

# Cloud Computing Assignment 2 (Additional Description)

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## 1 Overview

This description covers the services already implemented in the assignment, helping you better understand the created Leaf Image Management System, as well as the data and metrics for the service.

## 2 Detailed Data Description

The ML visual categorization application identifies the categories of foliar diseases for the following leaves:

- Potato (3 types of leaves)
- Pepper (2 types of leaves)
- Tomato (10 types of leaves)

As observed, each type of leaf can have various possible diseases that the system can detect. Fig. 1 illustrates that each type has its own set of diseases, where each disease constitutes a class. For example, potato leaves encompass three classes.

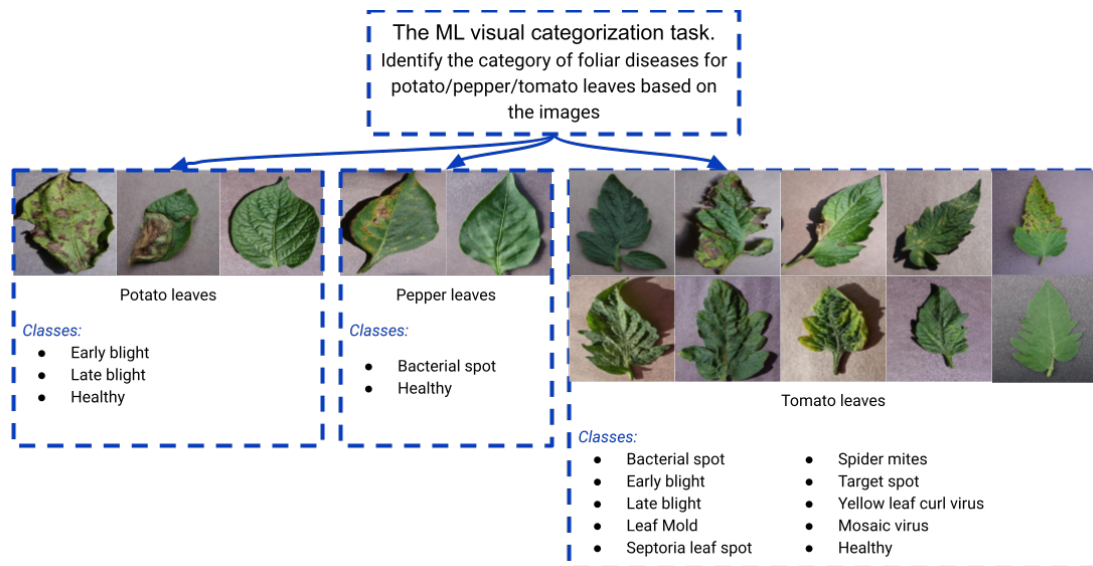


Figure 1: Leaf Diseases Classes

### 3 Detailed APIs' Description

#### 3.1 Image API (already implemented)

The description about this service is represented in the main assignment file. However, you can delve deeper into the Image API, as it produces messages that you will need to consume.

This service features an API with the following handlers:

##### 1. Ping the service's status.

**Request** has no attributes. This handler checks the service's operational status.

```
[GET] /ping
```

**Response** provides the following information if the service is functioning (content-type: application/json):

```
"Hello, I am alive"
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

##### 2. Get a potato/tomato/pepper image with metadata by id.

**Request** has a consistent structure for all three handlers and only requires the image's id, where ids are sequential starting from 1:

```
[GET] /image-plant/potato/{image_id}
[GET] /image-plant/tomato/{image_id}
[GET] /image-plant/pepper/{image_id}
```

### Example:

```
[GET] /image-plant/potato/1
```

**Response** also maintains a consistent structure for these three handlers (content-type: application/json):

```
{
  "id": 1,
  "camera_id": 1,
  "data": "ffd8ffe000104a46...", (encoded-image-data)
  "gps_coordinates": [
    48.476563,
    16.585654
  ],
  "created_at": "2023-10-08T15:39:49.123123",
  "updated_at": "2023-10-08T15:39:49.123123",
  "is_active": false,
  "is_deleted": false,
  "disease": null,
  "percentage": null
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

### 3. Get the total count of potato/tomato/pepper images.

**Request** has a consistent structure for all three handlers and does not require any data for transfer:

```
[GET] /image-plant/potato/total/
[GET] /image-plant/tomato/total/
[GET] /image-plant/pepper/total/
```

**Response** maintains a similar structure for all three handlers (content-type: application/json):

```
{
  "total_images": 2157
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

### 4. Get a random potato/tomato/pepper image based on filters.

**Request** has a consistent structure for all three handlers and includes two optional flags:

```
is_active
has_disease
```

These flags are utilized to obtain the appropriate random image. For example, to retrieve only an active random image or a random image that contains information about diseases.

```
[GET] image-plant/potato/random/  
[GET] image-plant/tomato/random/  
[GET] image-plant/pepper/random/
```

### Example:

```
image-plant/potato/random/  
image-plant/potato/random/?is_active=true  
image-plant/potato/random/?has_disease=true  
image-plant/potato/random/?is_active=true  
&has_disease=true
```

**Response** maintains a consistent structure for these three handlers (content-type: application/json) and mirrors the model from the second handler:

```
{  
  "id": 1,  
  "camera_id": 1,  
  "data": "ffd8ffe000104a46...", (encoded-image-data)  
  "gps_coordinates": [  
    48.476563,  
    16.585654  
  ],  
  "created_at": "2023-10-08T15:39:49.123123",  
  "updated_at": "2023-10-08T15:39:49.123123",  
  "is_active": false,  
  "is_deleted": false,  
  "disease": null,  
  "percentage": null  
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

## 5. Get the batch of potato/tomato/pepper images.

**Request** has a consistent structure for all three handlers and includes two optional flags:

```
is_active  
has_disease
```

These flags, identical to those in the fourth handler, are employed to fetch the appropriate random images. For instance, to retrieve only active random images or random images containing disease information.

Additionally, there are required parameters:

```
from_id
limit
```

These parameters allow users to specify a quantity of images starting from a particular number. Using flags in conjunction with these parameters facilitates fetching a specific number of active images from a subsequent list, or images marked with certain diseases.

```
[GET] image-plant/potato
[GET] image-plant/tomato
[GET] image-plant/pepper
```

### Example

```
[GET] /image-plant/potato/?from_id=2&limit=2
[GET] /image-plant/potato/?from_id=2&limit=2
&has_disease=false
[GET] /image-plant/potato/?from_id=2&limit=2
&is_active=true
[GET] /image-plant/potato/?from_id=2&limit=2
&is_active=true&has_disease=false
```

**Response** maintains a consistent structure for these three handlers (content-type: application/json):

```
{
  "image_list": [
    {
      "id": 2,
      "camera_id": 1,
      "data": "ffd8ffe000104a46...", (encoded-image-data)
      "gps_coordinates": [
        48.618306,
        16.87287
      ],
      "created_at": "2023-10-08T15:39:49.668000",
      "updated_at": "2023-10-08T15:39:49.668000",
      "is_active": false,
      "is_deleted": false,
      "disease": null,
      "percentage": null
    },
    {
      "id": 3,
      "camera_id": 1,
      "data": "cf719c28f4c1c1ad...", (encoded-image-data)
      "gps_coordinates": [
        48.038826,
        16.070844
      ]
    }
  ]
}
```

```

    ],
    "created_at": "2023-10-08T15:40:43.119000",
    "updated_at": "2023-10-08T15:40:43.345000",
    "is_active": false,
    "is_deleted": false,
    "disease": null,
    "percentage": null
  }
],
"total_images": 2157
}

```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

## 6. Create a potato/tomato/pepper image.

**Request** includes the following parameters:

```

camera_id
gps_coordinates

```

These parameters apply to all three handlers.

```

[PUT] /image-plant/potato
[PUT] /image-plant/tomato
[PUT] /image-plant/pepper

```

The remaining data for images is added automatically.

### Example:

```

{
  "camera_id": 1,
  "gps_coordinates": [
    48.476563,
    16.585654
  ]
}

```

**Response** maintains a consistent structure for these three handlers (content-type: application/json) and mirrors the model from the second handler:

```

{
  "id": 2158,
  "camera_id": 1,
  "data": "ffd8ffe000104a4...", (encoded-image-data)
  "gps_coordinates": [
    48.476563,
    16.585654
  ],

```

```

    "created_at": "2023-10-09T18:43:37.500688",
    "updated_at": "2023-10-09T18:43:37.500692",
    "is_active": false,
    "is_deleted": false,
    "disease": null,
    "percentage": null
  }

```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

## 7. Update a potato/tomato/pepper image.

**Request** maintains a consistent structure for all three handlers and includes the following parameters:

```

id
camera_id
gps_coordinates
disease
percentage
is_active
is_deleted

```

These parameters apply to all three handlers.

```

[POST] /image-plant/potato
[POST] /image-plant/tomato
[POST] /image-plant/pepper

```

### Example:

```

{
  "id": 1,
  "camera_id": 1,
  "gps_coordinates": [
    48.476563,
    16.585654
  ],
  "disease": "Healthy",
  "percentage": 0.995,
  "is_active": true,
  "is_deleted": false
}

```

**Response** also maintains a consistent structure for these three handlers and mirrors the model from the second handler (content-type: application/json):

```
{
  "id": 1,
  "camera_id": 1,
  "data": "ffd8ffe000104a4...", (encoded-image-data)
  "gps_coordinates": [
    48.476563,
    16.585654
  ],
  "created_at": "2023-10-08T15:39:49.666000",
  "updated_at": "2023-10-09T19:05:14.792000",
  "is_active": true,
  "is_deleted": false,
  "disease": "Healthy",
  "percentage": 0.995
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

#### 8. Delete a potato/tomato/pepper image by id.

**Request** has a consistent structure for all three handlers and requires only the image's id, with ids being sequential starting from 1:

```
[DELETE] /image-plant/potato/{image_id}
[DELETE] /image-plant/tomato/{image_id}
[DELETE] /image-plant/pepper/{image_id}
```

#### Example:

```
[DELETE] /image-plant/potato/1
```

**Response** also maintains a consistent structure for these three handlers (content-type: application/json):

```
{
  "message": "Image deleted successfully"
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

Image API features a Swagger interface (see Fig. 2) that can be accessed via:

```
{
  http://localhost:8080/docs#/ - locally
  image-api.leaf-image-management-system.svc.cluster
  .local:8080 - kubernetes
}
```



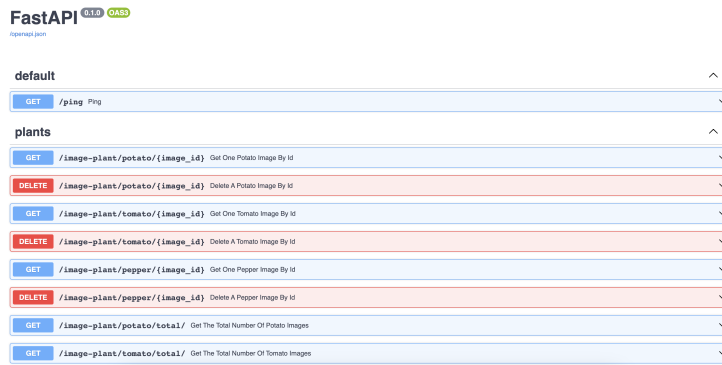


Figure 2: Image API - Swagger

## 3.2 Image Analyzer API (already implemented)

The Image Analyzer API is used to analyze potential foliar diseases. This service includes an API with the following handlers:

### 1. Ping the service's status.

**Request** has no attributes. This handler allows checking if the service works:

```
[GET] /ping
```

**Response** provides the following information if the service is operational (content-type: application/json):

```
"Hello, I am alive"
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

### 2. Classify diseases of potato/tomato/pepper leaves based on images.

**Request** requires .jpeg images of leaves to be recognized and classified for diseases. The specifics for these handlers are detailed below:

```
[POST] /potato/disease-classify
[POST] /tomato/disease-classify
[POST] /pepper/disease-classify
```

**Response** from these handlers provides the predicted classification of the image and the confidence level. Each handler is designated for a specific type of leaf (content-type: application/json):

```
{
  "predicted_class": "Healthy",
  "confidence": 0.8067989945411682
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

### 3. **Classify potato/tomato/pepper diseases from images (hex representation) decoded from bytes.**

**Request** includes the hex representation of images. However, internally, these handlers function identically to those in point 2. Each handler is designated for a specific type of leaf:

```
[POST] /potato/disease-classify-by-bytes
[POST] /tomato/disease-classify-by-bytes
[POST] /pepper/disease-classify-by-bytes
```

#### **Example:**

```
{
  "hex_bytes": "ffd8ffe000104a4649460...."
}
```

**Response** from these handlers, similar to the handlers in point 2, provides the predicted classification of the image along with the confidence level (content-type: application/json):

```
{
  "predicted_class": "Bacterial Spot",
  "confidence": 0.78
}
```

This response returns a 200 status code if the operation was successful, and a 4xx status code otherwise.

Image Analyzer API has a Swagger (Fig. 3), which can be opened by:

```
{
  http://localhost:8081/docs#/ - locally
  image-analyzer-api.leaf-image-management-system.svc
  .cluster.local:8080 - kubernetes
}
```



Figure 3: Image Analyzer API - Swagger

## 4 Mongo Database for producer/consumer description

We use MongoDB to store data, and it is deployed and populated automatically alongside other services. As we described, the entire schema contains two databases: Producer Image DB (mongodb-producer), Consumer Image DB (mongodb-consumer).

For the producer, you can open the database using the following address:

```
{
  http://localhost:27017 - locally
  mongodb-producer.leaf-image-management-system.svc
  .cluster.local:27017 - on Kubernetes
}
```

For the consumer, you can open the database using the following address:

```
{
  http://localhost:27018 - locally
  mongodb-consumer.leaf-image-management-system.svc
  .cluster.local:27017 - on Kubernetes
}
```

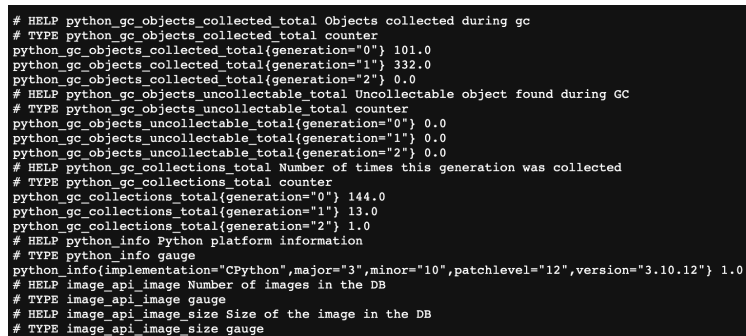
## 5 Prometheus and Grafana (already implemented)

### 5.1 Prometheus for Image API

Prometheus facilitates the retrieval of service metrics, which are utilized in Grafana. For the Image API, it tracks the number of metadata changes for images, as well as the size of messages sent to the Kafka cluster.

The Image API provides an open Prometheus port (see Fig. 4):

```
{
  http://localhost:8050 - locally
  image-api.leaf-image-management-system.svc.cluster
  .local:8050 - kubernetes
}
```



```
# HELP python_gc_objects_collected_total Objects collected during gc
# TYPE python_gc_objects_collected_total counter
python_gc_objects_collected_total{generation="0"} 101.0
python_gc_objects_collected_total{generation="1"} 332.0
python_gc_objects_collected_total{generation="2"} 0.0
# HELP python_gc_objects_uncollectable_total Uncollectable object found during GC
# TYPE python_gc_objects_uncollectable_total counter
python_gc_objects_uncollectable_total{generation="0"} 0.0
python_gc_objects_uncollectable_total{generation="1"} 0.0
python_gc_objects_uncollectable_total{generation="2"} 0.0
# HELP python_gc_collections_total Number of times this generation was collected
# TYPE python_gc_collections_total counter
python_gc_collections_total{generation="0"} 144.0
python_gc_collections_total{generation="1"} 13.0
python_gc_collections_total{generation="2"} 1.0
# HELP python_info Python platform information
# TYPE python_info gauge
python_info{implementation="CPython",major="3",minor="10",patchlevel="12",version="3.10.12"} 1.0
# HELP image_api_image Number of images in the DB
# TYPE image_api_image gauge
# HELP image_api_image_size Size of the image in the DB
# TYPE image_api_image_size gauge
```

Figure 4: Image API - Prometheus

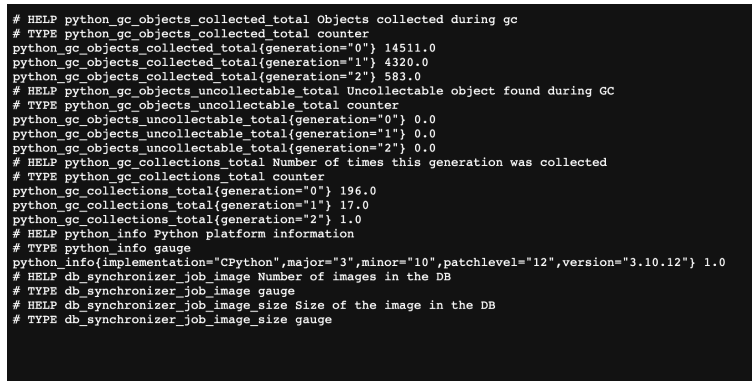
For Image API we gather the following metrics:

```
{
    image_api_image - counter of images
    image_api_image_size - size of the image in bytes
}
```

## 5.2 Prometheus for DB Synchronizer Job

This service also has a Prometheus port (see Fig. 5):

```
{
    http://localhost:8051 - locally
    db-synchronizer-job.leaf-image-management-system.svc
    .cluster.local:8050 - kubernetes
}
```



```
# HELP python_gc_objects_collected_total Objects collected during gc
# TYPE python_gc_objects_collected_total counter
python_gc_objects_collected_total{generation="0"} 14511.0
python_gc_objects_collected_total{generation="1"} 4320.0
python_gc_objects_collected_total{generation="2"} 583.0
# HELP python_gc_objects_uncollectable_total Uncollectable object found during GC
# TYPE python_gc_objects_uncollectable_total counter
python_gc_objects_uncollectable_total{generation="0"} 0.0
python_gc_objects_uncollectable_total{generation="1"} 0.0
python_gc_objects_uncollectable_total{generation="2"} 0.0
# HELP python_gc_collections_total Number of times this generation was collected
# TYPE python_gc_collections_total counter
python_gc_collections_total{generation="0"} 196.0
python_gc_collections_total{generation="1"} 17.0
python_gc_collections_total{generation="2"} 1.0
# HELP python_info Python platform information
# TYPE python_info gauge
python_info{implementation="CPython",major="3",minor="10",patchlevel="12",version="3.10.12"} 1.0
# HELP db_synchronizer_job_image Number of images in the DB
# TYPE db_synchronizer_job_image gauge
# HELP db_synchronizer_job_image_size Size of the image in the DB
# TYPE db_synchronizer_job_image_size gauge
```

Figure 5: DB Synchronizer Job - Prometheus

Prometheus allows you to retrieve metrics of the service, which are used by Grafana. For the DB Synchronizer Job, it counts the number of received images as well as the size of messages transmitted to the service.

For DB Synchronizer Job we gather the following metrics:

```
{
    db_synchronization_job_image - counter of images
    db_synchronization_job_image_size - size of the image in
    bytes
}
```

## 5.3 Prometheus and Grafana deployment

After implementing your consumer, you will need to use Prometheus to address Task 3, which involves comparing the bandwidth between the pre-implemented batch processing application and the stream processing application. The Prometheus cluster is deployed separately, and details about it can be found in the README file. We use a new namespace named 'metrics' to deploy the Prometheus cluster.

The Prometheus cluster gathers metrics from the Prometheus services associated with ImageAPI and DB Synchronizer Job. To access the Prometheus cluster, you need to connect to the following addresses:

```
{
  http://localhost:9090 - locally
  prometheus-kube-prometheus-prometheus.metrics.svc
  .cluster.local:9090 - kubernetes
}
```

Prometheus features a UI located in the aforementioned address as shown in Fig. 6.

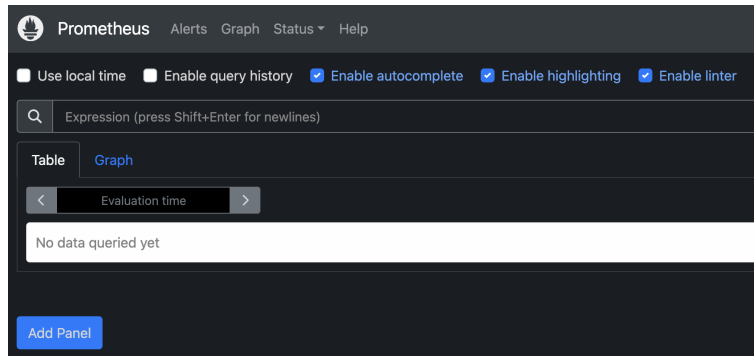


Figure 6: Prometheus - UI

While Prometheus collects metrics from the services, you need to utilize Grafana to visualize these metrics in a more convenient way. Grafana can be accessed through the following ports:

```
{
  http://localhost:3000 - locally
  grafana.metrics.svc.cluster.local:3000 - kubernetes
}
```

Grafana is deployed along with Prometheus in the 'metrics' namespace and also has its own UI (Fig. 7).

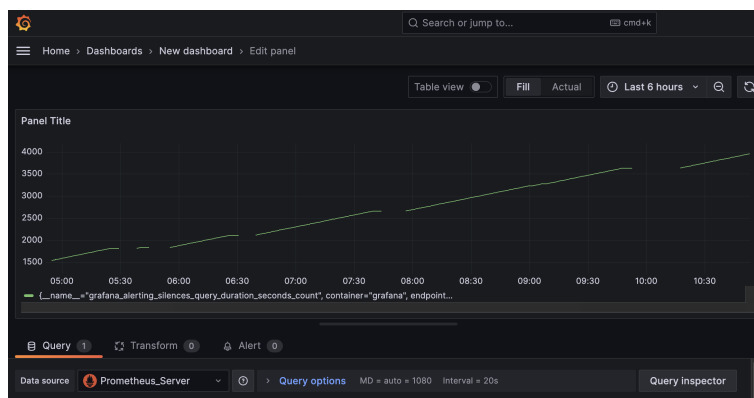


Figure 7: Grafana - UI