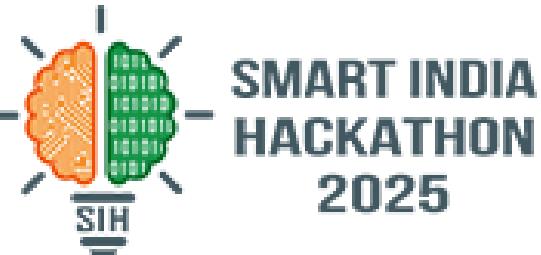
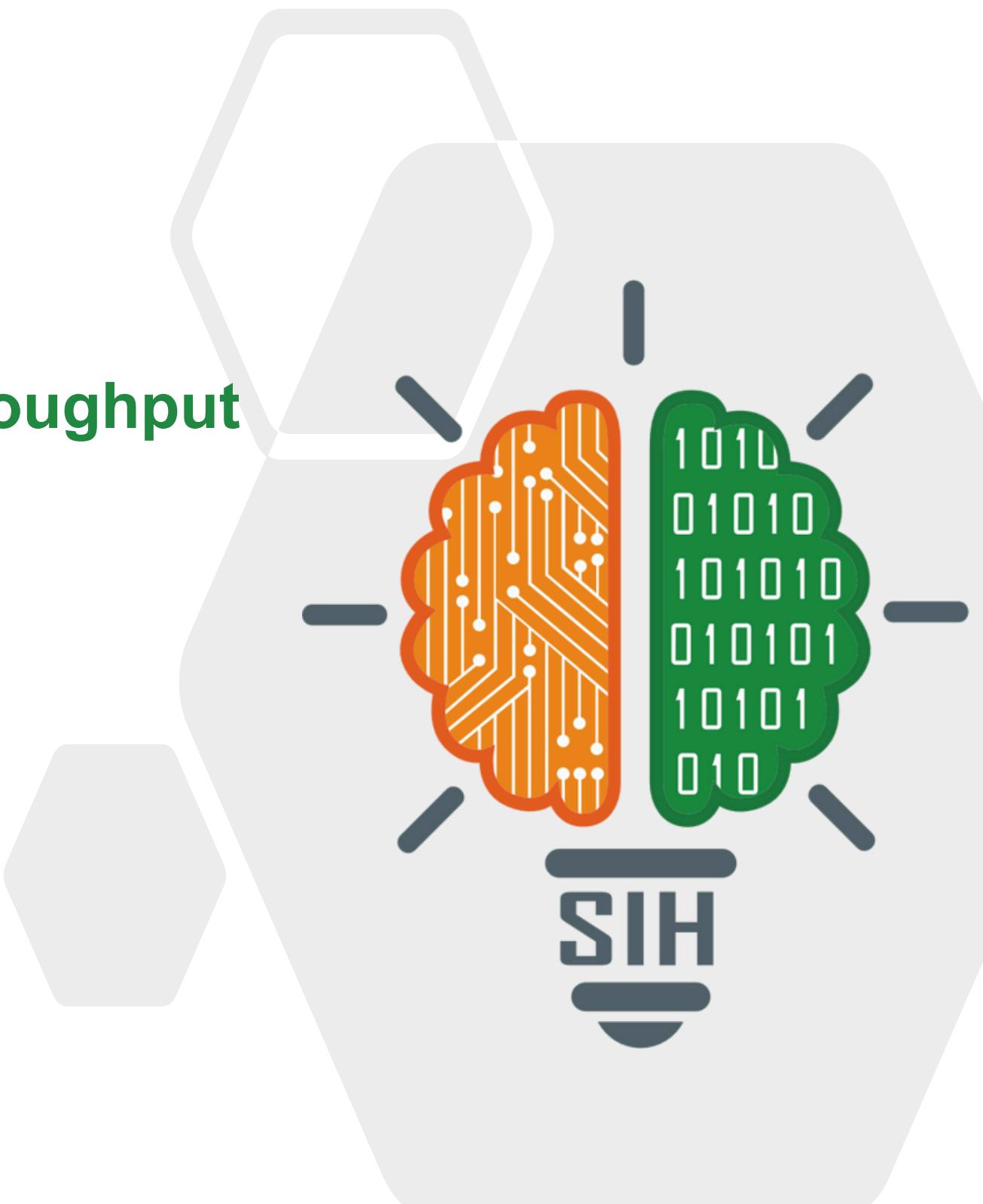


SMART INDIA HACKATHON 2025



TITLE PAGE

- Problem Statement ID - **25022**
- Problem Statement Title - **Maximizing Section Throughput**
Using AI-Powered Precise Train Traffic Control
- Theme - **Transportation & Logistics**
- PS Category- Software/Hardware - **Software**
- Team ID -
- Team Name (Registered on portal) - **Hacktopus**



Painpoint :

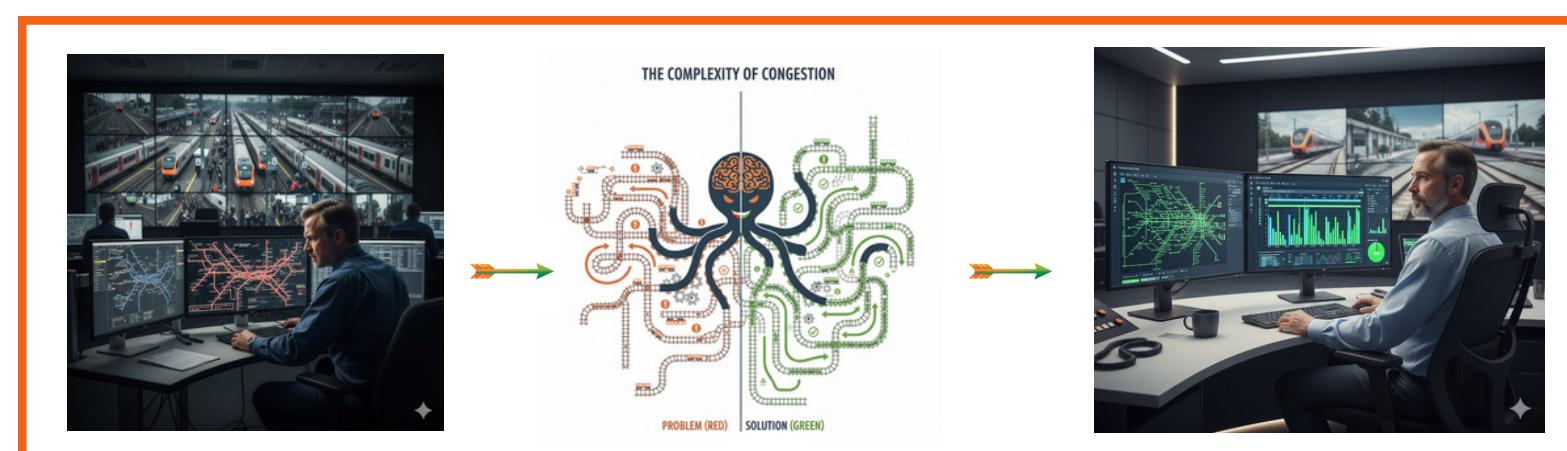
- **Core Problem:** The network is perpetually hit by disruptions—track maintenance, equipment failure, weather, and chain pulling.
- These events instantly shatter the master timetable, triggering delays that degrade service for passengers and freight.
- **Bottleneck in a Large-Scale Problem :** Controllers manually reschedule, but they are a cognitive bottleneck facing a large-scale combinatorial optimization problem.

Idea :

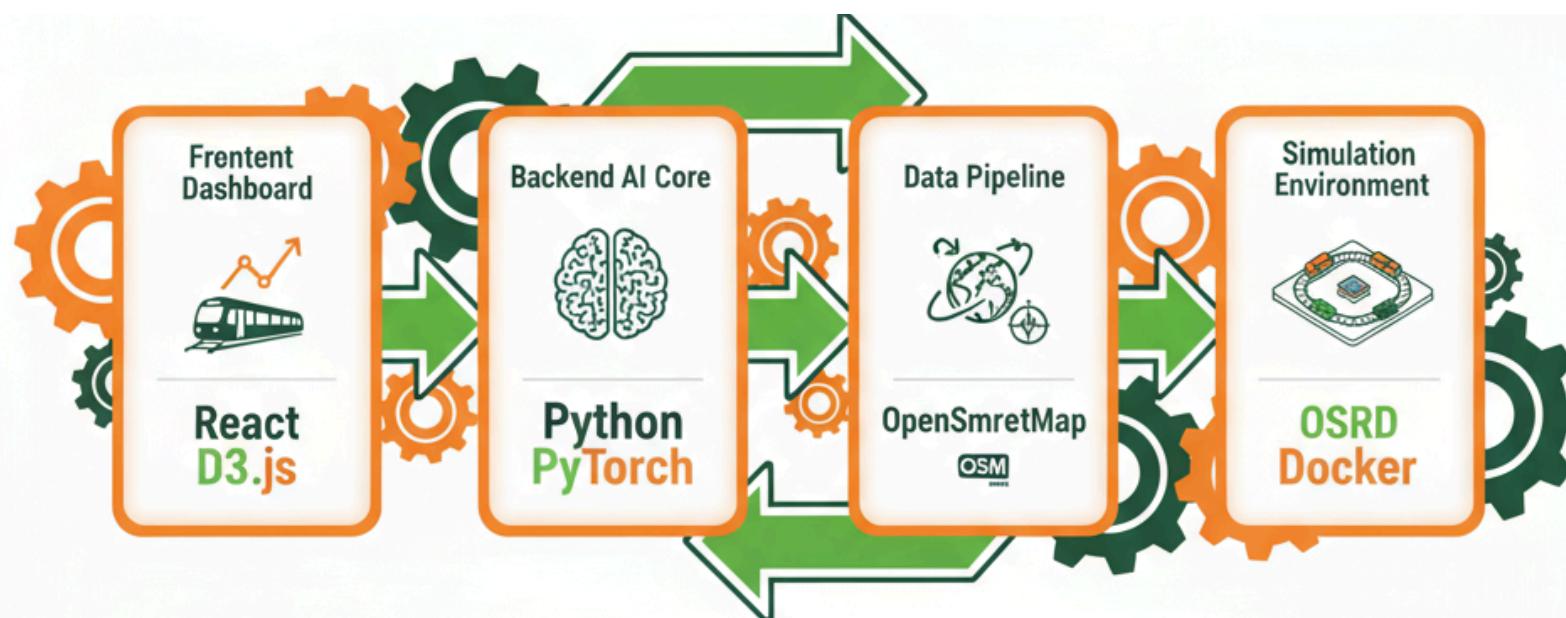
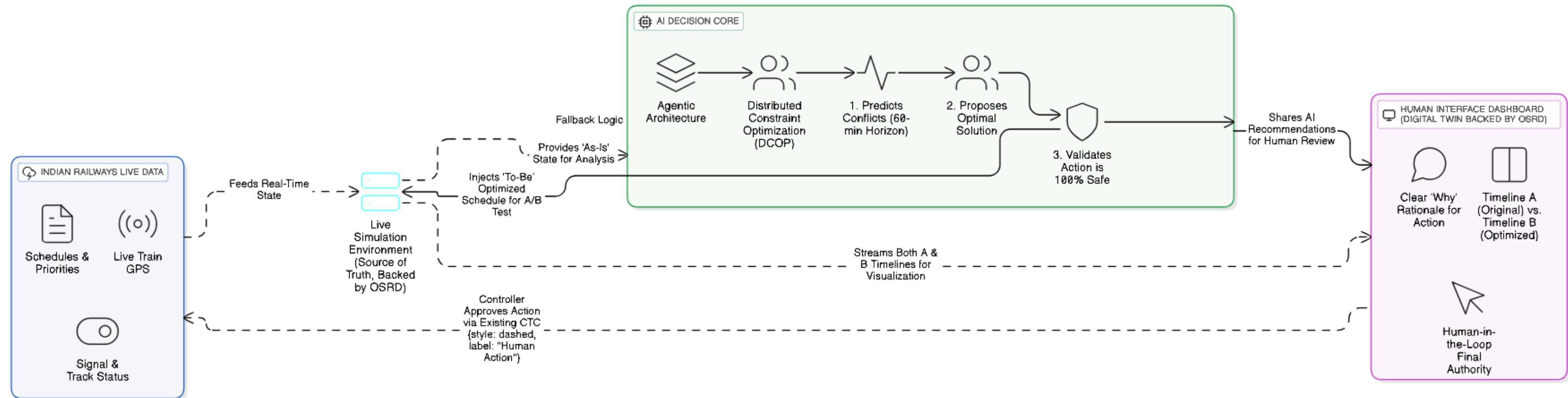
- AI-powered train rescheduling with Hybrid **Hierarchical-Parallel Architecture** for speed and coordinated control.
- Decentralized agents + command hierarchy ensure rapid conflict negotiation and strategic oversight.
- MARL in Digital Twin predicts disruptions and generates real-time, **conflict-free recovery plans autonomously**.

UVP :

- **Fully automated, real-time rescheduling** — moves beyond simple decision support to execute **conflict-free recovery plans autonomously**.
- **Optimized for Indian Railways KPIs** — improves punctuality, throughput, and measurable operational performance using data-driven strategies.
- Rapid response with strategic coordination — **combines thousands of parallel agents with command hierarchy to convert raw data into actionable insights**.



TECHNICAL APPROACH

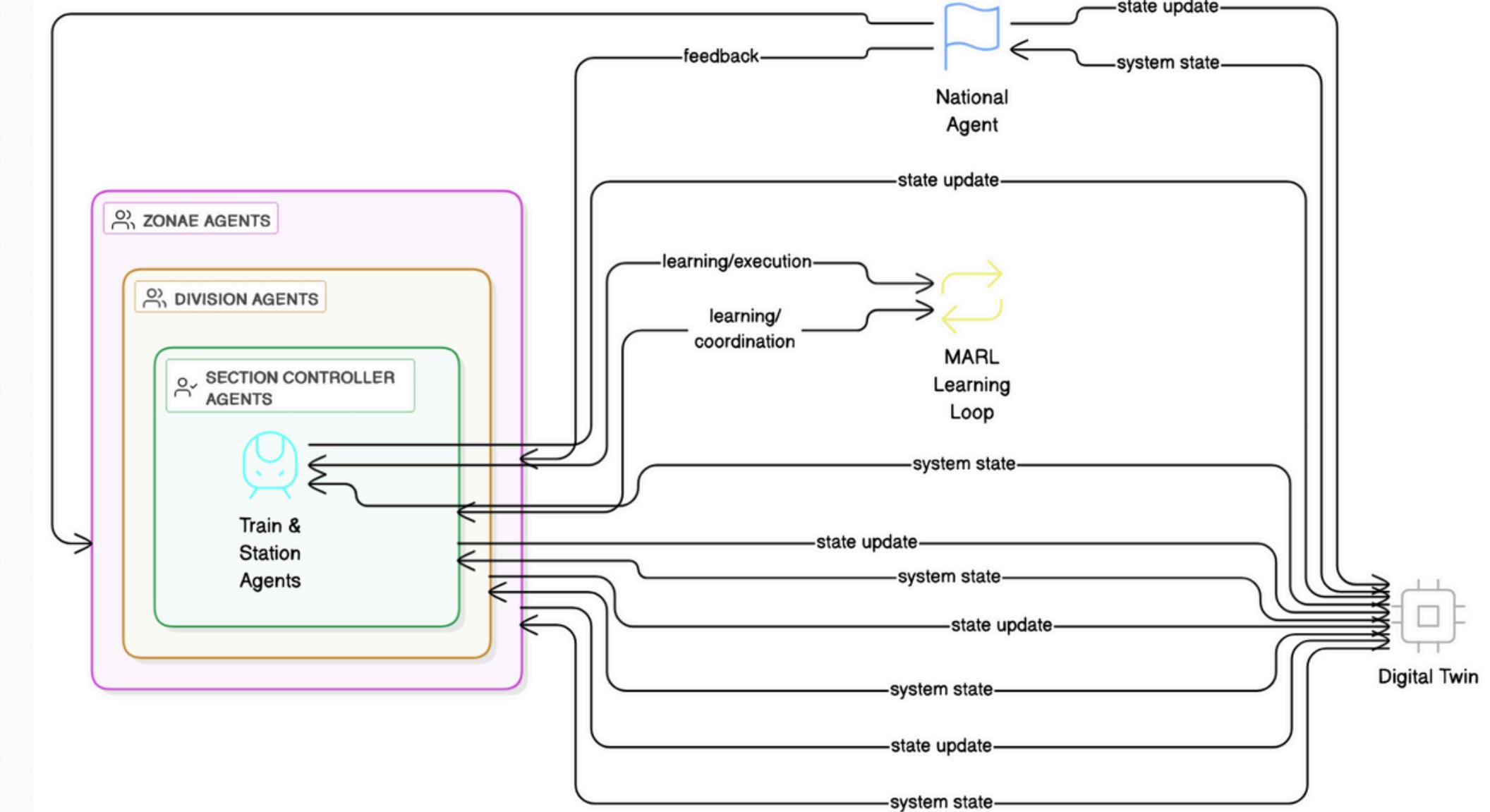


TechStack :

- **Frontend:** React, D3.js, **Embedded OSRD UI**
- **Backend & AI:** Python, PyTorch + PyG, **Custom Agents +** pyDCOP, **FastAPI**, Hugging Face Transformers, **Langchain**.
- **Data Pipeline:** OSM + Overpass API, osmnx, **GeoPandas**, NetworkX.
- **Simulation:** OSRD, Docker.

FEASIBILITY AND VIABILITY

Technical Feasibility	Operational Viability
 Data is Available Indian Railways has invested in digital infrastructure. COA, RTIS, and CTC already provide real-time data. The key challenge is integration, not invention.	 Data Integration Complexity Phased rollout starting with a well-instrumented section to perfect the Digital Twin before scaling.
 Infrastructure is Ready Modern signaling (MACLS, Automatic Block) and Centralized Traffic Control (CTC) are in place. AURA integrates seamlessly, requiring no hardware overhaul.	 AI "Black Box" Problem Explainable AI (XAI) dashboard provides plain-language reasoning for AI decisions (e.g. "Holding Train X for 4 mins prevents a 25-min cascading delay").
 AI is Proven MARL has been demonstrated to handle large-scale scheduling with linear scalability and instant decision-making, outperforming classical methods significantly.	 Cybersecurity Risks A Safety Validation Layer ensures all AI commands comply with hard-coded railway safety rules before execution.


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IMPACT AND BENEFITS

Economic Impact



Massive Throughput Increase

By dynamically optimizing schedules and minimizing delays, AURA can increase line capacity by 15-25% on existing infrastructure.



Boosted Asset Utilization

Higher average train speeds and reduced terminal detention directly improve critical revenue-generating KPIs like NTKM/wagon-day and Loco Utilization.



Reduced Operational Costs

Optimized, smoother train movements reduce energy consumption and minimize wear and tear on rolling stock.

Social & National Impact



Reduced Punctuality Improvement

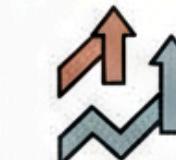
The system's ability to contain delay propagation will lead to a dramatic and measurable improvement in passenger and freight train reliability.



Enhanced Safety

Proactive conflict prediction and the hard-coded Safety Validation Layer create a system that is demonstrably safer than one reliant solely on human oversight.

Economic Impact



15-25%

15-25% Increase in Line Capacity on Existing Infrastructure & new lines.



Reduced Operational Utilization:

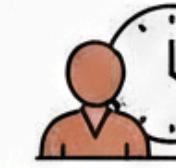


Optimized Train Movements

Improves revenue generating KPIs Reduced Energy Consumption & Minimized Wear & Tear.



Enhanced Safety:



Proactive Conflict Prediction & Human Validation

Social & National Impact



Higher Train Speeds & Reduced Terminal Delays

Improves revenue generating KPIs (NTKM/wagon-day, Loco Utilization).



Demonstrably Safer than Human Oversight

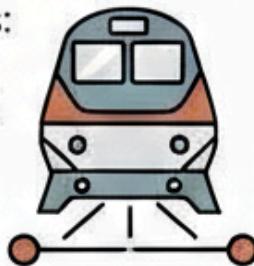


Dramatic Punctuality Improvement in Passenger & Freight Train Reliability

Future Vision: The Foundation for Foundactior Autonomous Logistics:

Critical First Step for Indian Railways:

- Automated Yard Management Hub-point 2
- Dynamic Freight Pricing



RESEARCH AND REFERENCES

- Agent-development:** <https://smythos.com/developers/agent-development/multi-agent-systems-in-traffic-management/>
- Traffic-management-system:** <https://digitale-schiene-deutschland.de/en/news/2025/Traffic-management-system-with-Multi-Agent-AI>
- Multi-agent:** <https://nexocode.com/blog/posts/multi-agent-in-action-michael-kupper-on-putting-railway-back-on-the-fast-track/>
- Railway-multi-agent-modelling:** <https://mssanz.org.au/modsim2019/B6/bretas>
- Traffic-flow-simulation:** <https://milvus.io/ai-quick-reference/how-do-multiagent-systems-simulate-traffic-flow>
- Cooperative-traffic-framework:** <https://www.scitepress.org/Papers/2024/124683/124683.pdf>

- Core AI Methodology** – Multi-Agent AI (DSD), Deep RL for traffic control (Rasheed et al.), and GNN-based train rescheduling (Yue et al.).
- Indian Railways Framework** – KPIs from Ministry of Railways, Control Organization & COA system as operational baselines.
- Control Organization (Control Rooms)** — the control organisation (zonal/divisional control rooms) is the operational nerve centre for train running and asset control; that structure is the natural integration point for decision agents



Discussed with
professionals

Chief Project
Manager/Co-ord BD
& Operations (Railway, Metro & Urban Mobility)



Station Master
KUMBAKONAM



THANK YOU
JAI HIND