DISTRIBUTED AI AND MARITIME TRAFFIC

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OTONOMA

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BACKGROUND

- Real-time maritime tracking is challenging due to distributed data, varying conditions, and the need for continuous live data and actionable insights.
- Parasail v2 extends the system with a **distributed Paranet architecture**, bve **trajectory prediction**, and an **interactive dashboard** for race monitoring.

OBJECTIVES

- Fault-tolerant distributed architecture on Paranet
- Integrate live telemetry, weather & marine traffic via RPA & APIs
- Deploy AI/ML models for trajectory & race-time prediction
- Build interactive dashboard for real-time visualization

REQUIREMENTS

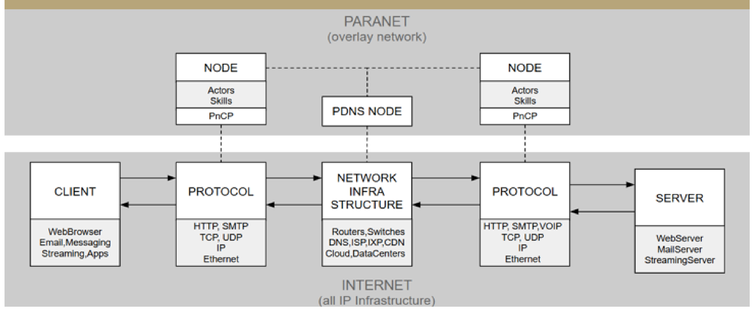
Distributed System
- Support multiple autonomous Paranet nodes (ingest, simulation, overview, coordination)
- Enable dynamic skill discovery and inter-node communication through PnCP

Data & Intelligence
- Ingest and normalize vessel telemetry, weather, and marine traffic data
- Support trajectory prediction using historical and live vessel-state information
- Preserve local vessel state for resilient operation with limited connectivity

User Interface
- Display vessel position, speed, heading, leaderboard, weather context, and replays
- Update the dashboard frequently for real-time monitoring and demonstration

Future Extension
- Support federated learning so vessels can train locally and share model updates without exposing raw local data

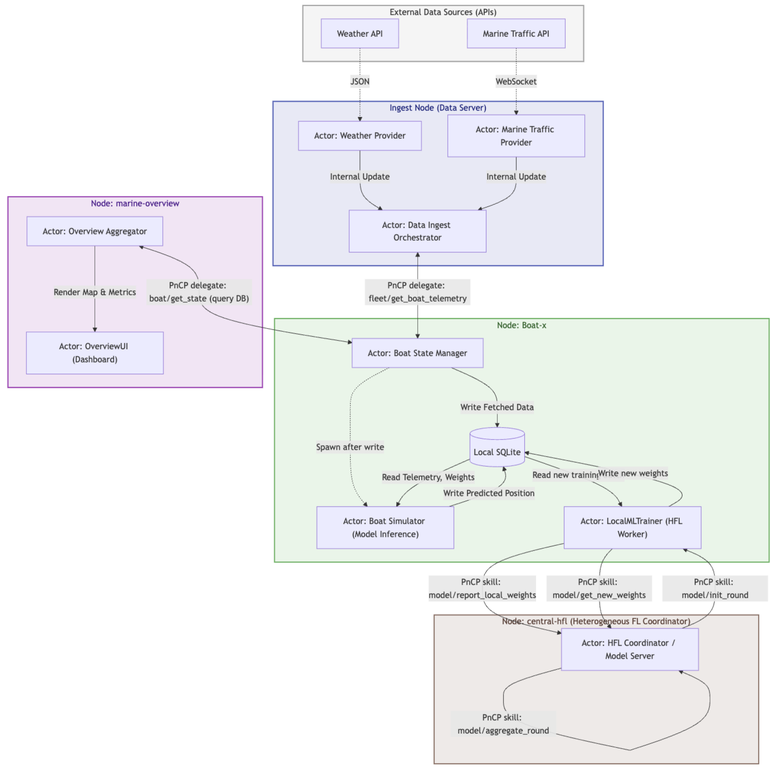
PARANET



Otonoma's Paranet platform enables autonomous nodes to discover and communicate through skills rather than fixed service addresses.

- **Dynamic Discovery:** Nodes can locate required capabilities at runtime
- **Skills-Based Interaction:** Actors expose reusable capabilities as callable skills
- **Distributed Ownership:** Each node can maintain its own state and logic
- **Resilience:** Local operation can continue even when network connectivity is limited

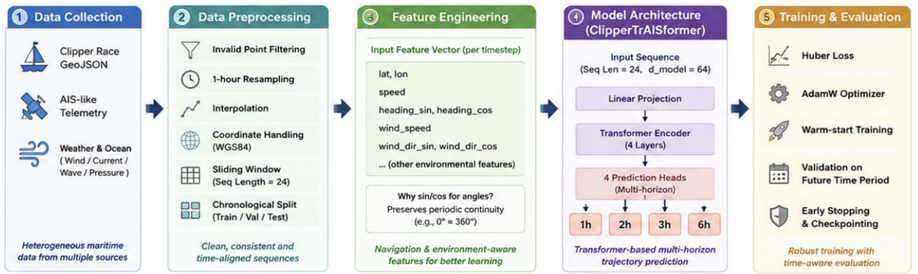
TECHNICAL DESIGN — SYSTEM ARCHITECTURE



Parasail v2 separates maritime intelligence into three distributed layers:
- **Ingest Node:** Collects and normalizes vessel telemetry, weather, and marine traffic data.
- **Sailboat Nodes:** Represent individual vessels, maintain local state, request environmental updates, and run trajectory prediction.
- **Marine Traffic Overview Node:** Aggregates fleet state and streams live updates to the dashboard.

TECHNICAL DESIGN — MACHINE LEARNING MODEL

We use a TrAISformer-inspired model to learn movement patterns from historical tracks and predict displacement, moving the system beyond real-time tracking toward short-term route prediction.



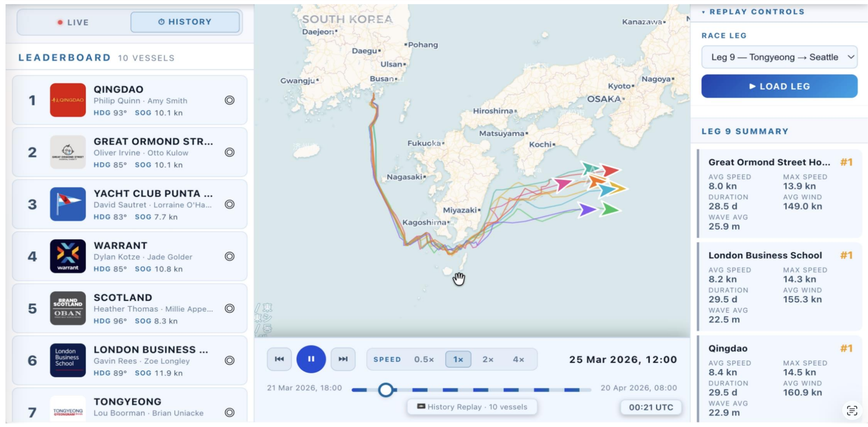
RESULTS

Delivered
- Built a distributed Paranet system with Ingest, Sailboat, Marine Traffic Overview, and HFL Coordinator nodes
- Implemented a React/TypeScript dashboard with leaderboard, vessel telemetry, track replay, and race-leg visualization
- Integrated Paranet Broadcast Objects to stream fleet-state updates to the dashboard
- Built the core federated-learning foundation: local training wrapper, shared model payload contract, coordinator aggregation, and FedAvg validation

ML Progress
- Reproduced and customized TrAISformer for maritime trajectory prediction
- Developed an end-to-end maritime ML pipeline including preprocessing, feature engineering, training, and evaluation
- Enhanced the model with environmental features such as wind speed and wind direction for sailing-specific forecasting

Current Integration Status
- Live-node smoke tests, model promotion flow, health metrics, and deployment hardening are in progress

DASHBOARD FEATURES



FUTURE WORKS

- Attention-based trajectory interpretation
- End-to-end federated maritime learning
- Real-time multi-vessel coordination
- Scalable ocean-scale deployment

CONCLUSION

Parasail v2 demonstrates how a distributed AI system can transform raw maritime data into real-time fleet awareness, historical replay, and short-term trajectory prediction. By separating ingestion, vessel intelligence, and visualization across autonomous Paranet nodes, the system provides a scalable foundation for maritime decision support.

ACKNOWLEDGEMENTS

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