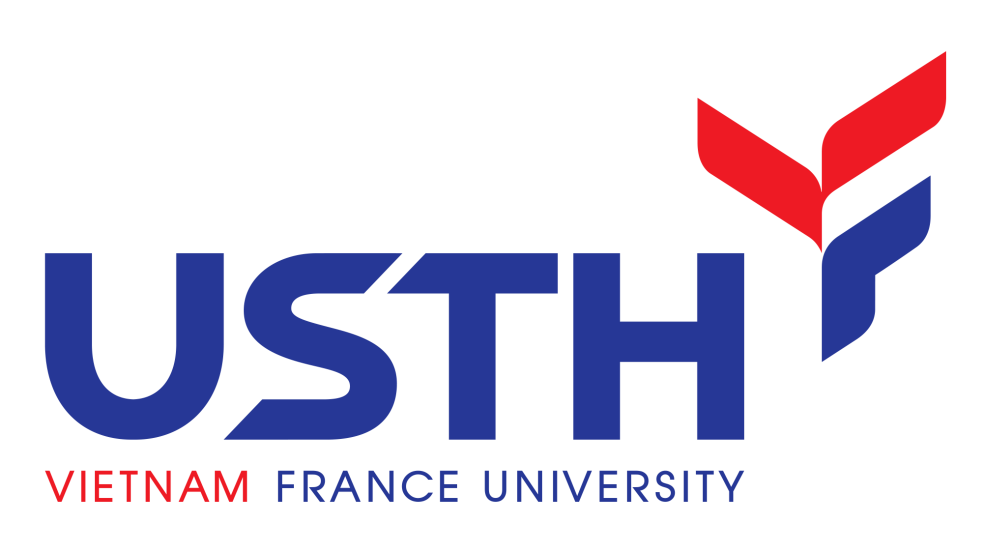
# DECLARATION

UNIVERSITY OF SCIENCE AND TECHNOLOGY OF HANOI

****

**MASTER THESIS**

By

**DANG THAI SON (2440045)**

*Information and Communication Technology (ICT)*

Title

**ETL Microservice for Data Ingestion into a Data Lake**

------------------------------------------------------------------------------------------------------------------

Supervisor: **Assoc. Prof. Trần Giang Sơn**

*ICT Laboratory - USTH*

**Hanoi, August 2025**

I, hereby, Dang Thai Son, declare that all the work and result in this thesis are entirely my own and are not plagiarized from any source. This thesis was written based on my research which was carried out at the Information and Communication Technology laboratory at University of Science and Technology of Hanoi, under the guidance of Assoc. Prof. Tran Giang Son.

Any scientific result, method, comment, and statistics inherited during the research from other authors has been cited thoroughly. In case there is any plagiarism in my thesis, I understand that this work will not be evaluated and I will take full responsibility for penalties from the thesis defense committee and my university.

# ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who offered me the chances to be capable of carrying out my project and then complete this thesis.

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# LIST OF ABBREVIATIONS

IDC International Data Corporation

AI Artificial Intelligence

ETL Extract, Transform, Load

# LIST OF TABLES

# LIST OF FIGURES

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# ABSTRACT

**This should be written last.**

1. WHY: Context and Problem (1-2 sentences)
   1. Context: The importance of data lakes
   2. Specific problem the project solves: The challenge of ingesting complex, authenticated data
   3. Keywords: Data Lake, data ingestion, analytics, machine learning, diverse data sources, authentication, pre-processing.
2. WHAT: Aim and Objectives (1 sentence)
   1. What is set out to achieve?
   2. Example: "This thesis presents the design and development of a robust ETL microservice for..."
3. HOW: Methodology and Implementation (2-3 sentences)
   1. The technology stack (Reactive microservice, Quarkus)
   2. The data source and APIs (Copernicus Data Space Ecosystem, Sentinel Hub Catalog/Process APIs)
   3. The persistence layer (PostgreSQL for metadata)
   4. The overall process (Extract STAC metadata, download imagery, persist records)
4. SO WHAT: Results and Significance (1-2 sentences)
   1. What was the final outcome? What was successfully built?
   2. Significance of the work. Why does it matter? What contribution does it make?
   3. Keywords: Functional pipeline, improved data availability, data quality, robust solution, scalable architecture, blueprint for modern data services.

Data lakes are central repositories for storing vast amounts of raw data for analytics and machine learning applications. However, a significant challenge lies in the automated and reliable ingestion of data from diverse and complex sources, especially those requiring authentication and extensive pre-processing. This thesis addresses this challenge by presenting the design, development, and implementation of a robust ETL microservice for the automated ingestion of satellite imagery from the Copernicus Data Space Ecosystem into a data lake. The solution is architected as a reactive microservice using the Quarkus framework, leveraging the Sentinel Hub Catalog and Process APIs to extract STAC metadata and corresponding satellite imagery. The extracted metadata is transformed and loaded into a PostgreSQL database, creating a searchable catalog linked to the locally stored image files. The primary outcome is a fully functional, non-blocking ETL pipeline capable of handling API authentication, processing geospatial queries, and atomically persisting both the metadata and the image data. This work provides a practical and scalable blueprint for building modern data ingestion services, improving data availability and quality within the data lake ecosystem.

* Word Count: Aim for 150-300 words.
* .

**Keywords**: *..*.

# INTRODUCTION

## I/ Overview

In today’s modern world, data grows exponentially and continuously in numerous domains. According to a report by International Data Corporation (IDC) and Seagate, the global datasphere which is the total amount of data created and duplicated all over the world is estimated to reach 163 zettabytes (1.63 × 1014 gigabytes) by 2025 [1]. This statistic is approximately ten times bigger than that a decade ago. This data deluge results in a new terminology called “big data” which generally involves enormous, fast-moving, and diverse datasets that challenge traditional data systems. Thanks to it, various information-based applications has been developed to serve critical needs such as analytical models in agriculture, or forecast framework in weather and climate fields [2]. Some popular big data systems supporting scientific research include Copernicus Global Land Services, Sentinel-2, Landsat Program, ALOS World 3D, and ERA5 that provide valuable environmental information.

In order to conveniently store, manage, and extract value from these massive and complex data sources, a new type of data storage architecture which is data lake has emerged. A data lake is defined as a highly scalable centralized repository that allows storing structured, semi-structured, and unstructured data in its raw format without the need to define a schema at the time of ingestion [3]. This schema-on-read mechanism provide a flexible way to work with heterogenous and high-volume data coming from sources like satellites, sensors, or user logs. Without the development of data lake, organizations would struggle with repetitive data preprocessing and they could even be unable to handle modern data volumes and velocities, which would drastically reduce the ability to implement AI models or to perform exploratory analysis on raw data. To meet these needs, several large-scale data lakes have been developed and widely adopted for either scientific or industrial use such as Amazon S3-based data lake, Google Cloud Storage, and Microsoft Azure data lake.

### 3. ETL

- Là gì

- Tại sao cần

- Nếu ko có thì nnao

- Một số ví dụ về ETL phổ biển

As organizations progressively rely on big data utilizes data lake as an efficient storage method, a structured data integration process known as ETL (Extract, Transform, Load) has become essential.

### 4. Purpose: ULake hiện tại thiếu ETL cho landsat =>> Objective

## II/ Objectives

- Xây dựng 1 microservice cho data ingestion ingest dùng ETL process =>> Sẽ giúp ích cho các ứng dụng phân tích và giúp quá trình thu thập dữ liệu cho các machine learning model thuận tiện hơn

# MATERIALS AND METHODS

## I/ Tools

### 1. Quarkus framework

- Là gì

- Why: phục vụ tốt khi làm việc với dữ liệu và tương thích với data lake hiện tại

- Cụ thể ở project: include extension, code style (reactive programming) and structure (folder structure)

### 2. Postgresql (persistence layer)

- Là gì

- Why: giúp việc lưu trữ dễ dàng

- How: Nếu ko có thì so sánh với usual mysql

#### a) Use-case diagram (ETL pipeline, microservice architecture, data flow)

#### b) Sequence diagrams

### 3. gdal\_translate

- Là gì

- Tại sao cần: cho bước Transform

- Nếu ko có thì nnao

## II/ Dataset

### 1. Mô tả dữ liệu vệ tinh

- Landsat/Sentinel/Ảnh vệ tinh nói chung là gì?

- Tại sao cần?

- Nếu ko có thì nnao?

### 2. Mô tả nguồn dữ liệu mình dùng

#### a) Copernicus là gì? Bao gồm cả Landsat/Sentinel

#### b) Tại sao cần: mục đích cụ thể của các vệ tinh từ Copernicus

- Trong project dùng landsat hay sentinel, vệ tinh gì, theo dõi dữ liệu của vùng nào, với mục đích gì

#### c) Nếu ko có thì sao?

#### d) Phương thức truy cập: Catalog/Process APIs

## III/ Methods

### 1. Microservice

- Là gì (cụ thể ở đây là package usth.m1: Reactive microservice)

- Tai sao lại cần microservice

- Nếu ko có thì phải dùng cgi thay thế? Bất tiện hơn nnao

### 2. Data Lake

- Loại data lake mình dùng là gì: Ulake

- Mô tả figure của data lake (mail thầy gửi)

- Chỉ ra microservice của mình nằm ở chỗ nào

### 3. ETL microservice flow

- Mô tả luồng chung: pull => save locally => upload  User requirements và use case diagrams (UML)???

- Extract (pull process)

- Setup token cho mỗi lần request

- Dữ liệu extract: ảnh true-color, ảnh full band, (STAC) metadata

- Khi lưu local: ảnh theo folder, metadata vào postgresql + time info + directory info

- Sequence diagram?

- Transform (preprocess: downsize image)

- Problem: raw images can be very large => need a downsize technique to be able to upload

- Nếu ko có thì quy trình sẽ phức tạp hơn: lưu ảnh ở cloud và chỉ save link ở lake

- Sequence diagram?

- Load (upload to lake)

- Retrieve token cho mỗi lần call

- Dùng file/folder microservice (nhắc về bất lợi Ulake nên ko dùng đc Object)

- Thông tin lưu: ảnh kèm 1 số thông tin cơ bản (nhắc về bất lợi Ulake nên ko upload đc metadata)

- Sequence diagram?

# RESULT AND DISCUSSIONS

### 1. Result

- Hoạt động nnao?

- Extract đc loại dữ liệu gì

- Dữ liệu preprocess thành công ko? Kết quả đầu ra preprocess nnao?

- Upload dữ liệu vào datalake đc ko? Du lieu gi?

### 2. Discussion

Magento is a complex framework due to its dense design patterns and programming techniques. If considering only the functions of this project, it may seem simple and minor. However, to finish the module without being familiar with Magento is impossible. Actually, according to the timeline, two thirds of the internship is spent to understand just the most fundamental parts of the platform. Therefore, as a whole, this project is not straightforward at all. Even when I was able to implement all use cases, there are still some bugs that I could not manage to fix including failure to deal with complex products and to show correct price form in the search area. I did not have enough time to remove those flaws, but I was suggested to improve the controller for the former and to develop a new data binding for the latter in the future.

# CONCLUSION

- Overview: Paraphrase lại intro

- Future works

- Tạo log để theo dõi quá trình ETL

- Tạo cronjob chạy hàng ngày cho ETL để theo dõi 1 vài khu vực nhất định phục vụ nghiên cứu

- Thêm các bước preprocess để đảm bảo dữ liệu sạch: deduplication, avoid các ảnh trống (thường các ảnh này sẽ chỉ toàn màu đen. Dẫn chứng 1 ảnh).

# REFERENCES

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[2] <https://journalofbigdata.springeropen.com/articles/10.1186/s40537-022-00659-3>

[3] <https://www.sciencedirect.com/science/article/pii/S0306437924001182>

- Tầm 15 mục, chủ yếu sẽ nằm ở intro