iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** III **Month of publication:** March 2022

DOI: https://doi.org/10.22214/ijraset.2022.40941

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue III Mar 2022- Available at www.ijraset.com

Review Paper on LoRa based technologies for Vehicular and Tracking applications

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Abstract: ***LoRa stands For Long Range. It is a low powered wide area network derived from chirp spread spectrum technology and encodes information through chirp pulses on to the radio waves. The range of LoRa greatly varies from few meters to approximately 100 Kilometers depending on the mode of operation. The main advantage of LoRa against Bluetooth, WiFi and ZigBee is its long range and it is well suited for transmission of small chunks of data with low bit rates. LoRa is generally operated at 915MHz, 868MHz and 433MHz which are Sub-Giga Heartz bands. These are a part of the ISM bands which are reserved for Industrial and Medical Purposes Internationally which are free of cost and do not require any kind of licensing. Vehicular communication is a form of exchanging messages between various vehicular and roadside units regarding their location, speed and much more. The LoRa technology when integrated with Vehicular Communication establishment of green corridors for Emergency vehicles by clearing the traffic and help in reaching the destination with minimal time delay.***
Keywords: LoRa, ISM Bands, Vehicular Communication

I. INTRODUCTION

LoRa is a technology developed and patented by the company SemTech. LoRa is characterized by large cells and multiple application domains, which can cause extremely high numbers of devices coexisting in the same cell. It provides adaptive data rate and wide communication coverage and it is good at resisting the multipath fade. Its application varies from medicine to agriculture.

LoRaWAN is a MAC layer protocol built using LoRa modulation, this is a software that controls LoRa hardware deciding when it transmits and receives messages. This is more suitable for sending small bits of sensor data over a long range. Hence making it more cost effective and most range covered then its competing wireless communications systems (WIFI, Bluetooth, Zigbee) LoRaWAN uses ultra-low power by being in sleep mode and transmitting only when required, this uses licence Free spectrum and has deep indoor penetration making it accessible indoors and it also

provides end-to-end security for each node in the network and makes roaming easier with seamless handover from one network to the other.

In any mode of communication there are a certain number of factors which need to be taken into consideration based on the end devices communicating and the mode of communication taking place. Similarly based on the end nodes vehicular communication can also be of various types like it can be Vehicle to Vehicle or Vehicle to Cloud or Vehicle to Infrastructure or Vehicle to Network or Vehicle to Grid. DSRC (Dedicated Short Range Communications) is the protocol which is currently used in Vehicle-to-Vehicle communication which operates at the 5.9 GHz alerting drivers to potential collisions and exchanging the data. When this kind of communication is established using the LoRa technology there are multiple factors which effect the transmissions like: Spreading factor, Signal Bandwidth, Carrier frequency, Code rate, Transmission Speed, reception Sensitivity and many more.

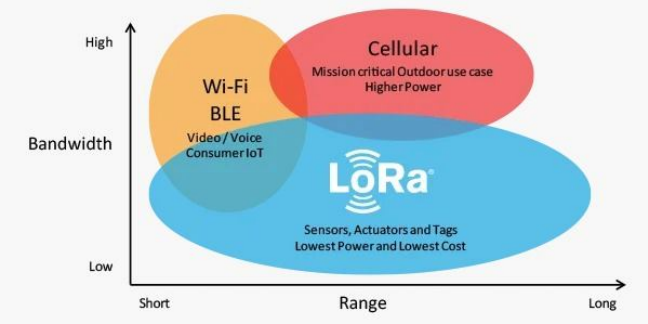

Figure 1. Range versus Bandwidth of different communication standards.

II. LITERATURE SURVEY

A. Alokkumar Rao,Bharat S. Chaudhari, Dr. Vishwanath Karad Development of LoRaWAN based Traffic Clearance System for Emergency Vehicles"(2020)

This paper proposes LoRa based emergency vehicle traffic signal clearance system, it combines both GPS module and LoRaWAN (gateway) technology to update website about the location of the Emergency Vehicle. LoPy nodes developed by pyCom are mounted on the emergency vehicles and these LoPy nodes can work with LoRa, wifi Bluetooth etc. These vehicles will have a unique ID and start sending their GPS coordinates to the nearest LoRa gateway and the LoRa devices mounted on traffic signal in the vicinity. And the LoRa that manages the signal and the the things network (TTN) receives identity, GPS coordinates and Received Signal Strength Indicator (RSSI), Through LoRa gateway, all this information is can be monitored in real time using TTN. This monitored value to can calculate the distance between the traffic signal and the vehicle, This value is compared with distance calculated by the LoRa module mounted on the signal making it more reliable. Through which a green corridor is established for the Vehicle to move with encountering minimum traffic.

B. Krasen Kirov Angelov " Development and Implementation of a Demonstration Model of Smart Parking with LoRaBased Communication Module "(2020)

This paper published in 2020. It proposes a smart parking model with the use of geo magnetic sensors, Adafruit, Solar panels. The Solar panel is connected to a battery for the constant autonomous power supply, which is in turn connected to the Adafruit feather 32u4 LoRa Board. The geo magnetic sensor is embedded into the ground and is used to detect if there is presence of any vehicle in the parking lot. If it detects any vehicle in the parking lot it shows it through the graphical interface which is a smart scalable platform for intelligent provisioning and monitoring the information of the empty and full parking spaces along with the temperature and humidity of the surroundings in large cities with complex urban environment.

C. Li-Hsiang Shen, Chien-Hung Wu, Wun-Ci Su, Kai-Ten Feng" Analysis and Implementation for Traffic-Aware Channel Assignment and Contention Scheme in LoRa-Based IoT Networks" (2021)

This paper published in 2021 is a very detailed paper discussing and proposing a scheme to solve a major drawback of LoRa, the Network Capacity and Latency in massive LoRa network. Network Capacity and Latency can affect the communication between nodes and the server in a sever manner, especially if many nodes are actively connected and trying to communicate with the gateway. To solve this problem a new scheme – TCBA which can be abbreviated as Traffic-Aware channel and Backoff window allocation is proposed. This scheme is evaluated by analytically deriving throughput maximization, which provides a sub-optimal solution for both homogenous and heterogeneous LoRa networks and comparing with the simulated values using MATLAB. Because of the low end-to-end latency and high throughput offered by the TCBA scheme, the number of nodes that can be connected to LoRa is increased, making this scheme suitable for a large LoRa network. An indoor outdoor experiment using a LoRa device with a temperature sensor is also presented in this paper, demonstrating that the TCBA scheme can flexibly adjust both channel and backoff settings to achieve the lowest packet drop-off rate and highest throughput in both normal and high traffic conditions.

D. Daniele Croce, Domenico Garlisi, Fabrizio Giuliano, Alice Lo Valvo, Stefano Mangione, Ilenia Tinnirell "Performance of LoRa for Bike-Sharing Systems" (2019)

This research paper provides the information about the LoRa technology as a tracking device in bike sharing system. In this LoRaWAN technology, MAC/PHY protocols and LoRa tracker module [Arduino Yun Board, SemTech sx1272 based LoRa transmission chip, USB based Global Positioning System module] is used to communicate between the bike and the base.

To adapt transmission characteristics to propagation conditions, the LoRaWAN network proposes an ADR (Adaptive Data Rate) mechanism. The Data Extraction Rate (DER) is used in this paper to ensure that packets are correctly received by the gateway, which is dependent on the number, location, and rate of LoRa end devices, as well as the distribution of SFs among them.

E. Flammini, F., Gaglione, A., Tokody, D., & Dohrilovic, D. " LoRa WAN Roaming for Intelligent Shipment Tracking"(2020)

With the help of Artificial Intelligence and Machine Learning, this paper proposes an extension of the LoRaWAN roaming protocol. "Agreement-less roaming" is the mechanism proposed in this project. When a vehicle from one shipment company in one country connects to a LoRaWAN network from another shipment company in another country, this mechanism manages roaming. The expanded network also introduces Distributed Servers which include Network servers Join Servers and Application Servers.

The future work in this domain would include establishing protocols between networks and BUS. And improving the security and tracking with the help of Artificial Intelligence and Machine Learning. The proposed model is expected to improve the shipping service's level of safety, comfort, and overall quality.

III. COMPARATIVE ANALYSIS

Name and Author of the Paper	Research	Remarks
A. *Alokkumar Rao,Bharat S. Chaudhari, Dr. Vishwanath Karad Development of LoRaWAN based Traffic Clearance System for Emergency Vehicles"(2020)*	This paper deals with creating a green corridor to emergency vehicles like fire truck, ambulance etc. to avoid traffic and cross the signal in the least time possible, to implement that this in this paper they have used LoRa and LoRaWAN gateway (the things network) to track the vehicle and update its location on a webpage, the green corridor is established by Emergency Vehicle talking to signals directly the distance is calculated using RSSI values.	Does not cover the specifics like network capacity and latency which are a huge factor in urban area where several nodes are connected to LoRa gateway resulting in huge traffic which can delay communication between Signal and vehicle which can hinder the establishment of green corridor to the emergency vehicles.
B. *Krasen Kirov Angelov " Development and Implementation of a Demonstration Model of Smart Parking with LoRaBased Communication Module "(2020)*	A smart parking system along with the temperature, humidity along with the availability of the parking spot.	Not much clear information about how the user gets the information regarding the availability. Unclear working procedure and lack of real-time results.
C. *Li-Hsiang Shen, Chien-Hung Wu, Wun-Ci Su, Kai-Ten Feng" Analysis and Implementation for Traffic-Aware Channel Assignment and Contention Scheme in LoRa-Based IoT Networks" (2021)*	This paper deals with assigning channel and backoff window size taking latency constraint of a LoRa network into consideration. the proposed TCBA and TCBA-D schemes have been verified as theoretical analysis approches the simulated once.	This paper proposes a new scheme, TCBA, to solve a major problem in massive LoRa by dynamically achieving low packet drop-off rate and highest throughput in various traffic conditions.
D. *Daniele Croce, Domenico Garlisi, Fabrizio Giuliano, Alice Lo Valvo, Stefano Mangione, Ilenia Tinnirell "Performance of LoRa for Bike-Sharing Systems" (2019)*	This paper focuses on cost efficient ways to provide protection to the bicycles by using Lora technology. Which mainly uses the LoRaWAN technology, MAC/PHY protocols and LoRa tracker module. By which the scalability of LoRa cell is obtained.	The gateway's location is crucial, and it should be carefully considered for optimal coverage.
E. *Flammini, F., Gaglione, A., Tokody, D., & Dohrilovic, D. " LoRa WAN Roaming for Intelligent Shipment Tracking" (2020)*	Proposes a system for intelligent tracking of goods which can be more effective since it helps in pinging the exact location of the shipping good.	Model is incomplete and real time testing of product produces extensive complications since it involves international tracking and approval of the product from all the governments is required. In the case of cargo establishing gateways in the ocean is quite difficult.

IV. CONCLUSION

After the research of existing methodologies and techniques used for tracking and vehicular communications different papers have described various technologies and most of the results obtained have definitely been better than the previous researches in the field and offer a new perspective of concepts. But, there is still a paved way for the development of the existing researches which can lead to multi-dimensional growth in the field of LoRa.

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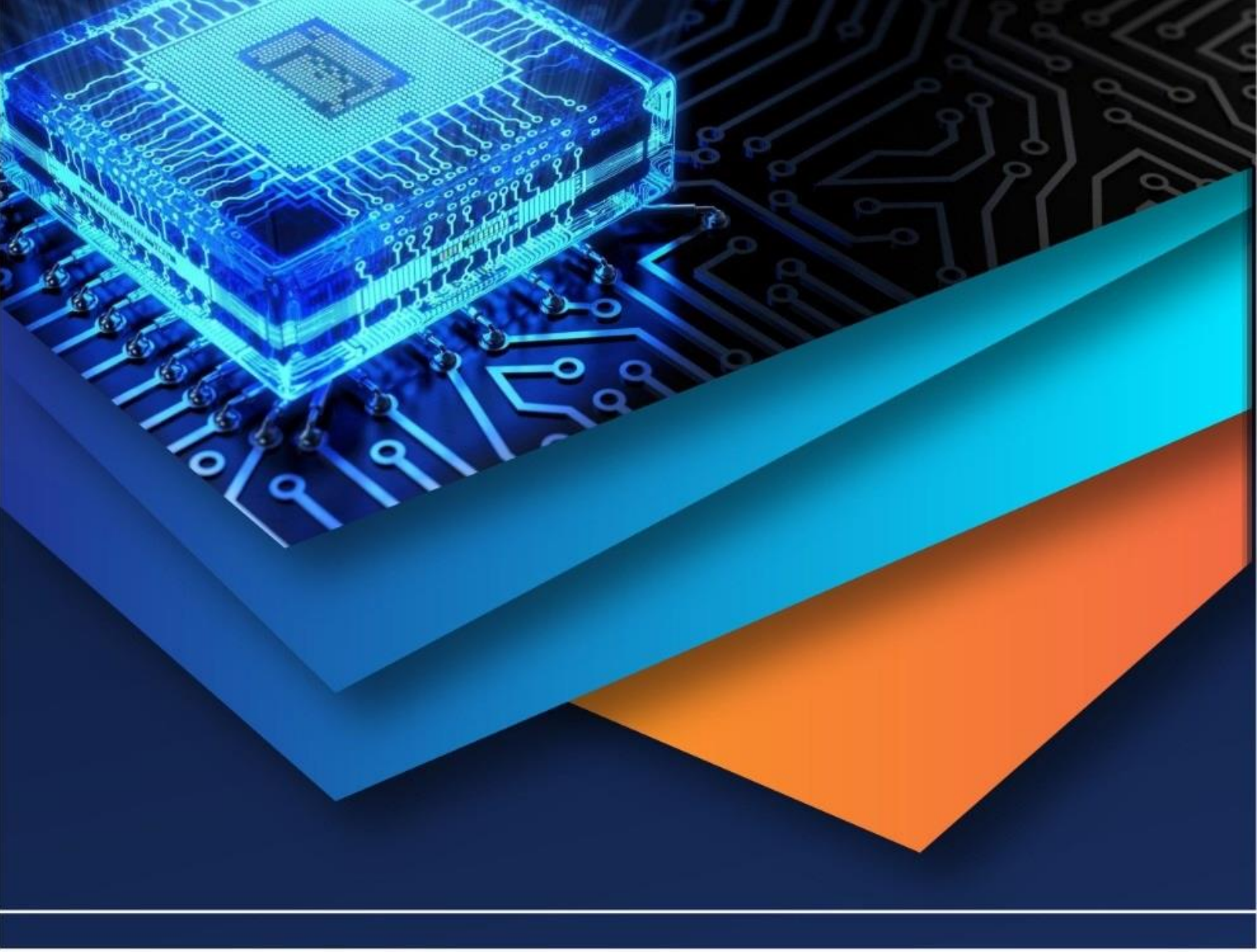

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