Li-Net: Towards A Smart Li-Fi Vehicular Network

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Abstract: Light Fidelity is popularly known as Li-Fi. This is a very new technology that is driven by German physicist Harald Haas [1] in 2011. The technology is proposed during a global talk on Technology Entertainment Design on VLC communications. Visible light communications are optical ways of communication that networks the LED for data transmission. The term Li-Fi uses the VLC communication for the high end communication that can be an alternative of Wi-Fi. The proposal of Harald Haas is comparable with IEEE 802.15.7 that is fully dual directional and networked standard built for 802.11.

Keywords: *Li-Fi, Li-Net, VaNet, Communication technology, Network, Smart Network*

1. Introduction

Now a days, the world is overcrowded with wireless communications. This communication uses the radio waves that transfer data from one place to another. These waves are fast growing network links that are very important for the day to day activities. The current wireless networks connect the whole world with multiple device support and backward compatibility [2]. The availability of fixed bandwidth is however a difficulty or the high speed data transfers that also creates a vulnerability in the secure ways of data communication. The radio waves transmission is part of EM spectrum that is used for the transmission of data. However, the new coming mechanism are broader in terms of data transmission technologies and provide more secure and faster communication using the light waves. Li-Fi is also such a medium. The ideology of Li-Fi transferred the data using quantization of LED lights [3]. The light is varied according to speed of data transfer and then human eyes cannot perceive the varying intensity [4]. Therefore, the data transfer can be accomplished. The visible spectrum of Gigahertz radio waves of data transfer is becoming the history in front of Li-Fi.

Figure 1. LED bulb- A Primary component of Li-Fi Network [24]

The smart traffic net is future of transport system that is based on Li-Fi net. Therefore, this is called as Li-net in this paper. This network is focused on allowing the stops signatories, signals, roadways that can communicate with other automobiles and provide a fast and smooth ride for the safety of passengers. The autonomous cars can be operated by using the radars and GPS with vision of computers. Odometer of cars is also controlled by them that can also allow the V2V communication. Previous use of radio waves for this purpose is very old technology that allows Vehicle-to-Vehicle and Vehicle-to-infrastructure communication. This technology is based on Li-Fi and is collectively known as V2X that allows the both Vehicle-to-Vehicle and Vehicle-to-infrastructure communication. The smart traffic system allows and utilizes the Li-Fi network that avoids the radio air waves and their potential fear of interference. This way TESLA auto pilot system [5] can also be alternated. The system is currently being operated by TESLA and is no widely adopted and used for their potential benefits in public. The system is not in use for urban streets because it cannot improvise the rush and interferences in these areas. The system on the other hand used wireless transmitters that are in-efficient for their use in cars and communication with the infrastructure. Our proposed system uses light signals that did not require additional transmitter and also has the ability of reprogramming for the exchanging rate of flash lights. A transmitter bulb of Light fidelity consists of following component.

- Bulb
- PA circuit (A RF power amplifier)
- PCB (printed circuit board)
- Enclosure

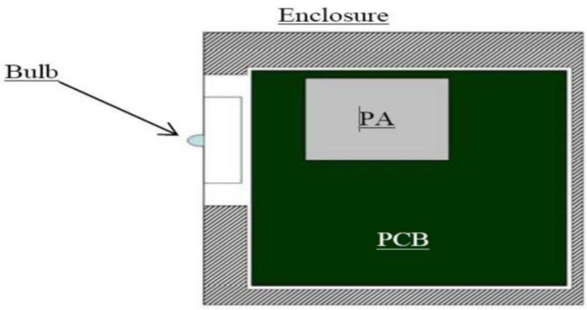

Figure 2. Block diagram of Li-Fi Assembly [23]

1.1 Primary attributes of Li-Fi Vehicle Network (Li-Net):

Since Li-FI Networks (Li-Net) acquire the vast majority of the qualities of MANets as their subset. Some exceptional qualities including high portability, density in network frequent topology change, communication patterns, power availability, no limitation on network size. As the batteries are rechargeable in vehicles so clients don't have limitation on energy availability [21]. Moving hubs move with high speeds and are vehicles (above 100 Km). Therefore, a critical quality is high portability. Additionally, topology regularly changes as vehicle move quickly or the drivers change their ways. Due to movement in streets, disengaged cluster are created as holes in the streets, additionally topology change in Li-FI Networks (Li-Net) shortens the length of the connection in length. The vehicles will need much time to pick the new way to perform communication. As the density decrease, the isolated cluster increase. This will create connection disengagements. This will create issues that need to adopt roadside units and amplifying nodes. There is also need of consistent availability and amplifying the messages in Li-FI Networks (Li-Net). Portability is constrained to the arrangement of roadways, streets, and lanes. It is important to know the position of hubs to better anticipate the choice of next receiver. Also as the portability model changes in parkways or urban conditions, it effects Li-Net control algorithms. The roadway model works better as one dimensional movement is always shown over motorways. On the other hands urban model is effected by different patterns of the streets and multi-dimensional movements, density, plazas and interferences by different trees & tall structures of buildings etc. These highlights make the plan of Li-FI Networks (Li-Net) in urban conditions unique and more difficult.

1.2 Communication Patterns in Li-Fi Vehicle Networks (Li-Net):

In Li-FI Networks (Li-Net) every vehicle may behave differently like sender, recipient and switch to lead correspondences. Vehicle to vehicle Communication (VC) can be stated as: 1) "Inter-Vehicle Communication (IVC)", 2)" Roadside-Vehicle Communication (RVC)", and 3) "Hybrid Vehicle Communication (HVC)" [5].

Inter Vehicle Communication are the interchanges between different travelling vehicles that are totally free of frameworks. This correspondence is dependent on OBUs for completing the interchanges. Inter Vehicle Communication are ordered into Single Hope Inter Vehicle Communication and Multi-Jump Inter Vehicle Communication interchanges. Single hope Inter Vehicle Communication is mostly used in short range correspondences like the applications who use path searching and other applications like that. Multi hop Inter Vehicle Communication are used for long range correspondences like the movement observing applications. RVCs build up the correspondence amongst OBUs and RSUs. On the other hand, RVCs are further described in two categories. These are 1) sparse RVC (SRVC) and 2) Ubiquitous RVC (URVC). The first category SRVCs give correspondence benefits as routing hotspots, while URVCs give the fast interchanges to every one of the hubs. URVCs may require additional hardware. At long last, HVCs are utilized for correspondence purpose amongst running automobiles. Their other function is working as base and supporting RVCs to broad their scope territory. likewise, if vehicles don't occur in the scope of wayside framework, then other automobiles become hotspot for HVCs. HVCs increment the transmission scope of RVCs. HVCs can't ensure the availability in low dense conditions. Figure below exhibits the correspondence designs in Li-FI Networks (Li-Net).

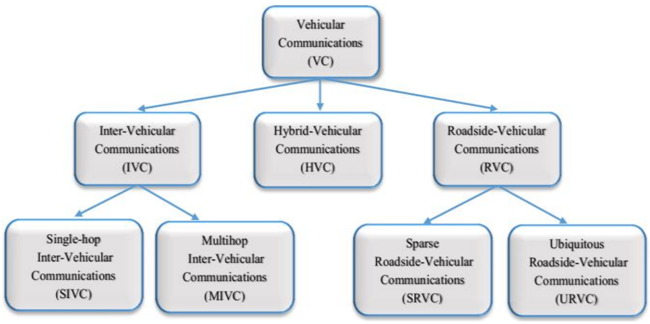

Figure 3. Communication Pattern in Li-Net

Traffic congestions result in efficiency issues of a network, and also an issues like adaptation of the technology. The same is the case with VaNet. VaNet is considered as new technology to overcome the traffic issues and correspondence between road traffic. As the quantity of vehicles develops quickly every year, more movement congestion happens on the roads, which is aimed to be solved by VaNets, turning into a major issue for engineers in every metropolitan city.

During the recent years, the work is done on congestion control activities. in the earlier researches, congestion control is focused to packet loss amid the networked nodes. Now a day, the special characteristics of the VaNets need to perform congestion control and to minimize delays and packet loss. This work focuses to develop a new strategy to control the congestion that will help to minimize the loss of packets and delay in transmission delay with the help of Li-Fi. Controlling congestion will help reduce the channel loads and efficiency of the network. This will also lead to adaptation of the technology that is popularly known as Li-Net.

The section 2 described the related work done on Li-Fi. Section 3 summaries the architecture of the Li-Net. In Section 4, we describe the scheduling methods for Li-Net. and the conclusion of the research describe in Section 5.

2. Related Work

As the concept of LI-Net is described in this paper for the first time. Therefore, there is no earlier literature to review on this topic. However, we review the concept of VANET and its relevant material to lit the base ground for the Li-Net.

[6] stated that in specific situations, a few RVs can communicate to particular EV. Such an example can be in the case of parking. Where vehicle don't know where to get exit. Such as situation, movement on expressway movement & city activity can cooperate with each other, if a channel is shared between both of them. [7] described that Issues can arise if data goes undesired/pointless then these packets create issues. These issues can be either a collision on roadway. This collision is due to contamination of system by undesired immaterial date packets. The un-seen hub issue is a notable situation in remote correspondences which brings about a parcel smash. The situation includes two transmitters which are not in gathering scope of each other, and one recipient in the center. [8] described that the collector is capable to listen the two transmitters however if one is sending data then the other will find the channel free and also sending data. This issues will cause collision as VaNet is not yet matured to use the ACK systems or synchronizations mechanism. When the second transmitter starts sending packets, smash happens. The collector is getting vitality from the two transmitters at the same time making whatever is left of the parcel be gotten with mistakes. Given the idea of roadways being long lines, this circumstance happens frequently [9]. [10] Stated that the equality of a DCC calculation is a critical factor that defines how all around appropriated an asset is. On account of V2V interchanges, reasonable utilization of the channel might be that everybody sends data a similar speed, also it is possible that availability of medium depends upon people use of that medium in that area. [11] also described DDC algorithm that uses Beacon Error Rate. Error rate depends on delay and loss of packets mostly due to congestion. [12] Beacon Reception Rate is dependent on sensitivity during the DCC analysis. It can be estimated as the quantity of data packets got from a particular vehicle in a characterized interim or the total of guides got from all vehicles per interim [13]. Inter-packets delay in transmission depends on the rate of getting packets by the reference point. Delay in channel access is the time that an EV faces before sending a data packet. A high value of access delay means that EV takes more time before transmitting packets. [14] described another measure known as CBR ratio. This describes how much time a channel is kept busy. It depends on CCA (clear channel access). CCA is measure as how much a channel remained free for access. [15] research main objective was to recognize crucial road portions and to protect circulation block before it originally happens. [16] research emphasis upon the features associated to circulation crescendos. [17] presented 5 different interconnection patterns which form the foundation of nearly all applications of VANET. For future development, 5 different patterns may utilize like foundation. For secrecy and security analysis, patterns may form the foundation and permit bottom-up conversation of security to obtain solutions for secrecy and security. [18] shows extensive detail and matching of several obtainable VANET reproduction software and their modules. For detecting various layers of circulation blockage, researcher research emphasis upon EDA which is an innovative technique to obtain VANET message. Also, it focuses on atmospheric data which is coming from exterior data assets like weather situations. [19] proposed a group of steering protocol's known as road oriented utilizing automobile circulation steering, that works well current steering protocol's within city oriented automobile ad-hoc systems. RBVT protocol's influence actual period automobile circulation data to make road oriented ways comprising of progressions of street connection have greater possibility, system connection between them [20].

3. Li- Net Architecture

There are three domains of Li-FI Network (Li-Net) incorporating into vehicle area, Ad hoc area, and third one is infrastructure space. In-vehicle area is framed of OBUs. Every vehicle is thought to be furnished with OBU. This is used during short range remote correspondence that is produced by OBUs for security and non-critical safety transmissions. Ad hoc area is made out of combinations of OBUs and RSUs. There is a network between OBUs this network is responsible for inter vehicle correspondences. OBUs transmission is performed as one-hop correspondence or multi-hop transmission depending upon sender applications (shen et al, 2013). Infrastructure domain consist of RSUs and the second component is Hotspots (HS). This domain is utilized for safety related and non-security applications. RSUs give web access, & Hot Spots are considered for low bandwidth conditions. For the situation that RSUs or HSs can't give web access, OBUs can utilize mobile systems architecture. These architectures include different networks like GPRS, GSM, UMTS, or any other for identification and Li-Fi for communication.

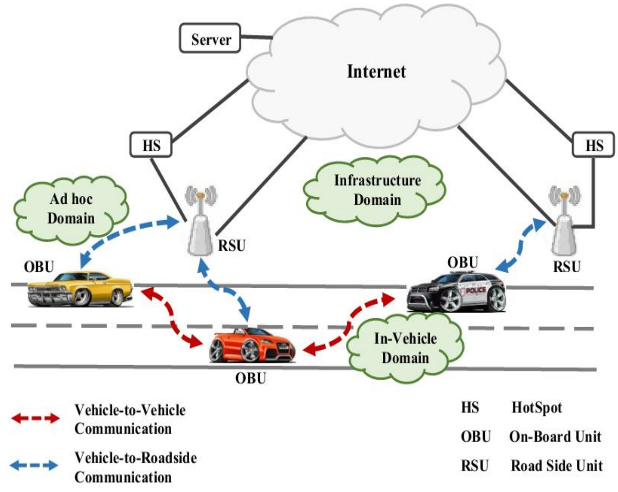

Figure 4. Li-Net Architecture [25], [26]

4. An Efficient Message Scheduling Method for Li-Net

We propose the use of meta-heuristic schemes can be used for Li-Net scheduling. Due to the constraints of automobile atmospheres, simple arranging problems are said to be NP-hard, as described by [21]. message arranging will also be NP-hard problem. For such type of problems, meta-heuristic schemes result closer find optimal solutions. Tabu algorithm as mentioned above is the best Meta scheme which normally utilized for automobile routing and problems of graph theory etc. This algorithm is actually defined by [22]. For every medium, Tabu can be utilized for dynamic scheduling & re-arranging procedure of messages. For dynamic scheduling, we describe the scheduling approach based on Tabu is described as Tabu scheduling(St-Sch).

In LI-NETs, for giving reliable and secure atmosphere, message delay of transmission must be reduced. So, for minimizing delay, jitter remained the focus of our work through use of Tabu algorithm. Memory schemes involve long, short and medium memories. A Tabu list is said to be the short memory that is used to store many solutions. When new solution is picked for

finding an appropriate solution then we put it into Tabu list. After that new solution contrasted with old solutions to check it is repeated or not. Size of Tabu list supposed to be 50 to put a threshold limit in this work. So, it assumed to be the limitation of Tabu list. Old solution will be deleted from list, if list has been filled and crosses over 50 solutions. For finding a better optimal solution, middle memory is utilized. Its size is 5 to put a check on maximum optimal solutions. Suggested Tabu algorithm chooses early solution between the lists of middle memory for creating new solutions. On the other side, search is expanded using long term memory to prevent set-up into local optimal solutions of short term and medium term memory. So, presented algorithm, searches the best solutions from Tabu list that contain many different solutions for message sending. In lines, neighborhood class described via altering the sequence of packets. Appropriate solution is picked between solutions within neighborhood class and then kept into applicant list. This way we can find solutions from list. Within proposed algorithm, quantity of repetitions is supposed to be 25, as the size of queues is described as 50. Given below figure presents pseudo-code of presented algorithm.

```
Input size of Tabu List
Input Iterations
Input Counter Diversifications

input current delay, jitter as So
Sout<- s0 // initilialize current colution as output solution
Divers_Count<-0
Insert Tabu_List(S0ut)
i<-0 // start iterations
intensifict_vari<-0
intensifict_var_rand(1, iteration)
 While(i<iterations)
 N(s)<- find(neighbourhood set) // re-ordering packets as per mid-term-memory
 T(s)<- find(TabuList)// re-ordering packets as per short-term-memory
 CandidiateList(s)<- N(s)+T(s)
 Intensific_Counter++
 If(intensific_counter==intensific_var) // randomely selecting solution from mid-term-memory
 Sout<-select(midTermlist)
 End if
 If empty(candidate_List(s)) //long-term-memory
 Divers_count++
 if Divers_count== diversification_counter // entrapping local minima
 so<- genNewSolution()
 go to step 2 // sout<-so
     End if
 End if

 While(!empty(candidate_list(s))
 if delay(Scandidate)<Delay sout && Jitter (Scandidate)<Jitter Sout)
 s0<-genNewSolution()
 go to step 2 .//sout<-so
     end if
 end if
 end while

  //update tabu_list step
  if(Length_tabuList<maxListSize)
  add current Sout to TabuList
  else
  Delete the oldest solution in TabuList
  End if
  End While
  Return (Sout)   //output_algo(Solution with Best Delay, Best Jitter,Ordered Queue)
```

Figure 5. Algorithm for Li-Net Scheduling

Our proposed scheduling method for Li-Net message scheduling is tested using Intel Prime II. This software provides the simulation environment for the Li-Fi. The codes are separated for the sender and receiver node and then analyzed for their characteristics. We have observed different QoS characteristics for the potential outcomes of our proposal. The results are evaluated from the test bench code that is written in VHDL.

5. Conclusion

Our proposed simulation is tested with the trivial VANET simulation as described by [5]. The scheduling in VAENT faces different issues like jitter, message delay and message throughput issues. It is evaluated that in case of Li-Fi, the vehicular network known as Li-Net worked smoothly in congested urban environment with the proposed scheduling mechanism.

Table 1. Comparison of Result Characteristics (VaNet vs Li-Net) [5]

Vehicle number	VaNet			Li-Net		
	Lost Packets	Average Delay	Through Put Avg.	Lost Packets	Average Delay	Through Put Avg.
50	0	0	1	1	1	2
80	2	0	2	2	2	2.5
100	1.5	0.5	2	1.5	2	3
120	1.5	1.2	3	2	2	4
150	1.5	1.5	4	2	3	6
200	3	4	7	3	5	8

Effect of automobiles quantity, ratio of message creation and time of simulation on above mentioned performance metrics calculated in the given in the simulation results. It illustrates outcomes of highway situation; it is evident that average delay of transmission grows with growing count of automobiles for all blocking approaches. Also it illustrates average delay of transmission resultant from scheduling approaches are lower from VaNet. Li-Net based scheduling goes towards smallest average delay of transmission. Tabu scheduling approach reduces delay of transmission during transmitting message for all sorts of messages. Li-Net scheduling approach also minimizes average delay of transmission when compare to VaNet. There is an issue that FIFO is unable for managing congestion of transport when quantity of transport goes high. Because in FIFO there is no priority in FIFO and hence some packets are de-queued irregularly. The results table display the packet loss for Va-Net and Li-Net scheduling. This is evident that loss of packet is low in both scheduling when it comes to comparison. Congestion can be easily controlled when it comes to planning and prioritization. Priority can be assigned to safety and repair messages. This results in lowering down the measure of collisions and resultantly the loss of packets during transmission in Li-Net.

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