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SOFTWARE-DEFINED EDGE COMPUTING FOR VEHICLE LOAD BALANCING

Dr K S Mohanasathiya
Assistant Professor, School of Computer Science, VET Institute of Arts and Science (Co-edu) College, Erode, Tamil Nadu, India, (sathyaanandh08@gmail.com)

Dr S Prasath
Assistant Professor & Research Supervisor, School of Computer Science, VET Institute of Arts and Science (Co-edu) College, Erode, Tamil Nadu, India.
(softprasaths@gmail.com)

Abstract

Cloud computing had emerged as a fundamental innovation in the field of Autonomous Vehicles (AV), which has been subjected to extensive research in successive years. Whereas cloud computing offers highly efficient computation, memory, and communication infrastructure, the AV still has low mobility support, poor location awareness, and significant processing latency. To solve those issues, we combine computing and Software-Defined Networking (SDN) in this study. By extending computing and storage towards the network edge, computers to enhance mobility and lower latency while also significantly reducing latency. SDN, meanwhile, gives the network adaptable centralized control and global knowledge. We develop a new SDN-based Improved Weighed Particle Swarm Optimization (SDN-IWPSO) logistic regression to effectively implement the SDN architecture in the AV. SDN-IWPSO utilizes the change of the light of particles in mutations and sequential reduce parameters to develop the efficiency of parameter Particle Swarm Optimization (PSO). According to the experimental result, the SDN-IWPSO algorithm would significantly reduce latency and raise the level of healthcare Quality of Service (QoS) inside the SDN architecture.

Keywords: Autonomous Vehicle; Edge Computing; Software Defined Network; Quality of Service; Optimization

1. Introduction

In the subject of automated driving, autonomous vehicles (AV) are a typical utilization of Internet of Things (IoT) technology. In addition to enabling wireless connectivity among cars, pedestrians, and the IoT, AV also enables smart transportation administration, smart dynamic data services to manage network integration [1]. Numerous features that enable pedestrian traffic transportation more convenient are anticipated to be offered in the AV, including automatic braking, traffic congestion monitoring, trip planning, infotainment, and others [2]. Therefore, to support those applications, a strong data center is required.

Increased core network bandwidth utilization and the centralization of cloud data centers, network congestion worsens as the number of requests made to the cloud rises [3]. When billions of devices are distributed globally, those consequences could worsen. As a result, real-time programs might not be adequately served by the use of alternative sources [4]. Computing is used to establish a central layer among IoT devices and cloud-based data centers to overcome those fundamental problems in Iot technology. Additionally, IoT resources such as smart routers, ports, gateways, detectors, and webcams are used in computation because they can handle the demands of time-sensitive applications [5]. A similar part of such a central portion that automatically distinguishes those applications to be executed on- or cloud-based is the gateway.

In addition, several innovative technologies, including live streaming, face detection, real-time processing,and distributed edge computing, are being created and put into use [6]. By 2020, 50–100 billion IoT devices are estimated to be installed, based on a Cisco survey. It is vital to consider and maximize the possible memory and processing resources employed in those other different applications close to the edge devices due to the constantly growing resource demand [7].

To link the automobiles and create a cloudlet, the vehicular cloud paradigm was presented. Commonly found in parking lots, such cloudlets offer cloud-like capabilities in addition to being connected using standard cloud networks to do activities inside a group [8]. Cloudlets can only be produced by a specific number of motor vehicles, and their distribution and abundance are constrained. As there are fewer cloudlets available, the connection becomes congested and the assets of the cars weren't used to their maximum potential [9]. Therefore, it is believed that automobiles can offer cloud-like services as devices.

2. Related Works

The load balancing technique, which is a crucial part of distributed information systems, recently garnered interest on a global scale [10]. The jobs are distributed among multiple organizations by a specific policy to balance the load among them, which could reduce processing time. With the growth of cloud computing, scholars in the field have recently started looking at the load-balancing techniques used in this technology. The heterogeneity of the network prevents the adoption of cloud computing task scheduling solutions even though it is thought about as a cloud near the ground [11]

Therefore, from this point, a multi-band load-balancing network strategy had been proposed that could manage how mobile devices might utilize the frequency with fewer connections. Utilizing the entire available wireless spectrum, the method may regulate the number of users among two bands, reducing congestion issues. However, the network does not consider task processing load equalization [12].

Additionally, a dynamic power control system based on a computational graph takes place in the form proposed, the first of which construct the diagram of virtual machine nodes before providing customers with services through dimension reduction and clustering [13]. However, it may take a longer amount of time for network capacity to maintain order if a node goes down since it only takes network load balancing into account [14].

Additionally, the exchange among latency and energy usage inside a cloud computing system produces a rough method that subdivides the primary into three main matching smaller problems [15]. Based upon that preceding, we employ SDN as a centralized control system within AV that can assist us in obtaining the necessary data before load balancing. Although the cloud is farther from the customers, it might nonetheless be in charge of some of the work. As a result, we combine the cloud, the SDN controller, to create an architecture that can be applied and AV [16]. We alter restricted optimization and particle swarm optimization to get the best load balance PSO.

In this study, we present a unique network configuration that fully incorporates cloud computing, computing, and SDN to decrease the load on the cloud and it will reduce task processing delay. One of the most common study findings in the IT sector is SDN, a developing networking paradigm [17]. SDN is an appealing solution to the AV problem because it controls the network in a methodical, centralized, also in a programmable manner by separating the control planes from the data planes. It has been thought of as a cloud close to the end customers to provide the computing and the services with the least latency [18]. Computing was an implicit platform that delivers computing, stockpiling, and connectivity services among edge devices and conventional cloud computing data centers. Therefore, the network is made up of a largenumber ofsystems, each of which has limited computing power. Additionally, it may be challenging for a single device to adequately handle lots of data. As a result, distributed computing must be carried out in a network employing sophisticated networking hardware.

3. Proposed System

Automotive, vehicle-to-base, and the vehicle -to-infrastructure station communications, are all provided by the AV, which is made up of vehicles and infrastructure along the route. While cars in the AV are typically quite moving, there is a large need for execution power for services, particularly for latency-sensitive facilities like tracking the distance among automobiles, monitoring driving conditions in real-time in ambulances, requesting route maps, etc. Even though the operations might be supported by typical cloud computing infrastructure, the latency is very significant because the cloud center servers were located as far away as cars [19].

We incorporate the connection through cloud-based infrastructure to address this issue since it may meet the criteria for the least latency. Additionally, SDN controllers are needed, due to their adaptable central control that might collect information on the overall loading across all sources and the cloud. Figure 1 depicts the entire framework.

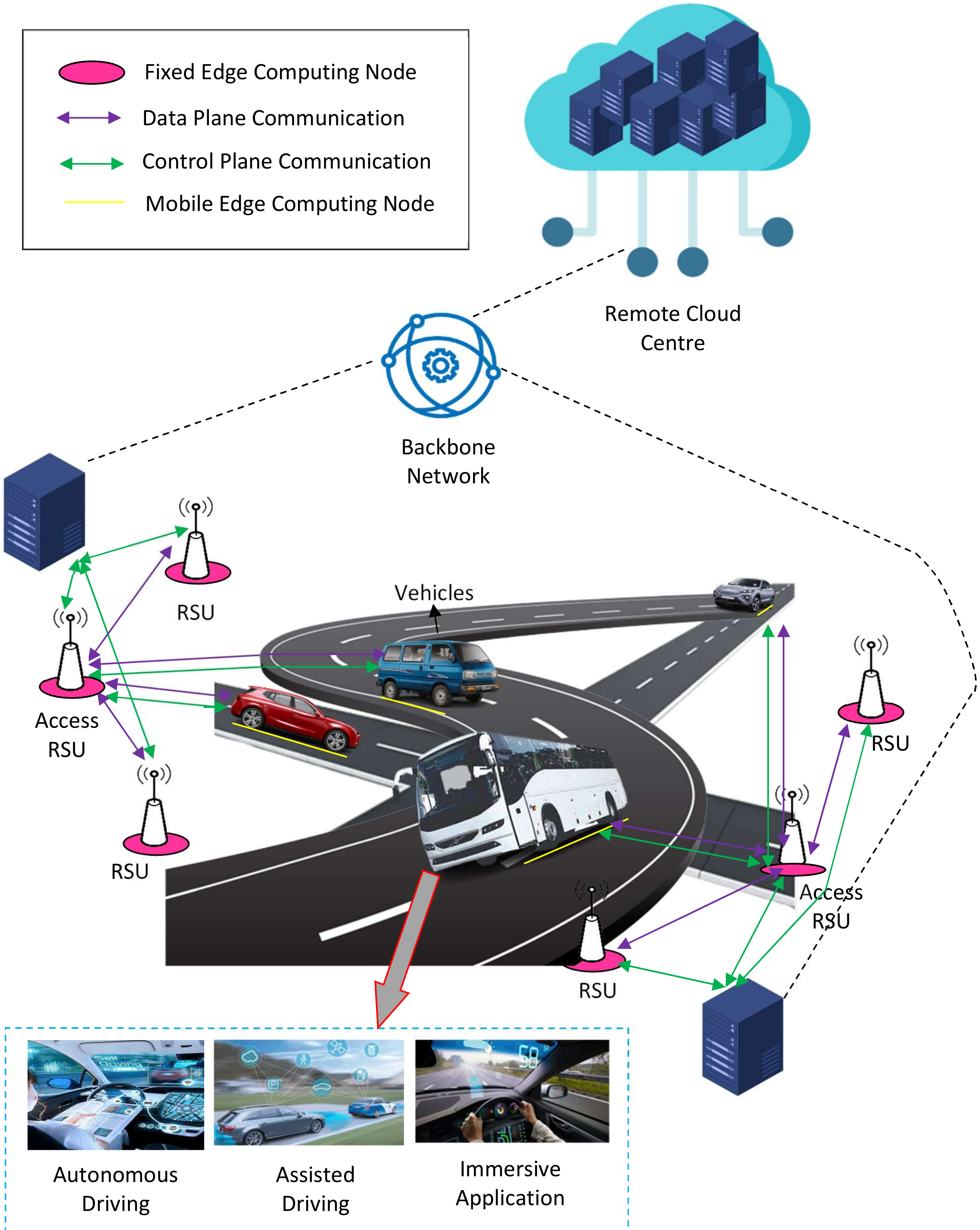

Figure 1: Architecture of SDN

Roadside units and BSs with storage and processing capabilities make up the computational layer. The OpenFlow protocol is being used by both the RSU and BSs to connect to the SDN controllers. BSs with RSUs were known as "networks" inside the SDN architecture [20]. By using dynamic buffering, an FN can access the resources and applications that it needs through cloud servers, and gather traffic information from nearby FNs and save important information that is sent across the network.

4 Results and discussions

Despite compromising generality, we'll assume that there are 10 FN within the layer. In Table I, associated SDN simulated variables are listed. In the real world, the total combined delivery latency and other latency equals network latency IJvi,vj. Except for delivery delay, another latency refers to lag produced even during the process of transmission. Table I includes all of the data when integrated also with the entire network configuration.

Table 1 SDN parameters

Parameter type	C	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
Cvi/Cd (Gbps)	11	3	2	2	0.6	0.5	0.8	00.7	0.4	0.6	2
Up-link Bandwidth (Mbps)	3	84.3	86	71	79	87	91	89	90	88	79
Downlink Bandwidth (Mbps)	1.8	101.8	102	99	100	103	106	104	104	103	99
Another delay in transmission (s)	0.02	0.002	0.002	0.0013	0.0012	0.0013	0.002	0.0014	0.002	0.0014	0.002

4.1 OoV at Ideal condition

In certain cases, the baseline residual energy of load-balanced and imbalanced parking schemes for parked automobiles is the same. That's because at first, only nodes that seem to be physically close to IoT devices are being used [21]. After a few, the nodes closest to the gateway become overloaded and require more energy. Moreover, the connectivity load was indeed higher among base stations using the proposed technique, as shown in Figure 2 (a) results in the network using less excess power.

Figure 2 (b) demonstrates that the end-to-end delay based on the proposed technique is compared to the unbalanced load scenario owing to capacity-based load balancing. Whenever the capability of in-range nodes is reached in an unbalanced load method, the length of such a balancing buffer is increased, increasing the network's end-to-end delay. Therefore the capacity of the weighting queue was adjusted in the proposed moderate approach, which decreases end-to-end delay as a result of ability stress distribution between nodes.

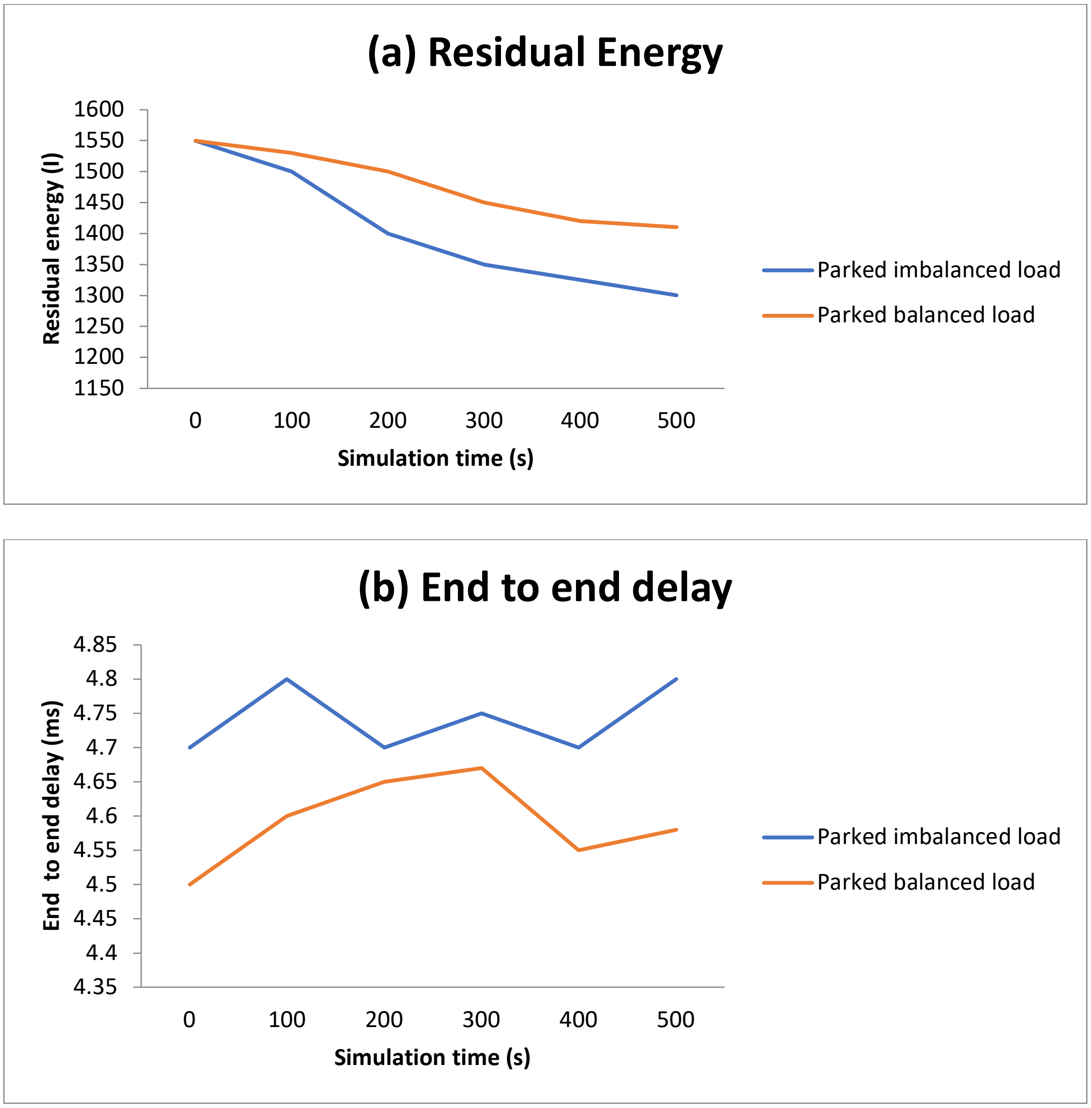

Figure 2: Evaluation of vehicular computing in terms of (a) residual energy, (b) end-to-end delay

4.2 AV at the moving condition

Moving vehicles may halt at signals and become caught in traffic too. The proposed strategy tries to use certain cars as devices while taking the accessibility aspect into account. According to the use of nearer nodes, the initial energy usage of both strategies is identical. Even so, as time has gone on in Figure 3 (a), the proposed approach's energy usage decreases as a consequence of the proper load allocation provided by load balancing. As a result, the network potential is fully used, which optimizes the automobile network's power consumption. As a simple consequence, the load-balancing strategy has greater node transmission power than the unbalanced load approach. The actual timebased on the network is extended as a result.

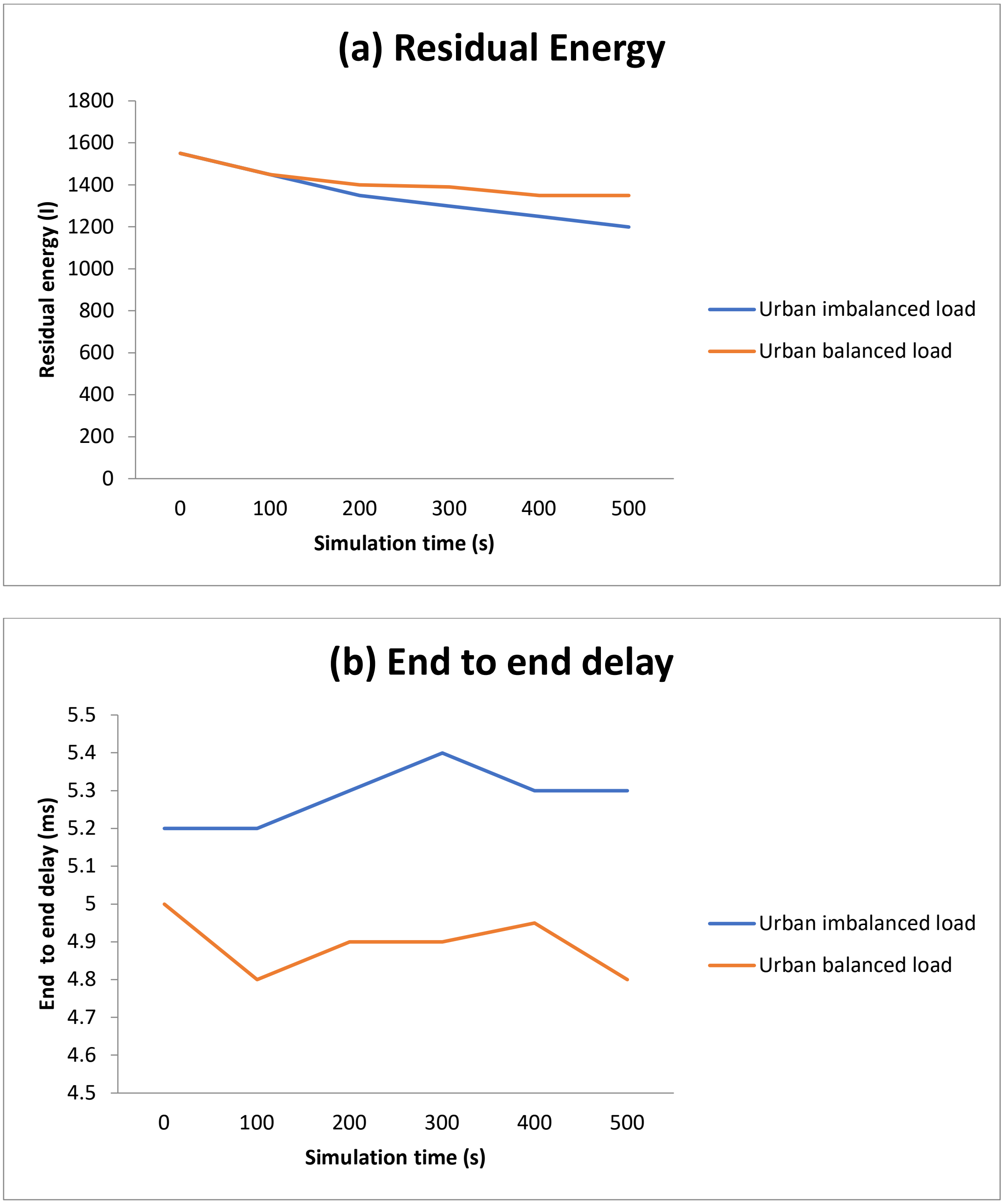

Figure 3: Evaluation of vehicular computing in terms of (a) residual energy, (b) end-to-end delay

Figure 3 (b) the end-to-end latency is shown. Unbalanced load distribution occurs when some nodes were overburdened while the other ones are inactive or underutilized. As a result, nodes closest to the gateways execute requests more slowly. Traffic in the system results from nodes' longer response time. The latency for IoT inquiries has grown as a result of enhanced network congestion, and it occasionally goes over task deadlines. The proposed load-balancing method effectively transfers the load between nodes that seem to be inactive toward the lessened traffic load. The network's end-to-end delay is also decreased because of the decrease in traffic.

Depending on each node's processing capabilities, the proposed technique effectively distributes the load between them [23]. Before moving a project to another eligible node for processing, it is also guaranteed that the job has been completed. This process can make the proposed technique faster than the technique without the need for a neutral point since it shortens the responsiveness.

4.3 Comparative approach

We assess the SDN's latency performance in comparison to cloud networks and organizations with good SDN-IWPSO methodology. Figure 4 displays the latency correlation. Although cloud computing is faster than FN, there is minimal change in latency between cloud and SDN whenever the job load is lesser than 0.05Gb. The latency of the cloud, though, seems to be much greater than either the latency of the remaining two systems with such a rise in the workload because of an improvement in transmission latency.

Although cloud servers were located distant from end customers, which significantly increases transmission delay, it has better connectivity than the cloud. Additionally, we can see in Figure 4 that the latency of SDN seems to be lesser than the apparent [22] whenever the task load has been high thanks to the cloud server's enhancement of the program's computation speed. since FN's actual computational power was constrained. SDN may indeed effectively enhance QoS and customer experience within latency-sensitive scenarios.

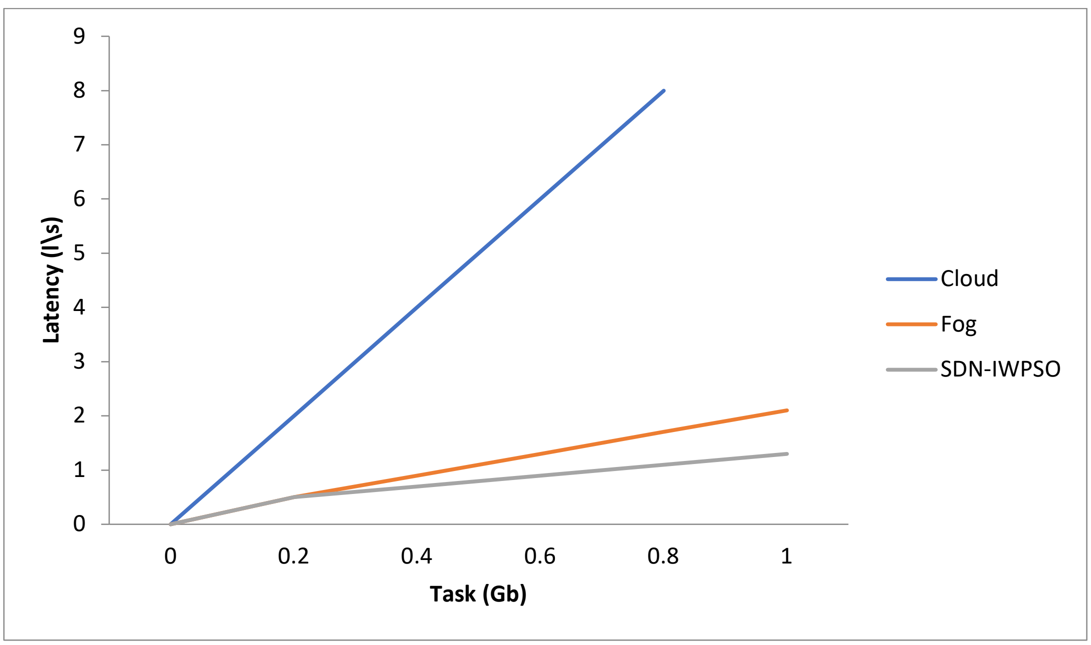

Figure.4: Comparison of SDN Vs Cloud based on latency

Figure 5 presents the outcomes of four methods that were implemented in an SDN scenario. To analyze the impossible particles using the regular PSO method, a specific fitness value is added to the PSO [24]. It can, however, prevent the process from reaching a local optimum. As a result, we modified the PSO algorithm to use the SDN-IWPSO algorithm, which reverses the direction of such a flight of mutation granules. According to Figure 5, the SDN-IWPSO algorithm provides lower latency than PSO, LBMM, and Greedy-LB because these algorithms need not account for transmission latency, while PSO might achieve the optimum solution. Additionally, Greedy-LB doesn't take into account the nodes' compute power, which results in the maximum latency whenever the Greedy-LB method is being used. Consequently, optimizing the SDN-IWPSO method for the SDN architecture could minimize the completion of the activity latency of AV.

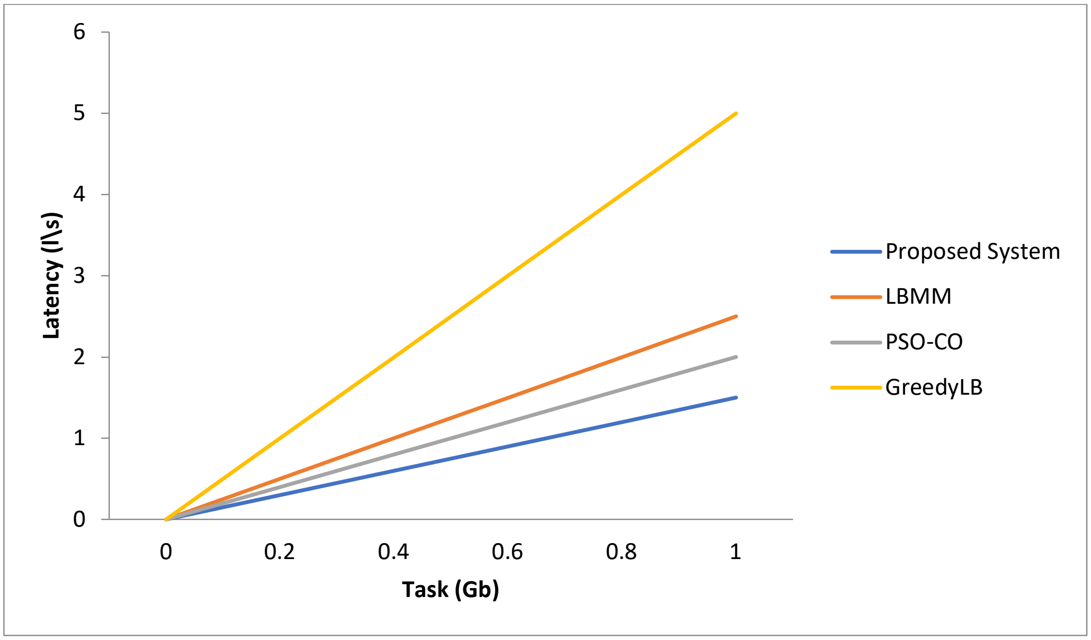

Figure 5: Comparison of proposed and existing system

4.4 Influence effect

Whereas when the job load was transferred to the cloud, the acquired capacity changed in real-time. Hence, it's indeed crucial to calculate the bandwidth's latency efficiency. The task load has been multiplied by 1 GB, and the outcome has been depicted in Figure. 6. This goes without saying also that up-link throughput increases and cloud latency significantly reduces. Once up-link bandwidth exceeds 28 Mbps, it reaches parity with SDN. SDN provides a low level in comparison to the cloud, making it much more suited for AV systems that provide quick response times.

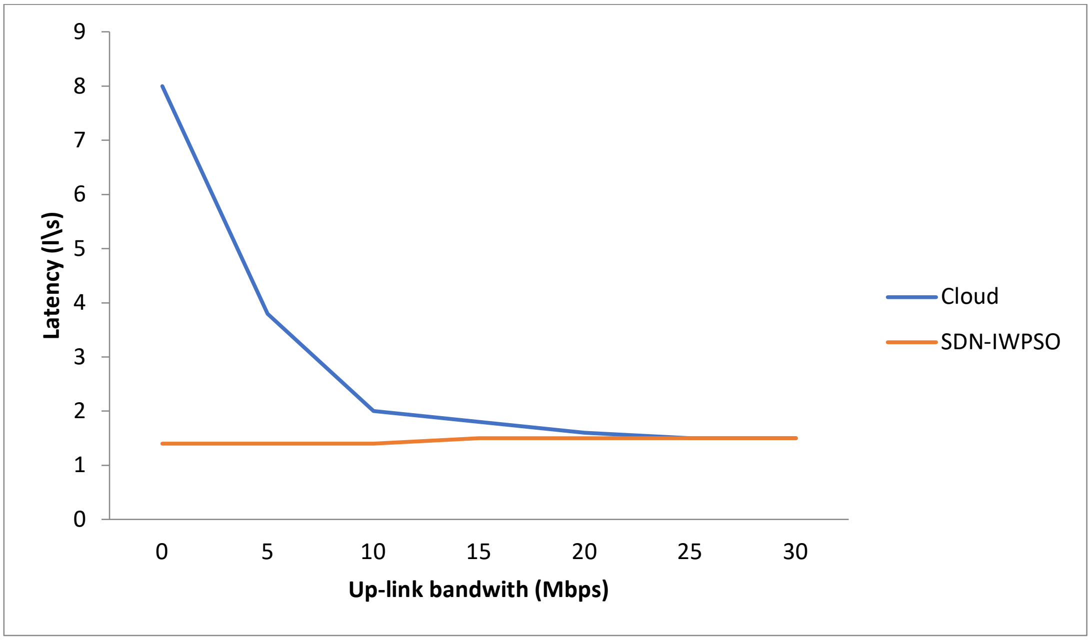

Figure 6: Multiple load balancing of edge computing comparison on proposed and existing system

5. Conclusions

From this study, We have described unique features throughout this research that blend computing and SDN with AV to reduce processing time for latency-sensitive applications. Then, using a combination of network, SDN, and cloud features with graph theory, we build a theoretical model of the software-designed infrastructure and network. Furthermore, based on that, researchers suggest an SDN-IWPSO centralized load balancing method to manage workload among clouds and devices, significantly limiting job processing delay. According to numerical simulations, the above approach may be used to lower latency and enhance QoS inside the SDN. Additionally, the outcomes of the simulations confirm that perhaps the SDN could be used to handle latency-sensitive applications inside the AV better effectively. According to our findings, variable grouping and capacity-based load balancing have been implemented in-vehicle networks to increase the network's energy consumption and the QoS.

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