BIG DATA PIPELINE INFRASTRUCTURE DESIGN IN MSME E-COMMERCE SYSTEMS WITH A FOCUS ON DATA SOURCE PROCESSING USING ORCHESTRATION TOOLS

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Abstract

In the digital era, Micro, Small and Medium Enterprises (MSMEs) need to utilize data to improve their business performance, such as increasing customer targets, product development and pricing strategies. Apache Airflow is a powerful tool for building data scraping pipelines that are scalable, flexible, and easy to monitor. One of them is the Central Java MSME data scraping pipeline, which collects business registration information, business type, location, contacts, products, and financial information from various websites, including the Central Java Provincial Government website, basic goods price comparison tables, and specialized news sites. The captured data is stored in a data warehouse for further analysis by the Central Java Souvenir entrepreneurs association (ASPOO) in the region. Apache Airflow is used to manage the scraping pipeline in the Central Java MSME E-Commerce system and ensure it runs smoothly. Apache Airflow also has a built-in dashboard for monitoring pipelines and troubleshooting issues. Overall, scraping pipeline in the Central Java MSME e-commerce system is a valuable tool for collecting and analyzing data on the MSME sector in Central Java. This pipeline is scalable, flexible and easy to use, and can be adapted to different user needs and can be integrated with various systems.

Keywords: Big Data Pipeline, Data Scraping, Pipeline, Apache Airflow, MSMEs

1. Introduction

Micro, Small and Medium Enterprises (MSMEs) are considered the backbone of the national economy because they are crucial in economic development and job creation [1]. In this rapidly developing digital era, the use of technology is also increasingly relevant to MSME business processes, especially in aspects of the e-commerce system.

One of the key elements in running an e-commerce business is data collection and analysis, which often involves large amounts of data or Big Data. Big Data is described as very large amounts of data (both structured and unstructured) that require sophisticated database management systems to capture, store, manage and analyze that data [2]. The importance of Big Data storage technology in supply chain integration which can influence...
SCP (Supply Chain Performance) which leads to sustainable business performance (i.e. environmental, social and economic) [3]. However, storing and managing Big Data is not a simple task. This is where the Big Data Pipeline concept becomes relevant. Big Data Pipeline is a series of steps and tools used to collect, transform and input data from various sources into a system that can be accessed and processed [4]. In the scope of performance on the MSME e-commerce platform, Big Data Pipeline plays a role in overcoming obstacles in organizing large data, converting it into a more structured format, and storing it in an appropriate system [5]. So that it can make more targeted decisions and based on accurate data analysis.

Web scraping is one way to optimize information utilization using the Big Data Pipeline. This strategy can be used to provide information to help make strategic decisions [6]. Web scraping is used because it provides daily information about Indonesia's economic activities, such as business and UMKM statistics, and price data for local goods, providing national price data every day. This program uses two websites to gather external data that can be integrated into the UMKM e-commerce system. Run in an orchestration tools environment so that the scraping program runs on an automated schedule, Selenium is used for browser optimization and dynamic web interaction, specifically BeautifulSoup, which parses and extracts HTML data, enabling efficient and accurate information extraction using Big Data Pipeline [7],[8].

Overall, the scope of this research is to examine the use of the Data Pipelining method in a Big Data environment by using orchestration tools combined with a scraping program to form a Big Data Pipeline concept which is useful for better data processing from various data sources. In an effort to build a data requirements flow system in the MSME e-commerce system, the stages of collecting, storing and analyzing Big Data play an important role. Using the Big Data Pipeline, MSMEs have started to explore different ways to utilize raw data [2]. This can help MSMEs to remain competitive in a business world that continues to transform into a more digital realm. In this way, this research is focused on developing a big data processing architecture based on a big data pipeline for the automated process of streaming data into database storage in the case of MSMEs to facilitate data collecting and data retrieving for MSMEs in a flexible manner that is adjusted to system needs.

2. Related Work

The new approach to big data processing requires a thorough analysis of the current research context and existing literature to identify key trends and issues. Previous studies have attempted various methods, but still face shortcomings and unresolved issues.

Many studies on orchestration and web scraping tools have been conducted. Orchestration tools can be integrated with various data processing programs to meet data needs, including cloud services in research [4]. Where an analysis process was carried out to check the capabilities of Apache Airflow to create data pipeline workflow management for DataCloud projects. Next, on big data processing services in research [9]. Apache Airflow is able to overcome the complexity of big data processing using the ETL (Extract, Transform, Load) method combined with the Apache Hadoop program to move data and convert from XML to Parquet, and PostgreSQL as a database for data transformation in testing using the KPIs dataset (Key Performance Indicators) in railway companies. Lastly, in research [10], when carrying out web scraping using UI Path Studio, limitations were also found in the research, one of which was that manual scraping was prone to errors and time consuming.

One of the gaps identified is the lack of a dynamic and adaptive approach that can be adapted to system needs in collecting data from the web. Several studies have attempted to address this issue, but there is still room for further development. Therefore, this research proposes an approach that can not only handle data collection automatically but also provides high reliability and scalability for integration in various systems.

In order to overcome the gaps that have been identified, this proposed method is designed by integrating the latest technologies in Big Data processing and scraping pipelines. The proposed method is based on a deep understanding of the main challenges faced by current pipeline scraping methods, the results of which can be integrated with the latest technologies such as machine learning to increase adaptability.

2.1. Research Method

This research was conducted in the ETL (Extract, Transform, Load) method using Apache Airflow. Testing the ETL method is an important and vital phase during data warehouse testing, because this phase affects the quality of the data [11]. Starting from creating a batch processing system with the need to collect external data from services, or from APIs and databases. However, this research will focus on retrieving data with the web scraping method that runs on Apache Airflow. Web scraping is the process of pulling data from website pages to collect information from web pages and store it in a format that is easier to use for further analysis [12]. Then the data will be forwarded to the data warehouse so that the data can be output in the form of .csv files so that it can be used in the Machine Learning and MLOps processes. The complete scraping steps in this research are shown in Figure 1.
2.2. Creation of big data pipeline infrastructure

Big Data Pipeline refers to a series of processes that collect, store, process and analyze data on a large scale (Big Data) to support decision making and other applications [13]. This pipeline will process data from various and diverse sources and present it in an easy-to-understand way for efficient decision making in supporting the sustainability of the system for collecting and analyzing structured and unstructured data through analytical dashboards and machine learning programs.

![Big Data Pipeline Proposed Approach](image1.png)

Figure 1. Big Data Pipeline Proposed Approach

2.3. Creating a scraping pipeline program to complete external data

This scraping programme serves to retrieve data from the website of the Market Monitoring System and Basic Needs of the Ministry of Trade of the Republic of Indonesia (https://sp2kp.kemendag.go.id), in Figure 1 is simulated as Scraping A and Business news portal website (https://bisnis.com/) as Scraping B, automatically. Apache Airflow is an open-source workflow management orchestration tool used to organise and monitor data workflows using a built-in web interface [14]. At this stage, the system is created to optimize the performance of the scraping program so that it carries out scheduled program execution automatically using Apache Airflow.

![Scraping Pipeline Proposed Approach](image2.png)

Figure 2. Scraping Pipeline Proposed Approach

When the scraping pipeline is operated, Scraping A and Scraping B will run a program to read website elements from page A and Page B. Selenium is a tool used to carry out testing on web-based applications [15]. Using a combination of Selenium and BeautifulSoup libraries is the best approach because it can process program execution faster [16]. The creation of a scraping pipeline is not just about creating a smooth flow of data extraction, but also opens up opportunities to gain deep insights from the acquired data. The differences in each function of the scraping tools used in this research can be seen in Table 1.

<table>
<thead>
<tr>
<th>Factors</th>
<th>BeautifulSoup</th>
<th>Selenium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensibility</td>
<td>Suitable for low-level complex projects</td>
<td>Best for projects dealing with Core JavaScript</td>
</tr>
<tr>
<td>Performance</td>
<td>Pretty slow compared to other libraries while performing a certain task</td>
<td>Can handle up to some level</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>It has a lot of dependencies on the ecosystem</td>
<td>It has a good ecosystem for the development</td>
</tr>
</tbody>
</table>

![Dockerfile Configuration](image3.png)

Figure 3. Dockerfile Configuration

![Docker Compose Configuration](image4.png)

Figure 4. File docker-compose.yml Configuration

2.4. Docker Compose and Dockerfile Configuration

Docker is an open-source platform that allows developers to package applications and their dependencies into containers that can run anywhere [18]. In order for Apache Airflow and the tools in this research to run on top of the Docker environment for data extraction tasks, it is necessary to configure Docker Compose and Dockerfile. All configurations are made including the environment, service, network, library and volume settings needed, created with Dockerfile in Figure 3 and Docker Compose in Figure 4.
2.5. Creation of a DAG file

Directed Acyclic Graph (DAG) describes the relationship between tasks and defines the order in which they are performed [19]. DAG files are operated from a Python script placed in the specified directory. In addition, the graph is also acyclic, meaning that there are no cycles or tasks that result in the running task returning to the previous task. The Scraping A and Scraping B pipelines in Figure 2 will be imported and assembled into a DAG file that will be run using Apache Airflow according to the schedule declared in Figure 5 in the schedule_interval='@daily' code section. This means that the scraping pipeline program will run automatically every day, and 'retries_delay': timedelta(minutes=5) is also added to give a pause for retrying if there is an interruption in program execution. After building the schedule, the next step is to assemble the scraping A and scraping B programs so that they become a task pipeline that runs according to the dependencies between tasks as in Figure 6. Thus, Apache Airflow and the concept of DAG preparation are an important foundation in managing complex workflows and ensuring the successful implementation of the tasks contained in them. Figure 7 and Figure 8 contain the respective scraping programmes that will be called upon to function in the DAG programme to execute the scraping pipeline proposed approach.

Figure 5. DAG File Composition

Figure 6. Main Function DAG File

Figure 7. Scraping A for Market Monitoring System

Figure 8. Scraping B for News Scraping for Specific Topics

3. Result and Discussion

From creating docker image components, scraping programs, to being assembled into a DAGs scraping pipeline. This research succeeded in collecting data in a structured format and can be analyzed. Scraping programmes capture web page content and store the data in a customised format or on a specialised database [20].

3.1. Scraping Result

Overall, the price comparison table data of basic necessities extracted on the website https://sp2kp.kemendag.go.id/ totalling 5 columns and 16 rows, while on the website https://bisnis.com/ consists of 5 columns and numbers from tens to hundreds of rows of data, following the availability of data from the website.
By using scraping pipeline program, we can extract the entire target table like the results in Table 2, while for news it is also successful in extracting data with the topic “MSMEs” or can be added or even replaced with other topics as needed, such as keywords that have been declared in the DAG program. Apart from that, here we can also limit the amount of news that will be extracted from the keywords entered on the website. So the news scraping results appear as in Table 3.

Table 2. Sample dataset scraping comparison table of prices of basic necessities

<table>
<thead>
<tr>
<th>Commodities</th>
<th>Unit</th>
<th>Price Yesterday (26-09-2023)</th>
<th>Price Today (27-09-2023)</th>
<th>Fluctuating Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium Rice</td>
<td>Kg</td>
<td>13.300</td>
<td>13.300</td>
<td>0</td>
</tr>
<tr>
<td>Premium Rice</td>
<td>Kg</td>
<td>15.000</td>
<td>15.000</td>
<td>0</td>
</tr>
<tr>
<td>Sugar</td>
<td>Kg</td>
<td>15.200</td>
<td>15.200</td>
<td>0</td>
</tr>
<tr>
<td>Premium Packaged</td>
<td>Lt</td>
<td>20.700</td>
<td>20.700</td>
<td>0</td>
</tr>
<tr>
<td>Cooking Oil</td>
<td>Lt</td>
<td>14.500</td>
<td>14.500</td>
<td>0</td>
</tr>
<tr>
<td>Bulk Cooking Oil</td>
<td>Lt</td>
<td>15.100</td>
<td>15.100</td>
<td>0</td>
</tr>
<tr>
<td>&quot;MINYAKITA&quot;</td>
<td>Lt</td>
<td>137.400</td>
<td>137.400</td>
<td>0</td>
</tr>
<tr>
<td>Cooking Oil Beef</td>
<td>Kg</td>
<td>35.800</td>
<td>35.800</td>
<td>0</td>
</tr>
<tr>
<td>Hamstrings Purebred</td>
<td>Kg</td>
<td>30.000</td>
<td>29.900</td>
<td>-0.33</td>
</tr>
<tr>
<td>Chicken Meat Purebred</td>
<td>Kg</td>
<td>13.300</td>
<td>13.300</td>
<td>0</td>
</tr>
<tr>
<td>Chicken Eggs Flour</td>
<td>Kg</td>
<td>15.100</td>
<td>15.100</td>
<td>0</td>
</tr>
<tr>
<td>Import Soybeans</td>
<td>Kg</td>
<td>40.700</td>
<td>41.400</td>
<td>1.72</td>
</tr>
<tr>
<td>Curly Red Chilies</td>
<td>Kg</td>
<td>40.400</td>
<td>41.300</td>
<td>2.23</td>
</tr>
<tr>
<td>Red Cayenne Pepper</td>
<td>Kg</td>
<td>40.100</td>
<td>40.100</td>
<td>0</td>
</tr>
<tr>
<td>Large Red Chili</td>
<td>Kg</td>
<td>25.000</td>
<td>25.200</td>
<td>0.8</td>
</tr>
<tr>
<td>Red Onion</td>
<td>Kg</td>
<td>37.500</td>
<td>37.400</td>
<td>-0.27</td>
</tr>
</tbody>
</table>

Table 3. Sample news website scraping dataset

<table>
<thead>
<tr>
<th>Title</th>
<th>Link</th>
<th>Tag</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinating Minister for SMEs is happy that Persib is collaborating with 2 local fashion brands to develop together</td>
<td><a href="https://bandung.bisnis.com/om/read/2023-09-26-1711267400/mengkompaskan-persib-sungai-singa-candang-2-jenama-fesyen-lokal-berkembar-bersama">https://bandung.bisnis.com/om/read/2023-09-26-1711267400/mengkompaskan-persib-sungai-singa-candang-2-jenama-fesyen-lokal-berkembar-bersama</a></td>
<td>West Java News</td>
<td>September 26 2023</td>
<td>Minister of Cooperatives and Small and Medium Enterprises Teten Masduki welcomed and supported the collaborational program initiated by Persib with MSME players.</td>
</tr>
<tr>
<td>MSME Association TikTok Shop is used more by influencers</td>
<td><a href="https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara">https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara</a></td>
<td>MSME</td>
<td>26 September 2023</td>
<td>The MSME Association believes that TikTok Shop is more widely used by artists and influencers.</td>
</tr>
<tr>
<td>Social Commerce Regulations Are Said to Make MSMEs Breathe More Easily</td>
<td><a href="https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara">https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara</a></td>
<td>Trade</td>
<td>26 September 2023</td>
<td>It is believed that the regulations that separate social media and e-commerce will allow MSMEs to breathe more easily.</td>
</tr>
<tr>
<td>TikTok Prohibited from Selling MSME Association: Look for Other E-Commerce</td>
<td><a href="https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara">https://ekonomi.bisnis.com/om/read/2023-09-26-1711267400/mobingkopi-tiktok-tenggara</a></td>
<td>Trade</td>
<td>26 September 2023</td>
<td>The Indonesian MSME Association assesses that the government’s policy of prohibiting TikTok sales is correct.</td>
</tr>
</tbody>
</table>

3.2. Apache Airflow Monitoring Interface

This interface allows users to monitor the performance of each DAG and the status of Apache Airflow. More powerful than traditional WMS (Workflow Management System) cron-based implementations, Airflow scheduler allows multiple tasks to run at specific times or intervals, while monitoring them [21]. Figure 9 below is a display of the dashboard in the DAGs scraping pipeline program which contains detailed information on the pipeline design being built to help users in comprehending the program’s...
operations and identifying potential issues during the pipeline program.

Figure 9. DAGs Dashboard Monitoring Interface

3.3. Measuring the Scraping Result

To ensure that the program that has been created is running properly, the program implementation process can be monitored using the Audit Log feature, or if you want to know in more detail the process of each program. In the bar on the left, there is a series of tasks, each box representing a program/operator written in the DAGs in red in Figure 9 and Figure 10.

Figure 10. Audit Log for DAGs Features

If the scraping pipeline program runs successfully, the bar on each task will show green. If it fails, you can check the color on the bar with the following details:

1) Deferred (violet): The task in this program is postponed and has not been scheduled for execution.
2) Failed (red): The task being executed experienced an error or failure.
3) Queued (dark grey): The task has been scheduled for execution and is being processed.
4) Removed (light gray): The task is removed from the queue and is not executed.
5) Restarting (purple): The task is in the process of re-executing.
6) Running (light green): The task is currently executing.
7) Scheduled (brown): The task has been scheduled for execution and is waiting for the specified execution time.
8) Shutdown (dark blue): The task was stopped manually or for some reason.
9) Skipped (pink): Task is skipped during the execution process.
10) Success (dark green): Task completed successfully without errors.
11) Up For Reschedule (aqua): Tasks can be rescheduled for execution.
12) Up For Retry (yellow): Task can be re-executed after experiencing a previous failure.
13) Upstream Failed (orange): The task cannot be executed because one or more previous tasks failed.
14) No_Status (empty): Task has no clear status or cannot be determined.

Apart from that, we can also check the logs of failed tasks to find out further error details. So, if the program in a series of pipelines runs successfully, it will produce data like the sample scraping results from each data source shown in Table 2 Sample dataset scraping comparison table of prices of basic necessities and Table 3 Sample news website scraping dataset. This is different from conventional scraping programs. We cannot monitor the running program process, cannot find details of where the error is in the program, and require manual steps to run it, even though it is assisted by a cron job, it still does not have the features mentioned previously. By building a data scraping program that runs on Apache Airflow, we can combine various existing data sources to build a dataset that runs automatically every day.

4. Conclusion

One of the important findings in this research is to develop a Big Data Pipeline in the data extraction process from various data sources using a combination of Selenium and BeautifulSoup algorithms that complement each other for the data needs in this research. Especially in the scraping process so that the data obtained can later be used for analysis and machine learning process needs so that later the collection of data sources that are run in the pipeline can be processed to produce insights that can help MSMEs in making decisions about their business processes. On this occasion, Apache Airflow, an Orchestration Tool that functions as a WMS (Workflow Management System), is able to create data pipelines using the ETL method in a Big Data Pipeline environment.

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