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Original Article

Li-Fi Computing Based Vehicle-to-Vehicle Communication for Traffic Management Utilization of Detour Global Domination the Graph's Number

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***Abstract* - *Light fidelity (Li-Fi) is an emerging technology that uses light as a medium for signal transmission. It is a completely networked wireless communication method that is bidirectional and concentrates on using Light-Emitting Diodes (LEDs). The proposed LI-FI-based Vehicle-to-Vehicle Communication (V2V) for Detour Global Domination uses the Graph's Number to communicate data between vehicles. This work introduces us to detour GD in several popular graphs and graph coronas. These graphics use readers so electronic information on the vehicles can be retrieved easily, allowing for a proper study of the automobiles' location. Using this Li-Fi technology, many lives can be saved and road accidents avoided. An ultrasonic distance-detecting sensor is used to permit communication between cars that are close enough to touch. As a result, this project will focus on eco-friendly visible light data transmission between autos. The visible light consists of white LEDs that send audio impulses to the receiver. VLC has a promising future and improves existing RF communication by increasing efficiency. The result of the proposed approach ensures highly reliable communication between cars, reducing the increasing number of road accidents in the present times and identifying v2v distance.*

Keywords - *Light Fidelity (Li-Fi), Visible light communication, Vehicle to Vehicle communication (V2V), Detour number, Detour global domination number.*

1. Introduction

Since light is used, a large range of wavelengths and frequencies are available [1]. Optical Wireless Communication (OWC) devices based on Light-Emitting Diodes (LEDs) have been developed recently [2]. In particular, Visible Light Communication (VLC), an OWC technique utilising visible light LEDs, has drawn a lot of interest [3]. Compared to conventional lighting sources like fluorescent lamps and incandescent bulbs, the LED can vary light intensity more quickly, making it a suitable choice for an optical-signal-sending device. In addition, LEDs are cheap, widely utilised in lighting and signage, have a long lifespan, and have a high energy efficiency. Additionally, LEDs' fundamental qualities are continuously being enhanced while their costs continue to drop. These days, radio waves are used for remote correspondence.

Nevertheless, there are problems with the effectiveness, accessibility, security, or limit of radio waves. An essential need for remote communication is range. The current radio wave range ignores the problem, which creates a limit issue as innovation and clientele increase [4]. In order to address all of the problems, we developed the concept of Li-Fi, a relatively new invention that uses LED lights to transmit information remotely. This technology facilitates information transmission much more quickly and is highly adaptable because of its durability, effectiveness, and long lifespan [5].

Another area that most of them are working in is autonomous vehicles. Keeping track of neighbouring vehicles is necessary for autonomous vehicle development [6]. We must communicate data with our neighbouring cars in order to accomplish this. Thus, maintaining vehicle connectivity is crucial to achieving autonomous driving. To connect vehicles, Vehicle to Vehicle (V2V) communication is necessary [7]. Most nations in the world have a concerning history of injuries and fatalities brought on by a high number of accidents. The majority of road accidents are caused by irresponsible driving [8].

It's a form of Visible-Light Communication (VLC) system that communicates using light. Due to its wide frequency and wavelength range and use of light as a communication medium, Li-Fi offers increased availability. Compared to Wi-Fi, it is faster, more secure, and more efficient [9]. With the use of technology, an LED light bulb may produce invisible light pulses that carry data that can be communicated to and from receivers. The receivers then gather and process the data [10]. This research discusses Li-Fi-based vehicle-to-vehicle communication, where data is transmitted between two vehicles to prevent accidents on the road. The study of these ideas was done in [11].

Numerous authors examined and contrasted different diversion distance findings with geodesic distance. These days, wireless networks of many kinds—including mobile, radio, and others, are growing in popularity [12]. Which frequencies are allocated to two transmitters depends on their distance from one another. The intriguing ramifications of triangle-free detour dominance principles extend to channel assignment problems in radio technology. The construction of secure communication networks is another use for these concepts [13].

The structure of this document is as follows: A synopsis of the Li-Fi vehicle communications system is provided in Section II. The transmission and receiving of Li-Fi vehicle communication is covered in Section III. A prototype for vehicle communication that reduces crashes using Li-Fi is described in Section IV. This paper concludes in Section V. The most important contributions are as follows:

- In order to decrease traffic accidents, this study introduces V2V communication.
- The authors employ the Li-Fi technology to facilitate data transmission between two developed prototypes.
- The prototype model showed that Li-Fi could successfully transfer the speed and distance of the leading car to the following vehicle.
- The discovery allows the alert message to spread via Li-Fi technology via a non-emergency vehicle, from a crisis vehicle to the traffic signal controller.

2. Literature Survey

T. Kimura et al. (2021) [14] have proposed a Cooperative vehicular network facilitated by Vehicle-to-Vehicle (V2V) communication, which is crucial for the advancement of smarter transportation networks because they provide a number of applications for reducing traffic and increasing road safety. Recently, concepts for commercially sponsored Vehicle-to-Vehicle (V2V) communications were put out in response to the performance limitations of existing Devoted Short-Range Communication (DSRC) technology. Cellular Base Stations (BSs) facilitate Vehicle-to-Vehicle (V2V) communications by sending signals between cars. Such cellular-assisted communications seem to enable longer transmission distances and better capacity V2V connections.

This study investigates the theoretical performance of Vehicle-to-Vehicle (V2V) communications via Cellular-Relay (CR) systems, in which a vehicle delivers a message via uplink to the nearest Base Station (BS), which subsequently relays it to a target vehicle via downlink.

Runsheng Xu et al. (2022) [15] have proposed utilizing vehicle-to-vehicle communication to enhance the perception of performance with self-driving technologies, which has garnered a lot of attention lately. However, the development and assessment of cooperative perception technologies have been challenging due to the lack of an appropriate publicly available dataset for benchmarking algorithms. In order to achieve this, we offer the first publicly available large-scale simulated dataset for vehicle-to-vehicle perception. Next, we use state-of-the-art LiDAR detection techniques to build a comprehensive benchmark of 16 fully functional models, which we use to evaluate different information fusion procedures. Furthermore, we propose a novel application of the Pipeline for attentive intermediate fusion to combine data from several linked automobiles.

M S Mekala et al. (2022) [16] have proposed a Vehicular network that has traditionally operated based on communications between individual automobiles and between vehicles and infrastructure. In order to boost network service utility rates and consolidate RSU services, a number of important open research challenges must be addressed. These concerns include deciding which utilities to buy from network providers, picking the appropriate RSUs for dependable, efficient service, and maintaining the improved vehicle quality of experience. In order to increase service reliability, we create a two-model RSU Service Compression Approach in this article that is motivated by deep learning. An adaptive packet-error detection system at the edge of the cooperating vehicular network uses content matching to maximize operational dependability.

Marco Meucci et al. (2022) [17] have proposed that a future smart vehicle will require real-time data sharing between vehicles. However, much remains to be discovered in this subject, especially with regard to bidirectional Vehicle-to-Vehicle (V2V) employing Visible Light Communications (VLC). In this study, we describe a system that uses VLC to transfer data back and forth between cars. More specifically, we use real motorbike Headlights (HL) and Rear Lights (RL) to create a bidirectional VLC link for the first time. We also provide a characterization of gearbox performances for real distances (up to 30 m) and relative positions between two cars in an outdoor setting under direct sunlight.

T. Brendan et al. (2023) [18] have proposed a based on data gathered from other V2V-enabled cars, drivers individually decide how carelessly to drive; the collective conduct that follows affects the risk of accidents (and consequently, the data transmitted through the vehicular network). Using our new notion of equilibrium, we give a thorough characterization concerning the game-theoretic constants of this model. According to our model, when compared to zero V2V information sharing, V2V information sharing surprisingly raises the equilibrium number of accidents throughout a large range of the parameter space. Additionally, it could increase the equilibrium cost to society.

3. Proposed System

The proposed Li-Fi-based Vehicle-to-Vehicle Communication for Detour Global Domination uses the Graph's Number to transport data between vehicles. The Detour global dominance number is used to send any type of data, including text, video, and audio, over Li-Fi. Using this Li-Fi technology, many lives can be saved and road accidents avoided [19-29]. An ultrasonic distance-detecting sensor permits communication between cars close enough to touch. This architecture should be able to transport data between devices efficiently using LEDs, thereby establishing a confined Li-Fi network. Data is transmitted between vehicles using visible LED illumination.

Figure 1 depicts the methods taken to recognize and avoid car accidents utilizing Li-Fi-based Vehicle-to-Vehicle Communication for Detour Global Domination of the Graph's number. The researchers would use a regular intersection on a smaller route to evaluate the Li-Fi system. The data kept on the central computers would be shared via Li-Fi, allowing for more safe and secure access to the information. The block diagram above depicts how the information received by readers and light sensors is used to analyse traffic movement in accident regions. This paper discusses detour GD in various popular graphs and graph coronas. This graph uses readers to readily retrieve electronic information on the vehicles, resulting in a proper study of the automobiles' whereabouts.

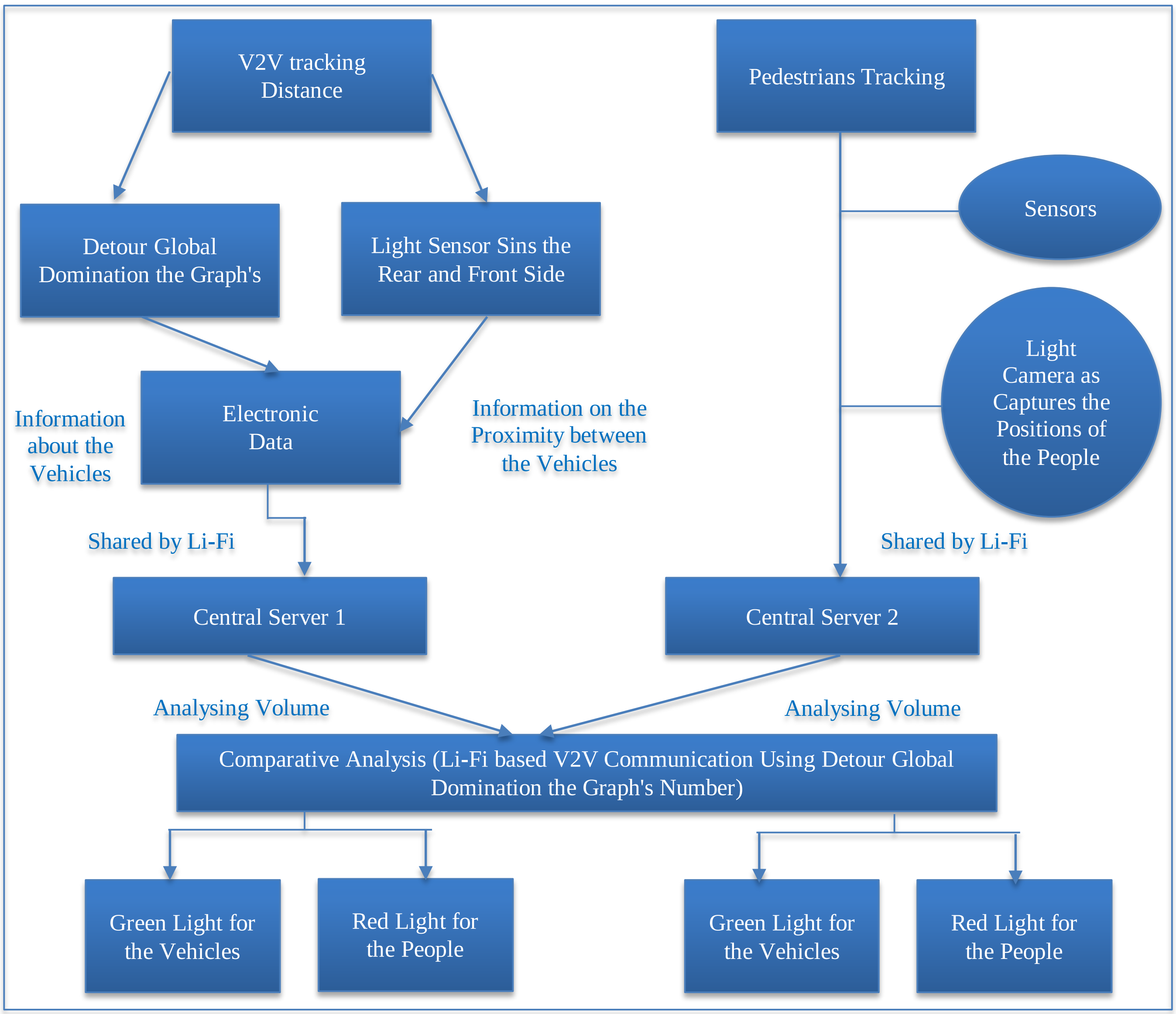

Fig. 1 The proposed block diagram for traffic management

Furthermore, light sensors installed at the opposite end of the road would help determine pedestrian placements. While doing so, the volume of persons would be analysed so that the system could determine their count. Li-Fi technology will be used to transfer the data to central servers 1 and 2, where accurate analysis will be carried out. The system's ability to distinguish between the various car and pedestrian volumes depends on the counting that the sensors do.

3.1. Li-Fi Based V2V Communication System Using Global Domination Number

3.1.1. Li-Fi Technology

The core idea behind Light Fidelity, or Li-fi technology, is to use an LED lightbulb as a channel for data transmission in lighting. The method's main achievement is the creation of a high-brightness LED that can be cycled on and off multiple times per minute. If the LED only sends binary data, one is transmitted while the other is not.

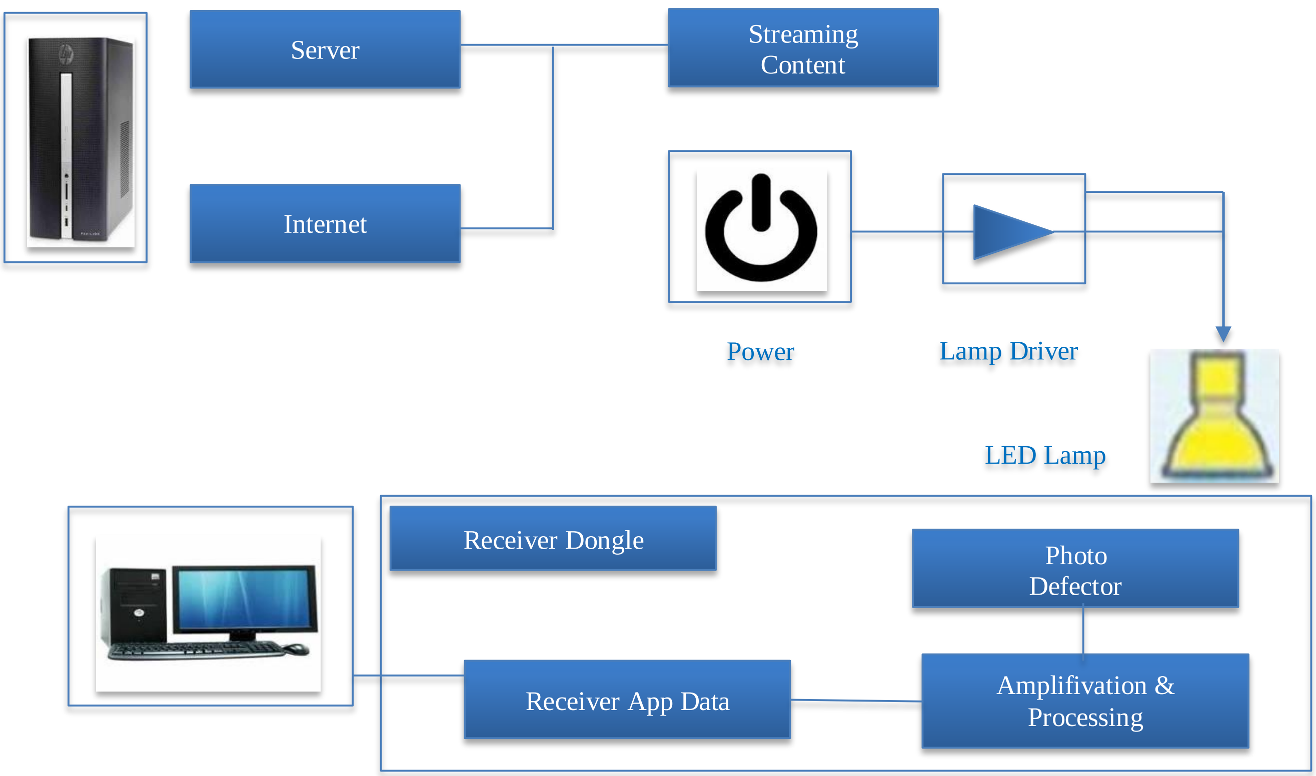

Fig. 2 Li-Fi working principal sources

At one end, a transmitter takes the form of a reliable light source, like an LED bulb. A light sensor or photodetector is used at the receiving end to retrieve transmitted data. Furthermore, A multicolored LED matrix or thousands of flashes of the LED bulb are used to create a message, allowing for changing data speeds within a specific range of megabits per second. The data is delivered by the photodetector in binary format, and the transmission is primarily determined by what the LED bulb sees. The receiver consists of a data converter, and the converter data is then supplied to a server or mobile device, which takes the necessary action.

3.1.2. V2V Communication

Figure 3 depicts the system of optical V2V communication. An innovative car (LV) equipped with LED transmitters that use the headlights, brake lights, and tail lights of the vehicle is depicted in this image. A vehicle (FV) at the rear is housing the camera receiver. The LV collects its own internal data, including speed, and transfers it to the FV using optical signals. Simultaneously, the camera receiver on the FV takes pictures and uses image processing methods to find LED zones in the pictures. Green rectangles encompass the LED areas in Figure 3. The receiver system receives the optical signals, which also monitor changes in light intensity in the identified LED zones.

3.2. Li-Fi Based V2V Communication System

LED lights act as internet access points in Li-Fi technology, while visible lights facilitate communication between nodes. Li-Fi technology is based on Visible Light Communications (VLC), which works by turning on and off bulbs in nanoseconds.Although Li-Fi bulbs need to be turned on to transmit data, they may be dimmed to the point where they are functional but not visible to the human eye. Li-Fi-enabled LED headlights, taillights, and traffic signal lights can be utilized to manage traffic and improve road safety through V2V communication.

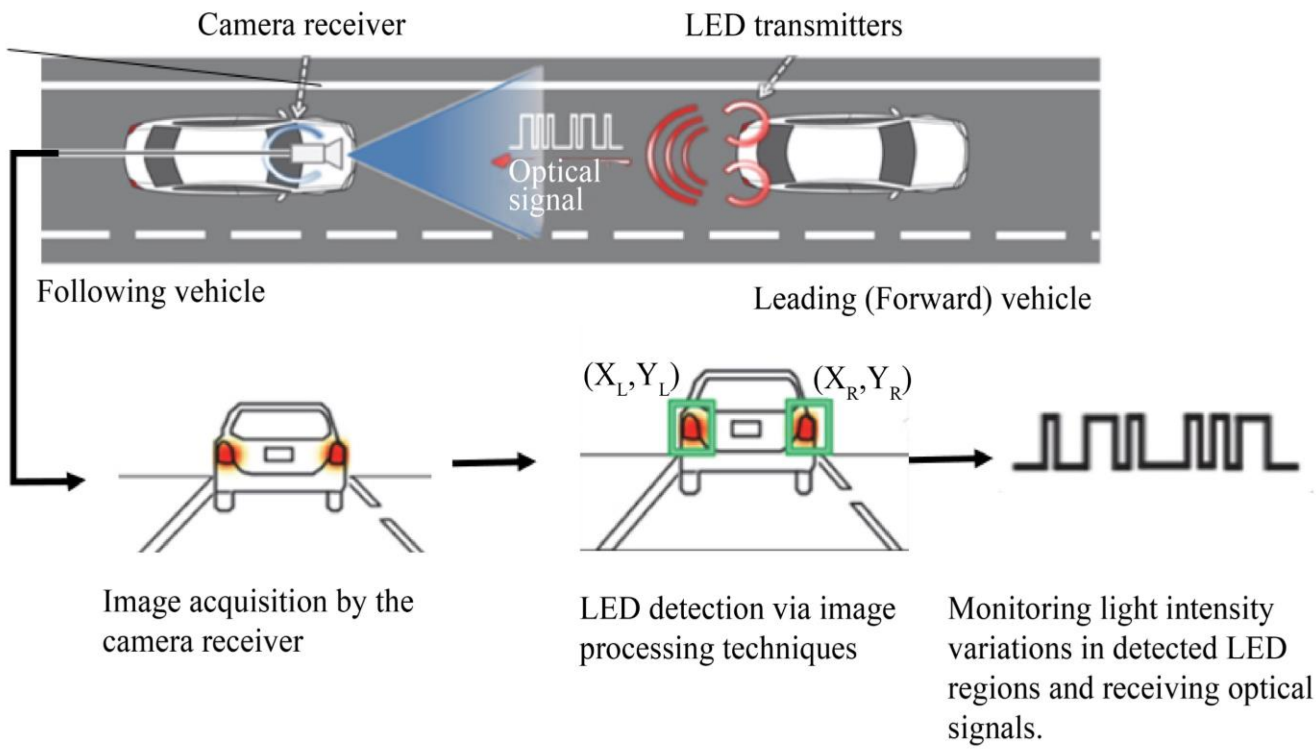

Fig. 3 Illustration of the optical V2V communication system

The dates are sent to Detour's global dominance number. Each automobile must have a transmitter and a receiver, and the LED headlights and taillights act as transmitters and receivers on both the rear and front sides. The cars were able to interact among each other using the echo system, which used light sensors on the front and back sides of the vehicles to detect the distance between them,

$$distance = \frac{S \times T}{2} \quad (1)$$

Where S represents the vehicle's speed and T represents time**.**

The communication and connectivity of Li-Fi are much superior in speed, stability, and security compared with other traditional internet technologies.

3.2.1. LED Transmitter and Camera Receiver Systems

This transmitter system comprises a controller that includes a PC and an LED array unit. The controller gathers and packages different data types before encoding and packetizing them for transmission. The LED array unit has an optical power of up to 4 W and is equipped with LED drivers. 870 nm Near-Infrared (NIR) LEDs with a high modulation speed (fc: 55 MHz) are employed in this system in an indicative capacity. The output is processed at each optical V2V communication system layer, as the following formulas show.

The broadcast and received signal vectors are denoted by s and y, respectively, and the channel matrix H comprises the LoS and NLoS (diffuse) components. The symbol ⊗ denotes the convolution process. The entire variance in noise is provided as

$$y = H \otimes s + z \quad (2)$$

where σ_n^2 is the total amount of thermal, dark, and shot noise and $\sigma_c^2$is the clipping noise. The Poisson process can be used to mimic the incident photons that arrive at random from sunlight and LED light, which is the cause of the shot noise.

$$\sigma = \sigma_n^2 + \sigma_c^2 \quad (3)$$

The channel matrix *H* is given as

$$H = [h1\ h2] \quad (4)$$

Each entry of matrix *H* can be given as

$$h_{RT}(t) = h_{LoS}(t) + h_{NLoS}(t) \quad (5)$$

Where hLoS(t) hNLoS(t) are the CIR for LoS and NLoS paths, respectively.

It should be emphasized that, unless otherwise indicated, the term "power" refers to a comparable optical power that is proportionate to the LED's driving current. In the electrical domain, the two sent signals are layered in this manner.

$$s = \sum_{i=1}^{2} P_i s_i \quad (6)$$

where the total transmit power of the corresponding car headlamp LED is provided by

$$P = \sum_{i=1}^{2} P_i \quad (7)$$

$$x = \sqrt{P}(\sqrt{\propto_1 x_1 + \sqrt{\propto_2 x_2}} \quad (8)$$

The copy of × that, after travelling across channel h1, is received at the nearby user, or user 1, is

$$y_1 = h_1 x + w_1 \quad (9)$$

Likewise, the duplicate of × that user 2 at a distance receives after it propagates across channel h_2 is

$$y = h_2 x + w2 \quad (10)$$

3.2.2. Global Domination Number of a Graph

For a graph G with $n \geq 2$ and $D \leq 4$, then $\overline{\gamma}_{dn}(G) = 2$ if G is either K_2 or P_4 or G is the class of graphs given in

Proof: Case (i). $D = 1$. Then $G = K_2$, Theorem is true.

Case (ii).$D = 2$. Then by Theorem 2.9, no graph exists.

Case (iii).$D = 3$, G is a tree, $G = P_4$, which meets the requirement. If G contains a cycle, then G has a cycle length of four. If $G = C_4$, then G satisfies the conditions. If $G \neq C_4$, then there persists one vertex, say v in G, v is the vertex of C. Hence $D \geq 4$,

Case (iv).$D = 4$. Since $\overline{\gamma}_{dn}(G) = 2$, G contains a cycle. Hence $C(G) \leq 5$, where $C(G)$ is the cycle in G. Let $C: v_1, v_2, \ldots, v_l$be a cycle , where $l = C(G)$. There are three subcases.

Subcase (iv) a$C(G) = 3$. Since $G \neq C_3$, there persists at least one vertex v not on C such that v is adjacent to, say v_1. Since $n \geq 5$, by Theorem 2.6 $G \neq K_4 - \{e\}$ and $G \neq K_{1,3} + e$. Therefore, there persists u in G such that $uv \in E(G)$. If v is adjacent to either v_2 orv_3. If v is adjacent to v_2 and v_3, and so $\overline{\gamma}_{dn}(G) \geq 3$, not possible.

Subcase (iv)b$C(G) = 4$. Since $G \neq C_4$, there persists at least one vertex v not on C such that v is adjacent to, say v_1. Which meets the needs of this theorem? If v is adjacent to either v_1 or v_4. If v is adjacent to v_1 and v_4, then the graph is like the graph G.

Subcase (iv)c$C(G) = 5$. Let $S = \{u, v\}$ be a $\overline{\gamma}_{dn}$-set of G, which yields that $uv \in E(G)$, ,By Theorem 2.7, $\overline{\gamma}_{dn}(G) = 2$. So, we have an open problem.

Theorem 2.11.$\overline{\gamma}_{dn}(G) = n - 2$ if G is either a double star or C_4 or C_5 or $K_1 + 2K_2$

Proof: Assume $\overline{\gamma}_{dn}(G) = n - 2$. Let $n = 4$. Then $G = C_4$ or P_4. Theorem follows. So let $n \geq 5$. The double star is a tree. So, we have done. G contains a circuit. By Theorem 2.12, $C(G) \leq 5$. Let $C: v_1, v_2, \ldots, v_l$ be a cycle in G.

Case (i)$C(G) = 5$. If $G = C_5$. Let $G \neq C_5$. Then there persists at least one vertex v not on $C, vv_1 \in E(G)$ (say). Let $S = V(G) - \{v_2, v_3, v_l\}$, $\overline{\gamma}_{dn}(G) \leq n - 3$.

Case (ii)$C(G) = 4$. If $G = C_4$,. Let $G \neq C_4$. Then there persists at least one vertex v not in C such that $vv_1 \in E(G)$, (say). Let $S = V(G) - \{v_1, v_2, v_4\}$. Hence $\overline{\gamma}_{dn}(G) \leq n - 3$.

Case (iii)$C(G) = 3$. By Theorem 2.10, $G \neq C_3$. Also, by Theorem 2.6, $G \neq K_{1,n-1} + e$.

Subcase (iii)(a)G contains only one cycle. Let $C: v_1, v_2, v_3, v_1$ be the cycle in G. If $deg(v_i) \geq 3$ $(1 \leq i \leq 3)$, then $S = V(G) - \{v_1, v_2, v_3\}$ is a detour GD set, $\overline{\gamma}_{dn}(G) \leq n - 3$, $deg(v_1) \geq 3$ and $deg(v_2) \geq 3$ and $deg(v_3) = 2$. Then the edges incident at v_1 and $v_2$are end vertices. G is G, $deg(v_1) \geq 3$ and $deg(v_1) = deg(v_3) = 2$. Since $\overline{\gamma}_{dn}(G) = n - 2$, edge incident at v_1 is not an end vertex of G. Let vv_1 be an edge incident at v_1 and uv be an edge incident at v. Then $S_1 = V(G) - \{v, v_1, v_3\}$ is a detour GD set, $\overline{\gamma}_{dn}(G) \leq n - 3$,

Subcase (iii)(b) G contains two cycles $C_1$and C_2. First, assume that $C_1$and C_2 have a common vertex, say v. Let $C_1: v_1, v_2, v, v_1$ and $C_2: u_1, u_2, v, u_1$ be the two cycles in G, v is a universal vertex of G, v in the detour GD set. If $deg(v) = 4$, then G is $K_1 + 2K_2$, If $deg(v) \geq 5$, then the edges incident at v are end edges, G is the graph like the graph. Hence, the theorem.

Subcase (iii)(c)G has at least two cycles $C_1$and C_2, which are connected by a path, say $v, w_1, w_2, \ldots, w_l = u$. Then $S_2 = V(G) - \{v_2, v, u, u_2\}$ is a detour GD set, $\overline{\gamma}_{dn}(G) \leq n - 4$.

The converse is clear. When a red light appears, all cars should come to a halt. However, certain automobiles do not intend to observe this guideline. Li-Fi technology has the potential to prevent traffic signal violence. Every vehicle can be allocated a unique number, and information related to this number must be recorded in a central database.

4. Results and Discussion

There are times when the PAR drastically drops; in Figure 4, the worst PAR is 38%. The rough road then pitches the FV. The receiver misses packet preamble and/or post-amble when significant pitching that exceeds the LED detection rate happens during packet waiting or receiving. This measurement confirms that one of the most frequent reasons for packet losses is vehicle pitching. Packet losses will be reduced by increasing the LED detection rate or the flag image's output rate.

Additionally, lowering the payload size would increase the PAR. However, because the overhead size is comparatively larger, the data transmission efficiency would be reduced. The PAR measurement result is displayed every 5 seconds in Figure 4. There are times when the PAR drastically drops; in Figure 4, the worst PAR is 38%.

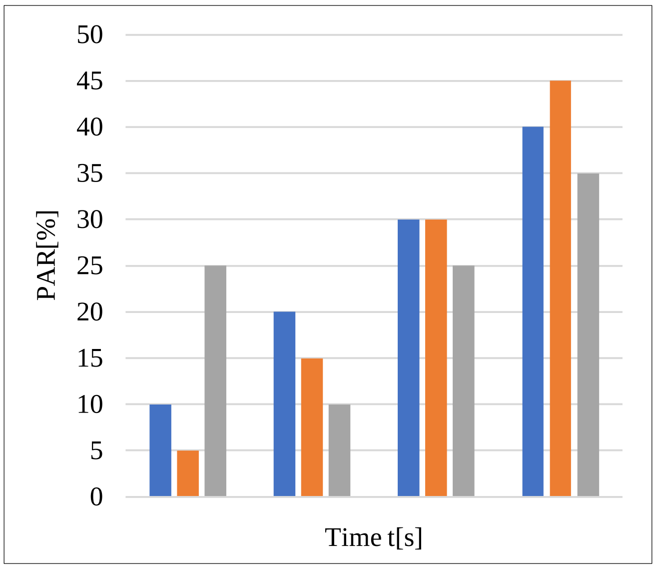

Fig. 4 PAR measurement result per 5 seconds

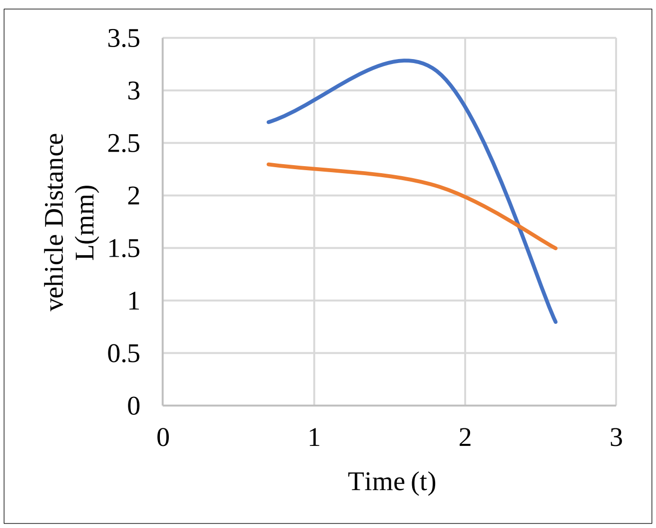

Fig. 5 The outcome of the vehicle distance calculation for 50 seconds

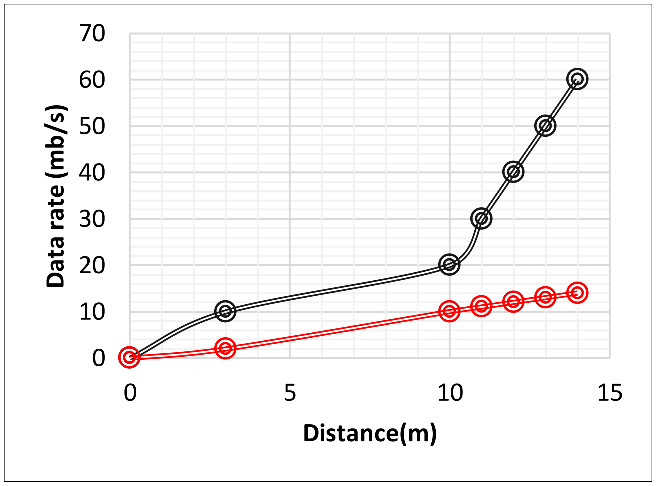

Fig. 6 LiFi technology connects outdoor and indoor spaces

Figure 5 shows the inter-vehicle length L calculation result for 50 seconds. The range function of this optical communication system has been accomplished without the need for additional sensor devices, sophisticated processing technologies, or higher costs. Figure 5, lower left corner, displays the received front-view image. The vehicle distance is 7.781 meters, and the predicted relative speed is 1.4 km/h.

Additionally, the receiver system successfully receives a variety of data during the night. The LV's headlights, right indicator and brake lights are on, as seen in Figure 5.

These days, cellular networks are the only way to access the Internet while you're outside. WiFi is primarily intended for use indoors; in most cases, it cannot be utilized outside. LiFi technology, on the other hand, will use outdoor lamps to enable easy Internet connectivity. Thus, as long as there are lamps nearby, someone may easily use the Internet whether playing in the park, strolling down the street, or relaxing on the beach.

The data rate result is shown in Figure 6 for different User Device (UD) and Access Point (AP) distances. That being said, the external environment under consideration is in ideal conditions that is, there is neither fog nor rain. However, the performance of an outdoor Li-Fi system will drastically suffer in such circumstances.

5. Conclusion

The paper proposes LI-FI-based Vehicle-to-Vehicle Communication (V2V) for Detour Global Domination, with the Graph's Number employed to transport data between cars. This paper discusses detour GD in various popular graphs and graph coronas. This graph uses readers to readily retrieve electronic information on the vehicles, resulting in a proper study of the automobiles' whereabouts. Using Li-Fi technology can save many lives and prevent road accidents. First, it has been changed because data pre-processing has a big influence on model performance. Factor visualization and analysis are useful tools for identifying and preventing anomalies like missing values and outliers. This involves a number of fascinating aspects that should be found and worked on, beginning with performance evaluation and the conventional communication approach. Li-Fi technology has advanced dramatically for car communication over the past ten years. Thus, this work presents a Li-Fi-based, cost-effective communication solution. Data exchanged between vehicles and infrastructure on operations and safety is known as Vehicle-to-Infrastructure (V2I) communication. The study indicated that by using light sensors positioned on the front and back sides of the vehicles, they could compute the relative distances and avoid unnatural death on the road due to driver recklessness. So, it is time to put this fantastic technology into action to move forward into the digital world.

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