PREDICTIVE MONITORING SYSTEM FOR COAL DELIVERY VESSEL

Group 2 :
1. Angga Pratama Suryabrata (2506565654)
2. Rina Widyasti Habibah (2506566240)
3. Putri Nur Meilisa (2506566190)

Arsitektur Perangkat Lunak untuk Digital Enterprise 2025

OVERVIEW

01 Background and Project Objectives

02 Unified Modeling Language (UML)

03 Features & Deliverables

04 Timeline, PIC & Mockups

05 Reference

01 Background and Objectives

Company Context

PT Bahtera Adhiguna (BAg) is a subsidiary of PT PLN (Persero) managing coal & energy transport for PLN and its partners.

Key Challenge

Fuel accounts for up to 40% of BAg's operational cost across 16 vessels using mixed manual/digital systems.

Project Goal

Deploy an on-premise Fuel Monitoring System (FMS) for Zalecha Baruna & Kencana Baruna to enhance capacity, accuracy, and efficiency.

Objectives

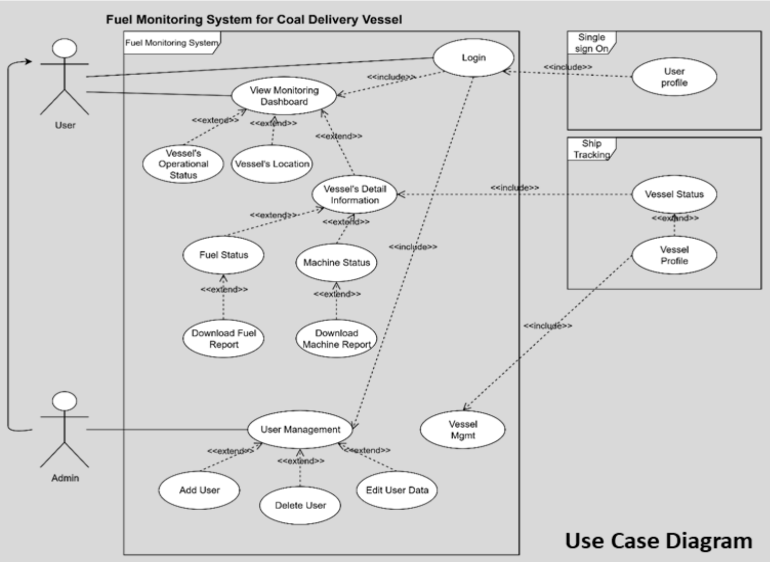
1. Automatic measurement of fuel inventory in each tank.
2. Automatic measurement of fuel consumption for Auxiliary and Main Engines.
3. Integration of manual readings into centralized FMS dashboard.
4. Predictive fuel consumption and Estimated Time of Arrival (ETA).

Scope: View-only roles (NOC, Fleet Manager, Auditor) • Focus on accuracy, efficiency, and on-prem operation.

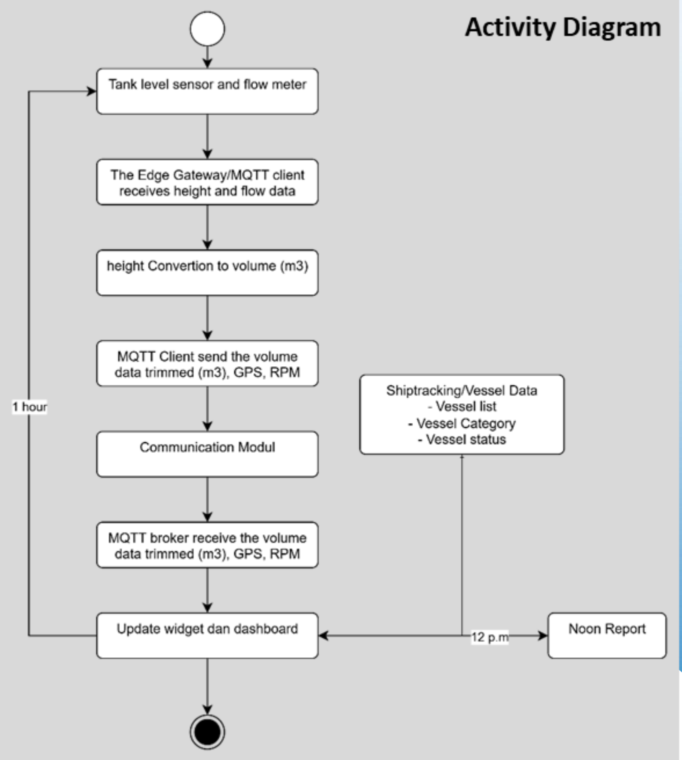
02 UNIFIED MODELING LANGUAGE (UML)

To achive the goal of this project, the primary objectives of this project are follows :

1. Design a real-time fuel monitoring system for bulk carrier by integrating flowmeter sensors, tank level gauges, and engine operational data.
2. Develop reliable MQTT-based communication framework (publisher, broker, subscriber) that enables efficient, lightweight, and secure data transmission between shipboard sensors, edge gateway, and monitoring dashboards.
3. Create visualization and analytics tools such as dashboards, trend charts, key performance indicators for real-time analysis and evaluation of fuel consumption and efficiency.
4. As a basis for operational decision making by providing accurate and real-time fuel usage information, identifying abnormal consumption patterns, and supporting trip optimization.
5. Ensure the fuel monitoring system can be used on other vessels, is integrated with cloud platforms, and is aligned with international standards on energy efficiency (e.g. IMO EEOI).
6. To develop data for Predictive fuel consumption and predictive time arrival



Use Case Diagram



Activity Diagram

03 FEATURES & DELIVERABLES (1/4)

Ship Configuration System

Connects the central system with real-time data from each vessel, including fuel sensors and tank capacity information. Ensures every vessel has a unique configuration for more accurate and consistent fuel measurement.

Central Application System

The main platform used by operators to monitor vessels.Displays ship status, location, fuel level, and consumption history in an interactive dashboard.

Designed to be user-friendly for NOC operators, fleet managers, and auditors.

Analytics & Visualization

Provides visual and analytical insights into fuel consumption patterns, vessel performance, and estimated speed and arrival time.

Equipped with port and route maps, and a dark mode interface for improved usability in control room environments.

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03 FEATURES & DELIVERABLES (2/4)

Must Have

- Auth & RBAC – Role-based read-only
- UI Frame – UI Kit
- Fleet Map & Status – Clustering, filters
- Vessel Dashboard – Tank cards
- Trends & History – 24h/7d charts
- Alert Center – View-only
- Export – CSV/PDF snapshot
- UI/Performance – Auto-refresh + loaders

Should Have

- Calibration Viewer – Curve overlay
- Geofence – Port/Route overlay
- Analytics Widgets – Top-N vessels
- Analytics – Speed Prediction (read-only)

Could Have

- Dark Mode / PWA (optional)

03 FEATURES & DELIVERABLES (3/4)

IoT Edge Gateway

Level Radar Sensor

Marine Inertial Measurement Unit

Edge Gateway Computing

Payload → Central System (Agreement)

TrimCalc – Calculate Volume by Ship Trim

VolCalc – Level Sensor → Volume Curve

AssetTank & AssetSensor – IDs & Info

03 FEATURES & DELIVERABLES (4/4)

Deliverables Summary

🧱 Design System

- Wireframes & Mockups
- Lightweight Design System

🧪 Testing

- UI & E2E Test Plan

📈 Data/Model

- View/Data Model
- Calibration Curve Overlay (viewer)

04 TIMELINE, PIC & MOCKUP (1/4)

Estimated Start Month: September 2025

Current Progress: ✅ Report Design (Sprint 5) — Analysis & Design Phase Completed

Business Modelling
Sprint 1–2

Define business case, scope, and baseline workflow.

Requirements & Design
Sprint 2–5

Document requirements and design prototypes.

Development
Sprint 5–9

Build central app modules: Fleet Map, Dashboard, Alerts, Reports.

Testing & Deployment
Sprint 9–10

UAT, data migration, and final go-live.

04 TIMELINE, PIC & MOCKUP (2/4)

Business & Requirements (Sprint 1–4) – ✅ Done

Analysis & Design (Sprint 4–5) – ✅ Done (Report Design completed)

Development (Sprint 6–9) – 🔄 Ongoing (UI Kit, Fleet Map, Dashboard)

Testing & Deployment (Sprint 9–10) – ⏳ Pending

Next Milestones:

- Start UI Kit & Fleet Map Development (Sprint 6)
- Begin API Integration setup
- Prepare UAT Environment (Sprint 9)
- Target Go-Live: **Februari 2026**

04 TIMELINE, PIC & MOCKUP (3a/4)

List Available Team			QTY
PM	:	Project Manager	1
BA	:	Business Analyst	1
FE	:	Front End Engineer	2
BE	:	Back End Engineer	2
QA	:	Quality Assurance	2
TW	:	Technical Writer	1
EBE	:	Embedded System Engineer	1

PM, FE, BE, QA, EBE : Angga P. S
FE, BE, QA, TW : Rina W.H
BA, QA, TW : Putri N.M

No	List	List Feature		PIC	Plan / Actual	Estimated Start Month : September 2025																			
						Sprint 1		Sprint 2		Sprint 3		Sprint 4		Sprint 5		Sprint 6		Sprint 7		Sprint 8		Sprint 9		Sprint 10	
						W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20
1	Business Modelling																								
		1.1	Business Modelling	PM, BA	P																				
					A																				
2	Requirements																								
		2.1	Feature Requirements	PM, BA, FE,BE, QA, TW	P																				
					A																				
		2.2	System Requirements	PM, BA, FE,BE, QA, TW	P																				
					A																				
3	Analysis & Design																								
		3.1	User & Feature Matrix	PM, BE	P																				
					A																				
		3.2	Data Table Design	PM, BE	P																				
					A																				
		3.3	User Interface (Prototyping)	PM, FE	P																				
					A																				
		3.4	Report Design	PM, FE	P																				
					A																				
4	Development																								
			Central Application System																						
		4.1	Login & Role-based Read-only	PM, FE, BE	P																				
					A																				
		4.2	UI Kit	PM, FE, BE	P																				
					A																				
		4.3	Fleet Map & Status	PM, FE, BE	P																				
					A																				
		4.4	Tank Cards	PM, FE, BE	P																				
					A																				
		4.5	24h/7d Charts	PM, FE, BE	P																				
					A																				
		4.6	Alert History (View-only)	PM, FE, BE	P																				
					A																				
		4.7	Report Export	PM, FE, BE	P																				
					A																				
		4.8	Auto-Refresh & Loading Indicators	PM	P																				
					A																				

04 TIMELINE, PIC & MOCKUP (3b/4)

List Available Team			QTY
PM	:	Project manajer	1
BA	:	Business Analyst	1
FE	:	Front End Engineer	2
BE	:	Back End Engineer	2
QA	:	Quality Assurance	2
TW	:	Technical Writer	1
EBE	:	Embedded System Engineer	1

PM, FE, BE, QA, EBE : Angga P. S
FE, BE, QA, TW : Rina W.H
BA, QA, TW : Putri N.M

No	List		List Feature	PIC	Plan / Actual	Estimated Start Month : September 2025																			
						Sprint 1		Sprint 2		Sprint 3		Sprint 4		Sprint 5		Sprint 6		Sprint 7		Sprint 8		Sprint 9		Sprint 10	
						W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20
4	Development																								
		4.9	Calibration Curve Overlay (Read-only)	PM, FE, BE	P										■										
					A																				
		4.10	Port/Route Overlay	PM, FE, BE	P											■									
					A																				
		4.11	Top-N Vessels	PM, FE, BE	P												■								
					A																				
		4.12	Speed Prediction Widget (Read-only)	PM, FE, BE	P													■							
					A																				
		4.13	Dark Mode / PWA	PM, FE, BE	P														■						
					A																				
		4.14	API Integration	PM, FE, BE	P															■					
					A																				
			Ship System																						
		4.15	Asset Unique ID, List & Connection	PM, EBE	P									■											
					A																				
		4.16	Asset Unique ID, Tank Information	PM, EBE	P									■											
					A																				
		4.17	Volume Calculation	PM, EBE	P									■											
					A																				
		4.18	Trimmed Calculation	PM, EBE	P										■	■	■	■							
					A																				
		4.19	Payload	PM, EBE	P														■	■					
					A																				
5	Testing																								
		5.1	UAT Environment Preparation	PM	P														■	■					
					A																				
		5.2	UAT (User Acceptance Test)	PM, QA	P																■	■			
					A																				
		5.3	Documentation	PM, TW	P	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
					A																				
6	Deployment																								
		6.1	Production Environment Preparation	QA	P																■	■			
					A																				
		6.2	Deploy to Production	QA	P																		■		
					A																				
		6.3	Migration Data	QA	P																		■		
					A																				
		6.4	Cut Off and Go-Live	QA	P																			■	
					A																				
		6.5	Sign Off	QA	P																				■
					A																				

04 TIMELINE, PIC & MOCKUP (4/4)

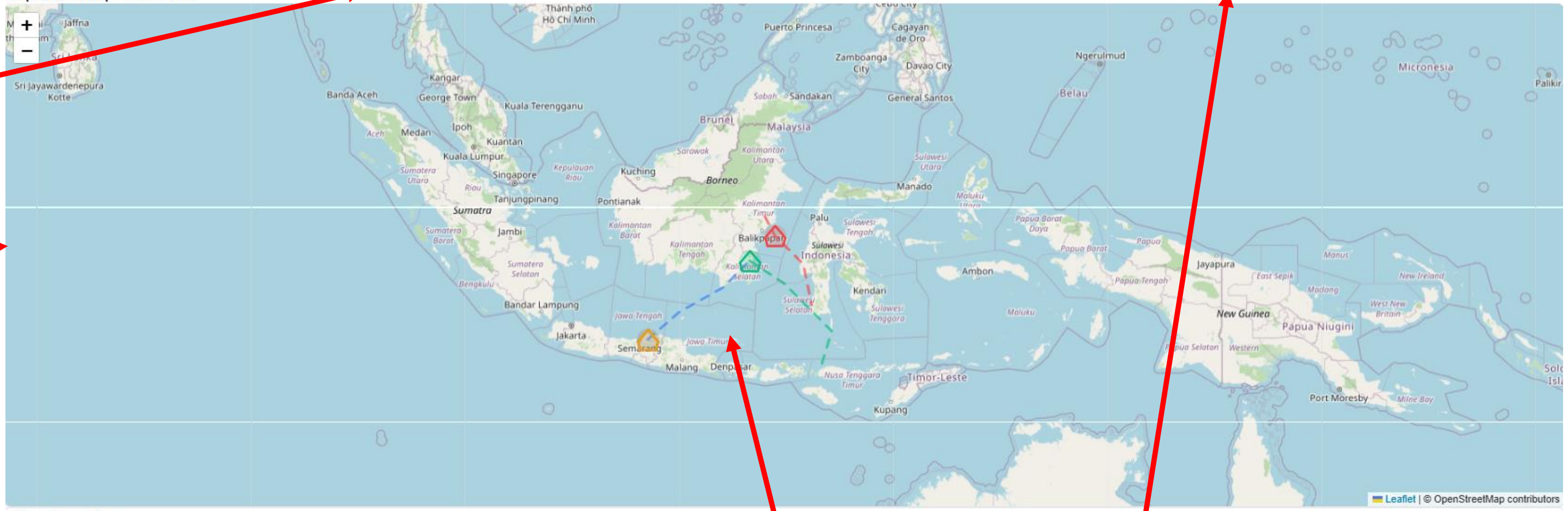
TytoAlba
Ship Route & Fuel Management

12/10/2025, 21.43.48 WIB

Arrival Prediction

Selected Ship	Estimated Arrival	Port Destination	Fuel on Arrival (Est.)
Rasuna Baruna	13 Okt 2025, 21.43	Taboneo Port	8500 L

Ship Route Map - Indonesia



Ship Information

No	Ship Name	Port Destination	ETA	Estimated Fuel on Arrival	Status
1	Rasuna Baruna	Taboneo Port	13 Okt 2025, 21.43	8,500 L	In Progress
2	Latifah Baruna	Labuan Bajo	14 Okt 2025, 09.43	7,200 L	In Progress
3	Martha Baruna	Jepara Port	12 Okt 2025, 23.43	9,800 L	In Port
4	Meutia Baruna	Makassar Port	14 Okt 2025, 21.43	6,500 L	In Progress

Estimated Arrival

Indonesia Bounding Box

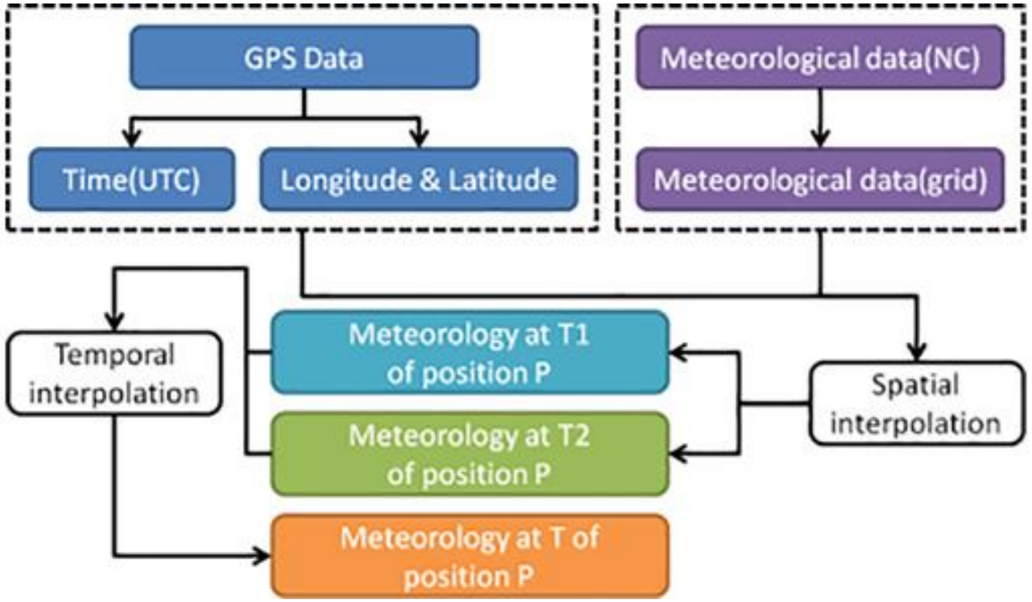
UI Auto Refresh.
Click on row to focus

Ship Route

Estimate Fuel on Arrival

05 REFERENCE(1/5)

Research on Ship Main Engine Fuel Consumption Model With Data Integration and Noise Cleaning

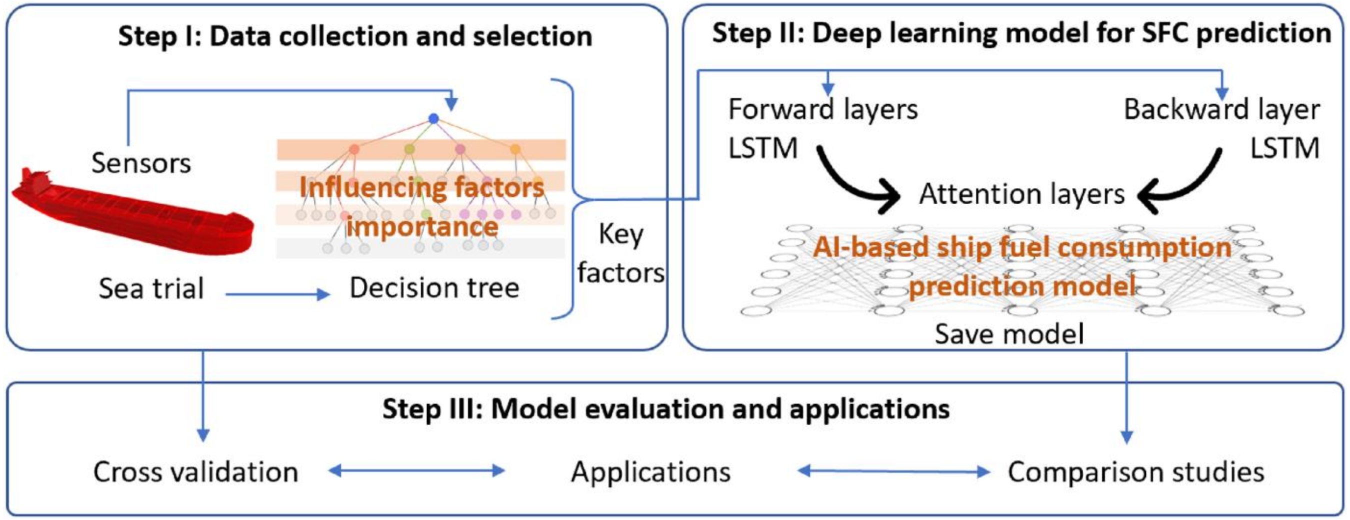


Integrate meteorological data into ship operational data, taking into account temporal and spatial variations, to enhance the dimensionality of the operational data and improve the quality of models for predicting fuel consumption in vessels

Zhang, M., Tsoulakos, N., Kujala, P., & Hirdaris, S. (2024). A deep learning method for the prediction of ship fuel consumption in real operational conditions. Engineering Applications of Artificial Intelligence, 130(December 2023), 107425. https://doi.org/10.1016/j.engappai.2023.107425

05 REFERENCE(2/5)

A deep learning method for the prediction of ship fuel consumption in real operational conditions



In this paper, a decision tree (DT) is used to evaluate the importance of factors encompassed on extensive big data analytics records and consequently select key influencing factors with impact on SFC.

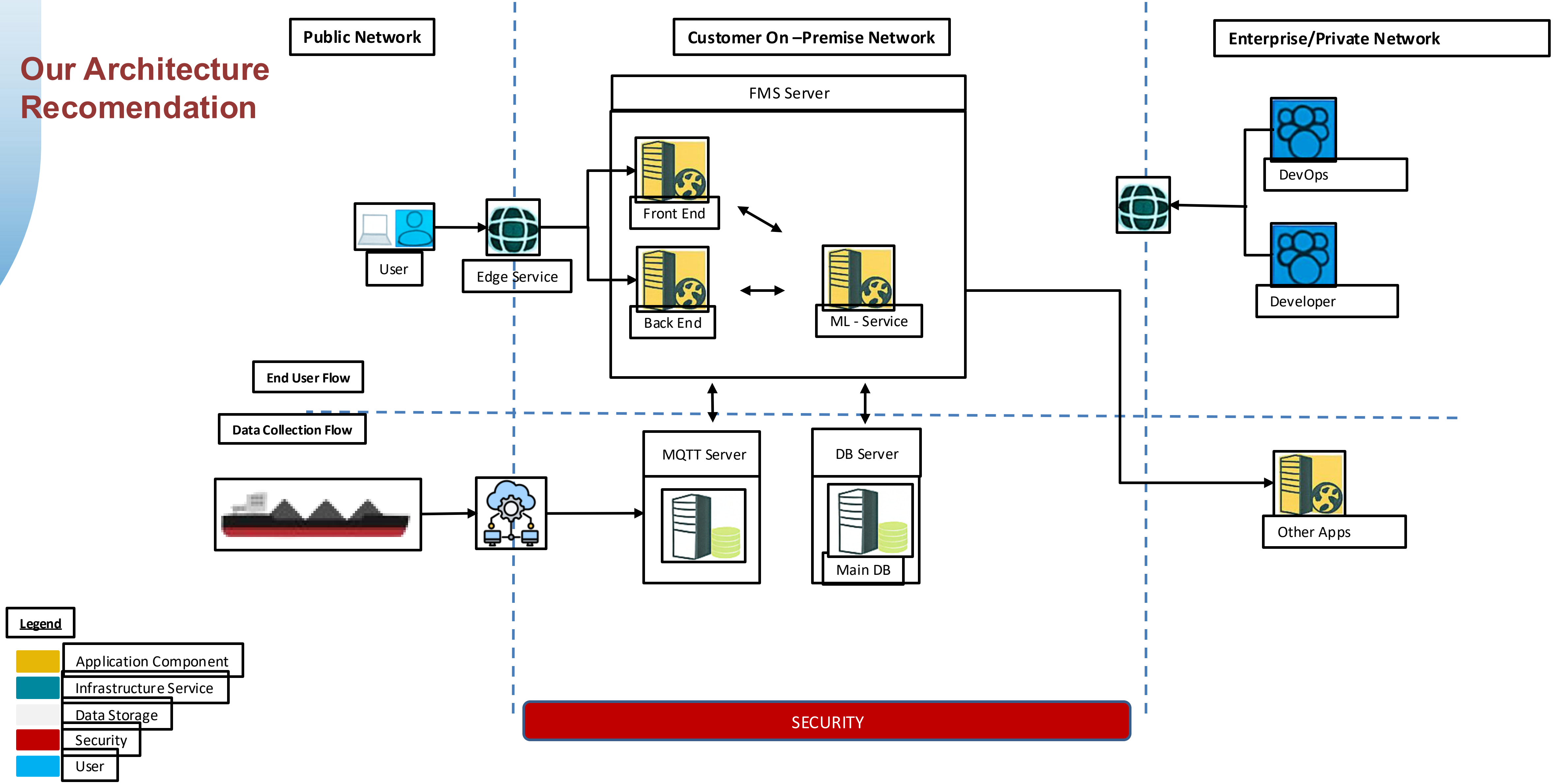
A Bi-LSTM (Bidirectional Long Short Term Memory) with attention mechanism method is employed. The methodology presented comprises of the following three steps :

1. Data collection and the importance evaluation of influencing factors
2. A DLM for the prediction of ship fuel consumption.
3. Cross validation, comparison, and applications

Zhang, M., Tsoulakos, N., Kujala, P., & Hirdaris, S. (2024). A deep learning method for the prediction of ship fuel consumption in real operational conditions. *Engineering Applications of Artificial Intelligence*, *130*(December 2023), 107425. https://doi.org/10.1016/j.engappai.2023.107425

05 REFERENCE(3/5)

Our Architecture Recomendation



05 REFERENCE(4/5)

TytoAlba
-Backend
-Database
-docker
-frontend
--public
--src
-ml-service
--train-arrival-model.py
--train-fuel-model.py

--train-arrival-model.py

```python
# Train model
    print("\n🔧 Training Random Forest model...")
    predictor = ArrivalPredictor()
    predictor.train(X_train, y_train)

 # Evaluate model
    print("\n📊 Evaluating model...")
    y_pred_train = predictor.predict(X_train)
    y_pred_test = predictor.predict(X_test)

 # Calculate metrics
    train_mae = mean_absolute_error(y_train, y_pred_train)
    train_rmse = np.sqrt(mean_squared_error(y_train, y_pred_train))
    train_r2 = r2_score(y_train, y_pred_train)

    test_mae = mean_absolute_error(y_test, y_pred_test)
    test_rmse = np.sqrt(mean_squared_error(y_test, y_pred_test))
    test_r2 = r2_score(y_test, y_pred_test)
```

--train-fuel-model.py

```python
# Train model
    print("\n🔧 Training Random Forest model...")
    predictor = FuelPredictor()
    predictor.train(X_train, y_train)

# Evaluate model
    print("\n📊 Evaluating model...")
    y_pred_train = predictor.predict(X_train)
    y_pred_test = predictor.predict(X_test)

# Calculate metrics
    train_mae = mean_absolute_error(y_train, y_pred_train)
    train_rmse = np.sqrt(mean_squared_error(y_train,y_pred_train))
    train_r2 = r2_score(y_train, y_pred_train)

    test_mae = mean_absolute_error(y_test, y_pred_test)
    test_rmse = np.sqrt(mean_squared_error(y_test, y_pred_test))
    test_r2 = r2_score(y_test, y_pred_test)
```

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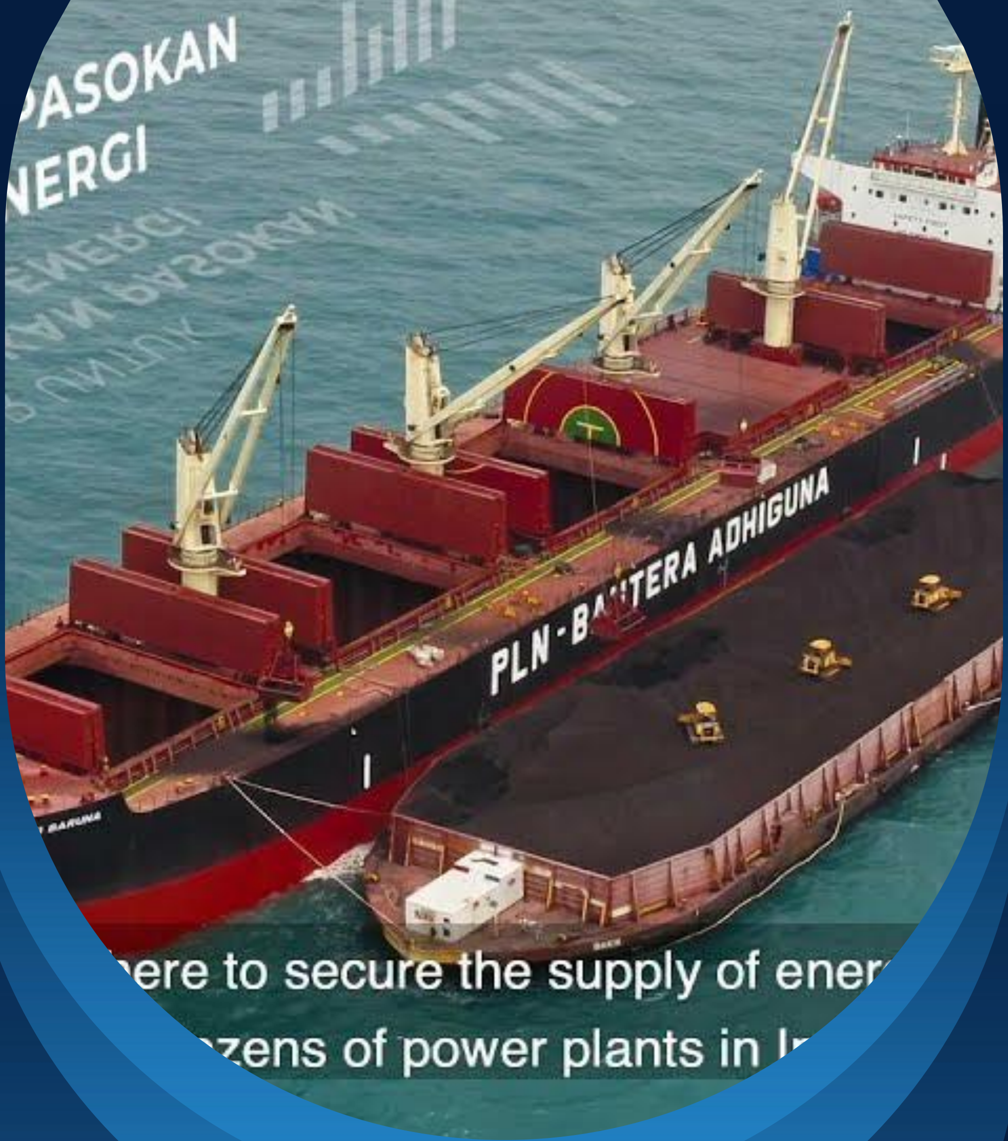
05 REFERENCE(5/5)

1. Abdi, A., & Amrit, C. (2024). Enhancing vessel arrival time prediction: A fusion-based deep learning approach. *Expert Systems with Applications*, *252*(PA), 123988. https://doi.org/10.1016/j.eswa.2024.123988
2. Zhang, M., Tsoulakos, N., Kujala, P., & Hirdaris, S. (2024). A deep learning method for the prediction of ship fuel consumption in real operational conditions. *Engineering Applications of Artificial Intelligence*, *130*(December 2023), 107425. https://doi.org/10.1016/j.engappai.2023.107425
3. Chen, Y., Huang, Z., & Feng, L. (2024). Research on Ship Main Engine Fuel Consumption Model With Data Integration and Noise Cleaning. IEEE Access, 12(October), 154546–154569. https://doi.org/10.1109/ACCESS.2024.3478783
4. Kim, S.; Kim, H.; Jeon, H. Development of a Simplified Performance Monitoring System for Small and Medium Sized Ships. J. Mar. Sci. Eng. 2023, 11, 1734. https://doi.org/10.3390/jmse11091734

THANK YOU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NERGI
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zens of power plants in I