SMART TRAFFIC MANAGEMENT SYSTEM USING CLOUD COMPUTING

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Abstract---
Traffic congestion is a major problem in many cities worldwide, including India. Poor traffic management, law enforcement, and signal failure contribute to the issue. Unfortunately, expanding infrastructure is not always an option. Traffic congestion negatively impacts the economy, environment, and quality of life. To address this, smarter traffic management is necessary. The current system relies on manual control, which is inefficient and lacks real-time data. A smarter approach uses a management system that controls traffic lights based on real-time data from sensors or Google Maps. This system optimizes green signal release, reducing fuel consumption and health issues caused by manual errors.

Keywords— Traffic Management, Cloud Computing

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I.INTRODUCTION

In today's world, traffic congestion has become a major hurdle in transportation systems. Recent statistics reveal that transportation ranks second in greenhouse gas emission factors in the USA (STATISTICS, 2015). The impact of traffic congestion is staggering, with 6.9 billion hours of citizenry and 3.1 billion gallons of fuel wasted in 2014 alone, resulting in a loss of 160 billion dollars to the US economy (STATISTICS, 2015). While infrastructure improvement is an expensive solution to this challenge, a Traffic Management System (TMS) can be a crucial component of an Intelligent Transportation System (ITS) that can potentially reduce road traffic congestion, improve response time to incidents, and enhance the travel experience for commuters. The TMS offers several essential services, including vehicle routing to shorten commuter journey, traffic prediction that enables early detection of bottlenecks, parking management that ensures optimal usage of parking spots, and infotainment services that provide useful information for both drivers and passengers (Djahel et al., 2015). Traffic congestion arises when the number of vehicles on the road exceeds its capacity, leading to slower speeds, increased trip time, and queuing of vehicles. In India's metropolitan cities, traffic congestion is a major problem caused by saturation, where demand outweighs available road capacity. Individual incidents, such as accidents or sudden braking, can have rippling effects, leading to traffic jams. Additionally, anti-social elements can cause severe security problems in traffic systems, leading to stagnation of traffic in one place. In India, congestion results in an annual loss of Rs 60,000 crores, including fuel wastage. Congestion has also led to reduced speed of freight vehicles, increased waiting time at checkpoints and toll plazas. The average speed of vehicles on key corridors like Mumbai-Chennai and Delhi-Chennai is less than 20kmph, while it is a mere 21.35kmph on the Delhi-Mumbai stretch. According to the transport corporation of India and IIM, India's freight volume is increasing annually at a rate of 9.08%, and that of vehicles at 10.76%, but that of the road is only by 4.01%. This has resulted in reduced road space in accordance with the number of total vehicles. The average fuel mileage in India is only 3.96kmpl, primarily due to traffic congestion. As India is the second-most populated country in Asia after China, with an increase in population, the number of vehicles also increases. Economic growth has also had an impact on urban traffic, with rising incomes leading to more people opting for cars rather than two-wheelers. Therefore, there is a need to manage traffic in a smart way, as conventional methods like signaling systems have not been effective in curbing vehicular traffic congestion

II. Literature Review

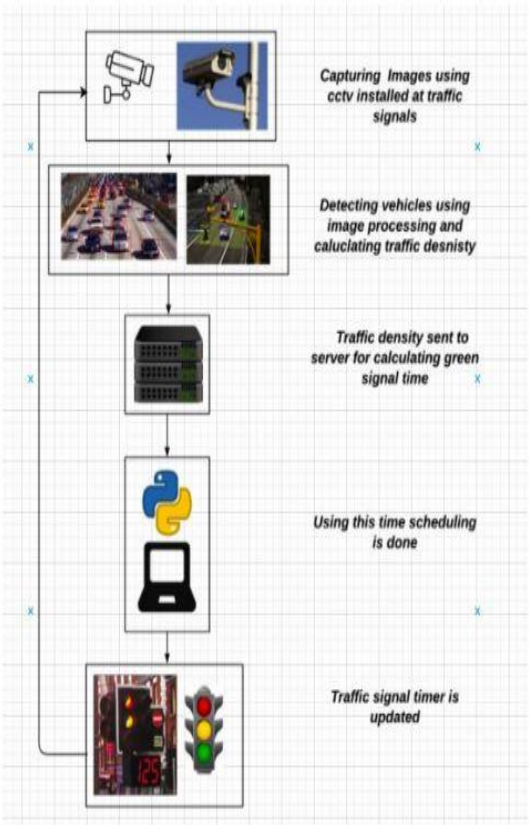
Traffic congestion is a common problem that affects both peak and regular hours, which slows down the speed of vehicles. Unfortunately, the current infrastructure has limited resources to control traffic, which exacerbates the issue. However, real-time traffic density management using the Internet of Things (IoT) has proven to be an effective solution. By optimizing traffic switching and controlling traffic flow, it helps prevent congestion and provides updates on traffic status through a website. This allows people to avoid traffic jams and find alternative routes. During emergencies, this system also enables faster access for vehicles to reach their destinations. To further improve the traffic monitoring system, the author proposes a framework based on traffic density. This framework aims to reduce vehicle emissions in the most polluted road sections while maximizing vehicle flow. To achieve this, the framework utilizes data from air quality monitoring stations, low-cost pollution sensors, contextual data, and road network data. These data are used to calculate air quality indexes and generate a dynamic traffic network represented by a weighted graph that evolves according to pollution indexes. The author also suggests combining agent technology with machine learning and Big Data tools, such as Artificial Neural Networks (ANN) and the Dijkstra algorithm, for air quality prediction and finding the least polluted path in the road network. All data processing is performed over a Hadoop-based framework, using HBase and MapReduce. Moreover, the author proposes an intelligent traffic light controlling algorithm that coordinates with each other to generate an efficient traffic schedule for the entire road network. The algorithm considers real-time traffic characteristics of the competing traffic flows at signalized road intersections and adopts the ITLC algorithm to design a traffic scheduling algorithm for an arterial street scenario. This arterial traffic light (ATL) controlling algorithm aims to reduce traffic congestion and improve traffic flow. In summary, the proposed framework and algorithms offer a comprehensive solution to traffic congestion and air pollution. By utilizing IoT, machine learning, and Big Data tools, this system can optimize traffic flow, reduce emissions, and provide real-time updates to commuters.

III. EXISTING SYSTEM

Traffic management in many areas is still reliant on the presence of traffic police officials. While this may appear to be an effective method, there are some significant drawbacks to this approach. For one, the system is not always capable of dealing with the complexities of traffic congestion, often leaving drivers frustrated and stuck in gridlock. Additionally, the decision-making process of traffic police officials can be unpredictable, leading to situations where roads are blocked for extended periods of time or vehicles are allowed to pass through intersections without proper consideration. Even the use of traffic lights, which are intended to provide a more automated solution to traffic control, can be limited in their effectiveness. The timings for red and green signals are often fixed, meaning that they may not be responsive enough to adjust to changing traffic conditions. As a result, the problem of traffic congestion persists, even in areas where traffic lights are installed. In some regions, traffic police officials continue to be present on duty, despite the presence of traffic lights. This suggests that the system requires a significant amount of manpower to function effectively, which can be both costly and inefficient. Ultimately, it is clear that a more intelligent and efficient method of traffic management is needed to address the challenges of congestion on our roads.

IV. PROPOSED FRAMEWORK

Our cutting-edge proposed system is designed to revolutionize traffic management by utilizing advanced image processing and object detection techniques. The system takes input from CCTV cameras installed at traffic junctions, enabling real-time traffic density calculation. The system comprises three modules, each playing a crucial role in ensuring seamless traffic flow. The first module, the Vehicle Detection module, employs YOLO to detect the number of vehicles of each class – cars, bikes, buses, and trucks – in the image captured by the CCTV camera. This information is then used to calculate the density of traffic at the intersection. The second module, the Signal Switching Algorithm, utilizes the traffic density data, along with other factors, to determine the optimal green signal timer for each lane. This ensures that traffic is efficiently managed, and red signal times are updated accordingly. To prevent the starvation of any particular lane, the green signal time is restricted to a maximum and minimum value. Finally, the Simulation module is developed to showcase the system's effectiveness and compare it with the existing static system. This simulation highlights the system's ability to accurately calculate traffic density and adjust signal timings in real-time, resulting in smoother traffic flow and reduced congestion.



4. METHODOLOGY:

The Signal Switching Algorithm is a complex system that is designed to optimize traffic flow at intersections. It takes into account a number of factors, including the density of traffic, the number of vehicles in each class, and the processing time required to calculate the green light duration. This information is fed into the algorithm in JSON format, with the object label serving as the key and the confidence and coordinates as the values. Once the input is parsed, the algorithm calculates the total number of vehicles in each class and assigns a green signal time accordingly. It also adjusts the red signal timers of other signals to ensure that traffic flow is optimized. This process is repeated cyclically, with the algorithm switching between signals according to the timers. One of the key considerations in developing the algorithm was the processing time required to calculate traffic density and the green light duration. This information is used to determine when the image needs to be acquired. Other factors, such as the number of lanes, the total count of vehicles, and the traffic density, are also taken into account. In addition, the algorithm considers the time added due to lag each vehicle suffers during start-up and the non-linear increase in lag suffered by vehicles at the back. The

average speed of each class of vehicle when the green light starts and the minimum and maximum time limit for the green light duration are also factored in to prevent starvation. Overall, the Signal Switching Algorithm is a sophisticated system that can be scaled up or down to any number of signals at an intersection. Its ability to optimize traffic flow and reduce congestion makes it an essential tool for traffic management.

IMPLEMENTATION

Upon initializing the algorithm, the default time is established for the first signal within the initial cycle. Subsequently, the algorithm sets the times for all other signals within the first cycle, as well as all signals within subsequent cycles. A separate thread is then initiated to handle the detection of vehicles for each direction, while the main thread manages the timer of the current signal.

As the green light timer of the current signal (or the red-light timer of the next green signal) approaches zero seconds, the detection threads capture a snapshot of the next direction. The resulting data is parsed, and the timer of the next green signal is set accordingly. All of this occurs seamlessly in the background, allowing for the timer assignment to remain uninterrupted and preventing any potential lag.

Once the green timer of the current signal reaches zero, the next signal in the sequence becomes green for the duration of time set by the algorithm. An image is captured at the precise moment the signal that is next to turn green reaches zero seconds. This provides the system with a total of five seconds (equal to the value of the yellow signal timer) to process the image, detect the number of vehicles of each class present in the image, calculate the green signal time, and subsequently set the times for both the current and next signals. To optimize traffic management, the average time it takes for each class of vehicle to cross an intersection can be customized based on location, such as region, city, locality, or even intersection-specific characteristics. This can be achieved by analysing data from respective transport authorities.

$$GST = \frac{\sum_{vehicleClass} (NoOfVehicles_{vehicleClass} * AverageTime_{vehicleClass})}{(NoOfLanes + 1)}$$

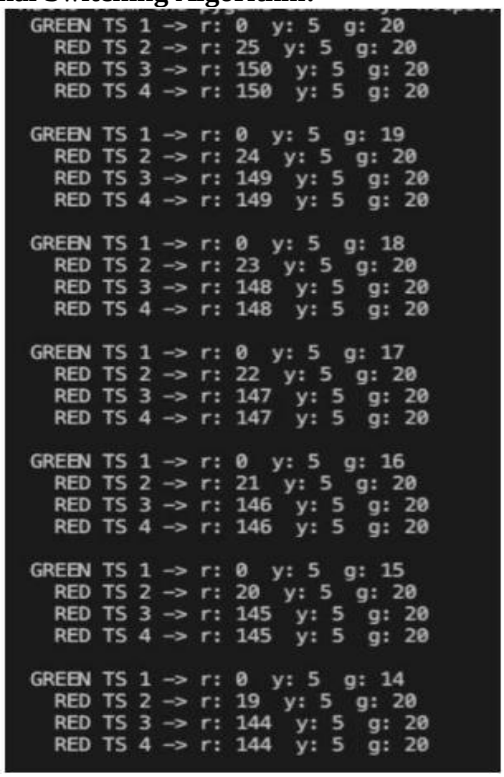
Where:

- GST is green signal time
- no of Vehicles of Class is the number of vehicles of each class of vehicle at the signal as detected by the vehicle detection module,
- Average Time of Class is the average time the vehicles of that class take to cross an intersection, and
- no of Lanes is the number of lanes at the intersection

The signals switch in a cyclic fashion and not according to the densest direction first. This is in accordance with the current system where the signals turn green one after the other in a fixed pattern and does not need the people to alter their ways or cause any confusion. The order of signals is also the same as the current system, and the yellow signals have been accounted for as well

Order of signals: Red → Green → Yellow → Red

Following are some images of the output of the Signal Switching Algorithm:



```
GREEN TS 1 -> r: 0  y: 5  g: 20
  RED TS 2 -> r: 25  y: 5  g: 20
  RED TS 3 -> r: 150  y: 5  g: 20
  RED TS 4 -> r: 150  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 19
  RED TS 2 -> r: 24  y: 5  g: 20
  RED TS 3 -> r: 149  y: 5  g: 20
  RED TS 4 -> r: 149  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 18
  RED TS 2 -> r: 23  y: 5  g: 20
  RED TS 3 -> r: 148  y: 5  g: 20
  RED TS 4 -> r: 148  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 17
  RED TS 2 -> r: 22  y: 5  g: 20
  RED TS 3 -> r: 147  y: 5  g: 20
  RED TS 4 -> r: 147  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 16
  RED TS 2 -> r: 21  y: 5  g: 20
  RED TS 3 -> r: 146  y: 5  g: 20
  RED TS 4 -> r: 146  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 15
  RED TS 2 -> r: 20  y: 5  g: 20
  RED TS 3 -> r: 145  y: 5  g: 20
  RED TS 4 -> r: 145  y: 5  g: 20

GREEN TS 1 -> r: 0  y: 5  g: 14
  RED TS 2 -> r: 19  y: 5  g: 20
  RED TS 3 -> r: 144  y: 5  g: 20
  RED TS 4 -> r: 144  y: 5  g: 20
```

(i): Initially, all signals are loaded with default values, only the red signal time of the second signal

is set according to green time and yellow time of first signal.

```
  GREEN TS 1 -> r: 0  y: 5  g: 1
    RED TS 2 -> r: 6  y: 5  g: 20
    RED TS 3 -> r: 131  y: 5  g: 20
    RED TS 4 -> r: 131  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 5  g: 0
    RED TS 2 -> r: 5  y: 5  g: 20
    RED TS 3 -> r: 130  y: 5  g: 20
    RED TS 4 -> r: 130  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 4  g: 0
    RED TS 2 -> r: 4  y: 5  g: 20
    RED TS 3 -> r: 129  y: 5  g: 20
    RED TS 4 -> r: 129  y: 5  g: 20

 Green Time:  9
 YELLOW TS 1 -> r: 0  y: 3  g: 0
    RED TS 2 -> r: 3  y: 5  g: 10
    RED TS 3 -> r: 128  y: 5  g: 20
    RED TS 4 -> r: 128  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 2  g: 0
    RED TS 2 -> r: 2  y: 5  g: 10
    RED TS 3 -> r: 127  y: 5  g: 20
    RED TS 4 -> r: 127  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 1  g: 0
    RED TS 2 -> r: 1  y: 5  g: 10
    RED TS 3 -> r: 126  y: 5  g: 20
    RED TS 4 -> r: 126  y: 5  g: 20

    RED TS 1 -> r: 150  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 10
    RED TS 3 -> r: 15  y: 5  g: 20
    RED TS 4 -> r: 125  y: 5  g: 20

    RED TS 1 -> r: 149  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 9
    RED TS 3 -> r: 14  y: 5  g: 20
    RED TS 4 -> r: 124  y: 5  g: 20
```

ii): The leftmost column shows the status of the signal i.e. red, yellow, or green, followed by the traffic signal number, and the current red, yellow, and green timers of the signal. Here, traffic signal 1 i.e. TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are calculated and a green time of 9 seconds is returned for TS 2. As this value is less than the minimum green time of 10, the green signal time of TS 2 is set to 10 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+10=15.

```
  GREEN TS 1 -> r: 0  y: 5  g: 1
    RED TS 2 -> r: 6  y: 5  g: 20
    RED TS 3 -> r: 119  y: 5  g: 20
    RED TS 4 -> r: 134  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 5  g: 0
    RED TS 2 -> r: 5  y: 5  g: 20
    RED TS 3 -> r: 118  y: 5  g: 20
    RED TS 4 -> r: 133  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 4  g: 0
    RED TS 2 -> r: 4  y: 5  g: 20
    RED TS 3 -> r: 117  y: 5  g: 20
    RED TS 4 -> r: 132  y: 5  g: 20

 Green Time:  25
 YELLOW TS 1 -> r: 0  y: 3  g: 0
    RED TS 2 -> r: 3  y: 5  g: 25
    RED TS 3 -> r: 116  y: 5  g: 20
    RED TS 4 -> r: 131  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 2  g: 0
    RED TS 2 -> r: 2  y: 5  g: 25
    RED TS 3 -> r: 115  y: 5  g: 20
    RED TS 4 -> r: 130  y: 5  g: 20

 YELLOW TS 1 -> r: 0  y: 1  g: 0
    RED TS 2 -> r: 1  y: 5  g: 25
    RED TS 3 -> r: 114  y: 5  g: 20
    RED TS 4 -> r: 129  y: 5  g: 20

    RED TS 1 -> r: 150  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 25
    RED TS 3 -> r: 30  y: 5  g: 20
    RED TS 4 -> r: 128  y: 5  g: 20

    RED TS 1 -> r: 149  y: 5  g: 20
  GREEN TS 2 -> r: 0  y: 5  g: 24
    RED TS 3 -> r: 29  y: 5  g: 20
    RED TS 4 -> r: 127  y: 5  g: 20
```

(iii): After a complete cycle, again, TS 1 changes from green to yellow. As the yellow timer counts down, the results of the vehicle detection algorithm are processed and a green time of 25 seconds is calculated for TS 2. As this value is more than the minimum green time and less than maximum green time, the green signal time of TS 2 is set to 25 seconds. When the yellow time of TS 1 reaches 0, TS 1 turns red and TS 2 turns green, and the countdown continues. The red signal time of TS 3 is also updated as the sum of yellow and green times of TS 2 which is 5+25=30.

CLOUD COMPUTING

Cloud Computing is an innovative technology that presents us with a revolutionary way of accessing applications as utilities through the Internet. This technology enables us to create, configure, and customize applications online, providing us with the flexibility and convenience we need to thrive in today's digital age. The term Cloud refers to a network or the Internet, which means that it is something that exists at a remote location. Cloud services can be provided over public networks or private networks such as WAN, LAN, or VPN.

Cloud Computing is a powerful tool that allows us to run various applications like e-mail, web conferencing, and customer relationship management (CRM) in the cloud. It involves manipulating, configuring, and accessing applications online, offering us online data storage, infrastructure, and application services.

One of the most popular Cloud Computing providers is the Google Cloud Platform (GCP). It is a suite of cloud computing services that runs on the same infrastructure that Google uses internally for its end-user products like Google Search, Gmail, Google Drive, and YouTube. Alongside a set of management tools, GCP provides a series of modular cloud services including computing, data storage, data analytics, and machine learning.
To register for GCP, all you need is a credit card or bank account details. This platform offers infrastructure as a service, platform as a service, and serverless computing environments, making it a versatile and flexible option for businesses and individuals alike. With Cloud Computing, the possibilities are endless, and GCP is an excellent example of how this technology can transform the way we work and live.

IV. CONCLUSION AND FUTURE SCOPE

The proposed work is truly revolutionary as it focuses on the creation of a Smart Traffic Management System using Cloud Computing.

This system has the potential to eliminate the drawbacks of the current traffic management system, which includes high implementation costs and dependency on environmental conditions. With the implementation of this system, traffic congestion can be managed effectively and at a much lower cost than the existing system.

Moreover, this study highlights the global problem caused by traffic congestions in metropolitan areas. These congestions have a severe impact on the economy, the environment, and the overall quality of life. The proposed system aims to tackle this problem by allocating the signal timer based on the traffic density. It is remarkable that the system can allocate as little as 10-20 seconds if there are very few vehicles on the road, and allocate more time if there are heavy vehicles.

The system uses OpenCV, which is a perfect model for detecting vehicles, and it is also integrated with cloud computing. This means that anyone can access the system from anywhere, using any device. The possibilities of this system are endless, and we are thrilled to be at the forefront of this exciting new technology.

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