Desenvolvimento de Aplicações com Arquitetura Baseada em Microservices

Prof. Vinicius Cardoso Garcia
vcg@cin.ufpe.br :: @vinicius3w :: assertlab.com

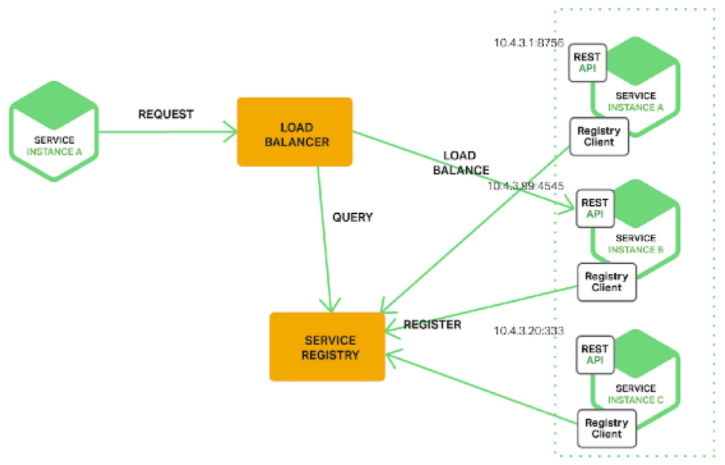
[IF1007] - Tópicos Avançados em SI 4
https://github.com/vinicius3w/if1007-Microservices

Licença do material

Resources

- There is no textbook required. However, the following are some books that may be recommended:
  - Building Microservices: Designing Fine-Grained Systems
  - Spring Microservices
  - Spring Boot: Acelere o desenvolvimento de microsserviços
  - Microservices for Java Developers A Hands-on Introduction to Frameworks and Containers
  - Migrating to Cloud-Native Application Architectures
  - Continuous Integration
  - Getting started guides from spring.io

AssertLab
Advanced Software and Systems Engineering Research Technologies

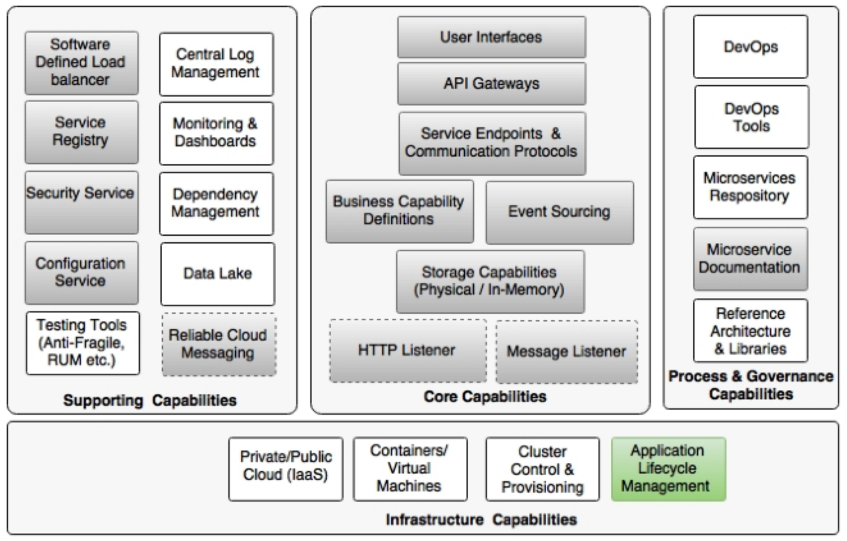


Autoscaling Microservices

Context

- Spring Cloud provides the support essential for the deployment of microservices at scale
- This lecture will detail out how to make microservices elastically grow and shrink by effectively using the actuator data collected from Spring Boot microservices to control the deployment topology by implementing a simple life cycle manager

Reviewing the microservice capability model


Software Defined Load balancer
Central Log Management
Service Registry
Monitoring & Dashboards
Security Service
Dependency Management
Configuration Service
Data Lake
Testing Tools (Anti-Fragile, RUM etc.)
Reliable Cloud Messaging
Supporting Capabilities
User Interfaces
API Gateways
Service Endpoints & Communication Protocols
Business Capability Definitions
Event Sourcing
Storage Capabilities (Physical / In-Memory)
HTTP Listener
Message Listener
Core Capabilities
DevOps
DevOps Tools
Microservices Respository
Microservice Documentation
Reference Architecture & Libraries
Process & Governance Capabilities
Private/Public Cloud (IaaS)
Containers/ Virtual Machines
Cluster Control & Provisioning
Application Lifecycle Management
Infrastructure Capabilities

AssertLab

This lecture will cover the Application Lifecycle Management capability in the microservices capability model discussed in lecture 4, Applying Microservices Concepts

Scaling microservices with Spring Cloud

- How to scale Spring Boot microservices using Spring Cloud components
- Two key concepts of Spring Cloud that we implemented are self-registration and self-discovery ~> enable automated microservices deployments
- Self-registration ~> central service registry ~> discovering service instances
- Registry is at the heart of this automation

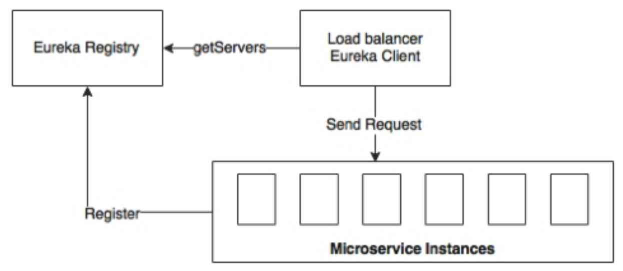
With self-registration, microservices can automatically advertise the service availability by registering service metadata to a central service registry as soon as the instances are ready to accept traffic. Once the microservices are registered, consumers can consume the newly registered services from the very next moment by discovering service instances using the registry service. Registry is at the heart of this automation.

Scaling with traditional J2EE

- Server instances' IP addresses are more or less statically configured in a load balancer
  - Cluster approach is not the best solution for automatic scaling in Internet-scale deployments
    - They have to have exactly the same version of binaries on all cluster nodes

Key components

- Key components in our automated microservices deployment topology
  - Eureka registry
  - Eureka client
  - Microservices instances
- However, there is one gap in this approach
  - When there is need for an additional microservice instance, a manual task is required to kick off a new instance

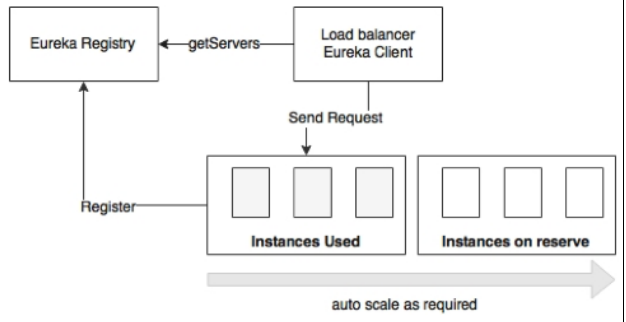


AssertLab

Eureka registry: REST APIs are used by both consumers as well as providers to access the registry
Eureka client, together with the **Ribbon client**, provide client-side dynamic load balancing
Microservices instances developed using Spring Boot with the actuator endpoints enabled

Understanding the concept of autoscaling

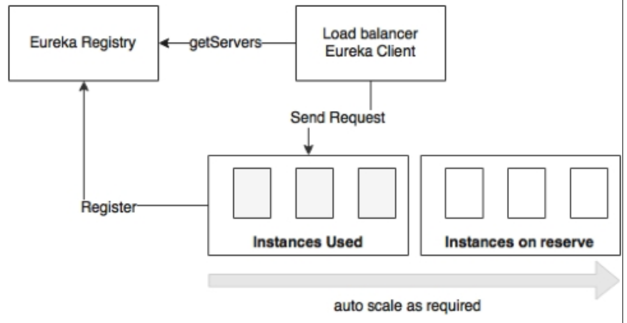
- Automatically scaling out instances based on the resource usage to meet the SLAs by replicating the services to be scaled
- Autoscaling is done, generally, using a set of reserve machines
- This approach is often called elasticity or dynamic resource provisioning and deprovisioning



The system automatically detects **an increase in traffic**, spins up additional instances, and makes them available for traffic handling. Similarly, when the **traffic volumes go down**, the system automatically detects and reduces the number of instances by taking active instances back from the service

Resource pool of instances

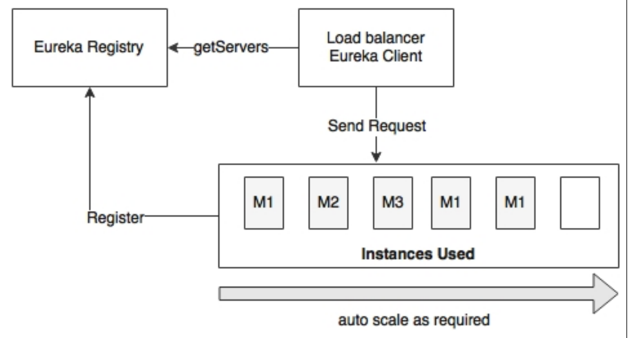
- Based on the demand, instances will be moved from the resource pool to the active state to meet the surplus demand
- In advanced deployments, the Spring Boot binaries are downloaded on demand from an artifact repository such as [Nexus]() or [JFrog]()



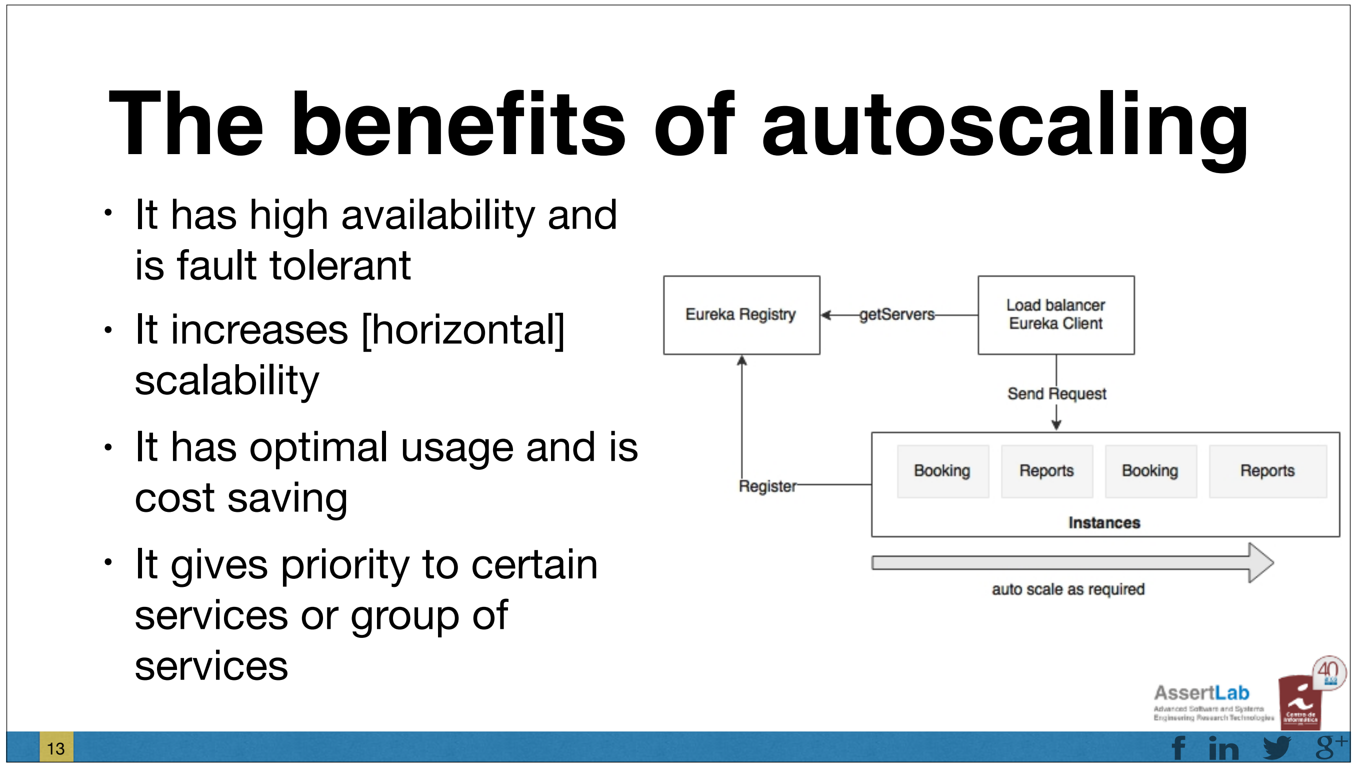
These instances are not pretagged for any particular microservices or prepackaged with any of the microservice binaries

The benefits of autoscaling

- In traditional deployments, administrators reserve a set of servers against each application
- With autoscaling, this preallocation is no longer required

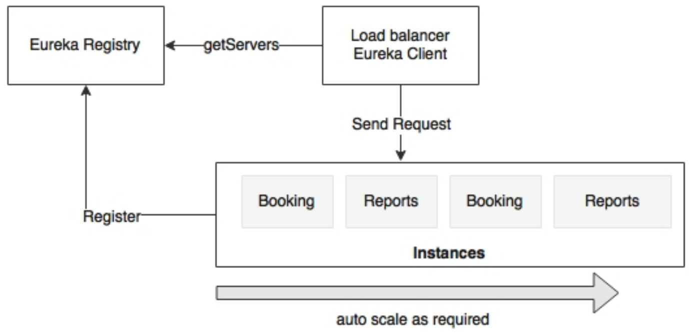


With hundreds of microservice instances, preallocating a fixed number of servers to each of the microservices is not cost effective
A better approach is to reserve a number of server instances for a group of microservices without preallocating or tagging them against a microservice



The benefits of autoscaling

- It has high availability and is fault tolerant
- It increases [horizontal] scalability
- It has optimal usage and is cost saving
- It gives priority to certain services or group of services



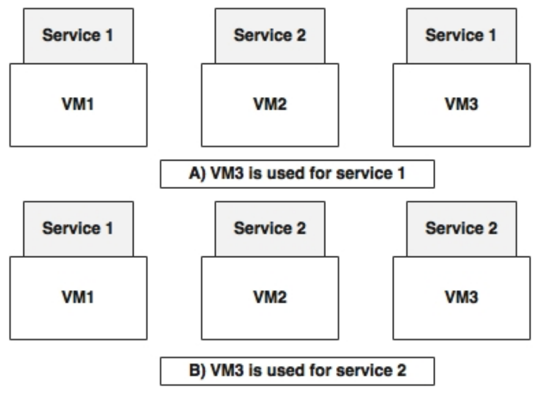
With autoscaling, it is possible to give priority to certain critical transactions over low-value transactions. This will be done by removing an instance from a low-value service and reallocating it to a high-value service

Different autoscaling models

- Autoscaling can be applied at the application level or at the infrastructure level
- In a nutshell, application scaling is scaling by replicating application binaries only, whereas infrastructure scaling is replicating the entire virtual machine, including application binaries

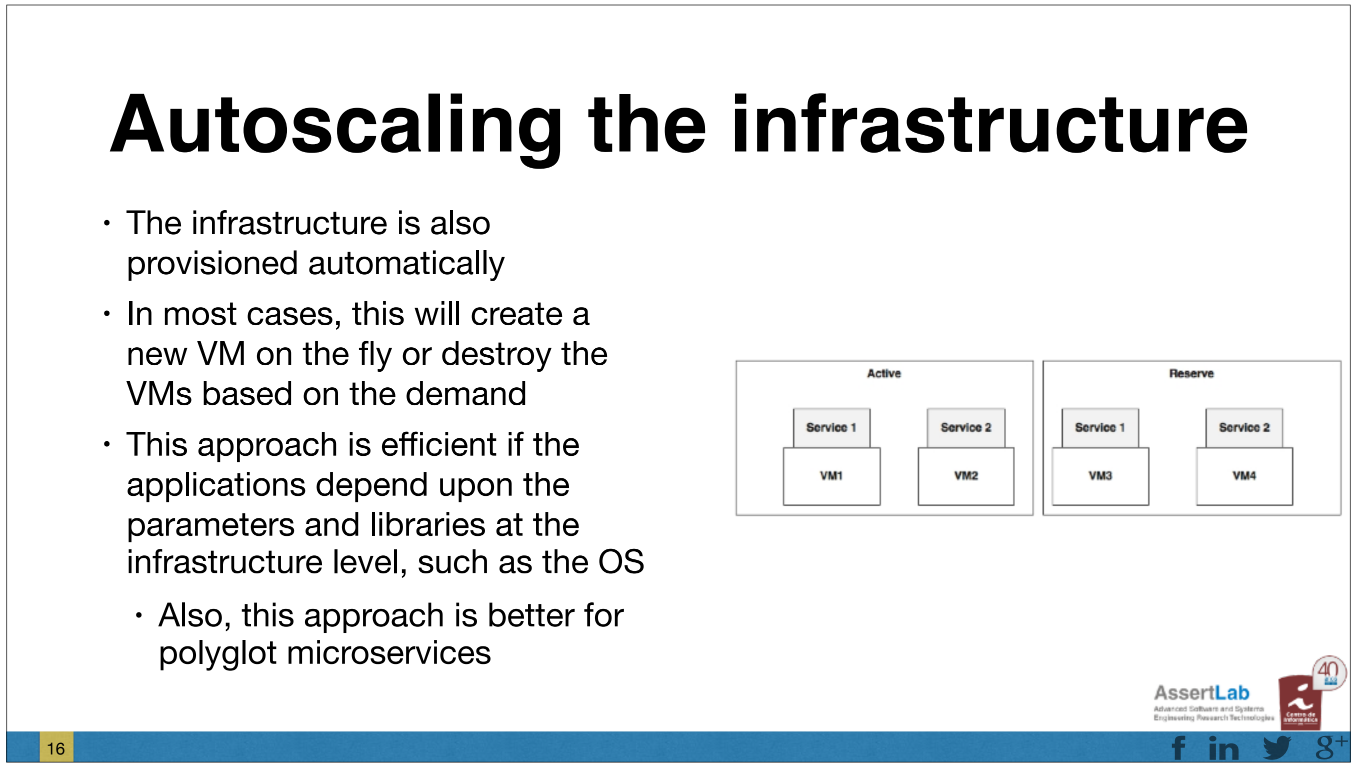
Autoscaling an application

- Scaling is done by replicating the microservices, not the underlying infrastructure
- Flexibility in reusing the same virtual or physical machines for different services
- Is there a downside in this approach?



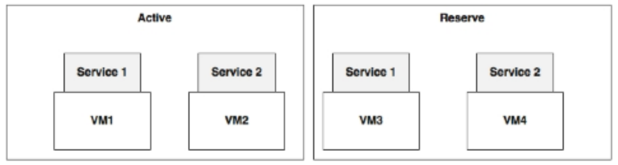
AssertLab
Advanced Software and Systems Engineering Research Technologies

The assumption is that there is a pool of VMs or physical infrastructures available to scale up microservices. These VMs have the basic image fused with any dependencies, such as JRE. It is also assumed that microservices are homogeneous in nature. This gives flexibility in reusing the same virtual or physical machines for different services



Autoscaling the infrastructure

- The infrastructure is also provisioned automatically
- In most cases, this will create a new VM on the fly or destroy the VMs based on the demand
- This approach is efficient if the applications depend upon the parameters and libraries at the infrastructure level, such as the OS
  - Also, this approach is better for polyglot microservices



As shown in the preceding diagram, the reserve instances are created as VM images with predefined service instances. When there is demand for Service 1, VM3 is moved to an active state. When there is a demand for Service 2, VM4 is moved to the active state.

Autoscaling in the cloud

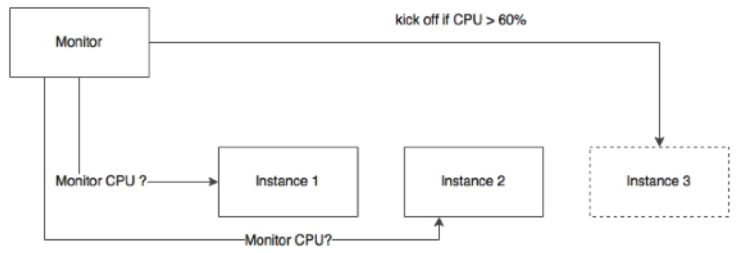
- Elasticity or autoscaling is one of the fundamental features of most cloud providers
- Cloud providers use infrastructure scaling patterns, as discussed in the previous section
- These are typically based on a set of pooled machines

Autoscaling approaches

- Autoscaling is handled by considering different parameters and thresholds
- What are the different approaches and policies that are typically applied to take decisions on when to scale up or down?

Scaling with resource constraints

- Based on real-time service metrics collected through monitoring mechanisms
- Generally, the resource-scaling approach takes decisions based on the CPU, memory, or the disk of machines
- This can also be done by looking at the statistics collected on the service instances themselves, such as heap memory usage



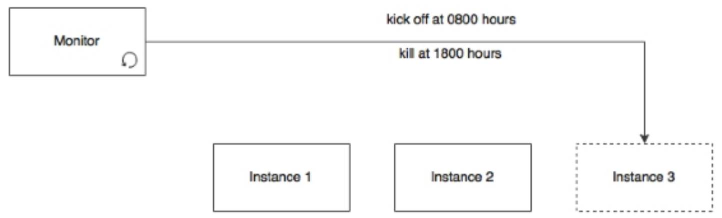
A typical policy may be spinning up another instance when the CPU utilization of the machine goes beyond 60%. Similarly, if the heap size goes beyond a certain threshold, we can add a new instance. The same applies to downsizing the compute capacity when the resource utilization goes below a set threshold. This is done by gradually shutting down servers

Sliding window or a waiting period

- An example of a response sliding window is if 60% of the response time of a particular transaction is consistently more than the set threshold value in a 60-second sampling window, increase service instances
- In a CPU sliding window, if the CPU utilization is consistently beyond 70% in a 5 minutes sliding window, then a new instance is created
- An example of the exception sliding window is if 80% of the transactions in a sliding window of 60 seconds or 10 consecutive executions result in a particular system exception, such as a connection timeout due to exhausting the thread pool, then a new service instance is created

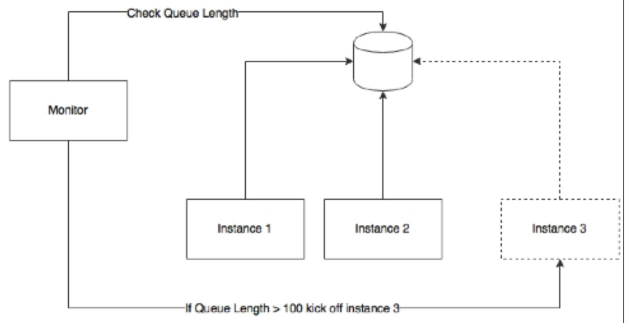
Scaling during specific time periods

- Time-based scaling is an approach to scaling services based on certain periods of the day, month, or year to handle seasonal or business peaks
- For example, some services may experience a higher number of transactions during office hours and a considerably low number of transactions outside office hours



Scaling based on the message queue length

- Particularly useful when the microservices are based on asynchronous messaging
- New consumers are automatically added when the messages in the queue go beyond certain limits
- This approach is based on the [competing consumer pattern]

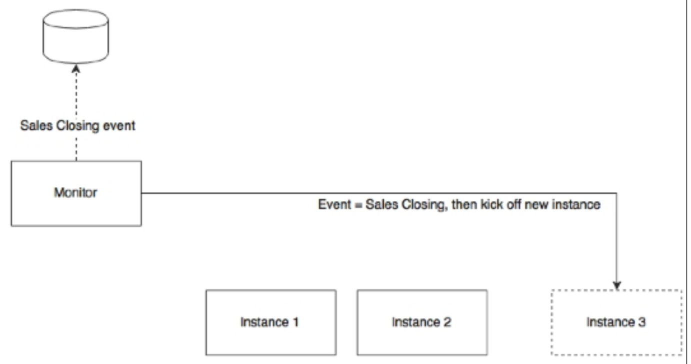


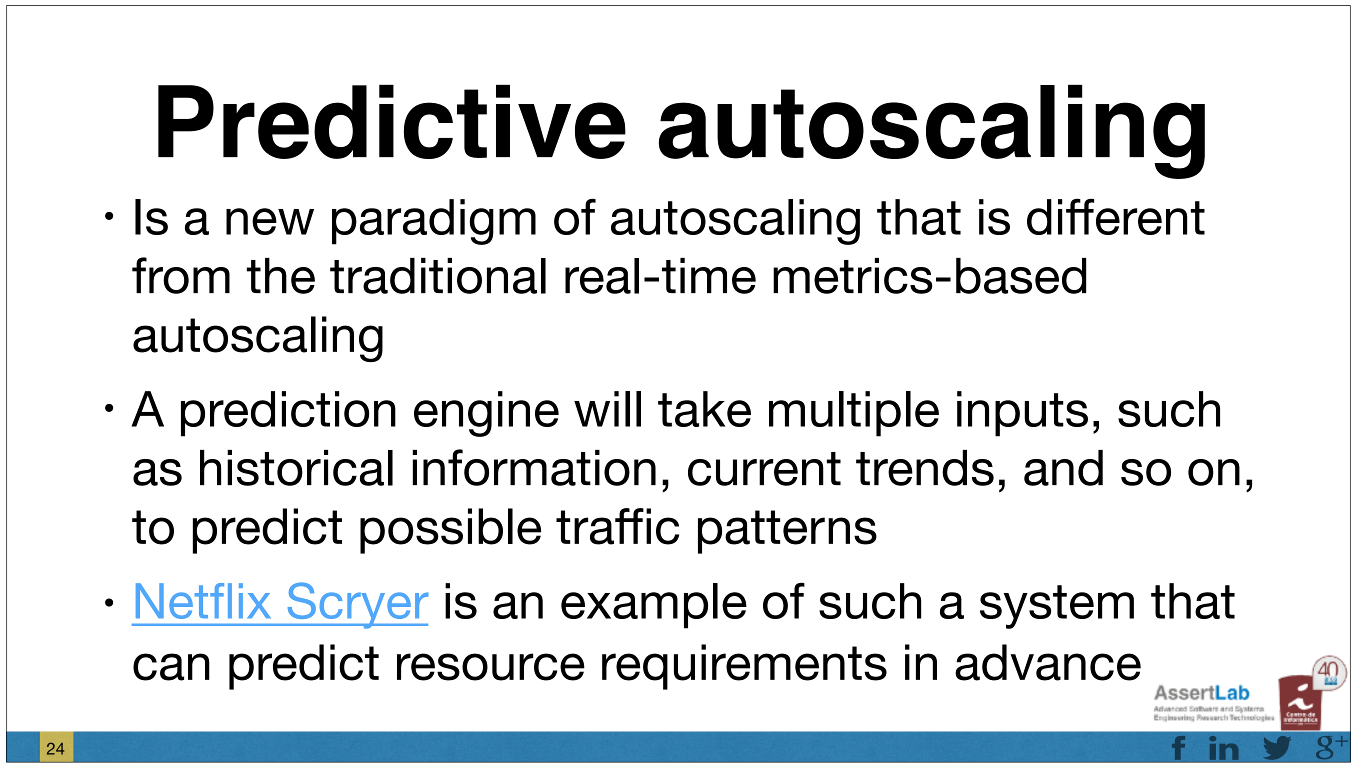
AssertLab

In this case, a pool of instances is used to consume messages. Based on the message threshold, new instances are added to consume additional messages.

Scaling based on business parameters

- Adding instances is based on certain business parameters—for example, spinning up a new instance just before handling **sales closing** transactions
- As soon as the monitoring service receives a preconfigured business event (such as **sales closing minus 1 hour**), a new instance will be brought up in anticipation of large volumes of transactions
- This will provide fine-grained control on scaling based on business rules

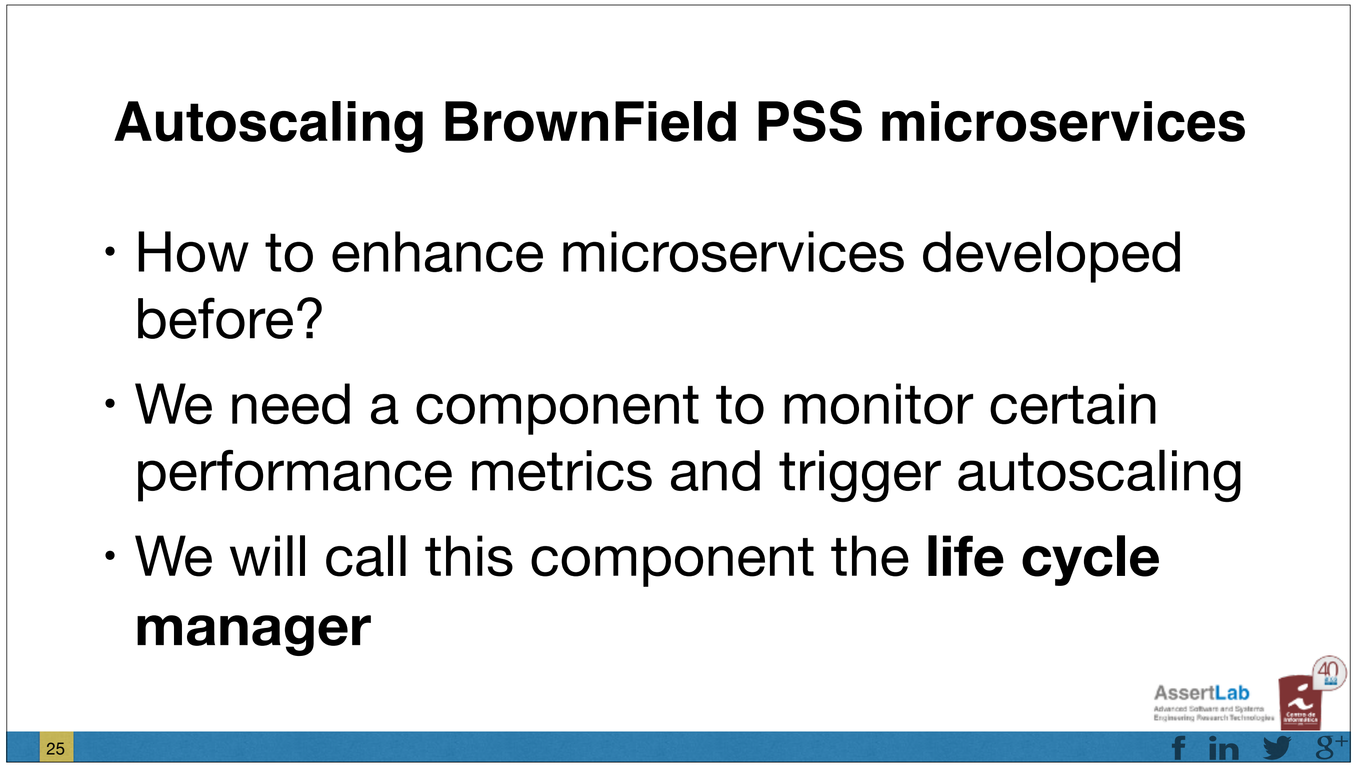




Predictive autoscaling

- Is a new paradigm of autoscaling that is different from the traditional real-time metrics-based autoscaling
- A prediction engine will take multiple inputs, such as historical information, current trends, and so on, to predict possible traffic patterns
- Netflix Scryer is an example of such a system that can predict resource requirements in advance

Autoscaling is done based on these predictions. Predictive autoscaling helps avoid hardcoded rules and time windows. Instead, the system can automatically predict such time windows. In more sophisticated deployments, predictive analysis may use cognitive computing mechanisms to predict autoscaling



Autoscaling BrownField PSS microservices

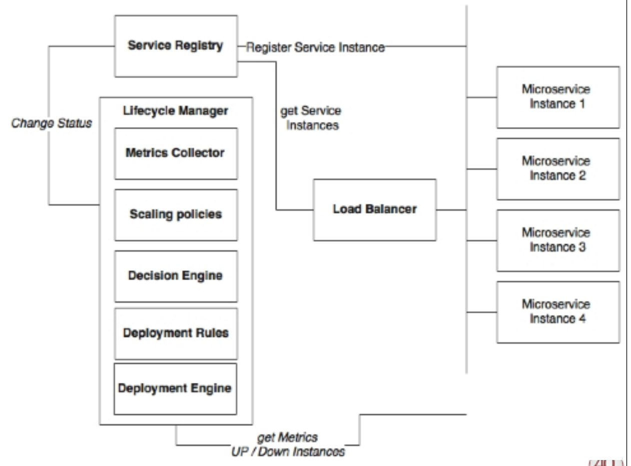
- How to enhance microservices developed before?
- We need a component to monitor certain performance metrics and trigger autoscaling
- We will call this component the **life cycle manager**

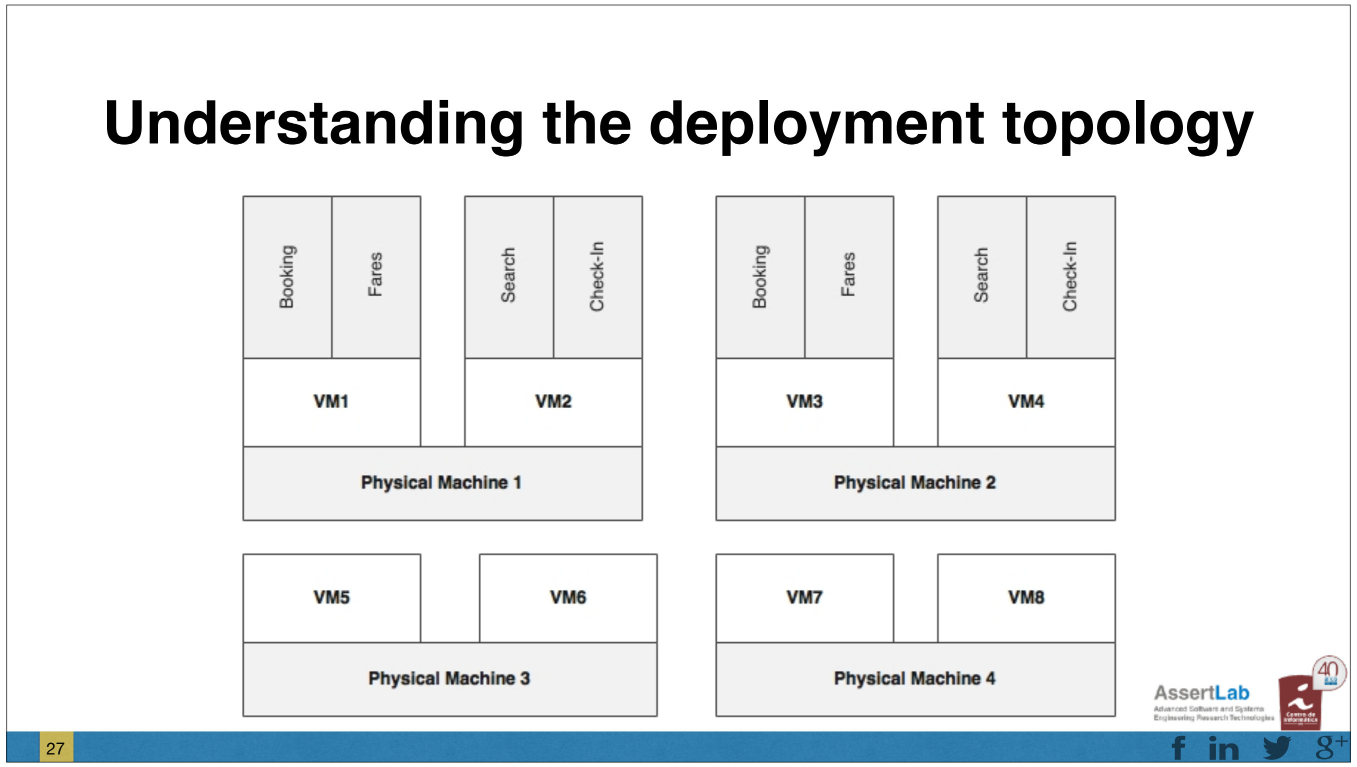
AssertLab

The service life cycle manager, or the application life cycle manager, is responsible for detecting scaling requirements and adjusting the number of instances accordingly. It is responsible for starting and shutting down instances dynamically

The capabilities required for an autoscaling system

- Metrics Collector: responsible for collecting metrics from all service instances
- Scaling policies: sets of rules indicating when to scale up and scale down
- Decision Engine: responsible for making decisions based on the aggregated metrics and scaling policies
- Deployment Rules: DpE decide which parameters to consider when deploying services
- Deployment Engine: can start or stop MS instances or update the registry by altering the health states of services





Understanding the deployment topology

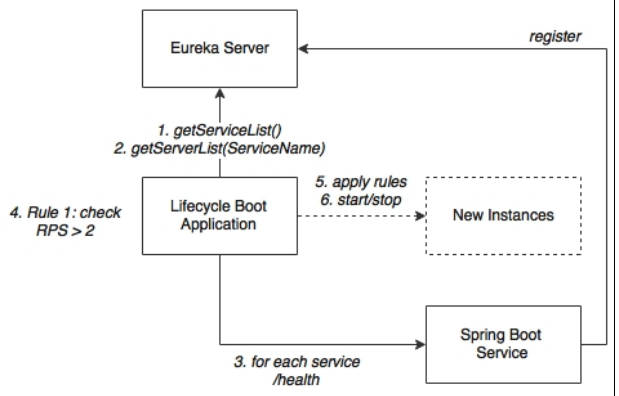
As shown in the diagram, there are four physical machines. Eight VMs are created from four physical machines. Each physical machine is capable of hosting two VMs, and each VM is capable of running two Spring Boot instances, assuming that all services have the same resource requirements.

Four VMs, VM1 through VM4, are active and are used to handle traffic. VM5 to VM8 are kept as reserve VMs to handle scalability. VM5 and VM6 can be used for any of the microservices and can also be switched between microservices based on scaling demands. Redundant services use VMs created from different physical machines to improve fault tolerance.

Our objective is to scale out any services when there is increase in traffic flow using four VMs, VM5 through VM8, and scale down when there is not enough load. The architecture of our solution is as follows.

Understanding the execution flow

- The Spring Boot service represents microservices such as Search, Book, Fares, and Check-in, at startup automatically register endpoint details to the Eureka registry
- With the collected metrics information, the life cycle manager executes a list of policies and derives decisions on whether to scale up or scale down instances
- In the case of shutdown, it connects to the server using an actuator endpoint and calls the shutdown service to gracefully shut down an instance
- In the case of starting a new instance, the deployment engine of the life cycle manager uses the scaling rules and decides where to start the new instance and what parameters are to be used when starting the instance

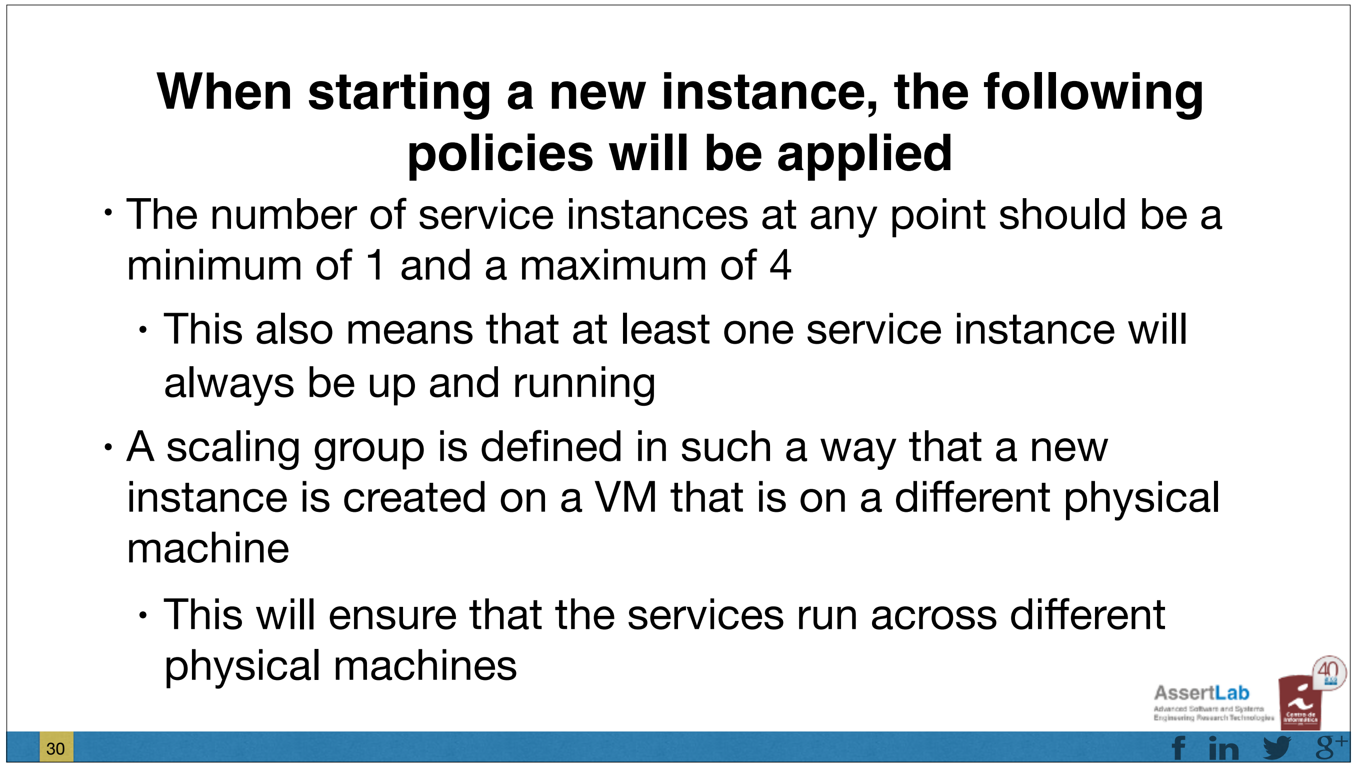


AssertLab
Advanced Software and Systems Engineering Research Technologies

The life cycle manager service is nothing but another Spring Boot application. The life cycle manager has a metrics collector that runs a background job, periodically polls the Eureka server, and gets details of all the service instances. The metrics collector then invokes the actuator endpoints of each microservice registered in the Eureka registry to get the health and metrics information. In a real production scenario, a subscription approach for data collection is better.

Understanding the execution flow

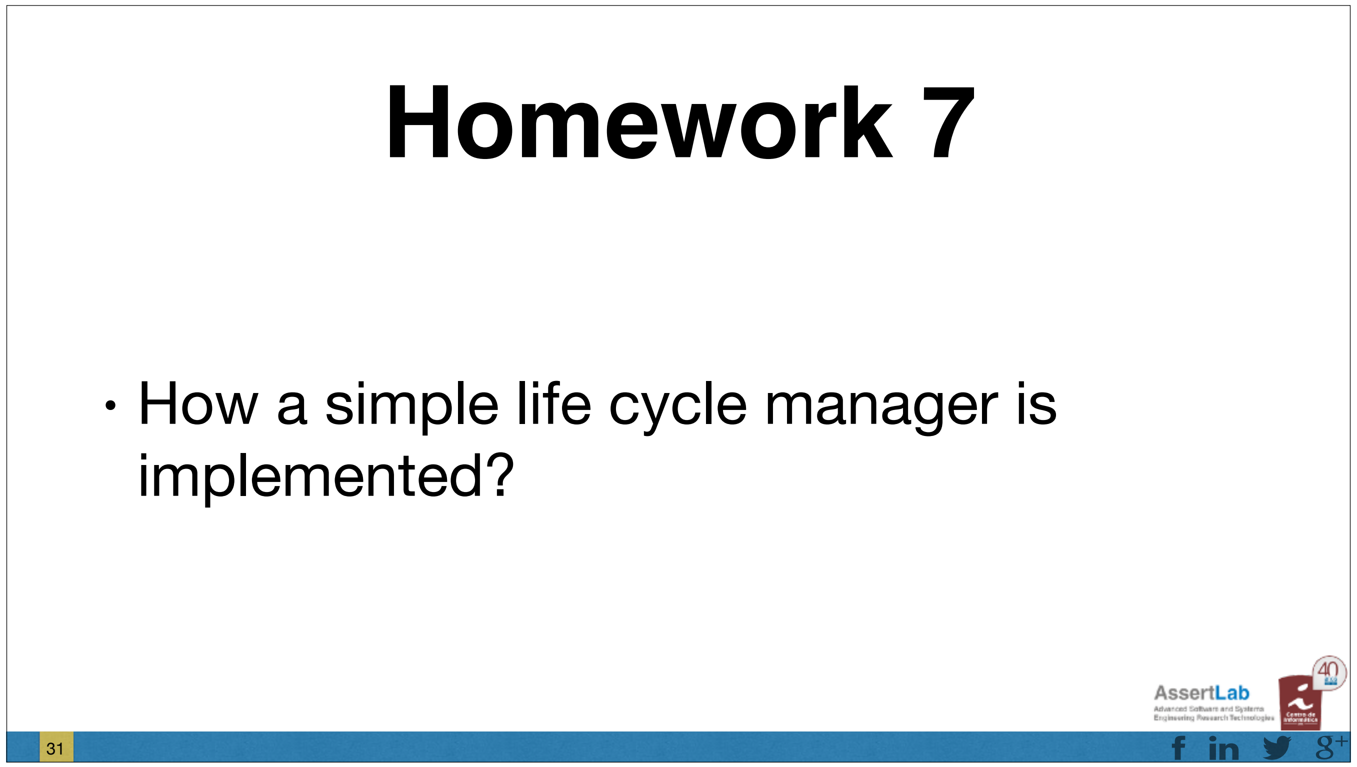
- In this example, we will use TPM (Transactions Per Minute) or RPM (Requests Per Minute) as sampler metrics for decision making
- If the Search service has more than 10 TPM, then it will spin up a new Search service instance
- Similarly, if the TPM is below 2, one of the instances will be shut down and released back to the pool



When starting a new instance, the following policies will be applied

- The number of service instances at any point should be a minimum of 1 and a maximum of 4
  - This also means that at least one service instance will always be up and running
- A scaling group is defined in such a way that a new instance is created on a VM that is on a different physical machine
  - This will ensure that the services run across different physical machines

These policies could be further enhanced. The life cycle manager ideally provides options to customize these rules through REST APIs or Groovy scripts



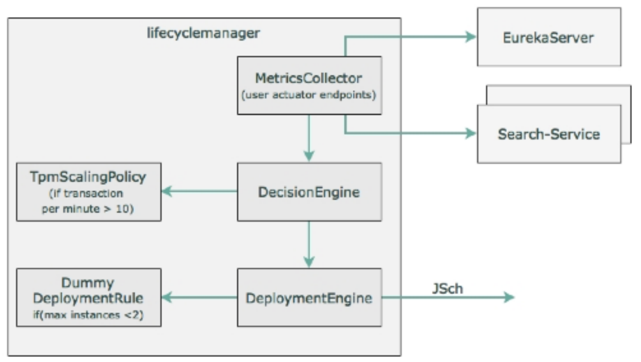
Homework 7

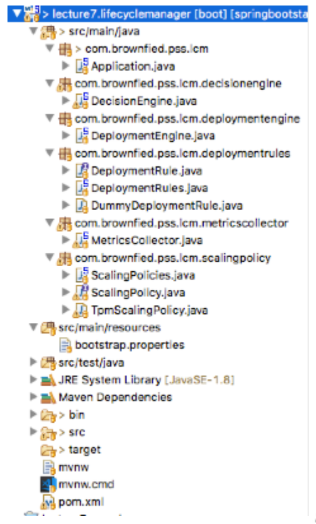
- How a simple life cycle manager is implemented?

The chapter5.configserver, chapter5.eurekaserver, chapter5.search, and chapter5.search-apigateway are copied and renamed as chapter6.*, respectively.

A walkthrough of the life cycle manager code

- Create a new Spring Boot application and name it `lecture7.lifecyclemanager`
- The flowchart for this example is as shown in the following diagram

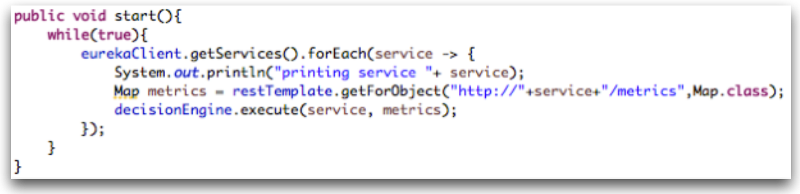

lifecyclemanager
MetricsCollector (user actuator endpoints)
EurekaServer
Search-Service
TpmScalingPolicy (if transaction per minute > 10)
DecisionEngine
Dummy DeploymentRule if(max instances <2)
DeploymentEngine
JSch



```
> lecture7.lifecyclemanager [boot] [springbootsta
  > src/main/java
    > com.brownfied.pss.lcm
      Application.java
    com.brownfied.pss.lcm.decisionengine
      DecisionEngine.java
    com.brownfied.pss.lcm.deploymentengine
      DeploymentEngine.java
    com.brownfied.pss.lcm.deploymentrules
      DeploymentRule.java
      DeploymentRules.java
      DummyDeploymentRule.java
    com.brownfied.pss.lcm.metricscollector
      MetricsCollector.java
    com.brownfied.pss.lcm.scalingpolicy
      ScalingPolicies.java
      ScalingPolicy.java
      TpmScalingPolicy.java
  src/main/resources
    bootstrap.properties
  src/test/java
  JRE System Library [JavaSE-1.8]
  Maven Dependencies
  > bin
  > src
  > target
  mvnw
  mvnw.cmd
  pom.xml
```

A walkthrough of the life cycle manager code

- Create a `MetricsCollector` class with the following method
- At the startup of the Spring Boot application, this method will be invoked using `CommandLineRunner`

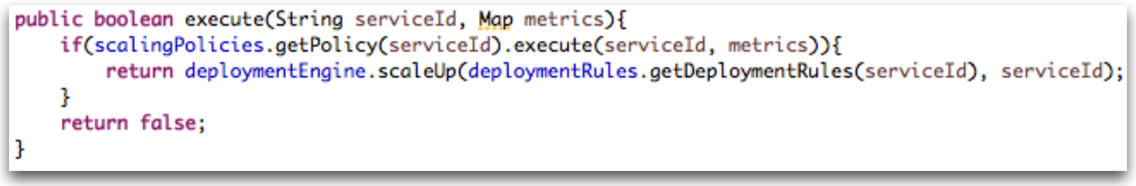


```
public void start(){
    while(true){
        eurekaClient.getServices().forEach(service -> {
            System.out.println("printing service "+ service);
            Map metrics = restTemplate.getForObject("http://"+service+"/metrics",Map.class);
            decisionEngine.execute(service, metrics);
        });
    }
}
```

- The preceding method looks for the services registered in the Eureka server and gets all the instances
  - In the real world, rather than polling, the instances should publish metrics to a common place, where metrics aggregation will happen

A walkthrough of the life cycle manager code

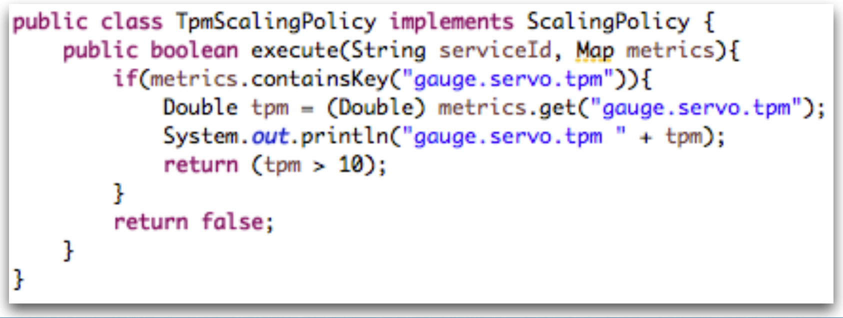
- The following **`DecisionEngine`** code accepts the metric and applies certain scaling policies to determine whether the service requires scaling up or not



```
public boolean execute(String serviceId, Map metrics){
    if(scalingPolicies.getPolicy(serviceId).execute(serviceId, metrics)){
        return deploymentEngine.scaleUp(deploymentRules.getDeploymentRules(serviceId), serviceId);
    }
    return false;
}
```

A walkthrough of the life cycle manager code

- Based on the service ID, the policies that are related to the services will be picked up and applied. In this case, a minimal Transactions Per Minute scaling policy is implemented in `TpmScalingPolicy`



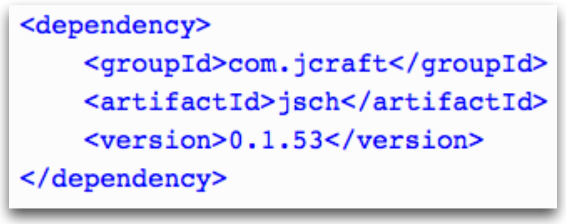
```java
public class TpmScalingPolicy implements ScalingPolicy {
    public boolean execute(String serviceId, Map metrics){
        if(metrics.containsKey("gauge.servo.tpm")){
            Double tpm = (Double) metrics.get("gauge.servo.tpm");
            System.out.println("gauge.servo.tpm " + tpm);
            return (tpm > 10);
        }
        return false;
    }
}
```

A walkthrough of the life cycle manager code

- If the policy returns true, `DecisionEngine` then invokes `DeploymentEngine` to spin up another instance
- `DeploymentEngine` makes use of `DeploymentRules` to decide how to execute scaling
- The rules can enforce the number of min and max instances, in which region or machine the new instance has to be started, the resources required for the new instance, and so on
- `DummyDeploymentRule` simply makes sure the max instance is not more than 2

A walkthrough of the life cycle manager code

- `DeploymentEngine`, in this case, uses the JSch (**Java Secure Channel**) library from JCraft to SSH to the destination server and start the service. This requires the following additional Maven dependency



```xml
<dependency>
    <groupId>com.jcraft</groupId>
    <artifactId>jsch</artifactId>
    <version>0.1.53</version>
</dependency>
```

A walkthrough of the life cycle manager code

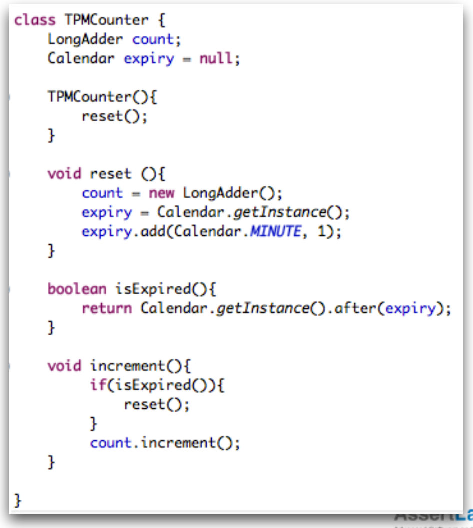
- The current SSH implementation is kept simple enough as we will change this in future chapters
- In this example, `DeploymentEngine` sends the following command over the SSH library on the target machine:

```
String command ="java -jar -Dserver.port=8091 ./work/
codebox/chapter6/chapter6.search/target/search-1.0.jar”;
```

- Integration with `Nexus` happens from the target machine using Linux scripts with Nexus CLI or using curl
  - In this example, we will not explore Nexus

A walkthrough of the life cycle manager code

- The next step is to change the Search microservice to expose a new gauge for TPM
  - We have to change all the microservices developed earlier to submit this additional metric.
  - We will only examine Search in this homework, but in order to complete it, all the services have to be updated
- In order to get the **`gauge.servo.tpm`** metrics, we have to add **`TPMCounter`** to all the microservices



```
class TPMCounter {
    LongAdder count;
    Calendar expiry = null;

    TPMCounter(){
        reset();
    }

    void reset (){
        count = new LongAdder();
        expiry = Calendar.getInstance();
        expiry.add(Calendar.MINUTE, 1);
    }

    boolean isExpired(){
        return Calendar.getInstance().after(expiry);
    }

    void increment(){
         if(isExpired()){
             reset();
         }
         count.increment();
    }
}
```

TPMCounter na classe SearchRestController

A walkthrough of the life cycle manager code

- The following code needs to be added to `SearchController` to set the `tpm` value:

```
class SearchRestController {
  TPMCounter tpm = new TPMCounter();
  @Autowired
  GaugeService gaugeService;
   //other code
```

- The following code is from the get REST endpoint (the search method) of `SearchRestController`, which submits the `tpm` value as a gauge to the actuator endpoint:

```
tpm.increment();
gaugeService.submit("tpm", tpm.count.intValue());
```

Running the life cycle manager

- Edit `DeploymentEngine.java` and update the password to reflect the machine's password, as follows. This is required for the SSH connection: `session.setPassword(“rajeshrv");`
- Build all the projects by running Maven from the root folder via the following command:

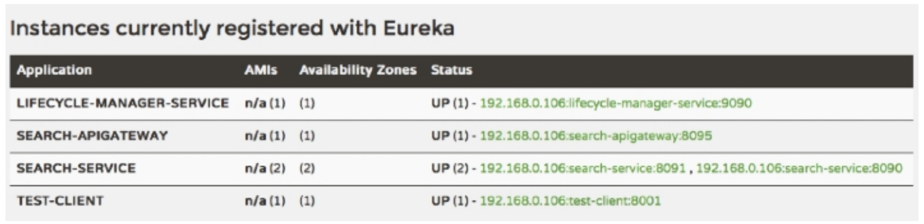
```
mvn -Dmaven.test.skip=true clean install
```

- Then, run RabbitMQ, as follows: `./rabbitmq-server`
- Ensure that the Config server is pointing to the right configuration repository. We need to add a property file for the life cycle manager.
- Run the following commands from the respective project folders:

```
java -jar target/config-server-0.0.1-SNAPSHOT.jar
java -jar target/eureka-server-0.0.1-SNAPSHOT.jar
java -jar target/lifecycle-manager-0.0.1-SNAPSHOT.jar
java -jar target/search-1.0.jar
java -jar target/search-apigateway-1.0.jar
java -jar target/website-1.0.jar
```

Running the life cycle manager

- Once all the services are started, open a browser window and load **`http://localhost:8001`**
- Execute the flight search 11 times, one after the other, within a minute. This will trigger the decision engine to instantiate another instance of the Search microservice.
- Open the Eureka console (**`http://localhost:8761`**) and watch for a second **SEARCH-SERVICE**. Once the server is started



Instances currently registered with Eureka

Application	AMIs	Availability Zones	Status
LIFECYCLE-MANAGER-SERVICE	n/a (1)	(1)	UP (1) - 192.168.0.106:lifecycle-manager-service:9090
SEARCH-APIGATEWAY	n/a (1)	(1)	UP (1) - 192.168.0.106:search-apigateway:8095
SEARCH-SERVICE	n/a (2)	(2)	UP (2) - 192.168.0.106:search-service:8091 , 192.168.0.106:search-service:8090
TEST-CLIENT	n/a (1)	(1)	UP (1) - 192.168.0.106:test-client:8001

AssertLab
Advanced Software and Systems Engineering Research Technologies