CS544

LESSON 13
MONITORING

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
November 28 **Lesson 1** Introduction Spring framework Dependency injection	November 29 **Lesson 2** Spring Boot AOP	November 30 **Lesson 3** JDBC JPA	December 1 **Lesson 4** JPA mapping 1	December 2 **Lesson 5** JPA mapping 2	December 3 **Lesson 6** JPA queries	December 4
December 5 **Lesson 7** Transactions	December 6 **Lesson 8** MongoDB	December 7 **Midterm Review**	December 8 **Midterm exam**	December 9 **Lesson 9** REST webservices	December 10 **Lesson 10** SOAP webservices	December 11
December 12 **Lesson 11** Messaging	December 13 **Lesson 12** Scheduling Events Configuration	December 14 **Lesson 13** Monitoring	December 15 **Lesson 14** Testing your application	December 16 **Final review**	December 17 **Final exam**	December 18
December 19 **Project**	December 20 **Project**	December 21 **Project**	December 22 **Presentations**			

SPRING BOOT LOGGING

Zero configuration logging

```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-logging</artifactId>
</dependency>
```

- When you add this dependency, Spring boot automatically uses Log4J for logging.

Using a Logger

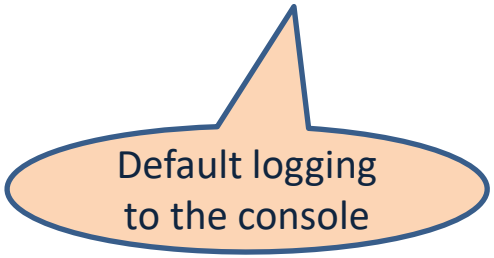
```
@Component
public class CustomerService {
   Logger logger = LoggerFactory.getLogger(CustomerService.class);

   public void addCustomer(){
      logger.trace("A TRACE Message");
   }

   public void updateCustomer(){
      logger.debug("A DEBUG Message");
   }

   public void removeCustomer(){
      logger.info("An INFO Message");
   }

   public void findCustomerById(){
      logger.warn("A WARN Message");
   }

   public void findCustomersByName(){
      logger.error("An ERROR Message");
   }
}
```

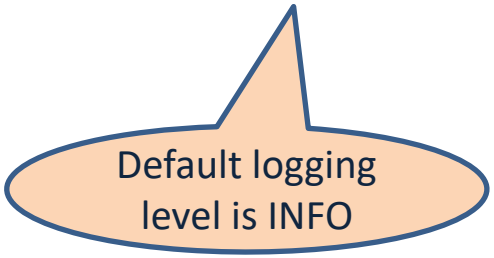
The application

```
@SpringBootApplication
public class CustomerApplication implements CommandLineRunner {

  @Autowired
  private CustomerService customerService;


  public static void main(String[] args) {
    SpringApplication.run(CustomerApplication.class, args);
  }

  @Override
  public void run(String... args) throws Exception {
    customerService.addCustomer();
    customerService.updateCustomer();
    customerService.removeCustomer();
    customerService.findCustomerById();
    customerService.findCustomersByName();
  }
}
```

The output

```
  .   ____          _            __ _ _
 /\\ / ___'_ __ _ _(_)_ __  __ _ \ \ \ \
( ( )\___ | '_ | '_| | '_ \/ _` | \ \ \ \
 \\/  ___)| |_)| | | | | || (_| |  ) ) ) )
  '  |____| .__|_| |_|_| |_\__, | / / / /
 =========|_|==============|___/=/_/_/_/
 :: Spring Boot ::                (v2.5.4)

2022-07-05 13:32:45.706  INFO 1948 --- [           main] app.CustomerApplication                  : Starting CustomerApplication using Java
 11.0.1 on DESKTOP-BVHRK6K with PID 1948 (C:\EnterpriseArchiteture\demo code\Lesson13Logging\target\classes started by vedam in
 C:\EnterpriseArchiteture\demo code\Lesson13Logging)
2022-07-05 13:32:45.708  INFO 1948 --- [           main] app.CustomerApplication                  : No active profile set, falling back to
 default profiles: default
2022-07-05 13:32:46.216  INFO 1948 --- [           main] app.CustomerApplication                  : Started CustomerApplication in 0.936
 seconds (JVM running for 1.381)
2022-07-05 13:32:46.218  INFO 1948 --- [           main] app.CustomerService                      : An INFO Message
2022-07-05 13:32:46.218  WARN 1948 --- [           main] app.CustomerService                      : A WARN Message
2022-07-05 13:32:46.218 ERROR 1948 --- [           main] app.CustomerService                      : An ERROR Message
```





Logging level

- TRACE: gives detailed information about the code
- DEBUG: gives more specific diagnostic information that you need during debugging
- INFO (default level): gives high level information
- WARN: potential problems that might cause problems
- ERROR: serious issues like exceptions

Logging level

Default logging level is INFO

```
#logging.level.root=DEBUG
```

```
2022-07-05 12:18:51.737  INFO 29548 --- [           main] app.CustomerService                      : An INFO Message
2022-07-05 12:18:51.737  WARN 29548 --- [           main] app.CustomerService                      : A WARN Message
2022-07-05 12:18:51.737 ERROR 29548 --- [           main] app.CustomerService                      : An ERROR Message
```

```
logging.level.root=WARN
```

```
2022-07-05 12:19:52.173  WARN 2692 --- [           main] app.CustomerService                       : A WARN Message
2022-07-05 12:19:52.175 ERROR 2692 --- [           main] app.CustomerService                       : An ERROR Message
```

```
logging.level.root=ERROR
```

```
2022-07-05 12:20:57.133 ERROR 3560 --- [           main] app.CustomerService                      : An ERROR Message
```

Logging level

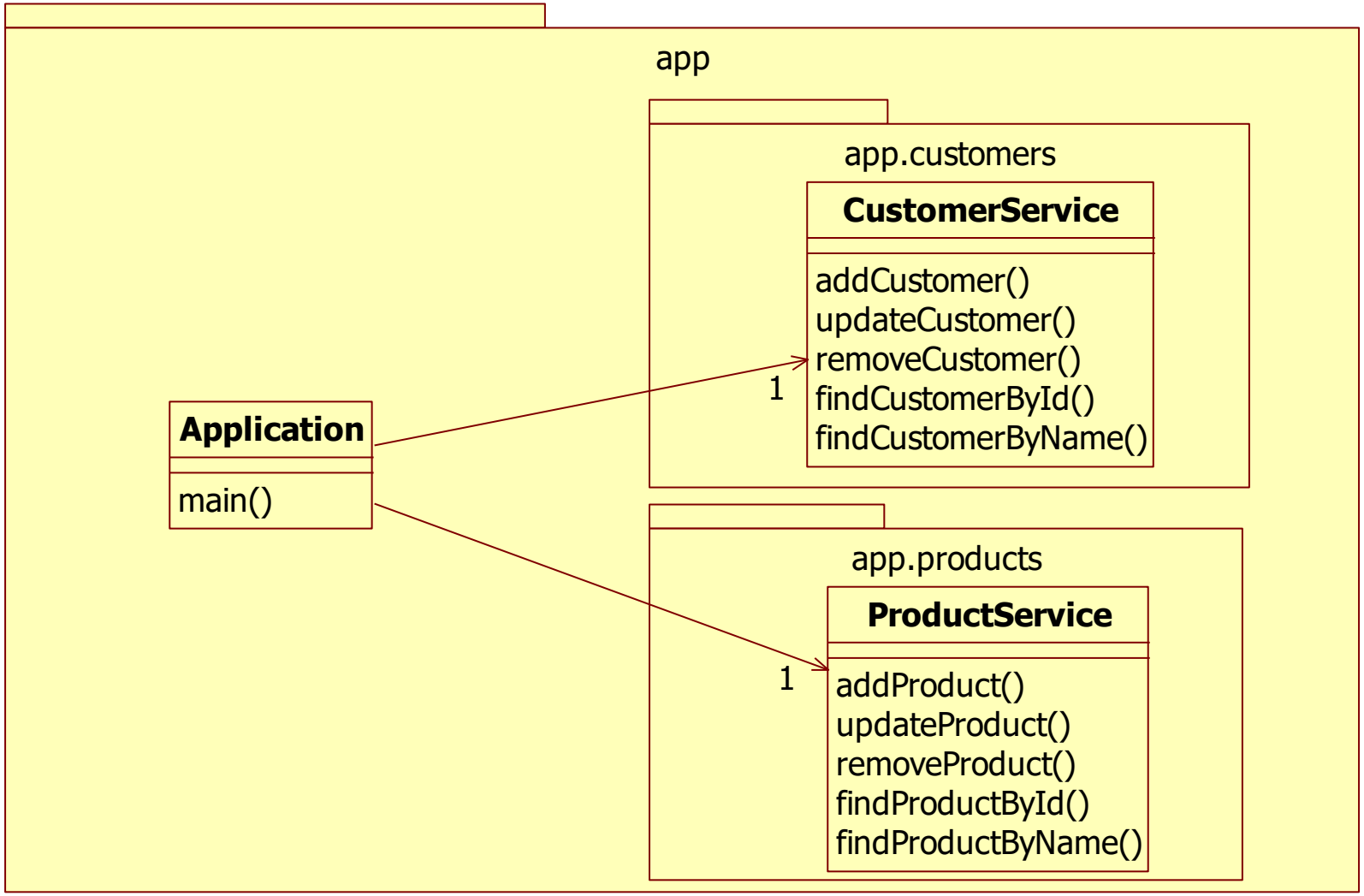
```
logging.level.root=DEBUG
```

```
2022-07-05 12:16:15.581 DEBUG 29812 --- [           main] app.CustomerService                      : A DEBUG Message
2022-07-05 12:16:15.581  INFO 29812 --- [           main] app.CustomerService                      : An INFO Message
2022-07-05 12:16:15.581  WARN 29812 --- [           main] app.CustomerService                      : A WARN Message
2022-07-05 12:16:15.581 ERROR 29812 --- [           main] app.CustomerService                      : An ERROR Message
```

```
logging.level.root=TRACE
```

```
2022-07-05 12:13:47.372 TRACE 8380 --- [           main] app.CustomerService                      : A TRACE Message
2022-07-05 12:13:47.372 DEBUG 8380 --- [           main] app.CustomerService                      : A DEBUG Message
2022-07-05 12:13:47.372  INFO 8380 --- [           main] app.CustomerService                      : An INFO Message
2022-07-05 12:13:47.372  WARN 8380 --- [           main] app.CustomerService                      : A WARN Message
2022-07-05 12:13:47.372 ERROR 8380 --- [           main] app.CustomerService                      : An ERROR Message
```

Logging level on packages

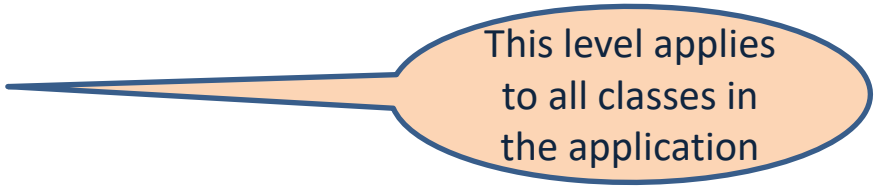


The application

```
@SpringBootApplication
public class Application implements CommandLineRunner {
  @Autowired
  private CustomerService customerService;
  @Autowired
  private ProductService productService;

  public static void main(String[] args) {
    SpringApplication.run(Application.class, args);
  }

  @Override
  public void run(String... args) throws Exception {
    Logger logger = LoggerFactory.getLogger(Application.class);
    logger.info("An INFO Message");
    logger.error("An ERROR Message");

    customerService.addCustomer();
    customerService.updateCustomer();
    customerService.removeCustomer();
    customerService.findCustomerById();
    customerService.findCustomersByName();

    productService.addProduct();
    productService.updateProduct();
    productService.removeProduct();
    productService.findProductById();
    productService.findProductByName();
  }
}
```

Logging level on packages

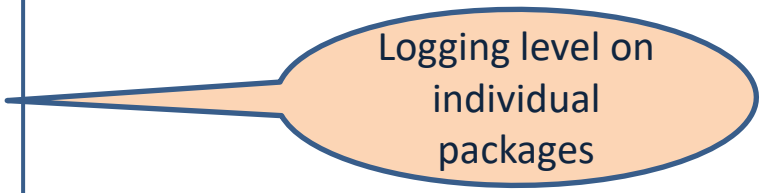
```
logging.level.root=INFO
```




```
2022-07-05 19:10:59.036  INFO 29528 --- [           main] app.Application                          : An INFO Message
2022-07-05 19:10:59.036 ERROR 29528 --- [           main] app.Application                          : An ERROR Message
2022-07-05 19:10:59.036  INFO 29528 --- [           main] app.customers.CustomerService            : An INFO Message
2022-07-05 19:10:59.036  WARN 29528 --- [           main] app.customers.CustomerService            : A WARN Message
2022-07-05 19:10:59.036 ERROR 29528 --- [           main] app.customers.CustomerService            : An ERROR Message
2022-07-05 19:10:59.036  INFO 29528 --- [           main] app.products.ProductService              : An INFO Message
2022-07-05 19:10:59.036  WARN 29528 --- [           main] app.products.ProductService              : A WARN Message
2022-07-05 19:10:59.036 ERROR 29528 --- [           main] app.products.ProductService              : An ERROR Message
```

Logging level on packages

```
logging.level.root=INFO
logging.level.app.customers=ERROR
logging.level.app.products=TRACE
```




```
2022-07-05 19:21:21.497  INFO 30568 --- [           main] app.Application                          : An INFO Message
2022-07-05 19:21:21.497 ERROR 30568 --- [           main] app.Application                          : An ERROR Message
2022-07-05 19:21:21.497 ERROR 30568 --- [           main] app.customers.CustomerService            : An ERROR Message
2022-07-05 19:21:21.497 TRACE 30568 --- [           main] app.products.ProductService              : A TRACE Message
2022-07-05 19:21:21.497 DEBUG 30568 --- [           main] app.products.ProductService              : A DEBUG Message
2022-07-05 19:21:21.497  INFO 30568 --- [           main] app.products.ProductService              : An INFO Message
2022-07-05 19:21:21.497  WARN 30568 --- [           main] app.products.ProductService              : A WARN Message
2022-07-05 19:21:21.497 ERROR 30568 --- [           main] app.products.ProductService              : An ERROR Message
```

Log format

```
2022-07-05 12:13:47.372 TRACE 8380 --- [           main] app.CustomerService                      : A TRACE Message
2022-07-05 12:13:47.372 DEBUG 8380 --- [           main] app.CustomerService                      : A DEBUG Message
2022-07-05 12:13:47.372  INFO 8380 --- [           main] app.CustomerService                      : An INFO Message
2022-07-05 12:13:47.372  WARN 8380 --- [           main] app.CustomerService                      : A WARN Message
2022-07-05 12:13:47.372 ERROR 8380 --- [           main] app.CustomerService                      : An ERROR Message
```

1 2 3 4 5 6 7

1. Date and Time
2. Log level
3. Process ID
4. The separator ---
5. Thread name
6. Logger name source class
7. Log message

Change Log format

```
logging.level.root=INFO

logging.pattern.console= %d{yyyy-MM-dd HH:mm:ss} - %logger - %msg%n
logging.pattern.file=%d{yyyy-MM-dd HH:mm:ss} - %logger - %msg%n
```

```
2022-07-05 12:37:13 - app.CustomerService - An INFO Message
2022-07-05 12:37:13 - app.CustomerService - A WARN Message
2022-07-05 12:37:13 - app.CustomerService - An ERROR Message
```

Change Log format

```
logging.level.root=INFO

logging.pattern.console= %d{yyyy-MM-dd HH:mm:ss} - %logger - %msg%n
logging.pattern.file=%d{yyyy-MM-dd HH:mm:ss} - %logger - %msg%n
```

```
2022-07-05 12:37:13 - app.CustomerService - An INFO Message
2022-07-05 12:37:13 - app.CustomerService - A WARN Message
2022-07-05 12:37:13 - app.CustomerService - An ERROR Message
```

```
logging.pattern.console= %d{yyyy-MM-dd HH:mm:ss} [%thread] %level %logger - %msg%n
logging.pattern.file= %d{yyyy-MM-dd HH:mm:ss} [%thread] %level %logger - %msg%n
```

```
2022-07-05 12:46:26 [main] INFO app.CustomerService - An INFO Message
2022-07-05 12:46:26 [main] WARN app.CustomerService - A WARN Message
2022-07-05 12:46:26 [main] ERROR app.CustomerService - An ERROR Message
```

Logging to a file

```
logging.file.name=c:/temp/application.log
```

C:\temp\application.log

```
2022-07-05 13:52:49.002  INFO 5640 --- [main] app.CustomerApplication                : Starting
CustomerApplication using Java 11.0.1 on DESKTOP-BVHRK6K with PID 5640 (C:\EnterpriseArchiteture\demo
code\Lesson13Logging\target\classes started by vedam in C:\EnterpriseArchiteture\demo code\Lesson13Logging)
2022-07-05 13:52:49.005  INFO 5640 --- [main] app.CustomerApplication                : No active profile set,
falling back to default profiles: default
2022-07-05 13:52:49.628  INFO 5640 --- [main] app.CustomerApplication                : Started
CustomerApplication in 1.141 seconds (JVM running for 1.569)
2022-07-05 13:52:49.634  INFO 5640 --- [main] app.CustomerService                    : An INFO Message
2022-07-05 13:52:49.634  WARN 5640 --- [main] app.CustomerService                    : A WARN Message
2022-07-05 13:52:49.634 ERROR 5640 --- [main] app.CustomerService                    : An ERROR Message
```

Logging to a file

```
logging.file.path=c:/temp/logs
```

C:\temp\logs\spring.log

```
2022-07-05 13:52:49.002  INFO 5640 --- [main] app.CustomerApplication                  : Starting
CustomerApplication using Java 11.0.1 on DESKTOP-BVHRK6K with PID 5640 (C:\EnterpriseArchiteture\demo
code\Lesson13Logging\target\classes started by vedam in C:\EnterpriseArchiteture\demo code\Lesson13Logging)
2022-07-05 13:52:49.005  INFO 5640 --- [main] app.CustomerApplication                  : No active profile set,
falling back to default profiles: default
2022-07-05 13:52:49.628  INFO 5640 --- [main] app.CustomerApplication                  : Started
CustomerApplication in 1.141 seconds (JVM running for 1.569)
2022-07-05 13:52:49.634  INFO 5640 --- [main] app.CustomerService                      : An INFO Message
2022-07-05 13:52:49.634  WARN 5640 --- [main] app.CustomerService                      : A WARN Message
2022-07-05 13:52:49.634 ERROR 5640 --- [main] app.CustomerService                      : An ERROR Message
```

ACTUATORS

/actuator

localhost:8080/actuator

localhost:8080/actuator


```
{"_links":{"self":{"href":"http://localhost:8080/actuator","templated":false},"beans":
{"href":"http://localhost:8080/actuator/beans","templated":false},"caches-cache":
{"href":"http://localhost:8080/actuator/caches/{cache}","templated":true},"caches":
{"href":"http://localhost:8080/actuator/caches","templated":false},"health":
{"href":"http://localhost:8080/actuator/health","templated":false},"health-path":
{"href":"http://localhost:8080/actuator/health/{*path}","templated":true},"info":
{"href":"http://localhost:8080/actuator/info","templated":false},"conditions":
{"href":"http://localhost:8080/actuator/conditions","templated":false},"shutdown":
{"href":"http://localhost:8080/actuator/shutdown","templated":false},"configprops":
{"href":"http://localhost:8080/actuator/configprops","templated":false},"configprops-prefix":
{"href":"http://localhost:8080/actuator/configprops/{prefix}","templated":true},"env":
{"href":"http://localhost:8080/actuator/env","templated":false},"env-toMatch":
{"href":"http://localhost:8080/actuator/env/{toMatch}","templated":true},"loggers":
{"href":"http://localhost:8080/actuator/loggers","templated":false},"loggers-name":
{"href":"http://localhost:8080/actuator/loggers/{name}","templated":true},"heapdump":
{"href":"http://localhost:8080/actuator/heapdump","templated":false},"threaddump":
{"href":"http://localhost:8080/actuator/threaddump","templated":false},"metrics-requiredMetricName":
{"href":"http://localhost:8080/actuator/metrics/{requiredMetricName}","templated":true},"metrics":
{"href":"http://localhost:8080/actuator/metrics","templated":false},"scheduledtasks":
{"href":"http://localhost:8080/actuator/scheduledtasks","templated":false},"mappings":
{"href":"http://localhost:8080/actuator/mappings","templated":false}}}
```

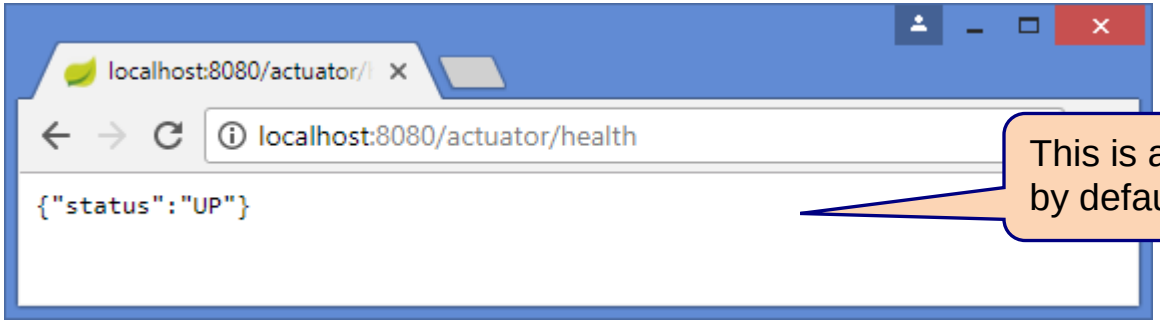
Actuator

- Actuator brings production-ready features to our application

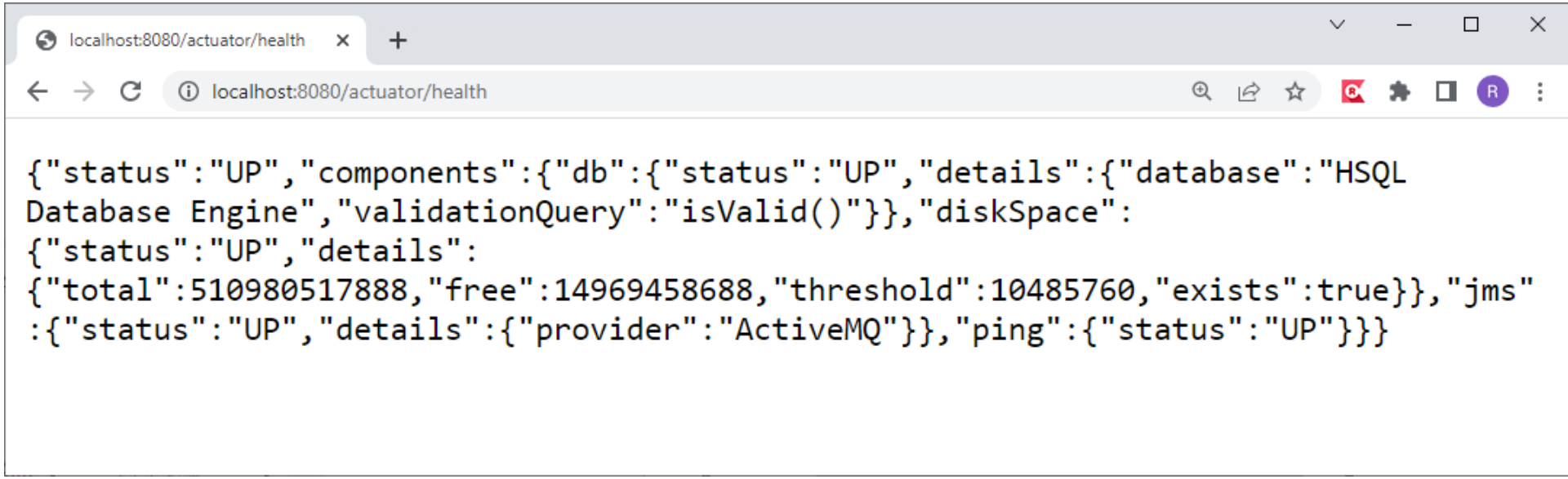
```
<dependency>
  <groupId>org.springframework.boot</groupId>
  <artifactId>spring-boot-starter-actuator</artifactId>
</dependency>
```

- Once this dependency is on the classpath several endpoints are available for us out of the box.
- You can modify existing actuators and you can write you own actuators

/actuator/health



This is all that is shown by default




```
management.endpoint.health.show-details=ALWAYS
```

Show all health information

Exposing actuators

- Only the /health actuator is exposed by default

- Exposing particular actuators

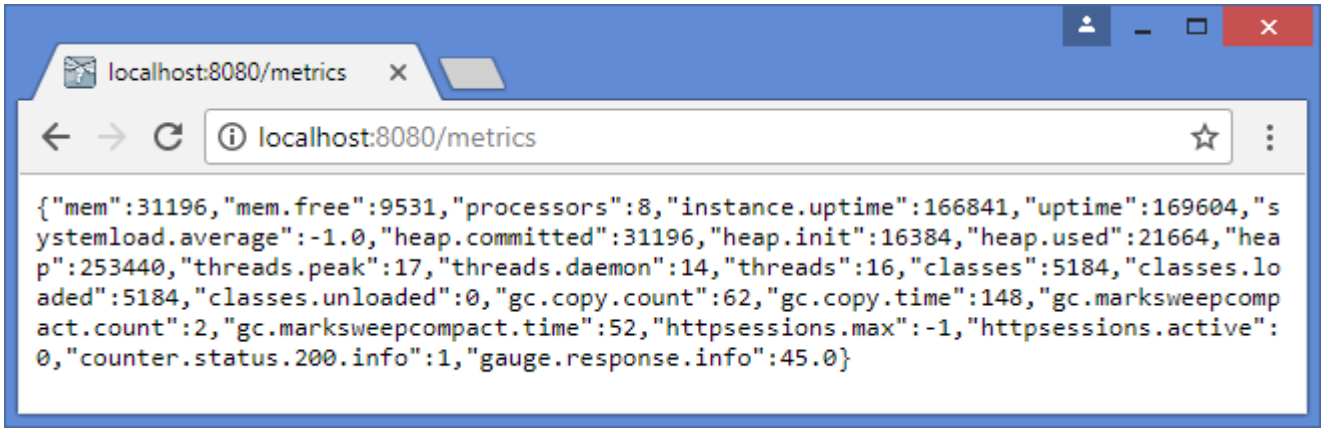
```
management.endpoints.web.exposure.include=beans,mappings
```

- Exposing all actuators

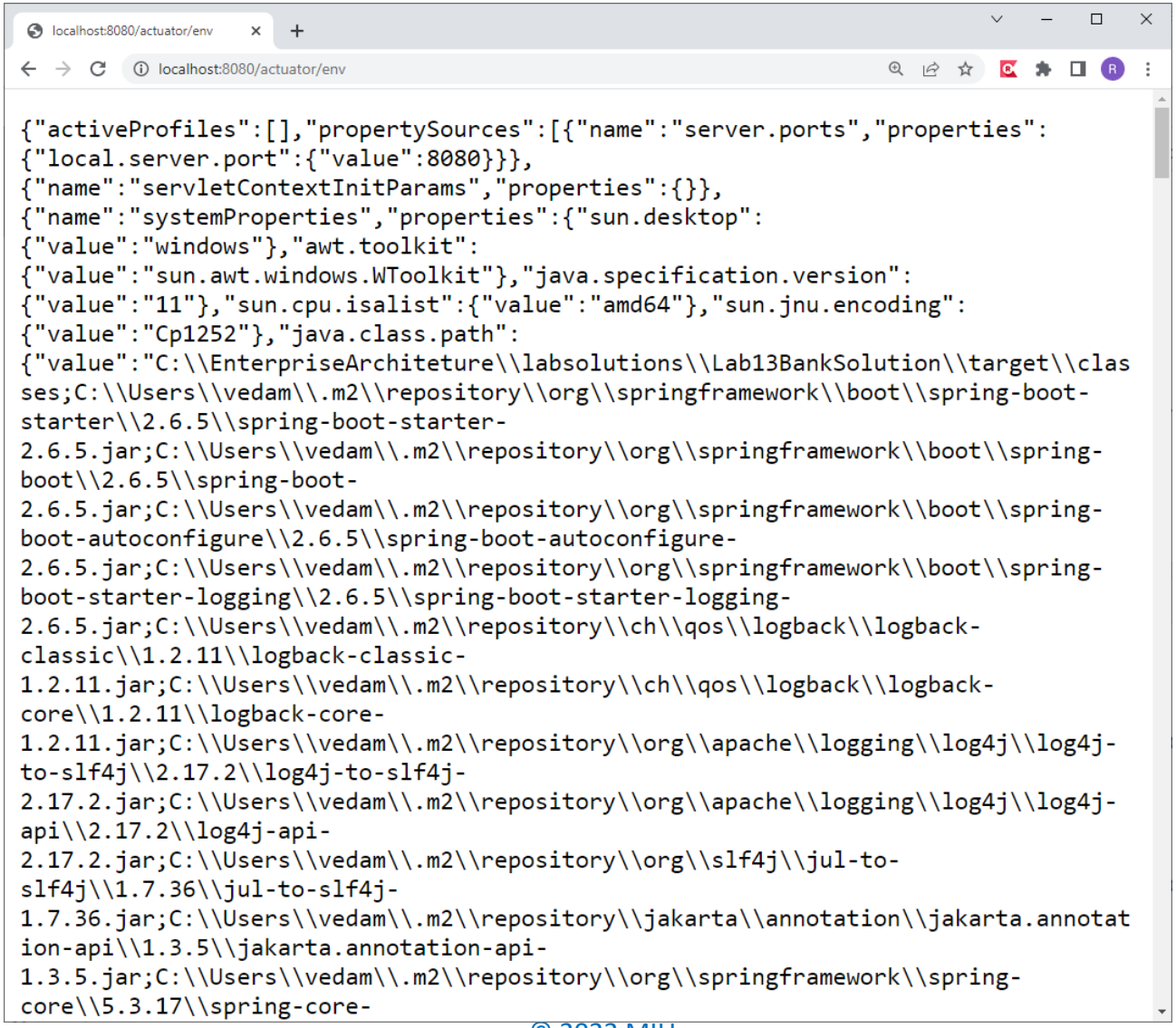
```
management.endpoints.web.exposure.include=*
```

/actuator/metrics

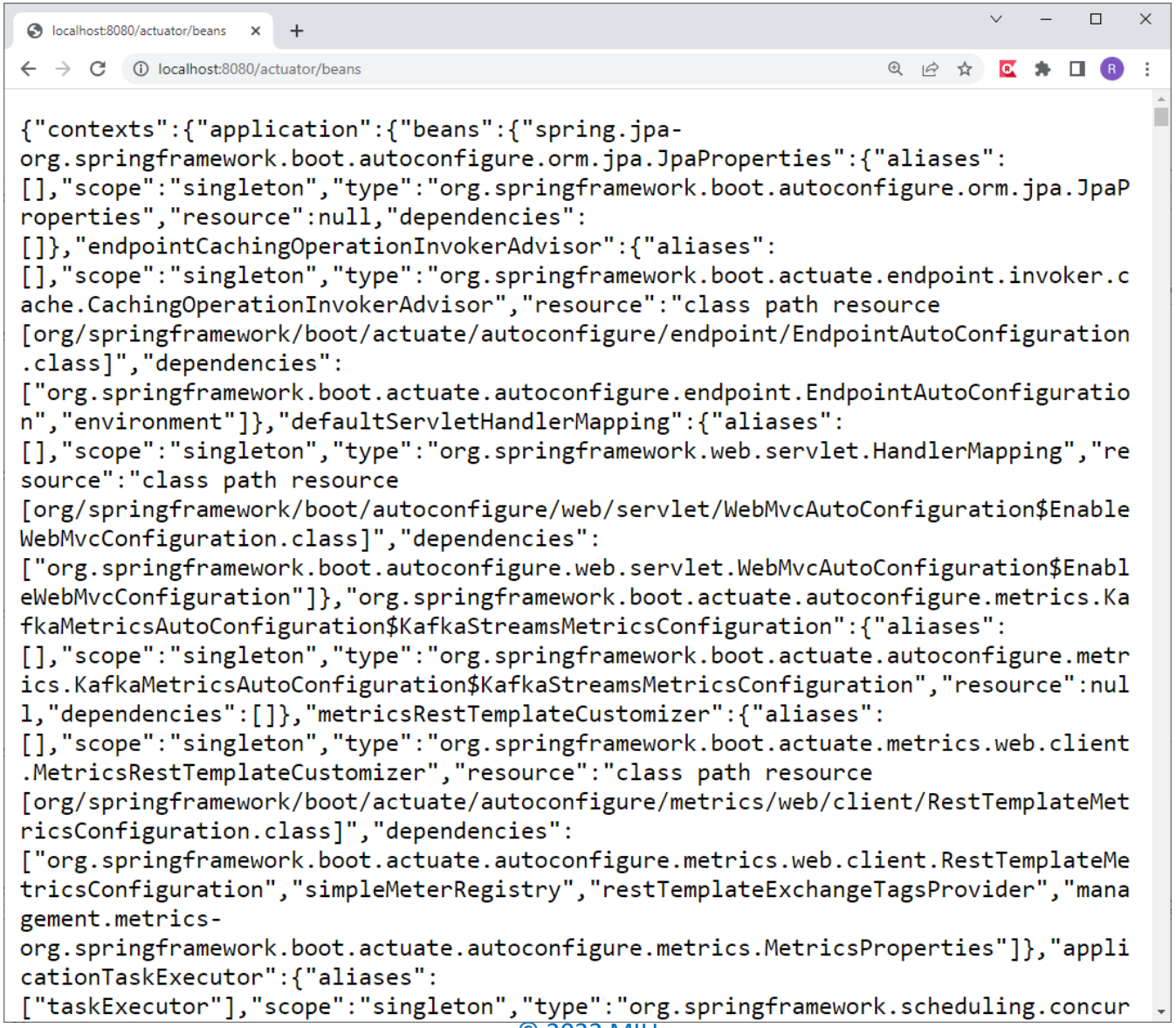
- Gives information such as memory, heap, processors, threads, classes loaded, classes unloaded, thread pools along with some HTTP metrics as well



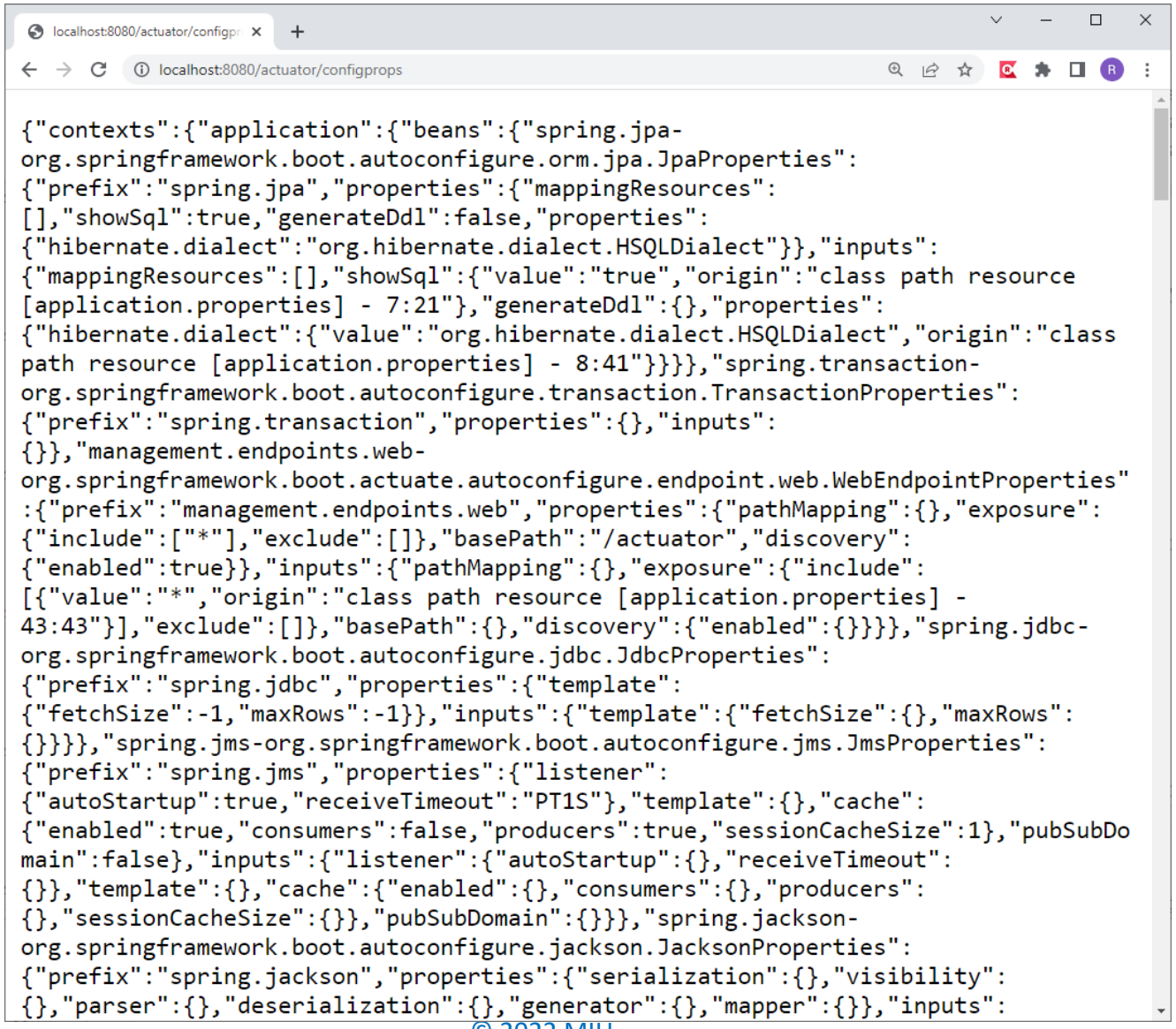
/actuator/env



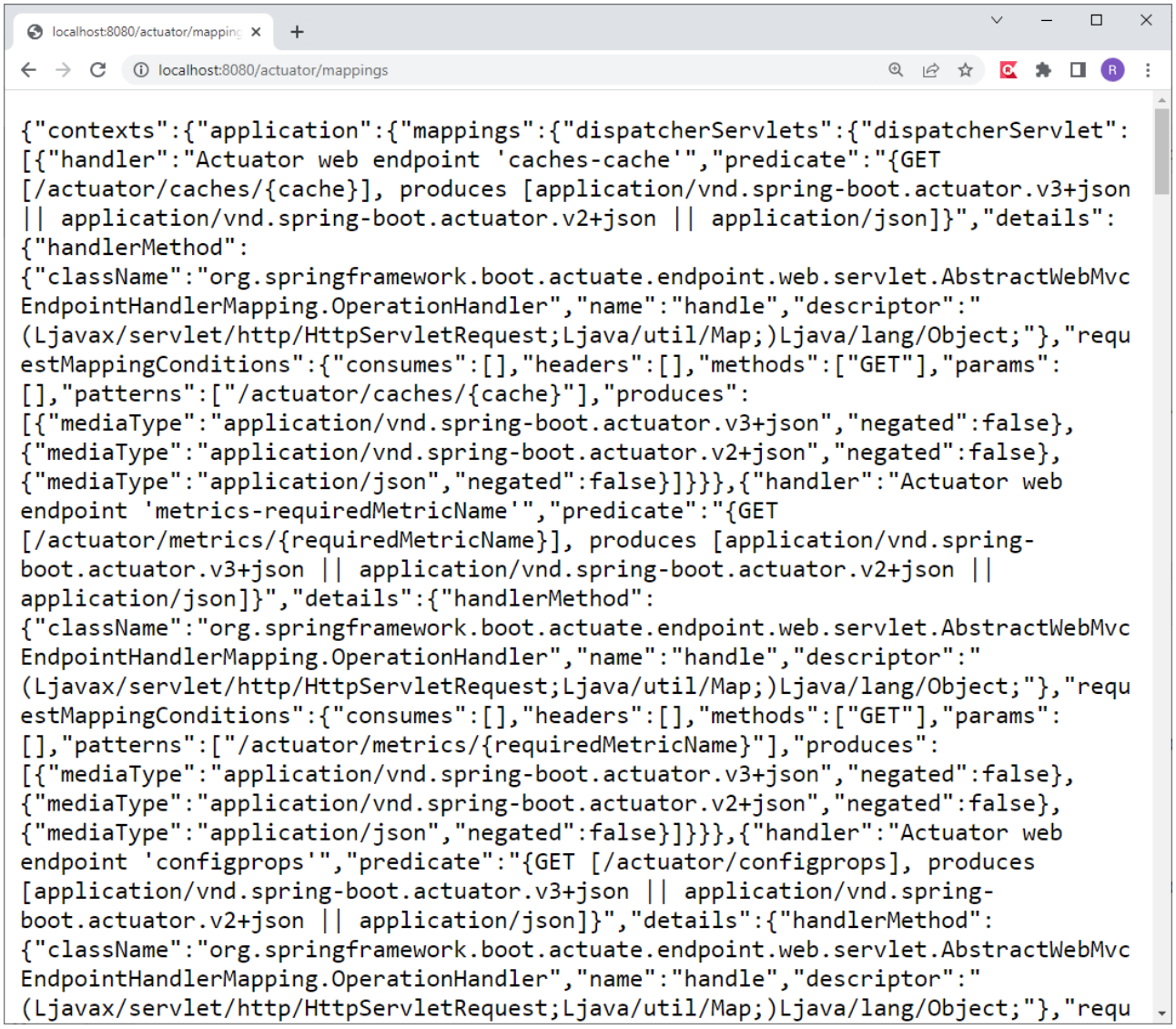
/actuator/beans



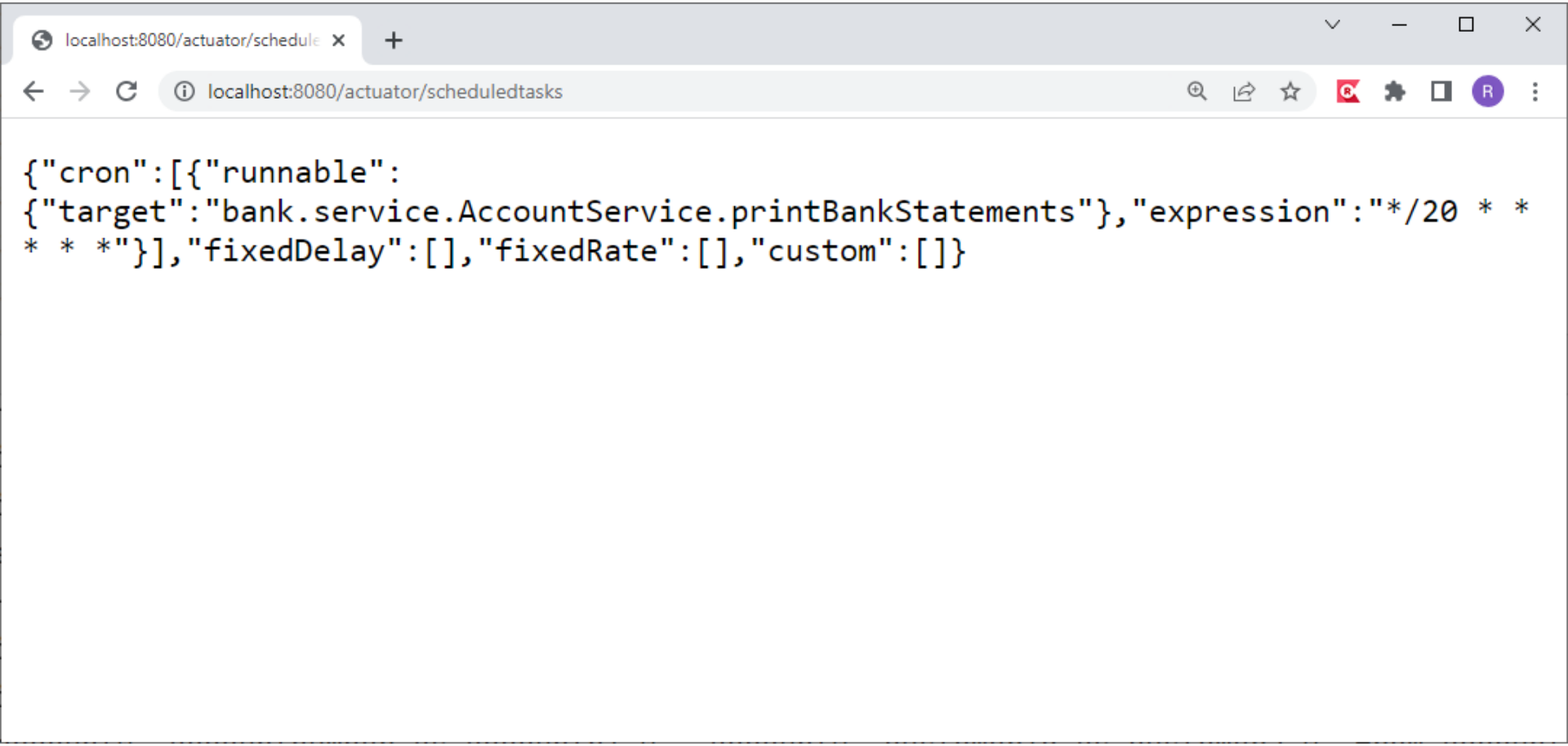
/actuator/configprops



/actuator/mappings



/actuator/scheduledtasks



Available actuators

GET	/autoconfig	Provides an auto-configuration report describing what auto-configuration conditions passed and failed.
GET	/configprops	Describes how beans have been injected with configuration properties (including default values).
GET	/beans	Describes all beans in the application context and their relationship to each other.
GET	/dump	Retrieves a snapshot dump of thread activity.
GET	/env	Retrieves all environment properties.

Available actuators

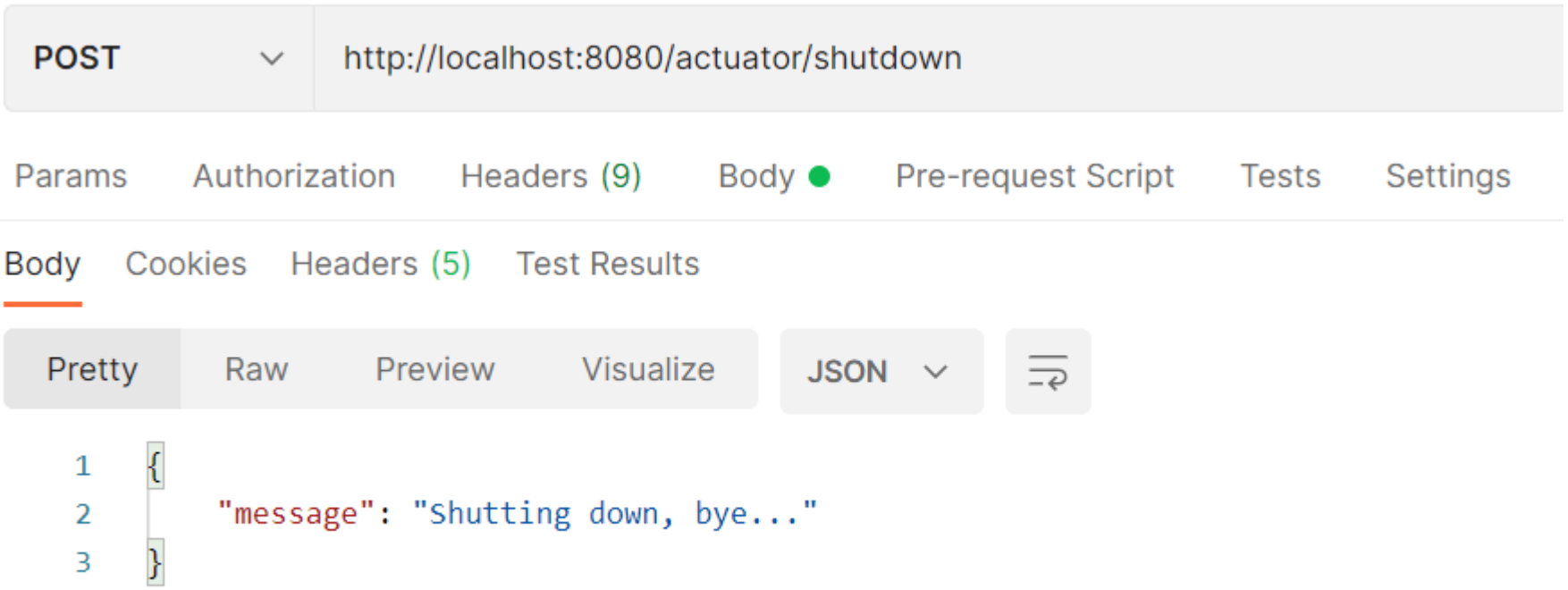
GET	/env/{name}	Retrieves a specific environment value by name.
GET	/health	Reports health metrics for the application, as provided by HealthIndicator implementations.
GET	/info	Retrieves custom information about the application, as provided by any properties prefixed with info.
GET	/mappings	Describes all URI paths and how they're mapped to controllers (including Actuator endpoints).
GET	/metrics	Reports various application metrics such as memory usage and HTTP request counters.

Available actuators

GET	/metrics/{name}	Reports an individual application metric by name.
POST	/shutdown	Shuts down the application; requires that endpoints.shutdown.enabled be set to true.
GET	/trace	Provides basic trace information (timestamp, headers, and so on) for HTTP requests.

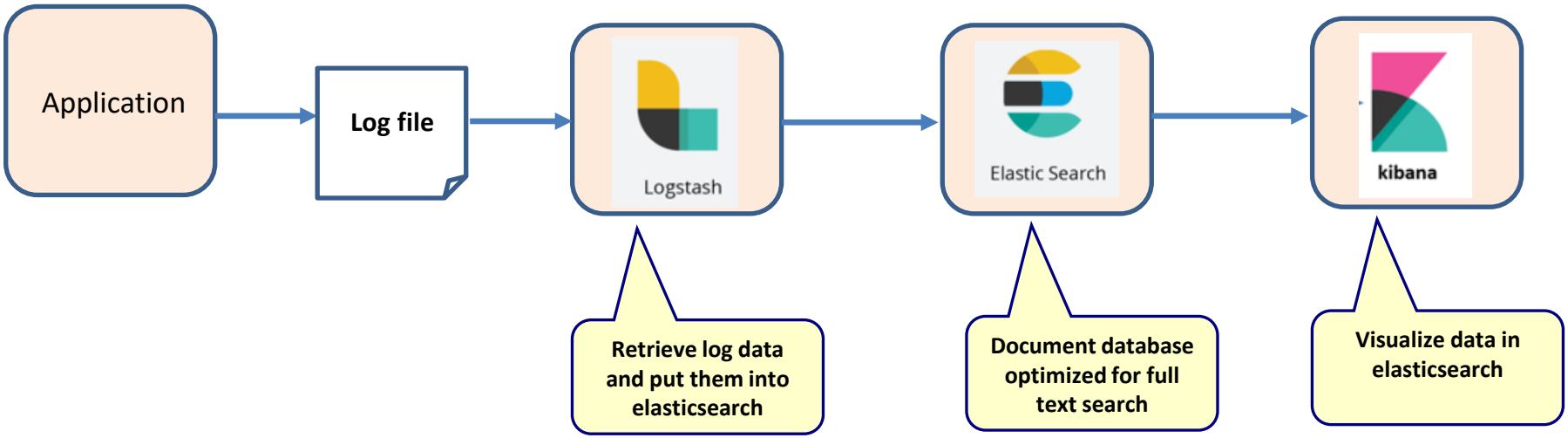
shutdown

```
management.endpoint.shutdown.enabled=true
```



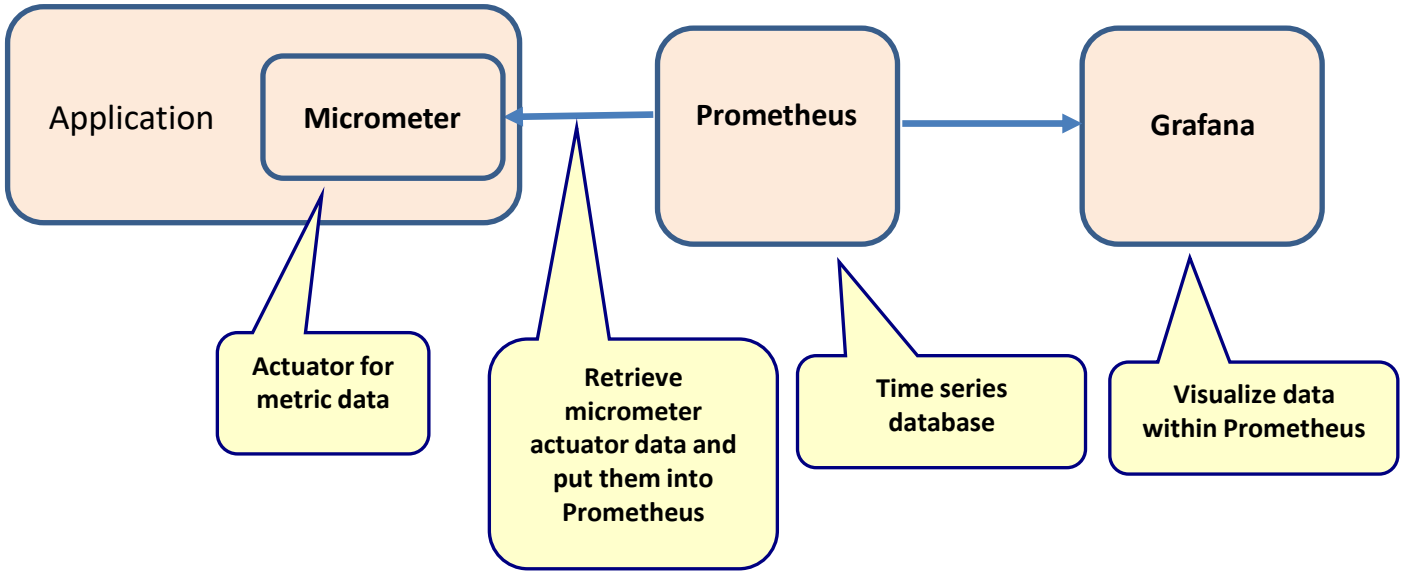
APPLICATION MONITORING

Approach 1: ELK stack



- Good for application specific log data

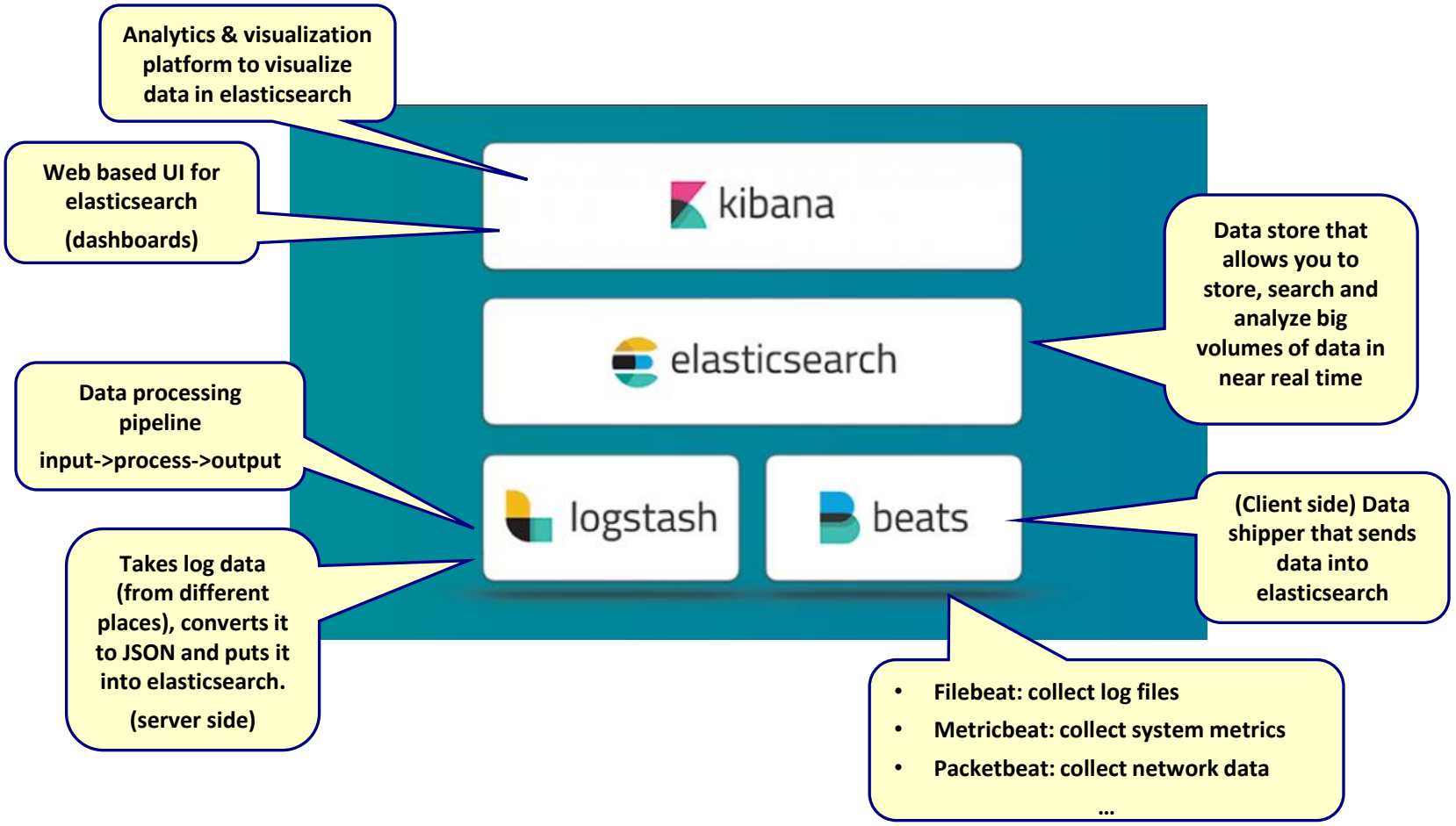
Approach 2: Prometheus/Grafana



- Good for metric data
  - Memory usage
  - CPU usage
  - JVM specific data

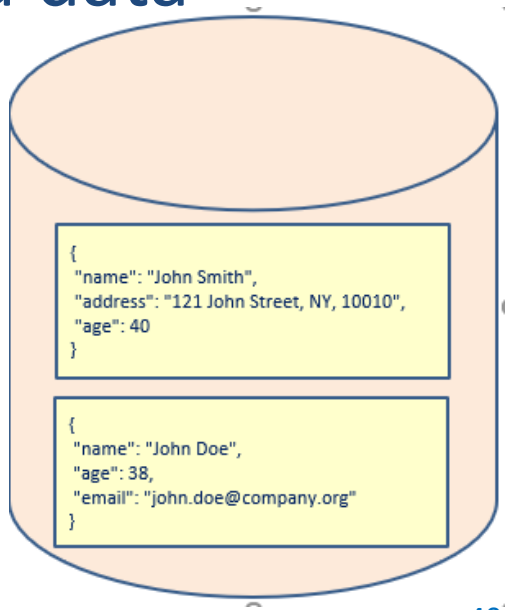
THE ELASTIC STACK

Elastic stack components

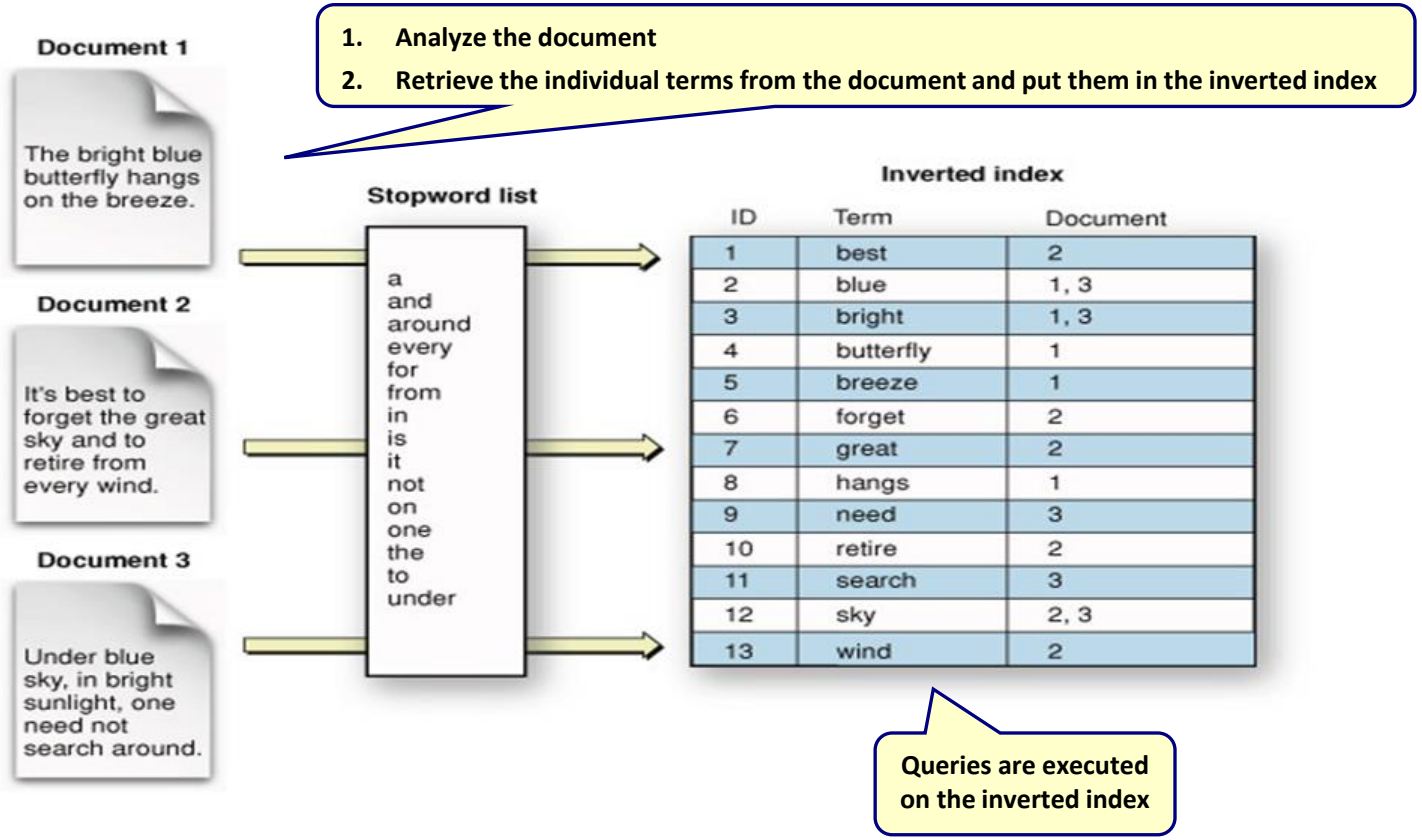


What is Elasicsearch?

- Database
  - Data is stored as documents
  - Data is structured in JSON format
- Full text search engine
- Analytics platform for structured data



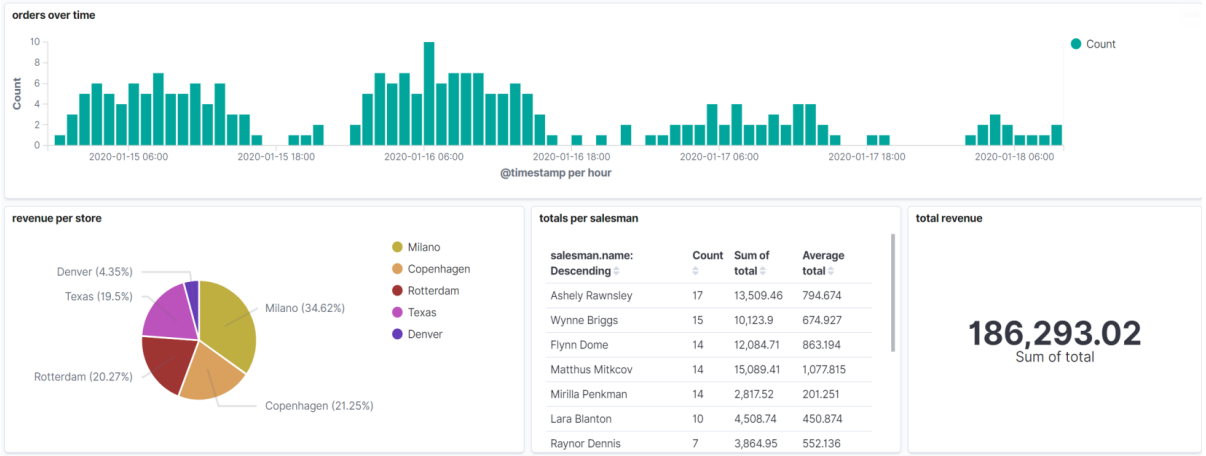
Inverted index



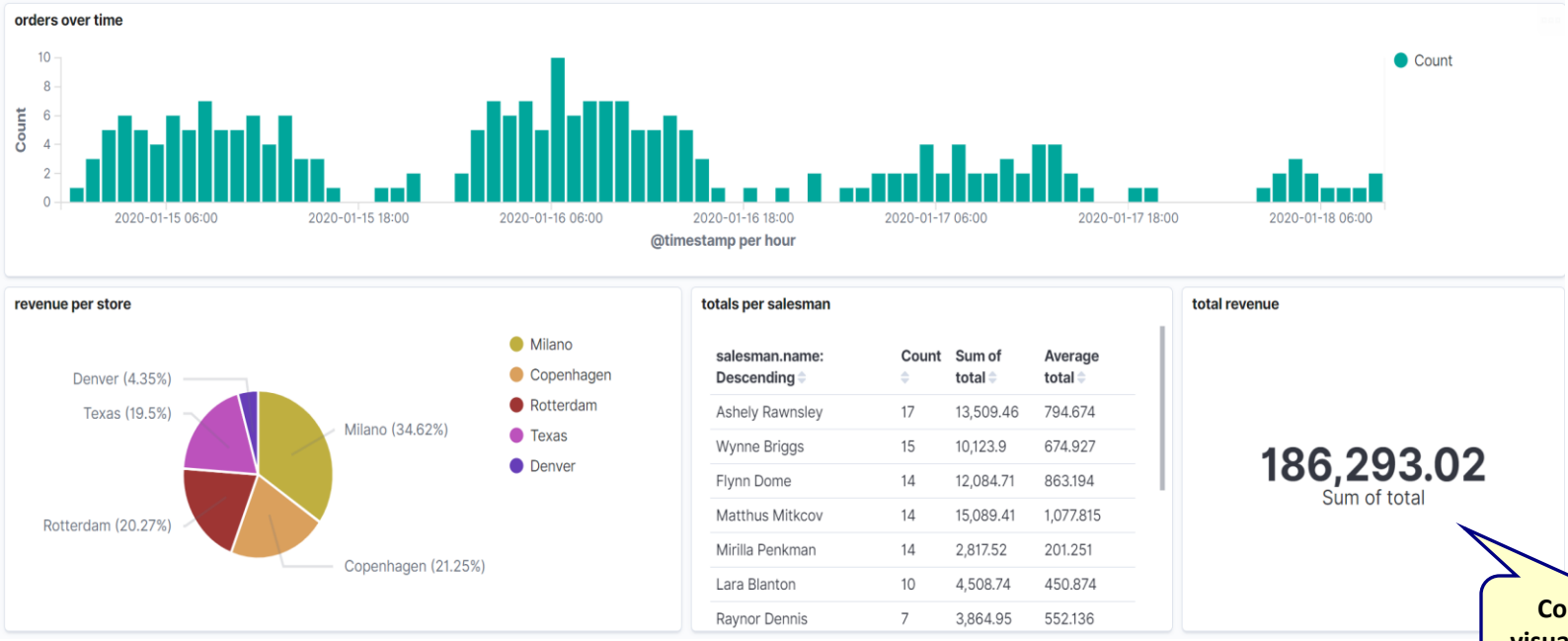
KIBANA

Kibana

- Web UI on top of elasticsearch
- Has its own Kibana query language (KQL)
- Objects (Queries, visualizations, dashboards, etc.) are saved in elasticsearch



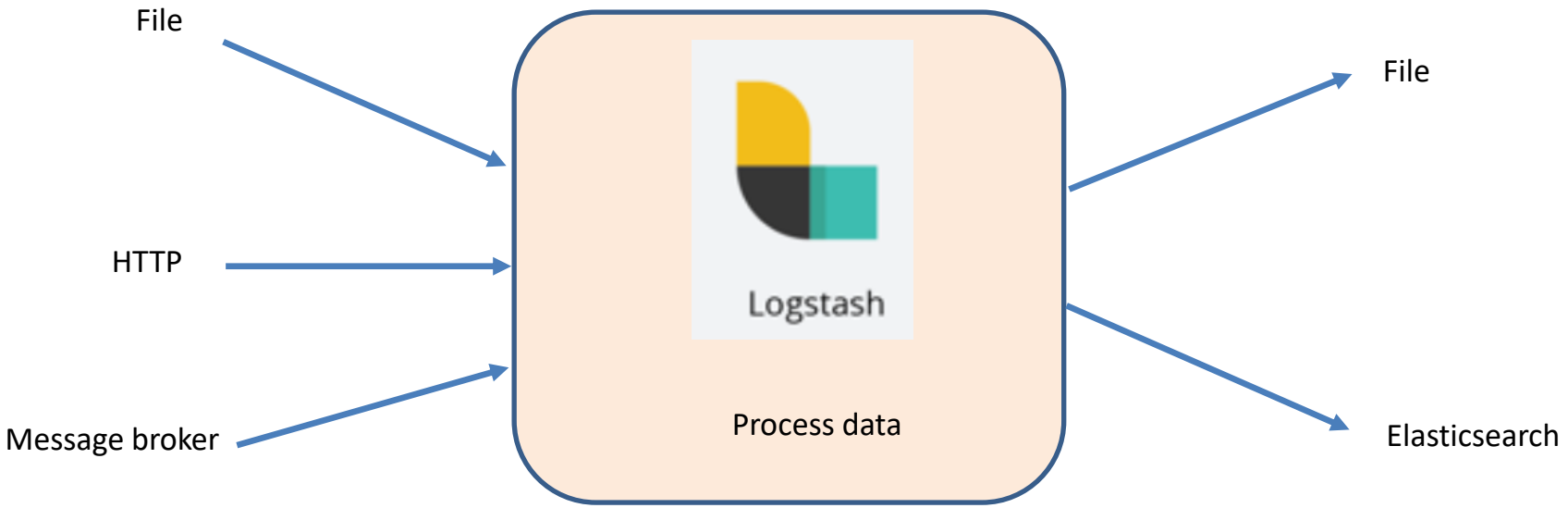
Dashboard



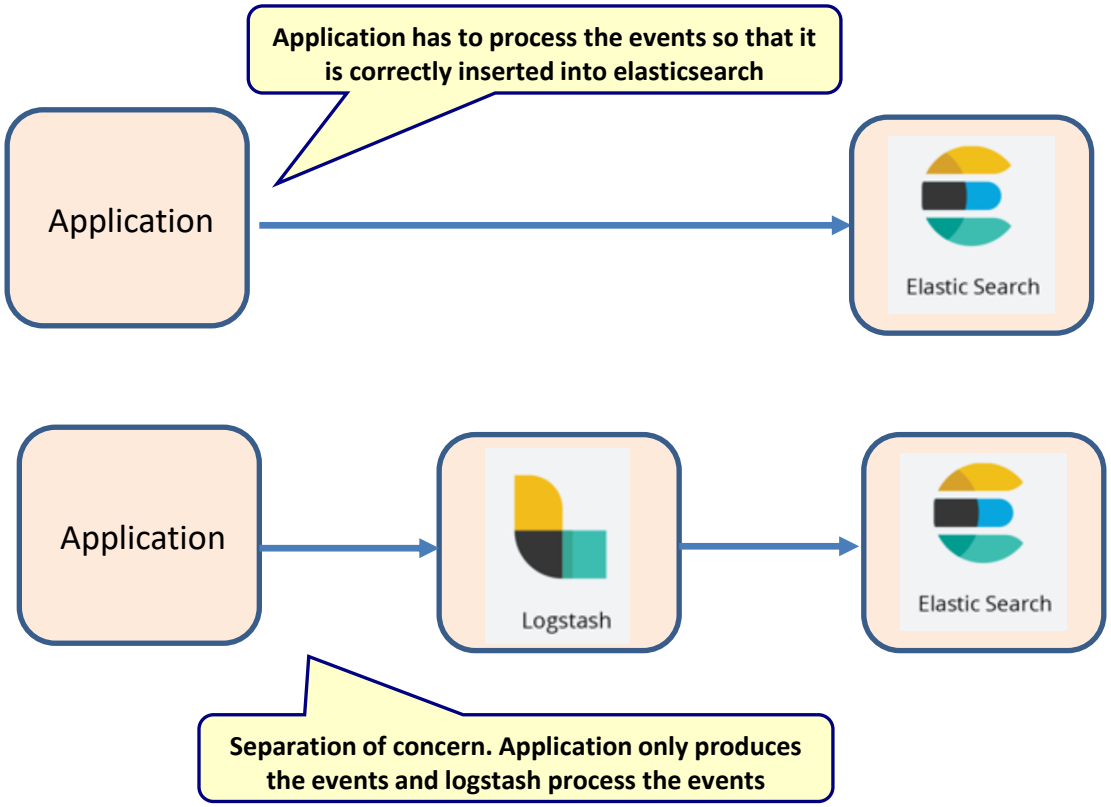
LOGSTASH

Logstash

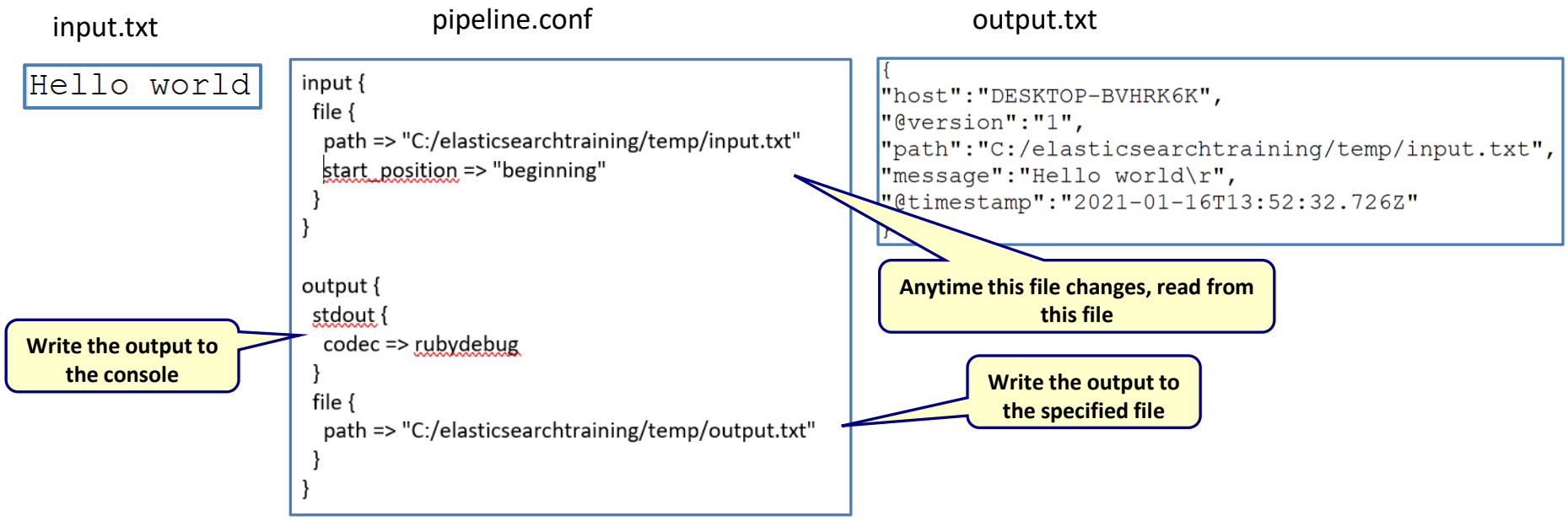
- Event processing engine



Why logstash in ELK?



Logstash configuration



Logstash configuration

input.txt

```
Hi there
```

pipeline.conf

```
input {
  file {
    path => "C:/elasticsearchtraining/temp/input.txt"
          start_position => "beginning"
  }
}

filter {
   mutate {
      uppercase => ["message"]
   }
}

output {
  stdout {
    codec => rubydebug
  }
  file {
    path => "C:/elasticsearchtraining/temp/output.txt"
  }
}
```

output.txt

```
{
"path":"C:/elasticsearchtraining/temp/input.txt",
"message":"HI THERE\r",
"host":"DESKTOP-BVHRK6K",
"@version":"1",
"@timestamp":"2021-01-16T14:17:10.537Z"
}
```

Logstash configuration

input.txt

```
get 2500 300
```

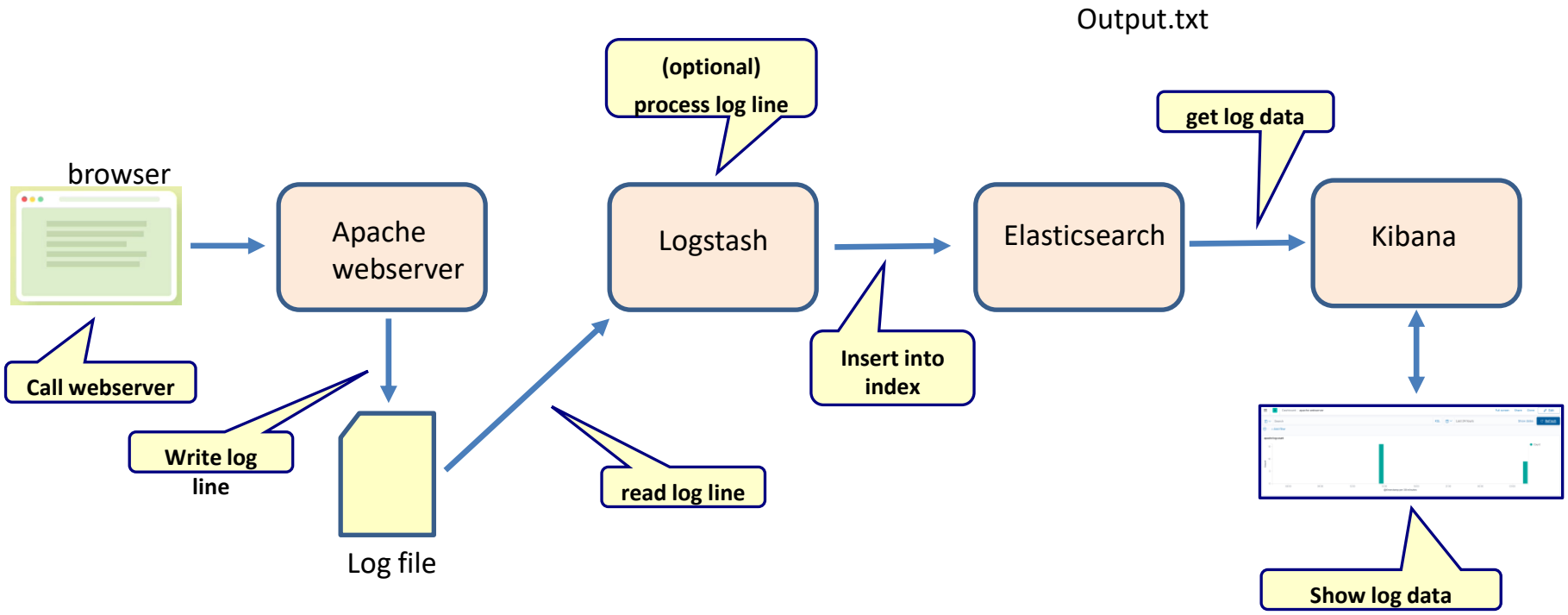
output.txt

```
{
"bytes":"2500",
"@timestamp":"2021-01-16T14:46:40.613Z",
"path":"C:/elasticsearchtraining/temp/input.txt",
"duration":"300",
"method":"GET",
"@version":"1",
"message":"get 2500 300\r",
"host":"DESKTOP-BVHRK6K"
}
```

pipeline.conf

```
input {
  file {
    path => "C:/elasticsearchtraining/temp/input.txt"
    start_position => "beginning"
  }
}

filter {
    grok{
      match => {"message" => "%{WORD:method} %{NUMBER:bytes} %{NUMBER:duration}"}
    }
    mutate {
        uppercase => ["method"]
    }
}

output {
  stdout {
    codec => rubydebug
  }
  file {
    path => "C:/elasticsearchtraining/temp/output.txt"
  }
}
```

logstash example

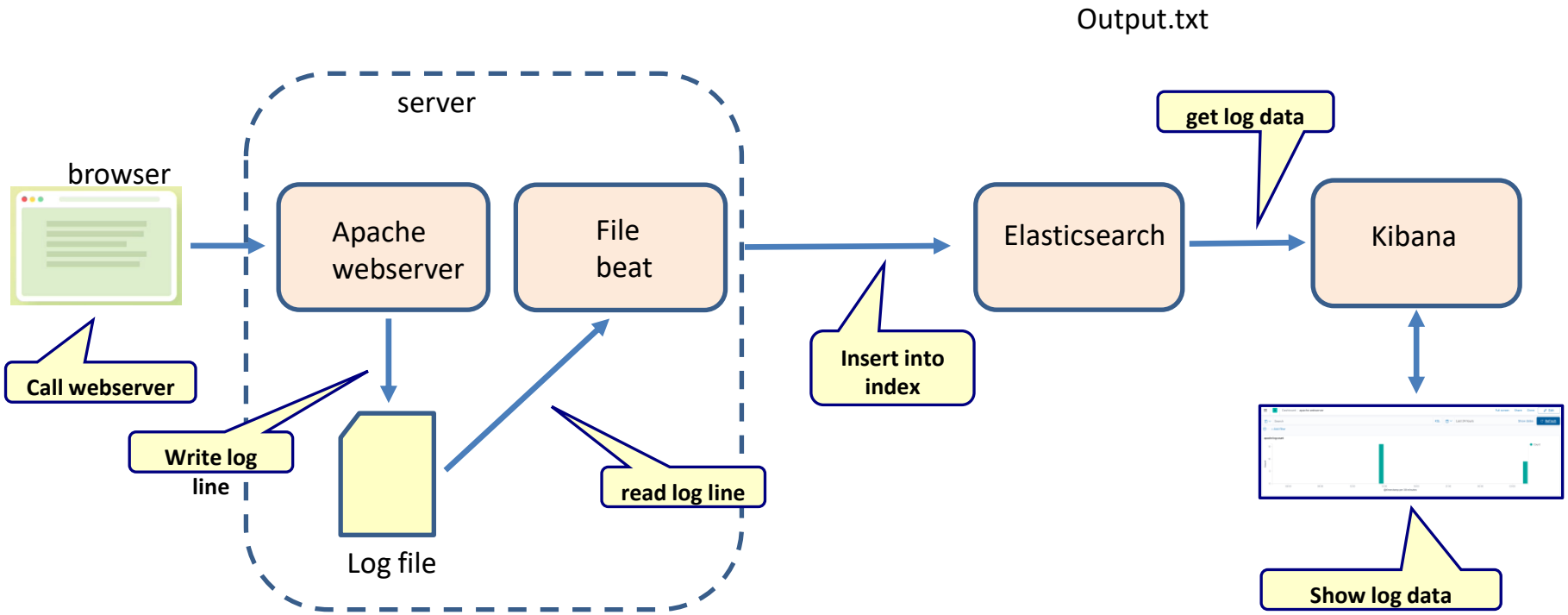


BEATS

Beats

- Data shippers that act as agents installed on the different servers in your infrastructure for collecting logs or metrics
  - log files (Filebeat)
  - network data (Packetbeat)
  - server metrics (Metricbeat)
- Once collected, the data is sent either directly into Elasticsearch or to Logstash for additional processing

filebeat example



Filebeat configuration

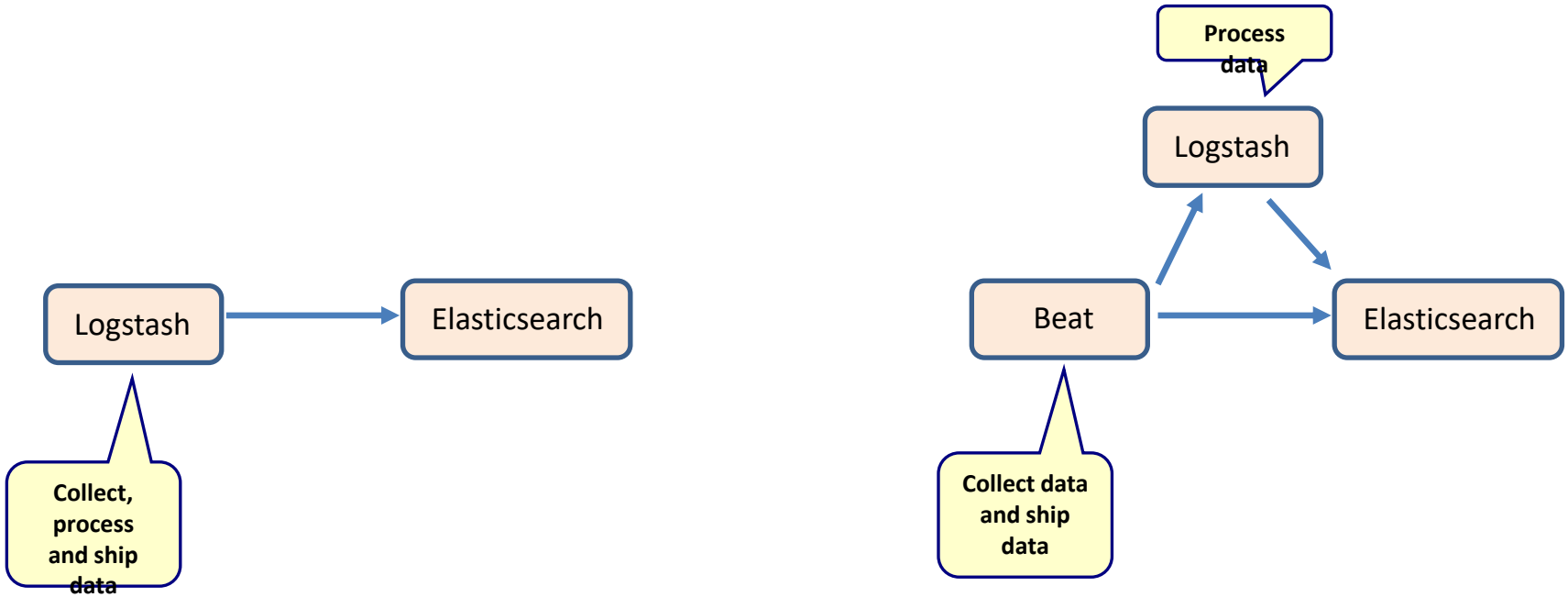
filebeat.yml

```
filebeat.inputs:

# Each - is an input. Most options can be set at the input level, so
# you can use different inputs for various configurations.
# Below are the input specific configurations.

- type: log

  # Change to true to enable this input configuration.
  enabled: true

  # Paths that should be crawled and fetched. Glob based paths.
  paths:
    - C:/elasticsearchtraining/Apache24/logs/access.log


output.elasticsearch:
  # Array of hosts to connect to.
  hosts: ["localhost:9200"]
```

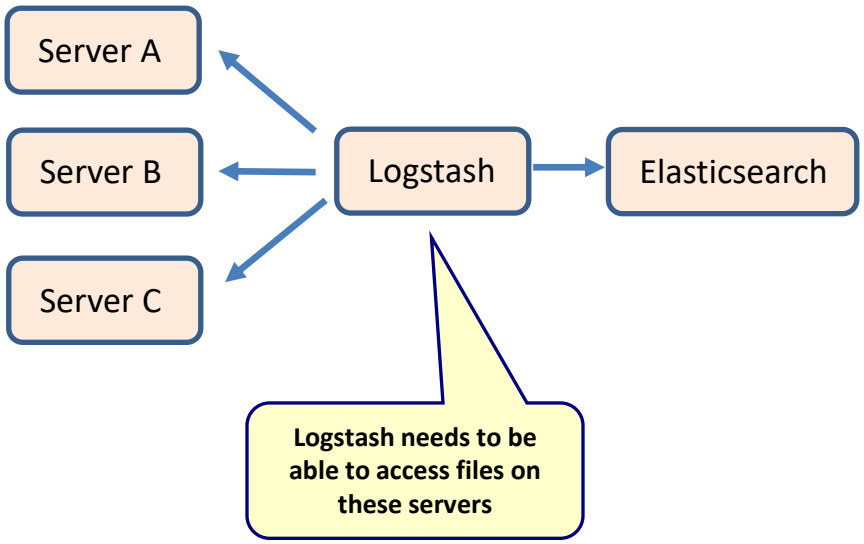
read the access log file

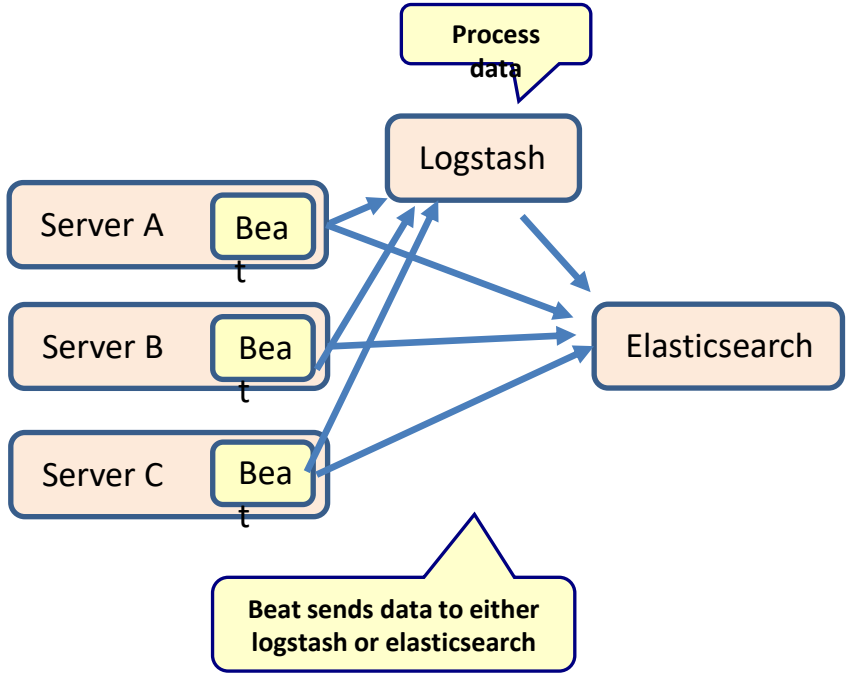
Output to default index 'filebeat' in elasticsearch

Difference between beats and logstash



Difference between beats and logstash





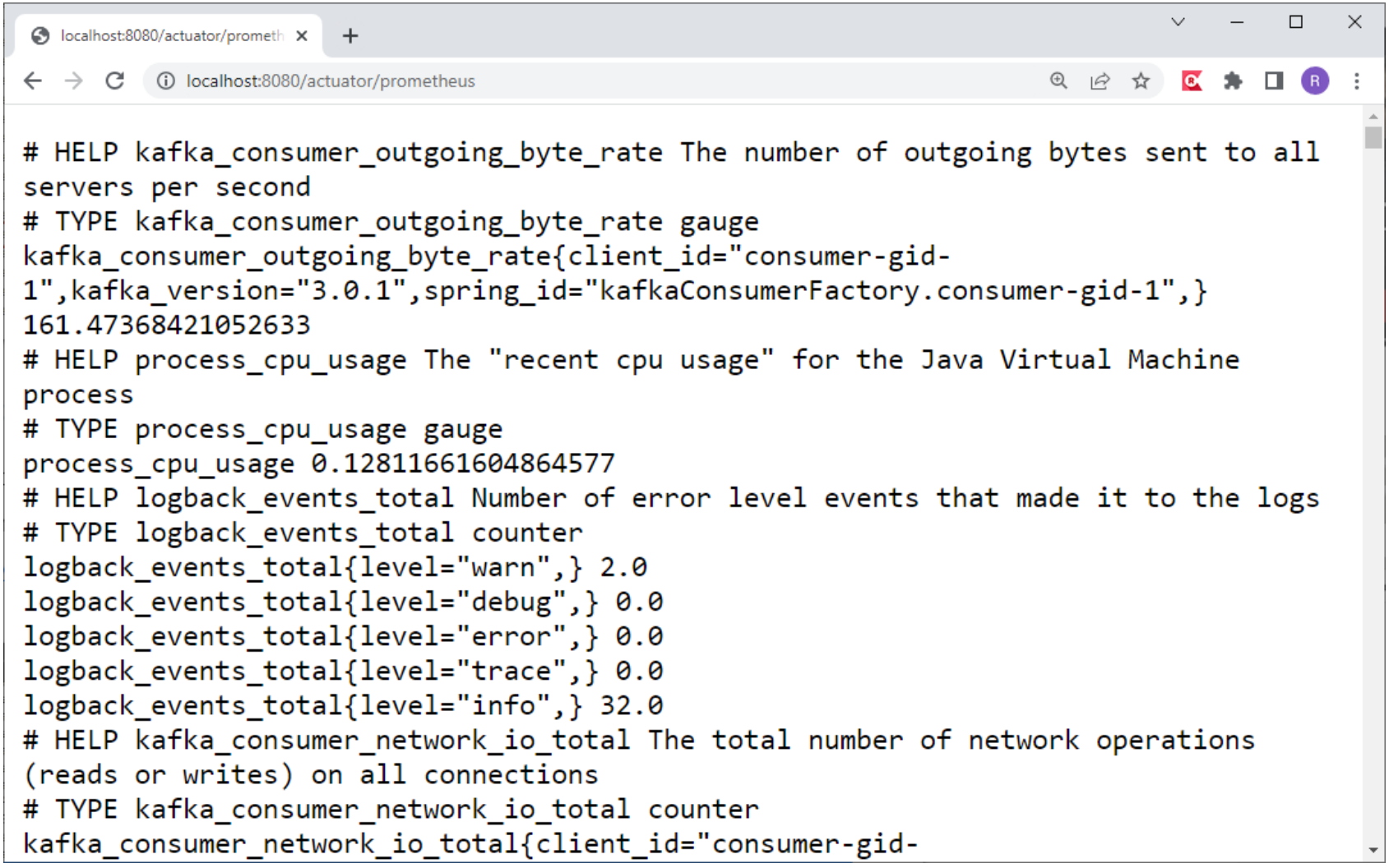
MONITOR ACTUATOR DATA

Micrometer

- Captures metric data and expose this data via an actuator endpoint

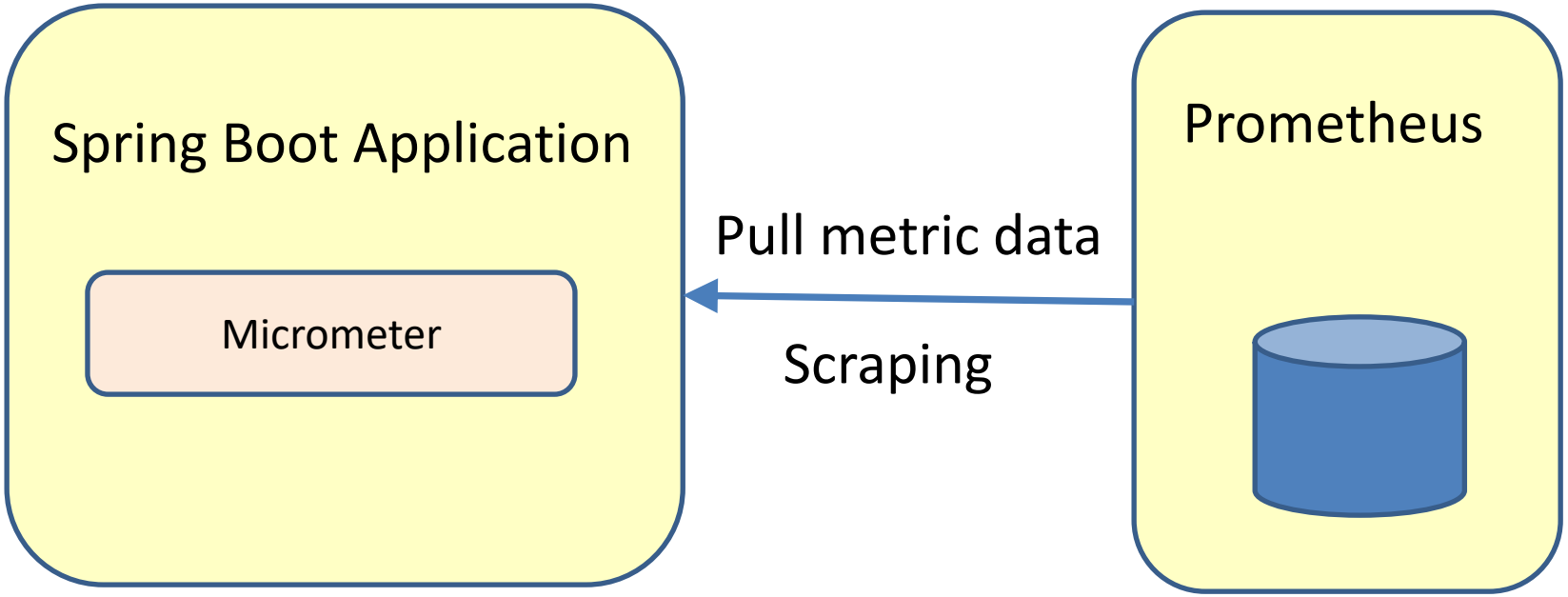
```
<dependency>
  <groupId>io.micrometer</groupId>
  <artifactId>micrometer-registry-prometheus</artifactId>
</dependency>
```

Actuator/prometheus



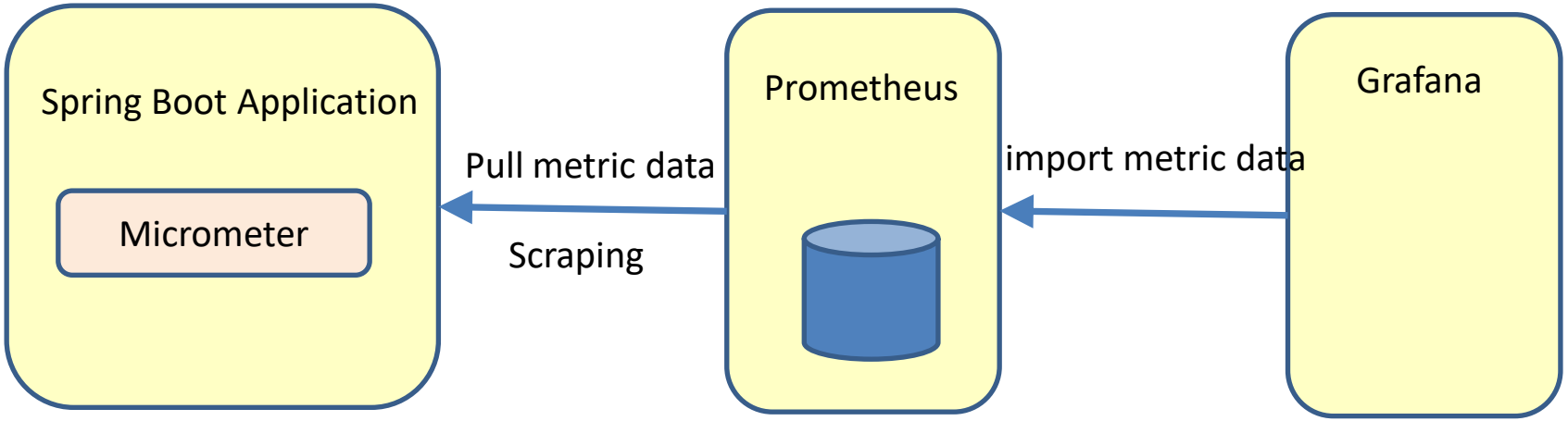
Prometheus

- Time series database
- Stores metric and performance data

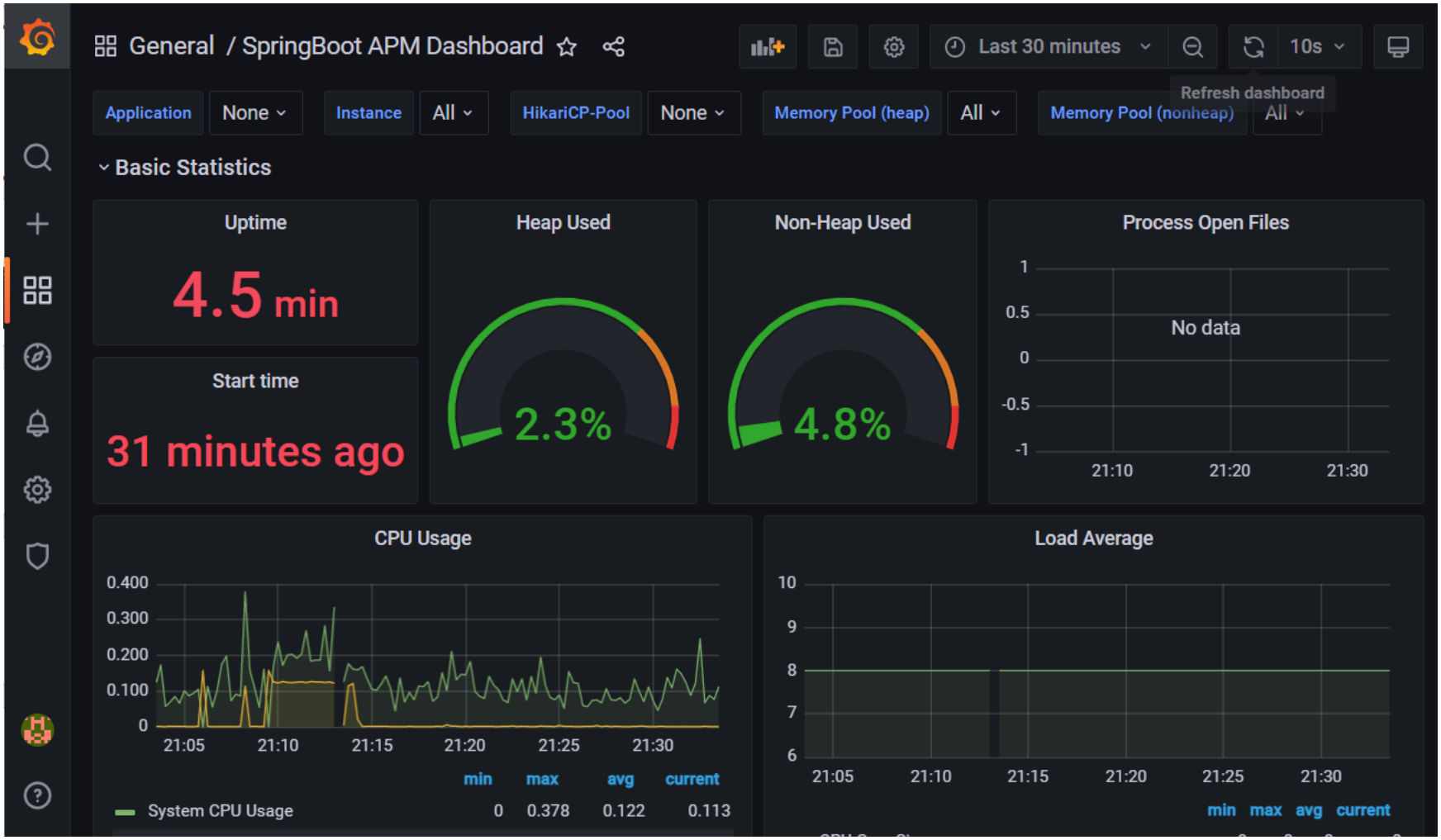


Grafana

- Dashboard to visualize metric data

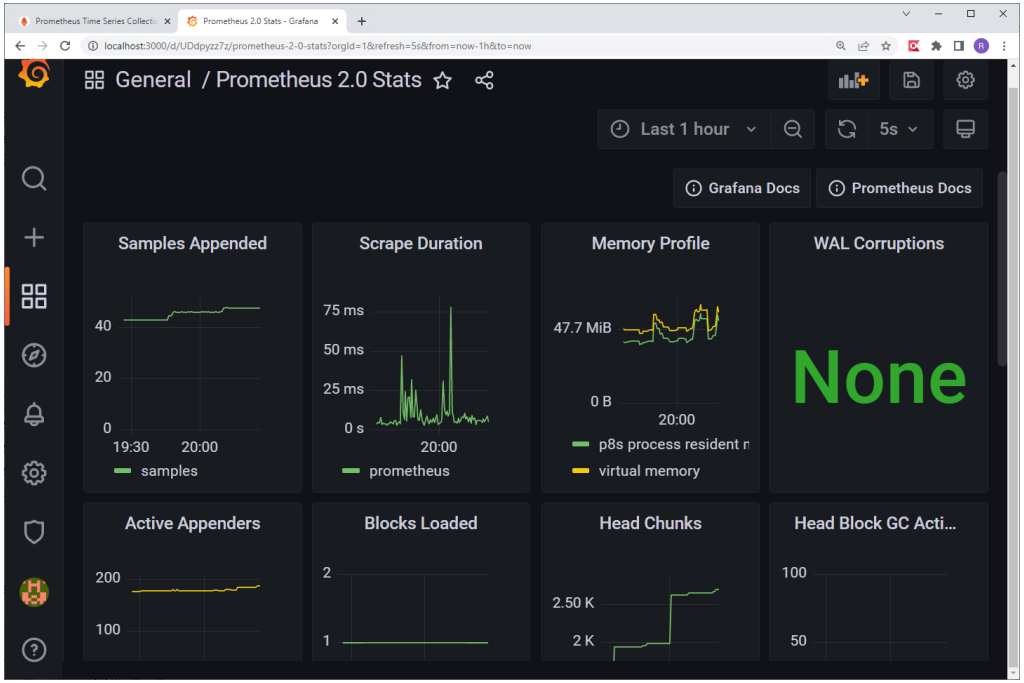


Grafana dashboard



Grafana

- Make your own dashboards
- Alerts
- Refresh interval
- Timespan



UNIT TESTING WITH JUNIT

What is unit testing?

- A unit test is a test that test one single class.
  - A test case test one single method
  - A test class test one single class
  - A test suite is a collection of test classes
- Unit tests make use of a testing framework

- A unit test
  1. Create an object
  2. Call a method
  3. Check if the result is correct

Example of unit testing

```
package count;

public class Counter {
    private int counterValue=0;

    public int increment(){
       return ++counterValue;
    }
    public int decrement(){
       return --counterValue;
    }
    public int getCounterValue() {
       return counterValue;
    }
 }
```

Example of unit testing

```
public class Counter {
    private int counterValue=0;

    public int increment(){
       return ++counterValue;
    }
    public int decrement(){
       return --counterValue;
    }
    public int getCounterValue() {
       return counterValue;
    }
}
```

```
public class CounterTest {
    private Counter counter;

    @BeforeEach
    public void setUp() throws Exception {
      counter = new Counter();
    }
    @Test
    public void testIncrement(){
       assertEquals("Counter.increment does not work correctly",1,counter.increment());
       assertEquals("Counter.increment does not work correctly",2,counter.increment());
    }
    @Test
    public void testDecrement(){
       assertEquals("Counter.decrement does not work correctly",-1,counter.decrement());
       assertEquals("Counter.decrement does not work correctly",-2,counter.decrement());
    }
}
```

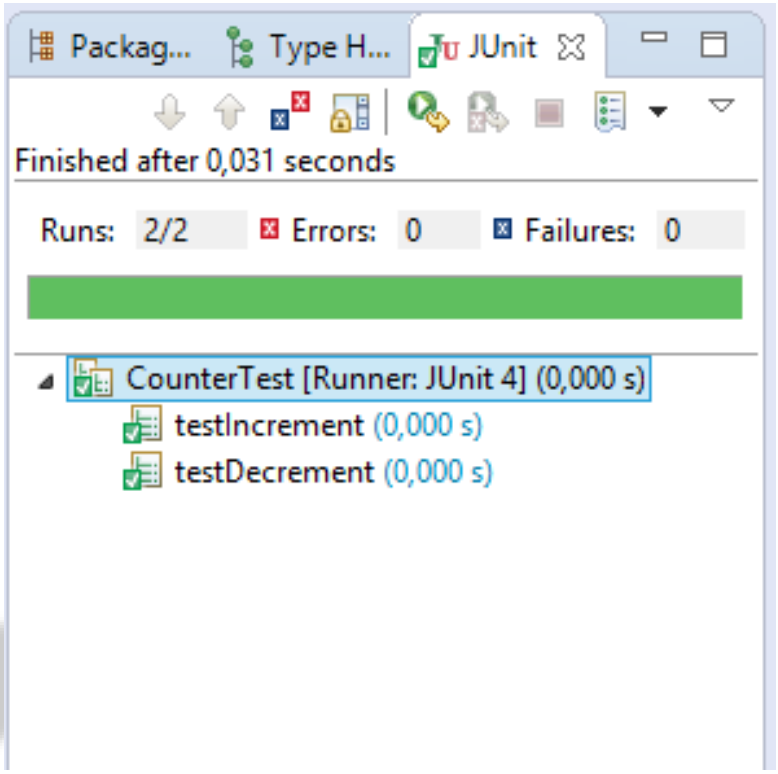
Initialization

Test method

Test method

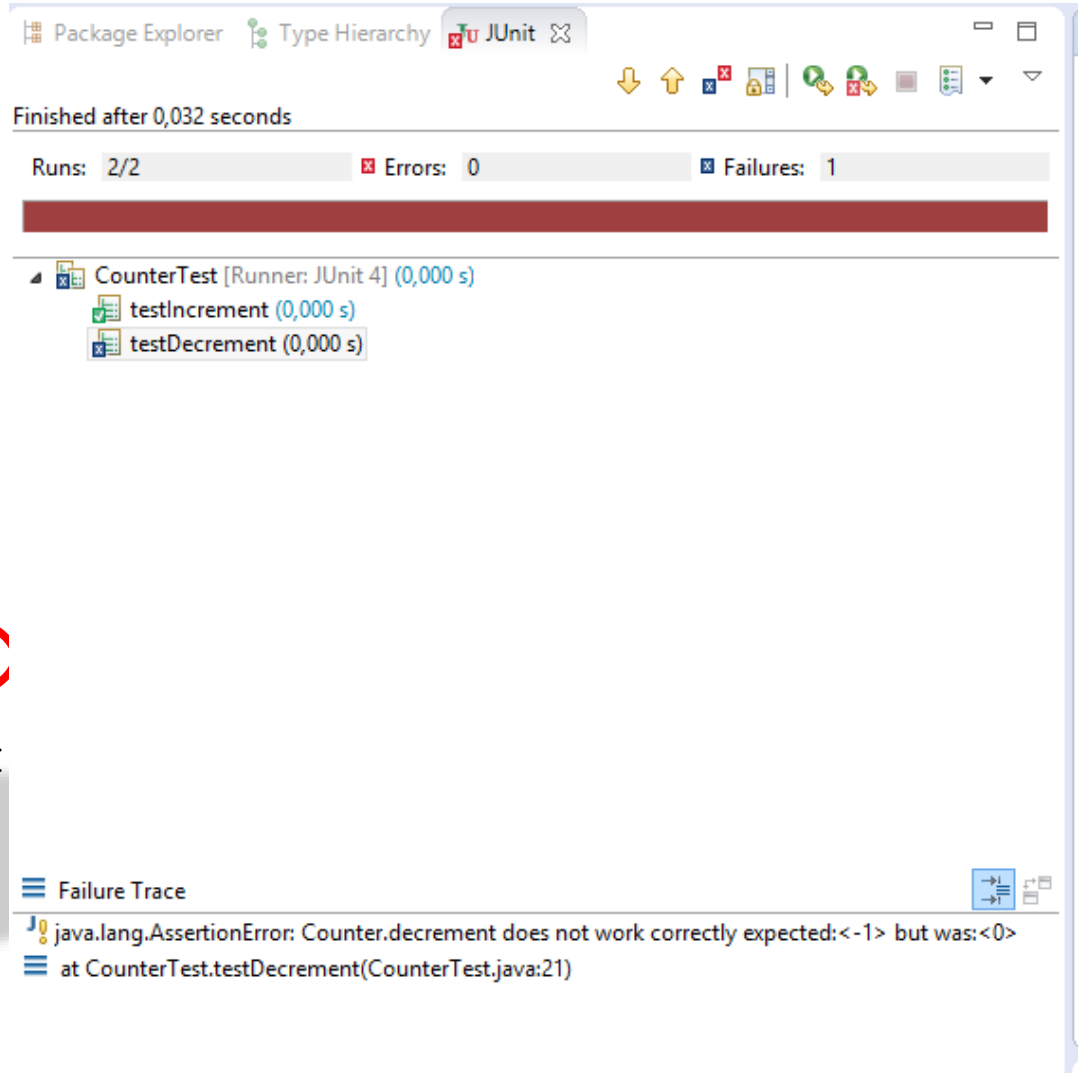
Running the test

```
package count;

public class Counter {
    private int counterValue=0;

    public int increment(){
        return ++counterValue;
    }
    public int decrement(){
        return --counterValue;
    }
    public int getCounterValue() {
        return counterValue;
    }
 }
```



Running the test

```
package count;

public class Counter {
    private int counterValue=0;

    public int increment(){
       return ++counterValue;
    }
    public int decrement(){
       return counterValue;
    }
    public int getCounterValue() {
       return counterValue;
    }
 }
```



JUnit test case

```
public class Calculator
{
    public double add( double number1, double number2 )
    {
        return number1 + number2;
    }
}
```

```
public class CalculatorTest
{
    @Test
    public void add()
    {
        Calculator calculator = new Calculator();
        double result = calculator.add( 10, 50 );
        assertEquals( 60, result, 0 );
    }
}
```

expected

Value to assert

delta

Junit assert methods

- static void assertTrue(boolean ***test***)
- static void assertTrue(String **message**, boolean ***test***)

- static void assertFalse(boolean ***test***)
- static void assertFalse(String **message**, boolean ***test***)

- assertEquals(Object ***expected***, Object ***actual***)
- assertEquals(String **message**, ***expected***, ***actual***)

- assertSame (Object ***expected***, Object ***actual***)
- assertSame(String **message**, Object ***expected***, Object ***actual***)

- assertNotSame(Object ***expected***, Object ***actual***)
- assertNotSame(String **message**, Object ***expected***, Object ***actual***)

- assertNull(Object ***object***)
- assertNull(String **message**, Object ***object***)

- assertNotNull(Object ***object***)
- assertNotNull(String **message**, Object ***object***)

- fail()
- fail(String **message**)

http://junit.org/apidocs/org/junit/Assert.html

@Before and @After

```
public class CounterTest {
    private Counter counter;

    @BeforeEach
    public void setUp() throws Exception {
        counter = new Counter();
    }

    @AfterEach
    public void tearDown() throws Exception {
        counter=null;
    }
    @Test
    public void testConstructor(){
        assertEquals("Counter constructor does not set counter to
                    0",0,counter.getCounterValue());
     }
}
```

This method is called before every testmethod

This method is called after every testmethod

@BeforeClass and @AfterClass

```
public class CounterTest {
    private static Counter counter;

    @BeforeClass
    public static void setUpOnce() throws Exception {
        counter = new Counter();
    }

    @AfterClass
    public static void tearDownOnce() throws Exception {
        counter=null;
    }
    @Test
    public void testConstructor(){
        assertEquals("Counter constructor does not set counter to
                      0",0,counter.getCounterValue());
     }
}
```

This method is called once, before the testmethods are called

This method is called once, after the testmethods are called

Timeout tests

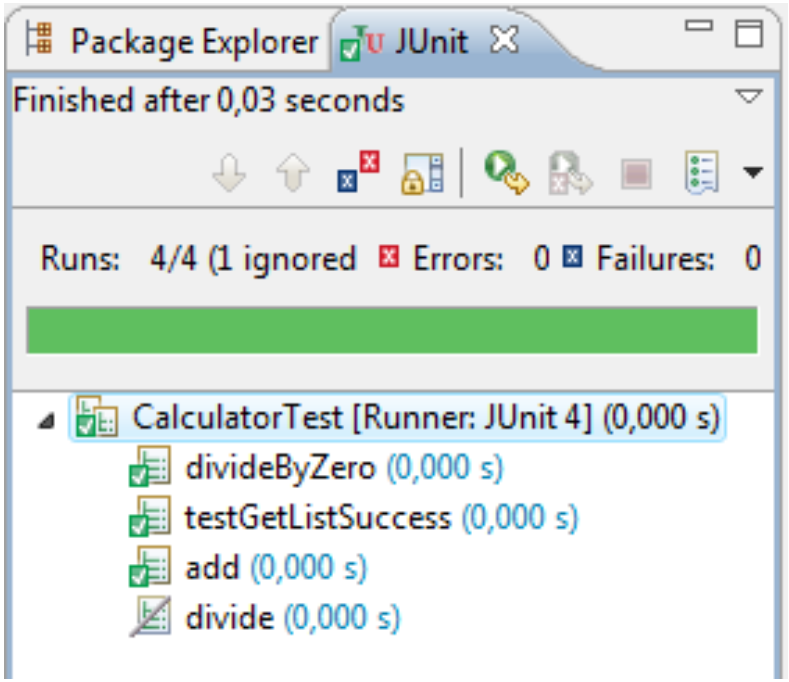
```
@Test(timeout=2000)
public void longOperation() {

}
```

Fail if the test method takes longer than 2000 milliseconds

Skip a test

```
@Test
@Ignore
public void divide(){
    assertEquals( 5, calculator.divide( 10, 2 ), 0 );
}
```

Skip this test



Test suite

```
@RunWith(value=Suite.class)
@SuiteClasses(value={CalculatorTest.class, ParameterizedTest.class})
public class CalculatorTestSuite {

}
```

Suite of 2 test classes

- You can also have a suite of suites
- Organize your tests

JUnit example: Calculator

```
public class Calculator {
    private double value;

    public Calculator() {
      value =0.0;
    }
    public void add(double number) {
      value = value + number;
    }
    public void subtract (double number) {
      value = value - number;
    }
    public void multiply(double number) {
      value = value * number;
    }
    public void divide (double number) throws DivideByZeroException{
      if (number == 0){
        throw new DivideByZeroException();
      }
      value = value / number;
    }
    public double getValue() {
      return value;
    }
}
```

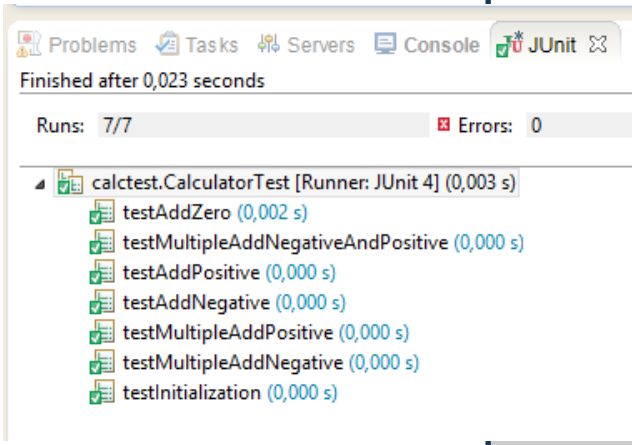
JUnit example: CalculatorTest

```
import calculation.Calculator;

public class CalculatorTest {

  private Calculator calculator;

  @BeforeEach
  public void setup(){
    calculator = new Calculator();
  }

  @Test
  public void testInitialization() {
    assertEquals(0.0, calculator.getValue(),0.0000001);
  }

  @Test
  public void testAddZero() {
    calculator.add(0.0);
    assertEquals(0.0, calculator.getValue(),0.0000001);
  }
```

JUnit example: CalculatorTest

```
@Test
public void testAddPositive() {
  calculator.add(23.255);
  assertEquals(23.255, calculator.getValue(),0.0000001);
}
@Test
public void testAddNegative() {
  calculator.add(-23.255);
  assertEquals(-23.255, calculator.getValue(),0.0000001);
}
@Test
public void testMultipleAddPositive() {
  calculator.add(23.255);
  calculator.add(10.255);
  assertEquals(33.510, calculator.getValue(),0.0000001);
}
@Test
public void testMultipleAddNegative() {
  calculator.add(-23.255);
  calculator.add(-10.255);
  assertEquals(-33.510, calculator.getValue(),0.0000001);
}
@Test
public void testMultipleAddNegativeAndPositive() {
  calculator.add(-23.255);
  calculator.add(10.250);
  assertEquals(-13.005, calculator.getValue(),0.0000001);
}
```

Only test methods for add()



HAMCREST MATCHERS

Traditional asserts

- Parameter order is counter-intuitive
- Assert statements don't read well

assertEquals(***expected***, ***actual***)

```
import static org.junit.Assert.*;

@Test
public void AssertEqualToRed(){
    String color = "red";
    assertEquals("red", color);
}
```

assertThat with hamcrest matchers

```
import static org.junit.Assert.*;
import static org.hamcrest.CoreMatchers.*;
import org.junit.jupiter.api.Before;
import org.junit.jupiter.api.Test;

public class CalculatorHamcrestTest{
Calculator calculator=null;

    @BeforeEach
    public void createAcalculator(){
      calculator = new Calculator();
    }

    @Test
    public void add(){
        assertThat( calculator.add( 10, 50), equalTo (60.0));
    }

    @Test
    public void divide(){
        assertThat(calculator.divide( 10, 2 ), equalTo (5.0));
    }
}
```

Static import of matchers

matcher

assertThat

actual

expected

assert vs assertThat

```java
@Test
public void AssertEqualToRed(){
    String color = "red";
    assertEquals("red", color);
}
```

assert

```java
@Test
public void hamcrestAssertEqualToRed(){
    String color = "red";
    assertThat(color, equalTo("red"));
}
```

assertThat

assertThat equality tests

```
String color = "red";
assertThat(color, is("red"));
```

assertThat … is

```
String color = "red";
assertThat(color, equalTo("red"));
```

assertThat … equalTo

```
String color = "red";
assertThat(color, not("blue"));
```

assertThat … not

```
String color = "red";
assertThat(color, isOneOf("blue","red"));
```

assertThat … isOneOf

```
List myList = new ArrayList();
assertThat(myList, is(Collection.class));
```

assertThat … is a class

assertThat testing for null values

```
String color = "red";
assertThat(color, is(notNullValue()));
assertNotNull(color);
```

notNullValue

```
String color = null;
assertThat(color, is(nullValue()));
assertNull(color);
```

nullValue

assertThat testing with collections

```
List<String> colors = new ArrayList<String>();
colors.add("red");
colors.add("green");
colors.add("blue");
assertThat(colors, hasItem("blue"));
```

hasItem

```
assertThat(colors, hasItems("red","blue"));
```

hasItems

```
String[] colors = new String[] {"red","green","blue"};
assertThat(colors, hasItemInArray("blue"));
```

hasItemInArray

```
assertThat("red", isIn(colors));
```

isIn

```
List<Integer> ages = new ArrayList<Integer>();
ages.add(20);
ages.add(30);
ages.add(40);
assertThat(ages, not(hasItem(lessThan(18))));
```

Combined matchers

Hamcrest matchers

- Core
  - anything - always matches, useful if you don't care what the object under test is
  - describedAs - decorator to adding custom failure description
  - is - decorator to improve readability
- Logical
  - allOf - matches if all matchers match, short circuits (like Java &&)
  - anyOf - matches if any matchers match, short circuits (like Java ||)
  - not - matches if the wrapped matcher doesn't match and vice versa
- Object
  - equalTo - test object equality using Object.equals
  - hasToString - test Object.toString
  - instanceOf, isCompatibleType - test type
  - notNullValue, nullValue - test for null
  - sameInstance - test object identity
- Beans
  - hasProperty - test JavaBeans properties
- Collections
  - array - test an array's elements against an array of matchers
  - hasEntry, hasKey, hasValue - test a map contains an entry, key or value
  - hasItem, hasItems - test a collection contains elements
  - hasItemInArray - test an array contains an element
- Number
  - closeTo - test floating point values are close to a given value
  - greaterThan, greaterThanOrEqualTo, lessThan, lessThanOrEqualTo - test ordering
- Text
  - equalToIgnoringCase - test string equality ignoring case
  - equalToIgnoringWhiteSpace - test string equality ignoring differences in runs of whitespace
  - containsString, endsWith, startsWith - test string matching