How to develop your first cloud-native Applications with Java

Niklas Heidloff
Developer Advocate, IBM
@nheidloff

Harald Uebele
Developer Advocate, IBM
@Harald_U

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

Cloud-native applications provide new capabilities, which challenge developers

- New tasks
- Old tasks in new context

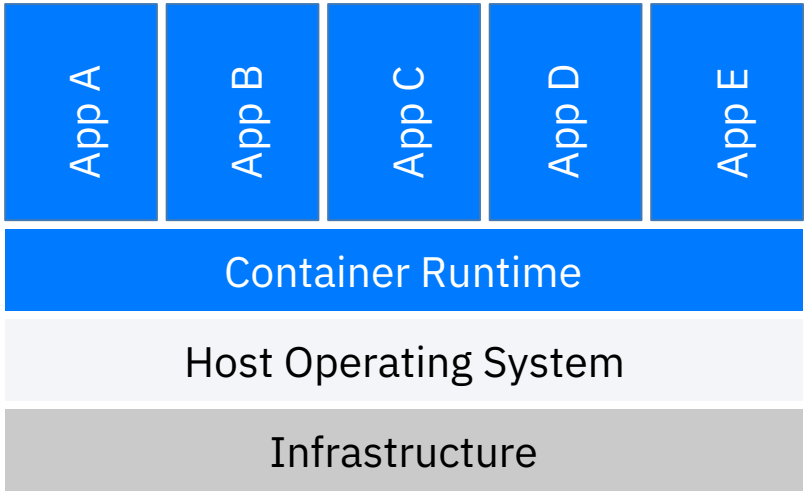
Service discovery and traffic management

Distributed monitoring, logging and tracing

Authentication and authorization between services

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

docker.com



Java Image

Open source stack

OpenJ9 0.12.1

OpenJDK 8u202-b08 from AdoptOpenJDK

Open Liberty 18.0.0.4

MicroProfile 2.1

Dockerfile

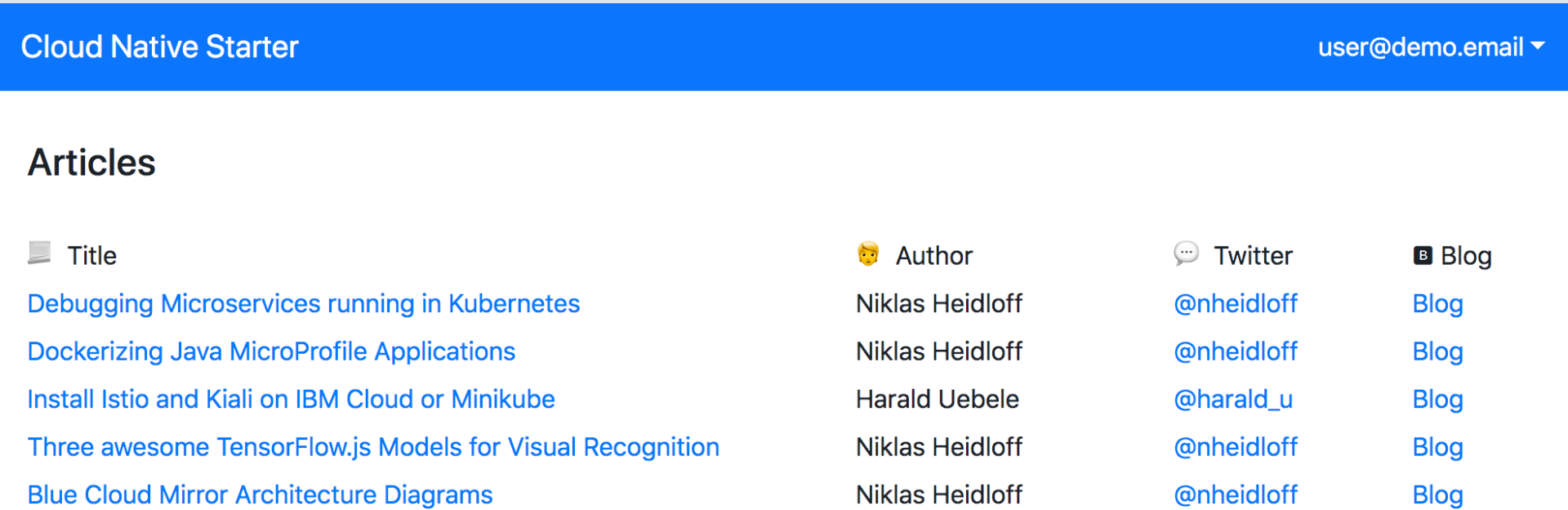
```
FROM open-liberty:microProfile2-java11

COPY liberty/server.xml /config/

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

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

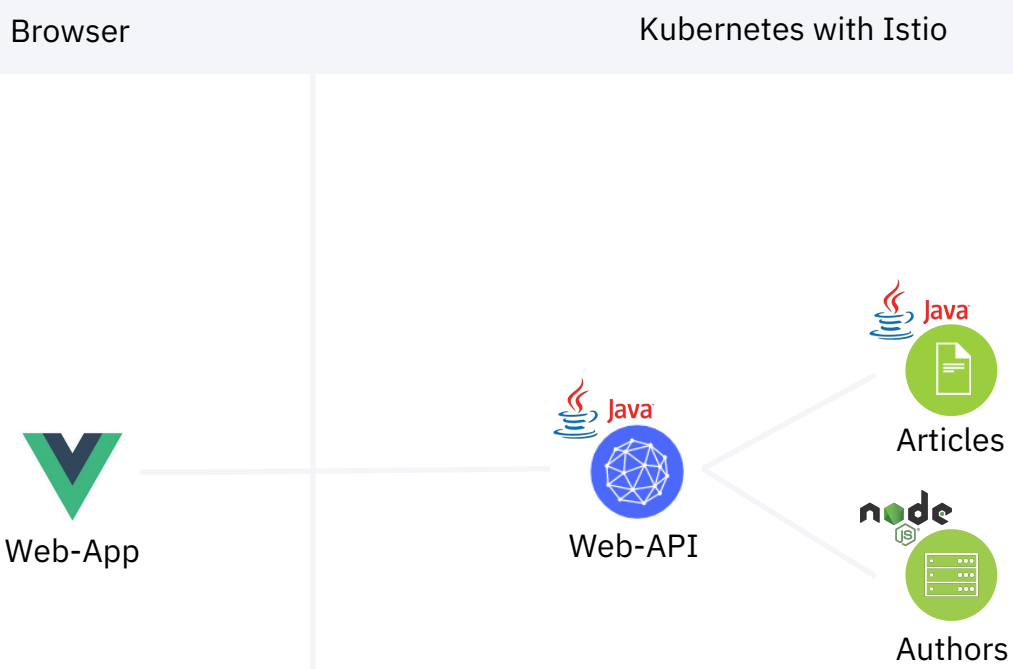
kubernetes.io

kubernetes

Example Application



Example Application – REST APIs



Exposing REST APIs

JAX-RS

Java API for RESTful Web Services

@nheidloff @Harald_U

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

@nheidloff @Harald_U

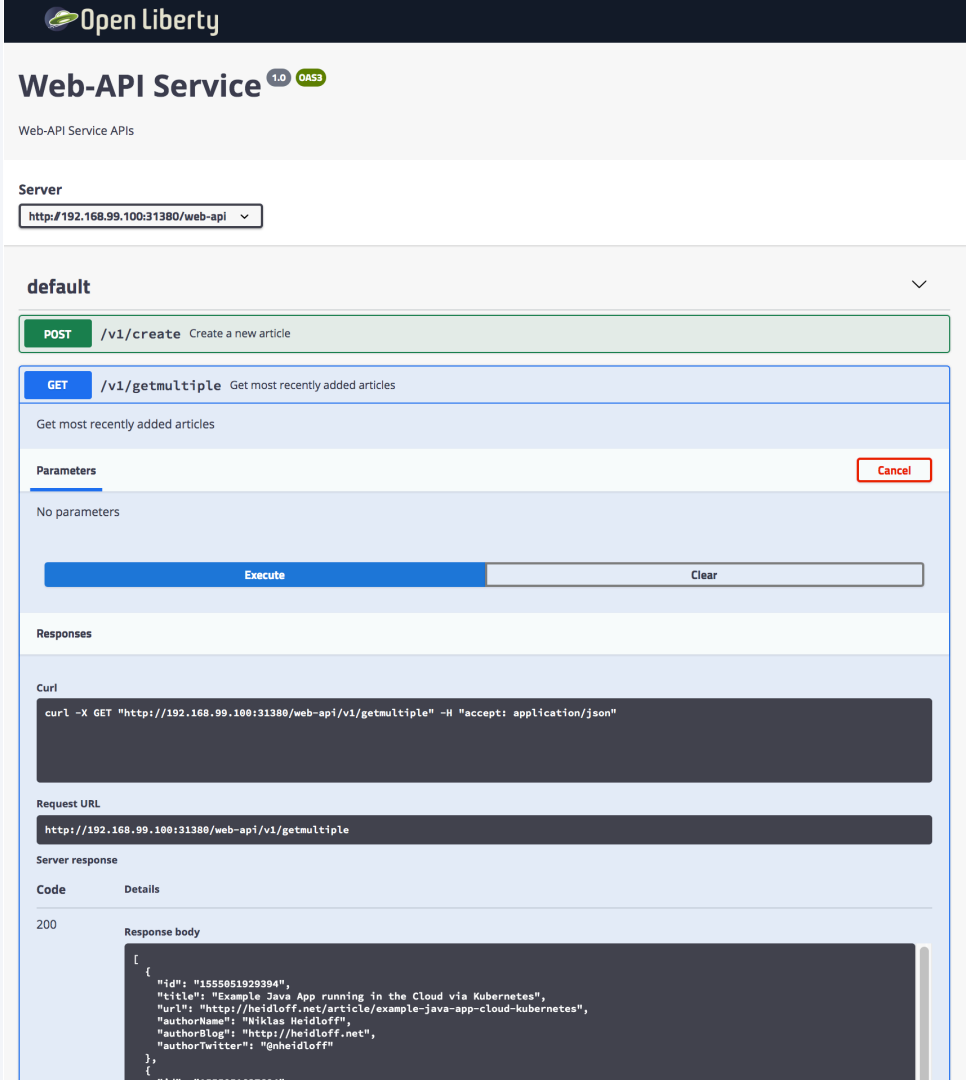
GetArticles.java

```
@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



@nheidloff @Harald_U

Consuming REST APIs

MicroProfile Rest Client

Type-safe approach to invoke RESTful services

@nheidloff @Harald_U

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);
```

Consuming REST APIs

MicroProfile Rest Client

Type-safe approach to invoke RESTful services

@nheidloff @Harald_U

AuthorsService.java

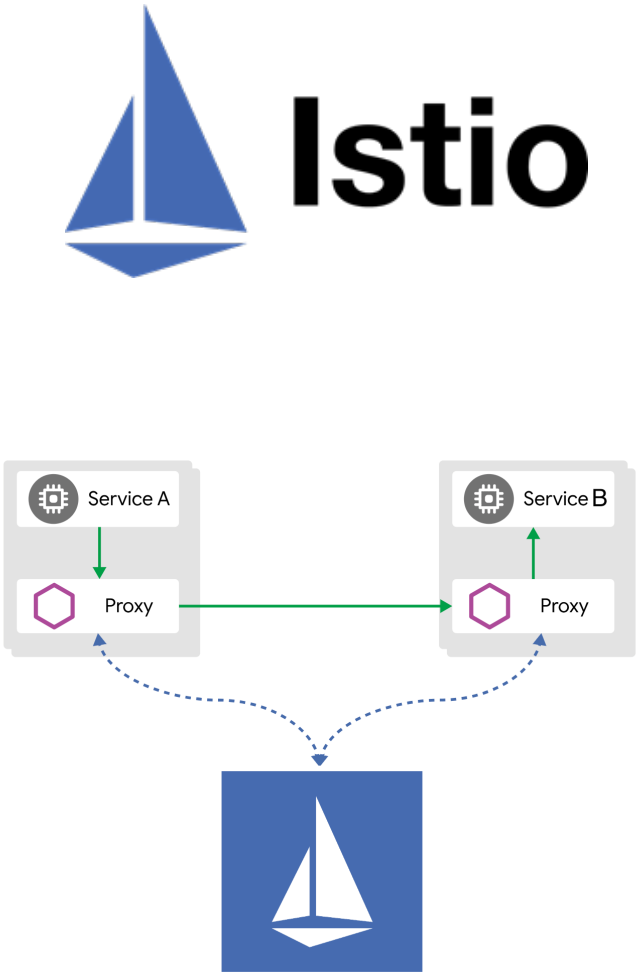
```
@RegisterProvider(ExceptionMapperArticles.class)
public interface AuthorsService {

  @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);
```

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

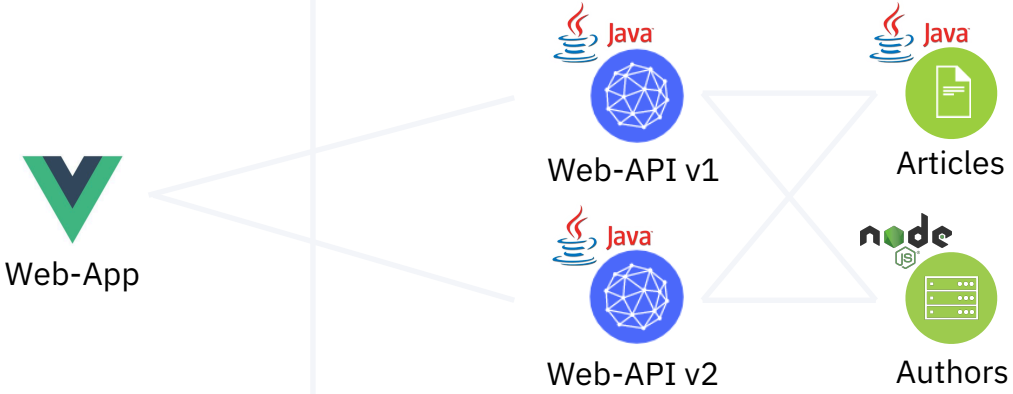
`github.com/istio/istio`



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

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
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

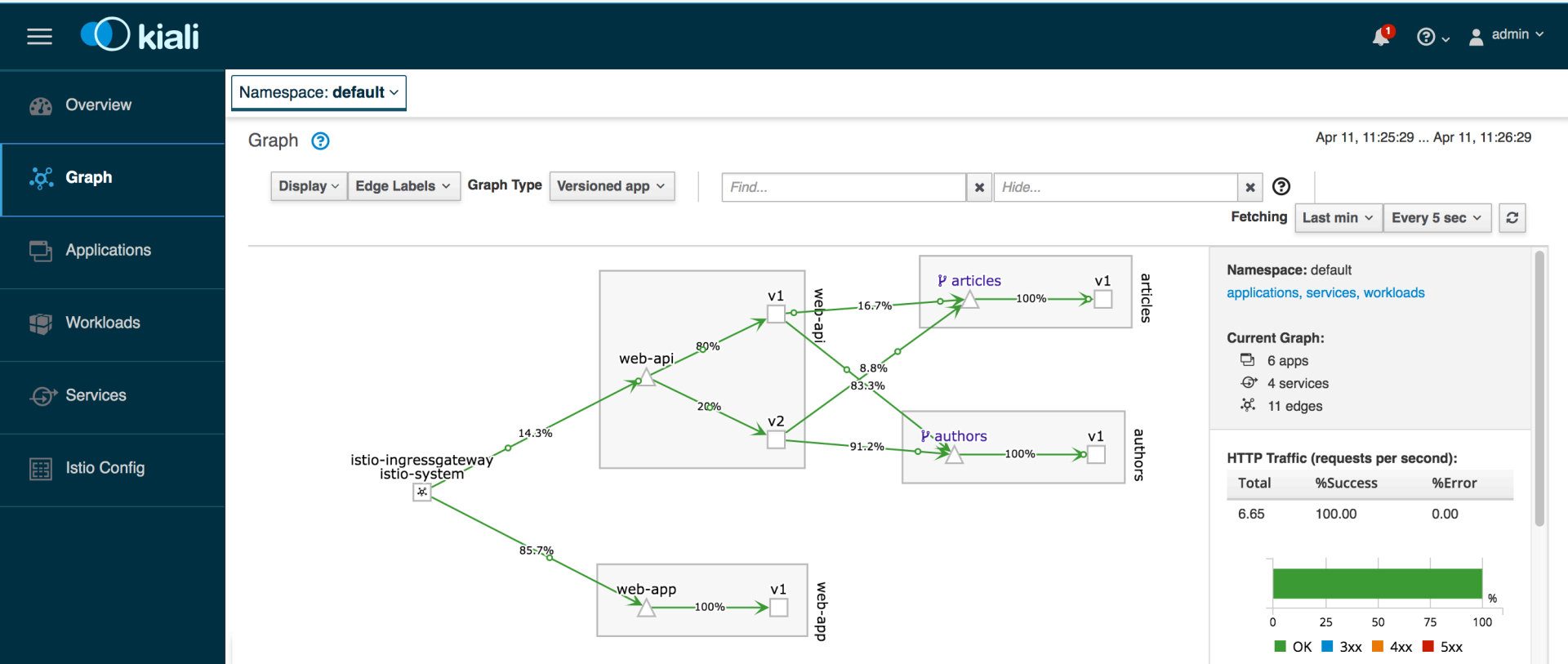
Traffic Management

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



“Optimizing Enterprise Java for a Microservices Architecture.

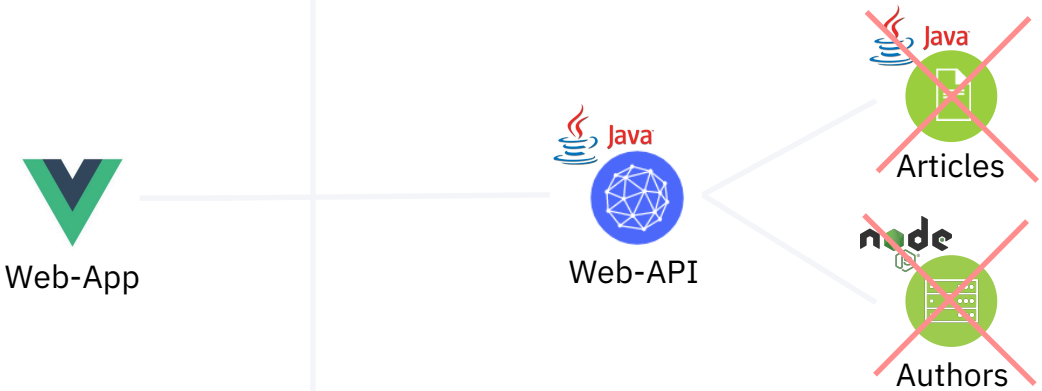
[...] by innovating [...] with a goal of standardization.”

`microprofile.io`

Example Application – Resiliency

Browser

Kubernetes with Istio



Resiliency

Authors service not available

Usage of default values

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 @Harald_U

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

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

Resiliency Demo

Cloud Native Starter user@demo.email

Articles

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

Authentication and Authorization

OpenID Connect

Identity layer on top of the OAuth 2.0 protocol

IBM App ID

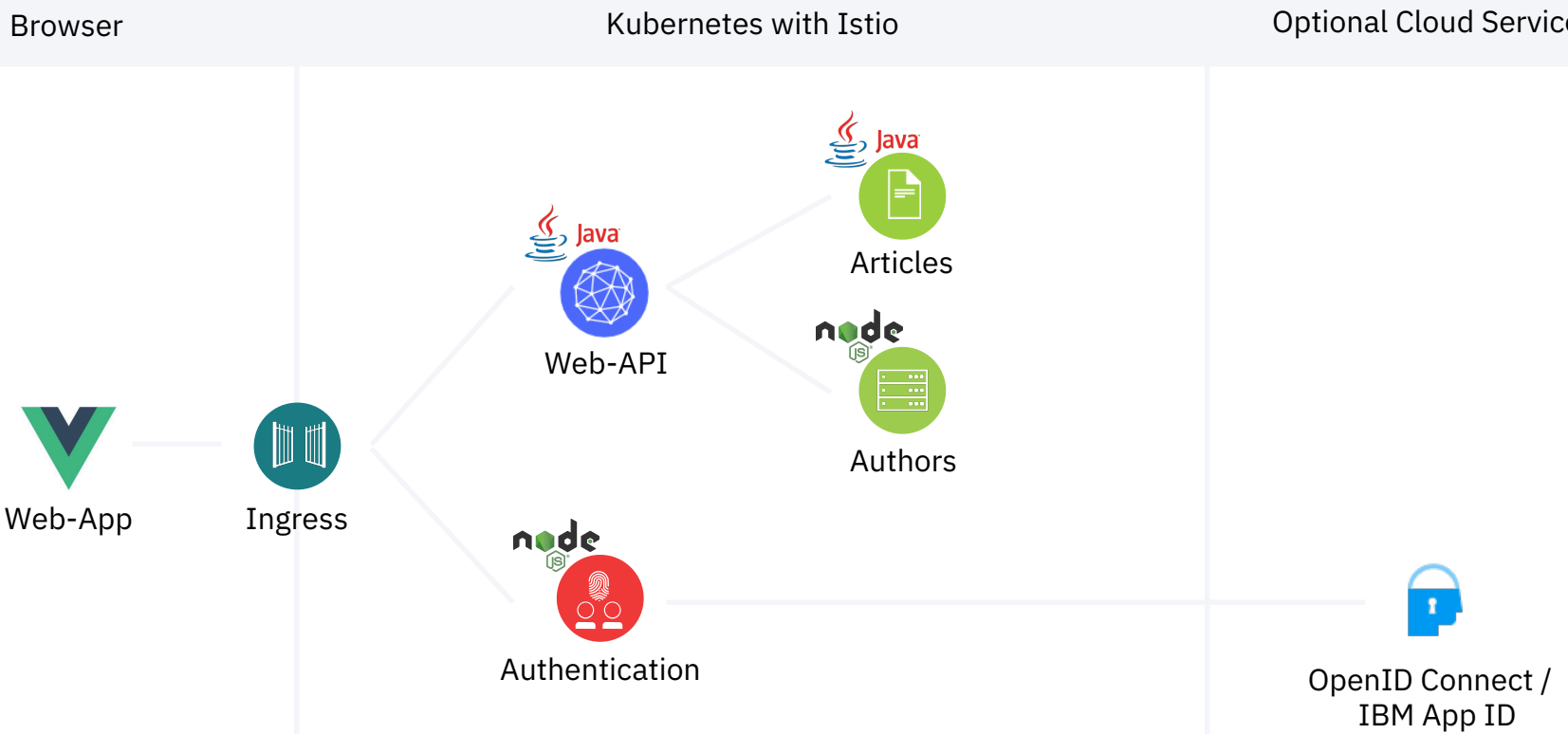
IBM service to authenticate users and protect APIs

policy.yaml

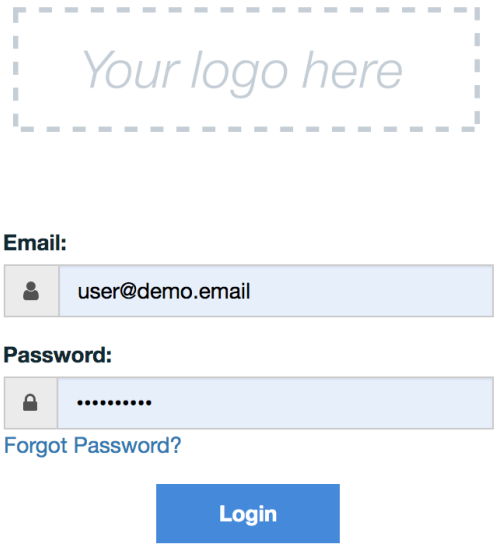
```yaml
apiVersion: "authentication.istio.io/v1alpha1"
kind: "Policy"
metadata:
  name: "protect-web-api"
spec:
  targets:
  - name: web-api
  origins:
  - jwt:
      issuer: "https://us-south.appid.cloud.ibm.com/oauth/v4/xxx"
      jwksUri: "https://us-south.appid.cloud.ibm.com/oauth/v4/xxx/publickeys"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

@nheidloff @Harald_U

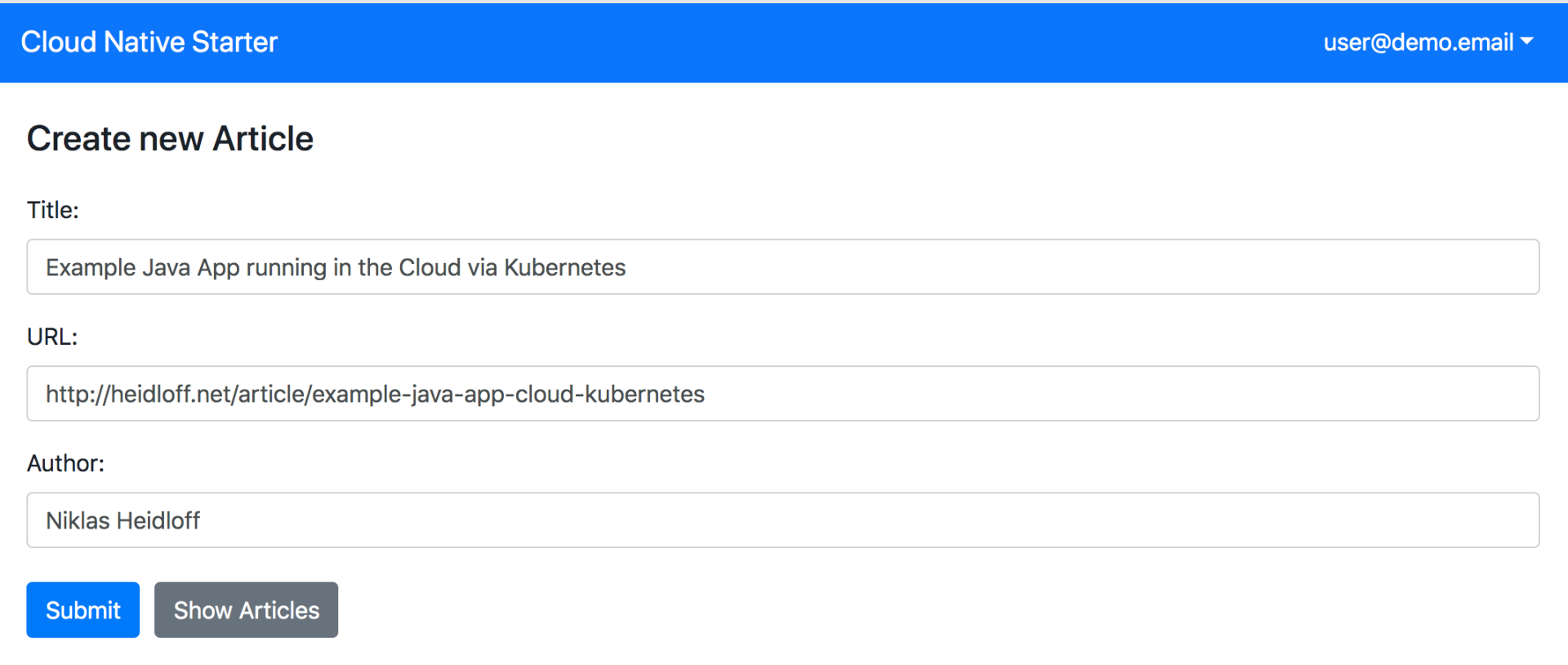
Example Application – Authentication and Authorization



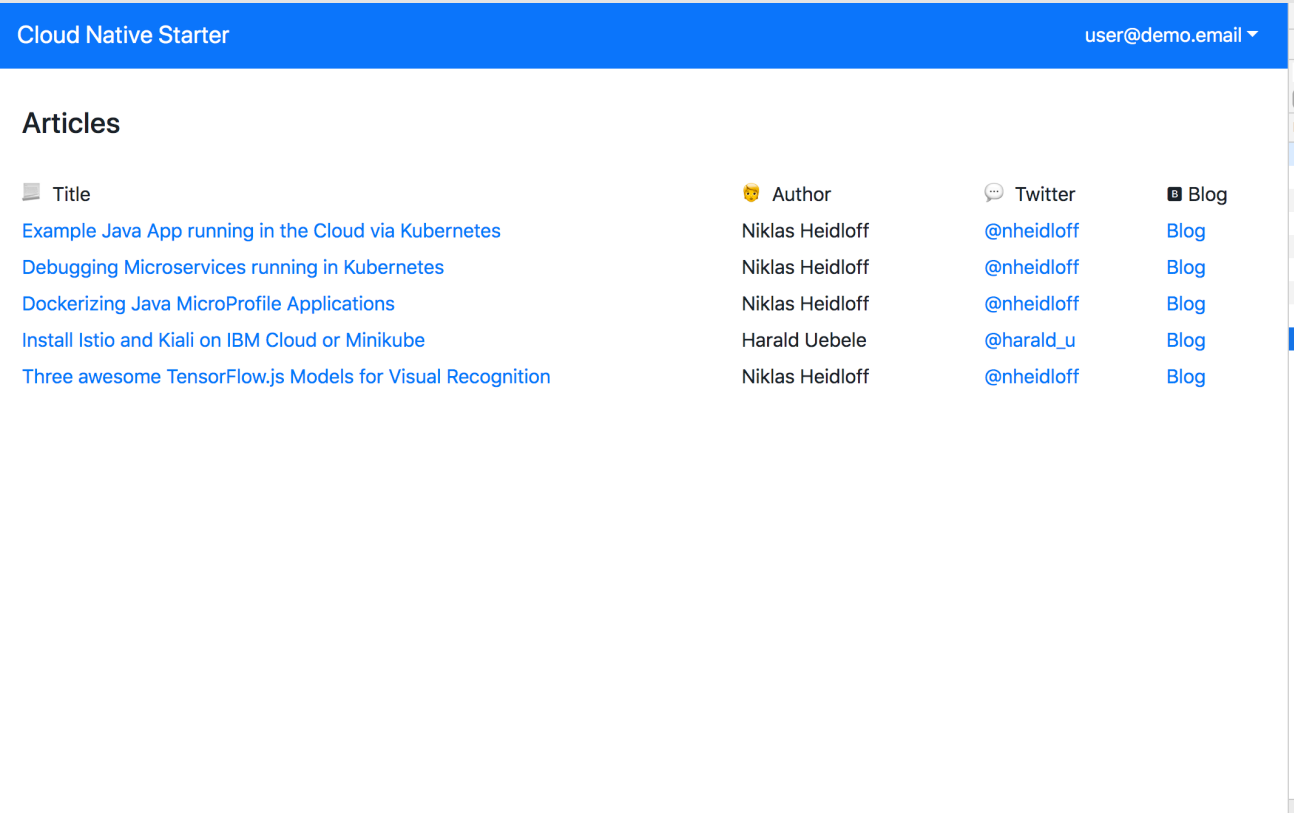
Authentication

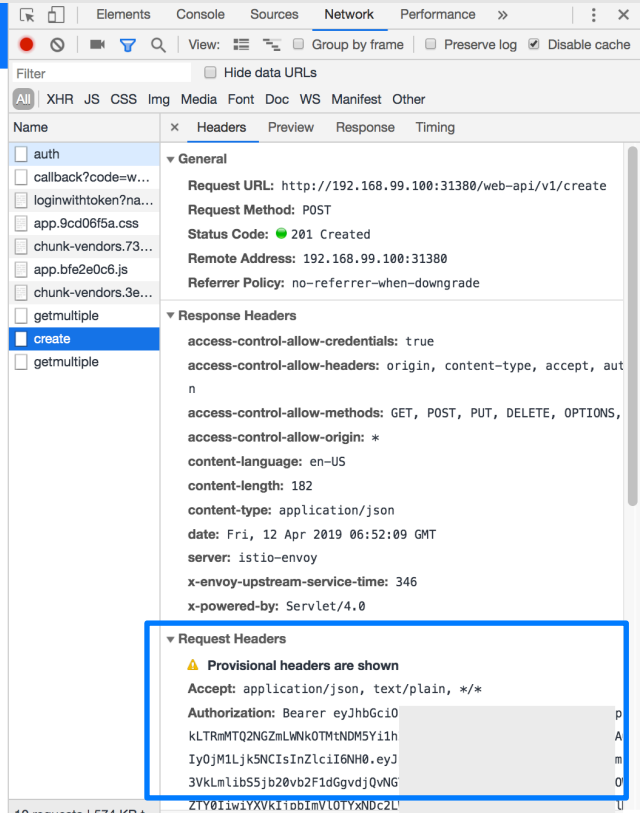


Authorization



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>
```

@nheidloff @Harald_U

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

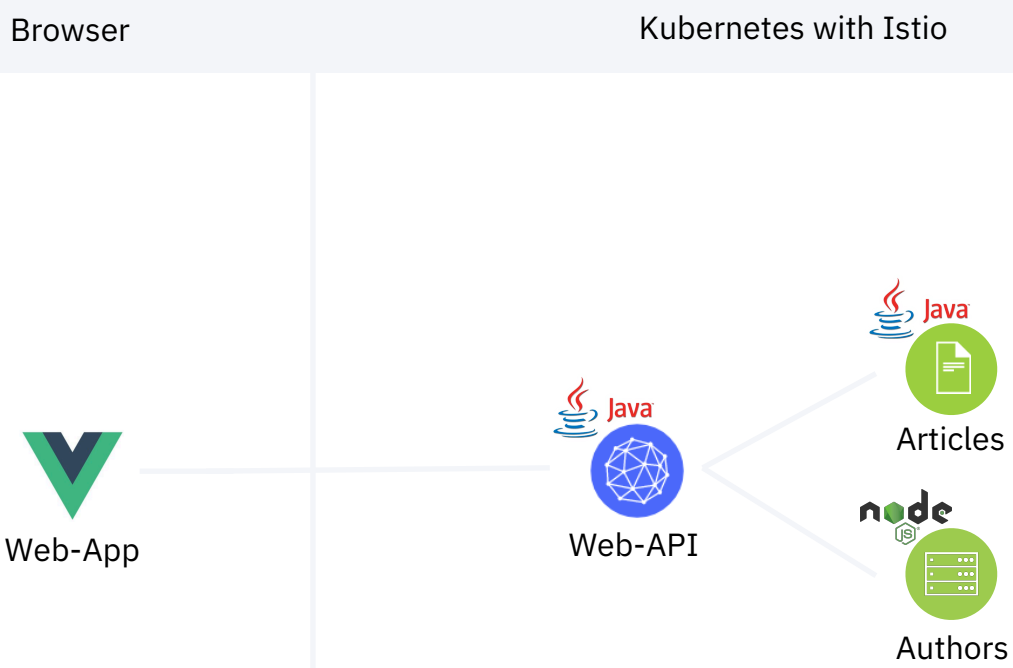
→ Ephemeral

Chained invocations

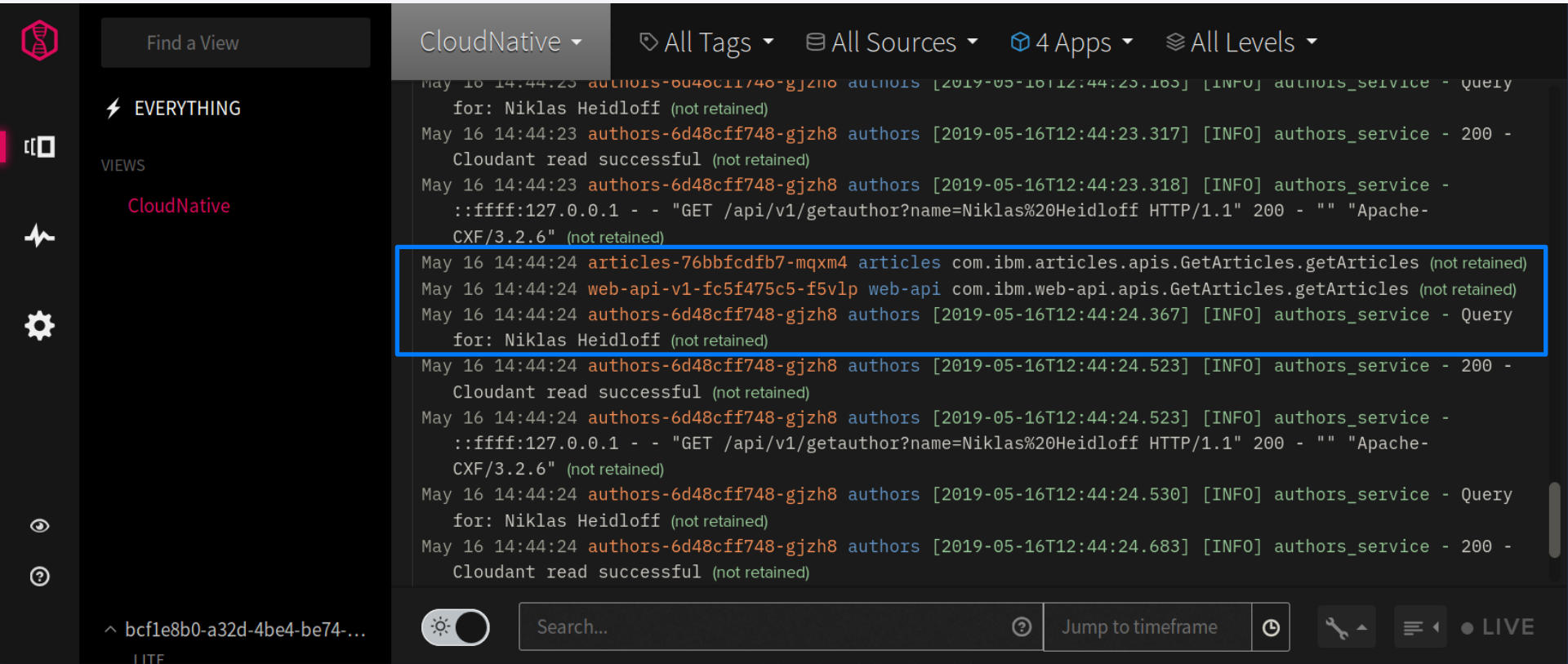
Kubernetes

→ 1 service = N pods

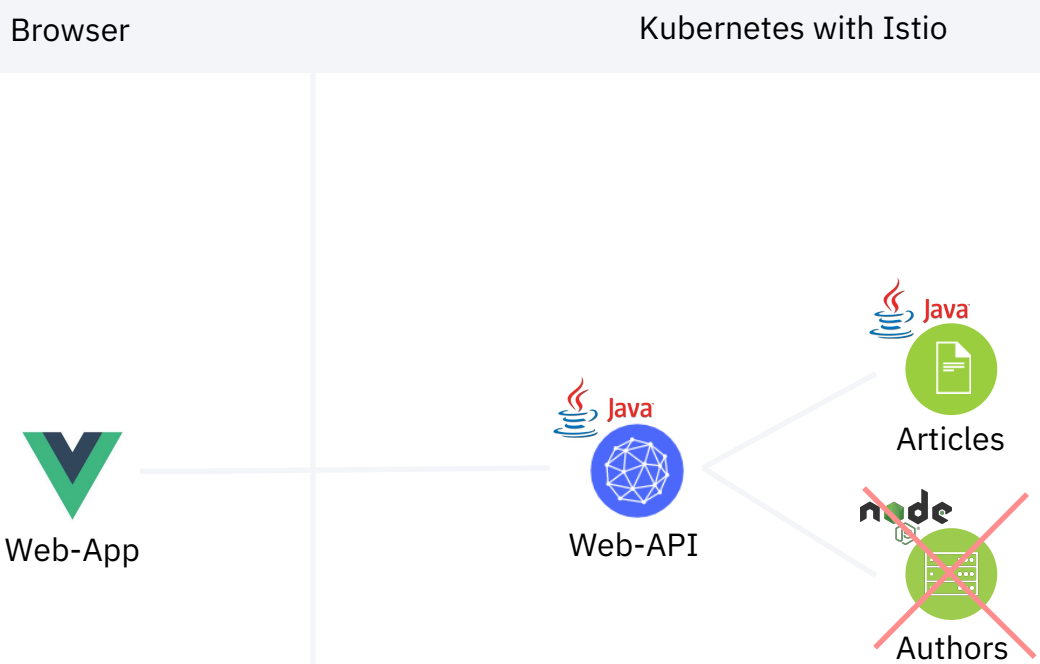
Example Application – Distributed Logging



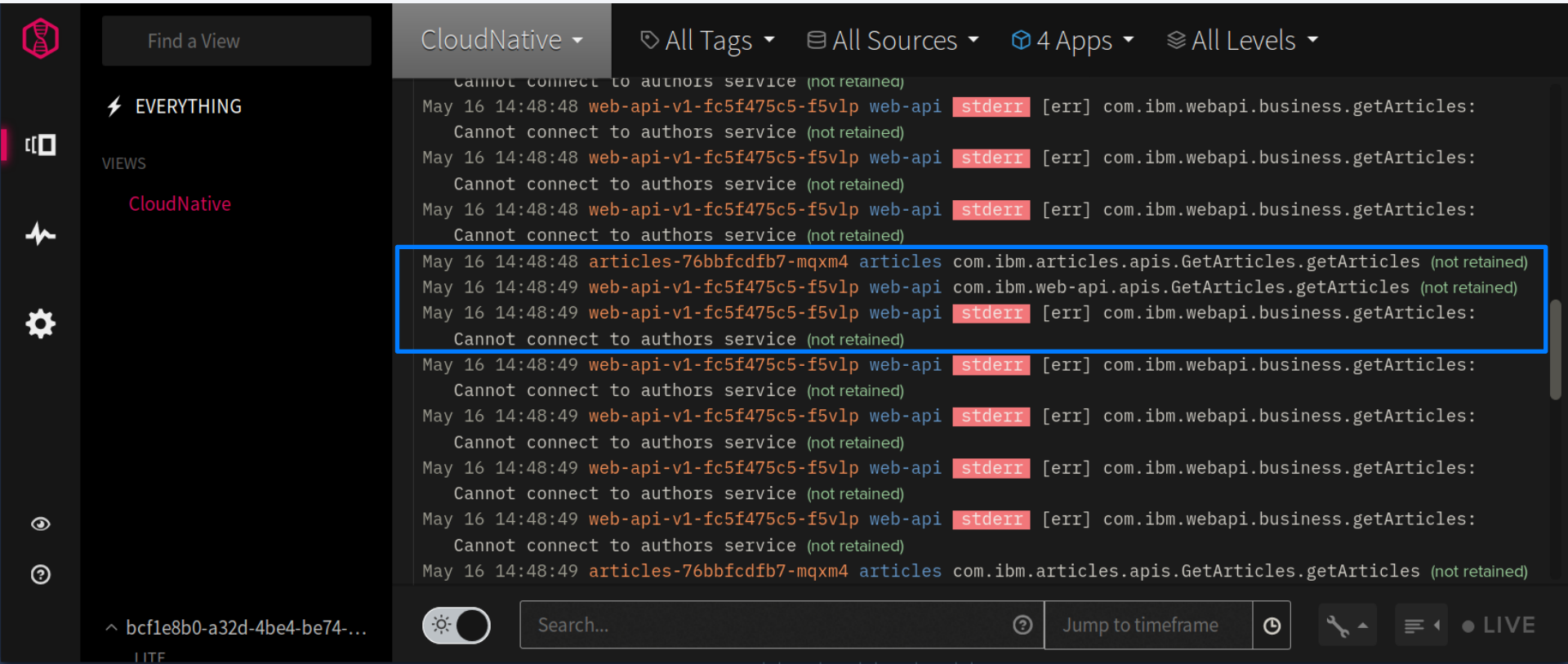
Distributed Logging



Example Application – Distributed Logging



Distributed Logging



Tracing

OpenTracing

Vendor-neutral APIs and instrumentation for distributed tracing

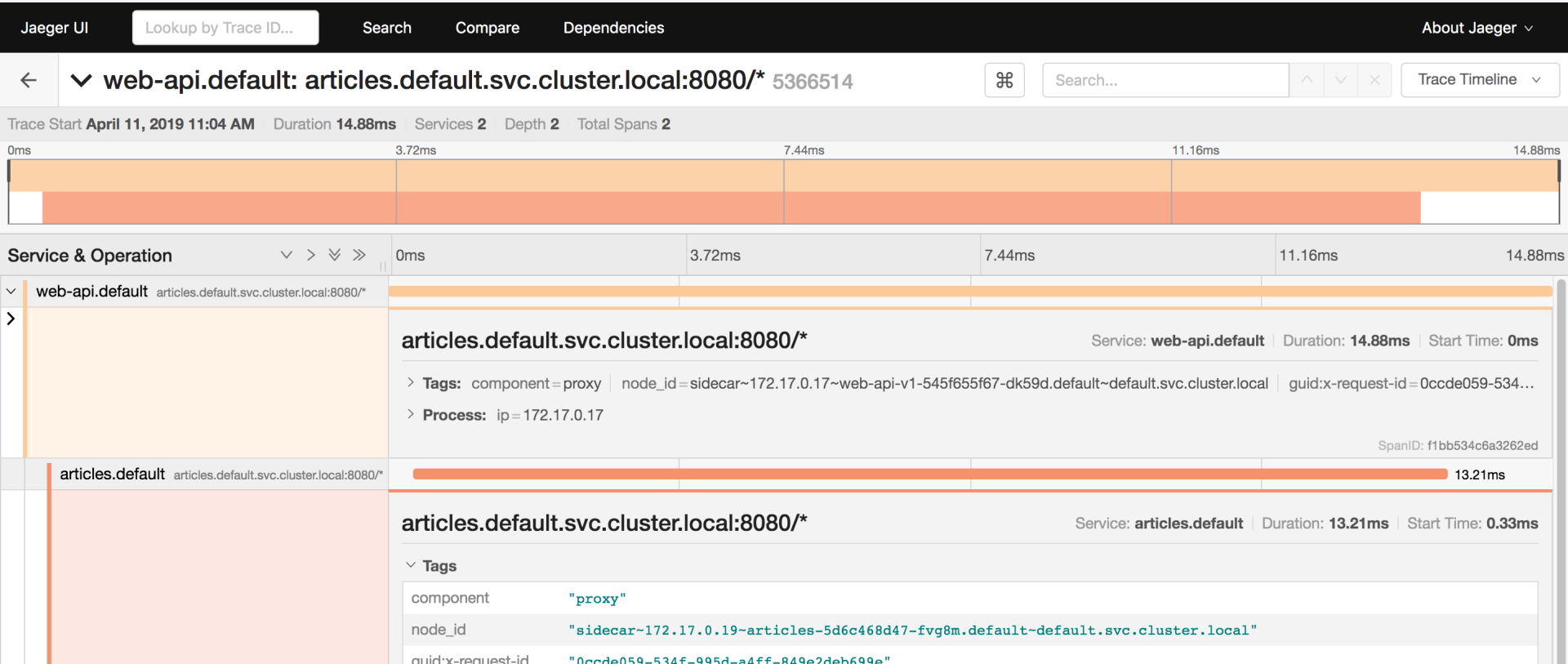
Jaeger and Zipkin

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

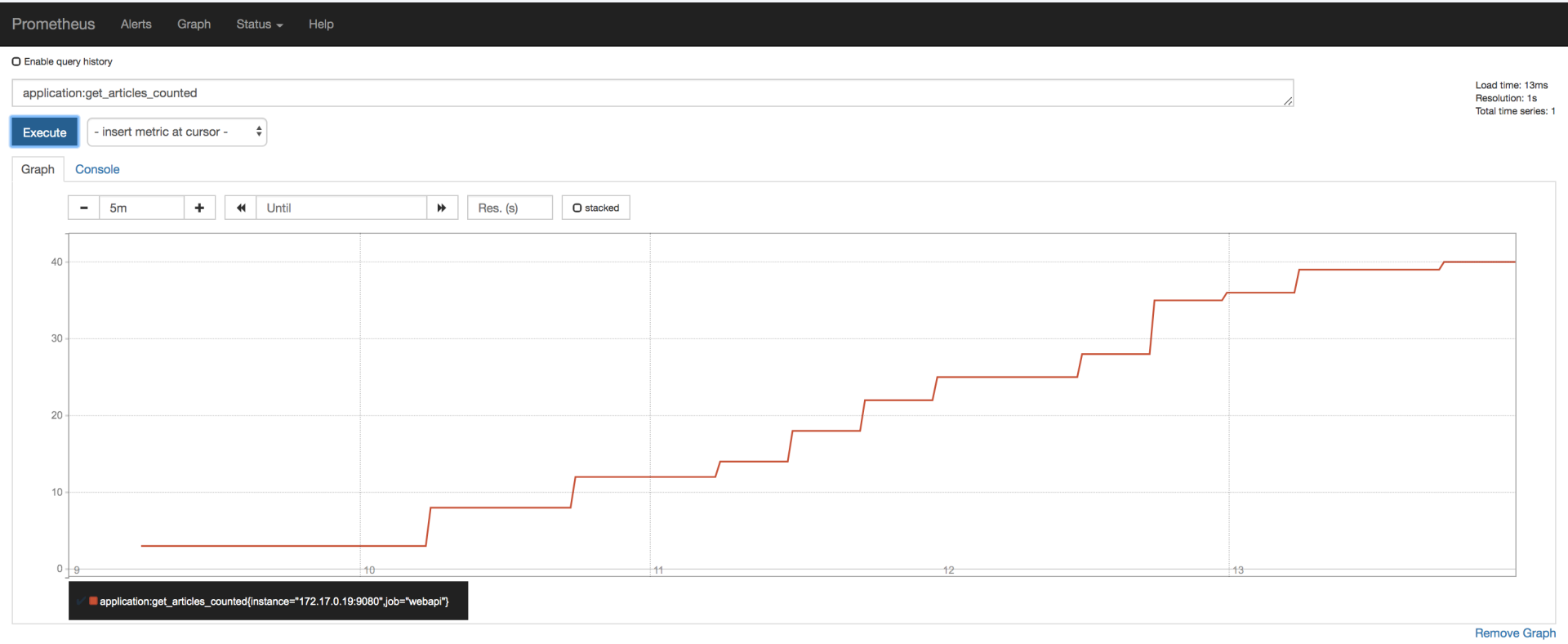
Prometheus

Monitoring system and time series database

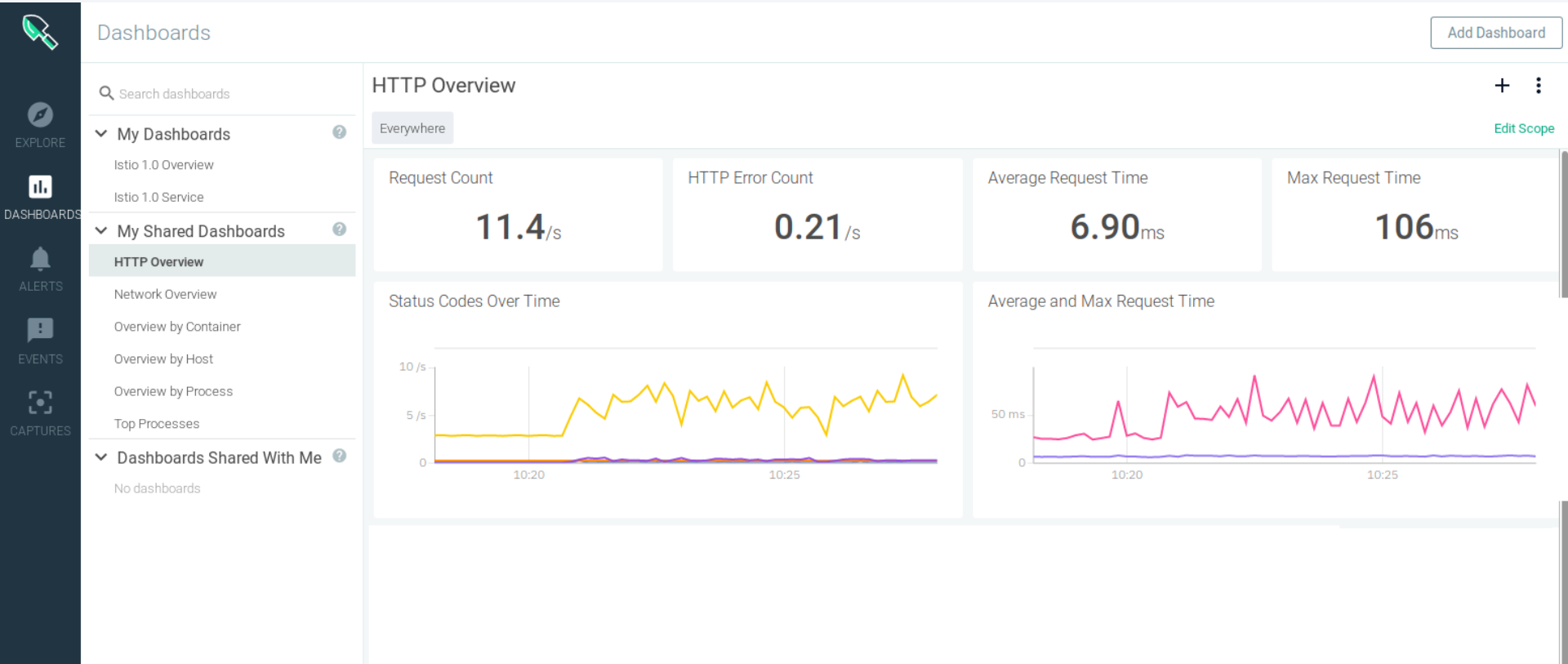
GetArticles.java

```
@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

Sysdig


Dashboards
Add Dashboard
EXPLORE
DASHBOARDS
ALERTS
EVENTS
CAPTURES
Search dashboards
My Dashboards
Istio 1.0 Overview
Istio 1.0 Service
My Shared Dashboards
HTTP Overview
Network Overview
Overview by Container
Overview by Host
Overview by Process
Top Processes
Dashboards Shared With Me
No dashboards
HTTP Overview
Everywhere
Edit Scope
Request Count
11.4/s
HTTP Error Count
0.21/s
Average Request Time
6.90ms
Max Request Time
106ms
Status Codes Over Time
10 /s
5 /s
0
10:20
10:25
Average and Max Request Time
50 ms
0
10:20
10:25

Healthchecks

MicroProfile Health

Liveness probes and readiness probes

@nheidloff @Harald_U

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

@nheidloff @Harald_U

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>
```

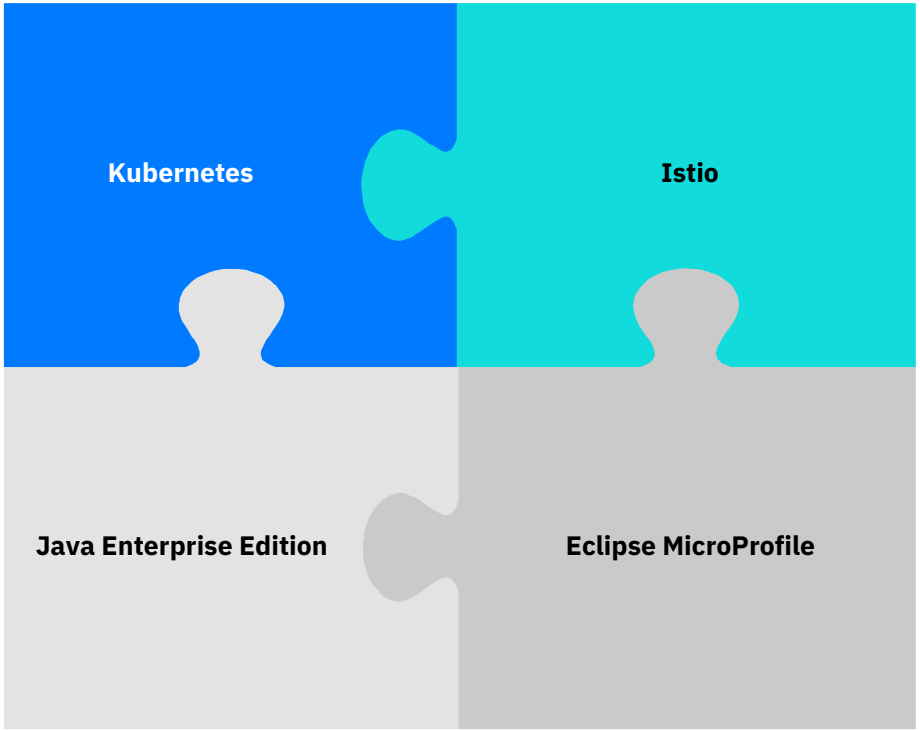
Persistence

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() {
    }
```

How to use all Pieces together?



Leverage platforms as much as possible.

Use frameworks for app specific logic.

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

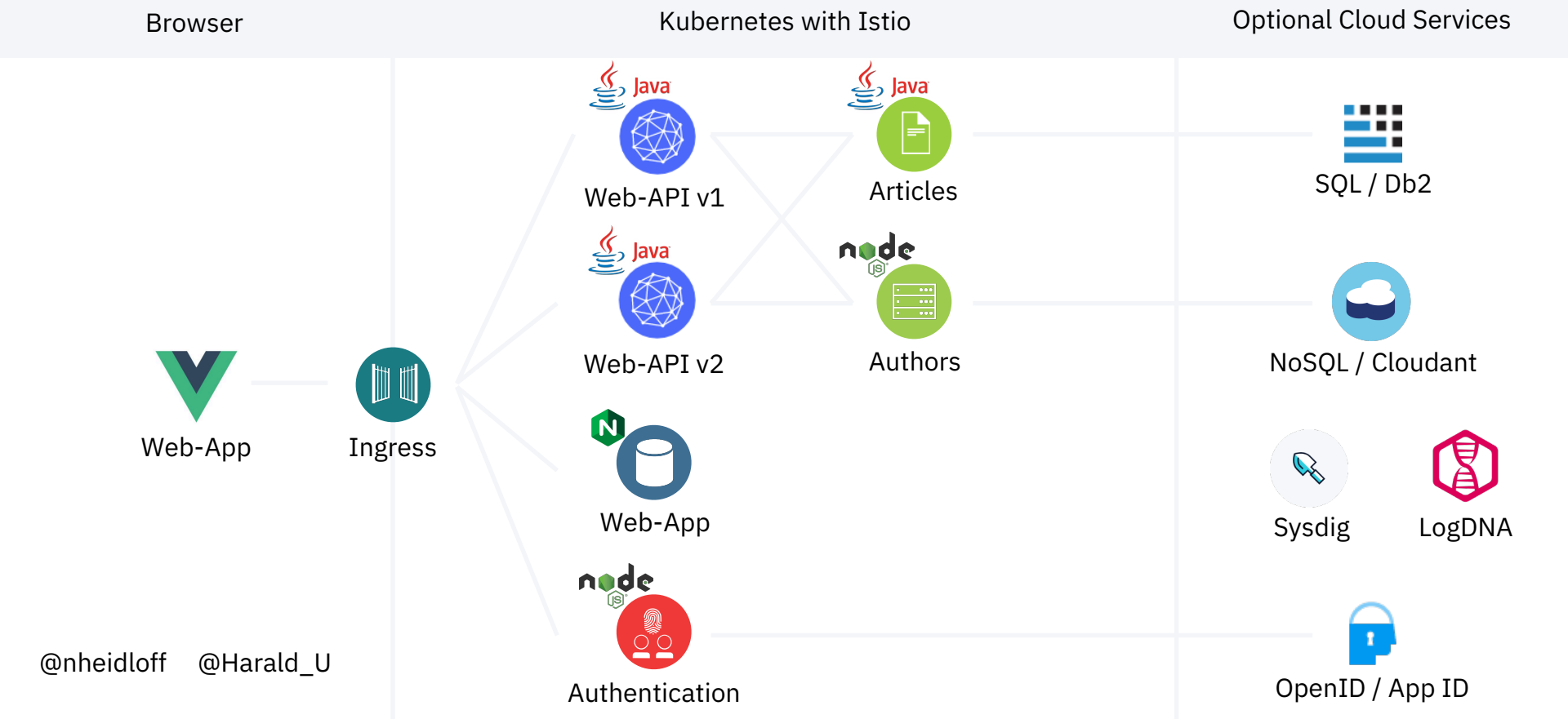
Design principles for the end-to-end example ‘cloud-native-starter’

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

Make the first time experience as simple as possible

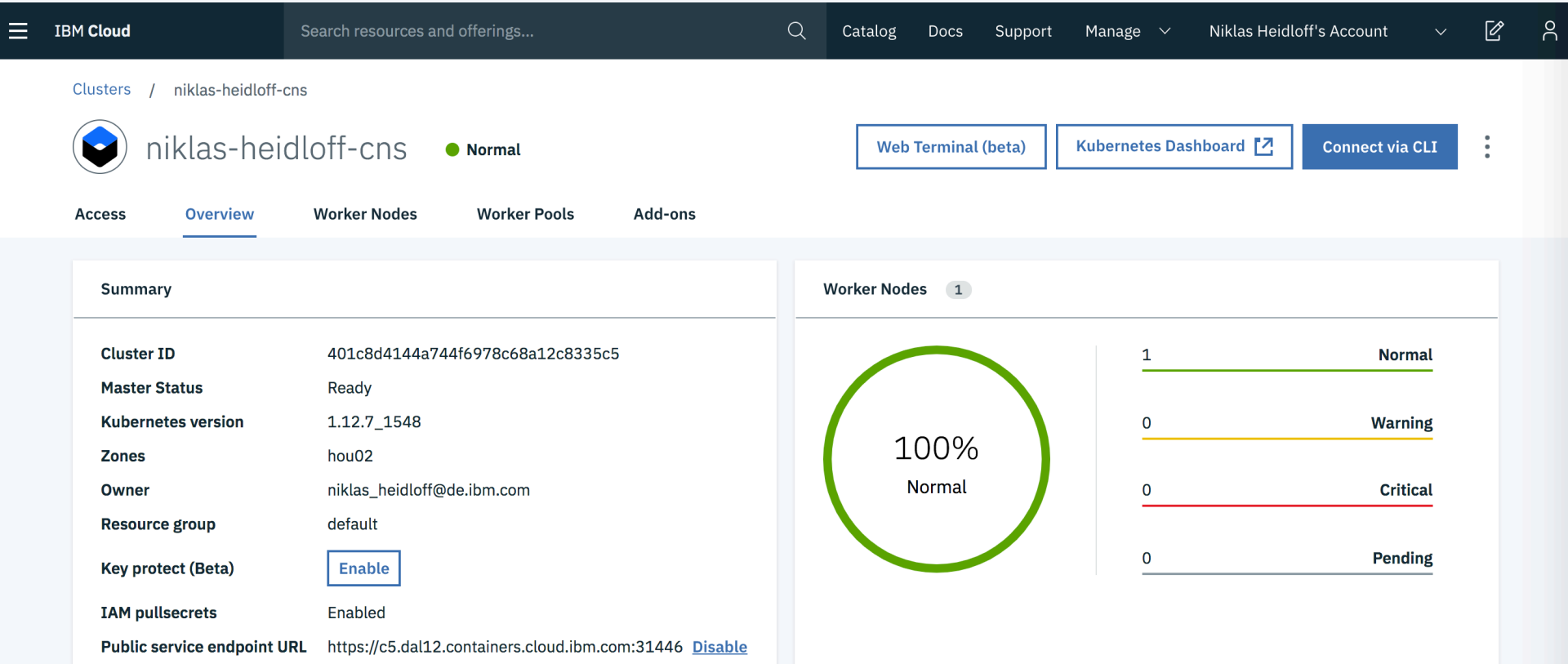
Be able to run the application in different environments

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



@nheidloff @Harald_U

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

@nheidloff @Harald_U

#IBMDeveloper github.com/nheidloff/cloud-native-starter


IBM