AIoT-Enabled Smart Traffic Management for Sustainable and Low-Carbon ASEAN Cities

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Problem Background

Jakarta ranked top-10 globally for congestion [1]

Bangkok drivers lose ~100+ hours/year in congestion [1]

Two-wheelers dominate; emissions and safety concerns rising [2]

WHY?

TRAFFIC LIGHT CONTROL

- Inductive loop signals
- Timed based control

LOCAL DECISION MAKING

- Disorganized flow
- Local control
- Limited real time coordination

ASEAN Smart CIties Network (ASCN) calls for synchronised, smart mobility upgrades [3]

[1] Global Traffic Scorecard 2024, INRIX Report
[2] Nguyen Thi Bich, H.; Le Dinh, T. Overcoming Barriers to Sustainable Green Transportation in Ho Chi Minh City: A Pathway Toward Achieving SDGs 11 and 13. Sustainability 2024, 16, 10629.
[3] ASEAN Monotoring & Evaluation Report 2024, ASEAN Smart Cities Network (ASCN)

Aim and Objectives

The aims of this project to develop a scalable, sustainable, and resilient traffic orchestration model, tailored specifically to the infrastructural and societal needs of ASEAN smart cities.

To Design Data Fusion Framework

Integrate real-time data from various sources to enhance traffic visibility

To Develop AI Traffic Control Models

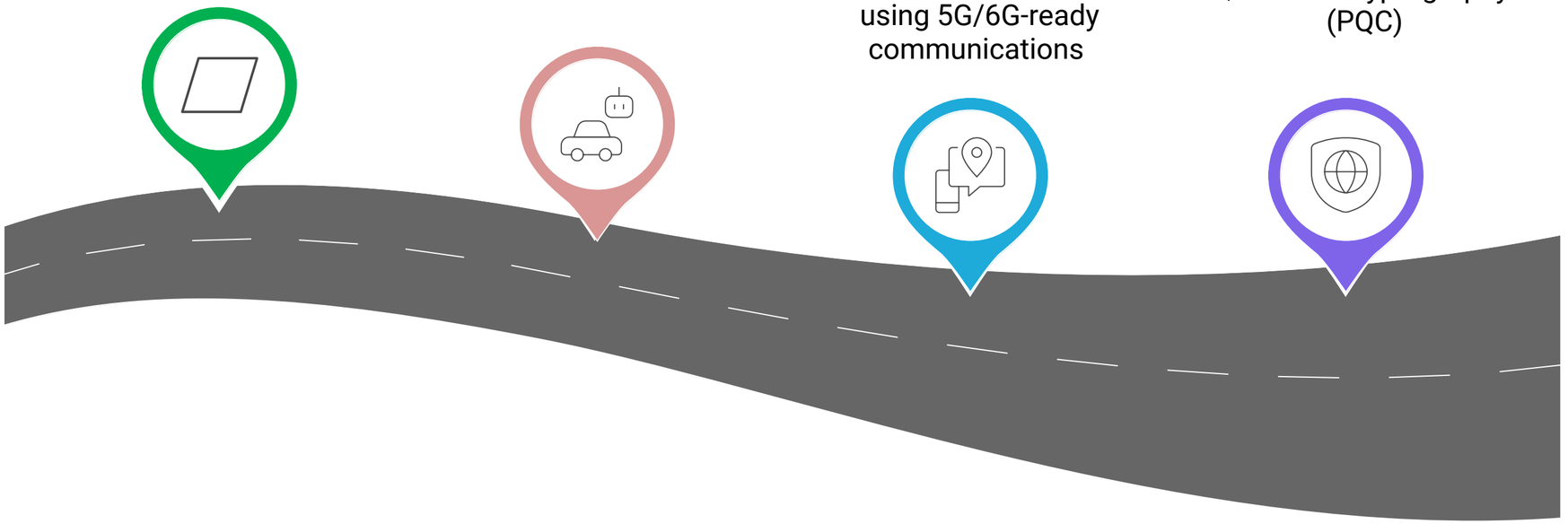
Use AI to predict and adapt traffic control based on congestion

To Implement and evaluate an AIOT Reference Architecture

Deploy the end-to-end architecture using 5G/6G-ready communications

To Embed Cybersecurity Framework

Ensure operational security and data privacy using Post Quantum Cryptography (PQC)



Proposed Method: Conventional Traffic Management Model

Communication & Security

- Conventional password/VPN
- Communication via copper/fiber/4G; bandwidth used mainly for status polling and occasional detector counts.

Central Monitoring/ Coordination

- Used to adjust signal timings based on loop data at selected junctions
- Monitor status of signals.
- No data analysis

Local Controller Layer

Intersection controllers

- Fixed-time (pre-timed) plans OR actuated / semi-actuated control using loop inputs.
- Limited or no coordination between adjacent intersections.

Sensing & Field devices layer

Traffic controller

Loop sensors

Pedestrarian push button

Monitoring CCTV

Data

Command

→ Secure 5G/6G backbone Embedded cybersecurity & privacy

→ Deep learning model for traffic planning

→ Edge intelligence

→ Multi modal sensing

Proposed Method: Enhanced Traffic Management Model

Centralized Traffic Management Layer

- Fuses data from many edges.
- Runs AI/RL/forecast models to learn patterns (peak hours, bottlenecks, incidents)
- Updates global control policies, coordination plans

- New signal timing plans / phase splits.
- Priority rules (e.g. emergency vehicles, buses).
- Speed recommendations, route guidance, lane control rules.

5G/6G with encryption + integrity protection

Edge Intelligence Layer

Edge node at/near the junction

- Pre-processes video/data (object detection, counting, incident flagging).
- Filters noise, extracts features, aggregates short-term statistics.

Each edge node:

- Translates global strategy into local control parameters (cycle time, offsets, green splits, threshold values).

Signed/encrypted (where feasible)

Sends real-time commands

Sensing layer & Control layer

Capture traffic and environment

Loop sensors

AI camera

License Plate Recognition (LPR)

Automatic Number Plate Recognition (ANPR)

IoT control

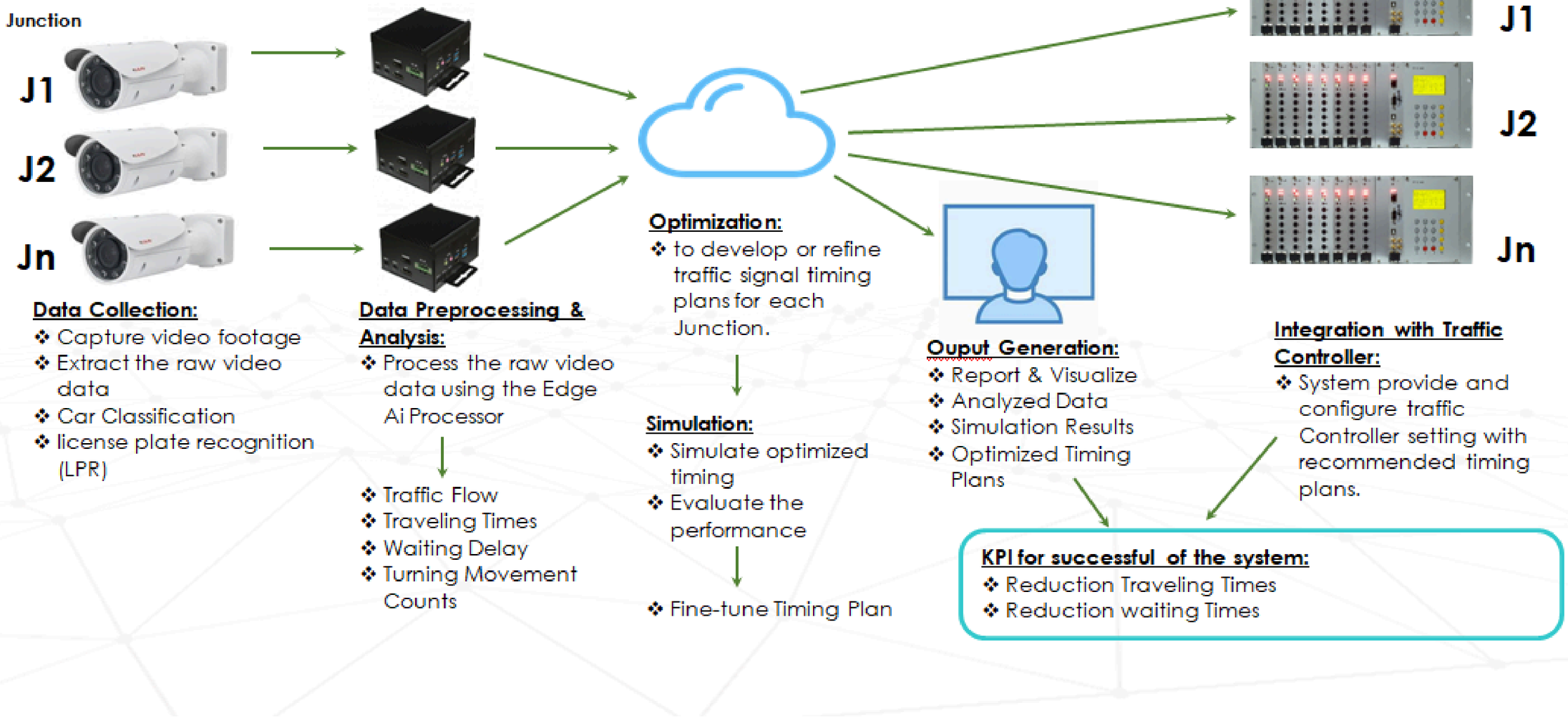
- Traffic signal controllers
- Variable message signs
- Smart crossing, bollards

Data

Command

A robust cybersecurity and data privacy framework based on Post Quantum Cryptography (PQC) is embedded throughout the system to ensure resilience against threats and compliance with privacy standards, especially for mobile and video data

Proposed Method: Pre-Experimental Setup



Impact: Scientific & Technological Impact

The proposed model upgrades legacy fixed-time and loop-based control into a secure AIoT orchestration framework tailored for ASEAN intersections.

1 Multimodal Sensing & Data Fusion

- Fuse CCTV analytics, roadside IoT sensors, and anonymised network/probe data.
- Improve accuracy of traffic state, incidents, and demand patterns.

2 Edge Intelligence & AI Control

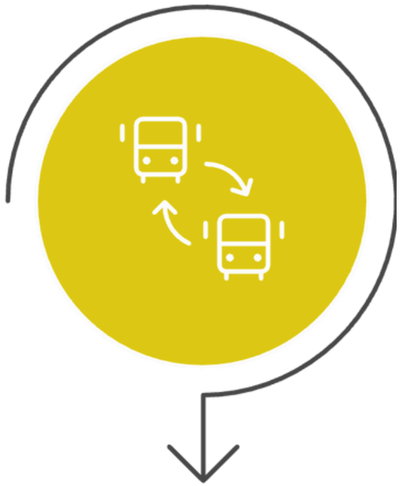
- Run detection, prediction, and RL-based signal timing at edge nodes.
- Enable real-time response with low latency and coordinated corridors.

3 Secure 5G/6G-Ready Architecture

- Use reliable links for video + control with end-to-end encryption.
- Design is post-quantum–ready to protect critical transport infrastructure.

Impact: Societal, Environmental & Policy Impact

Commuters & Operators

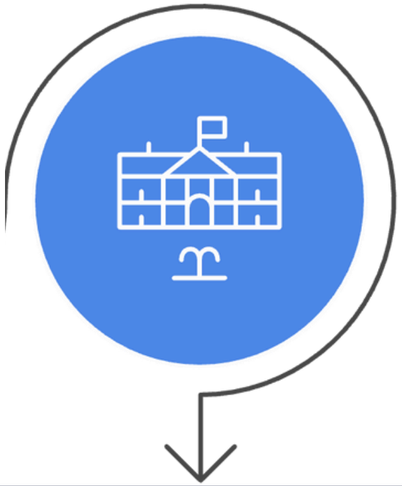


- Shorter and more reliable travel times.
- Faster incident detection and safer junctions.
- Priority for emergency and public transport.

Environment & Economy

- Smoother flow → less idling, lower fuel use and emissions.
- Cost-effective migration path using current CCTV and controllers.

Policymaker



- Aligned with ASEAN smart city and ITS roadmaps.
- Built-in cybersecurity, auditability, and privacy for video and mobility data.

Impact: Collaborative

- TelkomU, UTM
- Validate 5G/B5G slices and QoS for safety-critical traffic control

Low latency Communication system

- UTM , MIMOS, Meiji University
- Co-develop RL/AI modules, publish open algorithms and datasets.

Edge intelligence

Embended cybersecurity based on PQC

- NECTEC, TelkomU
- Quantum-safe, end-to-end security stack for ITS.

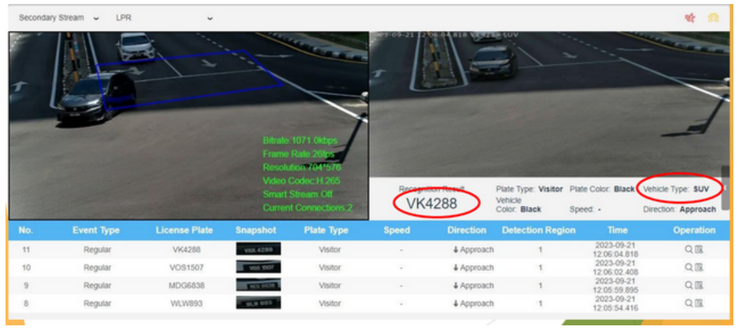
Integrated ASEAN AIoT Traffic Orchestration Prototype

- UTM, VNU JKR, PPK
- Deploy and benchmark sensor fusion at real intersections.

Multimodal sensing

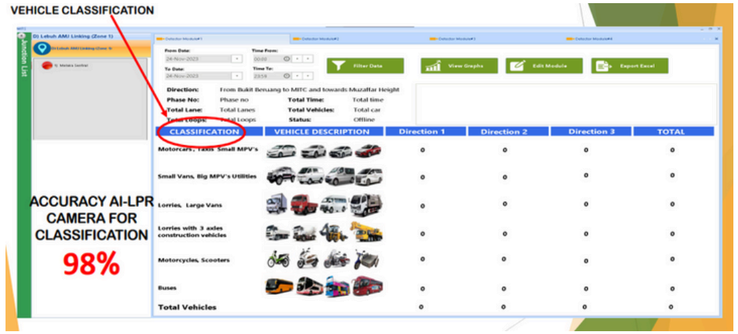
A shared reference platform and testbed

Output/Outcome: Preliminary Outputs & Existing Capabilities



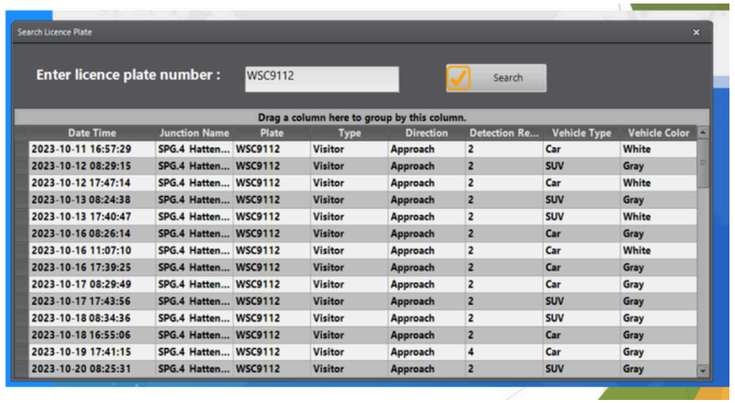
Automatic License Plate Recognition & Vehicle Detection

- Working LPR engine and dashboard for plate capture, event logging, and search.
- Demonstrates our ability to process real junction video streams in real time.



Vehicle Classification & Analytics

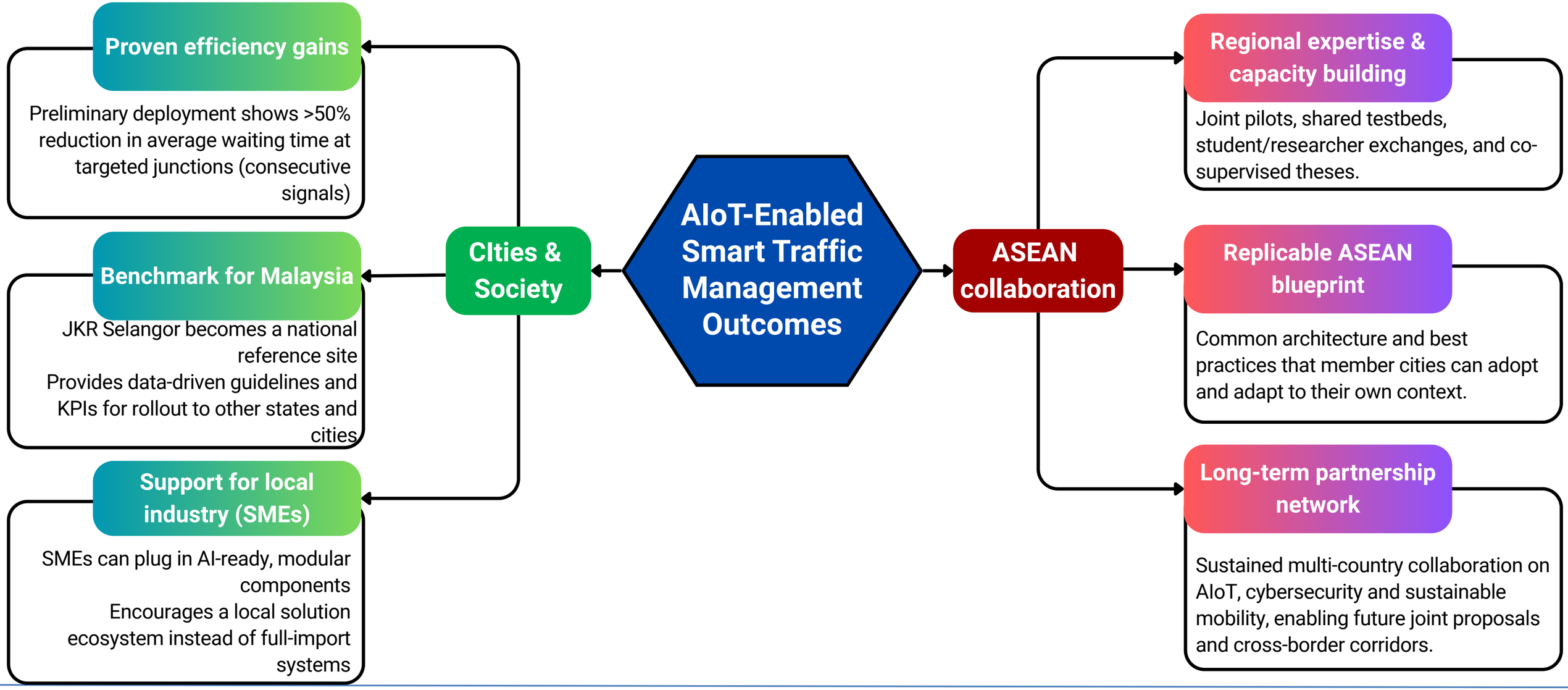
- Prototype that classifies vehicle types and counts with high accuracy.
- Provides input features (class, flow, approach) needed for adaptive signal control and demand modelling.



Integrated Monitoring Interface

- Existing UI/database to store events, support queries, and visualise traffic behaviour.
- This will evolve into the edge–cloud data fusion and control interface in the proposed project.

Output/Outcome:Societal, Industrial & Collaborative Outcomes



Conclusion & Way Forward

AIoT-enabled, edge–cloud, PQC-ready traffic orchestration model that upgrades existing ASEAN junctions from fixed-time control to data-driven, adaptive, and secure operations.

DELIVERABLES

Multimodal sensing + edge intelligence + low-latency communication + embedded cybersecurity as one reference architecture for ASEAN cities.

Preliminary trials indicate >50% reduction in waiting time at selected consecutive junctions, showing strong feasibility for real deployments.

Clear guidelines, algorithms, and modules that road authorities and SMEs can adopt to scale smart traffic systems across Malaysia and the region.

Form a practical model for ASEAN cities, expected to improve travel times, safety, and emissions, and to support local innovation and long-term regional cooperation