Bengaluru Last Mile Challenge 2025

Predictive optimization for Urban Last-Mile Mobility

Team Bengaluru Vega

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Implemented by

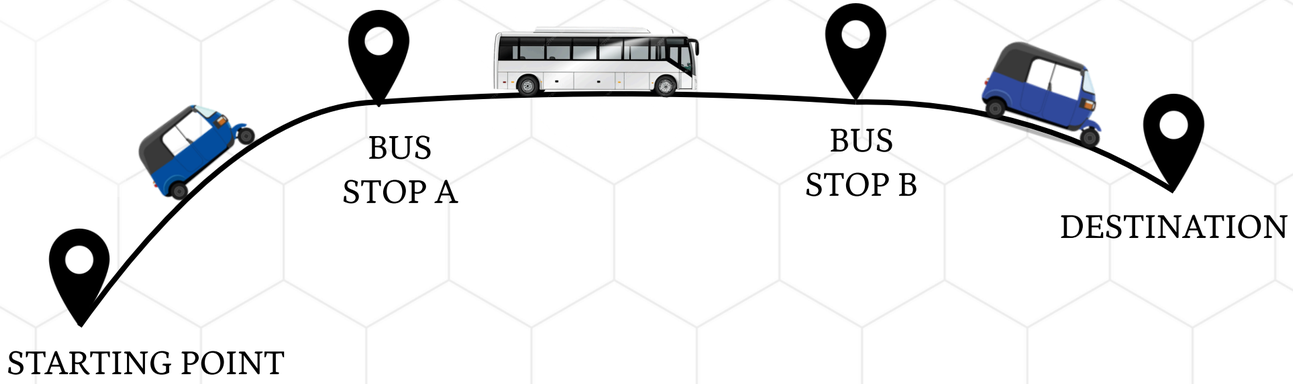
Introduction To Solution

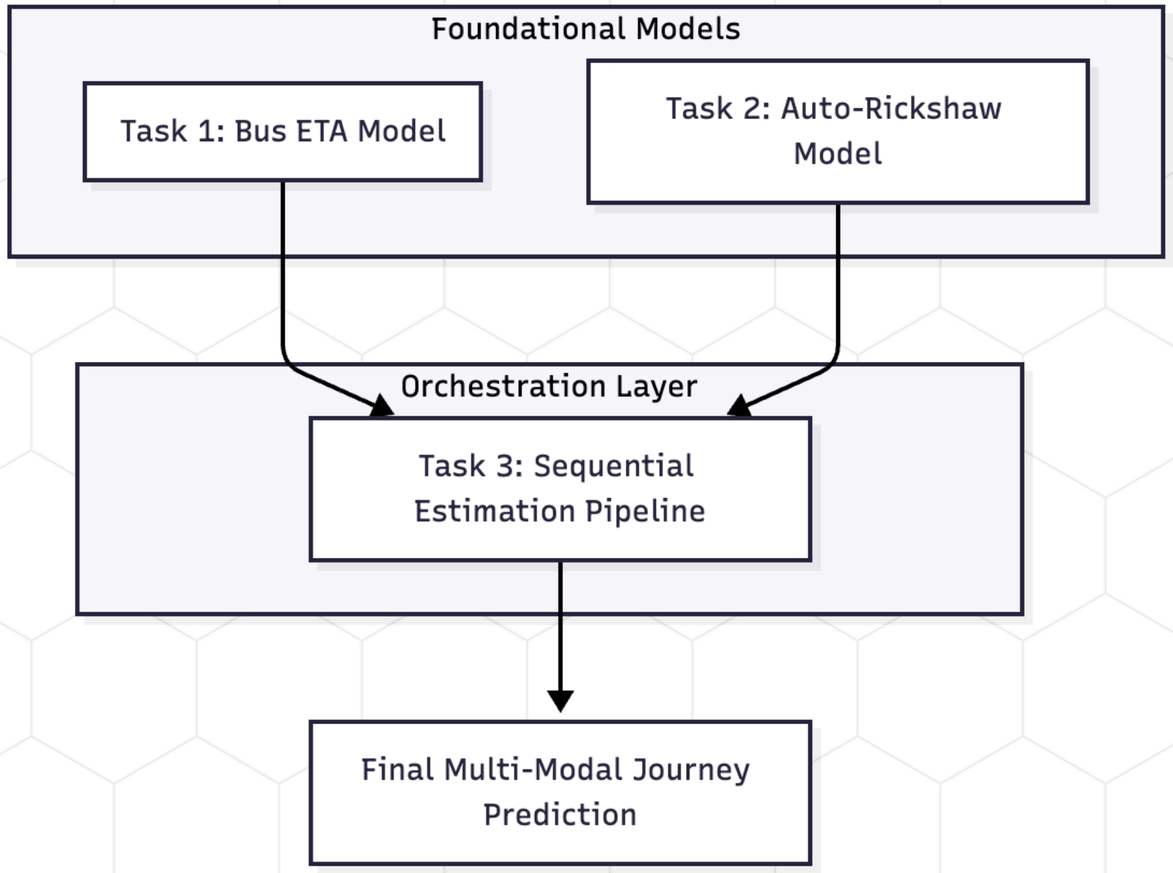
High-Level Architecture

Approach:

A modular system of specialized expert models, orchestrated sequentially to handle each component of the journey. Each model focuses on a specific leg:

- Task 1: Bus ETA prediction using XGBoost.
- Task 2: Auto-rickshaw trip prediction using SDR data and city graph features.
- Task 3: Sequential Estimation Pipeline to combine predictions for multi-modal journeys.





Task 1 - Bus ETA Prediction:

Methodology:

Route-aligned Preprocessing

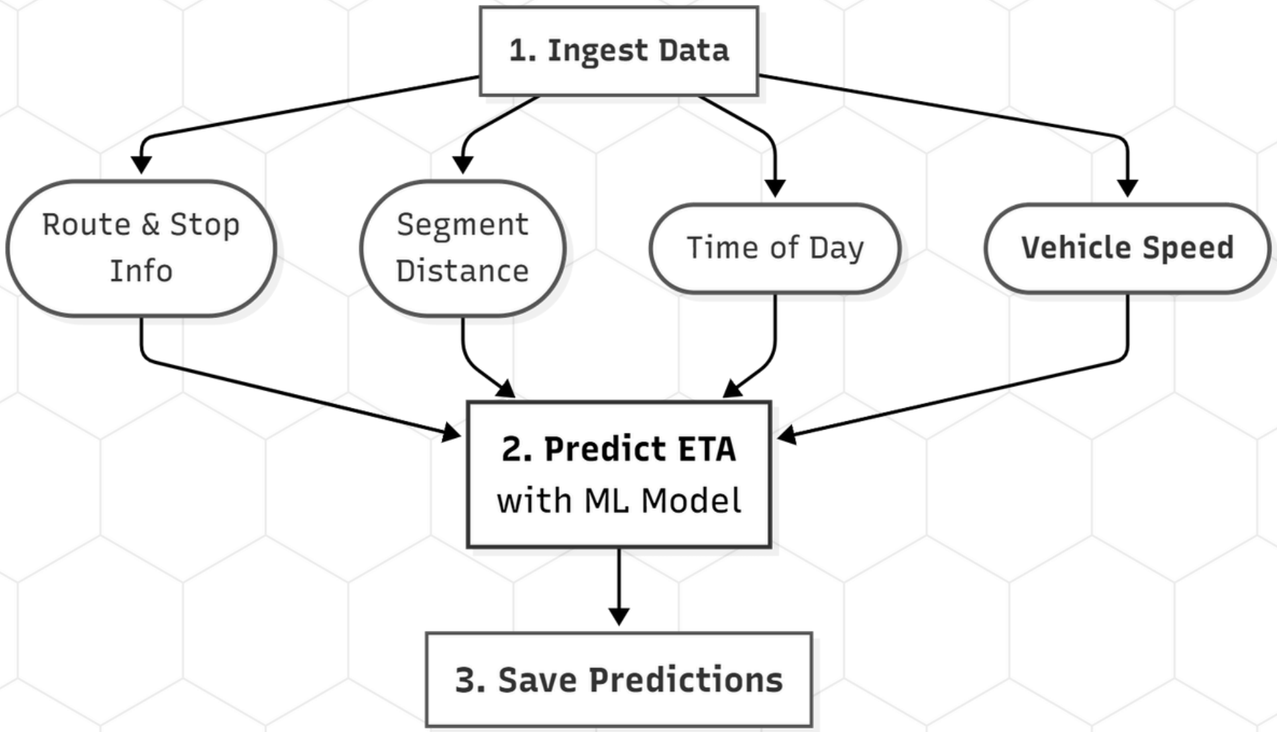
Raw GPS data is cleaned and map-matched to the bus's route sequence to identify the last visited stop and upcoming stops.

Feature Engineering

For each upcoming stop, a rich feature set is generated, combining: hour, day, distance, average speed over that route.

Training

The model is trained to predict the travel time from the bus's current location to a specific future stop, making a separate, granular prediction for each stop in the sequence.

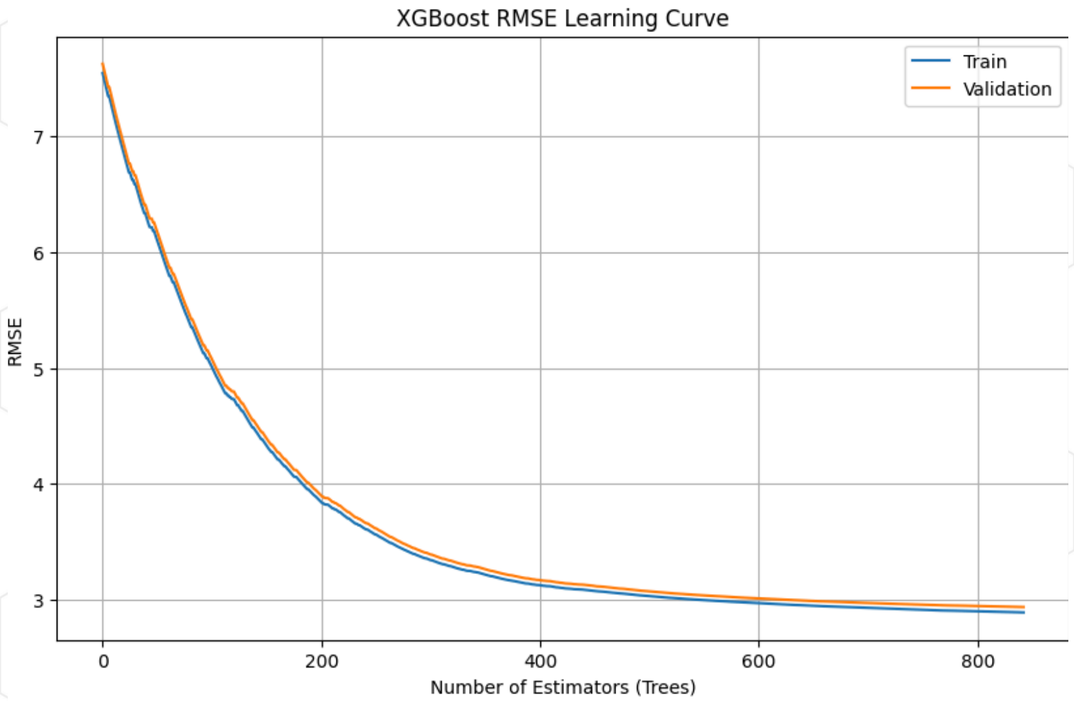


Task 1 - Bus ETA Prediction:

Novelty & Results

Novelty

- Hybrid Speed Calculation: The pipeline intelligently combines three sources of speed information in a hierarchical manner:
  - 1st Priority: Real-time speed calculated from the current trip's live GPS pings.
  - 2nd Priority: Historical average speed for that specific route if real-time data is unavailable.
- Data Cleaning: Filtered out invalid or inconsistent routes from the trip dataset, extracting key attributes and discarding redundant or irrelevant data.



Task -2 Autorickshaw Total Trip Time

Methodology

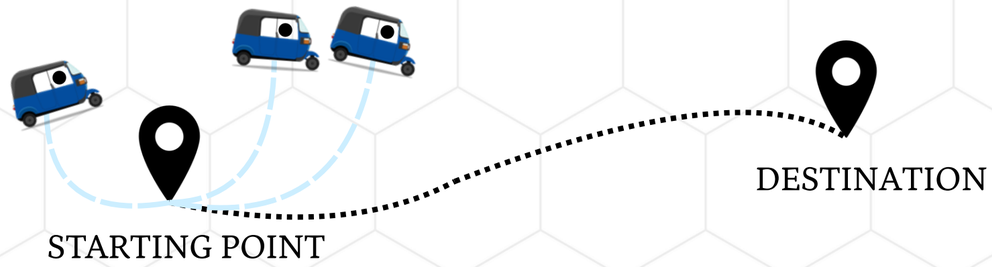
Objective

Predict the Total Travel Time (TTT) into three components:

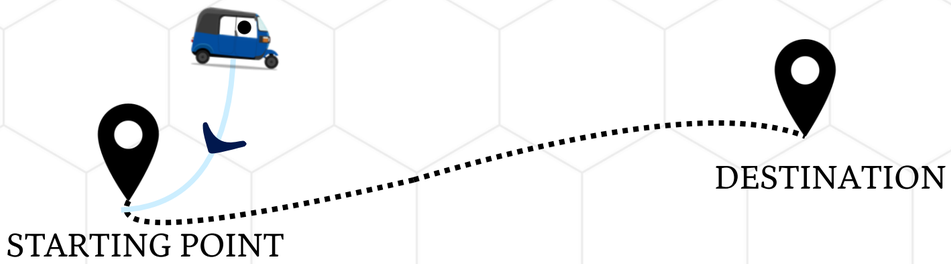
- Pa: Request Acceptance Time
- Pb: Pickup Time
- Pc: Trip Time

Modeling Approach

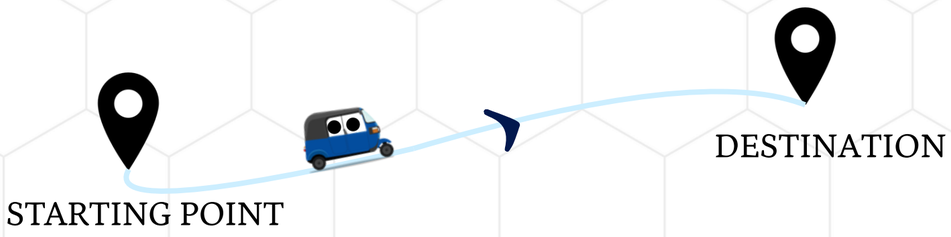
- Heuristic pa and pb models, inversely proportional to SDR, finely tuned using submission evaluation for accuracy.
- Graph-based pc model utilizing OSMnx for shortest path calculations, optimizing route efficiency.



Matching an Auto: Request Acceptance time



Auto Reaching to Starting Point: Pickup Time



Reaching to the final Destination: Trip Time

Task -2 Autorickshaw Total Trip Time

Methodology

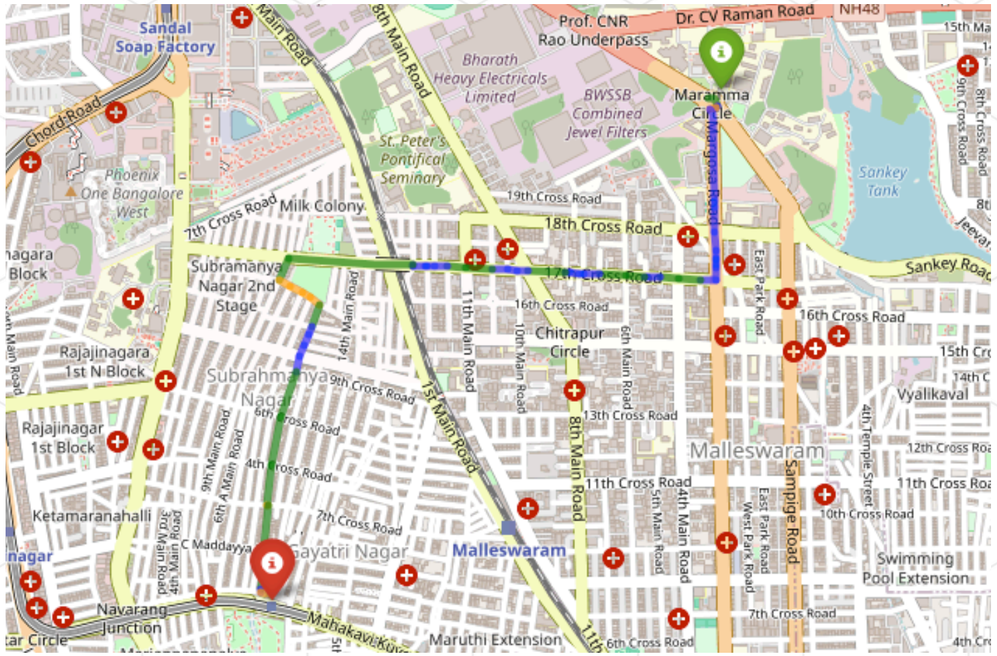
Objective

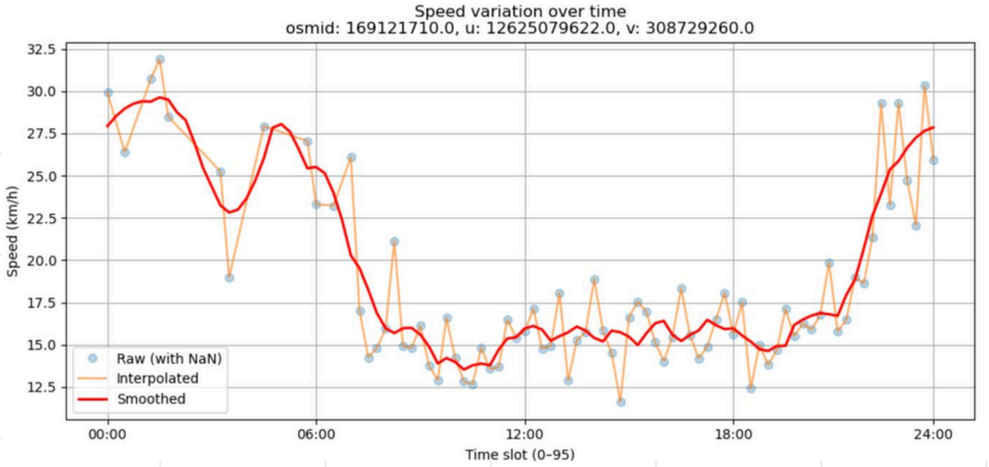
Predict the Total Travel Time (TTT) into three components:

- Pa: Request Acceptance Time
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Modeling Approach

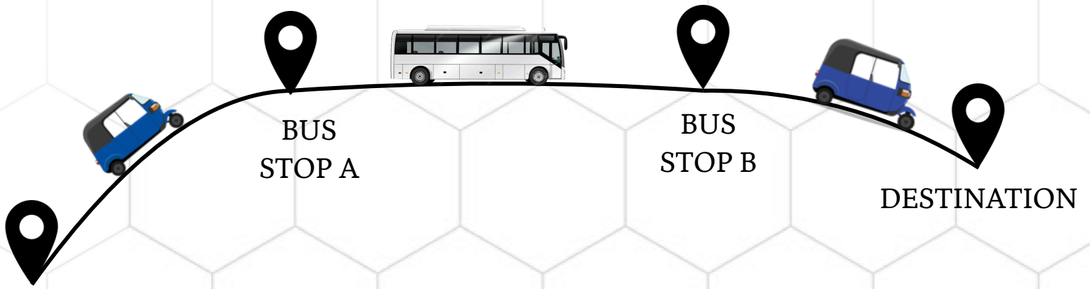
- Heuristic pa and pb models, inversely proportional to SDR, finely tuned using submission evaluation for accuracy.
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Task -2 Autorickshaw Total Trip Time

Novelty & Results



Modeling Approach

- Introduced a refined SDR formula that integrates trip starts, ends, intra-hex rides, and idle vehicles with Laplace smoothing to capture true supply–demand balance
- Graph-based pc model utilizing OSMnx for shortest path calculations, optimizing route efficiency.

$$\text{SDR} = \frac{(\text{End Count} + \text{Idle Count}) + 0.5}{(\text{Start Count} + \text{Intra-Hex Rides}) + 0.5}$$

$$\text{log_transformed_sdr} = \log(1 + \text{weighted_sdr})$$

$$\text{prob} = \frac{1}{1 + e^{-(\alpha \cdot \text{log_transformed_sdr} + \beta)}}$$

$$\text{predicted_pa} = 9.0 \times (1 - \text{prob})$$

Task 3 - Multi-Modal Journey

Architecture

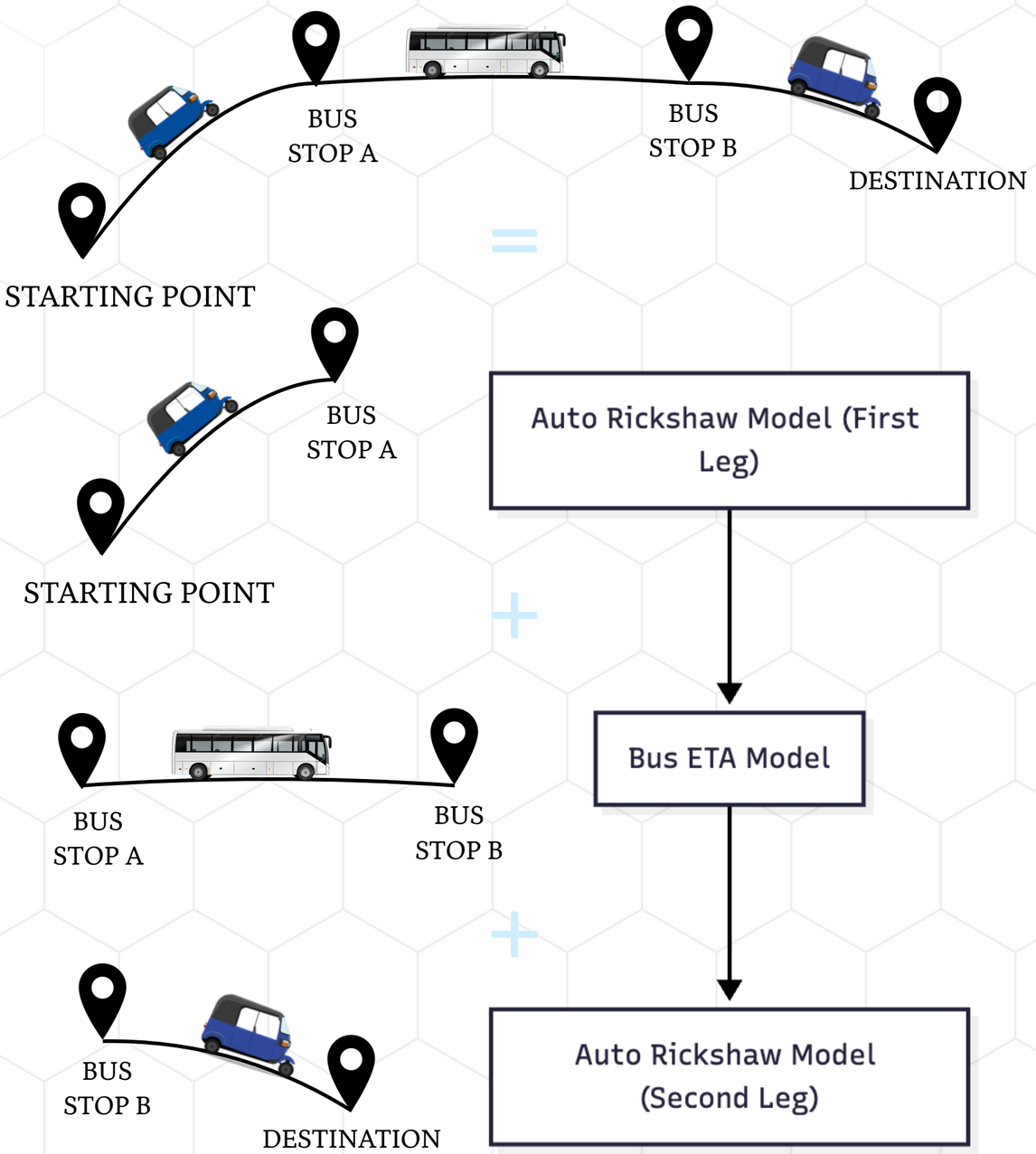
Objective

Predict a journey for a bi-modal trip:

- Auto → Bus → Auto.

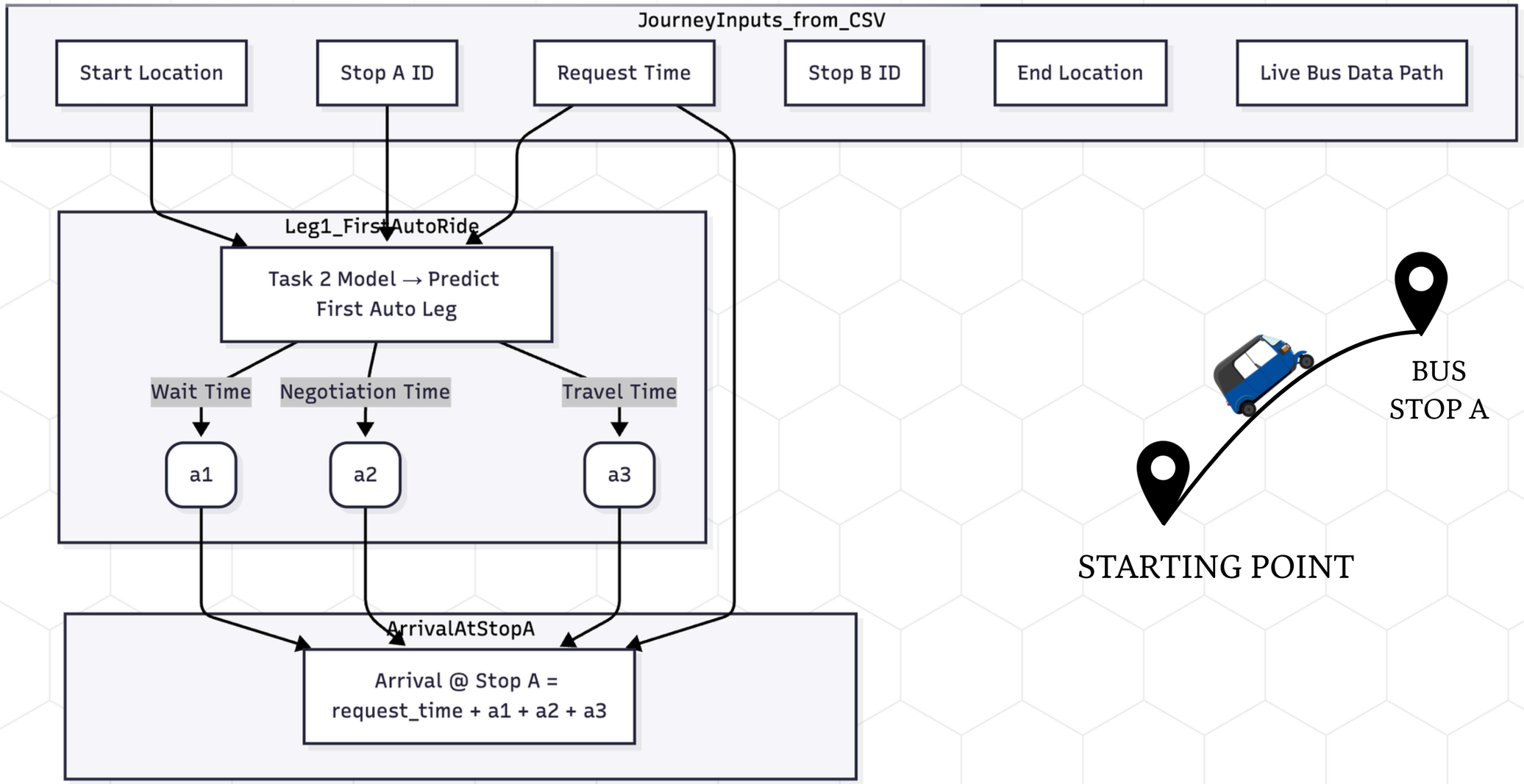
Modeling Approach

- Chaining of the specialized Task 1 and Task 2 models into a single, cohesive pipeline that simulates the entire journey.
- Dynamic Transfer Modeling: Bus wait time is dynamically computed based on the passenger's predicted arrival and the live bus's ETA, rather than using a static average.



Task 3 - Multi-Modal Journey

First leg of Auto Rickshaw Model



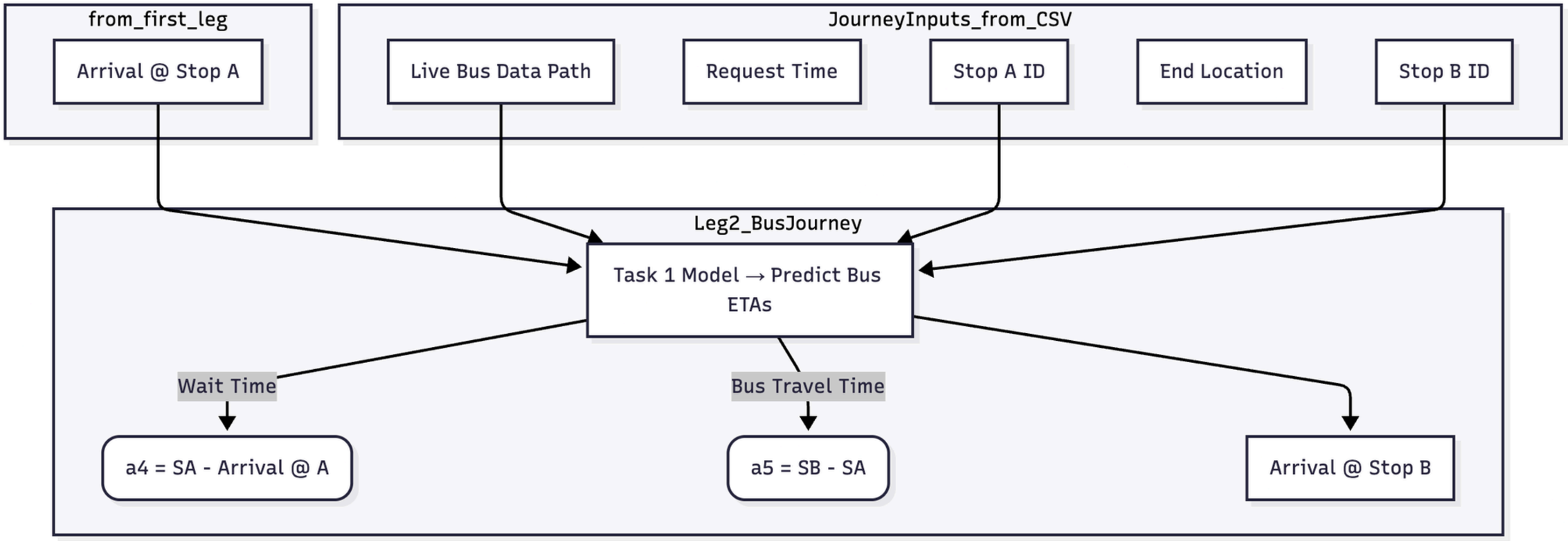
Task 3 - Multi-Modal Journey

Bus Model



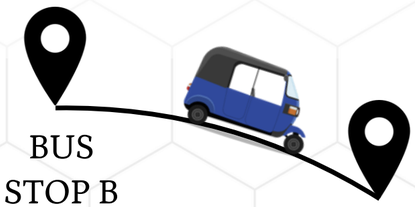
BUS
STOP A

BUS
STOP B



Task 3 - Multi-Modal Journey

Second leg of Auto Rickshaw Model



fron_bus_model

Arrival @ Stop B

JourneyInputs_from_CSV

Stop A ID

Request Time

Stop B ID

End Location

Live Bus Data Path

Leg3_SecondAutoRide

Task 2 Model → Predict
Second Auto Leg

Wait Time

Negotiation Time

Travel Time

a6

a7

a8


THANK YOU!