An Architecture and Review of Intelligence Based Traffic Control System for Smart Cities

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Abstract

City traffic congestion can be reduced with the help of adaptable traffic signal control system. The technique improves the efficiency of traffic operations on urban road networks by quickly adjusting the timing of signal values to account for seasonal variations and brief turns in traffic demand. This study looks into how adaptive signal control systems have evolved over time, their technical features, the state of adaptive control research today, and Control solutions for diverse traffic flows composed of linked and autonomous vehicles. This paper finally came to the conclusion that the ability of smart cities to generate vast volumes of information, Artificial Intelligence (AI) approaches that have recently been developed are of interest because they have the power to transform unstructured data into meaningful information to support decision-making (For instance, using current traffic information to adjust traffic lights based on actual traffic circumstances). It will demand a lot of processing power and is not easy to construct these AI applications. Unique computer hardware/technologies are required since some smart city applications require quick responses. In order to achieve the greatest energy savings and QoS, it focuses on the deployment of virtual machines in software-defined data centers. Review of the accuracy vs. latency trade-off for deep learning-based service decisions regarding offloading while providing the best QoS at the edge using compression techniques. During the past, computationally demanding tasks have been handled by cloud computing infrastructures. A promising computer infrastructure is already available and thanks to the new edge computing advancement, which is capable of meeting the needs of tomorrow's smart cities.

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1. Introduction

In this work, a survey on "An Architecture and Review of Intelligence-Based Traffic Control System for Smart Cities" is conducted. I have collected 110 papers on this subject. Gathered (74) and sorted papers (36). The Journals collected from IEEE, Elsevier, Science Direct, Research Gate, ACM, Springer and others. The Conferences collected from ICNS Conference, IOP Conference Series and IEEE International Conference on Communications.

The following are the search phrases or keywords, as well as the search procedures employed when obtaining them are utilized to browse the papers used in this survey. Each search produced relevant results that directed users to our source resources. While conducting the poll, some keywords and search techniques were employed. And, +, are the search operations carried out to locate the quantity of articles in each journal, its name, and the number of journals we referred to during the survey procedure.

Table 1. Journal name with number of papers

S.No	Name of the Journal	No. of Articles
1.	IEEE	35
2.	Science Direct	4
3.	Research Gate	6
4.	Elsevier	5
5.	ACM	5
6.	Springer	8
7.	others	7

Table 2. Conference name with number of papers

S.No.	Name of the Conference	No. of Articles
1.	IOP Conference Series:	1
2.	ICNS conference	1
3.	IEEE International Conference on Communications	2

The following are the Colum charts and Line chart for Table 1, Table 2 and for both combinations table 1 & 2. i.e. Figure 1 shows the column chart for journals reviewed, Figure 2 shows the column chart for no. of conferences reviewed and Figure 3 shows line chart for both journals and conferences.
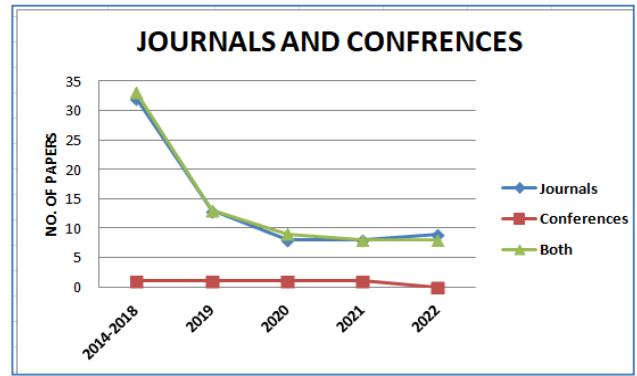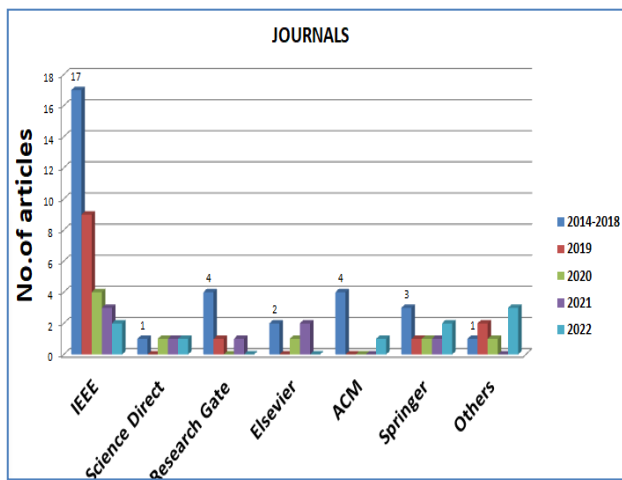

Figure 1. Column chart on no. of journals reviewed in last 5 years

Figure 2. Column chart on no. of Conferences reviewed in last 5 years
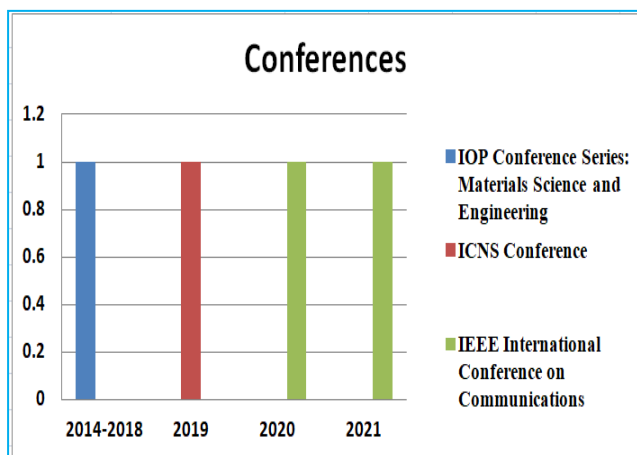

Figure 3. Line chart on no. of Journals and conferences reviewed in last 5 Years

2. Data Extraction

The four stages of the extraction procedure and how we filtered the gathered papers are depicted in the below **Figure 4.**
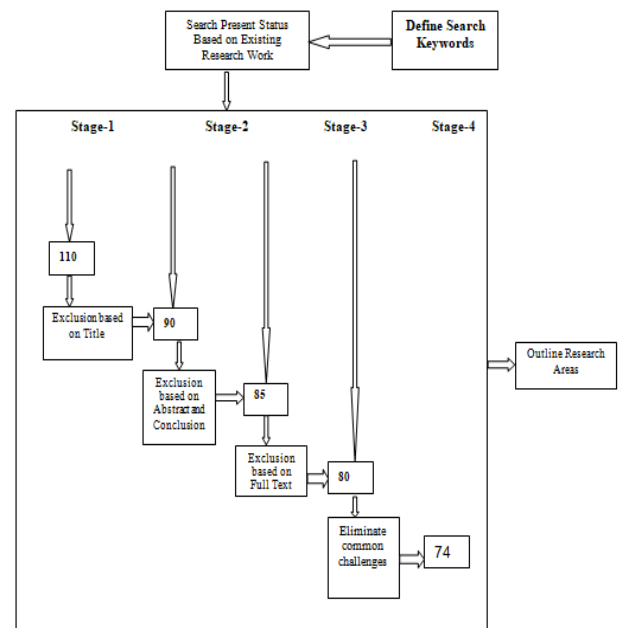
Figure 4. Extraction Process

2.1. Categories of the Topic

The following are the different categories of my survey. Traditional Networking algorithms used for maximize energy efficiency and QoS, Edge clouds and cloud computing are both utilized to make placement decisions in both static and dynamic environments, using fog networks for energy efficiency, latency, and user delay tolerance, Machine learning methods, such as the fusion-based virtual network's intelligent traffic congestion control system, which uses Machine Learning approaches achieve 95%

accuracy with a 5% have missed rate, improve the edge's deep learning techniques and EI model-based quality of service. Federated Reinforcement Learning allows edge enable traffic lights learn from one another's experiences by aggregating locally learned policy network settings instead of sharing raw data, lowering communication costs. The amount of traffic in the lanes is monitored by ultrasonic sensors; data is gathered at the controller's end and sent to a web server via a Wi-Fi module.

Table 3. Categories of the Topic

Category	No. of articles
Traditional Networking algorithms	6
Cloud Computing/Edge Clouds	14
Fog Networks	6
Fuzzy logic	5
Edge Intelligence	11
Deep Learning	11
Machine Learning	7
IoT	14

3. Selection Process

3.1 Inclusion criteria

a) Articles focusing on cutting-edge technology including edge intelligence, cloud computing, internet of things, deep learning, Smart Cities, QoS, Traffic flow, Offloading Decisions, Signal timing, Energy Saving that are employed in smart city traffic control systems.

b) Articles published within the last five years.

c) Research papers with Simulation and Edge clouds.

d) Papers that can be used in practice.

3.2 Exclusion criteria

a) Articles that fail to mention cutting-edge technology such as artificial intelligence (AI), the Internet of Things (IoT), edge computing/intelligence, deep learning, and methods.

b) Papers that have no use in real life.

c) Research papers on unrelated technologies

4. Discussion on Each Category

4.1 Traditional Networking algorithms

Wang et al.,[1], Examine the issue of where to deploy virtual machines in data centers in order to improve energy efficiency and QoS. The topology matrix, VM traffic, and resource requirements serve as the framework for Energy-Efficient and QoS Aware Virtual Placement's inputs in **Figure 5**. They first arrange the virtual machines based on how much the hop count has been reduced. Following that, energy-saving practices can be used to reduce the number of servers that are turned on. The Open Flow controller then adjusts traffic flow based on network state to avoid congestion.

Tseng et al., have used the Link-Aware Virtual Machine Placement (LAVMP) algorithm to optimize connection capability of VMs in order to reduce service communication time. The physical machines selected by the SOPMS method are given VMs by the LAVMP algorithm. Our ultimate objective is to cut down on communication time [2] and energy usage [3].

This study covers issues such as creating an appropriate equilibrium among utilization of resources and workload in VM placement, and also lowering migration costs to achieve dynamic VM deployment.
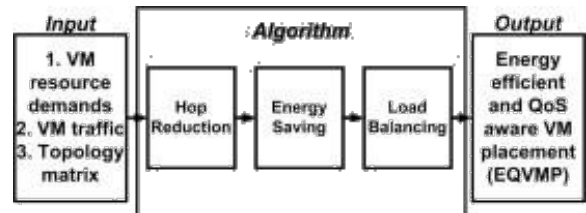

Figure 5. Model for Energy Efficient and QoS Aware Virtual Placement [1]

4.2 Cloud Computing/Edge Clouds

Turner et al., [4] have shown that NP-hard and greedy heuristic algorithms outperform QoS-based service placement in monitoring. Wang et al., focuses on adaptive placement, which involves making choices about placement over a period of time. In [5], *He et al.,* examined the case when edge clouds might share services among each other in order to collectively serve user requests.

Shi et al., [6] investigate different service implementations in a similar work. However, the emphasis in this work is on efficient query sequencing of streaming video workloads rather than service deployment [7] on edge clouds [8].

Cloud Computing/Edge Clouds are used in the preceding study for time-optimized smart vehicle routing and, as an effect, real-time congestion management. The right traffic load balance also enhances vehicle safety at intersections. The results show that the proposed system is effective for intelligent navigating, effective traffic load balancing as well as with improved the intersection security.

4.3 Fog Networks

Ning et al., present FogPlan, An adaptive fog computing architecture for dynamic service placement and delivery on fog nodes in IoT infrastructure [9]. Assume QoS-aware service placement, where QoS is solely measured in terms of latency and user acceptance [10].

Although the study of Vehicular Fog Computing (VFC)-enabled real-time traffic management is still in its early stages, address several potential research difficulties and future goals to create a roadmap for the VFC ecosystem.

4.4 Fuzzy logic

Mahmud et al., [11] present an app placement strategy that maximizes QoE by employing a fuzzy logic strategy that takes into account QoE by employing a fuzzy framework that includes groups for access rate, required resources, and processing durations.

The research of Gao *et al.* According to [12], QoS was delay indicator that uses a mixed decision problem for service distribution and networking selection. Consumers can be served by a number of cloud edge nodes. The Gurobi solvers provide the best solution for FSPP, a QoS aware services deployment problem. According to QoS descriptions, application limitations lead to this problem [13].

Finally, utilising a fuzzy framework, the study outcomes on optimising the Quality of Service (QoS) and maximizing the Quality of Experience (QoE). The service placement problem is modelled as a set optimisation problem. The system could eventually be enhanced by simultaneously evaluating many vehicles with priority in different lanes.

4.5 Edge Intelligence

The established field of edge intelligence (EI) was formed as a result of Xu *et al.,* investigation of moving services based on machine learning to the edge [14]. Because MEC environments have restricted potential for resource utilisation, one of essential goals of EI is to build models that use fewer resources to execute.

Wang et al., [15] For the EI service, pruning the deep neural network's structure essentially entails eliminating a predetermined number of neurons/units or entire layers. The design of the EI model is split across several MEC architectural layers (for instance, one component runs on the edge while another does so on the primary cloud) [16].

Zhou et al., [17] employ time-sequence behavioral analysis and stochastic behavior analysis to reduce transmission times for geographically distributed Internet of Things gates throughout the edge intelligence processing and the development of encrypted traffic detection systems. Finally, we minimize vehicle time spent in lanes with edge intelligence.

4.6 Deep Learning

Kato et al., used a deep learning strategy that has been proved to be effective to improve heterogeneity networking traffic management [18].

According to the *Dong et al.,* [19] study, future research will focus on two areas: (1) Using multi-agent Deep Reinforcement Learning (DRL) to detect irregular traffic. (2) Through adversarial learning amongst agents, Enhance the capacity for detection of a tiny quantity of data from samples.

Oliveira et al., [20] find the effective resource organization approaches, Bandwidth, for example, can be used to improve efficiency while cutting costs and improving quality of service (QoS). The latest deep learning algorithms are becoming increasingly prominent in the above survey, although here is a paucity of study on time sequence calculation, such as internet traffic. The emphasis in *X. Zhao's* study is on systems that employ deep learning, or DL [21], in traffic forecasting, which appears to have been relatively weak compared to prior surveys.

Network Traffic Monitoring and Analysis (NTMA) using deep learning Algorithm can be used for network identification and forecasts, incident management, and protection of networks.

Hudson et al.,[22] have been conducted research on Federated Reinforcement. Instead of exchanging data in its raw form, edge-enabled lights can combine locally learned policies and network settings to learn from one another's experiences, lowering the cost of communication.

The latest DL algorithms are becoming increasingly prominent in the above survey, Despite the fact that there has been little research on time series data as an internet forecasting tool, this sort of traffic.

4.7 Machine Learning

According to Saleem in [23], the Vehicular Network (VN) was a diverse communications network that was

independent, service-focused, and permits message transfer between automobiles and road infrastructure. When traffic is heavy, the demand it creates may be more than the route's capacity, resulting in gridlock on the roads. It focuses on the fusion-based ITCCS-VN, which gathers information from an IoV-enabled VN and then carefully analyzes it to forecast and manage traffic congestion. According to the results of the simulation, the suggested FITCCS-VN utilizing ML techniques has a 95% accuracy rate and an average failure rate of 5%, which is better than earlier methods. Future improvements to the assumed system's accuracy could be made via Alexnet and federated learning.

Zantalis et al., [24] have discussed Intelligent Parking and Intelligent Lighting Systems apps might not have enough ML coverage. In addition, the most common ITS applications among researchers are route optimization, parking, and accident detection.

Devi et al., [25] utilized an approach to estimate congestion based on machine learning. The logistic regression technique forecasts delays for an existing static roadway system in the form of a graph with an easy, correct and timely manner.

Gatto et al., [26] Already shown their feasibility in transportation sound monitoring and using machine learning techniques to identify sound signals in noisy environments is another option.

According to the study above, in a situation with heavy traffic, the workload produced by vehicular traffic might exceed the route's limits, resulting in traffic congestion. To predict and manage traffic congestion, ML techniques gather Information gathered by an IoV-enabled VN prior intelligently evaluating it.

IoT

Nagmode et al., [27], create a live traffic monitor system using an IoT architecture and sensors technology. This system uses ultrasonic sensors to gauge the amount of traffic on lanes. A controller collects data and sends it to an internet server via a module that uses Wi-Fi. The server archives and examines the material being watched. Here, A traffic signal control system that relies on lane-level volume of traffic monitoring is used to control traffic. When there is a lot of traffic in a lane, passing vehicles are given preference. RF transceivers are used to send and receive traffic-related messages from the primary network to the prioritized system. This type of technology is accessible at lane intersections and is dependable, basic, and simple to use.

According to *Xu et al.,* [28], utilizing cutting-edge technologies efficiently control traffic, The massive volume of data generated by traffic sensors must be properly kept [29]. Smart traffic control technologies that leverage cutting-edge technology to supplement traditional traffic control systems and efficiently address the stated issue include cloud computing, big data, IoT and 5G.AI and IoT are two emerging technologies that

will make it easier to make better decisions and support urban expansion.

4.9 Opportunities and Challenges (List of Issues):

The everyday growth in vehicle traffic in urban areas is making traffic conditions worse. The we are currently fighting about are listed below after carefully reading the papers mentioned above.

- Blockages and lengthy lines of moving vehicles emerge at junctions as a result of this increase, costing commuters important time, particularly during peak hours.

- The health, environment, and economy of the state all suffer from traffic congestion.

- Inadequate traffic management results in a lot of traffic jams, which makes it difficult to utilize the transportation infrastructure effectively and lengthens travel times, creates more air pollution, and uses more fuel.

5. Research Objectives

The proposed objectives for my research are listed below.

i. To lower latency by implementing AI-based apps (Edge act as AI sensors that capture live streams) in Edge computing infrastructure and offer the best possible services to the clients.

ii. Federated learning can be used for solving the Non-Intrusive Performance tracking problem, which lowers the communication costs of cutting-edge intelligence systems.

iii. Edge computing employs greedy algorithms and integer linear programming to place and schedule edge services in the best possible way.

iv. To increase available bandwidth by relocating some processing and analysing of data jobs from a cloud or a central server towards the network's edge, where information is produced or consumed.
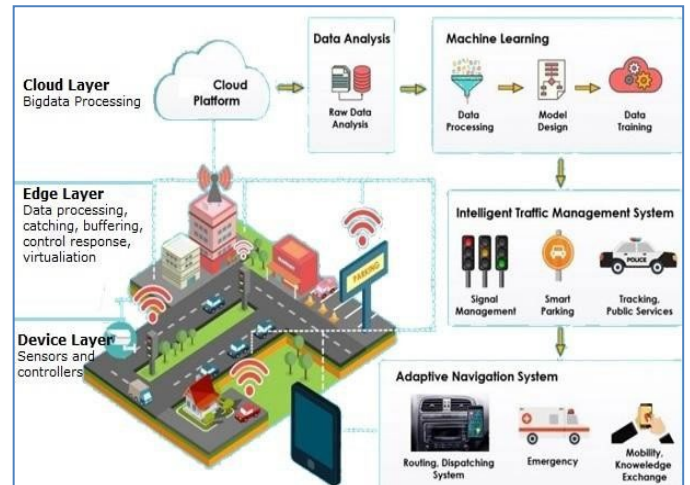
6. Architecture
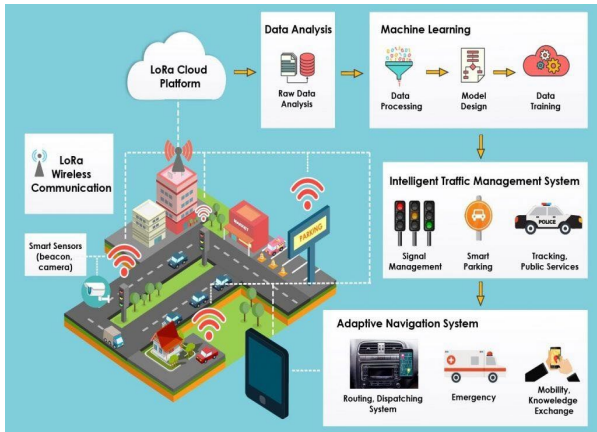
Figure 6. Existing smart traffic control Architecture [30]

In the above **Figure 6. [30]**, data from intelligent sensors is sent to a cloud platform. The Intelligence Traffic Management System (ITMS) is then fed data analysis and machine learning algorithms by the platform. As long as it is designed solidly, any application, such as an adaptive navigation system, can be developed on an ITMS.

Edge computing, which includes Cloudlets, by moving processing responsibilities to the outermost edge of the network, computing at the edge on handheld devices and fog technology are suggested as answers to the problems that cloud-based apps solve.

Utilizing the computational capacity and intelligence built into the network edge layer, it is possible to limit the amount of duplicate data sent to distant clouds while still responding quickly to applications. Edge computing's dispersed mode supports device mobility across many networks. Between the network of edge nodes and the cloud, this computer paradigm lacks a set framework to illustrate its capabilities. As seen in **Figure 7**, the 3-layer model has recently been put forth as a cutting-edge architecture by a number of scientists.

The use of edge devices has been created to extend the cloud computing concept to the network's edge, allowing for a variety of cloud-based applications (M2M, IoT and CPS) [31]. These features include reduced latency, location awareness, mobility, and enormous geographic dispersion. These properties make edge computing appropriate for a wide range of cloud applications. The accuracy of the suggested system could be increased by employing Deep Learning algorithms [32] such as Federated Learning and Alexnet [33].

Figure 7. Proposed Architecture for smart traffic control system

7. Conclusion

The everyday growth in vehicle traffic in urban areas is making traffic conditions worse. By reviewing the above papers, the following is the list of issues we are facing in present days. Blockages and lengthy lines of moving vehicles emerge at junctions as a result of this increase, costing commuters important time, particularly during peak hours. The health, environment, and economy of the state all suffer from traffic congestion. Inadequate traffic management results in a lot of traffic jams, which makes it difficult to utilize the transportation infrastructure effectively and lengthens travel times, creates more air pollution, and uses more fuel. Consequently, there are many potential applications for the linked achievements of the flexible control system for tomorrow's traffic environment.

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