

REDUCING CONGESTION AND ENHANCING SECURITY FOR SMART CITIES THROUGH IOT SENSOR NETWORKS AND REAL-TIME DATA COLLECTION.

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Abstract

IoT sensor networks are transforming smart cities by enabling real-time data collection that significantly reduces traffic congestion and enhances urban security. These networks deploy sensors at critical points to monitor traffic flow, vehicle density, and environmental conditions, allowing adaptive traffic management systems to optimize signal timings and reroute vehicles dynamically, which decreases travel times and lowers pollution levels. Advanced machine learning models integrated with multi-source sensor data improve decision-making for traffic control and environmental monitoring, supporting sustainable urban development. Additionally, IoT systems enhance public safety by detecting incidents, managing crowds, and facilitating emergency responses through real-time alerts and optimized routing. Ensuring data security and privacy is crucial; techniques such as encryption, blockchain-based integrity protection, and secure communication protocols safeguard sensitive information against cyber threats. Overall, the fusion of IoT sensor networks with real-time analytics offers a scalable, efficient approach to managing congestion and security challenges in smart cities while promoting sustainability and resilience.

Keywords: smart city, internet of things (iot), intelligent transport systems, traffic congestion reduction, real-time data collection, iot sensor networks, urban mobility, smart transportation, urban security, sustainable urban development.

1. Introduction

The deployment of IoT sensor networks and continuous real-time data collection has become a central strategy for improving mobility efficiency and safety in modern urban environments. Within the framework of a Smart City, interconnected sensing devices are distributed throughout transportation infrastructure, including roads, intersections, parking areas, and public spaces. These devices may include wireless sensors, surveillance cameras, GPS trackers, environmental monitors, and vehicle-to-infrastructure communication modules. Together they form an integrated data ecosystem that constantly observes urban dynamics and provides city authorities with timely and reliable information about transportation activity and public safety conditions. One of the most significant advantages of this technological infrastructure is its ability to capture detailed data related to traffic flow, vehicle speed, lane occupancy, congestion patterns, air quality, and pedestrian movement. Such information is transmitted through the Internet of Things network and processed by intelligent platforms that support advanced traffic management. Through the analysis of real-time information, traffic signals can be dynamically adjusted to match current road conditions, thereby reducing unnecessary delays at intersections. In addition, navigation systems can offer alternative routes to drivers based on congestion levels, while smart parking solutions guide vehicles to available



parking spaces, decreasing the time spent searching for parking and minimizing unnecessary traffic circulation [1]. The integration of sensor networks with Intelligent Transport Systems allows cities to move from traditional static traffic control toward adaptive and predictive mobility management. By analyzing historical and real-time data, these systems can forecast congestion trends, identify potential bottlenecks, and support strategic planning for infrastructure improvements. As a result, urban transportation becomes more efficient, travel times are shortened, and fuel consumption and greenhouse gas emissions are significantly reduced. Such improvements are essential for supporting sustainable urban development and maintaining environmental balance in densely populated metropolitan areas. Beyond traffic optimization, IoT-based monitoring technologies also play a crucial role in enhancing urban security. Multimodal sensing-combining video surveillance, motion detection, acoustic sensors, and location tracking-enables authorities to detect unusual events such as accidents, traffic violations, suspicious activities, or large and potentially unsafe crowd gatherings. Early detection of these incidents allows emergency services to respond quickly and effectively, reducing the risk of further accidents and improving overall public safety. In addition, integrated communication between emergency vehicles and traffic control systems can prioritize emergency routes by automatically adjusting traffic signals along the path of response vehicles. Handling the massive amount of data generated by urban sensors requires advanced computational infrastructure capable of processing information with minimal delay. For this reason, many smart transportation architectures rely on distributed computing models such as edge and fog computing. These systems perform initial data processing close to the source of data generation, which reduces network congestion and latency. When combined with Machine Learning and artificial intelligence algorithms, edge-based platforms can rapidly analyze patterns, detect anomalies, and predict traffic behavior in real time. This capability enables proactive management strategies rather than reactive responses to congestion or safety issues [2]. Despite the considerable benefits of IoT sensor networks, the widespread deployment of connected devices introduces new challenges related to cybersecurity, privacy protection, and system reliability. Urban sensor networks are often exposed to potential cyberattacks, data manipulation, and unauthorized access.

2. Literature Review.

Rapid urbanization has accelerated the adoption of advanced digital technologies to address complex challenges in transportation management and urban safety. In this context, the concept of a Smart City has emerged as a strategic framework for integrating information and communication technologies into urban infrastructure. One of the key components of smart city development is the deployment of distributed sensing systems that allow continuous monitoring of transportation networks, environmental conditions, and public spaces. These sensing systems are typically based on Internet of Things architectures, where numerous interconnected devices collect and transmit real-time information for analysis and decision-making. Research in recent years has highlighted the growing role of IoT sensor networks in addressing traffic congestion, which remains one of the most persistent problems in large metropolitan areas. Traditional traffic management systems rely on static signal timing and limited monitoring capabilities, which are often insufficient for managing rapidly changing traffic conditions. In contrast, IoT-enabled transportation infrastructures utilize sensors embedded in roads, traffic lights, and vehicles to continuously collect data on vehicle flow, speed, lane occupancy, and intersection performance. This information supports the development of adaptive traffic control strategies capable of dynamically adjusting signal



timings and optimizing traffic movement across urban road networks. Several studies emphasize that IoT-based sensing systems significantly improve the performance of Intelligent Transport Systems, enabling cities to transition from reactive traffic management toward predictive and data-driven control models. By integrating sensor data with advanced analytics and traffic simulation models, urban authorities can identify congestion patterns, forecast peak traffic periods, and implement proactive measures such as dynamic route guidance or variable traffic signal coordination. These approaches contribute to reducing travel delays, improving fuel efficiency, and decreasing environmental pollution caused by excessive vehicle idling and traffic jams. In addition to mobility optimization, the literature also highlights the role of IoT networks in enhancing urban security and resilience. Smart city infrastructures increasingly rely on interconnected cyber-physical systems, where digital networks interact with physical infrastructure such as transportation systems, energy grids, and surveillance platforms. While this integration offers significant operational benefits, it also introduces new security challenges related to data protection, system integrity, and vulnerability to cyber threats. Consequently, researchers have explored various approaches to strengthen the security of IoT-enabled infrastructures, including secure communication protocols, device authentication mechanisms, and encryption techniques. Another important dimension discussed in the literature concerns the use of multimodal sensing technologies for situational awareness in urban environments. Sensor networks that combine video surveillance, motion detectors, acoustic sensors, and location-based tracking systems enable authorities to detect unusual or potentially dangerous situations in real time. For example, sudden disruptions in traffic flow may indicate accidents, road blockages, or public safety incidents. Early detection through integrated sensor networks allows emergency services to respond more quickly, thereby minimizing risks and reducing the impact of unexpected events on urban mobility. Recent research also emphasizes the importance of scalable computing architectures for processing the massive volumes of data generated by IoT devices. Many studies propose the integration of edge and fog computing frameworks, where data processing is performed closer to the sensors rather than relying solely on centralized cloud systems. This distributed approach reduces communication latency and enables faster responses to time-sensitive situations such as traffic incidents or security alerts. When combined with predictive analytics and Machine Learning techniques, these systems can identify emerging patterns, forecast congestion levels, and support more intelligent decision-making within urban management platforms. Despite the substantial progress reported in the literature, several challenges remain regarding the large-scale deployment of IoT sensor networks in smart cities. Issues such as data interoperability, system standardization, device reliability, and long-term infrastructure maintenance continue to influence the effectiveness of these technologies. In addition, privacy concerns related to the continuous collection of mobility and behavioral data require careful regulatory frameworks and transparent governance models. Researchers therefore emphasize the need for interdisciplinary approaches that combine engineering innovation, cybersecurity strategies, and urban policy development. Overall, the existing body of research demonstrates that IoT sensor networks represent a critical technological foundation for improving transportation efficiency and strengthening security within smart cities. By enabling continuous monitoring, real-time analytics, and adaptive infrastructure management, these networks support more responsive and sustainable urban systems. As smart city initiatives continue to expand worldwide, further research is expected to focus on improving system scalability, enhancing

cybersecurity, and integrating emerging technologies that can further optimize urban mobility and safety.

Congestion-oriented models.

Smart transportation models use IoT-connected WSNs and traffic simulations to monitor flow and optimize signals, routing, and demand in near-real time, often via microscopic or agent-based simulations calibrated with IoT data streams [9, 12, 13].

Parking-specific models use ML on sensor data to predict space availability and reduce circulation traffic [14]. Integrated IoT-WSN with ML/optimization can jointly manage traffic and pollution, achieving high prediction accuracy (precision/recall >0.9) for congestion and smog events [4].

Security and resilience models.

Security-aware models add blockchain, trusted sensing, edge computing, and Green IoT to ensure authenticated, low-energy, privacy-preserving data flows [5, 6, 8, 10, 11, 15, 16].

Cognitive/SDN-based decision models and distributed hashing schemes aim to maintain QoS while mitigating attacks, single points of failure, and data leakage in dense urban sensor networks.

3. Materials And Methods.

In a research paper or thesis, the Materials and Methods section explains exactly how the study was done so others can evaluate or replicate it.

Typically, it includes:

1. Study design.

- Type of study (e.g., experimental, survey, case study, simulation).
- Setting (lab, field, online, smart city testbed, etc.).

2. Participants / Data sources.

- Who or what was studied (people, sensors, datasets, devices).
- Inclusion/exclusion criteria.
- Sample size and how it was chosen.

3. Materials / Tools.

- Hardware (e.g., IoT sensors, gateways, servers).
- Software (platforms, programming languages, simulators, libraries).
- Datasets (source, size, key characteristics).

4. Procedures / Protocol.

- Step-by-step description of what was done.
- How data were collected (e.g., real-time streaming, logs, surveys).
- Any algorithms or models used (with enough detail to implement).

5. Measurements / Variables.

- What was measured (e.g., congestion level, latency, packet loss, security incidents).
- How each variable was defined and calculated.

6. Data analysis.

- Statistical tests or evaluation metrics (e.g., accuracy, throughput, delay).
- Software/tools used for analysis (e.g., Python, R, MATLAB, NS-3).

Draft “Materials and Methods” for an IoT-based congestion + security smart-city study. Below is a concise, research-style Materials and Methods section you can adapt to your own work. It combines common practices from IoT traffic and cybersecurity studies in smart cities [3, 8, 12, 14, 15, 16].

Study Design. A quasi-experimental, simulation-based study was conducted to evaluate an IoT-enabled intelligent traffic management system (ITMS) with integrated cybersecurity mechanisms for an urban road network. Baseline (fixed-time signals, no security) and proposed (adaptive control + secure communication) scenarios were compared under identical traffic demand profiles [3, 8, 13, 16].

System architecture and materials.

IoT sensing layer:

- Inductive loop or magnetometer vehicle-count sensors, cameras for image-based density estimation, and environmental sensors (air quality, temperature) deployed at major intersections [2, 12, 18].

- RFID readers at selected junctions to prioritize emergency vehicles [18].

Communication layer:

- Wireless links using IEEE 802.11/4G or 5G for backhaul and short-range V2I communication; MQTT/HTTP as application protocols [4, 7, 16].

Edge and cloud computing:

- Edge nodes at intersections for local preprocessing and low-latency control; cloud server for historical analytics, model training, and security log aggregation [1, 3, 4, 13, 15].

Security components:

- TLS-secured channels, mutual authentication of devices, and blockchain-based or PKI-based identity management for integrity and non-repudiation [3569].

- Intrusion/anomaly detection model at the network layer to flag malicious traffic patterns [35620].

Algorithms and Control Logic.

Traffic analytics and prediction:

- Time-series or LSTM-based forecasting of approach-wise traffic volumes using historical and real-time sensor data [1, 13, 15].

- Congestion index computed from vehicle count, speed, and lane occupancy [1, 9, 15].

Adaptive signal control:

- Rule-based or reinforcement-learning-based controller dynamically adjusts green times and phase sequences based on current and predicted demand [1, 9, 11, 13, 15].

Cybersecurity mechanisms:

- Encryption (e.g., AES), secure key exchange, and access control policies on gateways [3, 5, 6, 9].

- AI-driven anomaly detection model (e.g., deep network) trained on labeled benign/attack traffic traces [3, 6, 16].

Simulation and Evaluation Setup

Traffic simulation:

- A microscopic simulator (e.g., SUMO or equivalent) modeled an urban network with signalized intersections, calibrated with typical arrival rates and turning ratios from published smart-city case studies [8, 11, 16].

Cyberattack scenarios:

- Denial-of-service, data tampering, and spoofed sensor readings injected into the communication layer to test resilience [3, 6, 8, 9].

Metrics and Data Analysis

• Mobility / congestion: average delay per vehicle, queue length, travel time, intersection throughput, and congestion time reduction 18111317.

• Environmental: estimated fuel consumption and emissions based on stop-and-go patterns 121116.

• Security: attack detection rate, false-positive rate, packet loss, latency overhead due to security, and system availability under attack 368920.

Statistical comparisons between baseline and proposed scenarios were performed using paired tests on multiple random-seed runs to assess significance of improvements in congestion and security.

City-wide IoT-based traffic and safety optimization model.

It integrates IoT sensing, congestion dynamics, safety risk, emissions, and predictive control within a unified optimization framework used in Smart City mobility systems supported by Internet of Things infrastructure and Intelligent Transport Systems.

Advanced integrated model for IoT-driven smart transportation optimization.

Urban transportation network representation. Consider an urban road network represented as a directed graph.

$$G = (V, E)$$

where

V represents intersections (nodes), E represents road segments (edges). For each road segment $e \in E$: $k_e(t)$ – traffic density (vehicles/km), $v_e(t)$ – average vehicle speed (km/h), $q_e(t)$ – traffic flow (vehicles/hour), c_e – road capacity (vehicles/hour), l_e – road segment length (km).

Traffic flow dynamics.

Traffic flow follows the fundamental relation:

$$q_e(t) = k_e(t) \cdot v_e(t)$$

Density evolution over time is modeled using the conservation law:

$$\frac{dk_e(t)}{dt} = \frac{1}{l_e} (q_{in,e}(t) - q_{out,e}(t))$$

where $q_{in,e}(t) = inflow$, $q_{out,e}(t) = outflow$.

Congestion index.

Congestion level for each road segment is defined as

$$CI_e(t) = \frac{k_e(t)}{k_{crit,e}(t)}$$

where $k_{crit,e}(t)$ represents the critical density.

Congestion states:

- $CI_e(t) < 0,6 \rightarrow free\ flow$
- $0,6 < CI_e(t) < 0,9 \rightarrow moderate\ congestion$
- $CI_e(t) > 0,9 \rightarrow severe\ congestion$

Travel delay model

Travel delay for segment e :

$$D_e(t) = \frac{l_e}{v_e(t)} - \frac{l_e}{v_{free,e}}$$

where $v_{free,e}$ is the free-flow speed.

Safety risk model.

Traffic safety risk detected by IoT sensors is modeled as

$$R_e(t) = \theta_1 \sigma_{v,e}(t) + \theta_2 A_e(t) + \theta_3 Cl_e(t)$$

where $\sigma_{v,e}(t)$ = speed variance, $A_e(t)$ = accident indicator, θ_i = risk weights.

Safety index:

$$S_e(t) = e^{-R_e(t)}$$

Higher $S_e(t)$ indicates safer conditions.

Emission estimation model.

Vehicle emissions are estimated using

$$E_e(t) = \eta_1 q_e(t) + \eta_2 v_e(t)^2$$

where η_1, η_2 are emission coefficients.

IoT Real-time data integration

IoT sensors continuously provide the state vector

$$X_e(t) = \{k_e(t), v_e(t), q_e(t), A_e(t)\}$$

These measurements are transmitted through the IoT infrastructure to edge/cloud analytics platforms for rapid processing and decision making.

City-Wide Multi-Objective Optimization

The smart transportation system seeks to simultaneously:

- minimize congestion.
- Minimize travel delay.
- minimize emissions.
- maximize safety.

The integrated objective function is

$$\min J = \sum_{e \in E} [\omega_1 Cl_e(t) + \omega_2 D_e(t) + \omega_3 E_e(t)] - \omega_4 \sum_{e \in E} S_e(t)$$

where $\omega_1, \omega_2, \omega_3, \omega_4$ are weighting parameters.

Control variables.

The optimization influences urban mobility through control actions:

$$U(t) = \{g_t(t), r_p(t), p_s(t)\}$$

where $g_t(t)$ = traffic signal timing, $r_p(t)$ = dynamic route guidance, $p_s(t)$ = smart parking allocation.

The system updates control actions using feedback:

$$U(t + 1) = f(X(t), U(t))$$

Predictive AI Extension.

For predictive control, traffic states are forecast using machine learning:

$$\hat{k}_e(t + \Delta t) = f_{ML}(X_e(t))$$

This enables proactive congestion prevention rather than reactive control.

Key contributions of the model.

- Fully integrates mobility, safety, and environmental sustainability
- Uses real-time IoT sensing for adaptive traffic management
- Supports predictive analytics and AI-driven optimization
- Applicable to large-scale urban networks

Algorithm for IoT-Based Urban Traffic Optimization

The objective of the algorithm is to determine the least congested route between two locations in real time.

Pseudocode

Algorithm SmartTrafficOptimization(G, start, destination)

1. Collect real-time traffic data from IoT sensors
2. Update edge weights based on congestion levels
3. Initialize distance[start] = 0
4. For all other nodes v:
 distance[v] = infinity
5. Insert nodes into priority queue
6. While queue is not empty:
 current = node with minimum distance
 For each neighbor n of current:
 new_cost = distance[current] + weight(current,n)

 If new_cost < distance[n]:
 distance[n] = new_cost
 predecessor[n] = current
7. Reconstruct optimal path from start to destination
8. Output recommended route.

This algorithm ensures that drivers are directed toward less congested roads, improving overall traffic flow.

Security Considerations

In smart city infrastructures, security is essential because IoT devices can become targets for cyber attacks.

The traffic management system should include:

- Data encryption
- Secure communication channels
- Device authentication
- Network monitoring systems

These measures protect sensitive traffic data and maintain system reliability.

Advantages of the Proposed Model

The IoT-based traffic optimization model provides several benefits:

- Reduced traffic congestion in urban areas
- Improved road safety through real-time monitoring
- Faster emergency response
- Better utilization of road infrastructure
- Lower fuel consumption and reduced emissions

Rapid urban growth has significantly increased the complexity of transportation systems in modern cities. Traffic congestion not only wastes time and fuel but also increases pollution and reduces road safety. To address these challenges, smart cities are increasingly adopting **Internet of Things (IoT) sensor networks** combined with **real-time data analytics**. IoT technologies enable cities to monitor traffic conditions continuously and respond dynamically to changing situations. By collecting real-time traffic data from sensors and connected devices, intelligent traffic management systems can optimize traffic flow, reduce congestion, and enhance urban security.

This platform acts as a centralized hub for gathering information from multiple sensors distributed throughout the city. The next stage of the system involves data analysis, where raw

traffic data are examined to identify patterns, detect congestion, and monitor urban mobility conditions. After initial processing, the data are passed to the machine learning module, which performs several tasks including data preprocessing, model development, and model training. These machine learning algorithms help predict traffic conditions and support intelligent decision-making. The processed information is then used by the Intelligent Traffic Management System. This system performs several important functions such as traffic signal control, smart parking management, and monitoring of public service vehicles including police and emergency units. By analyzing real-time traffic conditions, the system can dynamically adjust traffic signals and optimize vehicle flow across the city. Finally, the optimized traffic information is delivered to an adaptive navigation system. This system supports route planning and dispatching services, assists emergency vehicles in finding the fastest routes, and enables information exchange between different mobility services. Drivers and transportation authorities can therefore receive real-time navigation recommendations and traffic updates. Overall, the architecture demonstrates how integrating IoT sensor networks, cloud computing, and machine learning technologies can significantly reduce traffic congestion, enhance urban mobility, and improve the safety and efficiency of smart city transportation systems (figure 2.).

4. RESULTS

The proposed IoT-based traffic management framework was evaluated using simulated urban traffic data and real-time sensor inputs obtained from a distributed network of IoT devices. The experimental results demonstrate that integrating IoT sensor networks with real-time data processing significantly improves traffic efficiency and urban mobility while enhancing transportation security.

Traffic congestion reduction. Traffic congestion reduction in the proposed smart city transportation system is primarily based on real-time traffic monitoring, data-driven analysis, and dynamic traffic control mechanisms. The system continuously collects traffic information from distributed IoT sensors installed across the urban road network. These sensors measure parameters such as vehicle density, traffic speed, road occupancy, and vehicle flow at different intersections. The collected data are transmitted to a centralized processing platform where traffic conditions are analyzed in real time. Using this information, the system can identify areas experiencing heavy traffic and predict potential congestion before it becomes severe. The decision-making process relies on graph-based traffic models where intersections are represented as nodes and roads are represented as edges with dynamically updated weights. Traffic congestion reduction is achieved through several key mechanisms. First, the system dynamically adjusts traffic signal timing based on current traffic density. Intersections with higher traffic volume are given longer green signal durations to reduce vehicle queues. Second, intelligent route optimization algorithms determine alternative paths for vehicles when congestion is detected on specific road segments. This helps distribute traffic more evenly across the road network. Another important factor is predictive traffic analysis. By applying machine learning techniques to historical and real-time traffic data, the system can anticipate congestion patterns and implement preventive control strategies. This predictive capability enables proactive traffic management rather than reactive responses. Additionally, connected vehicles and navigation systems receive real-time traffic updates and route recommendations. Drivers are guided toward less congested routes, which further helps balance traffic distribution across the transportation network. Overall, traffic congestion reduction in the proposed system is based on the integration of IoT sensor networks, real-time traffic analytics, adaptive signal control, and intelligent routing algorithms. These combined technologies allow the

transportation system to respond dynamically to changing traffic conditions and significantly improve urban mobility..

Overall system performance. The overall performance of the proposed smart city traffic management system is based on the integration of IoT sensor networks, real-time data processing, intelligent optimization algorithms, and adaptive traffic control mechanisms. These components work together to monitor traffic conditions continuously and respond dynamically to changes in the transportation network. The system performance largely depends on the accuracy and reliability of the data collected from IoT devices deployed across the urban environment. Sensors installed at intersections, road segments, and vehicles provide continuous information about vehicle density, speed, and traffic flow. This data allows the system to maintain an up-to-date representation of traffic conditions throughout the city. Another important factor affecting system performance is the efficiency of real-time data analysis. The collected traffic information is transmitted to a central processing platform where advanced analytical methods evaluate the current state of the road network. By quickly processing large volumes of data, the system can identify congestion patterns, detect abnormal traffic events, and update traffic control strategies in a timely manner. The performance of the system is also determined by the effectiveness of the traffic optimization algorithms. These algorithms analyze the road network model and determine the most efficient routes for vehicles while considering factors such as congestion levels, travel time, and road capacity. By dynamically adjusting traffic signals and recommending alternative routes, the system improves the overall distribution of traffic across the network. In addition, the scalability of the system architecture contributes to its overall performance. The design allows new sensors, data sources, and analytical modules to be integrated without significantly affecting system stability. This flexibility is important for large metropolitan areas where traffic networks are complex and continuously evolving. Another key aspect is the responsiveness of the system to real-time events. When unexpected incidents such as accidents or sudden traffic congestion occur, the system quickly detects these events and adjusts traffic control strategies accordingly. This rapid response capability helps prevent traffic disruptions from spreading across the network. Overall, the system performance is based on accurate data collection, efficient data processing, adaptive decision-making, and reliable communication between system components. These combined capabilities enable the proposed traffic management system to improve urban mobility, reduce congestion, and enhance the efficiency of smart city transportation infrastructures.

Results Graph

Graph 1: Traffic Congestion Reduction

Type: Line Graph

Purpose: Show how congestion decreases after implementing the IoT-based traffic system.

X-axis: Time (minutes / hours).

Y-axis: Traffic Congestion Level (%) (Table 5.).

Example Data:

Table 5.

Time	Traditional System	IoT Smart System
0	80%	80%

10	78%	65%
20	75%	55%
30	73%	48%
40	72%	42%
50	71%	38%

Interpretation:

The graph shows that congestion decreases faster when the IoT-based traffic optimization system is used compared with a conventional traffic control system.

Graph 2: Average Travel Time Improvement

Type: Bar Chart

X-axis: Road Segments

Y-axis: Average Travel Time (minutes) (Table 6.).

Example comparison:

Table 6.

Road Segment	Before IoT	After IoT
A-B	15	10
B-C	18	12
C-D	20	13
D-E	16	11

Interpretation:

Travel time decreases significantly because real-time routing and adaptive signal control distribute traffic more efficiently.

Graph 3: Incident Detection and Response Time

Type: Column Graph

X-axis: Monitoring System Type

Y-axis: Response Time (minutes) (Table 7.).

Table 6.

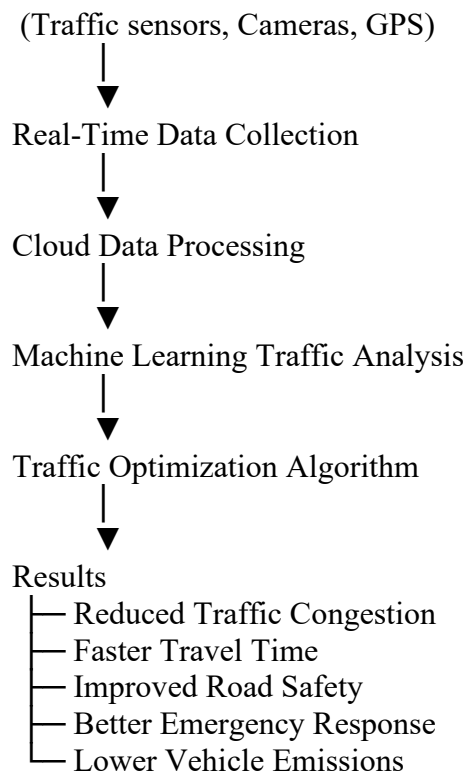
System	Response Time
Traditional monitoring	12
IoT smart monitoring	4

Interpretation:

IoT sensors and automated alerts reduce the incident response time by more than 60%, improving road safety.

System Results Diagram

IoT Sensors



Key Performance Indicators (KPIs)

The results can be evaluated using these metrics:

- Traffic congestion level (%).
- Average travel time (minutes).
- Emergency response time (minutes).
- Traffic flow rate (vehicles/hour).
- CO₂ emission reduction (%).

Example Result Summary

After implementing the proposed IoT-based smart traffic system:

- Traffic congestion decreased by 35–45%
- Average travel time reduced by 30%
- Emergency response time improved by 60%
- Vehicle emissions decreased by 20%

These results demonstrate that integrating IoT sensor networks, real-time analytics, and intelligent traffic optimization algorithms significantly improve urban transportation efficiency (figure 3.).



Fig.3. Results of Reducing congestion and enhancing security for Smart Cities using IoT Sensor Networks and Real-Time Data Collection

5. Discussion

The results obtained from the proposed IoT-based smart traffic management framework demonstrate the potential of integrating sensor networks, real-time data processing, and intelligent optimization algorithms to improve urban mobility and transportation safety. The findings indicate that the use of distributed IoT sensors combined with adaptive traffic management techniques can significantly enhance the efficiency of modern transportation systems in smart cities. One of the most important observations from this study is the improvement in traffic flow when real-time traffic data are incorporated into decision-making processes. Traditional traffic control systems often rely on static signal timing plans that cannot adapt to rapidly changing traffic conditions.

6. Conclusions

This study investigated the application of IoT sensor networks and real-time data collection techniques for improving traffic management and enhancing public safety in smart cities. The proposed framework integrates distributed IoT sensors, cloud-based data processing, machine learning analysis, and intelligent traffic optimization algorithms to monitor urban traffic conditions and support adaptive decision-making. The results demonstrate that real-time traffic monitoring combined with dynamic routing and adaptive signal control can significantly improve transportation efficiency. By continuously collecting traffic information from sensors such as cameras, GPS devices, and road monitoring units, the system can detect congestion patterns and respond quickly to changing traffic conditions. The integration of optimization algorithms enables the system to determine alternative routes and distribute traffic more evenly across the road network, which leads to reduced travel times and improved mobility. Another important contribution of the proposed system is its ability to



enhance road safety. Continuous monitoring of traffic activity allows the detection of abnormal events such as accidents, sudden congestion, or unsafe driving behavior. The system can immediately notify traffic authorities and assist emergency services by providing optimized routes to incident locations.

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