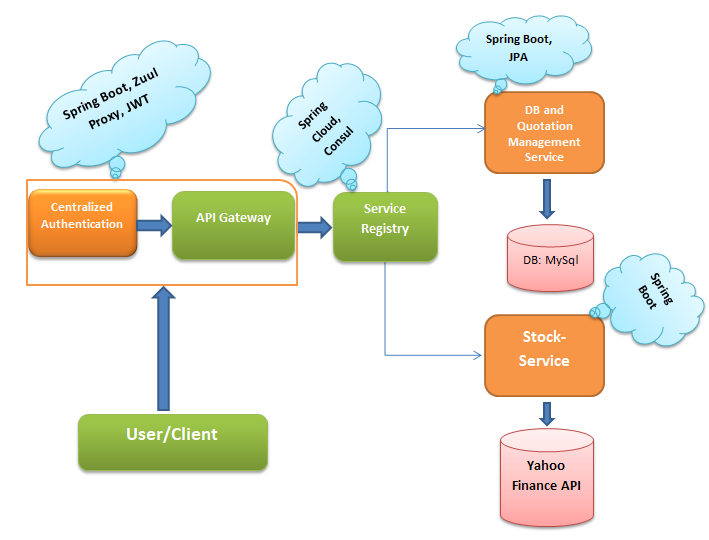
**Microservice Architecture with Spring Boot, Spring Cloud, JPA-Hibernate, Discovery Service (Consul), API gateway using Zuul Proxy and Centralized Authentication with JSON Web Token (JWT)**



**Fig: Microservice Architecture Diagram**

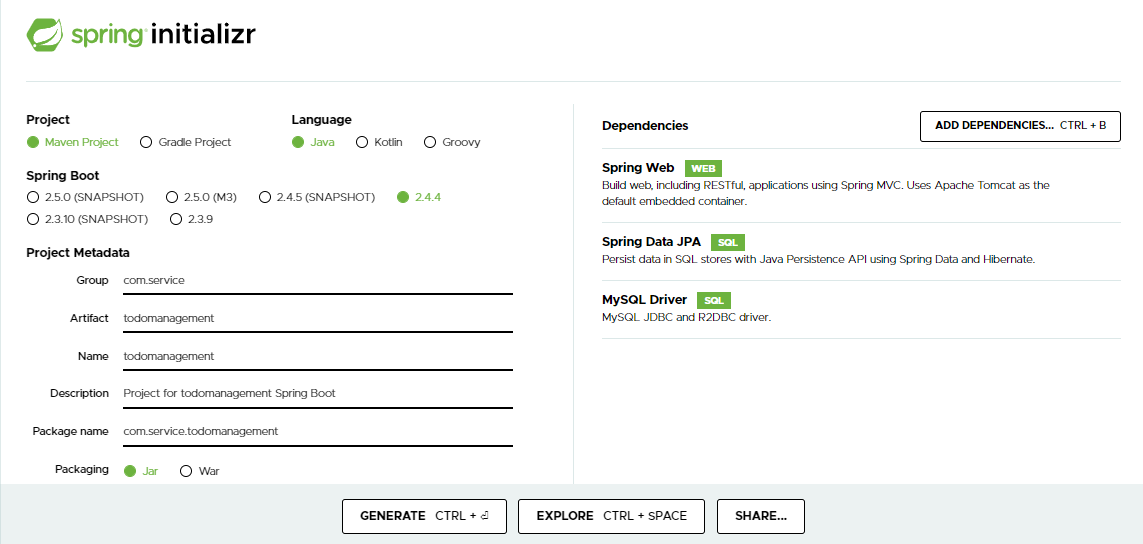
This is the diagram which I will implement in this article. Don’t be so serious to implement this microservice architecture in production but hopefully it will help you to learn something new. To implement the microservice I will follow the bottom up approach. In this article I will cover the following topics:

1. **Spring Boot application – todomanagement-service (Microservice - 1)**
2. **Spring Boot application - todo-service (Microservice - 2)**
3. **Integrating Spring Boot application with Consul discovery / Service Registry**
4. **Create Spring Boot API Gateway using Zuul Proxy and Integrating with Consul discovery / Service Registry**
5. **Centralized microservice security with JSON Web Token (JWT)**

Bullet point **1** and **2** is nothing but a simple spring boot application but **3, 4 and 5** will be interesting. In this article we will mainly focus on implementation and I am not going too much theoretical approach. So no more talk, let’s start the implementation.

1. **Spring Boot application - todo management service (Microservice- 1):**

Here my target is to create a service which will let you create a todo item and save it into the mysql database and you can also the get or delete todo item from db. Now I will create a spring boot project from spring initializer (<https://start.spring.io/>). Go to the spring website and select the item by following the screen shoot. Finally click on **Generate** button and import the project into eclipse as a maven project.



After importing the project, you may face some error for maven version dependency. To avoid this hustle, replace the properties tag with below code:

<properties>

<java.version>1.8</java.version>

<spring-cloud.version>2020.0.1</spring-cloud.version>

<maven-jar-plugin.version>3.1.1</maven-jar-plugin.version>

</properties>

And also add dependencyManagement tag under the dependencies closing tag in pom.xml file:

<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>

Then right click on project and run a maven update from eclipse UI.

Now execute the below database script in the mysql console to create the database and table:

**CREATE** DATABASE microservice;

**CREATE** **TABLE** todo (

id **int**,

user\_name **varchar**(56),

todo\_item **varchar**(1000),

**PRIMARY** **KEY** (id)

);

**Note: To avoid the unnecessary compile error when you create the java classes try to maintain the package structure which I follow.**

Let’s create the entity class Todo.java to persist the quotes table data:

**package** com.service.todomanagement.model;

**import** javax.persistence.\*;

@Entity

@Table(name = "todo", catalog = "microservice")

**public** **class** Todo {

@Id

@GeneratedValue(strategy = GenerationType.***AUTO***)

@Column(name = "id")

**private** Integer id;

@Column(name = "user\_name")

**private** String userName;

@Column(name = "todo\_item")

**private** String todoItem;

**public** Todo() {

}

**public** Todo(String userName, String todoItem) {

**this**.userName = userName;

**this**.todoItem = todoItem;

}

**public** Integer getId() {

**return** id;

}

**public** **void** setId(Integer id) {

**this**.id = id;

}

**public** String getUserName() {

**return** userName;

}

**public** **void** setUserName(String userName) {

**this**.userName = userName;

}

**public** String getTodoItem() {

**return** todoItem;

}

**public** **void** setTodoItem(String todoItem) {

**this**.todoItem = todoItem;

}

}

To get the todo list make a pojo class Todos.java:

**package** com.service.todomanagement.model;

**import** java.util.List;

**public** **class** Todos {

**private** String userName;

**private** List<String> todos;

**public** Todos() {

}

**public** Todos(String userName, List<String> todos) {

**this**.userName = userName;

**this**.setTodos(todos);

}

**public** String getUserName() {

**return** userName;

}

**public** **void** setUserName(String userName) {

**this**.userName = userName;

}

**public** List<String> getTodos() {

**return** todos;

}

**public** **void** setTodos(List<String> todos) {

**this**.todos = todos;

}

}

**Note:** follow the package structure com.service.todomanagement.model

Now create a repository **interface** TodosRepository.java which will be used to get the todo item list by user name from DB. So, let’s create it:

**package** com.service.todomanagement.repository;

**import** java.util.List;

**import** org.springframework.data.jpa.repository.JpaRepository;

**import** com.service.todomanagement.model.Todo;

**public** **interface** TodosRepository **extends** JpaRepository<Todo, Integer> {

List<Todo> findByUserName(String username);

}

Now we will make a rest controller which will provides /add todo rest service, get todo list by /{username} and /delete/{username} todo rest service.

**package** com.service.todomanagement.controller;

**import** java.util.List;

**import** java.util.stream.Collectors;

**import** org.springframework.beans.factory.annotation.Autowired;

**import** org.springframework.web.bind.annotation.GetMapping;

**import** org.springframework.web.bind.annotation.PathVariable;

**import** org.springframework.web.bind.annotation.PostMapping;

**import** org.springframework.web.bind.annotation.RequestBody;

**import** org.springframework.web.bind.annotation.RequestMapping;

**import** org.springframework.web.bind.annotation.RestController;

**import** com.service.todomanagement.model.Todo;

**import** com.service.todomanagement.model.Todos;

**import** com.service.todomanagement.repository.TodosRepository;

@RestController

@RequestMapping("/rest/db")

**public** **class** TodoServiceController {

@Autowired

**private** TodosRepository todosRepository;

@GetMapping("/{username}")

**public** List<String> getTodos(@PathVariable("username") **final** String username) {

**return** getTodosByUserName(username);

}

@PostMapping("/add")

**public** List<String> add(@RequestBody **final** Todos todos) {

todos.getTodos().stream().map(todo -> **new** Todo(todos.getUserName(), todo))

.forEach(todo -> todosRepository.save(todo));

**return** getTodosByUserName(todos.getUserName());

}

@PostMapping("/delete/{username}")

**public** List<String> delete(@PathVariable("username") **final** String username) {

List<Todo> todos = todosRepository.findByUserName(username);

todos.stream().filter(todo -> username.equals(todo.getUserName()))

.forEach(todo -> todosRepository.delete(todo));

**return** getTodosByUserName(username);

}

**private** List<String> getTodosByUserName(@PathVariable("username") String username) {

**return** todosRepository.findByUserName(username).stream().map(Todo::getTodoItem).collect(Collectors.*toList*());

}

}

Add the following configuration in **application.properties** file:

spring.application.name=todomanagement-service

server.port=8181

spring.datasource.url=jdbc:mysql://localhost:3306/microservice

spring.datasource.username=root

spring.datasource.password =Admin@12345

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.MySQL5Dialect

Let’s start the todomanagement-service:

From eclipse select > TodomanagementApplication.java Run as > Spring Boot App/Java Application.

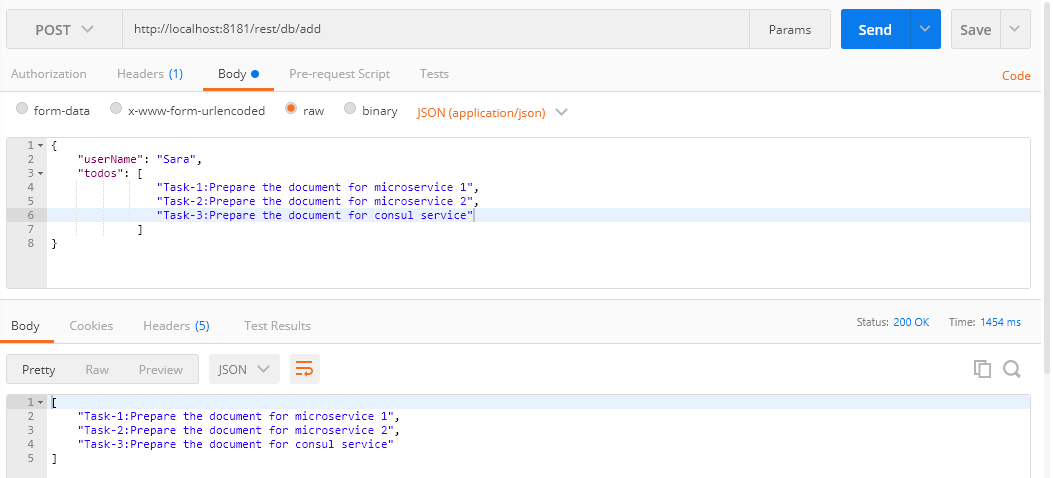
Now we will test this service using post man, you can use any other client which one is your favorite.

Add todos:

Service Url: <http://localhost:8181/rest/db/add>

Add Header: Content-Type: application/json

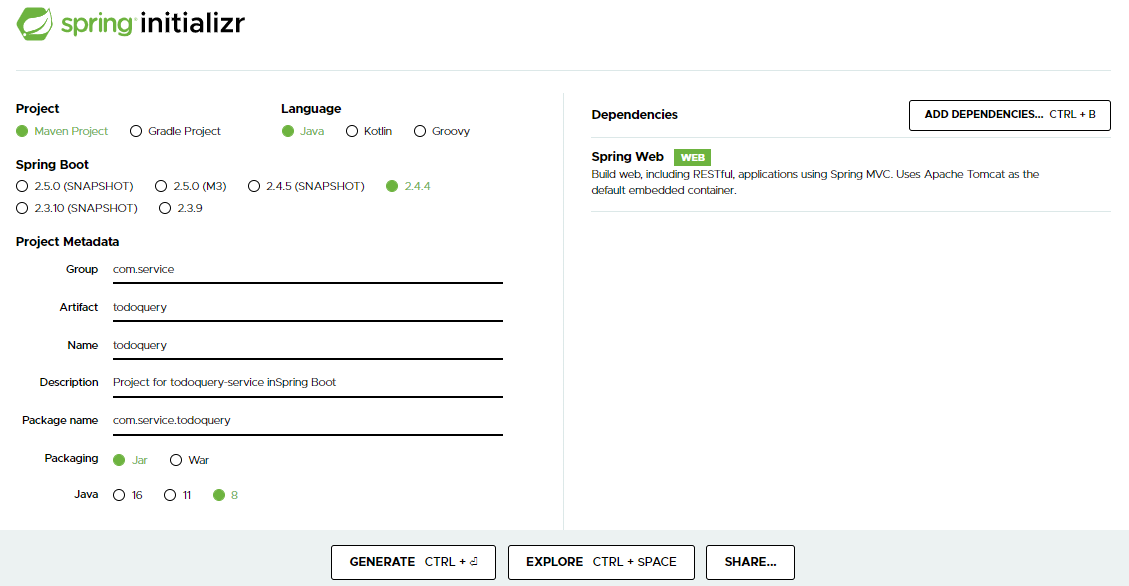
Request and Response Screen shoot:



Check the todo delete and get service by yourself.

1. **Spring Boot application - todoquery-service (Microservice - 2):**

Now my purpose is to create the **todoquery-service** which will gives the todo preview against the user name. Let’s create the service using spring initializer - <https://start.spring.io/>



Click generates, extract the project and import it into the eclipse as a maven project. It may show some error due to maven version dependency. To avoid this hustle replace the properties tag with below code:

<properties>

<java.version>1.8</java.version>

<spring-cloud.version>2020.0.1</spring-cloud.version>

<maven-jar-plugin.version>3.1.1</maven-jar-plugin.version>

</properties>

And also add dependencyManagement tag under the dependencies closing tag in pom.xml file:

<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>

Let’s put some configuration for application name and port in application.properties file:

spring.application.name=todoquery-service

server.port=8282

Now create pojo class Todo.java to persist the quotation data:

**package** com.service.todoquery.model;

**public** **class** Todo {

**private** Integer id;

**private** String userName;

**private** String todoItem;

**public** Todo() {

}

**public** Todo(String userName, String todoItem) {

**this**.userName = userName;

**this**.todoItem = todoItem;

}

**public** Integer getId() {

**return** id;

}

**public** **void** setId(Integer id) {

**this**.id = id;

}

**public** String getUserName() {

**return** userName;

}

**public** **void** setUserName(String userName) {

**this**.userName = userName;

}

**public** String getTodoItem() {

**return** todoItem;

}

**public** **void** setTodoItem(String todoItem) {

**this**.todoItem = todoItem;

}

}

In this application we will consume the rest api from todomanagement-service using **restTemplate** to get the todo list by user name. So, create Config.java class:

**package** com.service.todoquery.config;

**import** org.springframework.context.annotation.Bean;

**import** org.springframework.context.annotation.Configuration;

**import** org.springframework.web.client.RestTemplate;

@Configuration

**public** **class** Config {

@Bean

**public** RestTemplate restTemplate() {

**return** **new** RestTemplate();

}

}

Let’s create the controller which will provide a get rest service about the todo’s preview against the user name:

**package** com.service.todoquery.controller;

**import** java.util.List;

**import** org.springframework.beans.factory.annotation.Autowired;

**import** org.springframework.core.ParameterizedTypeReference;

**import** org.springframework.http.HttpMethod;

**import** org.springframework.http.ResponseEntity;

**import** org.springframework.web.bind.annotation.GetMapping;

**import** org.springframework.web.bind.annotation.PathVariable;

**import** org.springframework.web.bind.annotation.RequestMapping;

**import** org.springframework.web.bind.annotation.RestController;

**import** org.springframework.web.client.RestTemplate;

@RestController

@RequestMapping("/rest/todos")

**public** **class** TodoqueryServiceController {

@Autowired

RestTemplate restTemplate;

@GetMapping("/{username}")

**public** List<String> getTodos(@PathVariable("username") **final** String userName) {

ResponseEntity<List<String>> todoResponse = restTemplate.exchange("http://localhost:8181/rest/db/" + userName,

HttpMethod.***GET***, **null**, **new** ParameterizedTypeReference<List<String>>() {

});

**return** todoResponse.getBody();

}

}

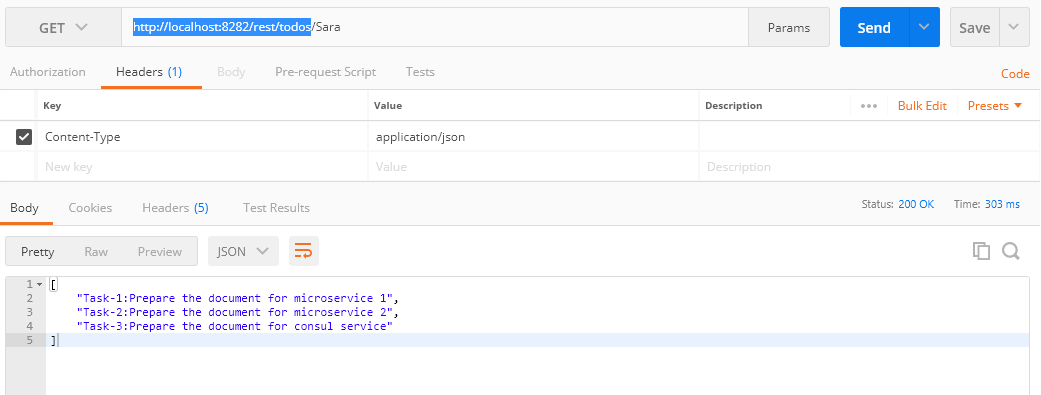
Let’s start the todoquery-service:

From eclipse select > TodoqueryApplication.java Run as > Spring Boot App/java application.

Service Url:

http://localhost:8282/rest/todos/{username}

Request and Response:



1. **Integrating Spring Boot application with Consul discovery / Service Registry:**

Consul offers multiple data centers and for delivering a scalable, highly available, abstract and resilient service. Consul Service act like a one stop service for microservice. Distributed application can use Consul for dynamically discovering the service endpoint. It also offers the health checking of registered service, in-memory KV store, Secure Communication, client load balancing, etc.

**Download and Configure the Consul Service:**

To centralize the configuration using Spring Cloud Consul follow below steps:

1. Download consul server from <https://www.consul.io/downloads> and extract it.
2. Then open the command prompt with as administrator and go to the folder directory where you put the consul.exe file.
3. Find and copy the local machine IP by using below command in command prompt:

ipconfig

1. Now run the below command:

consul agent -server -bootstrap-expect=1 -data-dir=consul-data -ui -bind=YOUR\_IP\_ADDRESS

**Example for my local machine:**

consul agent -server -bootstrap-expect=1 -data-dir=consul-data -ui -bind=192.168.0.101

1. Now check the service from browser <http://localhost:8500/>

At this stage we need to do some modifications for two microservices todomanagement-service and todoquery-service to integrate with consul service.

**Integrate todomanagement-service:**

Add below dependency in pom.xml file:

<dependency>

<groupId>org.springframework.cloud</groupId>

<artifactId>spring-cloud-starter-consul-discovery</artifactId>

</dependency>

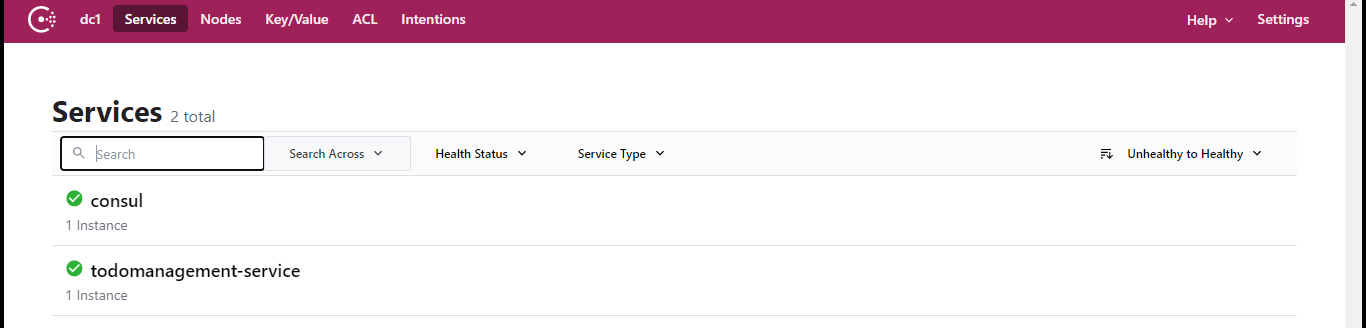
<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-actuator</artifactId>

</dependency>

Now run the TodomanagementApplication.java class as a spring boot app/ java application and refresh the Consul from browser: <http://localhost:8500/>



**Integrate todoquery-service:**

Similarly add all dependency which is already we did for **todomanagement-service** in pom.xml file and update the project. Now add **@EnableDiscoveryClient** annotation on top of **@RestController** to discover the **todomanagement-service** and also replace the **todoquery-service** url with the service name and also autowire the DiscoveryClient to retrieve services and instances data from Consul. Finally the class will look like below:

**package** com.service.todoquery.controller;

**import** java.net.URI;

**import** java.util.List;

**import** org.springframework.beans.factory.annotation.Autowired;

**import** org.springframework.cloud.client.discovery.DiscoveryClient;

**import** org.springframework.cloud.client.discovery.EnableDiscoveryClient;

**import** org.springframework.core.ParameterizedTypeReference;

**import** org.springframework.http.HttpMethod;

**import** org.springframework.http.ResponseEntity;

**import** org.springframework.web.bind.annotation.GetMapping;

**import** org.springframework.web.bind.annotation.PathVariable;

**import** org.springframework.web.bind.annotation.RequestMapping;

**import** org.springframework.web.bind.annotation.RestController;

**import** org.springframework.web.client.RestTemplate;

@EnableDiscoveryClient

@RestController

@RequestMapping("/rest/todos")

**public** **class** TodoqueryServiceController {

@Autowired

RestTemplate restTemplate;

// For consul service

@Autowired

DiscoveryClient discoveryClient;

@GetMapping("/{username}")

**public** List<String> getTodos(@PathVariable("username") **final** String userName) {

/\*

\* ResponseEntity<List<String>> todoResponse =

\* restTemplate.exchange("http://localhost:8181/rest/db/" + userName,

\* HttpMethod.GET, null, new ParameterizedTypeReference<List<String>>() { });

\*/

// Start for consul service integration

URI baseUrl = discoveryClient.getInstances("todomanagement-service")

.stream()

.map(service -> service.getUri())

.findFirst().map(url -> url.resolve("/rest/db/" + userName)).get();

ResponseEntity<List<String>> todoResponse = restTemplate.exchange(baseUrl, HttpMethod.***GET***, **null**, **new** ParameterizedTypeReference<List<String>>() {});

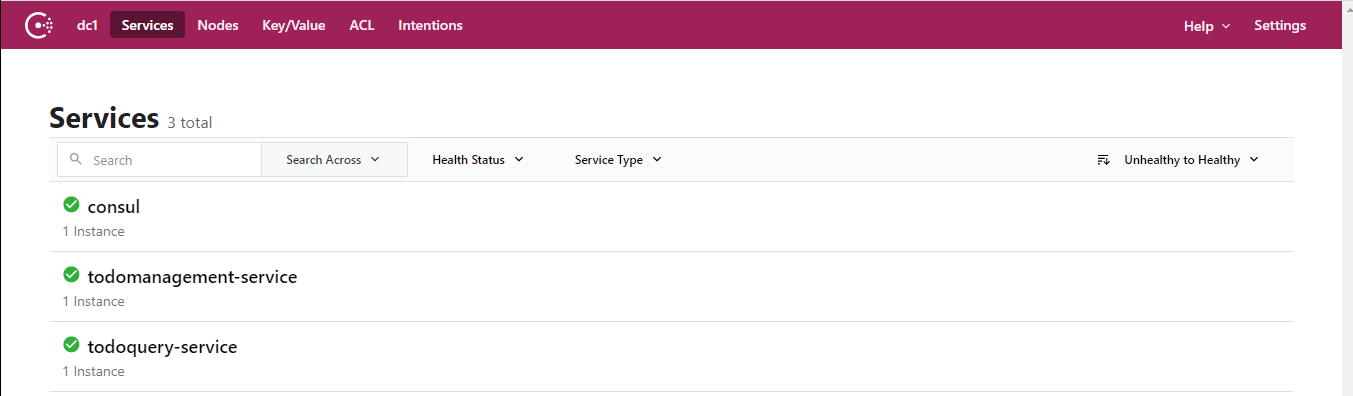
// End for consul integration

**return** todoResponse.getBody();

}

}

Now run the TodoqueryApplication.java class as a spring boot app and refresh the Consul from browser: <http://localhost:8500/> and see both microservice are registered in consul service.



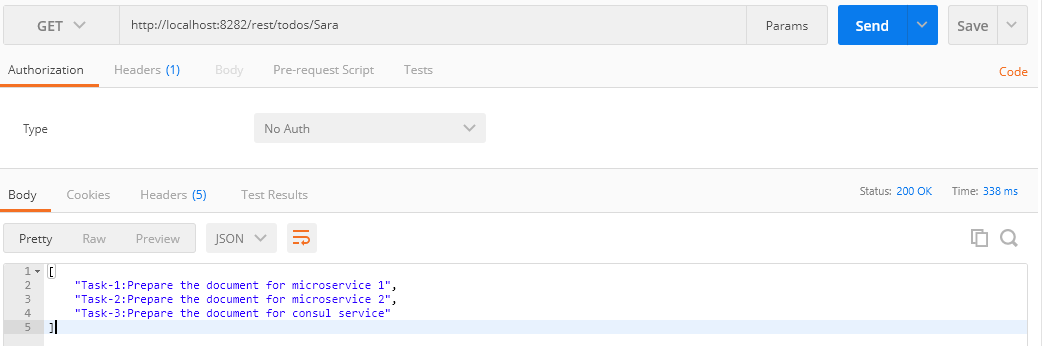
See the below line StockServiceController.java file,

URI baseUrl = discoveryClient.getInstances("todomanagement-service")

.stream()...

Here we are not to telling the API url but the service name only, this is an example how microservices are talking with each other’s via service registry. Now check the **todoquery-service API** using **postman** or any other client to see the Consul magic.

todoquery-service API URL: http://localhost:8282/rest/todos/Sara



1. **Create Spring Boot API Gateway using Zuul Proxy and Integrating with Consul discovery / Service Registry:**

For API Gateway we will use an embedded Zuul proxy service of Spring Cloud Netflix. It will act like a front door or entry point to handling all the request and perform dynamic routing for our microservices.

At this stage we have 2 microservices

- todomanagement-service:

<http://localhost:8181/rest/db/add>

[http://localhost:8181/rest/db/delete /{username}](%20http://localhost:8181/rest/db/delete%20/%7busername%7d)

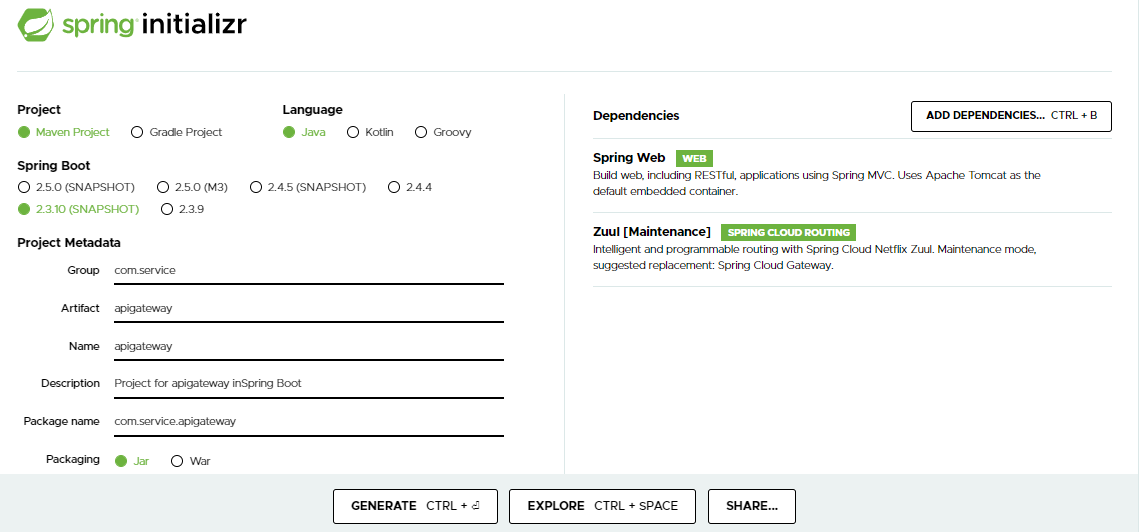
- todoquery-service:

[http://localhost:8282/rest/todos/{username}](http://localhost:8282/rest/stock/%7busername%7d)

In this section we will prepare a API gateway using zuul service and all those request will be receiving by this API gateway and the API gateway dynamically discover which service will invoke based on the request.

Let’s start making the gateway service step by step:

Go to the spring initializer website and select the item by following the screen shoot. Finally click on **Generate** button and import the project in eclipse as a maven project.



After importing the project, you might be faced some error about maven dependency because of maven versions. To bypass this unexpected issue, you have to add below properties inside the <properties> tag:

<maven-jar-plugin.version>3.1.1</maven-jar-plugin.version>

After adding the properties just run a maven update from the eclipse editor and hopefully all error will be disappeared. Now we will configure the API gateway and integrating it with consul service. For this task, create a application.yml file and place it into the resources folder of the project.

application.yml content:

spring:

application:

name: gateway-service

server:

port: 8383

cloud:

consul:

host: localhost

port: 8500

discovery:

healthCheckInterval: 5s

We will maintain another configuration file for the microservice routing. For this, create a bootstrap.yml in resources folder and place the below content into the file:

zuul:

#Service will be mapped under the /api URI

ignored-patterns: /actuator/\*\*

prefix: /api

routes:

todomanagement-service:

path: /todomanagement-service/\*\*

serviceId: todomanagement-service

stripPrefix: true

todoquery-service:

path: /todoquery-service/\*\*

serviceId: todoquery-service

stripPrefix: true

Now add below dependency in pom.xml for consul integration:

<dependency>

<groupId>org.springframework.cloud</groupId>

<artifactId>spring-cloud-starter-consul-config</artifactId>

</dependency>

<dependency>

<groupId>org.springframework.cloud</groupId>

<artifactId>spring-cloud-starter-consul-discovery</artifactId>

</dependency>

<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-actuator</artifactId>

</dependency>

At this stage we have configured the API gateway service as gateway-service and port 8383 and also integrating the service with consul service in application.yml file. After that we have configured the routing todomanagement-service and todoquery-service in bootstrap.yml file.

We are almost in the finishing stage. Now open the ApigatewayApplication.java file and add @EnableZuulProxy annotation just below @SpringBootApplication to enable the Spring Cloud Netflix embedded Zuul proxy. Then add @EnableDiscoveryClient annotation to register the Spring Boot server (gateway-service) with the discovery server (consul service). After all configuration the ApigatewayApplication.java file will look like below:

**package** com.service.apigateway;

**import** org.springframework.boot.SpringApplication;

**import** org.springframework.boot.autoconfigure.SpringBootApplication;

**import** org.springframework.cloud.client.discovery.EnableDiscoveryClient;

**import** org.springframework.cloud.netflix.zuul.EnableZuulProxy;

@SpringBootApplication

@EnableZuulProxy

@EnableDiscoveryClient

**public** **class** ApigatewayApplication {

**public** **static** **void** main(String[] args) {

SpringApplication.*run*(ApigatewayApplication.**class**, args);

}

}

Now run ApigatewayApplication.java as a java application and ensure that the others service is up and running. So, now we can call the microservice via API gateway instead of direct call of microservices.

For todo add service in todomanagement-service:

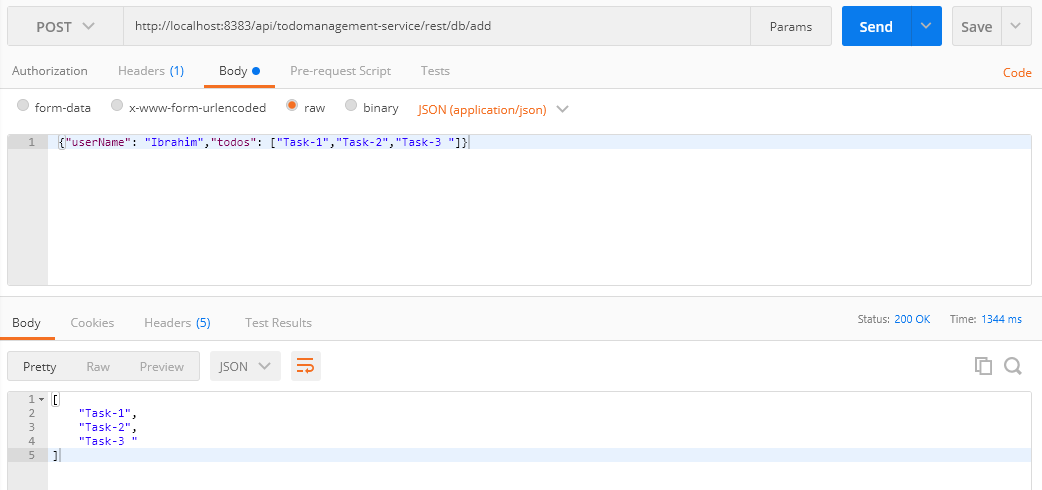
Url: http://localhost:8383/api/todomanagement-service/rest/db/add

Method:POST

Content-Type: application/json

Body: {"userName": "Ibrahim","todos": ["Task-1","Task-2","Task-3 "]}

Here is the screen shoot:



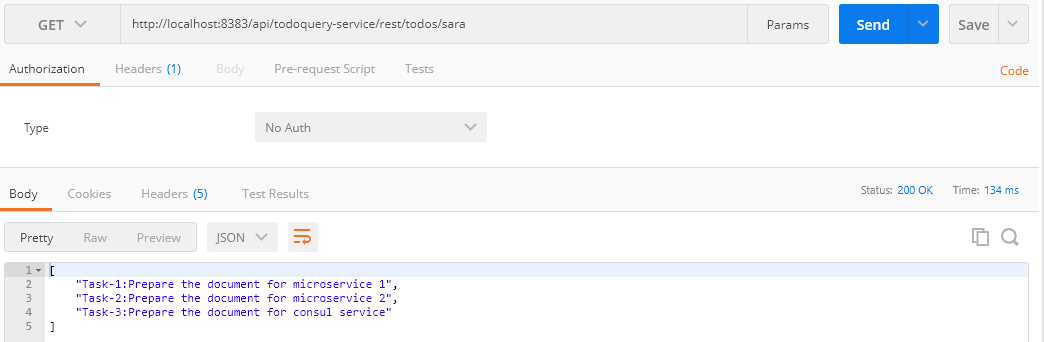
To user todo list from todomanagement-service:

Url: http://localhost:8383/api/todomanagement-service/rest/db/delete/{username}

For todo query service in todoquery-service:

Url:  [http://localhost:8383/api/todoquery-service/rest/todos/{username}](http://localhost:8383/api/stock-service/rest/stock/%7busername%7d)

Here is the screen-shoot:



1. **Centralized microservice security with JSON Web Token (JWT):**

There are many ways to securing the application but in this article we will focus only in JSON Web Token. To centralize the microservice security we will add JWT mechanism in API gateway service instead of implementing on microservice separately. Here we will go directly in implementation.

To know details about JWT you can read my another article, it will give you a complete overview on JWT with spring boot:

<https://javatechlearning.blogspot.com/2021/03/spring-boot-token-and-role-based.html>.

Here we will create a service endpoint to create user and login to generate the JSON Web Token. After that user will access the todomanagement-service and todoquery-service by sending the JSON Web Token through the request header. For the simplicity of this long article we will omit the role base authentication.

To integrate the JWT with API gateway follow below step by step instruction:

**Database Table Creation:**

Execute below script in mysql database to store the user’s information. We are using same database schema to keep the users, role and user role data.

**CREATE** **TABLE** users (

id **int**,

username **varchar**(56),

password **varchar**(256),

**PRIMARY** **KEY** (id)

);

**CREATE** **TABLE** user\_roles (

userid **int**,

roleid **int**,

**PRIMARY** **KEY** (userid,roleid)

);

**CREATE** **TABLE** roles (

id **int**,

name **varchar**(56),

**PRIMARY** **KEY** (id)

);

**INSERT** **INTO** roles(id,name) **VALUES**(1,'ROLE\_USER');

**INSERT** **INTO** roles(id,name) **VALUES**(2,'ROLE\_ADMIN');

For JWT security integration add bellow dependency in pom.xml of gateway-service:

<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-security</artifactId>

</dependency>

<dependency>

<groupId>org.springframework.boot</groupId>

<artifactId>spring-boot-starter-data-jpa</artifactId>

</dependency>

<dependency>

<groupId>mysql</groupId>

<artifactId>mysql-connector-java</artifactId>

<scope>runtime</scope>

</dependency>

<dependency>

<groupId>io.jsonwebtoken</groupId>

<artifactId>jjwt</artifactId>

<version>0.9.1</version>

</dependency>

Before writing any code we will configure the data source for mysql database and JWT configuration in **Application.properties** file:

jwt.signing.key.secret=mySecret

jwt.get.token.uri=/authenticate

jwt.refresh.token.uri=/refresh

jwt.http.request.header=Authorization

jwt.token.expiration.in.seconds=1800

spring.datasource.url=jdbc:mysql://localhost:3306/microservice

spring.datasource.username=root

spring.datasource.password =Admin@12345

spring.jpa.show-sql=true

spring.jpa.hibernate.ddl-auto=update

spring.jpa.properties.hibernate.dialect=org.hibernate.dialect.MySQL5Dialect

**Create entity class:**

**Create Repository:**

**Create Service:**

**Configure Spring Security for JWT:**

**Create API Controller:**

Ignoring heath check:

@Override

**protected** **void** configure(HttpSecurity http) **throws** Exception {

http.cors().and().csrf().disable()

.exceptionHandling().authenticationEntryPoint(unauthorizedHandler).and()

.sessionManagement().sessionCreationPolicy(SessionCreationPolicy.***STATELESS***).and()

.authorizeRequests().antMatchers("/api/authenticate/\*\*").permitAll()

.antMatchers("/api/resource/\*\*").permitAll()

.antMatchers("/actuator/health/\*\*").permitAll()

.anyRequest().authenticated();

http.addFilterBefore(authenticationJwtTokenFilter(), UsernamePasswordAuthenticationFilter.**class**);

}

Request sample for reg:

<http://localhost:8383/api/authenticate/reg>

Method: POST

Content-Type: application/json

Message Body:

{

"username": "Sara",

"password":"Admin@123",

"role":["admin"]

}

