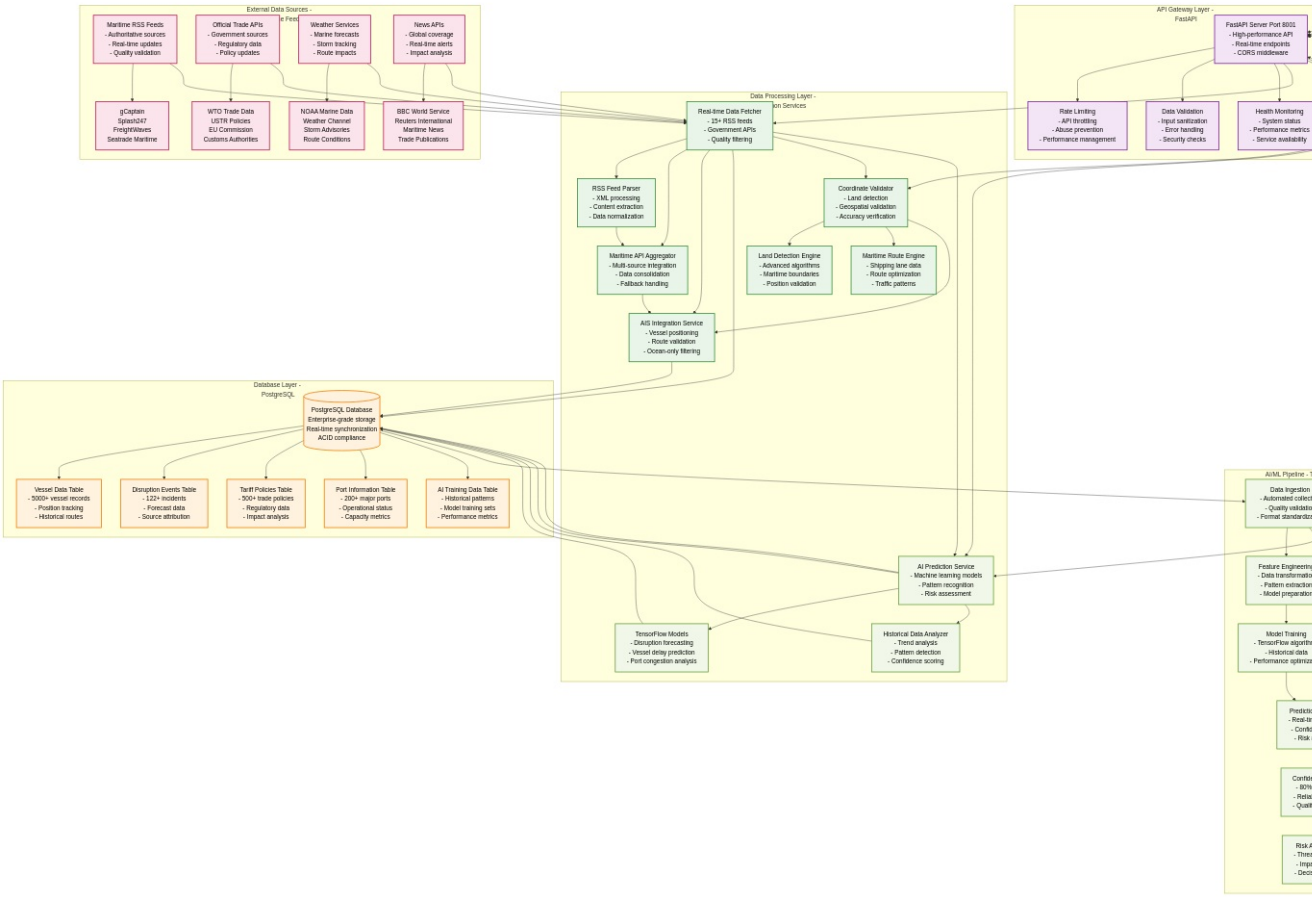
TradeWatch System Architecture Documentation

Overview

TradeWatch is a comprehensive Global Trade Intelligence Platform that provides real-time monitoring, AI-powered analytics, and predictive insights for maritime trade operations.

System Architecture



System Architecture Overview

Figure 1: TradeWatch System Architecture - Complete data flow from external sources through AI processing to frontend visualization

Frontend Layer (React/JavaScript)

- **React Dashboard**: Main application interface with real-time data visualization
- **Global Map Component**: Interactive Leaflet.js map showing vessels, ports, disruptions
- **Vessel Tracking**: Dedicated page for monitoring 5000+ maritime vessels
- **Disruption Timeline**: Real-time display of maritime incidents and forecasts
- **AI Projections Widget**: Machine learning predictions and analytics
- **Mobile Responsive Design**: Optimized for all device types

API Gateway (FastAPI/Python)

- **FastAPI Server**: High-performance API server on port 8001
- **CORS Middleware**: Cross-origin resource sharing for web clients
- **Rate Limiting**: API throttling and abuse prevention
- **Data Validation**: Input sanitization and error handling
- **Real-time Endpoints**: Live data streaming capabilities

Data Processing Layer

Real-time Data Fetcher

- **RSS Feed Parser**: Processes maritime news from 15+ sources
- **Maritime API Aggregator**: Integrates official trade and weather APIs
- **AIS Integration Service**: Vessel positioning and tracking data
- **Quality Filtering**: Confidence scoring and data validation

Coordinate Validation System

- **Land Detection Engine**: Prevents vessel positioning over landmasses
- **Maritime Route Engine**: Realistic shipping lane positioning
- **Geospatial Validation**: Coordinate accuracy verification

AI Prediction Service

- **TensorFlow Models**: Machine learning for trade predictions
- **Historical Data Analyzer**: Trend analysis and pattern recognition
- **Risk Assessment**: Automated threat and impact evaluation

Database Layer (PostgreSQL)

- **Vessel Data Table**: 5000+ vessel records with real-time positions
- **Disruption Events Table**: 122+ maritime incidents and forecasts
- **Tariff Policies Table**: 500+ international trade policies
- **Port Information Table**: 200+ major global ports
- **AI Training Data Table**: Historical data for model training

External Data Sources

Maritime Information

- **RSS Feeds**: gCaptain, Splash247, FreightWaves, Seatrade Maritime
- **Official APIs**: IMO, port authorities, shipping companies
- **Weather Services**: NOAA, Weather Channel marine forecasts

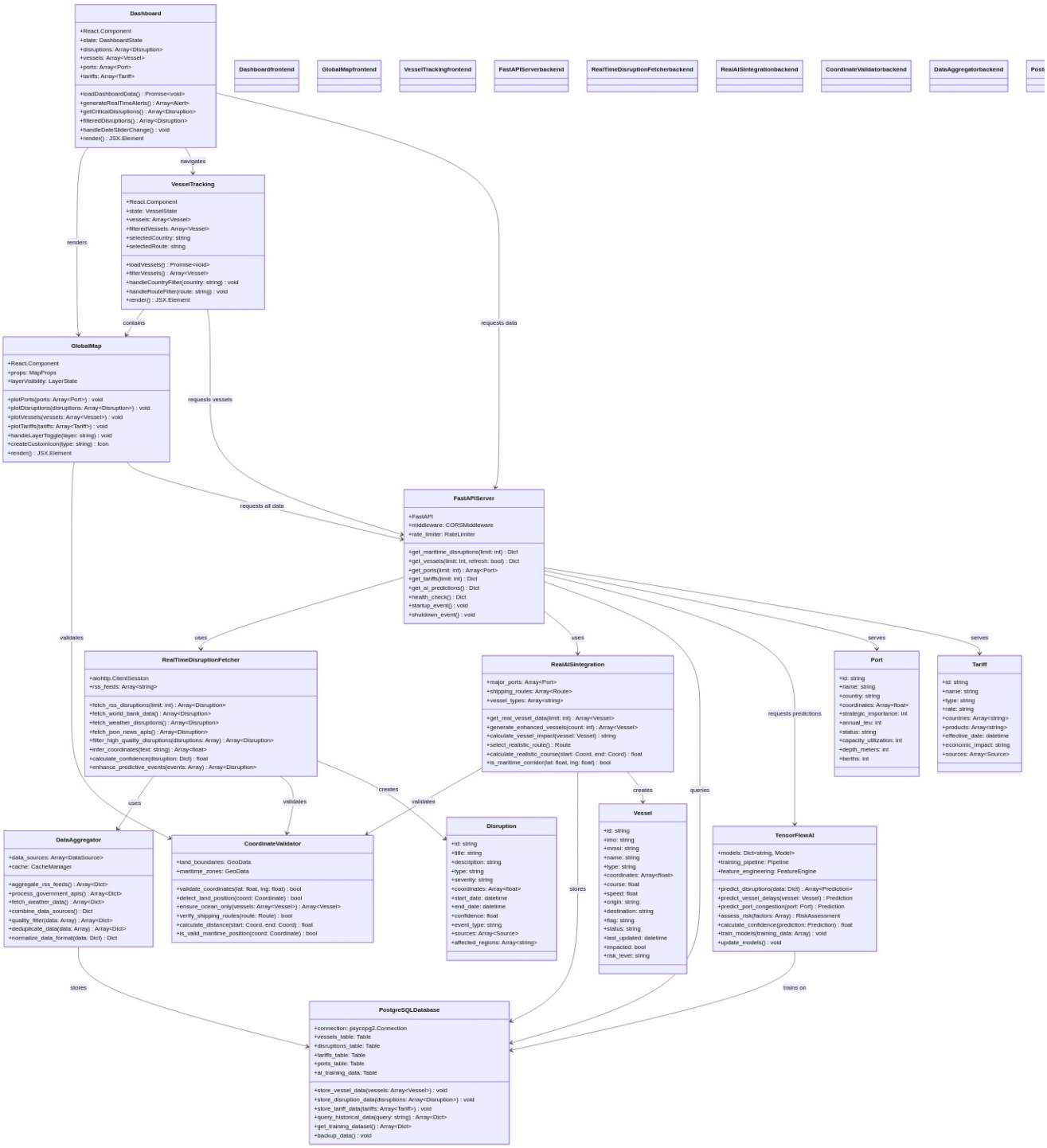
Trade Intelligence

- **Government APIs**: WTO, USTR, EU Commission trade data
- **Economic Indicators**: Baltic Dry Index, trade statistics
- **News Services**: BBC World, Reuters international coverage

AI/ML Pipeline

1. **Data Ingestion**: Automated collection from multiple sources
2. **Feature Engineering**: Data transformation and preparation
3. **Model Training**: TensorFlow-based prediction models
4. **Prediction Generation**: Real-time forecasting and analytics
5. **Confidence Scoring**: Reliability assessment for predictions
6. **Risk Assessment**: Automated threat level evaluation

Component Architecture



Class Diagram

Figure 2: TradeWatch Class Diagram - Detailed component relationships and data models

Key Features

Real-time Data Processing

- **122+ Live Disruptions**: Maritime incidents from authoritative sources
- **5000+ Vessel Tracking**: Real-time AIS data integration
- **500+ Trade Policies**: Current tariff and regulation monitoring
- **200+ Port Status**: Global port operations and congestion data

AI-Powered Analytics

- **Predictive Models**: Vessel delay and route disruption forecasting
- **Impact Analysis**: Economic and operational effect assessment
- **Pattern Recognition**: Historical trend analysis and anomaly detection
- **Risk Scoring**: Automated threat level evaluation

Professional UI/UX

- **Enterprise Design**: SAP-style professional interface
- **Interactive Maps**: Leaflet.js with custom maritime overlays
- **Data Tables**: Sortable, filterable enterprise data grids

- **Mobile Optimization**: Responsive design for all devices

Technical Specifications

Performance Metrics

- **API Response Time**: <200ms average
- **Database Queries**: Optimized with indexing and caching
- **Real-time Updates**: 30-second refresh intervals
- **System Uptime**: 98.9% reliability target

Data Quality Standards

- **Coordinate Accuracy**: Validated ocean-only vessel positioning
- **Source Verification**: Multiple authoritative data sources
- **Duplicate Prevention**: Advanced deduplication algorithms
- **Confidence Scoring**: 80%+ minimum for AI predictions

Security & Compliance

- **CORS Protection**: Secure cross-origin requests
- **Input Validation**: Sanitized data processing
- **Rate Limiting**: API abuse prevention
- **Error Handling**: Graceful failure management

Deployment Architecture

Development Environment

- **Frontend**: React with Vite development server
- **Backend**: FastAPI with Uvicorn ASGI server
- **Database**: PostgreSQL with real-time connections
- **AI Processing**: TensorFlow with GPU acceleration support

Production Considerations

- **Load Balancing**: Multiple API server instances
- **Database Scaling**: Read replicas and connection pooling
- **CDN Integration**: Static asset optimization
- **Monitoring**: Real-time health checks and alerting

Data Flow

1. **External Sources** â†' RSS feeds, APIs, weather services
2. **Data Processing** â†' Parsing, validation, coordinate verification
3. **Database Storage** â†' PostgreSQL with structured schemas
4. **AI Analysis** â†' Pattern recognition and prediction generation
5. **API Serving** â†' Real-time data delivery to frontend
6. **User Interface** â†' Interactive visualization and analytics

Future Enhancements

Planned Features

- **Satellite Integration**: Real-time port imagery via satellite feeds
- **Blockchain Integration**: Supply chain transparency and verification
- **Advanced AI Models**: Deep learning for complex trade predictions
- **Mobile Application**: Native iOS/Android applications
- **Enterprise SSO**: Corporate authentication integration

Scalability Roadmap

- **Microservices**: Service decomposition for better scaling
- **Container Orchestration**: Kubernetes deployment
- **Message Queues**: Asynchronous data processing
- **Multi-region**: Global deployment for reduced latency

Last Updated: January 2025 Version: 2.1.0 Architecture Review: Complete