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SMART INDIA HACKATHON 2025

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- **Problem Statement ID –25022**
- **Problem Statement Title-Maximizing Section Throughput Using AI-Powered Precise Train Traffic Control**
- **Theme-Transportation & Logistics**
- **PS Category- Software**
- **Team ID-**
- **Team Name**

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IDEA TITLE

AI-Powered Railway Traffic Management

AI Optimizer (Rule-Based + Greedy Approach)

- Simulates **real-time train scheduling** in a small railway division.
- Resolves **train conflicts** by dynamically assigning precedence.

Dynamic Decision-Making

- ✅ Decide which train gets precedence when blocks are contested.
- ✅ Reroute trains to loop lines to **reduce congestion**.
- ✅ Minimize **overall system delay** while ensuring **safety rules** (no two trains in the same block).

Interactive Dashboard (React/Streamlit)

- Real-time **visual simulation** of trains (dots/lines) moving on tracks.
- Provides a **clear, intuitive view** of congestion, delays, and scheduling impact.

Innovation & Uniqueness

- **Lightweight AI prototype** for hackathon scope (small division).
- Extensible → can scale to national level with **Kavach, IoT, GPS data integration**.

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TECHNICAL APPROACH

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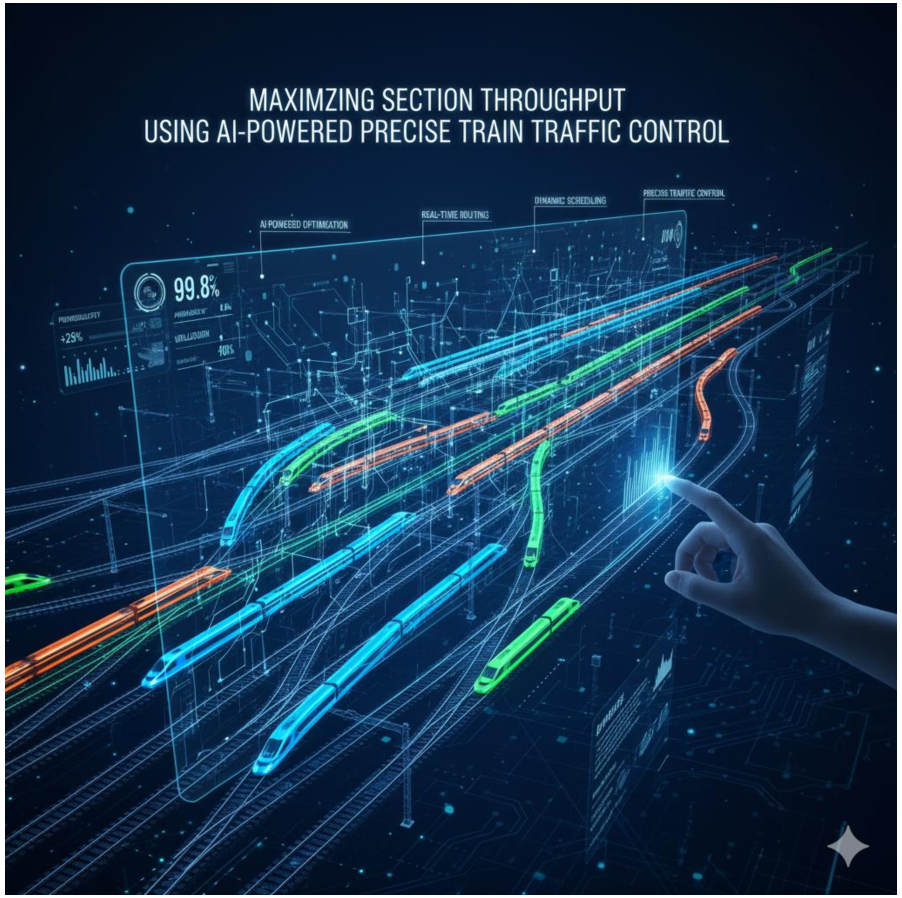
Technologies to be Used

- 💻 Programming: Python (AI engine, simulation), React/Streamlit (visualization).
- 📊 Frameworks: Pandas, NumPy, NetworkX (scheduling & graph modeling), Matplotlib/Plotly (dashboards).
- ☁ Infrastructure: Open-source tools, local/cloud deployment (prototype).
- 🔒 Future Integration: IoT sensors, GPS feeds, Kavach APIs (for real-time data).

Methodology & Process

- Data Layer → Synthetic schedules, routes, delays.
- AI Engine → Greedy + heuristic conflict resolution, safety rules.
- Decision Layer → Weighted cost functions (passenger vs freight priorities).
- Visualization Layer → Dashboard showing train positions, congestion, delay reduction



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FEASIBILITY AND VIABILITY

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⚠ Challenges & Risks

- Data unavailability (no real-time IR datasets).
- Train scheduling = NP-hard (computationally complex).
- Safety-critical operations → zero tolerance for errors.
- Conflicting priorities (passenger vs freight vs VIP).
- Scalability for national rollout (infra + compute)

Feasibility

- Prototype achievable with synthetic data & greedy AI.
- Real-time decision-making possible with lightweight algorithms.
- Scalable with modular architecture, though full nationwide rollout needs infra & APIs.

🛠 Strategies to Overcome

- Synthetic Digital Twin → simulate routes & delays.
- Greedy + heuristic algorithms → fast, near-optimal scheduling.
- Hard-coded safety rules → enforce block occupancy + fail-safe fallback.
- Weighted cost functions → balance fairness & punctuality.
- Modular architecture → future integration with APIs (Kavach, IoT, GPS).

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IMPACT AND BENEFITS

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1. Social Benefits

- Increased staff efficiency → less manual conflict resolution
- Fewer delays → more reliable passenger journeys
- Use digital twin simulations for training controllers

2. Economic Benefits

- Reduced train delays → saves fuel, manpower & passenger time
- Smoother freight operations → strengthens logistics & supply chains
- Prototype demonstrates cost-effective AI solutions for large-scale transport

3. Environmental Benefits

- Less train idling → lower fuel/electricity wastage
- Reduced congestion → fewer emissions
- More cargo via rail → eco-friendly alternative to road transport

Metric	Standard FCFS Model	Our AI Optimizer	Impact
Average Train Delay	High	Significantly Reduced	✂️
Network Throughput	Baseline	Increased Capacity	📈
Fuel & Energy Efficiency	Standard	Optimized Usage	✅
Conflict Resolution	Manual & Slow	Automated & Instant	⚡

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RESEARCH AND REFERENCES

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🚄 **Indian Railways Reports**: Annual Report 2022–23 (performance, modernization), National Rail Plan 2030 (capacity expansion).

🧠 **AI in Railways**: AI-Based Train Scheduling (Springer, 2020), AI in Indian Railways (IRJET, 2019).

🌍 **Global Best Practices**: ERTMS – Europe, Shinkansen AI Scheduling – Japan.

⚙ **Digital Twin Models**: IEEE (2021), ScienceDirect (2020).