
        <feature>webProfile-8.0</feature>
        <feature>microProfile-2.1</feature>
        <feature>usr:opentracingZipkin-0.31</feature>
    </featureManager>

    <httpEndpoint id="defaultHttpEndpoint" host="*"
        httpPort="8080" httpsPort="9443"/>

    <library id="DB2JCCLib">
        <fileset dir="${shared.resource.dir}"
            includes="jcc*.jar"/>
    </library>

    <dataSource id="articlejpadatasource"
                jndiName="jdbc/articlejpadatasource">
        <jdbcDriver libraryRef="DB2JCCLib" />
        <properties.db2.jcc databaseName="BLUDB"
            portNumber="50000"
            serverName="DB2-SERVER"
            user="DB2-USER"
            password="DB2-PASSWORD" />
    </dataSource>
</server>
```

Persistence

Via JPA

ArticleEntity.java

```
@Entity(name = "Article")
@Table(name = "Article")
@NamedQuery(name = "Article.findAll", query = "SELECT e FROM Article e")
@NamedQuery(name = "Article.findArticle", query = "SELECT a FROM Article a WHERE "
    + "a.title = :title AND a.url = :url AND a.author = :author")
public class ArticleEntity implements Serializable {
    private static final long serialVersionUID = 1L;

    @GeneratedValue(strategy = GenerationType.AUTO)
    @Id
    @Column(name = "articleId")
    private int id;

    @Column(name = "articleTitle")
    private String title;

    @Column(name = "articleUrl")
    private String url;

    @Column(name = "articleAuthor")
    private String author;

    @Column(name = "creationDate")
    private String creationDate;

    public ArticleEntity() {
    }
```

Configuration

Via MicroProfile

kubernetes.yaml

```yaml
kind: Deployment
apiVersion: apps/v1beta1
metadata:
  name: articles
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: articles
        version: v1
    spec:
      containers:
      - name: articles
        image: articles:1
        ports:
        - containerPort: 8080
        env:
        - name: samplescreation
          valueFrom:
            configMapKeyRef:
              name: articles-config
              key: samplescreation
        - name: inmemory
          valueFrom:
            configMapKeyRef:
              name: articles-config
              key: inmemory
      restartPolicy: Always
---
kind: ConfigMap
apiVersion: v1
metadata:
  name: articles-config
data:
  samplescreation: CREATE
  inmemory: USE_IN_MEMORY_STORE
---
```

Configuration

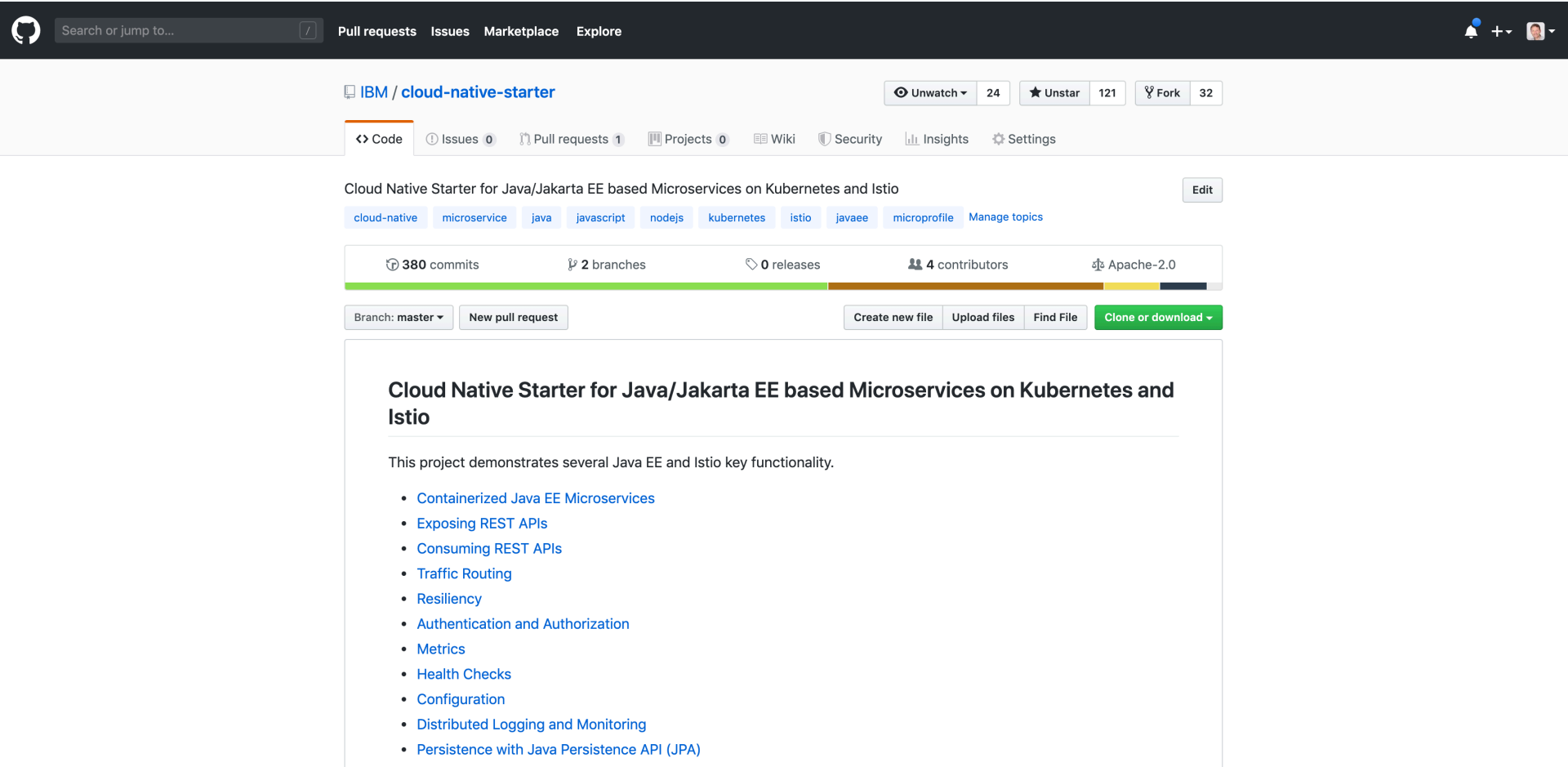
Via MicroProfile

CoreService.java

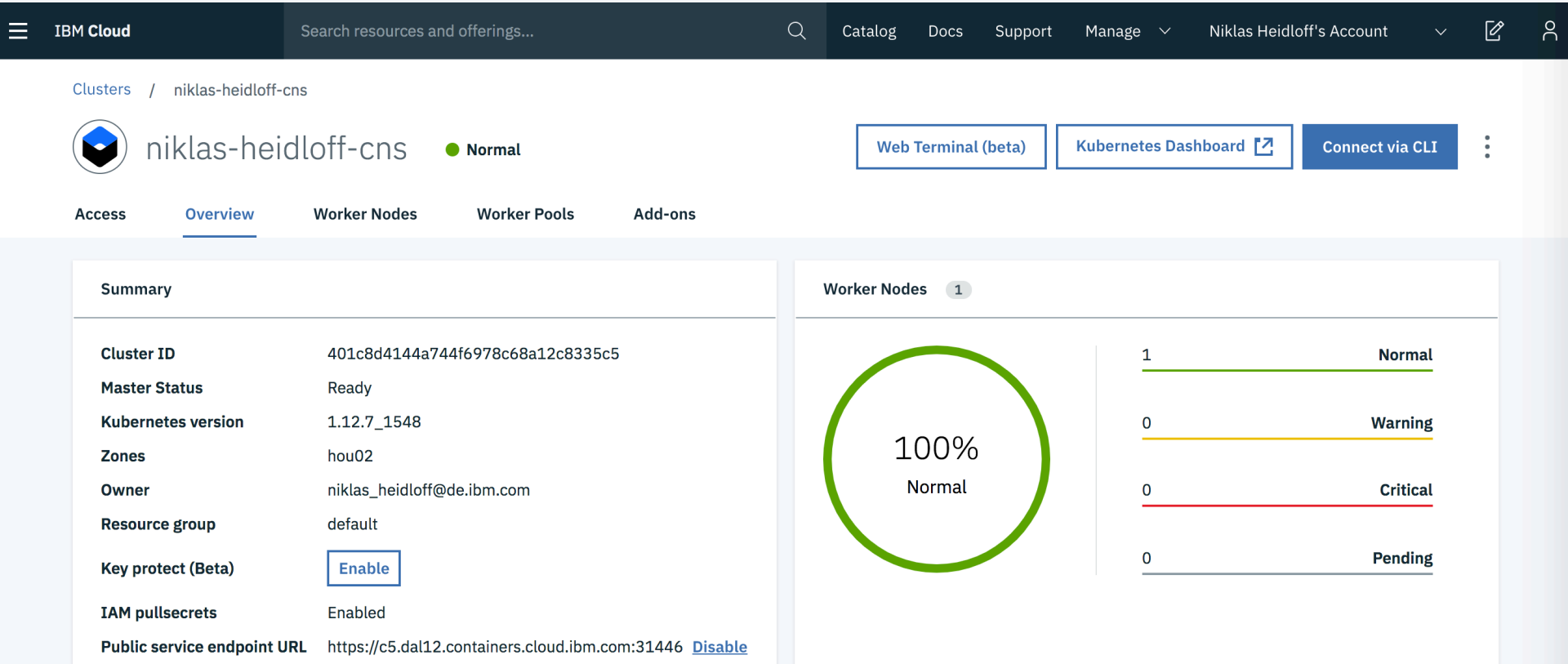
```
@ApplicationScoped
public class CoreService {

  private static final String CREATE_SAMPLES = "CREATE";
  private static final String USE_IN_MEMORY_STORE = "USE_IN_MEMORY_STORE";

  @Inject
  @ConfigProperty(name = "inmemory", defaultValue = USE_IN_MEMORY_STORE)
  private String inmemory;

  @Inject
  @ConfigProperty(name = "samplescreation", defaultValue = "dontcreate")
  private String samplescreation;

  @Inject
  private DataAccessManager dataAccessManager;

  @PostConstruct
  private void addArticles() {
    if (inmemory.equalsIgnoreCase(USE_IN_MEMORY_STORE)) {
      if (samplescreation.equalsIgnoreCase(CREATE_SAMPLES))
        addSampleArticles();
    }
  }
```

Try out the end-to-end microservices example cloud-native-starter!

Documentation



IBM Cloud Kubernetes Service including Istio and Knative



Summary

Get the code →

Leverage platforms as much as possible

Use frameworks for app specific logic

IBM loves open source

Kubernetes and Istio

OpenJ9 & AdoptOpenJDK

MicroProfile

Open Liberty

IBM Developer

developer.ibm.com

IBM Cloud Lite account

ibm.biz/nheidloff


IBM