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Revolutionizing HighwayNavigation: Exploring the Potential of LIFI Technology

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Abstract:

This research work tackles the challenge of reliable navigation in congested urban environments by proposing a novel system that combines LiFi and LoRa technologies. In existing methods of the navigation there are complications with interference with the infrastructure and limited bandwidth so these can be overcome by the presented prototype. The LiFi transmitter which is placed in the streetlights, uses visible light for the transmission of the information of location at particular co-ordinates, which is received by the LiFi receivers equipped in the vehicles, that transmitted information will be directly given to the navigation system, which provide with continuous seamless navigation even in the places where there no service available, moreover this advanced navigation system is also capable of broadcasting the present location of the vehicle through the LoRa module to the outer world, by which the present location of the vehicle can be monitored, thereafter in the prototype, transmitted LoRa signal is received by the LoRa module and displayed in the LCD, this LoRa module has very long range and uses very low power when compare to the cellular network. In the non-serviceable locations like terrines, valleys, tunnels this idea can be a major contribution in the field of navigation.

Keywords: Li-Fi, LoRa, streetlights, navigation, non- serviceable areas, less power consumption.

1. INTRODUCTION

This project proposes a navigation system with LiFi and LoRa technologies integrated together to overcome limitationsof existing navigation methods in non-serviceable location. Existing navigational systems often lack due to interference and limited bandwidth. Our idea uses particularly placed LiFi transmitters i.e. LED lights within streetlights for high-speedand short-range communication through the visible light. LiFitransmitters will transmit the location data directly to vehicleswhich is equipped with LiFi receivers which uses that information for enabling onboard navigation systems which will then provide with uninterrupted route navigation. Using LoRa transmitter placed in the vehicle, the location information will be captured by the LiFi receivers and then will be retransmitted by the LoRa transmitter. LoRa's long- range capabilities then transmit this information over extended distances to infrastructure and the outer world with LoRa receiversand LCD displays. By this, vehicle will be able to receive real-timenavigation updates and route guidance by displaying on the screens.This integrated system will offer many advantages. LiFi provides high bandwidth along with short-range communication for precise location updates, while LoRa provides long-range data transmission. Additionally, the system is designed to be immune to interference, ensuring reliable operation in exceptional environments. Through thorough testing and optimization, the project aims to demonstrate significant improvements in accuracy,reliability, and efficiency compared to traditional GPS-based navigation.

Li-Fi TECHNOLOGY

Li-Fi i.e. Light Fidelity is a perfect alternative for the existing wireless communication. It uses light for data transmission. LED lights will work as transmitters, where the data is encoded by modulating the light intensity of the LED. This innovative approach provides many advantages over existing navigational methods.in the same way Li-Fi provides significantly high data transfer rates, effective over Wi-Fi. Moreover Li-Fi provides enhanced security as light has limited penetrating capability, making it difficult to interrupt data from outside the effective area.It is immune to other interference which further strengthen the signal, Li-Fi's will make it a good solution for addressing the further development in modern connectivity.

LoRa TECHNOLOGY

LoRa, which is abbreviation Long Range, is a wireless communication technology on the Internet of Things (IoT) domain.It shines in applications requiring long-range communication, low power usage, and robust connectivity. While data rates are lower compared to other solutions, LoRa excels at transmitting small datapackets over significant distances.

2. LITERATURE SURVEY

Published by M. Ayyash; A .Khreisha.; H. Elgala; V. Jungnickel; T. Little; S. Shao; D. Schulz; M. Rahaim; J. Hilt; R. Freund in International Conference

The coexistence of Wi-Fi and Li-Fi toward 5G representsa paradigm shift in wireless communication, leveraging the strengths of both technologies to meet the increasing demands of connectivity in the 5G era. Wi-Fi, known for its ubiquity and reliability, operates in the radio frequency spectrum, while Li-Fi utilizes light waves for data transmission, offeringhigher bandwidth and potentially faster speeds.

This combination presents multiple opportunities, including enhancement in data transmission rates, low networkblocking, and expanded coverage through continuous handover between LoRa and LiFi networks. However, challenges such as operation in the device complexity, and security relates must be referred to realize the advantages of this integrated version of the navigation system. Interdisciplinary collaboration among researchers, engineers, and writing the policy is crucial to develop standards, protocols, and infrastructure that will provide with efficient coexistence of LoRa and LiFi within the 5G environment. Despite the challenges, the integration of LoRa and LiFi holdsthe promise of revolutionizing wireless communication, with highly connected, high-speed networks capable of supportingemerging applications such as augmented reality, IoT, and autonomous vehicles.

Published by M. Thanigavel in InternationalJournal of Engineering Research &Technology

Li-Fi i.e. Light Fidelity, technology is revolution in wireless communication by utilizing light waves instead of traditional radio frequencies to transmit data. Employing lightemitting diodes (LEDs) as transmitters, Li-Fi enables data transfer through modulation of light intensity at speeds far surpassing Wi-Fi. The technology mainly relies on the wide bandwidth of the visible light spectrum, which offers faster, more secure, and efficient data transmission. Implementation of Li-Fi gives good wireless network, finding applications inareas with radio frequency interference problem, likehospitals and cabins in the aircraft. Moreover, it enhances security because light cannot penetrate walls, minimizing therisk of data interception. Despite its good advantages, LiFi also has limitations in some fields which includes it relying online of sight communication and disadvantage to light transmission. But recent research is aiming to address these problems and further force LiFi will provide advantage in different domains, ranging from telecommunications andinternet of things (IoT) to smart lighting systems and vehicleto vehicle communication, including a future of faster and more reliable wireless connectivity.

Published by X. Tang, H. Li, Y. Z hang and X. Zhaoin IEEE 4th International Conference on Computer and Communications (ICCC), Chengdu, China

The performance analysis of LoRa modulation with residual frequency offset researching the impact of frequency deviation onthe efficiency and reliability of LoRa communication systems. LoRa i.e. Long Range, is one of the modulation techniques whichis widely used for low power and long-range wireless communication in the field of Internet of Things (IoT) and its applications. Residual frequency offset refers to the remaining deviation between the transmitted and received frequencies whichcan be caused because of the imperfections in hardware or environmental factors.

This analysis helps us to understand how residual frequency offset affects the communication range transmission and receiving data rate, and packet error rate of LoRa communication systems. By simulating various situations and verifying the effect of frequency offset on system performance, researchers are trying todevelop the mitigating techniques and optimize LoRa modulationparameters for real world deployment. This research is important toensuring the robustness and reliability of LoRa-based IoT networks, especially in environments where frequency stability may be compromised. Finally, the knowledge of this analysis contributes to the advancement of LoRa technology and its widespread adoption in different IoT applications.

Published by M. El Aasser, A. Gasser, M. Ashour and T. Elshabrawy in IEEE Global Conference on Internet of Things

Comparing the performance of LoRa and Frequency hopping-based LPWAN i.e. Low Power Wide Area Network technologies provides valuable insights for IoT i.e. Internet of Things and otherwireless communication applications. LoRa, known for its long- range capability and low power consumption, utilizes spread spectrum modulation techniques for data transmission. On the other hand, Frequency Hopping based LPWAN uses frequency responsiveness to mitigate interference and improve strength in challenging RF environments. Performance analysis involves evaluating key metrics such as range, throughput, latency, and power efficiency under various operating conditions. LoRa's advantage lies in its extended range and simplicity, making it suitable for applications requiring wide area coverage with minimum infrastructure requirements. However, Frequency Hopping based LPWAN offers enhanced reliability and resilience against interference, crucial for dense urban environments or industrial settings. Ultimately, the choice between the two technologies depends on specific deployment requirements, balancing factors like coverage, reliability, and power consumption to optimize network performance for the intended application.

3. PROPOSED SYSTEM

In this navigation system which is integrated with both LiFi and LoRa technologies to provide continuous communication between infrastructure and vehicle, ensuring reliable location services even in the remote areas and terrain areas where there will be no service. Streetlights act as transmitters, encoding location data into light signals using LiFi. Vehicles which are equipped with LiFi receivers capture this information of location from the streetlights.

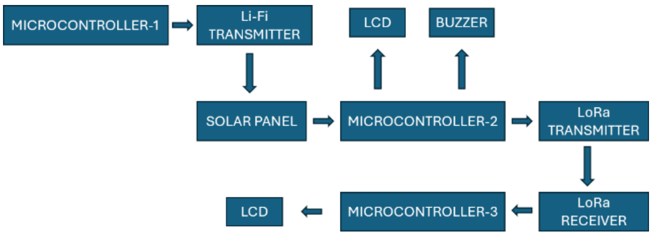

Fig-3: block diagram of proposed prototype

These streetlights are powered by solar panels which also used for transmitting the data. LoRa i.e. long range has capable enable relaying the location information to nearby infrastructure like communication towers, achieving wide area coverage even in difficult terrain. By combining LiFi's high-accuracy data transmission for short distances with LoRa's long-range communication, the system improves navigation accuracy and accessibility. This approach ensures reliable positioning for vehicles navigating remote environments.

TRANSMITTER-1

LED (Light Emitting Diode)

This acts as the light source and transmits data. The Arduino Nano controls the LED, turning it on and off rapidly to encode information into the light signal.

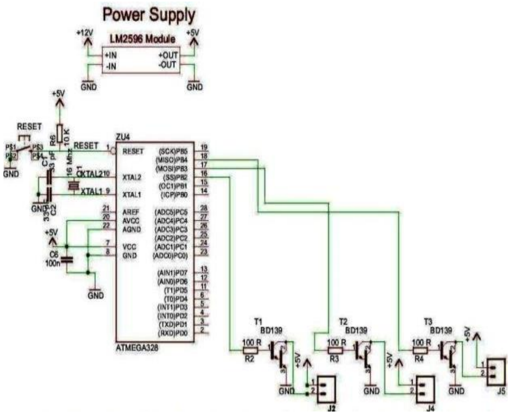

Fig 1: Transmitter section

ARDUINO NANO

This microcontroller is the brain of the transmitter. It takes data to be transmitted and encodes it by controlling the LED's light output based on programmed instruction.

RECEIVER-1

SOLAR PANEL

This sensor detects the light signals transmitted by the LED. As the LED blinks according to the encoded data, the light intensitychanges, which the LDR picks up. To detect variations in intensity of light emitted by LEDs, a Light Dependent Resistor (LDR) module is used in the receiver section as it demonstrates photoconductivity where its resistance changes according to light exposure and can convert these observations into electrical signals.

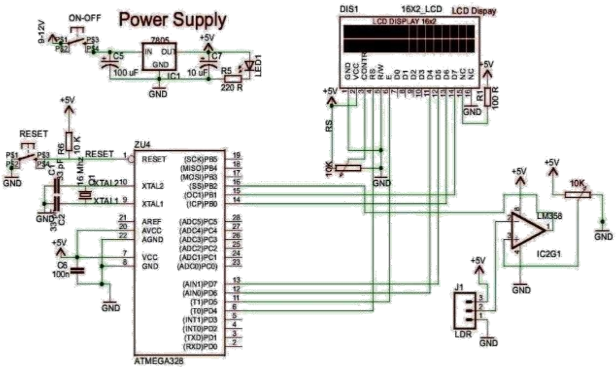

Fig 2: Receiver section

ARDUINO NANO

The receiver section utilizes an Arduino Nano, similar to the transmitter component, for processing of received light signals. Its function involves decoding modulated signals and extracting transmitted information.

BUZZER

The receiver section of the device includes a buzzer that gives audio notifications to the traveler. This feature comes in handy when there are upcoming diversions or crucial information which needs to be communicated, as it can effectively alert and inform them.

LIQUID CRYSTAL DISPLAY (LCD)

The microcontroller processes the received Li-Fi signals, and relayrelevant location information and upcoming diversions to be displayed on an LCD screen in the receiver section.

TRANSMITTER-2LoRa MODULE

The LoRa transmitter module acts as the brains behind data transmission. It's controlled by a microcontroller that processes information for sending and manages other crucial tasks like data encoding and packetization (organizing data into transmittable packets).

ARDUINO NANO

The LoRa transmitter module is controlled by the microcontroller. The data is processed for transmission, and it can also manage other functions. Activities like encoding of data and packetization.

RECEIVER-2

LoRa MODULE

Mirroring the transmitter, the receiver module plays a vitalrole in capturing LoRa signals. It utilizes an antenna to enhance reception distance and quality. Key components within the receiver include an RF receiver chip responsiblefor picking up the signal, a demodulator to convert the received signal into a usable format, and a decoder tointerpret the encoded data. Finally, a microcontroller within the receiver section processes the received information and manages the display unit.

ARDUINO NANO

The microcontroller acts as the brain of the system, controlling the LoRa transmitter module. It prepares the data for transmission by encoding and packetizing it, whilealso potentially managing other functionalities.

LIQUID CRYSTAL DISPLAY (LCD)

This visual interface serves as the user's window into thereceived data. It can display various information transmitted via LoRa, such as location coordinates, navigation instructions, or any other relevant details.

4. RESULT AND DISCUSSION

In this project we received the following results for thethree light poles used in the project.

AT RECEIVER-1

Table- 1: display shown by the poles in LiFi receiver.

POLES	POSITION
A	MLRIT ENTRANCE
B	ECE BLOCK
C	MLRIT LIBRARY

Fig-4 (a): Display of LiFi receiver at pole-1

The message displayed in figure 4(a) is the LCD display of the LiFi receiver for the response from pole 1.

Fig-4 (b): Display of LiFi receiver at pole-2

The message displayed in the figure 4(a) is the LCD displayof the LiFi receiver for the response from pole 2.

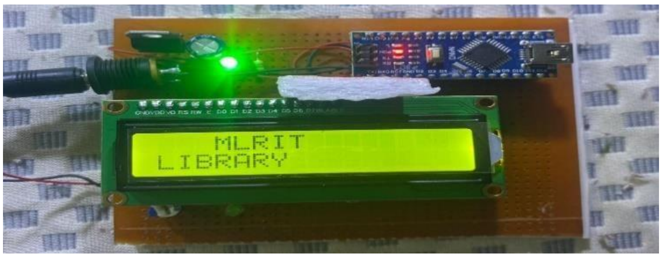

Fig-4(c): Display of LiFi receiver at pole-3

The message displayed in figure-4 is LCD display of the LiFi receiver for the response from pole 3.

Table- 2: comparison between cellular and LoRa technology

Parameters	LoRa Technology	Cellular Technology
Power consumption	10mV-95mV	1kW-8.5kW
Range	15km	1.5km-35.5km
Cost	10000/month	Several thousandmillions/month

AT RECEIVER-1

Table- 3: display shown by the poles in LoRa receiver.

POLES	POSITION
A	MLRIT ENTRANCE
B	ECE BLOCK
C	MLRIT LIBRARY

Fig-5 (a): Display of LoRa receiver at pole-1

The message displayed in figure 5(a) is the LCD display of the LoRa receiver for the response from pole 1.

Fig-5 (b): Display of LoRa receiver at pole-2

The message displayed in figure 5(a) is the LCD display of the LoRa receiver for the response from pole 2.

Fig-5 (c): Display of LoRa receiver at pole-3

The message displayed in figure 5(a) is the LCD display of the LoRa receiver for the response from pole 3.

V.CONCLUSION

This paper explores the potential of Li-Fi and LoRa technologies for navigation systems, particularly considering their advantages over traditional Wi-Fi. Li-Fi, leveraging the visible light spectrum, offers high-speed data transmission (hundreds of megabytes per second) due to its rapid modulation capabilities. This makes it ideal for seamless navigation on highways where fast data exchange is crucial. The proposed system integrates Li-Fi and LoRa to address location service limitations in remote areas. It utilizes existing infrastructure by transforming streetlights into Li-Fi transmitters that broadcast location data directly to vehicles equipped with Li-Fi receivers. These vehicles then act as LoRa transmitters, relaying the received information over long distances to other vehicles with LoRa receivers and LCD displays. This innovative approach will not only improve navigation accuracy but also expands coverage to areas with poor connectivity, especially in remote and challenging terrain.

The project shows how emerging technologies like Li-Fi and LoRa can overcome infrastructural barriers and improve the reliability and accessibility of location services. As know that wireless communication and the Internet of Things (IoT) continue to evolve, this combined approach carries efficient contribution for future applications within the smart transportation systems and beyond.

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