Journal of Intelligent Systems and Internet of Things
Vol. 09, No. 02, PP. 120-129, 2023
DOI: https://doi.org/10.54216/JISIoT.090209

Path Scheduling and Bandwidth Utilization for Urban Vehicular Adhoc Networks

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Abstract

Vehicular ad-hoc network (VANETs) is a promising technology that is used in the maximum of the applications of intelligent transport systems (ITS). VANETs become more attractive due to their communication methods such as vehicle-to-vehicle (V2V) and vehicle-to-roadside unit (RSU) communication. VANETs consist of a few special features such as unpredictable mobility, dynamic inter-vehicle spacing, high speed and so on which make communication ineffective. These features network delay and routing overhead increased which affects the stability and reliability of the network. In this paper Path Scheduling and Bandwidth Utilization for VANETs (PSBU-VANETs) are proposed. Through the path scheduling process, the changing topologies are predicted that the prediction path is scheduled for data transmission which leads to reduce the delay and overhead of the network. Through the effective utilization of bandwidth, the throughput and delivery rate of the network are increased. The simulation is performed in NS2 and SUMO and to measure the outcome the parameters which are considered are packet delivery ratio, end-to-end delay, routing overhead, and throughput. To perform a comparative analysis the results of the proposed PSBU-VANETs are compared with the earlier research works such as TDG-VANETs and ICB-VANETs. The proposed PSBU-VANETs achieve a high packet delivery ratio and throughput as well as lower end-to-end delay and routing overhead when compared with the earlier approaches.

Received: February 24, 2023 Revised: May 19, 2023 Accepted: September 03, 2023

Keywords: vehicular ad-hoc network; intelligent transport system; vehicle-to-vehicle; and vehicle-to-road side unit.

1. Introduction

Without the aid of an infrastructure device, like an access point or base station, an Ad Hoc Network is a wireless network that enables quick connection establishment between wireless client devices in the same physical area [1-6]. In general, VANETs perform vehicle-to-vehicle and vehicle-to-infrastructure-based data transmission and there must be the presence of significant improvement in the quality of communication hence VANETs deal with high-speed vehicles [7-10]. Nowadays VANETs have become a key technology in intelligent transport systems (ITS) so they must provide effective communication during data transmission. The coverage area of the vehicle is around 1km, so the vehicle-to-vehicle communication occurs when the destination is present inside the coverage area of the source vehicle or there are any other vehicles that are present at the line of sight to the destination. Else vehicle to infrastructure communication is performed hence most of the time vehicle to vehicle communication congestion and delay occur [11-17]. So, to reduce the delay and to increase the packet delivery ratio of the network in vehicular environments in earlier days' store-carry and forward strategy model are used that performs buffering activities at each instant of time to find the best path to each destination but the major drawbacks of this kind of methods are VANETs consists of highly unpredictable mobility so the instant change in the path make the system so ineffective during communication. That results in delay and routing overhead at the time of data transmission. Hence it is essential to develop a new model in VANETs communication to make it more effective when compared with the earlier method. As a result, in this paper novel path scheduling and bandwidth utilization are introduced in VANETs to improve their performance. The contribution of the research is described in the following:

- VANETs are equipped with high-speed mobility so the transmission model such as vehicle-to-vehicle and vehicle-to-infrastructure communication takes place at high speed.
- Due to the high-speed mobility delay and overhead occurring in the network to overcome this drawback a path scheduling with a bandwidth utilization process is performed.
- Path scheduling is used to find the optimal path occurring to the changing topology and bandwidth utilization increases the efficiency of the data transmission.
- Both these methods help to carry out communication in an effective way and help to improve the packet delivery ratio and throughput of the network.

The following is a list of the remaining sections in this paper: Section 2 discusses a related study about VANETs and some of their communication-related drawbacks. The network environment is covered in more detail in section 3. The proposed PSBU-VANETs approach is thoroughly discussed in section 3.B. The performance analysis of the suggested PSBU-VANETs approach is presented in section 4. The results and analysis are shown in Section 5. Finally, section 6 provided examples of the resolution and forthcoming work.

2. Related Work

In [18], the author provided an end-to-end transmission control strategy for VANETs aided by satellite networks and examined the bandwidth-delay product of these networks. The transmission time was drastically cut short using this architecture. But it falls short of keeping overhead low. In [19], the author introduced a dynamic event-triggered scheduling system for the urban VANET environment that considers bandwidth. This approach ensures a trade-off between effective communication and robust platooning control performance. However, greater packet loss is caused by this framework. In [20], the author developed an SDN-enabled Approach for Vehicle Path-Planning (SEARCH) in order to improve situational awareness on urban roadways, effectively gather traffic data in real-time, and choose the most effective navigation method. This strategy can offer enough bandwidth to accommodate all the data traffic required to update vehicles efficiently and instantly while they are traveling. However, this framework's increased communication time is its fundamental limitation. In [21], the author presented a Strength Pareto Evolutionary Algorithm which is a multi-metric routing protocol for VANET. With the most bandwidth and V2V connectivity, this framework selects the path with the least amount of latency, distance, and relative speed. However, a key limitation of this technique is that it increases packet loss as distance rises.

In [22], the author presented an RSU Cooperation-based Adaptive Scheduling (RCAS) algorithm for path scheduling in VANET. The key benefit of this framework is that it effectively handles the clusters for scheduling. However, this framework's primary flaw is that it adds to the communication cost. In [23], the author presented a parking-area-assisted spider-web routing protocol (PASRP), which employs a dynamic multi-priority scheduling technique. This approach speeds up convergence while lowering computational complexity but is unable to reduce packet loss. In [24], the author presented medium access control schemes to provide a hard guarantee on broadcast delay, without time synchronization and cooperation among the VANET nodes. This framework's primary benefit is its minimal path scheduling latency; however, the communication overhead is high. In [25], the author demonstrated peer-to-peer (P2P) data distribution for the efficient use of bandwidth while transmitting time-sensitive streaming media in vehicular ad-hoc networks (VANETs). However, this framework's higher packet loss is its main drawback.

In [26], the author presented an Event-Based Control and Scheduling (EBCS) code sign strategy in VANET. This approach improved communication effectiveness. However, the increased computational overhead of this framework is the main problem found. In [27], the author presented a reliable power control system to efficiently optimize the bandwidth of VANET and boost spectral efficiency. This framework's key benefit is that it works well in cases when there are congested networks. However, the main flaw identified in this network is increased computational delay. In [28], the author proposed a Real-Time Traffic-Aware Data Gathering Protocol (TDG) to improve the effectiveness of traffic monitoring, traffic flow, and traffic safety. This method performs dynamic segmentation switching, data collection and data forwarding process, and data aggregation. Through this method, the efficiency of the network is increased but it fails to reduce the routing overhead and delay processed during the process of communication in the network. In [29], the author improves the performance of VANETs using Contention Based Forwarding (CBF) protocol. The tasks performed by this protocol are intermittent re-transmission paradigm, indiscriminate inhibition rule, and continuous re-transmission process and relay selection. This method reduced the network delay but failed to achieve a high packet delivery ratio and throughput during communication. After analysing the earlier research works on VANETs it is concluded that the communication in VANETs still needs an improvement. As the results in the paper novel path scheduling and bandwidth utilization are performed in VANETs and it is detailed in the upcoming sections.

3. Network Environments

A. System Model

In VANETs the nodes are represented as a vehicle that is created to perform information exchange between them that includes the details such as the path to the distance, speed, and location. Here the vehicles are equipped with an On-Board Unit (OBU) that helps with communication and data sensing and tamper-proofing devices it performs tampering to find obstacles during communication. The vehicles carry out certain activities such as data transmitting, data forwarding, data collection as well and providing references. To control the vehicles the RSU is deployed on roadsides that are static in nature. It acts like a specific agent of authority that controls the entire activities of the vehicles effectively and it consists of an Application Unit (AU) that is used to monitor the entire network inside the coverage area of the vehicles. The system architecture of the network is shown in Figure 1.

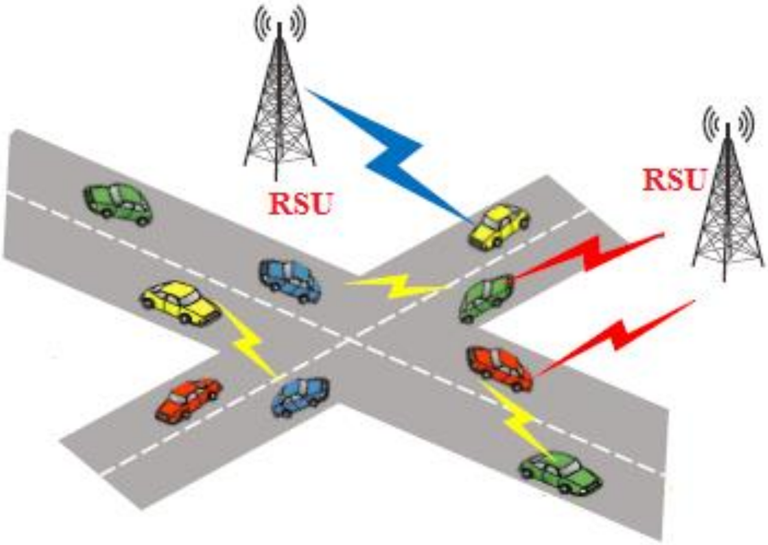

Figure 1: System Architecture

B. Proposed PSBU-VANETS Approach

To improve the performance of VANETs in the proposed PSBU-VANETs approach, path scheduling and bandwidth utilization are performed. Both these methods are used to improve the effectiveness of vehicle-to-vehicle communication and vehicle-to-RSU communication. The workflow of the process is shown in Figure 2.

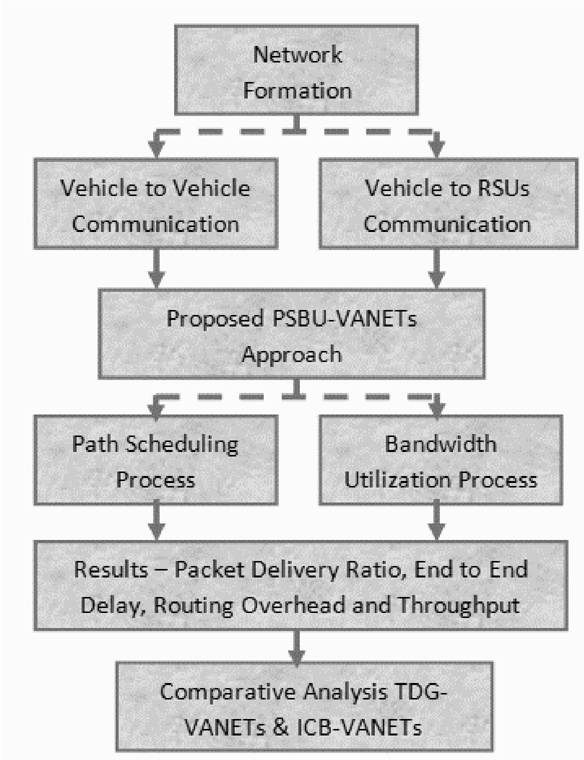

Figure 2: Workflow of the proposed TDQ-VANETs approach

C. Path Scheduling for VANETs

The path scheduling process is performed in VANETs to provide effective congestion avoidance in the network during the communication between the sources to the destination. In general, the source vehicle generates some information, and through the neighbor vehicle of the RSUs it reaches the destination. Through intermediate vehicles maximum of the data are transmitted so there are more possibilities for the occurrence of congestion. As so to reduce the congestion a cross-layering-based path scheduling is carried out between the MAC layer and the transport layer so intelligent dynamic routing is performed among these two layers. In the MAC layer, hop-by-hop communication is used with the CSMA/TDMA model where the data can be transmitted on a shift basis. Initially, it gets transmitted in the CSMA model once the transmission link reaches its threshold then automatically the shifting occurs to TDMA. This process continued for the entire transmission. In the transport layer, the number of packets that are received by the destination is properly monitored and to reduce the control packets and overhead it is essential to determine the proper queuing model to control and monitor the incoming packets. The pseudo-code for the process of path scheduling for VANETs is given below.

Pseudo Code for Path Scheduling

Input: Min. Queue and Max. Queue (½ Queue and ¾ Queue)

Output: Optimal Path

Step 1: The source vehicle generates the information and initiates the transmission.

Step 2: Packet headers are created to route the information according to the classification of a queue.

Step 3: Route the data to the currently created queue.

Step 4: If accepted Min. queue gets activated.

Step 5: Else if traversed.

Step 6: Route the data to the transit packet queue

Step 7: if accepted Max. the queue gets activated.

Step 8: Else if min queue reached.

Step 9: Priority condition:

- Generated packets given low priority
- Transmit packets given high priority

Step 10: Final queue generation according to its priority

D. Bandwidth Utilization for VANETs

VANETs consists of high-speed vehicle and the set of vehicles are represented as = {, …, }. Likewise, each vehicle consists of its own coverage area with the radius, the vehicle speed is represented as residual energy is represented and the corresponding rate of arrival is represented as and for the MAC model-based time slot calculation is used. Scheduling is performed using the TDMA-FDMA modes which utilize the system bandwidth in an effective way. At the initial stage, the best neighbor is shown as chosen and it is mathematically expressed in equation (1)

$$N_w = \left[{}^{50_w}/_{S_v * \mu_n}\right] \times \left[{}^{RE_v}/_{rad_v}\right] \quad (1)$$

During data transmission, due to several reasons, data loss may occur such as channel fading, path attenuation link failure so on. So it is essential to calculate the channel fading at the time of data transmission for each instant of time and it is shown in equation (2)

$$C_f = C * 10\, log_2 \left[{}^{E_c}/_{C * \propto (d_n + 1)}\right] \quad (2)$$

From equation (2), the term C denotes the channel transmission rate denotes the channel transmission power, denotes the distance between the sender and the receiver at each time slot, and α denotes the path loss during communication. In order to find the line of sight between two vehicles probability calculation is performed which is represented as in case the device is acting as an obstacle that is present at the line of sight between the vehicles and, through this obstacle may the line of sight of the vehicle decreases and it is denoted as and to reach the second best vehicle from this the equation is shown below by using the Fresnel ellipsoid in VANETs.

$$C_f = (S_{v2} - S_{v1}) \frac{D_{aff}}{S_k} + S_{v1} - S_{time} \quad (3)$$

From equation (3), the terms are the components of the source and the receiver, implies the distance between the obstacle which is present in the line of sight to the destination and with the sender, implies the obstacle zone, and implies the time taken for the sender to reach its receiver. Using equation (3) the obstacles which are present at the line of sight from the sender to the receiver are priory identified and using the path scheduling process (section 4) the data transmission is performed so that the vehicles can escape from the obstacles of congestion which is produced during the process of communication between them.

4. Performance Analyses

The performance of the proposed PSBU-VANETs is calculated with respect to packet delivery ratio, end-to-end delay, routing overhead, and throughput and it is compared with the earlier research works such as [28-29]. The implementation is carried out in NS2 under Ubuntu 16.04. The number of vehicles used in the simulation is 200 vehicles with a coverage area of 1000 m × 1000 m. In the simulation of proposed PSBU-VANETs both path scheduling and bandwidth utilization are performed. The simulation settings are shown in Table 1.

Table 1: simulation parameters

Input Parameters	Values
Software	**NS2/SUMO**
Running Time	**500 ms**
Dimension	**1000 m × 1000 m**
No of Vehicles	**200 Vehicles**
No of RSUs	**5 RSUs**
RSUs Radius	**200 m**
Initial Energy	**100 Joules**
Transmission Power	**0.05 Joules**

Receiving Power	**0.05 Joules**

A. Packet Delivery Ratio Calculation

The packet delivery ratio of the proposed PSBU-VANETs approach and the comparison such as TDG-VANETs and ICB-VANETs are shown in Figure 3. In general, the delivery ratio is the total amount of received packets with respect to the number of packets transmitted during communication. The packet delivery ratio achieved by the PSBU-VANETs approach is 97%, whereas the ratio achieved by comparison methods like TDG-VANETs and ICB-VANETs is 91% and 94%. The proposed PSBU-VANETs approach achieves a higher packet delivery ratio by using the combination of path scheduling and bandwidth utilization.

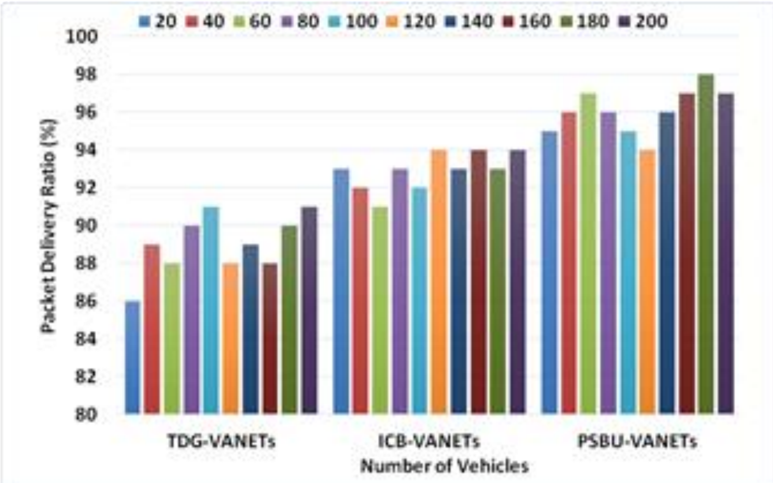

Figure 3: Packet Delivery Ratio Calculation

B. End-to-End Delay Calculation

The end-to-end delay of the proposed PSBU-VANETs approach and the comparison such as TDG-VANETs and ICB-VANETs are shown in Figure 4. The delay is the time taken to send the data from the source to the destination. The end-to-end delay calculated by the PSBU-VANETs approach is 124 ms, whereas the delay produced by the comparison methods like TDG-VANETs and ICB-VANETs is 186 ms and 147 ms. The proposed PSBU-VANETs produced lower end-to-end delay when compared with the earlier methods.

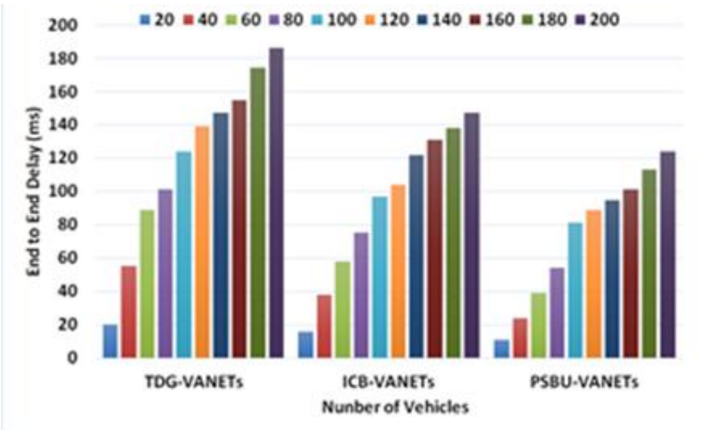

Figure 4: End-to-end delay calculation

C. Routing Overhead Calculation

The routing overhead of the proposed PSBU-VANETs approach and the comparison such as TDG-VANETs and ICB-VANETs are shown in Figure 5. To achieve effective communication in VANETs it is essential to reduce the amount of overhead produced in the network. The overhead calculated by the PSBU-VANETs approach is 347 packets, whereas the overhead produced by comparison methods like TDG-VANETs and ICB-VANETs is 968 packets and 745 packets. The proposed PSBU-VANETs produced lower routing overhead when compared with the earlier methods.

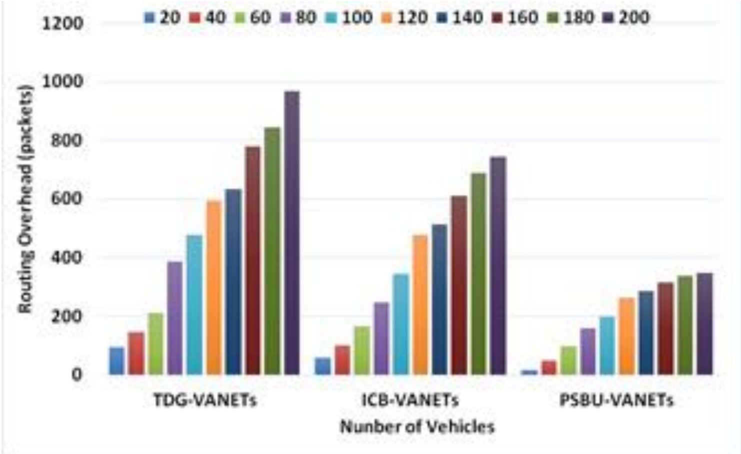

Figure 5: Routing Overhead calculation

D. Throughput Calculation

The throughput of the proposed PSBU-VANETs approach and the comparison such as TDG-VANETs and ICB-VANETs are shown in Figure 6. In general, the throughput is the total amount of data transmitted from the source to the destination for the entire transmission. The throughput achieved by the PSBU-VANETs approach is 745 kbps, whereas the ratio achieved by the comparison methods like TDG-VANETs and ICB-VANETs is 417 kbps and 496 kbps. The proposed PSBU-VANETs approach achieves higher throughput through path scheduling and bandwidth utilization.

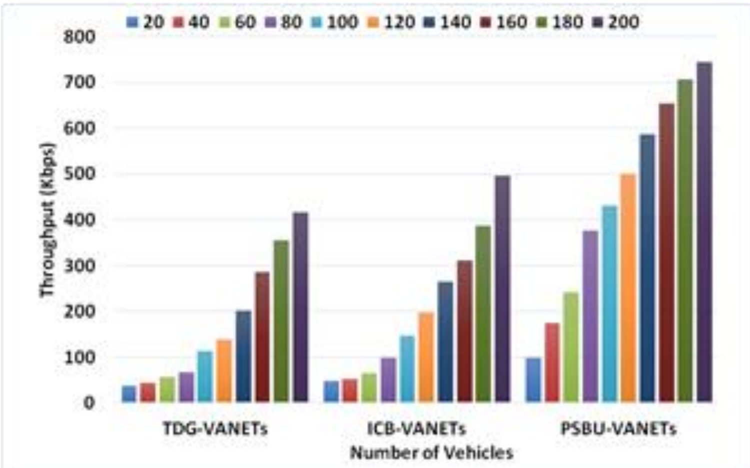

Figure 6: Throughput calculation

5. Results Analysis

In this section the results are analyzed for the methods such as TDG-VANETs, ICB-VANETs, and the proposed PSDU-VANETs approach are discussed in terms of packet delivery rate, end-to-end delay, routing overhead, and throughput. The calculated values of those methods are specified in Table 2.

Table 2: results analysis and measurements.

Parameters / Methods	TDG-VANET	ICB-VANET	PSBU-VANET
Packets Delivery Ratio	**91%**	**94%**	**97%**

End-to-End Delay	**186ms**	**147ms**	**124ms**
Routing Overhead	**968 packets**	**745 packets**	**347 packets**
Network Throughput	**417 Kbps**	**496 Kbps**	**745 Kbps**

Table 2 shows the performance of the proposed PSDU-VANETs approach is better in terms of packet delivery rate, end-to-end delay, routing overhead, and throughput when compared with the earlier works. In the packet delivery ratio calculation, the performance of the proposed PSDU-VANETs approach is 6% better than TDG-VANETs and 3% better than ICB-VANETs. In end-to-end delay output of the PSDU-VANETs approach is 69 ms lower than TDG-VANETs and 40 ms lower than ICB-VANETs. In routing overhead, the PSDU-VANETs approach is 600 packets lower than the TDG-VANETs and 400 packets lower than the ICB-VANETs. In terms of the throughput calculation, the PSDU-VANETs approach produced around 350 kbps higher throughput than TDG-VANETs and 250 kbps throughput higher than ICB-VANETs. The overall performance of the proposed PSDU-VANETs approach is higher than earlier works and that is because of the usage of path scheduling and bandwidth utilization process present in it.

6. Conclusion

In this paper to perform effective communication in both the vehicle-to-vehicle and vehicle-to-roadside unit communication, path scheduling, and bandwidth utilization are introduced. This method greatly helps to overcome the earlier VANET drawbacks like link failure and congestion occurrences. Using path scheduling the delay and overhead of the network are reduced. Using bandwidth utilization, the throughput and the delivery ratio of the network are increased. The simulation of the proposed PSBU-VANETs is carried out in NS2. Four parameters are measured for output validation they are packet delivery ratio, end-to-end delay, routing overhead, and throughput and it is compared with the TDG-VANETs and ICB-VANETs approaches. From the results, it is proven that the proposed PSBU-VANETs produced a 6% higher packet delivery ratio, 69ms lower end-to-end delay, 600 packets lower routing overhead, and 350 kbps higher throughputs when compared with the earlier methods. In the future direction, the idea is to enlarge the density of the network.

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