

# TradeWatch Complete Architecture - UML Class Diagram

VectorStream Systems

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## TradeWatch Complete Architecture - UML Class Diagram

### System Overview

This UML class diagram represents the complete TradeWatch Global Trade Intelligence Platform architecture, including the newly integrated TensorFlow AI processing system and PostgreSQL database infrastructure.

### Architecture Layers

#### 1. React Frontend Application

- **Main Application:** App component managing routing and global state
- **Layout System:** Responsive layout with mobile optimization and navigation
- **Page Components:** Dashboard, VesselTracking, TariffTracking, Analytics, LivePortView, MobileAppDownload

#### 2. Dashboard Components

- **GlobalMap:** Interactive Leaflet.js map with real-time data visualization
- **DateSlicer:** Temporal data filtering with mobile-responsive design
- **ActiveAlerts:** Real-time disruption and alert management
- **MetricsPanel:** Key performance indicators and system metrics
- **DisruptionTimeline:** Temporal visualization of trade disruptions

#### 3. TensorFlow AI Processing System

- **TensorFlowProcessor:** Main FastAPI application for AI processing
- **ModelManager:** Manages multiple AI models and their lifecycle
- **VesselMovementPredictor:** Advanced LSTM+Attention model for vessel prediction
- **DisruptionDetector:** Multi-modal AI for trade disruption detection
- **DataPipeline:** Real-time data ingestion and processing pipeline

#### 4. PostgreSQL Database Layer

- **DatabaseManager:** Async PostgreSQL connection and query management
- **Maritime Schema:** Vessels, vessel positions, ports, port performance, disruptions, tariffs, trade routes
- **AI Models Schema:** Model registry, predictions, training sessions, feature store
- **Analytics Schema:** Performance metrics, economic impact, risk assessments
- **Logs Schema:** System events, API requests, data quality logs

## 5. API Integration Layer

- **APIAggregator:** Centralized data aggregation with intelligent caching
- **RealTimeIntegration:** AIS, news, weather, and port data integration
- **TariffIntegration:** Comprehensive tariff data from multiple sources
- **NewsIntegration:** Maritime news analysis and disruption signal extraction
- **MaritimeAPIs:** Core maritime data APIs and services

## 6. Docker Container Infrastructure

- **DockerCompose:** Complete multi-container orchestration
- **PostgreSQLContainer:** PostGIS-enabled database with spatial indexing
- **TensorFlowContainer:** GPU-enabled AI processing with model serving
- **CeleryWorker:** Distributed task processing for background jobs
- **Monitoring Stack:** Prometheus, Grafana, Flower for system monitoring

## Key Features

### AI Processing Capabilities

- **Vessel Movement Prediction:** Uses LSTM networks with attention mechanisms to predict vessel positions and arrival times
- **Disruption Detection:** Multi-modal AI combining news sentiment, vessel anomalies, and economic indicators
- **Economic Impact Assessment:** Real-time calculation of disruption impacts on global trade
- **Continuous Learning:** Models that improve over time with new data

### Database Architecture

- **Geospatial Data:** PostGIS extension for efficient spatial queries and indexing
- **Time-Series Optimization:** Specialized indexing for temporal maritime data
- **AI Model Versioning:** Complete model lifecycle management and performance tracking
- **Real-Time Analytics:** Materialized views and aggregation tables for dashboard performance

### Scalability and Performance

- **Horizontal Scaling:** Docker Compose setup supports multi-instance deployment
- **GPU Acceleration:** TensorFlow models optimized for GPU processing
- **Intelligent Caching:** Multi-layer caching strategy for API responses and predictions
- **Connection Pooling:** Async PostgreSQL connection management for high throughput

### Real-Time Processing

- **Stream Processing:** Continuous data ingestion from multiple maritime APIs
- **Anomaly Detection:** Real-time identification of vessel behavior anomalies
- **Predictive Alerts:** Proactive notification system for potential disruptions
- **Live Updates:** WebSocket-based real-time dashboard updates

## Technology Stack

### Frontend

- **React 18:** Modern component-based UI framework
- **Leaflet.js:** Interactive mapping with mobile optimization

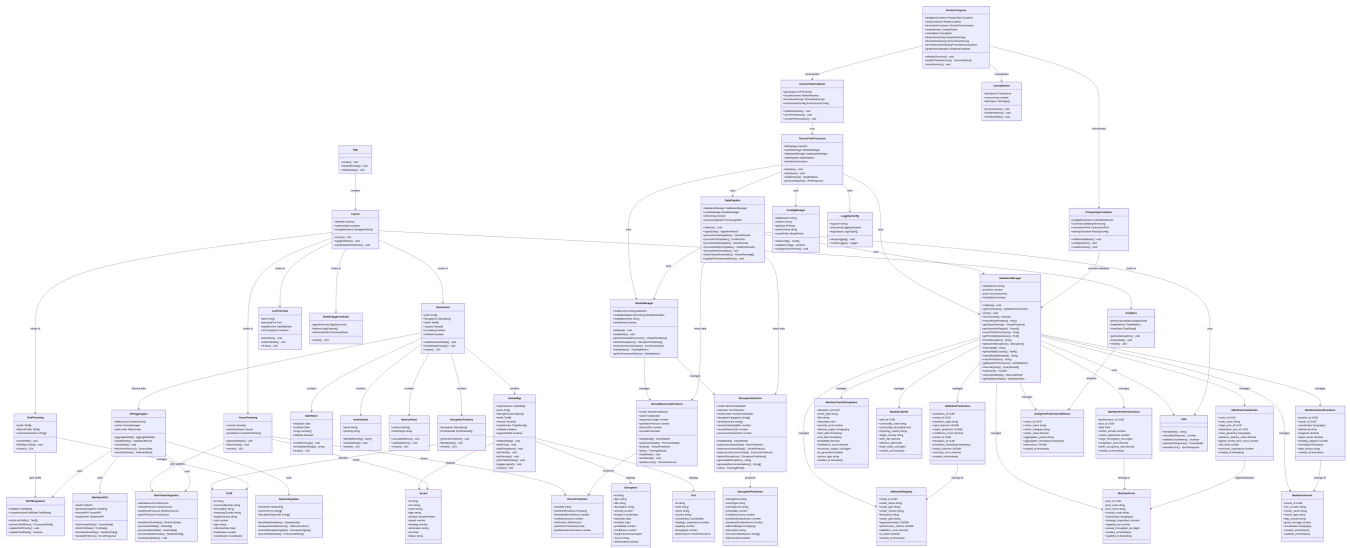


Figure 1: TradeWatch Complete UML Class Diagram

- **Tailwind CSS:** Utility-first styling with responsive design
- **Vite:** Fast development and build tooling

### Backend AI Processing

- **TensorFlow 2.15:** Advanced machine learning and neural networks
- **FastAPI:** High-performance async Python web framework
- **Celery:** Distributed task queue for background processing
- **Redis:** In-memory caching and message broker

### Database

- **PostgreSQL 15:** Robust relational database with ACID compliance
- **PostGIS 3.3:** Geospatial extension for maritime coordinate data
- **AsyncPG:** High-performance async PostgreSQL client

### Infrastructure

- **Docker Compose:** Multi-container application orchestration
- **Prometheus:** Metrics collection and monitoring
- **Grafana:** Visualization and alerting dashboards
- **TensorFlow Serving:** Model deployment and inference serving

### Data Sources

- **AIS Data:** Real-time vessel tracking and positioning
- **Port APIs:** Throughput, congestion, and performance metrics
- **News APIs:** Maritime news and disruption event detection
- **Weather APIs:** Environmental conditions affecting shipping
- **Tariff Databases:** International trade policy and tariff data

## Innovation Highlights

1. **Multi-Modal AI:** First maritime intelligence system combining news sentiment, vessel behavior, and economic indicators for disruption prediction
2. **Attention Mechanisms:** Advanced neural architectures specifically designed for maritime time-series prediction
3. **Real-Time Learning:** Continuous model improvement with live maritime data
4. **Geospatial Intelligence:** Comprehensive spatial analysis of global trade routes and chokepoints
5. **Economic Impact Modeling:** Quantitative assessment of disruption effects on global supply chains

This architecture represents a comprehensive, scalable, and intelligent maritime trade monitoring system capable of processing real-time data, making accurate predictions, and providing actionable insights for global trade stakeholders.