Desenvolvimento de Aplicações com Arquitetura Baseada em Microservices

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

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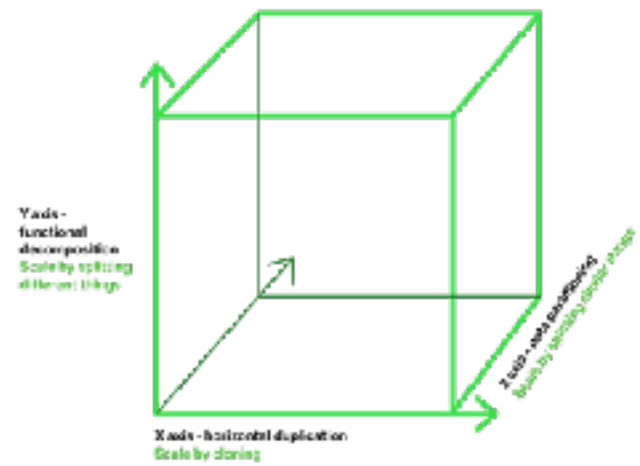
Resources

- 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



Scaling Microservices with Spring Cloud

Context

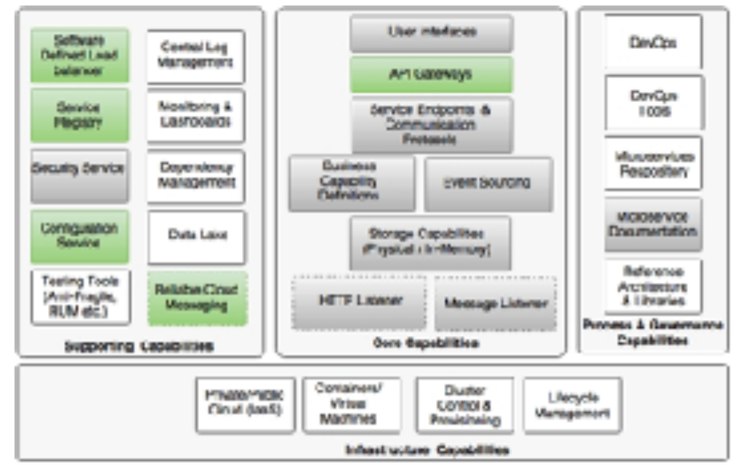
- Spring Cloud project has a suite of purpose-built components to achieve these additional capabilities effortlessly
- This lecture will provide a deep insight into the various components of the Spring Cloud project such as Eureka, Zuul, Ribbon, and Spring Config by positioning them against the microservices capability model
- How the Spring Cloud components help to scale the BrownField Airline's PSS microservices system

You will learn

- The Spring Config server for externalizing configuration
- The Eureka server for service registration and discovery
- The relevance of Zuul as a service proxy and gateway
- The implementation of automatic microservice registration and service discovery
- Spring Cloud messaging for asynchronous microservice composition

Reviewing microservices capabilities

- The examples explore the following microservices capabilities from the microservices capability model
  - Software Defined Load Balancer
  - Service Registry
  - Configuration Service
  - Reliable Cloud Messaging
  - API Gateways



Reviewing BrownField's PSS implementation

- We have accomplished the following items in our microservice implementation so far
  - Each microservice exposes a set of REST/JSON endpoints for accessing business capabilities
  - Each microservice implements certain business functions using the Spring framework.
  - Each microservice stores its own persistent data using H2, an in-memory database
  - Microservices are built with Spring Boot, which has an embedded Tomcat server as the HTTP listener
  - RabbitMQ is used as an external messaging service. Search, Booking, and Check-in interact with each other through asynchronous messaging
  - Swagger is integrated with all microservices for documenting the REST APIs.
  - An OAuth2-based security mechanism is developed to protect the microservices

The implementation is satisfactory from the development point of view, and it serves the purpose for low volume transactions

What is Spring Cloud?

- Is an umbrella project from the Spring team that implements a set of common patterns required by distributed systems, as a set of easy-to-use Java Spring libraries
- Are agnostic to the deployment environment
    - The cloud-ready solutions that are developed using Spring Cloud are also agnostic and portable across many cloud providers

“Built on Spring's "convention over configuration" approach, Spring Cloud defaults all configurations, and helps the developers get off to a quick start. Spring Cloud also hides the complexities, and provides simple declarative configurations to build systems. The smaller footprints of the Spring Cloud components make it developer friendly, and also make it easy to develop cloud-native applications.”

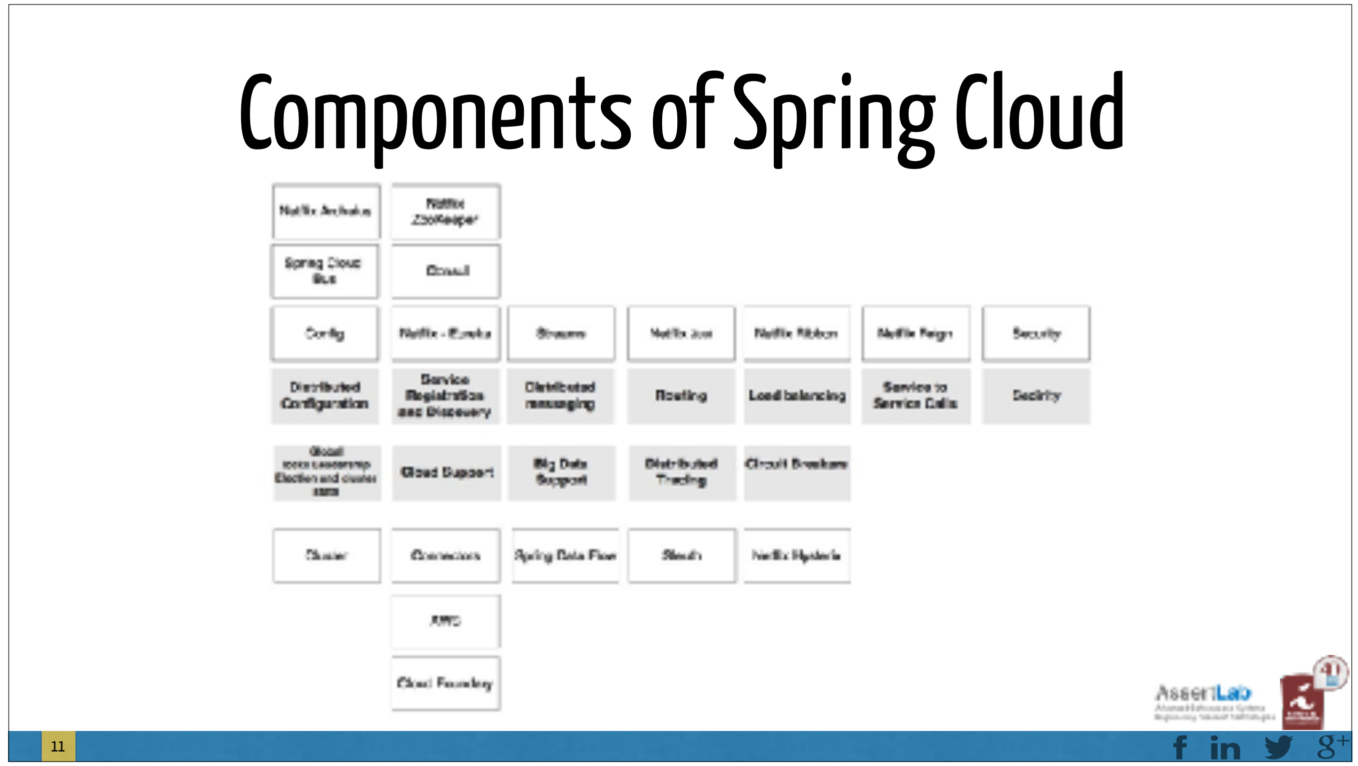
Excerpt From: “Spring Microservices.” iBooks.

Spring Cloud releases

- The Spring Cloud project is an overarching Spring project that includes a combination of different components. The versions of these components are defined in the `spring-cloud-starter-parent` BOM
  - We are relying on the `Brixton.RELEASE` version of the Spring Cloud

```
<dependency>
    <groupId>org.springframework.cloud</groupId>
    <artifactId>spring-cloud-dependencies</artifactId>
    <version>Brixton.RELEASE</version>
    <type>pom</type>
    <scope>import</scope>
  </dependency>
```


The names of the Spring Cloud releases are in an alphabetic sequence, starting with **A**, **following the names of the London Tube stations**. **Angel** was the first release, and **Brixton** is the second release



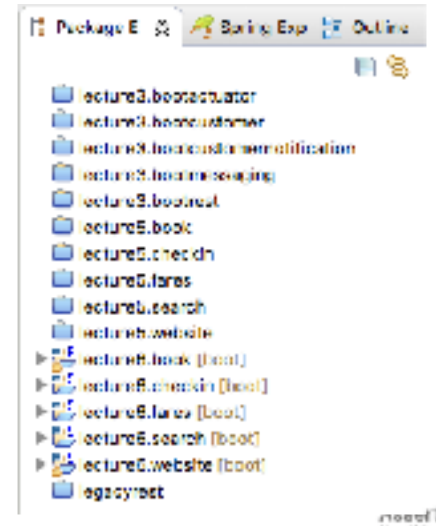
Distributed configuration: The distributed configuration management module is to externalize and centralize microservice configuration parameters.
Routing: an API gateway component, primarily used similar to a reverse proxy that forwards requests from consumers to service providers
Load balancing: a software-defined load balancer module which can route requests to available servers using a variety of load balancing algorithms
Service registration and discovery: enables services to programmatically register with a repository when a service is available and ready to accept traffic
Service-to-service calls: making RESTful service-to-service calls in a synchronous way. The declarative approach allows applications to work with POJO (Plain Old Java Object) interfaces instead of low-level HTTP client APIs
Circuit breaker: implements the circuit breaker pattern
Global locks, leadership election and cluster state: required for cluster management and coordination when dealing with large deployments
Security: building security for cloud-native distributed systems using externalized authorization providers such as OAuth2
Big data support: required for data services and data flows in connection with big data solutions
Distributed tracing: helps to thread and correlate transitions that are spanned across multiple microservice instances
Distributed messaging: provides declarative messaging integration on top of reliable messaging solutions
Cloud support: provides a set of capabilities that offers various connectors, integration mechanisms, and abstraction on top of different cloud providers such as the Cloud Foundry and AWS

Spring Cloud and Netflix OSS

- Many of the Spring Cloud components which are critical for microservices' deployment came from the Netflix Open Source Software (Netflix OSS) center
- These components are extensively used in production systems, and are battle-tested with large scale microservice deployments at Netflix

Setting up the environment for BrownField PSS

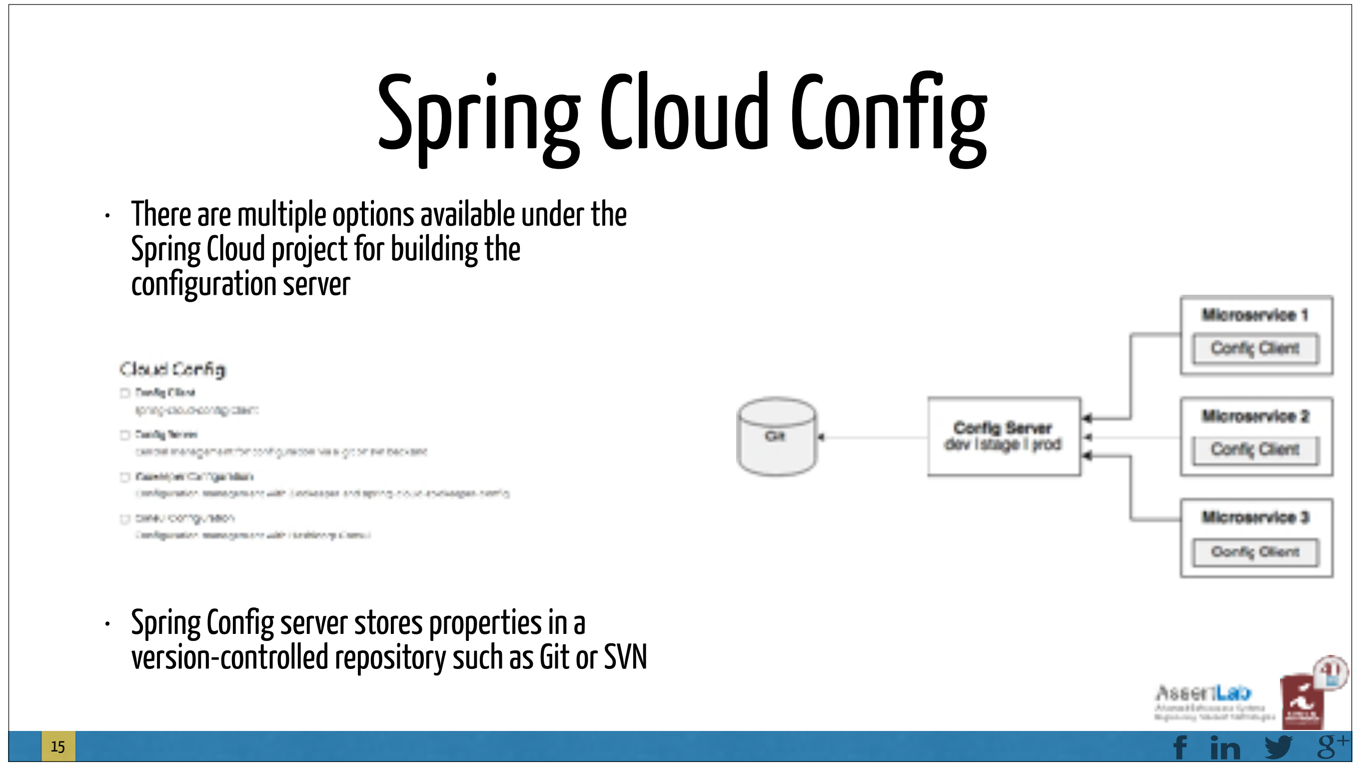
- We will amend the BrownField PSS microservices developed earlier
  - How to make these services enterprise grade using Spring Cloud components?
- In order to prepare the environment for this lecture, import and rename (`lecture5.*` to `lecture6.*`) projects into a new STS workspace



Spring Cloud Config

- The Spring Cloud Config server is an externalized configuration server in which applications and services can deposit, access, and manage all runtime configuration properties
  - `application.properties` or `application.yaml`
    - When microservices are moved from one environment to another?
- For large scale deployments, a simple yet powerful centralized configuration management solution is required

As shown in the preceding diagram, all microservices point to a central server to get the required configuration parameters. The microservices then locally cache these parameters to improve performance. The Config server propagates the configuration state changes to all subscribed microservices so that the local cache's state can be updated with the latest changes. The Config server also uses profiles to resolve values specific to an environment.



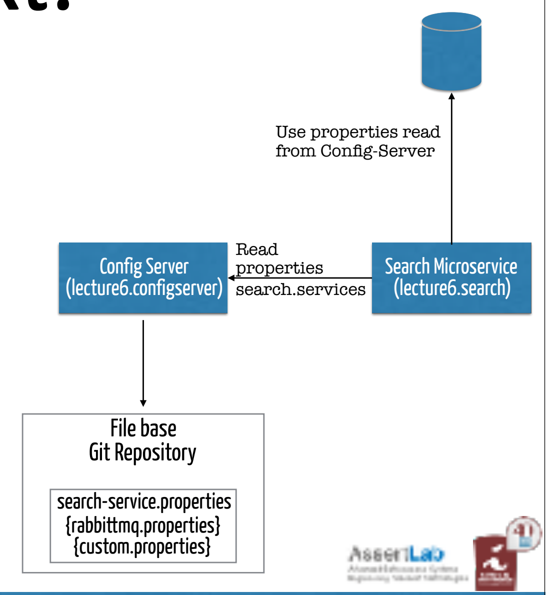
As shown in the preceding diagram, the Config client embedded in the Spring Boot microservices does a configuration lookup from a central configuration server using a simple declarative mechanism, and stores properties into the Spring environment. The configuration properties can be application-level configurations such as trade limit per day, or infrastructure-related configurations such as server URLs, credentials, and so on.

Spring Cloud Config

- Unlike Spring Boot, Spring Cloud uses a bootstrap context, which is a parent context of the main application
  - `bootstrap.yaml` or `bootstrap.properties` for loading initial configuration properties
- To make this work in a Spring Boot application, rename the `application.*` file to `bootstrap.*`

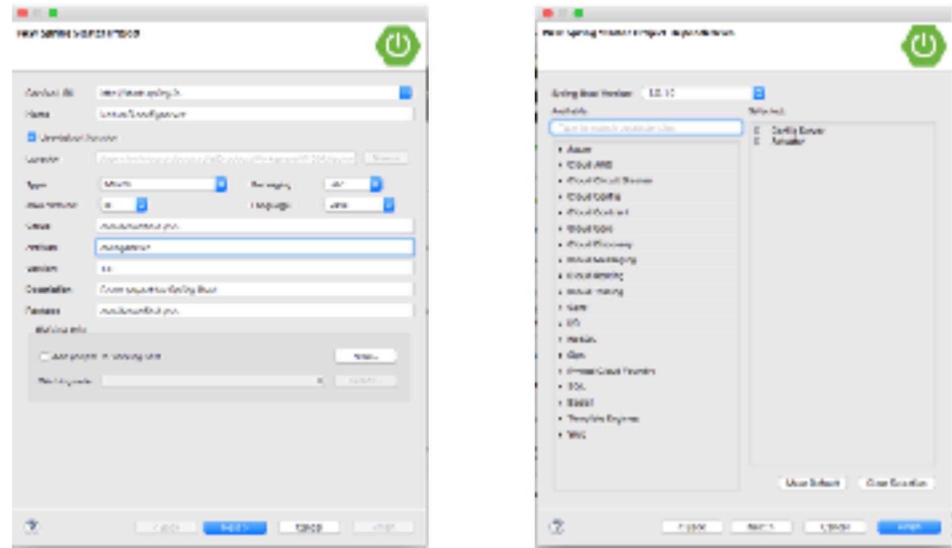
What's next?

- How to use the Config server in a real-world scenario?
- In order to do this, we will modify our search microservice (`lecture6.search`) to use the Config server



Search service will read the Config server at startup by passing the service name. In this case, the service name of the search service will be search-service. The properties configured for the search-service include the RabbitMQ properties as well as a custom property.

Setting up the Config server



Setting up the Config server

- Set up a Git repository. This can be done by pointing to a remote Git configuration repository like the one at https://github.com/spring-cloud-samples/config-repo
- Alternately, a local filesystem-based Git repository can be used. In a real production scenario, an external Git is recommended

```
$ cd $HOME
$ mkdir config-repo
$ cd config-repo
$ git init .
$ echo message : helloworld > application.properties
$ git add -A .
$ git commit -m "Added sample application.properties"
```

- This code snippet creates a new Git repository on the local filesystem
- The next step is to change the configuration in the Config server to use the Git repository created in the previous step ~> rename the file `application.properties` to `bootstrap.properties`

Setting up the Config server

- Edit the contents of the new bootstrap.properties file to match the following

```
server.port=8888
spring.cloud.config.server.git.uri:
file://${user.home}/config-repo
```

- Optionally, rename the default package of the auto-generated `Application.java` from `com.example` to `com.brownfield.configserver`. Add `@EnableConfigServer` in `Application.java`

Port 8888 is the default port for the Config server. Even without configuring server.port, the Config server should bind to 8888. In the Windows environment, an extra / is required in the file URL.

Setting up the Config server

- Run the Config server by right-clicking on the project, and running it as a Spring Boot app.
- Visit `http://localhost:8888/env` to see whether the server is running. If everything is fine, this will list all environment configurations. Note that `/env` is an actuator endpoint
- Check `http://localhost:8888/application/default/master` to see the properties specific to `application.properties`, which were added in the earlier step


```
{"name":"application","profiles":
["default"],"label":"master","version":"6046fd2ff4fa09d38437676
60d963866ffcc7d28","propertySources":[{"name":"file:///Users/
rvlabs /config-repo /application.properties","source":
{"message":"helloworld"}}]}
```

Understanding the Config server URL

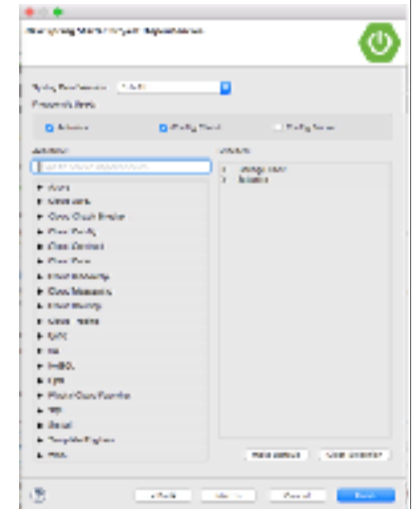
- `http://localhost:8888/application/default/master`
  - The first element in the URL is the application name, a logical name given to the application, using the `spring.application.name` property in `bootstrap.properties` of the Spring Boot application
  - The second part of the URL represents the profile. The two common scenarios are segregating different environments or segregating server configurations
  - The last part of the URL is the label, and is named master by default. The label is an optional Git label that can be used, if required.
  - `http://localhost:8888/{name}/{profile}/{label}`

Each application must have a unique name.
There can be more than one profile configured within the repository for an application.
To configure properties for different environments, we have to configure different files as application-development.properties and application-production.properties.

Accessing the Config Server from clients

- Add the Spring Cloud Config dependency and the actuator (if the actuator is not already in place) to the pom.xml file

```xml
<dependency>
  <groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-starter-config</artifactId>
</dependency>

<dependencyManagement>
     <dependencies>
          <dependency>
               <groupId>org.springframework.cloud</groupId>
               <artifactId>spring-cloud-dependencies</artifactId>
               <version>${spring-cloud.version}</version>
               <type>pom</type>
               <scope>import</scope>
          </dependency>
     </dependencies>
</dependencyManagement>
```



Accessing the Config Server from clients

- Rename `application.properties` to `bootstrap.properties`, and add an application name and a configuration server URL

```
spring.application.name=search-service
spring.cloud.config.uri=http://localhost:8888

server.port=8090

spring.rabbitmq.host=localhost
spring.rabbitmq.port=5672
spring.rabbitmq.username=guest
spring.rabbitmq.password=guest
```


search-service is a logical name given to the Search microservice. This will be treated as service ID. The Config server will look for search-service.properties in the repository to resolve the properties.

Accessing the Config Server from clients

- Create a new configuration file for `search-service`. Create a new `search-service.properties` under the `config-repo` folder where the Git repository is created
- Move service-specific properties from `bootstrap.properties` to the new `search-service.properties` file
- In order to demonstrate the centralized configuration of properties and propagation of changes, add a new application-specific property `originairports.shutdown` to temporarily take out an airport from the search, to the property file

search-service.properties

```
spring.application.name=search-service
spring.rabbitmq.host=localhost
spring.rabbitmq.port=5672
spring.rabbitmq.username=guest
spring.rabbitmq.password=guest
originairports.shutdown:SEA
```

Commit this new file into the Git repository by executing the following commands:

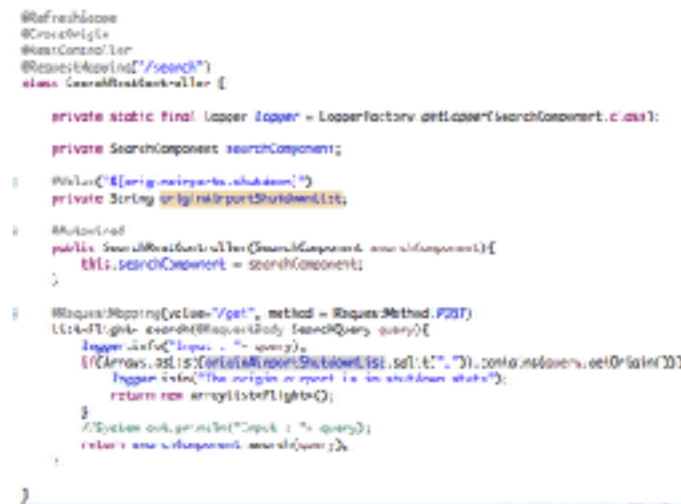
```
git add -A .
git commit -m "adding new configuration"
```


Note that search-service is the service ID given to the Search microservice in the bootstrap.properties file.

In this example, we will not return any flights when searching with SEA as origin.

Accessing the Config Server from clients

- Modify the Search microservice code to use the configured parameter, `originairports.shutdown`
- A `RefreshScope` annotation has to be added at the class level to allow properties to be refreshed when there is a change
- Add the following instance variable as a place holder for the new property that is just added in the Config server
- Change the application code to use this property



The search method is modified to read the parameter originAirportShutdownList and see whether the requested origin is in the shutdown list. If there is a match, then instead of proceeding with the actual search, the search method will return an empty flight list.

Accessing the Config Server from clients

- Start the Config server. Then start the Search microservice. Make sure that the RabbitMQ server is running ~> `rabbitmq-server`
- Modify the `lecture6.website` project to match the `bootstrap.properties` content as follows to utilize the Config server:

```
spring.application.name=test-client
server.port=8001
spring.cloud.config.uri=http://localhost:8888
```

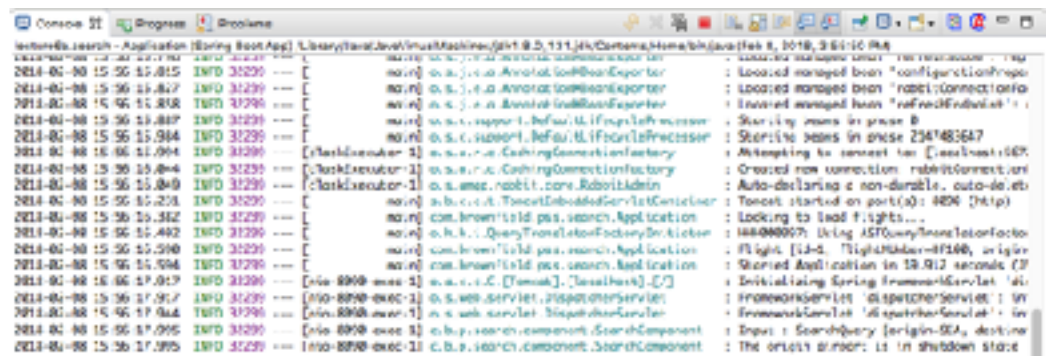
- Change the run method of `CommandLineRunner` in `Application.java` to query SEA as the origin airport:

```
SearchQuery = new SearchQuery("SEA","SFO","22-JAN-16");
```


https://dzone.com/articles/autowiring-using-value-and

Accessing the Config Server from clients

- Run the `lecture6.website` project. The `CommandLineRunner` will now return an empty flight list. The following message will be printed in the server:

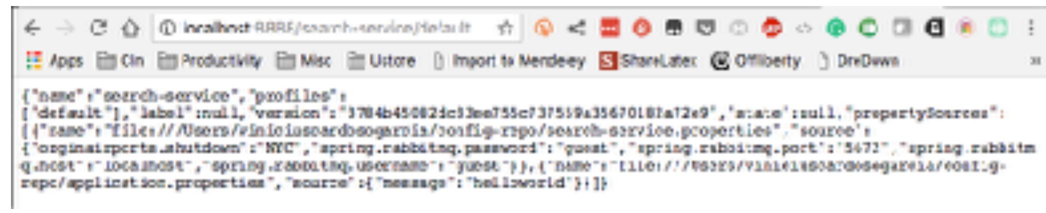


Handling configuration changes

- How to propagate configuration properties when there is a change?
- Change the property in the search-service.properties file to the following: `originairports.shutdown:NYC`
- Commit the change in the Git repository. Refresh the Config server URL (http://localhost:8888/search-service/default) and see whether the property change is reflected

If everything is fine, we will see the property change. The preceding request will force the Config server to read the property file again from the repository

Handling configuration changes



- Rerun the website project again, and observe the CommandLineRunner execution
- The service returns an empty flight list as earlier, and still complains as follows: `The origin airport is in shutdown state`
- In order to force reloading of the configuration properties, call the `/refresh` endpoint of the Search microservice

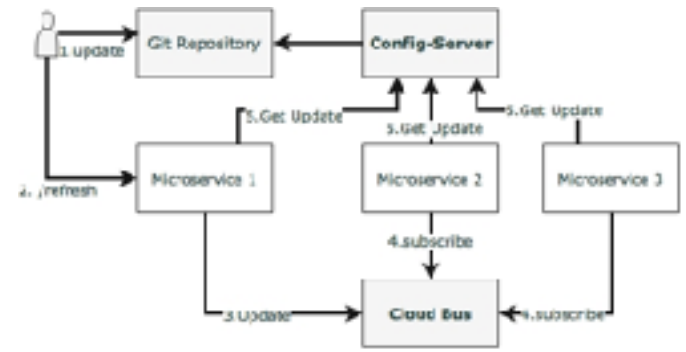
```
curl -d {} localhost:8090/refresh
```

- Rerun the website project, this should return the list of flights that we have requested from SEA.

This means the change is not reflected in the Search service, and the service is still working with an old copy of the configuration properties.
Tem que estar -> management.security.enabled=false

Spring Cloud Bus for propagating configuration changes

- Spring Cloud Bus provides a mechanism to refresh configurations across multiple instances without knowing how many instances there are, or their locations
- This is done by connecting all service instances through a single message broker



With the preceding approach, configuration parameters can be changed without restarting the microservices. This is good when there are only one or two instances of the services running. What happens if there are many instances?

Using RabbitMQ as the AMQP message broker

- Add a new dependency in the `leacture6.search` project's `pom.xml` file to introduce the Cloud Bus dependency:

```
<dependency>
    <groupId>org.springframework.cloud</groupId>
    <artifactId>spring-cloud-starter-bus-amqp</artifactId>
</dependency>
```

- The Search microservice also needs connectivity to the RabbitMQ, but this is already provided in `search-service.properties`

Using RabbitMQ as the AMQP message broker

- Rebuild and restart the Search microservice. In this case, we will run two instances of the Search microservice from a command line

```
java -jar -Dserver.port=8090  search-1.0.jar
java -jar -Dserver.port=8091  search-1.0.jar
```

- Rerun the website project

The two instances of the Search service will be now running, one on port 8090 and another one on 8091.

Using RabbitMQ as the AMQP message broker

- Now, update `search-service.properties` with the following value, and commit to Git: `originairports.shutdown:SEA`
- Run `curl -d {} localhost:8090/bus/refresh`
- Immediately, we will see the following message for both instances:

```
Received remote refresh request. Keys
refreshed [originairports.shutdown]
```


Note that we are running a new bus endpoint against one of the instances, 8090 in this case.

Using RabbitMQ as the AMQP message broker

- The bus endpoint sends a message to the message broker internally, which is eventually consumed by all instances, reloading their property files
- Changes can also be applied to a specific application by specifying the application name like so:
- `originairports.shutdown:SEA`

Note that we are running a new bus endpoint against one of the instances, 8090 in this case.

Using RabbitMQ as the AMQP message broker

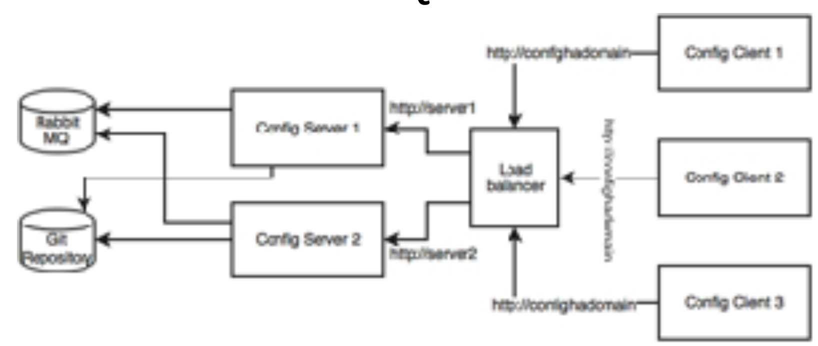
- The bus endpoint sends a message to the message broker internally, which is eventually consumed by all instances, reloading their property files
- Changes can also be applied to a specific application by specifying the application name like so:

```
/bus/refresh?destination=search-service:**
```

- We can also refresh specific properties by setting the property name as a parameter

Setting up high availability for the Config server

- The Config server is a single point of failure in this architecture
- The second one is the Git repository,
- and the third one is the RabbitMQ server



The Config server requires high availability, since the services won't be able to bootstrap if the Config server is not available. Hence, redundant Config servers are required for high availability. However, the applications can continue to run if the Config server is unavailable after the services are bootstrapped. In this case, services will run with the last known configuration state. Hence, the Config server availability is not at the same critical level as the microservices availability.

Setting up high availability for the Config server

- Since the Config server is a stateless HTTP service, multiple instances of configuration servers can be run in parallel
- Load balancer or DNS server URL will be configured in the microservices' `bootstrap.properties` file
- Using an external highly available Git service or a highly available internal Git service
  - The GitLab example for setting up high availability is available at https://about.gitlab.com/high-availability/

Setting up high availability for the Config server

- RabbitMQ also has to be configured for high availability
  - The high availability for RabbitMQ is needed only to push configuration changes dynamically to all instances
- RabbitMQ high availability can be achieved by either using a cloud service or a locally configured highly available RabbitMQ service
  - Setting up high availability for Rabbit MQ is documented at https://www.rabbitmq.com/ha.htm

Monitoring the Config server health

- The Config server is nothing but a Spring Boot application, and is, by default, configured with an actuator
- Hence, all actuator endpoints are applicable for the Config server
- The health of the server can be monitored using the following actuator URL: http://localhost:8888/health

Completing changes to use the Config server

- All microservices in the examples given in `lecture6.*` need to make similar changes to look to the Config server for getting the configuration parameters
- The Fare service URL in the booking component will also be externalized:

```
private static final String FareURL = "/fares";
@Value("${fares-service.url}")
private String fareServiceUrl;
Fare = restTemplate.getForObject(fareServiceUrl+FareURL +"/
get?flightNumber="+record.getFlightNumber()
+"&flightDate="+record.getFlightDate(),Fare.class);
```

- As shown in the preceding code snippet, the Fare service URL is fetched through a new property: `fares-service.url`

Warm up

- Open Feign is looking for maintainers…
  - https://github.com/OpenFeign/feign/issues/646

Feign as a declarative REST client

- In the Booking microservice, there is a synchronous call to Fare
- `RestTemplate` is used for making the synchronous call

The following code snippet is the existing code in the Booking microservice for calling the Fare service

```
Fare fare =
restTemplate.getForObject(FareURL +"/get?
flightNumber="+record.getFlightNumber()
+"&flightDate="+record.getFlightDate(),Fare.
class);
```

In order to use Feign, first we need to change the pom.xml file to include the Feign dependency

```
<dependency>
<groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-starter-feign</
artifactId>
</dependency>
```


When using Feign, we write declarative REST service interfaces at the client, and use those interfaces to program the client. The developer need not worry about the implementation of this interface. This will be dynamically provisioned by Spring at runtime. With this declarative approach, developers need not get into the details of the HTTP level APIs provided by RestTemplate.

Feign as a declarative REST client

- The next step is to create a new `FareServiceProxy` interface
- This will act as a proxy interface of the actual Fare service

```
@FeignClient(name="fares-proxy", url="localhost:8080/fares")
public interface FareServiceProxy {
  @RequestMapping(value = "/get", method=RequestMethod.GET)
  Fare getFare(@RequestParam(value="flightNumber") String
flightNumber, @RequestParam(value="flightDate") String flightDate);
}
```

- `@FeignClient` annotation tells Spring to create a REST client based on the interface provided

The value could be a service ID or a logical name. The url indicates the actual URL where the target service is running. Either name or value is mandatory. In this case, since we have url, the name attribute is irrelevant.

Feign as a declarative REST client

- In the Booking microservice, we have to tell Spring that Feign clients exist in the Spring Boot application, which are to be scanned and discovered
- This will be done by adding `@EnableFeignClients` at the class level of `BookingComponent`. Optionally, we can give the package names to scan.
- Change `BookingComponent`, and make changes to the calling part. This is as simple as calling another Java interface:

```
Fare = fareServiceProxy.getFare(record.getFlightNumber(),
record.getFlightDate());
```

- The URL of the Fare service in the FareServiceProxy interface is hardcoded: `url="localhost:8080/fares"`

For the time being, we will keep it like this, but we are going to change this later

Ribbon for load balancing

- In the previous setup, we were always running with a single instance of the microservice and the URL is hardcoded both in client as well as in the service-to-service calls
- In the real world, this is not a recommended approach, since there could be more than one service instance
    - load balancer or a local DNS server
- Ribbon is a client-side load balancer which can do round-robin load balancing across a set of servers

The load balancer then receives the alias name, and resolves it with one of the available instances. With this approach, we can configure as many instances behind a load balancer.

Ribbon for load balancing

- The Ribbon client looks for the Config server to get the list of available microservice instances, and, by default, applies a round-robin load balancing algorithm

```
<dependency>
<groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-starter-ribbon</
artifactId>
</dependency>
```

Ribbon for load balancing

- Update the Booking microservice configuration file, `booking-service.properties`, to include a new property to keep the list of the Fare microservices:

```
fares-proxy.ribbon.listOfServers=localhost:
8080,localhost:8081
```

Ribbon for load balancing

- Going back and editing the `FareServiceProxy` class created in the previous section to use the Ribbon client
- The value of the `@RequestMapping` annotations is changed from `/get` to `/fares/get` so that we can move the host name and port to the configuration easily

```
@FeignClient(name="fares-proxy")
@RibbonClient(name="fares")"
public interface FareServiceProxy {
  @RequestMapping(value = "fares/get", method=RequestMethod.GET)
```

- We can now run two instances of the Fares microservices. Start one of them on 8080, and the other one on 8081:

```
java -jar -Dserver.port=8080 fares-1.0.jar
java -jar -Dserver.port=8081 fares-1.0.jar
```

Ribbon for load balancing

- Run the Booking microservice, the `CommandLineRunner` automatically inserts one booking record ~> first server
- When running the website project, it calls the Booking service. This request will go to the second server
- On the Booking service, we see the following trace, which says there are two servers enlisted:

```
DynamicServerListLoadBalancer:{NFLoadBalancer:name=fares-proxy,current
list of Servers=[localhost:8080, localhost:8081],Load balancer stats=Zone
stats: {unknown=[Zone:unknown;  Instance count:2;  Active connections
count: 0;  Circuit breaker tripped count: 0;  Active connections per
server: 0.0;]
},
```

Eureka for registration and discovery

- If there is a large number of microservices, and if we want to optimize infrastructure utilization, we will have to dynamically change the number of service instances and the associated servers
- When targeting cloud deployments for highly scalable microservices, static registration and discovery is not a good solution considering the elastic nature of the cloud environment
- In the cloud deployment scenarios, IP addresses are not predictable, and will be difficult to statically configure in a file

Understanding dynamic service registration and discovery

- With dynamic registration, when a new service is started, it automatically enlists its availability in a central service registry
- Similarly, when a service goes out of service, it is automatically delisted from the service registry
- The registry always keeps up-to-date information of the services available, as well as their metadata

Dynamic discovery

- Dynamic discovery is applicable from the service consumer's point of view
- Dynamic discovery is where clients look for the service registry to get the current state of the services topology, and then invoke the services accordingly
- In this approach, instead of statically configuring the service URLs, the URLs are picked up from the service registry.

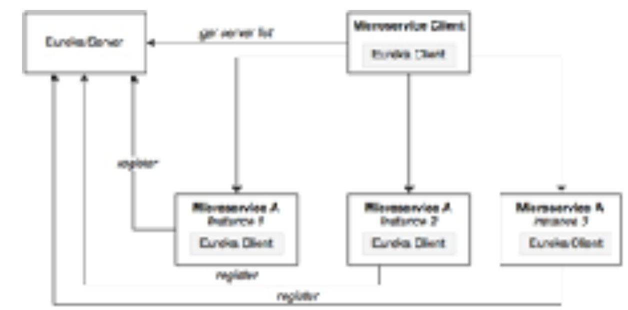
The clients may keep a local cache of the registry data for faster access

Understanding dynamic service registration and discovery

- There are a number of options available for dynamic service registration and discovery
  - Netflix Eureka, ZooKeeper, and Consul are available as part of Spring Cloud
- Etcd is another service registry available outside of Spring Cloud to achieve dynamic service registration and discovery

Understanding Eureka

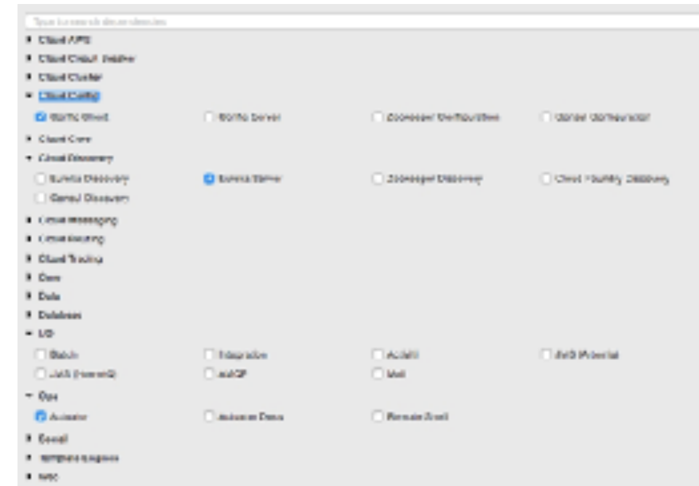
- Eureka is primarily used for self-registration, dynamic discovery, and load balancing
  - Eureka uses Ribbon for load balancing internally



As shown in the preceding diagram, Eureka consists of a server component and a client-side component. The server component is the registry in which all microservices register their availability. The registration typically includes service identity and its URLs. The microservices use the Eureka client for registering their availability. The consuming components will also use the Eureka client for discovering the service instances.

Setting up the Eureka server

- Start a new Spring Starter project, and select Config Client, Eureka Server, and Actuator



Setting up the Eureka server

- The Eureka server can be set up in a standalone mode or in a clustered mode
- By default, the Eureka server itself is another Eureka client
  - This is particularly useful when there are multiple Eureka servers running for high availability
  - The client component is responsible for synchronizing state from the other Eureka servers
- The Eureka client is taken to its peers by configuring the `eureka.client.serviceUrl.defaultZone` property

In the standalone mode, we point eureka.client.serviceUrl.defaultZone back to the same standalone instance

Setting up the Eureka server

- Create a `eureka-server1.properties` file, and update it in the Git repository.
- `eureka-server1` is the name of the application given in the application's `bootstrap.properties` file in the previous step
- `serviceUrl` points back to the same server

```
spring.application.name=eureka-server1
eureka.client.serviceUrl.defaultZone:http://localhost:8761/
eureka/
eureka.client.registerWithEureka:false
eureka.client.fetchRegistry:false
```

Setting up the Eureka server

- In EurekaserverApplication, add `@EnableEurekaServer`:

```
@EnableEurekaServer
@SpringBootApplication
public class EurekaserverApplication {
```

- Start the Eureka server, once the application is started, open `http://localhost:8761` in a browser to see the Eureka console
- In the console, note that there is no instance registered under Instances currently registered with Eureka
  - Since no services have been started with the Eureka client enabled, the list is empty at this point.

Setting up the Eureka server

- Making a few changes to our microservice will enable dynamic registration and discovery using the Eureka service. To do this, first we have to add the Eureka dependencies to the `pom.xml` file

```
<dependency>
  <groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-starter-eureka</artifactId>
</dependency>
```

- The following property has to be added to all microservices in their respective configuration files under config-repo

```
eureka.client.serviceUrl.defaultZone: http://localhost:8761/eureka/
```

Setting up the Eureka server

- Add @EnableDiscoveryClient to all microservices in their respective Spring Boot main classes
- Start all servers except Booking. Since we are using the Ribbon client on the Booking service, the behavior could be different when we add the Eureka client in the class path
- Going to the Eureka URL (http://localhost:8761), you can see that all three instances are up and running

Instances currently registered with Eureka

Application	AMIs	Availability Zones	Status
CHECKIN-SERVICE	n/a (1)	(1)	UP (1) - [illegible]
FARES-SERVICE	n/a (1)	(1)	UP (1) - [illegible]
SEARCH-SERVICE	n/a (1)	(1)	UP (1) - [illegible]

Time to fix the issue with Booking

- We will remove our earlier Ribbon client, and use Eureka instead. Eureka internally uses Ribbon for load balancing

```
<dependency>
  <groupId>org.springframework.cloud</groupId>
  <artifactId>spring-cloud-starter-ribbon</artifactId>
</dependency>
```

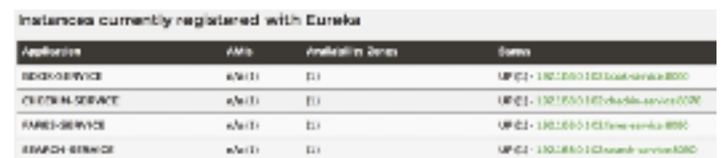
- Also remove the `@RibbonClient(name="fares")` annotation from the FareServiceProxy class
- Update `@FeignClient(name="fares-service")` to match the actual Fare microservices' service ID
  - In this case, fare-service is the service ID configured in the Fare microservices' bootstrap.properties. This is the name that the Eureka discovery client sends to the Eureka server

Time to fix the issue with Booking

- Also remove the list of servers from the `booking-service.properties` file. With Eureka, we are going to dynamically discover this list from the Eureka server:

```
fares-proxy.ribbon.listOfServers=localhost:8080, localhost:8081
```

- Start the Booking service. You will see that `CommandLineRunner` successfully created a booking, which involves calling the Fare services using the Eureka discovery mechanism



Time to fix the issue with Booking

- Change the website project's `bootstrap.properties` file to make use of Eureka rather than connecting directly to the service instances
- We will not use the Feign client in this case, we will use the load balanced `RestTemplate`. Commit these changes to the Git repository:

```
spring.application.name=test-client

eureka.client.serviceUrl.defaultZone: http://localhost:
8761/eureka/
```

- Add `@EnableDiscoveryClient` to the Application class to make the client Eureka-aware

Time to fix the issue with Booking

- Edit both `Application.java` as well as `BrownFieldSiteController.java`
- Add three `RestTemplate` instances. This time, we annotate them with `@Loadbalanced` to ensure that we use the load balancing features using Eureka and Ribbon. `RestTemplate` cannot be automatically injected

```
@Configuration
class AppConfiguration {
    @LoadBalanced
    @Bean
    RestTemplate restTemplate() {
        return new RestTemplate();
    }
}
@Autowired
RestTemplate searchClient;
@Autowired
RestTemplate bookingClient;
@Autowired
RestTemplate checkInClient;
```

Time to fix the issue with Booking

- We use these `RestTemplate` instances to call the microservices.
- Replace the hardcoded URLs with service IDs that are registered in the Eureka server.
- In the following code, we use the service names `search-service`, `book-service`, and `checkin-service` instead of explicit host names and ports

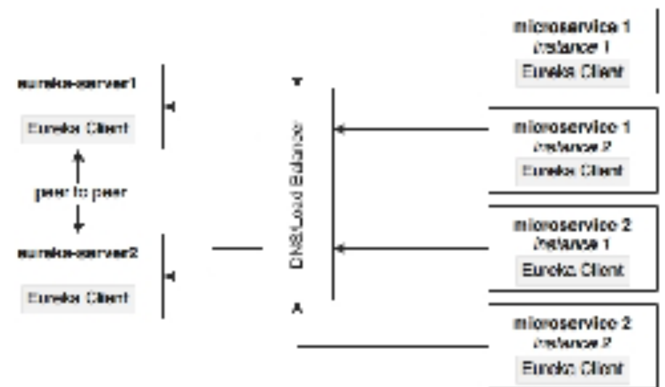
```
Flight[] flights = searchClient.postForObject("http://search-service/search/get", searchQuery,
Flight[].class);

long bookingId = bookingClient.postForObject("http://book-service/booking/create", booking, long.class);

long checkinId = checkInClient.postFor

Object("http://checkin-service/checkin/create", checkIn, long.class);
```

Time to fix the issue with Booking

- We are now ready to run the client
- Run the website project
  - If everything is fine, the website project's `CommandLineRunner` will successfully perform search, booking, and check-in
- The same can also be tested using the browser by pointing the browser to `http://localhost:8001`

Homework 6.1

- How to get high availability with Eureka?

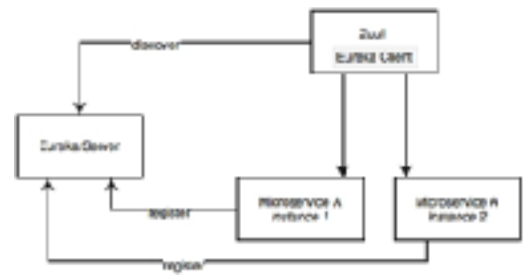


API Gateway

- In most microservice implementations, internal microservice endpoints are not exposed outside
- They are kept as private services. A set of public services will be exposed to the clients using an API gateway
  - Only a selected set of microservices are required by the clients.
  - If there are client-specific policies to be applied, it is easy to apply them in a single place rather than in multiple places. An example of such a scenario is the cross-origin access policy.
  - It is hard to implement client-specific transformations at the service endpoint.
  - If there is data aggregation required, especially to avoid multiple client calls in a bandwidth-restricted environment, then a gateway is required in the middle.

Homework 6.2

- How to use Zuul proxy as the API gateway?
- How to setup High availability capability of Zuul?



The Zuul proxy internally uses the Eureka server for service discovery, and Ribbon for load balancing between service instances.
The Zuul proxy is also capable of routing, monitoring, managing resiliency, security, and so on. In simple terms, we can consider Zuul a reverse proxy service. With Zuul, we can even change the behaviors of the underlying services by overriding them at the API layer.