IOT TRAFFIC MANAGEMENT SYSTEM

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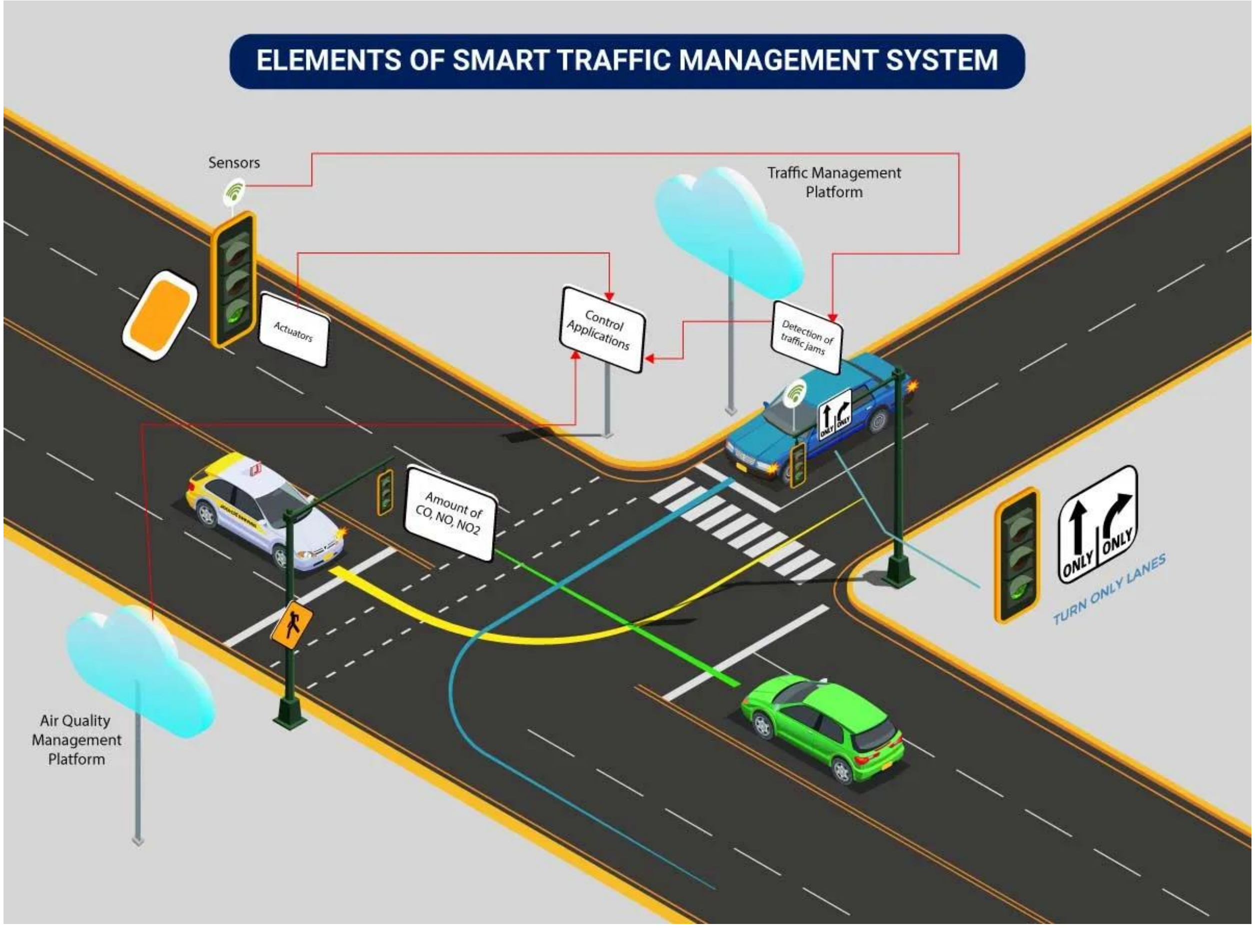
Phase 3 Submission Document

Project: Traffic Management



INTRODUCTION

The sustainability and smartness of the smart city concept rely on the technologies adopted to improve the people's quality of life. The smart city governance is one significant aspect of smart city initiatives, which will facilitate the planning techniques for better decision making. One of the key elements of the smart city governance framework is the public value generated out of the smart services provided.

- The government has to work on different aspects of smart city solutions such as smart health care, smart building management, smart traffic management, smart parking solutions, smart transportation, etc. to generate public value for the service they provided.

- The emergence of the internet of things (IoT) has evolved the concept of smart cities. In a smart city environment, the physical infrastructures of the city are equipped with smart devices, which continuously produce multidimensional data in different spaces and these data are processed to achieve intelligence for the infrastructure

- Ultimately, intelligence is applied to improve the socio-economic activities of the society.

- Smart traffic infrastructure is an essential component of smart city initiatives because traffic congestion is a severe issue that grows along with city development.

- Smart traffic management includes intelligent transport systems with integrated components like adaptive traffic signal controls, freeway management, emergency management services, and roadside units .

- Such systems collect real-time traffic data and take necessary measures to avoid or minimize any social issue created as part road congestions

- For example, access to real-time traffic maps will assist the residents in selecting appropriate route to save time and effort.

- The traffic pattern of urban roads or highways is different from that of collector roads.

- The users of collector roads include pedestrians, bicycles, motorbikes, and other vehicles; hence, the traffic pattern is different from the highways.

Wireless sensors for vehicle data collection

This section presents the review of sensors that are used for vehicle detection and classification.

The sensors used in intelligent traffic monitoring systems can be on-road sensors or in-vehicle sensors.

The on-road traffic sensors can be again classified into two types: intrusive and non-intrusive.

The intrusive sensors are paved on the road and are costly compared to non-intrusive sensors.

The intrusive sensors provide accurate information; however, they are questioned for the expenses in terms of installation. maintenance, repair costs.

The maintenance of such sensors requires road lane closures and traffic disruptions.

The non-intrusive sensors can be fixed on different parts of roads/roadsides.

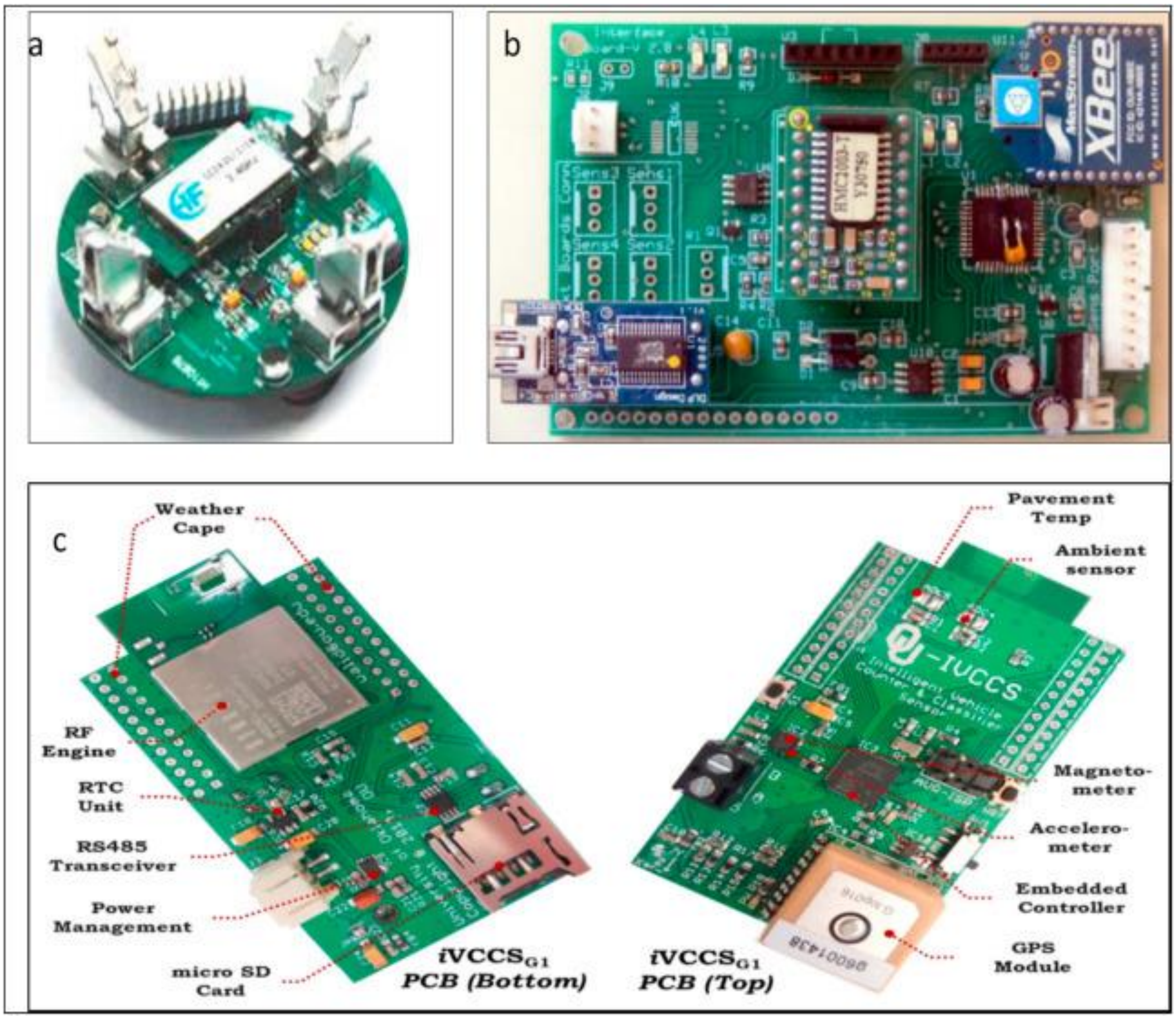
This includes magnetic sensors, ultrasonic sensors, infrared sensors, acoustic sensors, video cameras; Each sensor has its advantages and disadvantages.

The ultrasonic sensors are prone to environmental factors . The video monitoring systems are comparatively costly than other sensors when considering the purchase, installation, and maintenance costs.

The vehicle speed and length can be estimated by one or more magnetic sensors, which will help to approximate the road space occupancy measure.

Besides different types of sensors, a few research efforts have attempted to develop printed circuit boards (PCBs), which can be directly adapted for vehicle detection/speed estimation/classification such as PRS, LCTS , iVCCS, and CPIUS .

shows the PCBs of PRS, LCTS, and iVCCS sensor nodes.



(a) LCTS Sensor Node

(b) PRS Physical Board

(c) iVCCS Physical Board

a) LCTS is another low-speed congested traffic sensor node with a magnetic sensor specifically for a single lane road.

- The sensor node is designed using magnetic sensor HMC5883L. In addition to the magnetic sensor, the node also contains a sound sensor and four infrared sensors.
- However, the magnetic sensor alone performs vehicle detection and classification.
- The validation results show a detection accuracy of 99.05% and a classification accuracy of 93.66%.

b) PRS is a portable roadside sensor for vehicle detection, counting, classification, and speed estimation

- PRS uses a magnetic sensor for vehicle detection. The single PCB board of PRS contains two magnetic sensors (HMC2003).
- This sensor uses the XBee module for wireless communication. PRS shows an accuracy of 99% in vehicle detection, and the maximum error rate of speed estimation is 2.5% (in a range of 5–27 m/s). Besides, the system also detects the right intersection.
- The vehicle length and height are estimated from the magnetic length.

c)The iVCCS is an intelligent vehicle counting and classification sensor;

- the node has different sensors and components such as temperature sensor, accelerometer, magnetic sensor, GPS module, real-time clock unit, memory unit, etc.
- The iVCCS is a small battery-powered node with a 6-axis magnetic sensor and accelerometer FXOS8700.

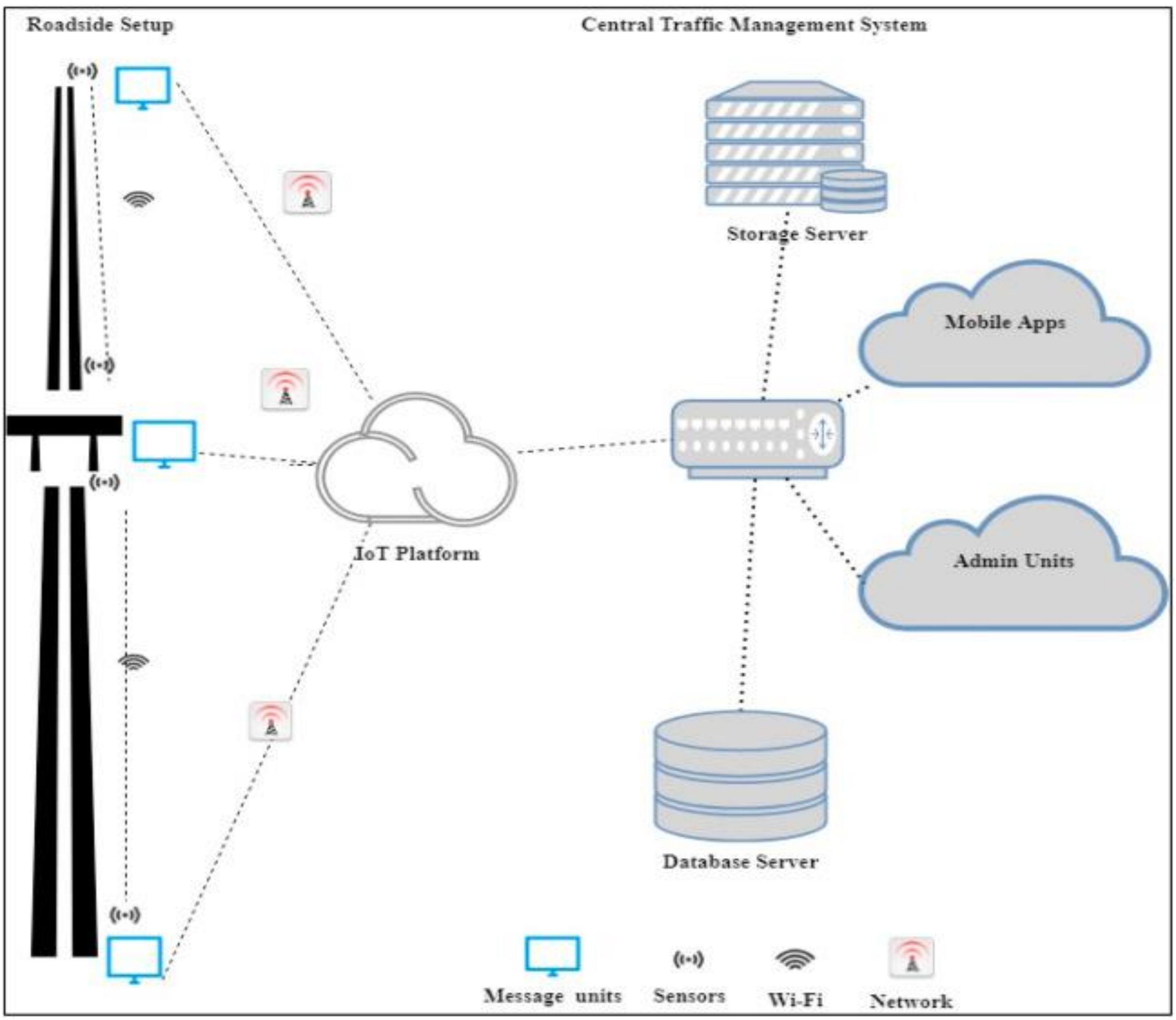
System design and development

This section discusses the proposed system model, different software and hardware components required, and algorithms to implement the proposed system.

The proposed system communication model is presented in , which has components installed at the roadside and a cloud-based central server.

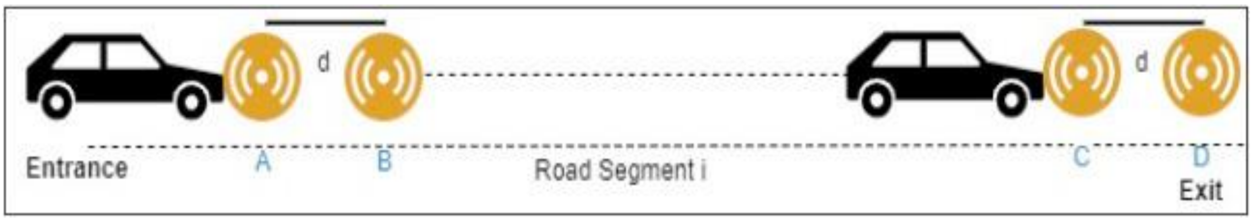
The roadside setup includes sensors and message boards. The sensors and boards will be installed between two road segment intersections.

The central server includes data storage, cloud services, and interfaces. The components can communicate with each other using WIFI.



Road occupancy and growing queues

The traffic congestion measures are mostly based on parameters such as speed, time and delay, reliability, service, space, etc. The road space occupancy is one such measure to determine the growing traffic queue. illustrates how the road occupancy measure is calculated. The VPL is estimated by the sensors when the vehicle crosses the sensor nodes, the physical length is added to the road occupancy measure and subtracts the length when the vehicle departs at exit points as in When sensor C detects a vehicle, sensor node D will estimate the physical length and send it to sensor B. The microcontroller associated with sensor B holds the occupancy measure and sends real-time traffic updates.



The road occupancy measure is estimated from vehicle physical length at the entrance and exit of the road segment.

The traffic warning message can be of two types:

(i) real-time updates on traffic density

(ii) messages on unusual road incidents by authorities.

- These updates can be accessed by drivers while driving through different modes such as smart mobile applications, radios, televisions, etc.
- Another method is to use roadside message boards at significant intersections.
- These units will reach the maximum public and help them to take alternate routes.

Vehicle detection and road occupancy estimation

The vehicle detection has been tested using a single roadside node. the experiment setup and the magnetic field fluctuations of a Renault Duster car when the sensor is placed at a distance of 100 cm. The earth's magnetic field flux intensity f, the geomagnetic field components x, y, z when the sensor detects a vehicle.

The relative error (RE) metric is used to evaluate both vehicle detection and road occupancy estimation. The system detected 30 vehicles and the accuracy of detection is 100%. The detection accuracy of this setup and the vehicles detected in an experiment at Road A, Road B, and Road C.

Road	Road Length	Actual Occupancy	Estimated Occupancy	Relative Error
A	300M	240M	254M	5.8%
B	200M	170M	182M	7.5%
C	400M	320M	338M	5.6%
Total	900M	730M	774M	Average = 6.35%

The system shows an average relative error of 6.35%. These results are achieved for passenger cars.

The medium, medium-long, or long vehicles are not considered, which is a limitation of this evaluation. As the length of the road increases, the error percentage also decreases. Hence, the system is expected to perform better in real road scenarios.

Python script on the IoT devices to send real-time traffic data to the traffic information platform.

Before running the script, make sure you have the required Python libraries installed. You can install the paho-mqtt library for MQTT communication:

pip install paho-mqtt

Here's a basic Python script:

```
import paho.mqtt.client as mqtt
import json
import time

# Configuration for the MQTT broker
broker_address = "mqtt.example.com"
port = 1883
topic = "traffic_data"
client_id = "traffic_sensor_1"

# Sample traffic data
traffic_data = {
    "location": "intersection_A",
    "timestamp": int(time.time()),
    "vehicle_count": 50,
```

```
        "average_speed": 40,
        "congestion_level": "low",
    }
def on_connect(client, userdata, flags, rc):
 if rc == 0:
            print("Connected to MQTT broker")
        else:
            print(f"Connection failed with code {rc}")

    def on_publish(client, userdata, mid):
        print(f"Message {mid} sent to topic {topic}")

    # Initialize MQTT client
    client = mqtt.Client(client_id)
    client.on_connect = on_connect
    client.on_publish = on_publish

    # Connect to the MQTT broker
    client.connect(broker_address, port, 60)

    try:
        while True:
            # Simulate data collection (replace with actual sensor data)
            traffic_data["timestamp"] = int(time.time())
            traffic_data["vehicle_count"] = 50 + int(10 * (time.time() % 10))
```

```
        traffic_data["average_speed"] = 35 + int(5 * (time.time() % 10))
        traffic_data["congestion_level"] = "low" if (time.time() % 20) < 10 else
      "high"

        # Publish data to the MQTT topic
        payload = json.dumps(traffic_data)
        client.publish(topic, payload)

        # Send data every 5 seconds (adjust the interval as needed)
        time.sleep(5)

except KeyboardInterrupt:
    print("Script terminated")

# Disconnect from the MQTT broker
client.disconnect()
```