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Development of Big Data Analytics Technology on Sea Freight Operational Performance Using the Agile Model

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Abstract

The development of industry 4.0 is still difficult for a country to produce all goods according to the required needs. Big data analytics technology has the potential to revolutionize how logistics companies, including freight forwarders, can facilitate real-time monitoring in the supply chain by increasing flexibility. Management information systems produce a number of data from different sources and in different formats according to business needs. The development of big data analytics uses a dynamic system development method or model (DSDM), which is a dynamic system development model that uses a rapid application development (RAD) approach. Software development with an emphasis on collaboration, customer engagement, and continuous delivery of working software. This model is very suitable for the development of big data analytics technology that can provide solutions that often involve complex and rapidly changing requirements with large amounts of data and the business need to provide feedback from stakeholders in real-time. It is hoped that the final results of this research will provide insight into sea freight operations that are more informative and efficient for the logistics industry in Indonesia.

Keywords: Sea Freight Operations, Big Data Analytics, Agile, DSDM

Introduction

Nowadays, developments are increasingly modern with technology created by information technology companies. The problems faced are still difficult for a country to produce all goods according to the required needs. Operational management is a series of activities that produce value in the form of goods or services by converting input into output (Najib et al., 2019). Sea freight operations are activities carried out in sending goods by sea.

All sea freight operational data is obtained from the internal system which will be processed automatically (Gruchmann et al., 2020). Freight forwarder companies can consider various analytics methods to improve the quality of data sets (Perera & Mo, 2017). Companies and organizations involved in shipping need adequate information and high flexibility so that they can know daily fluctuations in freight rates and trading conditions (Plomaritou & Jeropoulos, 2022). Along with concerns about human safety and safe management operations in the environment, it can be demonstrated from the results of service efficiency and technology applications (Gavalas et al., 2022).

To support these activities, exporters and importers usually use freight forwarder services to manage the export or import activities of their goods. Freight forwarder companies are tasked with providing consulting services, coordinating during the shipping process, reducing costs, saving time, providing comfortable transportation and improving product competitiveness (Hsu et al., 2022). Freight forwarder companies can act on behalf of the sender (exporter) or act on behalf of the sender (importer) or act on behalf of the sender and recipient depending on the scope of work that has been stated in the work contract agreed between the two parties (Dewi et al., 2021). Because this process requires knowledge of customs procedures, many export and import companies hand over this task to freight forwarders (Pajić et al., 2022).

With the development of industry 4.0 which includes AI technology, big data, CPS, Internet of Things (IoT), Cloud Computing, Industrial Information Integration and blockchain technology (Hayat et al., 2023). If a Big Data system only supports one type of data storage, the system will not be able to meet the needs of different users for data processing (Han & Yang, 2020). Big data analytics (BDA) can provide unexpected insights and benefits in overall decision making in various sectors including scientific, technical and humanitarian competency levels (Abuqabita et al., 2019). BDA can facilitate real-time monitoring in supply chains that can increase speed and flexibility by describing the process of collecting, storing, processing and analyzing large and complex data sets to extract valuable insights and make informed decisions (Tiwari et al., 2018).

The characteristics of big data consist of the first the data volume continues to grow exponentially with the amount of digital data produced from IDC as Datasphere will grow from 33 ZB in 2018 to 175 ZB in 2025.

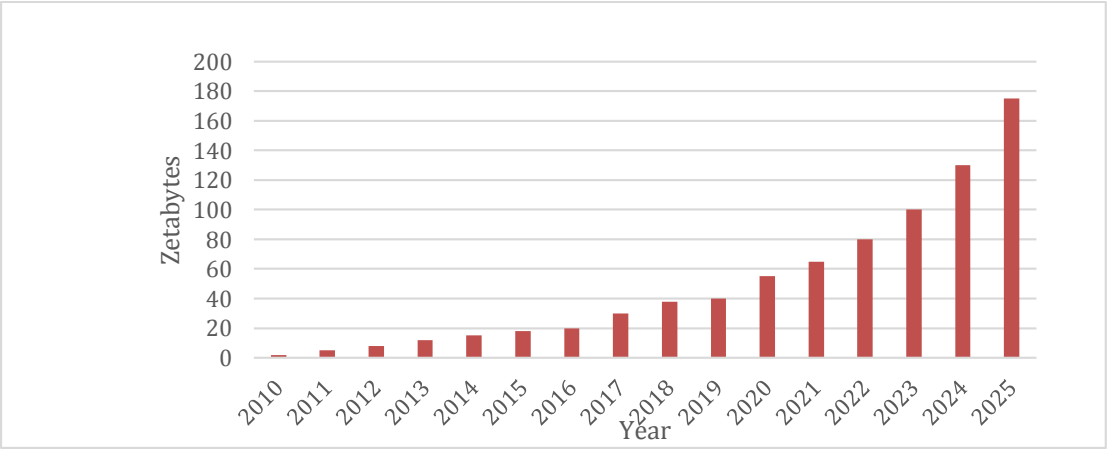


Fig.1. *Digital data growth between 2010 and 2025 in exabytes*

The second characteristic is that variations in unstructured data will require slightly different algorithms, such as text, image, sound and video data. The third speed characteristic is data that can be accessed at a very fast speed so that it can be used directly in real time. The fourth characteristic has vulnerabilities in terms of accuracy and validity so it requires depth in analyzing big data in order to produce the right decisions. The fifth characteristic is veracity which refers to how accurate and trustworthy the data is. The last characteristic has a very high value if it is processed in an appropriate way or it can also be said how valuable or meaningful the data (Bani, 2021). BDA technology can identify efficient structures for maritime transport operations and data sets that can be used to improve business processes, encourage innovation, and gain competitive advantage (Perera, 2017).

Literatur Review

The use of big data analytics in sea freight has the potential to revolutionize how the freight forwarding industry can operate efficiently. From the initial interview by Mr. Nurkholis as Operations Manager at PT Solid Logistics, he explained that there were several obstacles in operational performance in sea freight, including data management. Applied academics and professionals must have analytical skills and business understanding in management. This can be achieved by analyzing large amounts of data for making decisions that affect company performance (Daeng Bani et al., 2018). BDA also faces various challenges that make it different from, among others, having a massive number of data points (big data volume, high dimensions), the presence of complex data (high data variations with different classes and types), and the presence of high uncertainty (Jović et al., 2019). This variety of formats presents challenges in data storage because one type of database may not be optimal for storing and managing all types of data (Shoman et al., 2023). The agile model approach is software development that provides customer satisfaction through functionality that is developed quickly and demonstrated that can be implemented (Dharmapal & Sikamani, 2016). Problems can arise in several forms, including lack of resources, inefficient labor and poor work environments (Tripathi et al., 2021). The Agile model is a conceptual framework for software engineering that starts with the initial planning phase and then progresses to the deployment phase with iterative and incremental interactions during the project life cycle (Al-Saqqa et al., 2020). Agile models can encourage the development and delivery of software that functions with high quality (Ogala & Mughele, 2022). In the agile model, requirements in system development are broken down into small parts which can later be developed in stages, and which will be developed iteratively (Ramadhan et al., 2023). There are different frameworks under the agile development life cycle such as, scrum, feature driven development (FDD), extreme programming (XP), and dynamic system development method or model (DSDM) (Ghanghro et al., 2021). DSDM is the opposite of traditional methods where the list of functionality required in the system is determined first and then time and resources are allocated. This method is an iterative and incremental approach that prioritizes user or customer involvement.

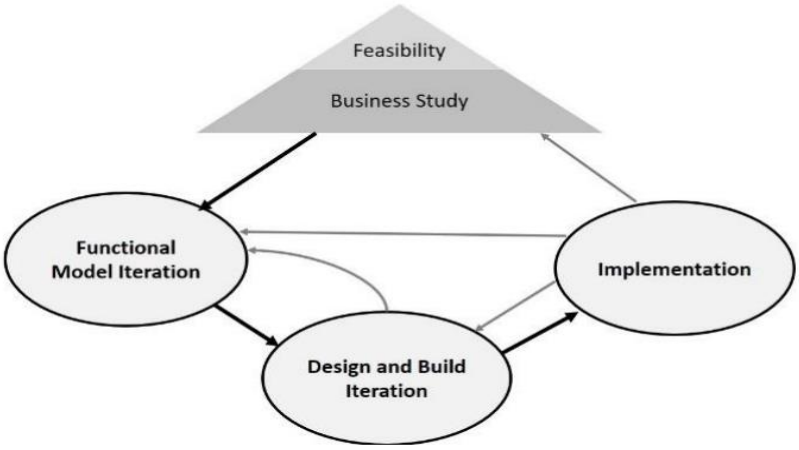


Fig.2. Dynamic System Development Method (Delima et al., 2018)

This model is especially suited to the development of big data analytics solutions that can deliver solutions, which often involve complex and rapidly changing requirements, large amounts of data, and the need to incorporate real-time stakeholder feedback on the freight forwarder company. Software development companies use Agile methods to develop their products or services efficiently and in a goal-oriented manner (Hinderks et al., 2022).

Research Method

2.1 Study Area

Several studies have carried out the development of big data analytics (BDA) for operations. Research has been carried out in developing BDA on Road Freight Transport (RFT) models which require the integration of different cargo modeling improvements, for example, traffic, demand and energy modeling so that they can provide useful information such as individual behavior and activity in addition to aggregate patterns using aggregates. conventional data (Shoman et al., 2023). In e-commerce companies, BDA is applied to distribute file systems and non-relational databases using Hadoop which is a distributed file storage system that can store large amounts of unstructured data and a parallel database system that can be compatible with all types of data (Shen, 2020). This is different from research which applies BDA in the maritime industry to provide information as Key Performance Indicators (KPI) from the interpretation of data analysis results which are better arranged in dashboards to improve decision making (Sarabia-Jacome et al., 2020). The research carried out also focuses on the maritime industry by developing BDA to collect datasets in the form of operational information on ship positions sent by various types of ships and collected through the Automatic Identification System (AIS) (Tritsarolis et al., 2022). Storage efficiency in the research carried out is identifying data collected from various sources, processed, stored and transferred to end users using the ETL/ELT process (Salisu & Khatwal, 2022).

2.2 *Dynamic System Development Method* (DSDM)

This research uses the Dynamic System Development Method (DSDM). There are 5

main stages in the process of developing big data analytics technology for sea freight operational performance, consisting of: The feasibility study stage is the first step in the DSDM method by identifying specific problems or challenges to be overcome in sea freight operational activities. This stage can involve issues such as increasing efficiency, reducing costs, or improving service quality. The forwarder company needs to consider the existing infrastructure and whether it needs upgrades or changes.

The business study stage involves analyzing business needs in sea freight operational activities in depth which includes identifying stakeholders, defining more specific business objectives, and determining metrics and Key Performance Indicators (KPI) that will be used to measure the success of BDA development. In conducting observations at PT. Solid Logistics is related to sea freight operational business processes which consist of sea export and sea import processes. Below shows the export business process.

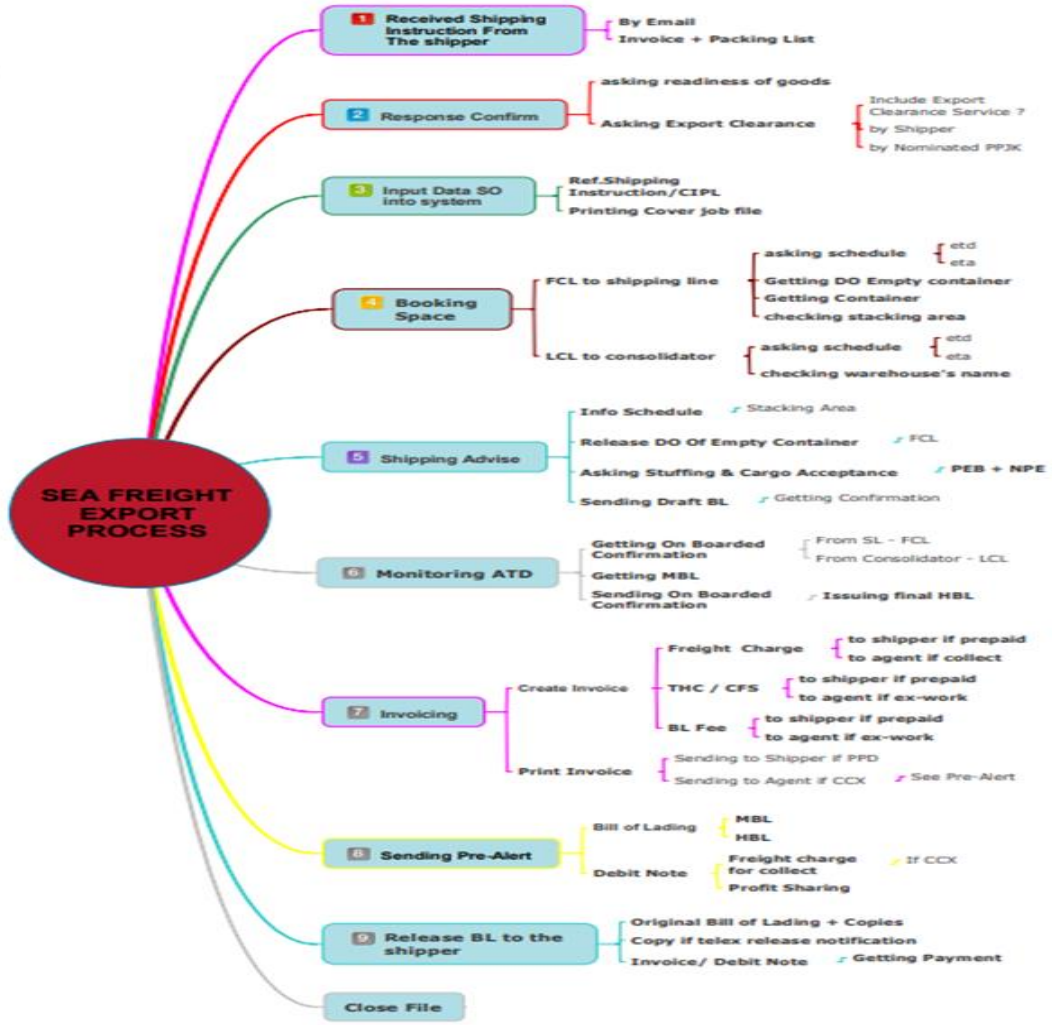


Fig.3. Sea Export Process

The export sea transportation process starts from receiving the booking from the exporter to the ship's departure from the country of origin. Sea freight import is a process begins with the selection of an overseas supplier or manufacturer. Negotiations are conducted to agree on prices, quality, order quantities, and shipping terms. Throughout the process, it's

essential to manage and maintain all necessary import documentation, including invoices, shipping documents, import permits, and other relevant paperwork to ensure compliance with regulations. After arriving at the port of destination, the goods go through customs clearance procedures with inspection, payment of import duties and import taxes, and fulfill import document requirements

The functional model iteration stage collects data from various sources, sea freight performance analysis, cost monitoring, risk management, and others. This stage includes selecting what data will be collected, how the data will be processed, the algorithms that will be used to analyze the data, and the displays and reports that will be produced. The data obtained from data sources in the form of operational data, financial data, marketing data and master data such as customer, company, vendor, country, port, customs office, currency and cost.

Design and development stages by understanding objectives, business needs and challenges to sea freight operational performance including key stakeholders, shipping agents and customers. This stage designs a suitable BDA architecture to address the identified business needs. During development, it is necessary to carry out functional testing, performance testing, and security testing continuously to ensure that the solution functions properly. Below is the big data architecture for a forwarder company.

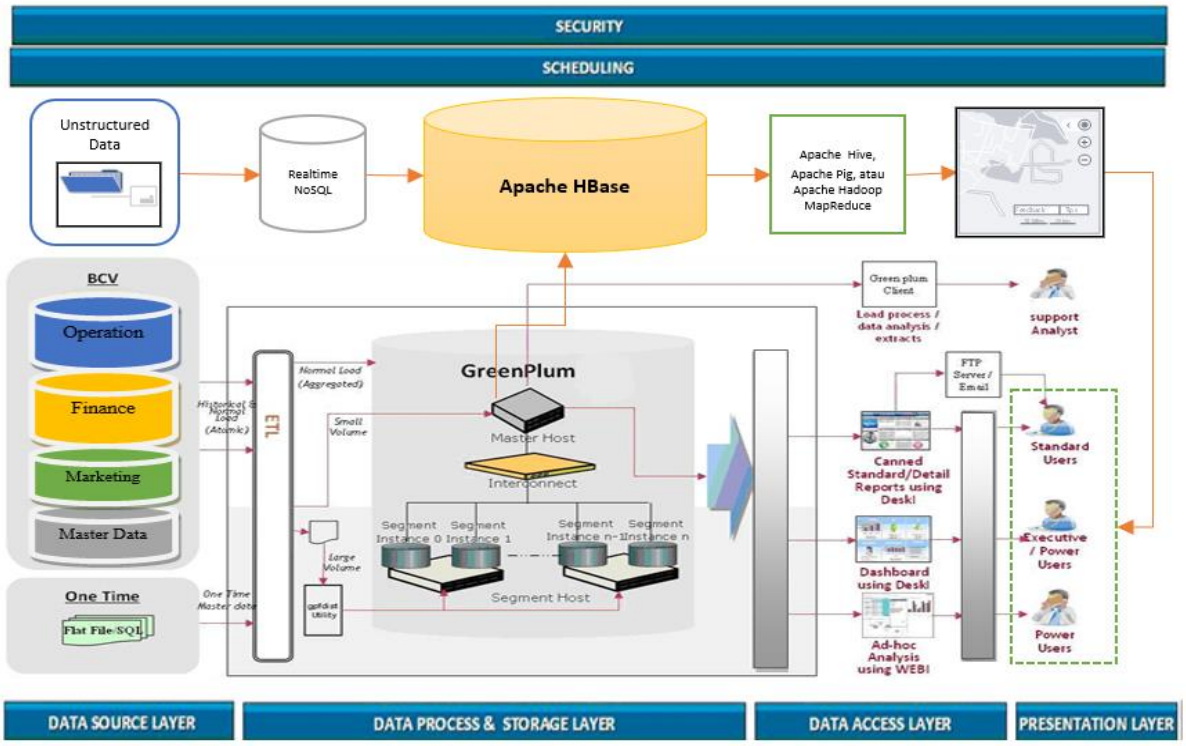


Fig.4. Big data architecture

This stage also designs an Entity Relationship Diagram (ERD) which will help with data structure. A visual representation that shows interconnected entities and attributes to meet business needs. Below is the ERD for operational processes in sea freight.

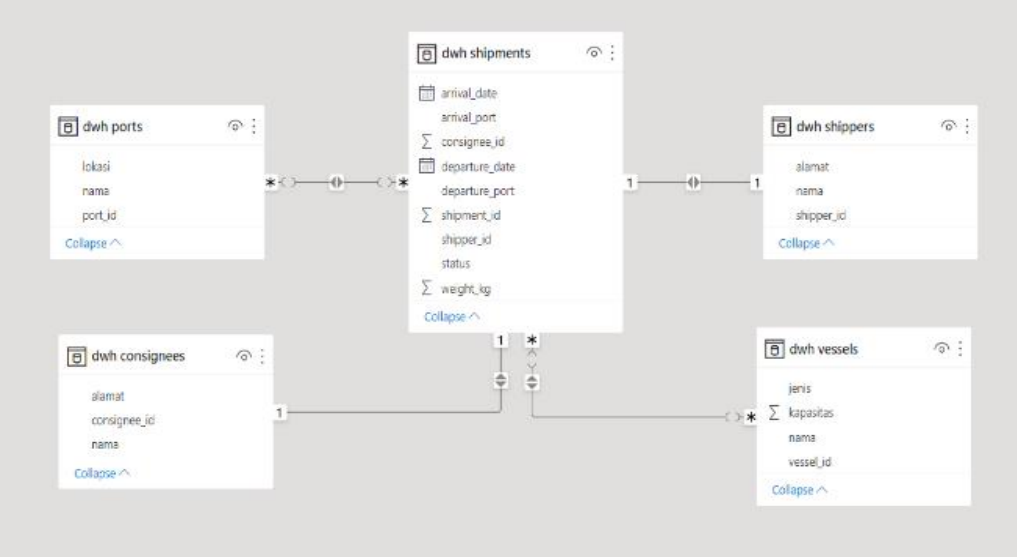
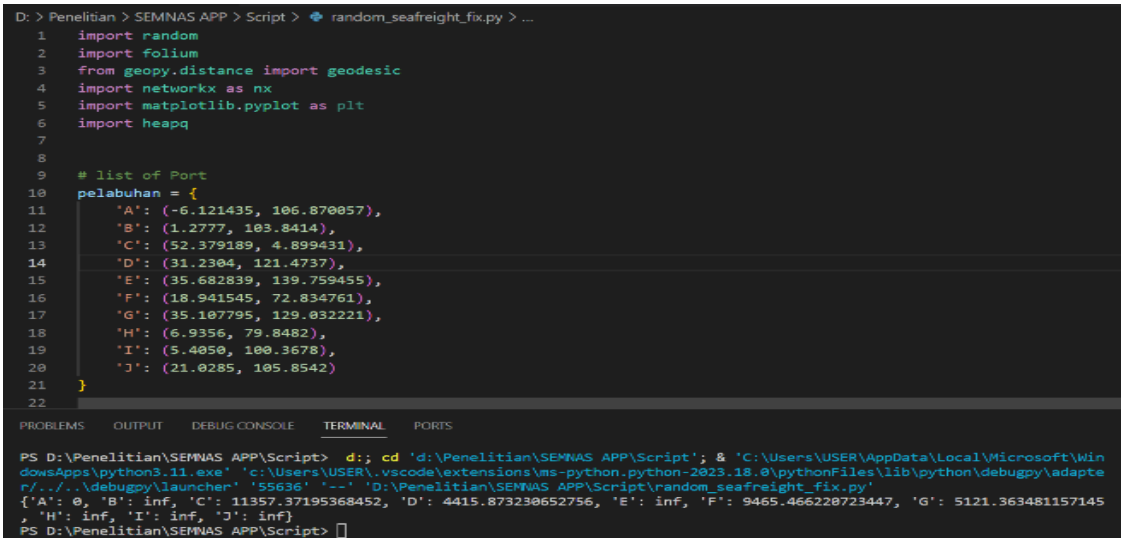


Fig.5. Entity Relationship Diagram

The implementation stages in the DSDM model are very important to ensure that the BDA system being developed can function properly well, meet business requirements, and provide added value to sea freight operations. Before implementation it can be ensured that the supervision and control system is adequate. Then carry out system testing before the software is implemented in a production environment, all software components and functions must undergo a series of strict tests. This testing includes functional testing, integration testing, stress testing, and security testing. The results of this test must meet the established business requirements. After the implementation stage, system performance optimization can be carried out which involves performance monitoring and continuous improvement to ensure that the system can run quickly and efficiently in dealing with large data volumes from sea freight operations.

Results and Discussion

The results of this research are optimization of operational processes for implementing Big Data Analytics in sea freight at forwarder companies which can monitor operational processes more efficiently. Below are the results of the Python script for map visualization.



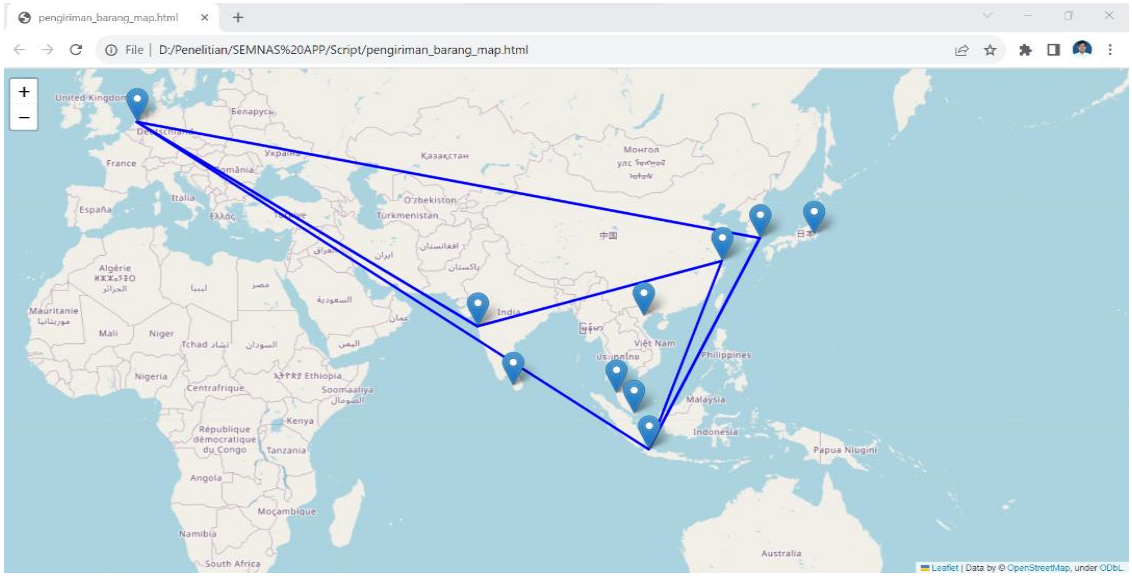


Fig.6. *Map visualization using Python*

Design and development in Big Data Analytics using SQL (Structured Query Language) and NoSQL (Not Only SQL) databases according to the business needs of the forwarder company.

By collecting and inserting data into the data processing pipeline that comes from various sources, such as databases, external APIs, log files, or other data streams. For SQL Database, it is structured data using a PostgreSQL database to store structured data that requires consistency and ease in searching for data such as operational data, financial data, marketing data and master data such as customer, company, vendor, country, port, customs office, currency and cost. Realtime NoSQL Database is semi-structured or unstructured data using HBase as a NoSQL database to store large volumes of data, both structured and semi-structured. Designing schemes for HBase tables using Pig scripts for data processing and ETL (Extract, Transform, Load) processes. Pig is well suited to working with large data sets and can cope with complex data transformation processes.

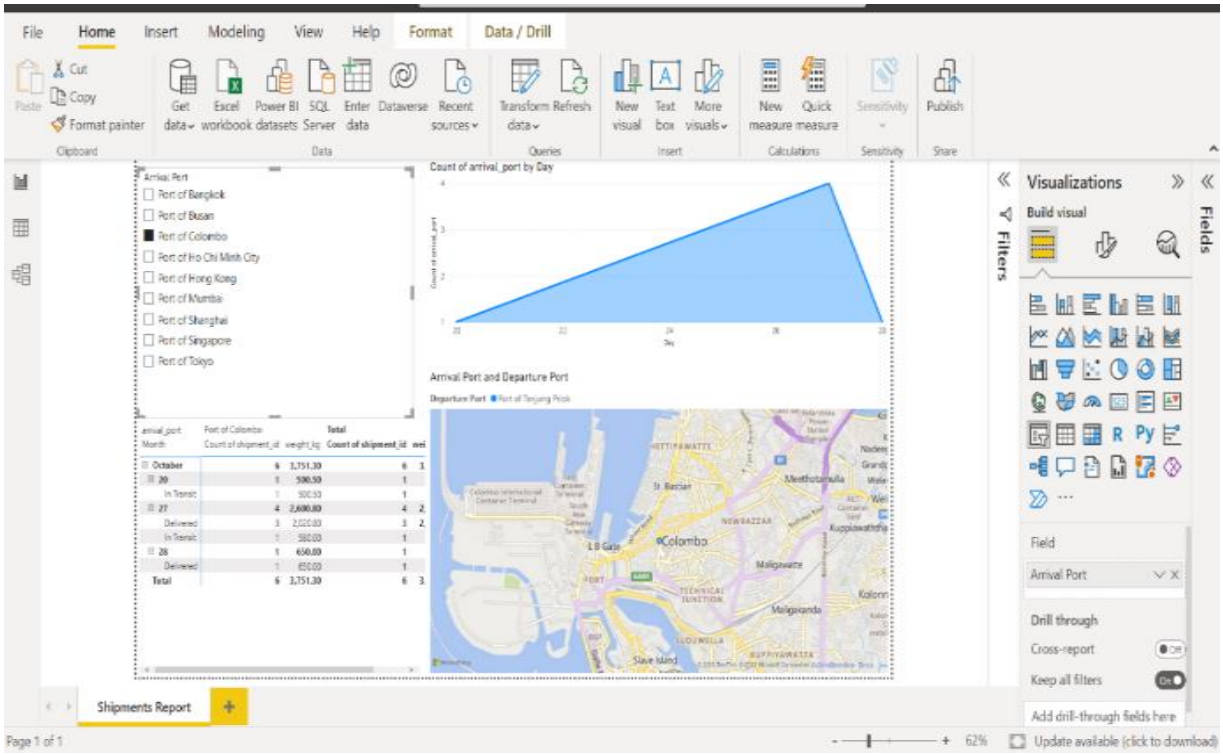


Fig.7. *Dashboard Shipment Report*

In presenting map visualizations of analysis results effectively which are generally used in Python such as Matplotlib, Seaborn, and Plotly. The process of creating visual representations of geospatial or geographic data to display geographic information, such as locations, regions, and other geographic patterns in the form of graphs or maps that are easy to understand. It is useful for spatial data analysis, mapping, planning, and presenting data with geographic context. Below is a map visualization design in Python for the shipments process. By combining the results of Python data analysis with the visualization capabilities of Power BI to create informative reports. Power BI can combine data from multiple sources, including big data, and be used to create visualizations that are interactive and easy to access for users. Below are the results of the Power BI visualization of the shipments process.

The testing stage must work together with stakeholders and the development team to understand the business processes well. The aim is to ensure that the requirements created by stakeholders are correct and well understood. Carry out testing in accordance with the test plan and design that has been created. Data Processing to ensure that data is being loaded into the big data storage or database without errors or data loss and verify that basic data transformations and processing are functioning correctly. Calculate the total number of shipments, average transit times, or any other critical data aggregations. Check for data integrity, ensuring that data is clean and valid. Data retrieval to execute sample queries or data retrieval requests to check if the system can provide real-time or near-real-time data for queries such as current shipment status, port congestion, or vessel locations. Data visualization to Verify that the system can generate basic visualizations and reports based on the big data, like charts, graphs, or maps. To ensure that these visualizations provide useful insights into sea freight operations. Check if the system can generate alerts or notifications for critical issues or anomalies in the sea freight data. For example, alerting when shipments are delayed or when

ports are congested. Test results will help the development team determine necessary improvements.

Table.1. Testing *Big Data Analytics*

Step	Description	Software/ Tools	Output	Remarks
1	*Data Collection*	*Apache Kafka, Apache NiFi, Oracle dan SQL Server*	Raw data in structured dan unstructured format	Success
2	*Data Storage*	*Apache HBase, Greenplum*	Data is stored in big data storage	Success
3	*ETL Processing*	*Apache Spark, Apache Flink, PySpark, IBM Datastage*	Data extraction process, data transformation and data loading	Success
4	*Data Analysis*	*Apache Hive, Apache Pig, Jupyter Notebook, PostgreSQL*	*Perfomance* data analysis	Success
5	*Data Presentation*	*Power BI, Matplotlib, dan Plotly*	Visualization dashboard results in trend report	Success

The implementation stages of big data analytics with the DSDM model are more adaptive to changing business needs and ensure the delivery of valuable results. This DSDM model provides a powerful structure for managing and analyzing big data in sea freight or maritime logistics. The training process is designed to prepare teams and stakeholders in the use of the tools and techniques necessary to be able to develop, analyze and communicate the results of big data analytics.

Conclusion

This research resulted in the development of big data technology on sea freight operational performance using the agile model which had a positive impact. The Agile approach provides flexibility, adaptability and rapid response to changing conditions, which is critical in the dynamic maritime transport industry. By collecting, processing and analyzing large volumes of data from multiple sources, forwarders can make informed decisions, optimize logistics, increase efficiency and improve overall performance in ocean freight operations. This research shows the potential of big data analytics and Agile models as important tools for improving the effectiveness of maritime transport management.

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